Wireless is Changing the Policy Calculus for Municipal Broadband

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Abstract

Historically, the justification for municipal provisioning of "last mile" communications infrastructure has focused on the natural monopoly aspect of wireline infrastructure. Growing interest in wireless ISPs, municipal hot spots, and access to public space for siting wireless infrastructure suggest new and expanded opportunities for local government participation in telecommunication services. This paper examines the implications of emerging wireless technologies for the policy debate over whether municipalities should be playing an active role in providing last mile broadband services, and if so, what the nature of that role should be.

I. Introduction

The future of the Internet is broadband, and the future of broadband will involve a large component of wireless services. The high costs of deploying next generation broadband infrastructure is raising questions as to how best to fund the requisite investment. How one answers this question is closely related to ones view of the industry structure that will best suit our collective needs for ensuring affordable, universal access to broadband services while at the same time ensuring that consumers have adequate choice and are not at risk from an abuse of unwarranted market power. While competitive markets are generally viewed as preferable to monopoly regulation, the viability of competition varies by locale. Because the costs of deploying broadband infrastructure and the demand for such services may vary greatly from location to location within a town, across a state, and across the nation, it is unlikely that any "one size fits all" broadband access solution will emerge, or if it does, will be optimal.

Over the last decade, regulatory reforms in the United States and elsewhere have sought to lower entry barriers and relax regulatory oversight to facilitate increased competition in last-mile access services. At the same time, technical and industry convergence have enhanced opportunities for cross-platform competition (*e.g.,* fixed line v. mobile telephone, telephone v. cable television, POTS v. Voice-over-IP).[1] Unfortunately, with the collapse of the competitive local exchange industry (CLEC) during the global telecom industry recession that began in 2000 and the subsequent consolidation in the industry, there is growing concern in some quarters that the private-sector might fail to invest widely enough or fast enough in delivering the needed next-generation facilities.[2]

Access to advanced communication services, including broadband data services, is increasingly viewed as essential infrastructure that is critical for the economic and social health of communities. Continuing innovation in computing and communications technology and the growth of the Internet and eCommerce have made data services increasingly important in modern life. Furthermore, there is growing awareness that next generation communications infrastructure, capable of delivering a bundle of high-speed services, may be a natural monopoly in at least some communities.[3] In light of the relaxed regulatory oversight from federal and state authorities of last-mile access providers (which has been justified on the promise of successful progress towards last-mile competition), some local authorities are finding it desirable to be more proactive in addressing the regulatory challenges of ensuring access to essential communications infrastructure.

The proliferation of new wireless technologies during the last decade impacts the policy calculus faced by communities. In our companion paper in this issue, we provide an introduction to the technologies in this changing wireless landscape.[4] However, the impact of these new technologies on municipal broadband policy is ambiguous. On the one hand, wireless technologies make it easier and expand the options for local governments to become engaged in providing broadband communication services; while on the other hand, also enhancing prospects for additional private-sector competition that might reduce the need for government entry.

In the United States and abroad, there has been growing interest in local governments playing a more direct role in providing communications infrastructure and services in their communities.[5] While the number of communities that are deploying their own infrastructure remains small, it has been growing rapidly. Prior to 2004, most of the municipalities that elected to offer some form of communication services were communities with Municipal Electric Utilities (MEUs).[6] By 2004, almost a third of the approximately two thousand MEUs in the United States were offering some form of communication services, more than twice the number that had offered communication services four years earlier.[7] While data on wireless deployments is more difficult to obtain, the best data we are aware of identified 117 municipal wireless deployments in the United States as of mid-2005 – double the number from a year earlier.[8] These small numbers might lead one to conclude that the interest in municipal entry into communication services is perhaps more hype than reality, but the rapid growth rate may mean that it is a harbinger of the future.[9] Whether hype or harbinger, municipal entry provides an interesting candidate for research. Munis have been the early adopters of cutting edge technologies, including fiber-to-the-home and broadband wireless, providing early insight into how these technologies perform in practice. Moreover, muni experiments provide valuable insight regarding alternative organizational models for deploying basic communications infrastructure.[10]

In the "pre-wireless" world, the communities that have been most likely to make the leap into providing telecommunication services have been those with MEUs[11] accustomed to pulling wire. Wireless expands the range of communities that are finding it feasible to consider offering communication services, and is expanding the range of trajectories by which local communication services are evolving.[12]

Whether municipal entry is desirable – compatible with private sector competition or better than private alternatives – remains a hotly debated question. Incumbent cable television and telephone companies have often opposed municipal entry into communication services as representing an unfair form of government-subsidized competition.[13] On the other side, proponents of local autonomy, community-based networking, and economic development have argued in favor of a larger role for local government in providing communications services.[14] In the United States, a number of states have passed laws restricting local government entry into communication services and the debate is on-going as to whether public policy ought to promote or restrict municipal entry.[15] Regardless of one's position on this debate, it is important to understand the impact of wireless.

The balance of this paper is organized into three sections. In Section II, we examine the traditional economic justifications for municipal provisioning of local broadband access services. This provides a basis for understanding how emerging trends in wireless change the decision-making calculus for municipal entry (discussed in Section III). Section IV concludes.

II. The Municipal Role in Providing Communications Infrastructure

Municipal entry into communication services may be justified economically in three basic ways: (1) as a response to a market failure; (2) as part of the local government's role in providing basic infrastructure services; or (3) as a way to opportunistically take advantage of scale or scope economies afforded by investments or services that were put in place for another reason.

A. Market failure rationale

According to the "market failure" rationale, government intervention may be justified if private alternatives are perceived to be inadequate. The costs of deploying infrastructure and operating services may be too high relative to the revenue that can be expected so that an insufficient number of private sector providers enter the market. In the most extreme cases, it may be uneconomic for *any* private carrier to offer service.

The lack of adequate competitive alternatives may arise for a number of reasons. The market may be too small to sustain more than one facilities-based provider (i.e., a natural monopoly), or even if there are two or three competitors, competition may fail to be sufficiently robust. The presence of significant sunk, fixed, and shared costs in the provisioning of communications infrastructure gives rise to substantial scale and scope economies that may limit the number of providers that can be sustained in any local market. Additionally, due to externalities and spillover benefits, private provider revenues may fail to appropriate a sufficient share of the benefits to make private sector provisioning economically viable. For example, there may be social benefits from wider broadband deployment that are not appropriable by a private firm, or private firms may face higher capital costs (greater investment risk) than a municipality.

Historically, the communities that are most likely to suffer from inadequate provisioning are those that are either high cost (e.g., low density rural communities where it is more costly per home passed to deploy outside plant) or economically less developed (i.e., poor) communities. Not surprisingly, the roll out of broadband has been uneven, with availability first occurring in dense urban areas where the economics of private market offerings are most favorable. However, over time as costs have fallen and demand has grown, broadband availability has expanded. Data from the Federal Communications Commission shows that as of December 2004, broadband was available from at least one provider in 95 percent of the nations zip codes, representing 99 percent of the nation's population.[16] This data overstates the extent of broadband coverage because it does not ensure that broadband is available throughout the zip code, is based on a rather anemic definition of what constitutes broadband (200 Kbps service in at least one direction), and does not control for either the price or quality of the offerings available.

More importantly, however, even when broadband is available, there may be a perceived "market failure" if the private sector fails to deliver adequate competitive alternatives in terms of the prices charged, the breadth of selection or the quality of broadband services offered. Very few communities have more than two facilities-based providers of broadband access services today (DSL and cable modem, although there may be numerous retail-providers reselling either the DSL or cable modem services).[17] With the roll-out of national 3G mobile wireless broadband services from providers such as Verizon Wireless, Cingular, and Sprint-Nextel, the range of competitive offerings will increase but these services are currently priced quite high, offer lower data rates than alternative broadband services, and are still quite limited in availability.

Among the communities that have private cable or broadband providers, there are a number that are unsatisfied with the quality/price of service from the private carriers, and look to municipally-owned providers to expand competitive choices. In a number of cases, such communities have found private carriers either unwilling or too slow to deploy new infrastructure or to provide ubiquitous coverage, or have been unhappy with the quality of service provided. For example, this was the case in Burlington VT and Braintree MA.[18]

Furthermore, in light of the need for new investment required to put in place next generation broadband infrastructure (*i.e.*, supporting data rates in the 10s to 100s of Mbps instead of today's generation of DSL/cable modem services which support at most a few Mbps)[19] and in response to the global telecommunications meltdown that began in 2000 and the collapse of much of the competitive local exchange (CLEC) industry, there is a valid concern that the private sector will fail to invest in providing for next generation services or that when such services are available, they will fail to be sufficiently competitive.

Moreover, if there is inadequate supply of facilities-based alternatives from the private sector, it is unclear where in the network the bottleneck might occur. For example, the bottleneck may arise at the level of the individual household connection (the so-called "last-mile") or it may occur at the point of interconnection with wider-area networks (the so-called "middle-mile"). In the former case, it may be uneconomic for multiple infrastructure providers to deploy fiber all the way to the home or even into the neighborhood. Because of the high fixed and sunk cost component associated with operating wired local access facilities, whoever deploys first may realize critical first-mover advantages that deter subsequent entry;[20] or alternatively, even if both the cable carrier and local telco deploy neighborhood fiber, it may turn out that the resulting competition ("Bertrand") is so severe that neither carrier can realize revenues sufficient to sustain investment in expanding capabilities and services. If this is the case, municipal ownership of the fiber infrastructure may make sense.

It is also possible that there may be a market failure associated with providing "middle mile" services. For example, while each house may be adequately served with far less capacity than is provided by a Fiber to the Home (FTTH) system, there may be significant economies of scope and scale associated with aggregating traffic from multiple homes and connecting these neighborhoods to wider area networks. These backhaul costs are an important operating cost for small-scale ISPs. If the market failure is associated with a bottleneck due to middle-mile costs, then it may make sense for the municipality to own the local access backbone infrastructure, and for it to provide this as a platform for competitive retail entry to provide last-mile and end-to-end service connectivity to individual households or businesses.

The existence of a "market failure" need not imply that the municipality needs to own and operate a local communications network. Indeed, the long-held belief that local telephone services and cable television constituted natural monopolies has justified public utility regulation of incumbent local telephone companies and municipally-franchised cable television operators. While public ownership *is* an alternative, it has been more common to use subsidies and restrictive regulation (*e.g.*, universal service, carrier-of-last-resort obligations, rate of return or price cap retail price regulation) to control the behavior of investor-owned utilities. A similar approach has been common in electric power, where most power is provided by investor-owned utilities; although with power, there are a large number of communities that are served by MEUs.[21] Even when the telephone company has been publicly owned (as was the case in many countries outside the U.S.), its scope of operation and regulation has been national or at least encompassing multiple communities.[22] Thus, the role of local government in providing communication services is relatively new.

Furthermore, even if a local government does decide to invest in local access infrastructure, this does not mean that the municipality needs to provide end-to-end retail services. There are a variety of business models available for how a municipality may offer such services. These include:

- (1) Retail Service Model;
- (2) Franchise Model;
- (3) Real Estate Model; and,
- (4) Coordination Model

In the *Retail Service* model, the municipality offers retail services to consumers over infrastructure that it owns and operates. Examples of these include MEUs that are currently offering advanced communication services to local businesses and residences such as BELD in Braintree, MA.[23] This form of entry requires the greatest degree of resources and operating involvement in providing communication services, and in the wired world as noted earlier, only communities with MEUs had the resources and business infrastructure in place to make considering such an undertaking viable. With wireless technology, however, there are additional community entities (other than an MEU) that could participate in owning and operating such services, including a local educational institution, public hospitals, or the police and fire departments. However, most municipalities do not have much experience in selling and supporting retail services for the general public.

Under the *Wholesale services* model, the municipality owns and operates a local access network which provides a wholesale access platform for retail ISPs and other communication service providers to use. This may be a complete Metropolitan Area Network (MAN), a back-bone (middle-mile) local access network, or last-mile access network. The “wholesale” service might be limited to dark fiber, or include advanced transport services.[24] Providing a wholesale service only would simplify the municipality's responsibilities in one respect, while potentially complicating them in another. On the one hand, providing customer service to a smaller subset of more sophisticated wholesale customers (network operators and sophisticated large end-customers like businesses) is easier than supporting mass market customers. On the other hand, however, the wholesale and retail services may be co-specialized, especially if the market is not large enough to sustain adequate retail-level competition. For example, unless the market can sustain multiple retailers of broadband video services, offering a wholesale version of such a service would create a bilateral monopoly, that might be more efficient if vertically integrated. Furthermore, it is unclear how best to price a wholesale platform service to ensure that the costs of providing the service are recovered, while enabling the maximal scope for competition (among a mix of single service and bundled service retailers, where the latter offer a bundle of video, voice and data services). Because of state laws which mandate open access, a number of municipalities have adopted wholesale-only business models such as several utilities in Washington state which are currently deploying open access infrastructure (*e.g.,* Grant County, WA).[25]

The most common model we have seen is the *Franchise* model wherein the municipality contracts with a private firm to build and operate the facilities. While it is possible that the incumbent telephone or cable company could respond to the municipality's bid, in most cases, the respondents are new carriers. The basic model is similar to the traditional model of municipally-franchised cable television service. Wireless alters the range of players that might be considered and the architectures/services that might be offered.

The *Real estate* model presents a much more limited form of municipal entry. Under this model, the municipality provides access to conduit or public rights-of-way. In the wired-world, this includes access for stringing or burying cables; while in the wireless world, it includes locations for siting antennas. In this model, the municipality partners with private providers to deliver end-to-end services to consumers. This model requires relatively limited investments in communications-specific resources and capabilities, yet offers an opportunity for the local government to manage access to outside plant structures/facilities (conduit, antenna sites) that require long-lived, sunk investments, and hence may create bottlenecks if privately provided.

Another minimalist and common form for municipal entry is the *Coordination* model. In this case, the municipality provides a nexus for demand aggregation (*e.g.*, buyer groups).[26] By aggregating demand, the municipality may be able to exert some monoposony power or, alternatively, reduce the risks (and costs) to private sector entry by demonstrating an assured base of demand for broadband services. Wireless technologies, and especially the potential for edge-based/customer-provided infrastructure via mesh networking, raise new opportunities for municipalities to help coordinate community networking efforts (WiFi cooperatives).[27] The municipality can help educate consumers as to new technical options for deploying local wireless hot spots and linking those together to support community-wide coverage networks.

Each of these prototypical business models differs in the level of involvement required by the municipality in the provisioning of communication services. Which model is right in which situation will depend on the local context, however, given the obvious risks and inherent problems with extending government activity into rapidly changing markets like those for communication services, it is worthwhile considering whether a lower level of involvement might offer the benefits of promoting wider availability of improved broadband access, while imposing a reduced burden on local government resources. Communities without a municipal utility or a technically sophisticated local resource (e.g., a local college with an IT department and professionals with network engineering expertise) would be ill-advised to assume too direct a role in the provisioning of broadband services. With wireless technologies especially, the franchise, real estate, or coordination models seem especially attractive.

The goal of this paper is not to determine whether municipalities should enter, or if they choose to enter, how best to enter. Instead, the goal is to explore how different wireless technologies might impact these decisions.

B. Basic infrastructure rationale

According to the "basic infrastructure" rationale, municipal networks may be justified as just another example of community provision of basic infrastructure services. These are services that are (1) used by everybody and are perceived as essential services; (2) may be a natural monopoly or have a public goods aspect (*i.e.*, excluding non-paying users is costly); and (3) provide important spill-over benefits that are central to or complementary to the role of government. Obvious examples include roads and water and sewage systems. While these *could* be provided via regulated private contractors, such an approach is relatively rare. Other basic infrastructure services include electric power and gas distribution and public transportation. With these services, we see examples of both public and private sector provisioning. For example, while most electric power is provided via investor-owned utilities, there are still a large number of communities with municipal electric companies. Similarly, there are a number of communities with municipally-owned telephone or cable television companies.

Because basic infrastructure is perceived as essential to economic activity (*i.e.*, it is used by most businesses), ensuring adequate access to such services is viewed as necessary to promote economic development goals. Additionally, access to communications and media services is often viewed as important for a number of social goals. For example, it can help maintain community cohesion, support democracy and the functioning of our civil society. Access to advanced communication services can facilitate access and political participation by the elderly or handicapped, can enhance access to educational opportunities, and can support communications between local government and institutions (churches, libraries, recreation) with the citizenry.

While the "basic infrastructure" rationale appears distinct, it may be subsumed as just another example of a "market failure" rationale.[28] For example, the market failure may also arise if the benefits of providing broadband services are not easily appropriated by a private provider. This may occur because of positive network externalities,[29] public goods aspects,[30] or other spillover effects.[31] Therefore, in the balance of this paper, we will focus on the impact of wireless on the incidence and appropriate response to a perceived market failure, while accepting that communities may appropriately regard access to high-speed broadband access services as an important element of basic infrastructure, akin to access to water, power, and roads.[32]

C. Opportunistic rationale

The third rationale – "opportunistic entry" – is associated with situations where the municipality is doing something else that makes it relatively low cost for them to expand into offering communication services. The municipality's entry into communication services may be able to take advantage of scale and scope economies when only an incremental investment is required to expand into communication services.[33]

The most obvious source of such investments is leveraging off of information technology (IT) investments made for the local governments internal use. For example, the municipality may have installed a backbone fiber network to provide data communication services among government buildings, local schools, and libraries. As IT has become more important in business operations for both private and public enterprises, and with increased interest in eGovernment to increase government efficiency and expand access, local governments have been increasing their investments in IT as part of their normal operations.

Additionally, many MEUs have been motivated to deploy advanced communications infrastructure in order to better manage their electric power business (*e.g.*, SCADA, automatic meter reading, on-line access for customer billing and service).[34] Once this capability is in place, the incremental cost of offering communication services is obviously lower. Electric power deregulation during the 1990s and the threat of increased competition have increased MEUs' interest in tapping new revenue streams and to exploit potential scale and scope economies to lower average costs.

Furthermore, with declines in the cost of deploying fiber optic cable, robust forecasts for the growth in demand for high capacity transport services, and the high cost of installing wired infrastructure (acquiring rights-of-way, digging up streets, and installing conduit), utilities of all sorts (water, electric, gas) and local businesses (campuses, malls, new housing/office developments) have found it opportunistically desirable to install dark fiber when outside plant construction is occurring for other reasons. Such fiber awaits the opportunity for low-cost access technologies to make it useful. As we discuss further below, wireless can play an important role in connecting such fiber to end-users and other network services.

In contrast to wired infrastructure which provides connectivity between specific physical locations (where the wire terminates), wireless infrastructure provides a bubble of connectivity that can blur the boundary between public and private infrastructure, or infrastructure installed for one purpose and its extension for use to serve another. For example, many communities already provide wired access to data services for their internal operations, and for the community via wired connections to the schools and public libraries, including public-access terminals for use by students or by the general public. In addition, public safety services (fire, police, and emergency care) all require access to information services, and in many cases, this includes access to mobile data services. Wireless makes it feasible to extend the reach and access to the general community for services that may originally have been installed solely to serve a specific government office, school, or even, the public safety services.

III. Policy Implications of Wireless for Municipal Networking

Emerging wireless technologies have a number of important effects on the rationale for municipal entry into telecommunications services. First, *ceteris paribus*, wireless increases incentives for local governments to invest in IT and local infrastructure. Second, wireless impacts the "market failure" rationale in ambiguous ways, which means that we cannot conclude at this stage in our research whether wireless supports or harms the economic case in favor of municipal provisioning of local telecommunications services. Third, when municipalities do decide to enter telecommunication services, wireless has a complex impact on the range of business cases and the selection of public policies that would best support enhanced broadband access.

A. Wireless expands municipal incentives to invest in local IT infrastructure

Wireless expands local government demand for and interest in deploying and adopting IT services and infrastructure. By expanding the range of IT-enhanced services that can be offered and their accessibility and usability (*e.g.,* eGovernment access, community building, at-home health care, utility metering, homeland security), wireless pushes out local government's demand curve for IT services.[35] An obvious example that is being widely exploited is installing wireless local area networks (LANs) in schools and government offices to increase access to existing IT infrastructure and services. Wireless also lowers the costs of supply because it expands the technology choice set. That is, although wireless is not the least expensive technology in all situations, when it is, it lowers the costs of deploying infrastructure.[36] For example, wireless can offer a low-cost alternative to leased line facilities from the incumbent local telephone company for backhaul interconnections between schools, libraries, and other government buildings in the community.

Wireless technology complements other IT investments, increasing demand for fixed line broadband access (*e.g.,* when a home WLAN allows a DSL or cable modem line to be shared in the home) and for mobile computing equipment, services, and applications. Taken together, these "supply" and "demand" effects mean that local governments will invest more in IT services and equipment. The growth of eGovernment and the investments in local government intranets and in broadband content will provide complementary assets that can lower the incremental costs of entry into telecommunication services.[37] This will reduce the cost of "opportunistic" entry.

Thus, *ceteris paribus*, wireless seems likely to increase local government incentives to enter into local telecommunications services and implies that local government will play a more important role in how broadband access evolves in the future than it has in the past. Of course, this conclusion could be reversed if the trend towards state or federal regulatory prohibitions against municipal participation in telecommunication services continues.

B. Wireless impact on "market failure" rationale is ambiguous

By lowering entry barriers and the costs of deploying local access networks, wireless may decrease the likelihood of a market failure in any particular community, thereby reducing the need for the municipality to provide communication services. Thus, private WISPs are now finding it profitable to offer services in rural communities that are still under-served by wired-providers. Moreover, the scalability of wireless technologies makes it feasible for private providers to serve smaller markets that may previously have been uneconomic. Finally, wireless may offer a low-cost option for new competitors to over-build wired-provider networks, thereby alleviating concerns about insufficient competition. From this perspective, it would seem that the principal impact of wireless might be to reduce the range of environments vulnerable to a market failure.

Alternatively, in those communities that remain underserved by private providers, wireless may make it feasible for the municipality to provide services – thereby remedying the most severe cases of market failure where even the local government finds it too costly to provide services. For example, wireless makes it feasible for communities to deploy infrastructure in rural areas where the low density makes wired infrastructure prohibitively expensive. Public access to water towers, grain silos or other infrastructure for siting antennas and technologies that use unlicensed spectrum can make deployment of wireless broadband relatively low cost and easy. Alternatively, in dense urban areas, municipal wireless may be used to promote economic development or to provide low cost broadband access even when higher-cost broadband is available from private sector competitors. For example, Philadelphia is planning to build a wide-coverage-area WiFi network to promote low-cost broadband access in direct competition to higher-priced services offered by Comcast, Verizon, and others.[38] In both cases, the lower cost of wireless makes it feasible for municipal governments to address perceived market failures more readily.

In both cases, some argue that the problem would be better solved by providing private carriers sufficient incentives (*e.g.*, subsidies) to address the market failure (*e.g.*, lack of any service in the rural case and service that is too expensive in the urban) rather than by municipal entry into an industry sector for which they may lack the requisite knowledge and institutional capabilities. On the other hand, there is no *a priori* reason to believe municipal entry would be inefficient.

In summary, therefore, wireless technology makes both private and municipal entry lower cost. The first effect reduces the number of situations in which a market failure may exist, while the second effect enhances the ability of municipal governments to address market failures. Which effect dominates depends on the nature of the communities under consideration. And, in any case, consumers unambiguously benefit from the increased service and coverage afforded by wireless services. Wireless will expand the range of service choices for all customers.

In addition to the above impacts, there is a sense in which wireless may exacerbate a market failure problem if it turns out that "Fiber-to-the-x" (FTTx)[39] is a natural monopoly (or oligopoly). That is, by lowering the costs of deploying very-high-bandwidth capable services deep into the neighborhood, wireless may accelerate the deployment of such technologies. This could result in the creation of a natural monopoly as discussed earlier. Some preliminary research suggests that wireless is likely to play a critical role in the deployment of next generation broadband access infrastructure that will depend on fiber deployment deep into neighborhoods.[40] On the other hand, if end-user demand for bandwidth is limited, advances in 3G/4G mobile services, wireless-supported broadband-over-power line (BPL) services, and broadband fixed wireless access (BFWA) services may eliminate the last-mile bottleneck altogether.

Finally, wireless may expand the range of situations in which a market failure arises associated with the "basic infrastructure" type of arguments discussed earlier. That is, (*e.g.,* layer 2 virtual LANs, MPLS VPNs, or routed IP traffic)wireless broadband results in social returns that exceed appropriable private returns (*e.g.,* economic development benefits of WiFi hotspots in depressed areas or broadband that improves human capital, or furthering non-economic social goals like enhancing community cohesion and political participation). In this case, wireless would accentuate the "market failure" rationale for municipal entry.

C. Wireless affects the optimal business model for municipal entry into telecommunications services

The diversity of wireless technology options also affects the optimal business model choice for municipalities. While different technologies from different vendors are optimized for different situations, there are usually a number of alternatives that might work in any situation. It is simply not possible to identify an optimal choice without considering the goals and special circumstances in the community.

For example, if the community's goal is to quickly put in place a solution that will provide some high-speed data access at low cost and with a short investment horizon, then a municipal network based on WiFi hot spots may offer an attractive option. Additionally, local government may be able to economically encourage broadband access by helping to promote or coordinate grass-roots efforts to virally deploy edge-based networks.[41] The local government could encourage community/neighborhood groups interested in building up a broadband mesh network by allowing them to interconnect their mesh at low cost to local government back-haul services, could provide access to public infrastructure and buildings for siting antennas, and can provide an information clearing house/education role to help grass-roots initiatives take-off. One big problem that confronts such grass-roots networks that wish to scale to higher traffic and wider-scale is how to pay for the backhaul interconnection to the Internet.[42]

Alternatively, the community may decide that the need for ubiquitous broadband is too great to leave to a viral/grass-roots growth approach and may decide to deploy a MAN-sized network. Whether it opts for a BFWA-type network based on large cell sites which each cover a relatively large area, or a mesh-type network based on many smaller cell sites that are interconnected will have implications for the way services are deployed and what services are deployed (*e.g.,* supporting voice telephony over a mesh-style network may be more difficult, but a mesh may offer more flexible deployment roll-out). The vendors offering these various technologies have emphasized different performance characteristics and the economic/performance trade-offs vary depending on what the network's principle purpose is.

Finally, if the community is trying to plan for its communication infrastructure needs for the next twenty to thirty years, it may opt for a FTTx system with some form of wireless mesh to provide connectivity to the neighborhood fiber.

Wireless technology continues to evolve and communities that wait will be able to take advantage of newer technologies and lower costs, but at the expense of delaying realization of the benefits of improved communication services. A community that adopts one of the newer, more capable systems before it is standardized risks being stranded with an incompatible system; while a community that fails to adopt a comprehensive plan may find itself with a mish-mash of ad hoc networks that are costly to integrate or evolve into a community-wide network. Communities will be challenged by the need to adopt a strategy that can adapt to changing technology and market needs (*i.e.*, scalable to higher speed bandwidth, wider area coverage, and new services). There are no silver bullets here.

The choice of technology also has implications for other aspects of municipal policy. For example, if the municipality opts for a technology based on small cell sites, it will need to install or provide access for lots of antenna sites (*e.g.*, antennas on lamp posts); while if it opts for larger cell sites, it may be able to locate the relatively small number of necessary antennas on a few government buildings. These decisions have implications for outside plant maintenance, customer premise equipment costs, system modification costs, and a host of other characteristics that define what services the municipal network can provide and how these evolve.

Moreover, because municipalities represent an important market for vendors of wireless networks and services – for MAN access networks, public safety networks, hot spots, and hybrids of everything in between – the buying decisions of municipalities will impact which technologies succeed in the market place and so will have feedback implications for the broadband industry more generally. Indeed, the municipalities by representing a concentrated locus of demand that is typically quite cost sensitive can offer an important potential early adopter of wireless technology.

Finally, because wireless technology reduces entry barriers for private service providers as well, wireless may change the types of business models that municipalities may seek to employ if they elect to provide telecommunication services in their communities. For example, they may be more inclined to favor private-public partnerships based on a franchise model wherein the municipality provides preferential access for base station siting and commits to adopting a particular technology for its internal use in return for a WISP-franchisee agreeing to install and operate the municipal wireless network. The municipality can use its wireless strategy to encourage additional infrastructure competition from these new types of last-mile access providers.

In summary, therefore, we should expect to see municipalities experimenting with a diverse array of technologies, and we should not be surprised if 20-20 hindsight allows us to identify many errors *ex post* in the approaches adopted by many of those municipalities that do choose to deploy networks. Fortunately, the low capital cost of wireless technology and its ability to be implemented incrementally limits the overall risk exposure. However, the coordination issues noted earlier mean that the lifecycle costs of supporting a wireless broadband network may not actually be lower for wireless infrastructure.[43] Whether it is remains to be seen.

IV. Conclusions

Broadband access services are increasingly viewed as essential infrastructure. Concerns over the viability of sufficiently robust private sector competition in light of the high costs of deploying next generation infrastructure and the collapse of the CLECs and industry consolidation after 2000 have resulted in increased interest in municipal efforts to provide broadband services. In the pre-wireless world, the costs of deploying wired infrastructure limited the range of communities that were considering deploying communications infrastructure to those with MEUs. Wireless expands the range of communities and alters the policy calculus for municipal broadband.

The traditional justifications for municipal broadband include concerns that there is a "market failure" that needs to be addressed or that such a move is warranted because of its low incremental cost (given that investments in complementary infrastructure have already been made for another reason). Thus, we have seen a number of rural communities and communities with municipal electric utilities (MEUs) in both urbanized and rural areas decide to offer municipally-provided broadband data services.

At the same time, we are in the midst of a revolution in wireless services that is changing the way broadband services are provided and used, and are impelling convergence of wireless and wireline networks and services. This paper considers the implications of emerging trends in wireless technology for municipal networking and the higher-level implications of wireless technology on the proper or likely role for local governments in providing communication services in the future.

We conclude that wireless technology is likely to increase local government's demand for and use of IT technology in general, and wireless services in particular, and therefore, local governments will become an even more important player in the last-mile broadband access landscape than they have been heretofore. At the same time, the underlying “market failure” justification for public entry into a market that has previously been served most often by investor-owned firms (at least in the United States) is impacted in ambiguous ways by emerging wireless trends. On the one hand, wireless technologies that lower entry barriers would appear to reduce the likelihood of a market failure and therefore a need for public entry. On the other hand, these same lower costs may make it feasible to address situations where before the failure was so severe as to even have precluded public provisioning. Furthermore, wireless may accelerate the deployment of next generation FTTx systems that, if a natural monopoly, could increase the likelihood that next generation infrastructure will be a natural monopoly. Alternatively, the benefits of wireless may enhance the perception that broadband constitutes essential infrastructure that needs to be provided by government because the social benefits of ensuring adequate access to such services exceed what private carriers can expect to appropriate.

This ambiguity makes it impossible at this stage to conclude whether encouraging or restraining municipal entry into communication services will further or harm the public interest. Public involvement in communication services may be a substitute for or a complement to private provisioning. While traditional incumbent local telephone and cable companies have mostly opposed municipal entry (including lobbying for state laws to block such entry), new types of carriers (WISPs) have obviously benefited from such entry. The impact of municipal entry on private sector alternatives (and visa versa) is complex. Competition from a municipality may work like competition from any other source as a spur to incumbents to lower costs and improve quality. On the other hand, a non-profit government-owned provider may have reduced incentives to be efficient and yet have both the opportunity and incentive to engage in anticompetitive strategies, thereby reducing community access to private alternatives.[44] Empirical research measuring the economic performance (prices, quality, costs, investment) of broadband access services in communities with and without municipal providers will shed useful light on this debate.

Finally, even if a municipality elects to provide telecommunications services, its optimal choice is complex and unlikely to become simpler in the near future in light of on-going wireless trends. Choosing the optimal strategy (network architecture, business model, service model) will depend on local conditions, community goals, and on-going technical and market changes that remain subject to substantial uncertainty. Because this preliminary research suggests that municipalities will have a growing need and desire to confront this uncertainty and to deploy wireless services – for their own internal needs, if not also for their communities – further research is needed. Additional studies of the costs and benefits of deploying alternative technologies are needed that will allow municipalities to make “apples-to-apples” comparisons, and when that is not possible, at least to map the spectrum of wireless options appropriately to local circumstances. These engineering design/cost studies also need to be evaluated with respect to the business model and public policy environment in which the technology will be provided.

Notes and References

[1] In the United States, the Telecommunications Act of 1996 (TA96) opened last-mile telephone networks to competition with mandatory resale and unbundling provisions. Analogous pro-competitive regulatory reforms were underway around the globe (in the European Community, UK, Japan, etc.). "POTS" is short for "Plain Old Telephone Service" which refers to basic fixed line voice-grade telephony.

[2] See Baller, J. and S. Stokes (2001). The Case for Municipal Broadband Networks: Stronger than ever. *Journal of Municipal Telecommunications Policy*, 9 (3) 19.

[3] See Computer Science and Telecommunications Board (CSTB) (2002). *Broadband: Bringing Home the Bits*. Washington, DC: National Academy Press; Franklin PUD (2004), WiFi Broadband for Pasco Businesses and Residences. press release, March 18, 2004; or Lehr, W. and R. Hubbard (2003), Economic Case for Voluntary Structural Separation. paper presented at the *31st Annual Telecommunications Policy Research Conference*, George Mason University, September 2003.

[4] See Sirbu, M., W. Lehr, and S. Gillett (2005), Evolving Wireless Access Technologies for Municipal Broadband, *Government Information Quarterly*, **[??]**.

[5] See, Gillett, S., W. Lehr, and C. Osorio (2004). Local government broadband initiatives. *Telecommunications Policy*, 28 (2004) 537-558; Barranca, M. (2004). Unlicensed Wireless Broadband Profiles: Community, Municipal and Commercial Success Stories. *Spectrum Policy Program Working Paper*. Washington DC: New America Foundation; or, Clark, K. and P. Baker, (2003). Municipal Advanced Telecommunication Infrastructure Project (MuniTIP). *Georgia Center for Advanced Telecommunications Technology*, *Office of Technology Policy & Programs*, OTP Policy Study No. 50103.

[6] As we explain further below, this is because of the high costs of deploying wired local access network facilities. Prior to the emergence of wireless alternatives, only communities with MEUs had the resources and capabilities to make deploying wired communications infrastructure economically viable.

[7] This estimate is based on updated data provided by the American Public Power Association (APPA) which reported that 621 of their members were providing some type of communication service as of 2004. The APPA data is described more fully in Gillett, Lehr, and Osorio (2004), endnote 5 *supra*. (Only about a fifth of the households in the U.S. receive their power from publicly-owned utilities; most are served by a smaller number of very large investor-owned utilities.)

[8] This is based on data reported by Esme Vos in her first two MuniWireless.com anniversary reports (available at: http://www.muniwireless.com). Since this includes only the deployments she tracks, it is likely conservative. Her data also identifies 72 deployments outside the United States.

[9] Furthermore, the national debate over whether legislation should limit or enable municipal entry demonstrates the seriousness with which policymakers and industry

participants are considering the issue of expanded municipal entry into communication services.

[10] Of particular interest are the new "edge-based" models for deploying infrastructure associated with the viral spread of customer-owned wireless infrastructure. For further discussion of this see Lehr, W. (2004), "Economic Case for Dedicated Unlicensed Spectrum Below 3GHz," available at: http://itc.mit.edu/itel/docs/2004/wlehr_unlicensed_doc.pdf; Benkler, Y. (2002). Some Economics of Wireless Communications. *Harvard Journal of Law and Technology* 16 (1) 25-83; or Werbach, K. (2003), Radio Revolution: The Coming Age of Unlicensed Wireless. white paper prepared for New America Foundation, Washington, DC, December 2003.

[11] See Gillett, Lehr, and Osorio (2003), endnote 5 *supra*, and Osorio, C. (2004), *Municipal Broadband*. Master of Science Thesis, Massachusetts Institute of Technology, May 2004.

[12] For discussion of wireless cooperatives, see Sandvig, Christian (2003). An Initial Assessment of Cooperative Action in Wi-Fi Networking. paper presented at the *31st Annual Telecommunications Policy Research Conference*, George Mason University, September 2003. Also, even among MEU communities, wireless is affecting strategies for deploying infrastructure.

[13] See Rizzuto, R. & Wirth, M. (1998). *Costs, Benefits, and Long-Term Sustainability of Municipal Cable Television Overbuilds.* Denver, CO: GSA Press; or, Sappington, D. and G. Sidak (2003). Incentives for Anticompetitive Behavior by Public Enterprises. *Review of Industrial Organization*, 22, 183-206.

[14] See Baller and Stokes (2001), endnote **Error! Bookmark not defined.** *supra*; Strover, S., G. Chapman, and J. Waters (2003). Beyond Community Networking and CTCs: Access, Development and Public Policy. paper presented to the *31st Annual Telecommunications Policy Research Conference*, George Mason University, September 2003; Barranca (2004), endnote 5 *supra*; or Gonick, L. (2004). Connecting, Enabling, Transforming our Community. presentation to New America Foundation Workshop, Washington, DC, April 16, 2004.

[15] As of 2005, fourteen states have enacted legislation that limits municipal entry (see, American Public Power Association (APPA). Powering the 21st Century Through Community Broadband Services. Washington, DC, September 2005). A larger number of states are considering legislation. This activity has inspired opponents too, leading to proposals for new federal legislation to enable municipal entry. For example, the draft "Broadband Internet Transmission Services" (BITS) legislation from the House Energy and Commerce Committee published on September 15, 2005 (available at: http://energycommerce.house.gov/108/News/09152005_1642.htm) would expressly permit municipal entry. For further discussion of Federal and state policies impacting municipal entry into telecommunications services, see related papers in this issue. [**WHICH PAPERS???**].

[16] See Federal Communications Commission (FCC). High-speed services for Internet access: Status as of December 31, 2004. Washington, DC, July 2005 (available at: http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/hspd0705.pdf).

[17] The FCC data does not allow us to determine the number of facilities-based competitors in most communities because it does not distinguish between facilities-providers and resellers (retail-only) of broadband services. Moreover, the FCC data includes municipal deployments.

[18] See Gillett, S., W. Lehr, and M. Sirbu (2004). Broadband Open Access: Lessons from Municipal Network Case Studies. paper presented at the *32nd Annual Telecommunications Policy Research Conference*, George Mason University, September 2004.

[19] The marketing research firm, Render Vanderslice & Associates report 652 communities have deployed Fiber to the Home (FTTH) systems as of September 2005, passing almost 2.7 million households (less than 3 percent of all U.S. households) and up from less than 200 thousand passings as recently as a year earlier. This large increase is due the huge fiber deployments underway by SBC and Verizon. See Render Vanderslice & Associates. FTTH/FTTP Update. October 4, 2005 (available at: http://www.ftthcouncil.org/documents/732751.pdf).

[20] See Banerjee, A. and M. Sirbu (2003). Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure. paper presented at at the *31st Annual Telecommunications Policy Research Conference*, George Mason University, September 2003.

[21] MEUs first emerged to provide street lighting over a century ago, and then later, as part of efforts to provide power to under-served (mostly rural) areas (see Osorio, 2004, endnote 11 *supra*).

[22] There are a large number of small independent local telephone companies in the United States, however most of these are investor-owned, and collectively, these account for a relatively small number of the total access lines served.

[23] See Gillett, Lehr, and Osorio (2004), endnote 5 *supra* for numerous examples.

[24] The wholesale service could operate at a variety of levels in the protocol stack. For example, it could be a Layer 2 (link layer) virtual LAN; a Multiprotocol Label Switching (MPLS) virtual private network (VPN); or routed Internet Protocol (IP) traffic. Each involves different choices for the technology deployed and the range of services that could be offered to downstream retailers and end-customers.

[25] There are many ways in which the wholesale model may be implemented, and the discussion of open access regimes is beyond the scope of this paper. See Gillett, Lehr, and Sirbu (2004), endnote 18 *supra*.

[26] See Gillett, Lehr, and Osorio (2004), endnote 5 *supra*. Typically, local government is one of the heaviest local users of telecommunication services and it can use its monopsony power as an anchor tenant to induce private carriers to provide services.

[27] See Sandvig (2004), endnote 12 *supra*.

[28] Since economists typically focus on efficiency and generally prefer markets to governments for allocating scarce resources, there is a common presumption that market-based provisioning of services is to be preferred whenever it is feasible. However, efficiency is not the only concern for government and the private-ownership/capitalist paradigm that governs the allocation of most services in the economy is neither the only nor necessarily the most efficient mechanism for allocating scarce resources. Thus, while we do not do so here nor believe that it is generally the case, it is possible to support an economic argument in favor of public ownership of infrastructure *even* when such ownership substitutes for or precludes private ownership.

[29] These arise when the value of the network is higher to each subscriber when the number of subscribers increases. A local broadband network may be more valuable to everyone if it is really ubiquitous. For example, schools and community groups could use such an ubiquitous network and be assured that everyone in the community can be reached, and thereby avoid the cost of providing announcements via other channels. With a new service such as "broadband," early adopters subsidize later adopters and the presence of such positive network externalities may result in a market failure.

[30] A hot-spot zone in a downtown area that encourages increased shopping traffic offers public goods benefits since stores that do not support the hot spots but are in the coverage area and benefit from the traffic will still derive benefit.

[31] Broadband benefits that enhance community quality of life, political participation, and other social goals that may not be translated into potential revenue for a private service provider.

[32] There is a long-standing debate over how much bandwidth is enough. If one takes the view that basic telephone service is all that one needs, then we already have effective competition and ample alternatives in most locales in the United States. Implicit in the discussion here is the belief that the current generation of broadband services are insufficient to meet the "basic infrastructure" standard that will prevail in the future and that additional investment in new infrastructure is needed to meet this demand.

[33] Opportunistic, low-cost entry may also arise as a consequence of some other special circumstances. For example, a community may be able to take advantage of special development funds targeted at IT investments, or of a special circumstance. Examples of the latter include the need to upgrade IT capabilities for an upcoming Olympics; or the desire to deploy an advanced sensor net in communities near the US-Mexico or US-Canada border to enhance Homeland Security.

[34] Osorio (2004), endnote 11 *supra*, shows that MEUs that have upgraded their facilities to support advanced IT-management of their electric power business are more likely to also offer telecommunication services. Similarly, the cable television operators that were most aggressive early on in offering two-way broadband data services, were those carriers that had earlier been more aggressive in installing two-way capabilities to address the perceived threat from direct broadcast satellite services.

[35] Of course, these could be provided by private sector providers. Higher demand reduces the likelihood of a market failure, but also increases motivation to act if market failure continues.

[36] See Wanichkorn, K. and M. Sirbu (2002). The Role of Fixed Wireless Access Networks in the Deployment of Broadband Services and Competition in Local Telecommunications Markets. paper presented at the *30th Annual Telecommunications Policy Research Conference*, Alexandria, VA, 2002.

[37] For example, local government efforts to implement eGovernment capabilities and services will require building IT-saavy human capital resources that will also be available to support public access networking if the municipality elects to go that way.

[38] See Wireless Philadelphia Business Plan, February 9, 2005, available at: http://www.phila.gov/wireless/, visited May 23, 2005.

[39] FTTx is used to refer generically to the deep neighborhood deployment of fiber optic transmission systems. The "x" may be to the neighborhood, the block, the curb, or even all the way to the home. Wireless provides greater flexibility in the choice of where "x" is (since the last few hundred feet can be wireless), and thus can lower the costs of fiber deployment.

[40] See Zhang, H. (2004). Wireless in Access Networks. presentation to New America Foundation Workshop, April 16, 2004. Zhang provided a discussion of the potential role of wireless in the “100 x 100” project underway at Carnegie Mellon University and several other universities. This project is looking at the challenges for delivering 100Mbps to 100 million homes and 1Gbps to 1 million businesses in the United States.

[41] Wireless networks may be deployed as a mesh, wherein the radios in customer equipment at the edge of the network cooperatively forward each other's traffic. In this way, it may be possible to create "service-provider-less" local access networks based solely on the collection of end-user radios. This mesh of radios can route traffic to a common aggregation node for connection to the wider Internet. See Sirbu, Lehr, Gillett (2005), endnote 4 *supra* for further discussion.

[42] Most of the back-haul services for such networks are currently provided via wired DSL or cable modem services that are provided on a flat-monthly fee basis so the incremental cost for the DSL/cable subscriber of sharing this connection via a WiFi “hot spot” is limited to the potential congestion which should be negligible as long as traffic is relatively light. If traffic is more intense or if carriers move to usage-based pricing, these costs will have to be paid. The community could elect to tax itself to recover the revenue needed to pay for backhaul costs.

[43] The potential for evolving a mish-mash of different generations of wireless technologies that are not well-coordinated may result in higher lifecycle costs. This is analogous to the realization that the life-cycle costs to an enterprise of putting a PC on every employee's desk involves much more than just the initial purchase price of the PC and its software.

[44] Sappington and Sidak (2003), endnote 13 *supra*, discuss the incentives for a publicly-owned enterprise to engage in anticompetitive activities. While their analysis does not

lead to a conclusion that municipal provisioning of services would be less efficient or more prone to anticompetitive behavior, it does identify the risk posed to sustainable competition from municipal entry.