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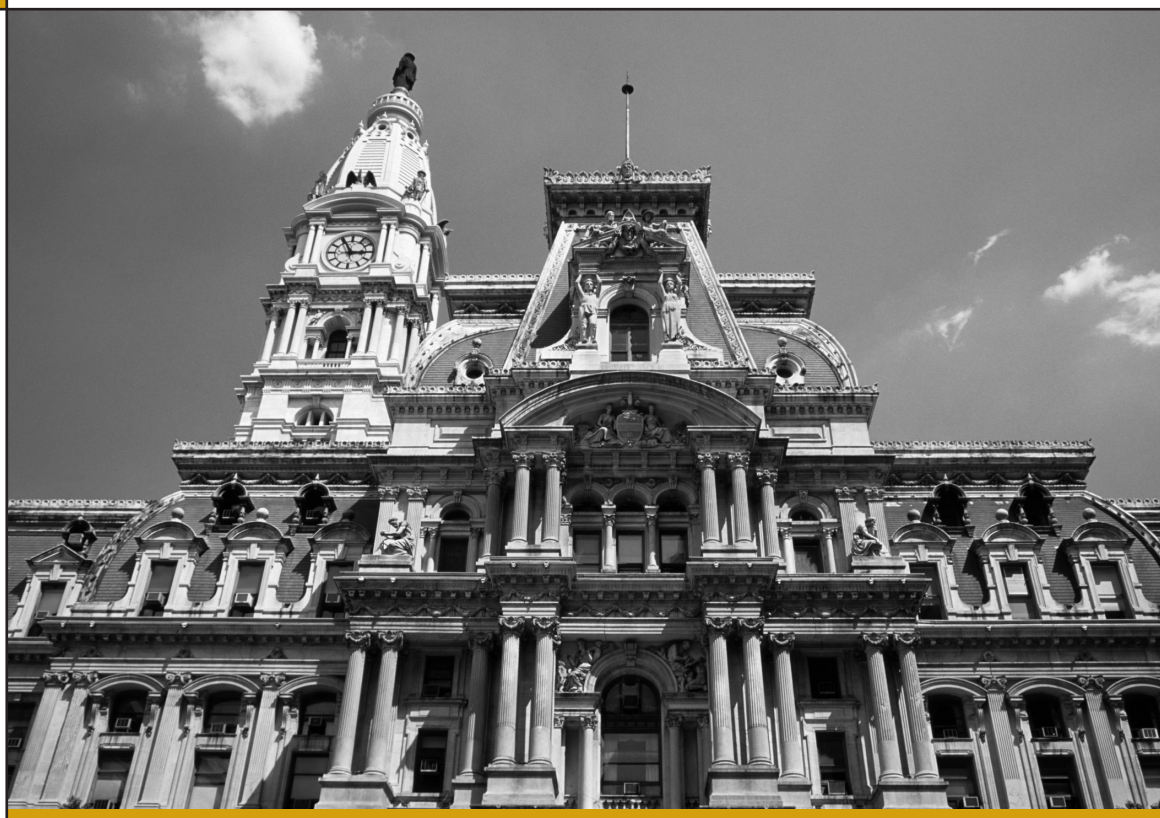
Can Governments Create Universal Internet Access? The Philadelphia Municipal Wireless Network Story



E-Government Series

Abhijit Jain
Assistant Professor
Cisler College of Business
Northern Michigan University

Munir Mandviwalla
Executive Director
Irwin L. Gross Institute for Business and Information Technology
Fox School of Business
Temple University

Rajiv D. Banker
Merves Chair and Director of the Center for Accounting and Information Technology
Fox School of Business
Temple University

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for Business and Information Technology
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for Accounting and Information Technology
Fox School of Business, Temple University

IBM Center for
The Business of Government

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FOREWORD

On behalf of the IBM Center for The Business of Government, we are pleased to present this report, "Can Governments Create Universal Internet Access? The Philadelphia Municipal Wireless Network Story," by Professors Abhijit Jain, Munir Mandviwalla, and Rajiv D. Banker.


Albert Morales

In the global information society, the importance of the Internet cannot be overemphasized. Certain geographical areas and populations, however, lag behind others in terms of Internet access. To remedy this situation, communities and governments are actively seeking alternative approaches to accelerate the availability of universal broadband Internet to citizens.

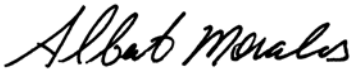
A confluence of factors has recently made municipal wireless networks (MWNs) an increasingly feasible and attractive option for municipal governments seeking to promote more equitable and universal access to the Internet within their communities. Given its evolving nature, the successful application of the MWN concept rests on a number of key drivers. To provide a better understanding of this approach, this report describes the drivers and inhibitors to MWNs. These insights are based on a case study of the development of the Philadelphia municipal wireless network, illustrating the practical application of the MWN concept and specific lessons learned from the Philadelphia experience.


Curtis Clark

In 2004, the city government of Philadelphia announced that it would seek to build an MWN to address the digital divide in the city. Despite some initial opposition and doubts about the project, Philadelphia now has completed a 15-square-mile proof of concept. The authors describe the project and provide a case study of how municipal government can be a catalyst for the adoption of technology, with the goal of promoting social and economic change as well.

The Philadelphia story offers important lessons and insights for other municipalities and governments considering similar initiatives. In the short term, MWN projects require a strong champion who can respond to different stakeholders and is able to balance private and public demands. To sustain the MWN, municipalities should understand the potential and the danger of focusing only on the digital divide, and have a plan in place to respond to the public interest and concerns about MWNs.

We hope that the lessons and recommendations outlined in this report will be informative and useful to public executives across the nation as local governments continue to expand their understanding of the potential use of municipal wireless networks.



Albert Morales
Managing Partner
IBM Center for The Business of Government
albert.morales@us.ibm.com

Curtis Clark
Director, Global e-Government Solutions
IBM Public Sector
cclark1@us.ibm.com

Introduction

Telecom is the central nervous system for non-telecom business.

—John Rutledge, economist

Overview

As the Internet becomes an increasingly indispensable component of the global economy, Internet access is an increasingly important arbiter of which societies and peoples will have access to the tools and information necessary to adequately exploit social, economic, and educational opportunities. However, due to various reasons, around the world certain geographical areas and populations lag behind others in terms of Internet access.

A number of communities and governments around the world are actively seeking solutions to speed up the process of universal broadband Internet availability. One potential solution that is currently receiving extensive attention is the concept of municipal wireless networks (MWNs), which are defined as wireless Internet access networks created with active local leadership and involvement. However, MWNs are still an evolving concept, and there are a number of drivers and inhibitors that may accelerate or reduce their impact.

In this report we describe the development of the Philadelphia MWN. In 2004, the city government of Philadelphia announced that it would seek to build an MWN to address the digital divide in the city. Despite considerable opposition and doubts about the project, by March 2007 a 15-square-mile proof of concept was completed and is available to use, and full implementation is expected in late 2007. The report describes how the project was organized around sequential stages that include goals, stakeholder expectations, policy, applications, technology, management, funding, and implementation.

Municipal Wireless Network (MWN)

Municipal wireless networks, or MWNs, are wireless Internet access networks created with active local leadership and involvement. They are based on a point to multi-point link between a base station and subscriber equipment. A base station is an outdoor antenna connected to the Internet that sends data wirelessly to subscriber equipment such as laptops. Typical usage of an MWN involves using the built-in wireless card included in most laptops to connect to the Internet.

The case provides an example of government acting as a catalyst for the introduction of technology—with the intention of promoting social and economic change. The case also provides important lessons for municipalities and governments contemplating similar roles in developing MWNs.

In the short term, MWN projects require a strong champion who can respond to different stakeholders and balance private and public demands, and identify the main application of the MWN. To sustain the MWN, municipalities should also understand the potential and danger of focusing only on the digital divide, and have a plan in place to respond to the many issues surrounding MWNs and the underlying technology.

Why MWNs in Philadelphia?

In the global information society, the centrality and importance of the Internet cannot be overemphasized. The Internet has rapidly become a significant

resource and tool for many aspects of life. For individuals and institutions alike, it is a critically important platform for communication and interaction. It has the potential to be the leveling agent for the existing economic system and the inspiration for the development of new systems. Evolving concepts such as e-government have significant implications for how individuals interact with governments and for how government can be reorganized to better serve citizens.

In the city of Philadelphia, 40 percent of the population identify themselves as non-users of the Internet. If 40 percent of the population of a large American city cannot participate in the Internet revolution—no matter what the reason—there can be serious repercussions for the economic, political, educational, and social future of that city. In the face of considerable opposition from political and commercial entities, the city government of Philadelphia decided to address the access problem and create a municipal wireless network (MWN) to provide affordable, reliable, and high-speed Internet access in every part of Philadelphia. It began the process by convening various constituents and stakeholders to set in motion a discussion on innovative ways to translate this vision into reality. The city government acted as a catalyst to accelerate a process that may have taken several more years to complete if left to its own devices.

The city's initial plan was to subcontract the construction of the network but to retain ownership. However, this required a significant funding commitment to a private contractor. To accomplish zero net-cost to taxpayers, a plan and business model were created that would allow the city to recoup its investments over the next few years. Eventually the city was able to close a deal with a private contractor who would fund the entire cost of building the network, own it, maintain it, and also provide sustainable funding and tools to address the city's digital divide.

In this report, we examine the city government of Philadelphia's quest to enable ubiquitous wireless Internet access. This report is directed toward managers and leaders who are contemplating similar projects. It is organized as follows. The next section discusses the catalyzing role of government in general and in the telecommunications industry. This section provides a historical and political context to MWNs and will be useful to readers who are unfamiliar with the context in which MWNs operate and the legal and political controversies that exist

Temple University's Fox School of Business and Wireless Philadelphia

The Fox School's Irwin L. Gross Institute for Business and Information Technology (IBIT) in 2004 had a strong relationship with the Philadelphia Mayor's Office of Information Services (MOIS). Along with several other universities, we were asked by Dianah Neff, the Chief Information Officer of Philadelphia, in the summer of 2004 to assist the city in the wireless Philadelphia initiative. As the project evolved, our role kept expanding and eventually included:

- Analyzing the needs of key stakeholders including managing and analyzing the results of 13 focus group sessions.
- Analyzing the potential demand for broadband services using available secondary economic and demographic data.
- Analyzing the state of the art of wireless technologies and providing recommendations.
- Analyzing the current state of wireless projects in the U.S. and worldwide.
- Developing business models to fund, implement, and manage broadband wireless services.
- Creating a scorecard to compare the impact of requirements on the opportunities and constraints afforded by different business models.

The project team included two of the authors of this report. We did not charge the city for our services and, though we worked closely with key personnel in the city, the team remained independent. Our primary motivation was the opportunity to participate in an exciting community development project. We were not involved with the negotiations with vendors or with any of the implementation-related work that is currently under way.

today. In the subsequent section, we discuss the emergence of MWNs as a prominent new information technology infrastructure concept, and the drivers and inhibitors of MWNs. This section will be useful to readers who are unfamiliar with the technical and competitive forces that are driving MWNs. The first two sections provide the historical, political, economic, and technical context for the following section, in which we provide a detailed description and analysis of the Philadelphia wireless project using a stage-based framework to delineate key milestones. Next, we present a list of lessons learned, and conclude with a summary of key issues relevant for managers and leaders of similar projects.

The Catalyzing Role of Government

Throughout history, there has been an ongoing debate about the appropriate role and scope of government. In the past, governments have often acted as catalysts to usher in new innovations and networks for society. For example, in most nations, the railways, highways, public education, electricity, and telecommunication systems have been developed with key support from respective governments. Many high-technology and medical advances are derived from government-funded basic research. For example, the demonstration of the first telegraph was funded by the U.S. government, and the Internet was created under a U.S. government program. In each of these cases, government intervention led to significant economic and human capital growth, and resulted in large-scale transformations in society.

However, such interventions are increasingly being questioned because of renewed interest in the potential of purely market-based mechanisms, the failure of some government-originated initiatives, and the existing burden of substantial government fiscal debt. It is becoming increasingly problematic, therefore, for governments to play the role of catalyst in achieving technological and social objectives.

According to economic theory, it is appropriate for governments to intervene in the provision of goods and services that are considered public goods or that utilize public goods (Cornes and Sandler, 1986). Public goods are defined as follows: First, they are non-excludable. That is, it is excessively difficult or costly to differentiate between paying and non-paying consumers of the goods or services. Thus, public goods have positive externalities—they have the potential to be consumed by individuals regardless of whether they are paying consumers or not, and they benefit society in a telescopic manner; that is, as more individuals consume them, correspondingly more individuals are indirectly benefited by them. Examples include lighthouses, streetlights, a standing national defense force, contagious disease prevention, and law enforcement. Second, it may be problematic or unethical to assign private ownership to them—e.g., air and ocean water—and they are thus naturally regarded as publicly owned resources.

As a result of such properties, from a producer perspective, it can be difficult for private producers of public goods to be adequately compensated because of the existence of non-paying consumers. From a consumer perspective, allowing private businesses to exploit publicly owned resources can lead to abuse of both the resources and the public's rights. Such a situation is believed to be ripe for market failure, and thus considered appropriate for government intervention to apply corrective measures. Moreover, the existence of positive externalities ensures that a rapid growth in the consumption of such goods and services can potentially have an accelerating impact on society, which is another rationale for government intervention.

Based on such justifications, it has been argued that wireless Internet access fulfills the requirements for government intervention because it utilizes the publicly owned radio frequency (RF) spectrum, and it can increase the potential for new innovations and societal benefits as more and more individuals have access to the Internet and become Internet literate.

Government intervention does not necessarily imply that the government itself has to produce such goods and services. It could opt instead for a regulatory role wherein it regulates how the private sector produces such goods and services. In different societies, the

decision on whether a government should play a producer role, a regulatory role, or avoid intervening—in relation to a good or service—is usually borne out of a number of factors that include the society's historical and socio-political context, its government's overall philosophical and economic postures, and the nature of the good or service. For instance, in capitalist societies, governments are likely to have a more hands-off approach than in socialist societies. National defense is typically never outsourced to the private sector because that could create security problems. And law enforcement is rarely supplied by the private sector because it can lead to ethical problems (e.g., in some U.S. states, some prisons have been privatized, leading to a situation where owners of lucrative prison businesses have, at least hypothetically, a strong interest in seeing increases in crime).

U.S. government intervention in the area of telecommunications provision is not a new concept. However, it is a highly controversial one. Until the early 1980s, the telecommunications sector in the U.S. was quasi-monopolistic and dominated by AT&T Corporation and its subsidiaries, which were closely regulated by the U.S. government. However, this quasi-monopolistic situation was to the detriment of several categories of customers, especially those in rural areas and in lower-income groups, for whom access to telecommunications services was often unavailable or unaffordable.

Since then, the U.S. government has undertaken a series of legislative measures over several years to open up the U.S. telecommunications market to greater competition. The last such major legislative measure was the Telecommunications Act of 1996. That act included various incentive schemes and mandated provisions intended to ensure more universal availability of telecommunications services and infrastructure in the U.S. The necessity of government intervention to ensure universal availability becomes manifest in findings such as a 2001 study that found several inhabited areas in the U.S. where even simple telephone service was not available (Choura et al., 2003).

Another reason why the U.S. government sought to change the quasi-monopolistic structure of the telecommunications industry was that monopolies are often slow to respond to change. Although AT&T may be credited in many ways for its role in ushering in the modern telecommunications era and for many great innovations, its monopolistic status caused it over the years to become increasingly protective of its turf and sunk investments, and thus less interested in adopting new technologies that could threaten its existing businesses. For example, when the Internet was being commercialized in the mid-1980s, AT&T was reluctant to invest in building the infrastructure necessary to provide Internet access to the general public. It was overtaken in that business by AOL, an unknown start-up that quickly became an Internet access giant with a dominant market share.

More recently, the U.S. government has intervened to encourage growth in Internet penetration via schemes such as E-rate and the No Child Left Behind Act. E-rate is a mechanism by which the U.S. government requires Internet service providers (ISPs) to subsidize the cost of Internet access to certain classes of consumers such as schools, libraries, and certain kinds of rural communities. The No Child Left Behind Act includes provisions that encourage schools to adopt Internet technology in the classroom by offering them additional funding based on various levels of adoption of such technology.

In recent times, an issue that has commanded attention and galvanized governments to action around the world is the issue of Internet access, or, more precisely, lack of Internet access. As the Internet becomes an increasingly indispensable component of the global economy, Internet access becomes an increasingly important arbiter of which societies and peoples will have access to the tools and information necessary to adequately exploit social, economic, and educational opportunities. Consequently, governments around the world are making the availability of Internet access a high priority. In the U.S., it took 100 years for telephone penetration to reach about 75 percent of the population (King, 2005). However, with heightened government interest and priority, Internet access penetration may reach near universal levels in another 15 years. For example, the state of Pennsylvania has officially declared its intention to achieve universal broadband Internet penetration by 2015 (Pennsylvania State Government Press Release, 2004).

Role of Governments

According to Gillett et al. (2004), there are four non-exclusive ways in which government can intervene to act as a catalyst to encourage growth in Internet

penetration and adoption. It can act as (1) a consumer of Internet services, (2) a rule maker or regulator, (3) a financier, and (4) an infrastructure developer (see Figure 1).

As a consumer, governments can Internet-enable the processes of interacting with citizenry, thereby providing an incentive to citizens to adopt the Internet.

As a rule maker or regulator, the government can enforce legislation designed to encourage private sector participation in the provision of Internet access and services. For instance, the government can reduce or remove restrictions on the use of rights-of-way assets by private companies, who need such assets to install Internet access infrastructure. Also, the government can require certain kinds of constituents to adopt the Internet—for example, it can require government-funded schools to offer Internet access and training to students, or it can require government-funded libraries and community centers to offer the same to the general public.

As a financier, the government can offer tax breaks, subsidies, or cheap credit for the creation of Internet access infrastructure and services, or for buying equipment (such as computers) required for accessing the Internet.

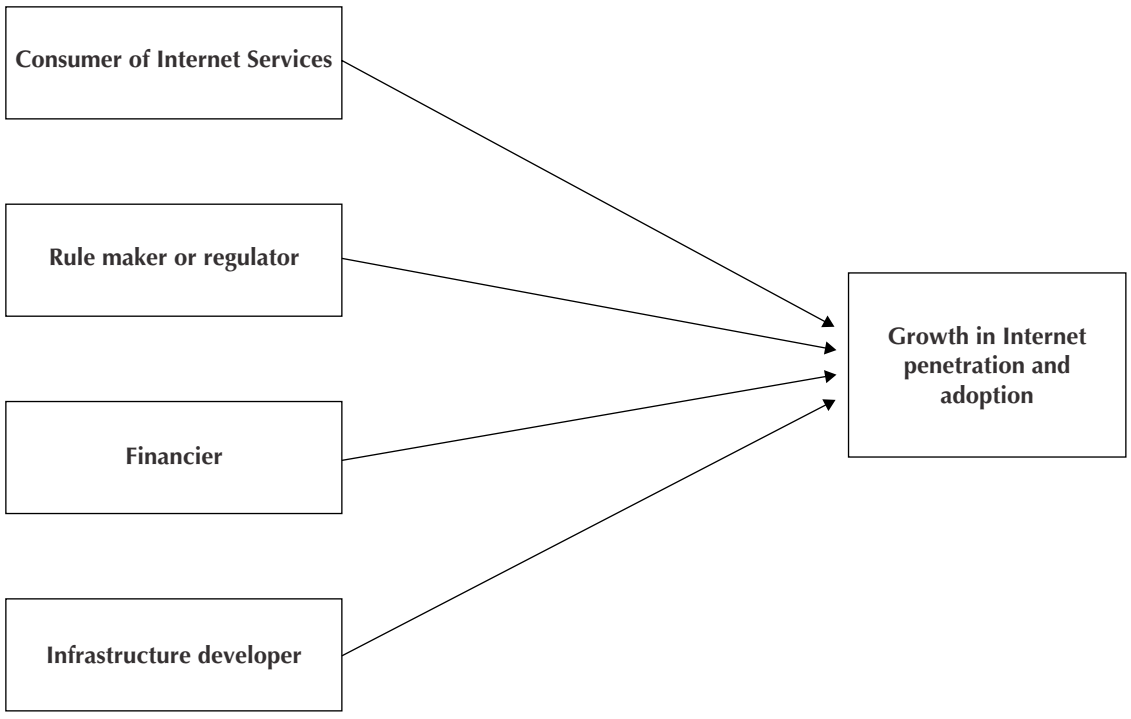
As an infrastructure developer, the government can directly take up the role of creating the infrastructure (or parts of it), or it could become an ISP. Table 1 on page 12 lists the elements of this framework and provides relevant examples.

Pitfalls of Government Intervention

There are also pitfalls involved in government acting as a catalyst, especially in the high-tech area. Although such interventions are usually prompted by lofty goals such as a desire to promote social change or reduce disparity, government espousal of a particular technology, or of a particular course of action in relation to a technology, usually tends to be accompanied by an attendant set of problems. Government interventions intended to promote penetration and adoption of certain technologies can skew the playing field for entities involved in the development and deployment of technology, and can thus result in unintended consequences.

Government support for a particular technology may create monopolistic conditions for the technology,

Figure 1: Catalyzing Roles for Government



Source: *Gillett et al., 2004.*

Table 1: Examples of Government Roles

Government Role	Example of Government Action
Consumer	Introduce e-government, use e-mail for internal communications.
Rule maker or regulator	Introduce laws to regulate subscription fees charged by ISPs or to encourage competition among ISPs. Provide access to government-owned assets and properties, such as rights-of-way assets, that may be needed for installation of network components. Require government-funded libraries to offer Internet access to the public.
Financier	Offer tax incentives or subsidies for developing Internet access infrastructure in neglected areas. Support fundamental research into new Internet access technologies via research grants.
Infrastructure developer	Act directly to create access infrastructure by laying down a network and offering services, as happens in the case of government-owned utility companies.

Source: *Based on Gillett et al., 2004.*

and thus create resistance to new technologies that threaten incumbent technologies. Thus, what may seem like a success for a while may eventually lead to problems. For example, in France, the government-backed Minitel system for information dissemination achieved widespread use before the Internet became popular, and for many years was internationally acknowledged to be a government-intervention success story. However, the same Minitel system caused delays in the adoption of the Internet in France because the Internet was perceived as a threat to Minitel, and because for some time there were unsuccessful attempts to make the Internet accessible via the Minitel system (instead, today the Minitel system is accessible via the Internet).

There are also examples of municipalities that have made inadvisable high-tech infrastructure investments. For example, over the last three decades, 217 municipalities in 37 states have built fiber-optic networks to service their jurisdictions (Barthold, 2005). Ostensibly, these networks were built because the private sector was not taking the initiative to do so. However, many municipalities were also attracted to build these networks because they saw in them the potential to diversify their revenues and reduce internal local government communication costs. As of today, not a single one of these networks is profitable, and municipalities have begun the process of selling them off to the private sector at a loss (Rockwell, 2006).

Government interventions are advisable mainly under conditions of unacceptable degrees of market failure; i.e., when free-market entities are uninterested in or incapable of providing desirable levels of infrastructure or services in free-market conditions. There is broad consensus that monopolistic and quasi-monopolistic conditions can be problematic, and that governments should try to create market conditions where monopolies are discouraged and competition is encouraged. If government interventions result in certain technologies or entities achieving monopolistic stature, governments may again need to intervene to ensure that such monopolistic conditions do not stifle the adoption of new and risky technology, and that service offerings continue to grow in the future.

The above scenarios are ideal cases; the reality in today's interconnected markets and complex partnerships between government and industry is that even when conditions are perfect for intervention, many challenges face government in taking on the role of catalyst. The next section discusses why municipal wireless networks have attracted so much grassroots and governmental attention.

The Emergence of Municipal Wireless Networks (MWNs)

Although the growth in the number of people accessing the Internet over the past decade has been impressive, this growth has not been uniform. Around the world, certain geographical areas and populations lag behind others in terms of Internet access. To address such digital divides, a number of communities and governments around the world are actively seeking solutions to speed up the process of universal broadband Internet availability. A confluence of factors has recently made municipal wireless networks, or MWNs, an increasingly feasible and attractive option for municipal governments that seek to act as catalysts in promoting more equitable and universal access to the Internet within their communities.

A municipal wireless network is defined as a wireless Internet access network that is created with active local government leadership and involvement (Mandviwalla et al., forthcoming). MWNs are currently among the most talked about innovations involving Internet access, and are receiving extensive attention in communities around the world. In the U.S., sales of wireless Internet access related hardware are expected to grow from under $100 million in 2004 to around $1 billion by 2009 (Lawinski, 2005), driven in substantial part by investments related to MWNs. Apart from the estimated 300-plus MWN projects currently under way in the U.S., at least another 100 are under development in the rest of the world (see the sidebar "Silicon Valley Metro Connect" for an example). MWNs have also received substantial encouragement from the private sector. For instance, to further encourage such projects, a group of large technology companies led by Intel has formed a consortium called the Digital Communities Initiative to develop technology, best practices, and financing options for MWNs. To better understand the nature of the interest and debate, we discuss the drivers and inhibitors of MWNs (summarized in Figure 2 on page 14).

Silicon Valley Metro Connect

One of the largest MWN projects under development will cover the region known as Silicon Valley in California (Richtel, 2006). This multi-municipal network will cover 42 municipalities, and serve 2.4 million people over 1,500 square miles. Named "Silicon Valley Metro Connect," the network is being developed by a consortium of firms comprising IBM and Cisco Systems, among others.

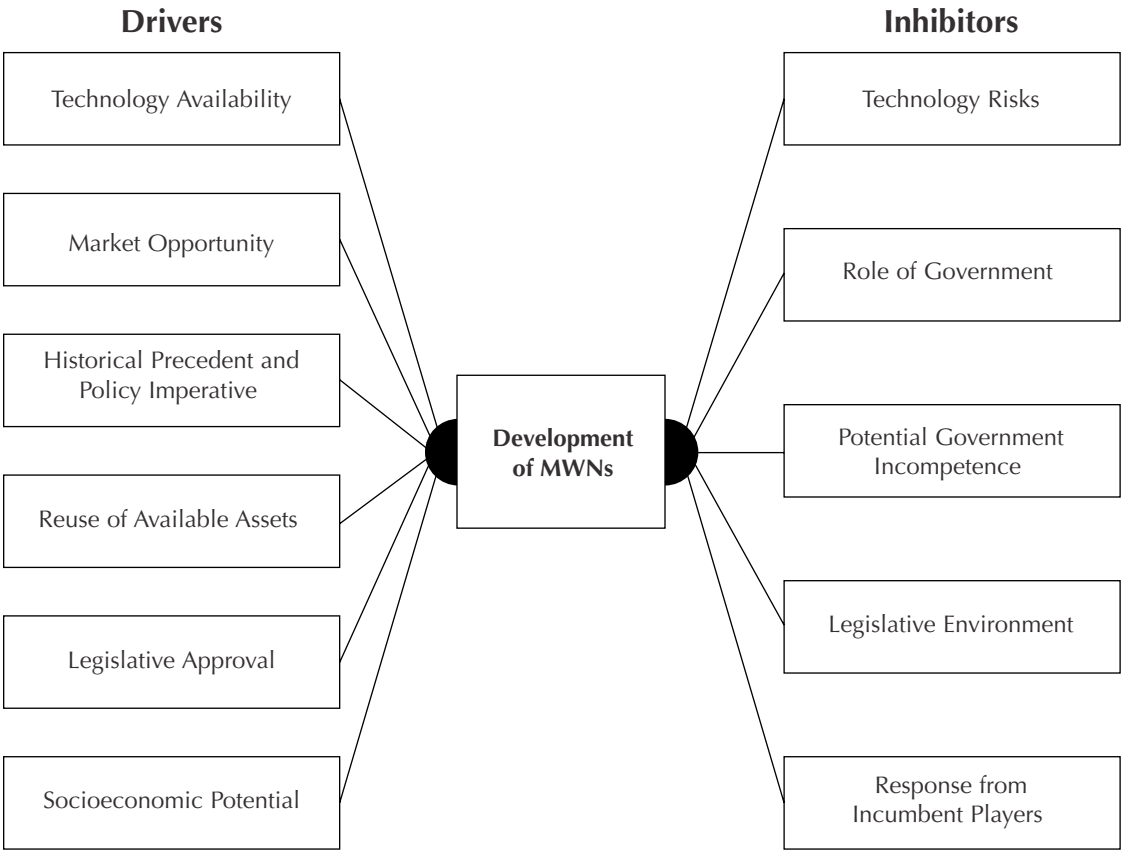
This multi-use network will be built using the latest available mesh technologies, will be privately owned and operated, and will offer wholesale bandwidth access to other ISPs. The plan is to offer a basic service for free and a premium service for a fee. The basic service will offer speeds up to 1 megabit per second, while the premium service will offer much higher speeds and additional features such as value-added services and technical support. IBM's roles in this project will include helping to design and integrate services, and developing innovative applications for public utilities and agencies—such as vehicular traffic management solutions and remote metering of utility services.

Drivers of MWNs

Technology Availability

Recent developments in broadband wireless standards and technology, coupled with steep declines in prices of such technology, have made the deployment of broadband MWNs more convenient and cost-effective than ever before, and

Figure 2: Drivers and Inhibitors of MWNs



a viable alternative to cable, DSL, and other wired technologies.

The technology that makes MWNs feasible did not follow the traditional path traversed by most telecommunications technologies. Instead of being driven in a top-down manner by telecommunications companies, the concept of MWNs emerged in a bottom-up manner through the efforts of discrete end users of wireless Internet technology and of communities that stand to benefit from MWNs.

In the U.S., certain bands in the radio frequency spectrum such as the 900 MHz, 2.4 GHz, and 5.8 GHz bands are available for unlicensed usage by the general public. These RF bands are typically used for applications such as cordless telephones, wireless headphones, off-the-shelf short-range walkie-talkies, remote-controlled car keys, remote-controlled model airplanes, and remote-controlled toys. In the late 1990s, technology was developed and marketed that allowed home and office Internet users to create wireless local area networks (WLAN) very easily using such unlicensed RF bands. The coverage area of such a WLAN typically extended up to a few hundred feet, and was called a "hotspot." Over a few years, the cost of installing WLANs decreased substantially and they became much simpler to use, thus their popularity increased dramatically. There are now estimated to be over 10 million WLANs in homes across the U.S., and at least an equal number in offices and other commercial establishments around the country (Fleishman, 2006).

As such networks continued to proliferate, the beginnings of a new idea in networking began to take shape. Users realized that it was technically possible to tie up proximate hotspots to create large wireless networks that seamlessly spanned the areas covered by the individual hotspots. Such networks are called "mesh" networks, and to build them, certain devices called "meshing" devices are needed to link the hotspots together. Because the technology needed to build such networks is low cost and available off-the-shelf, such networks can be built very easily and with relatively low investment. And because no license fees are needed to use such networks, they cost very little to operate.

Further, because there is no need to install fiber or wires, mesh networks can be deployed quickly to provide large areas with wireless Internet access. To cater to the potential demand for mesh networking, there is currently an ongoing industry-wide effort by hardware vendors to develop standards so that mesh networks can offer rich features, and robust and secure performance.

A major attraction of such wireless technology is that it offers not just a replacement or substitute for existing forms of Internet access, but in fact has the potential to offer a radical departure from existing capabilities. Such Internet access has the potential to give rise to a new generation of mobile Internet-enabled devices and applications to support personal and business goals. For example, wireless, ubiquitous broadband Internet access could lead to a new form of telecommunications convergence to inexpensively support advanced forms of interactive television broadcasts and voice-over-Internet-protocol (VOIP) cellular telephony. Entrepreneurs are also working on new kinds of applications to exploit such networks—for example, handheld wireless devices that provide tourists in a city with rich and interactive information about structures such as buildings and tourist attractions.

Market Opportunity

Private sector Internet service providers tend to focus their services toward more financially attractive markets and consumers, and thus invariably tend to neglect certain constituencies. In the U.S., private firms often end up ignoring or under serving poorer urban and rural communities. Therefore, a potential market opportunity exists that several firms are trying to exploit. For example, several Internet service providers (e.g., Earthlink) are creating business units to service municipalities interested in creating wireless networks. Several major hardware vendors have created units to promote and support wireless networks (e.g., Intel and Cisco). More recently, Internet aggregators such as Google have announced plans to create such networks for their local constituencies.

Historical Precedent and Policy Imperative

Historically, municipalities have often been involved in providing various services and utilities for citizens and local businesses, especially when the private sector was unable or uninterested in providing them. In many jurisdictions in the U.S. even today, certain essential services such as electricity, water, health clinics, and education are provided by municipal local governments. Moreover, beyond the historical precedent, according to economic theory, it is appropriate for government to intervene in the provision of a service if the service utilizes public goods and has the potential to result in significant positive externalities (Cornes and Sandler, 1986). It has been argued by proponents that wireless Internet service provision fulfills these requirements because it utilizes the publicly owned radio frequency spectrum, and can accelerate the potential for new innovations and societal benefits as more citizens get connected. Therefore, for many locales, a municipality-owned MWN seems like no more than a high-tech extension of an already existing portfolio of services owned or provided by the municipality's local government.

Reuse of Available Assets

A major strategic advantage that municipalities have with regard to wireless infrastructure deployment is that they usually own or control public facilities such as traffic lights and streetlights. Wireless Internet networks need the installation of antennae and nodes that are geographically dispersed and proximate to points from where the network will be accessed. Assets such as traffic lights and streetlights are considered highly appropriate for installing such network components because they are usually spread out across most communities. There is thus an expectancy that municipalities will find it especially easy to set up the underlying network infrastructure because they have ready and free access to properties needed for such installations.

Legislative Approval

In the U.S., the concept of MWNs received a significant boost in March 2004 when the U.S. Supreme Court reached a decision in *Nixon v. Missouri Municipal League* which confirmed that municipalities could set up municipal wireless networks and sell access to the public. This case involved a group of municipalities in Missouri that had set up or were planning to set up MWNs. This group was sued by a number of entities including the state government of Missouri and various telecommunications companies, who argued that municipal governments should not be allowed to

behave like telecommunications companies by selling access to such networks. According to the Supreme Court decision, under existing telecommunications laws municipalities could indeed set up and sell access to these networks, but state governments could bar them from doing so. At that time, there were already approximately 100 MWN projects in various stages of progress around the country. However, all of these were in small municipalities. This Supreme Court judgment encouraged much larger municipalities to consider MWN projects, as long as their state governments did not have a problem with these projects.

Socioeconomic Potential

For municipalities, a major attraction of wireless networks is their potential to improve the socioeconomic condition of individuals and institutions. Increasing anecdotal and research evidence supports the idea that broadband Internet access has a non-trivial, positive impact on socioeconomic growth in local communities (Gillett et al., 2006). Therefore, civic leaders and politicians see such networks as catalysts to (1) address the digital divide in their communities, (2) improve the image of the community, and (3) attract new businesses to the area. In addition, by embracing such networks for their own administrative processes, municipalities could save on internal communications costs and improve the capabilities and efficiency of their staff and operations.

Inhibitors of MWNs

Technology Risks

There are several reasons why it can be an extremely risky prospect for municipalities to get involved with high-tech ventures such as MWNs. If such investments turn out to be unfruitful—as happened with municipal investments in fiber networks—it could result in a costly burden for taxpayers to shoulder.

A major concern is that in its current stage of development, MWN technology may not be ready for sustained large-scale usage. The technology was originally developed for independent hotspots, and at that time the idea of meshing such hotspots together was not considered. Therefore, it is not certain how well the technology will perform in large mesh network conditions. So far, only small-sized mesh networks have been deployed, and they have not always performed as well as promised by equipment manufacturers and vendors. Various network reliability and throughput speed issues have been encountered. Therefore, it is not known what kinds of issues may emerge when such networks are deployed in citywide dimensions in large cities. Nor is mesh technology yet standardized. Standards are currently under development, but until they are accepted, municipalities have to use proprietary technologies, which can make them overly dependent on particular vendors.

Another challenge is that MWNs could interfere with other devices that use the unlicensed radio frequency bands such as home WLANs, cordless phones, keyless automobile entry systems, remote-controlled toys, and walkie-talkies. When used for municipality-wide deployment, wireless Internet access points need to broadcast RF signals at relatively high power. The high-power signal could drown out other signals on similar frequencies. As it stands today, this matter is still unresolved, and it is simply not certain what will happen in terms of channel interference when MWNs compete for limited unlicensed bandwidth with all these other technologies.

Rapid obsolescence is also a concern. Wireless technology is a hotbed of research and development activity, and a flurry of new innovations and standards is expected every few years. In high-tech areas, the private sector is used to managing cycles of creative destruction so that new technologies and systems periodically emerge to supplant status quo arrangements. However, governments are not usually used to handling such cycles.

Role of Government

Perhaps the most conspicuous policy level and philosophical criticism against MWNs is that they are a form of government entry into the competitive arena of Internet service provision. Incumbent Internet service providers and their supporters argue that MWNs will result in the formation of government-owned quasi-monopolies that will compete unfairly against commercial ISPs. Incumbent commercial ISPs argue that local governments pay no taxes, have access to tax-exempt bonds, and lack clear

accounting practices. Thus, not only would MWNs be indirectly subsidized by taxpayers, but also it would be difficult to accurately gauge MWN costs and expenses within overall municipal government budgets, making it possible for municipalities to cross-subsidize one activity with another. Further, they argue that MWNs would result in re-appropriation of a freely available public asset—the unlicensed RF bands—by the government. They contend that all of this would distort the market for wireless Internet service provision and would be unfair to existing commercial ISPs, especially those telecommunications companies that have invested in RF spectrum licenses in order to be able to provide wireless services. Finally, they argue that there are significant potential long-term economic consequences if the government interest in MWNs results in the formation of a quasi-monopolistic or monopolistic economic environment for wireless Internet service provision. The potential consequences include long-term damage to competitive practices, a slowdown in the development of new innovations, and the possibility of commercial ISPs going out of business.

Supporters of MWNs argue that government health clinics and public libraries did not put private hospitals or book publishers out of business. But critics warn that if MWNs offer low-cost, high-speed, and wireless access to the Internet, they could seriously undermine commercial telecommunications and broadcast businesses as they are currently recognized. Thus, it is contended that instead of trying to get into the business of building MWNs, municipalities should make it easier for commercial ISPs to build and operate such networks. Municipalities could do this by reducing or eliminating barriers to entry such as licensing fees, and by giving easier access to rights-of-way assets such as city-owned lampposts that are needed for installing the network infrastructure. Further, telecommunications is one of the most heavily taxed industries (King, 2005), and it is claimed that municipalities can easily create strong incentives by providing corporations tax relief for building wireless infrastructure.

Potential Government Incompetence

Other critics are less concerned with the policy and philosophical objections of government intervention and instead point to a long history of failures that have resulted from governmental involvement. Whereas in the short run MWNs may accelerate penetration of wireless Internet access, over the long term the potential economic negatives associated with monopolistic practices may outweigh the short-term gains. In the European nation of Macedonia, for instance, a state-run monopoly has been given rights to provide Internet access across the entire nation. Although this ISP was initially appreciated because it built Internet access infrastructure in all areas of the nation, including parts where commercial ISPs would not typically have cared to provide Internet access, it is quickly losing support from consumers because the quality of service is poor and because it is reacting slowly to upgrade service levels. Thus, although this ISP provided wide coverage, the quality of service is poor. And there are now calls for opening up the market to competition from other ISPs because the state-run ISP's services could be disastrous for the long-term economic future of the nation (Wood, 2006).

Legislative Environment

All of this interest and activity at the state level has prompted the U.S. federal government to initiate an overhaul of the Telecommunications Act of 1996 to address MWNs and other similar local-level broadband Internet access efforts. Among federal legislators, there are proponents on both sides of the fence. Whereas Senator John Ensign (R-NV) and Representative Pete Sessions (R-TX), backed by lobbying from telecommunications companies, have introduced legislation to altogether ban municipalities from building MWNs, there is a bipartisan effort by Senators John McCain (R-AZ) and Frank Lautenberg (D-NJ) to introduce a bill that would grant all municipalities the right to build MWNs whether their state government allows them to or not. Such legislative wrangling adds to uncertainty surrounding MWNs.

Response from Incumbent Players

For incumbent telecommunications and broadcast corporations, MWNs are a disruptive technology and a significant threat to their existing lines of business. The Internet has multi-application, multi-purpose capabilities, and can support all traditional communication needs such as text, voice, and video. A wireless, high-speed, and high-performance Internet has the potential to replace traditional channels of cellular telephony, television, and radio broadcast delivery. Based on various advantages of Internet-based

communications, it is highly likely that at some point in the future, traditional forms of communication that are currently considered distinct from the Internet (e.g., telephone, cellular phones, and television) will eventually be delivered via the Internet. For instance, it is expected that traditional cellular telephony systems will be replaced by wireless Internet-based telephones using VOIP. Thus, incumbent telecommunications and broadcast corporations have compelling reasons to be concerned about tax-exempt and taxpayer-subsidized competition emanating from the government. As a result, some firms have come out strongly to reduce the potential threat via actions such as lobbying, legal challenges, funding of studies that dispute the potential advantages of MWNs, and, more recently, pricing incentives to gain market share.

Overall, although the last three years have seen tremendous developments and advances in the concept of MWNs, these are still early days for MWNs. A large number of claims have been made in favor of creating MWNs, but there are also a large number of caveats and threats. It may take a few years before there is clarity on issues such as whether and to what extent municipalities should own or build MWNs, as well as the question of who should be responsible for addressing issues such as service pricing, reliability, flexibility, security, coverage, user-training, and customer service. The case of Philadelphia, discussed in the next section, provides a detailed illustration of the challenges and opportunities presented by MWNs.

The Development of Philadelphia's Municipal Wireless Network

The city of Philadelphia is the fifth largest city in the U.S. and prides itself as a city of firsts. It was the site of the Declaration of Independence and the drafting of the U.S. Constitution. The U.S. flag is believed to have been designed there, and the Liberty Bell resides there alongside Independence Hall. For much of U.S. history, Philadelphia has been one of the nation's leading cities in terms of economic, political, and cultural influence. In the industrial era Philadelphia has experienced a reversal of fortunes. The economy has performed poorly and the population has declined. Various indicators related to socioeconomic factors such as education, crime, and quality of life measure well below the U.S. average (see Table 2 for statistics). Over the years, the city government has attempted various measures to try to stem the decline, but results have been mixed. However, there has been some improvement relative to previous years. For example, during the 1990s Mayor Ed Rendell led various initiatives to improve tourism including the construction of a convention center. Several neighborhoods in the downtown area were revitalized, leading to a mini housing boom, new restaurants, and cultural attractions. Philadelphia covers an area of about 135 square

Table 2: About Philadelphia

Population		
	Philadelphia 2000	Philadelphia 2005
	1,517,550	1,406,415

Socioeconomic Performance			
	Philadelphia 2000	Philadelphia 2005	U.S. 2005
Individuals below poverty level	23%	25%	13%
Per capita income	$16,509	$19,140	$25,035
Population over 25 with college degree or higher	18%	22%	27%

Crime Level		
	Per 100,000 People in 2004	
	Philadelphia	U.S.
Violent crimes	1408.3	465.5
Murders	22.2	5.5
Robberies	657.4	136.7

Sources: *Population and socioeconomic performance statistics from U.S. Census; crime statistics from the FBI.*

miles and currently contains about 660,000 households. The city government has a budget of about $3.5 billion, 52 departments and agencies, and 25,000 employees.

How It All Started

In January of 2000, the city elected a new mayor—John Street. At that time, the city was going through a positive period with new residents moving in and several new visible construction projects under way such as the new Constitution Center. In May of 2000, the mayor appointed a new Chief Information Officer (CIO)—Dianah Neff—to the Mayor's Office of Information Technology (MOIS). MOIS was an important department of the city with a budget of about $80 million and approximately 450 employees.

Neff had prior senior-level information technology experience in the city governments of San Diego, California; Bellevue, Washington; and Palo Alto, California; and had become well-known for steering innovative information technology projects in those cities. For example, while she was in Palo Alto, the city became the first in the U.S. to have an official city government website. The new CIO was given a strong mandate to use information technology to bring favorable changes to the city government's workings and to the city of Philadelphia. By the middle of 2002, Philadelphia began to gain national attention for its efforts to make local government services accessible via the Internet. For instance, Philadelphians could apply for permits online, and could pay various taxes and fines online.

However, in the beginning of 2003, internal analyses conducted by the city government showed that across the city's population, there was uneven awareness and appreciation of the e-government efforts. Also, a significant proportion of the population could not benefit from e-government because of lack of access to or knowledge of computers and the Internet. The city government realized that in order to continue making strides in e-government, they had to better understand and address this digital divide.

A study conducted by the city government in 2003 found that approximately 40 percent of the city's population identified themselves as non-users of the Internet. Moreover, only 45 percent of the population had Internet access at home, compared with a national rate of over 70 percent. Of these, 72 percent were slow dial-up connections, compared with a national rate of less than 50 percent (Fleishman, 2006). The city was seriously lacking in Internet usage, particularly in broadband Internet usage, and something drastic had to be done to ameliorate the situation.

About that time, a few small communities around the country had begun to draw attention to setting up community-wide wireless networks for Internet access. For the city government of Philadelphia, this was an increasingly attractive option. The technology was cheap and available off the shelf. And for municipal governments, there was a great advantage in that such wireless networks could be created by installing wireless equipment on geographically dispersed municipality-owned rights-of-way assets such as lampposts and traffic lights.

Initial Steps

Figure 3 presents a timeline of the key milestones of the Philadelphia wireless initiative that are discussed further below. In January 2004, the city government installed free wireless hotspots in a few test locations in the city. There was considerable favorable media coverage of this development, and there ensued intense media speculation and interest in the city's future plans vis-à-vis such hotspots.

The plan was called the Philadelphia Wireless Initiative, and in August 2004 the mayor announced that a nonprofit organization, Wireless Philadelphia, had been created to oversee the plan (Philadelphia City Press Release, 2004). Wireless Philadelphia had an Executive Committee that was composed of a number of eminent and influential Philadelphians who had achieved a high degree of prior success in various community, entrepreneurial, and technology-related activities. As CIO of Philadelphia, Neff was appointed an ex-officio member of that committee. Wireless Philadelphia began working on a project plan to bring the Philadelphia Wireless Initiative to fruition. The project planning process and eventual implementation is described below using the framework in Figure 4 on page 22.

The overall project plan would be carried out in three stages. In Stage 1 of the MWN planning process, Wireless Philadelphia identified its goals, explored the needs and expectations of diverse stakeholders, and addressed key policy issues. In

Figure 3: Timeline of the Wireless Philadelphia Initiative

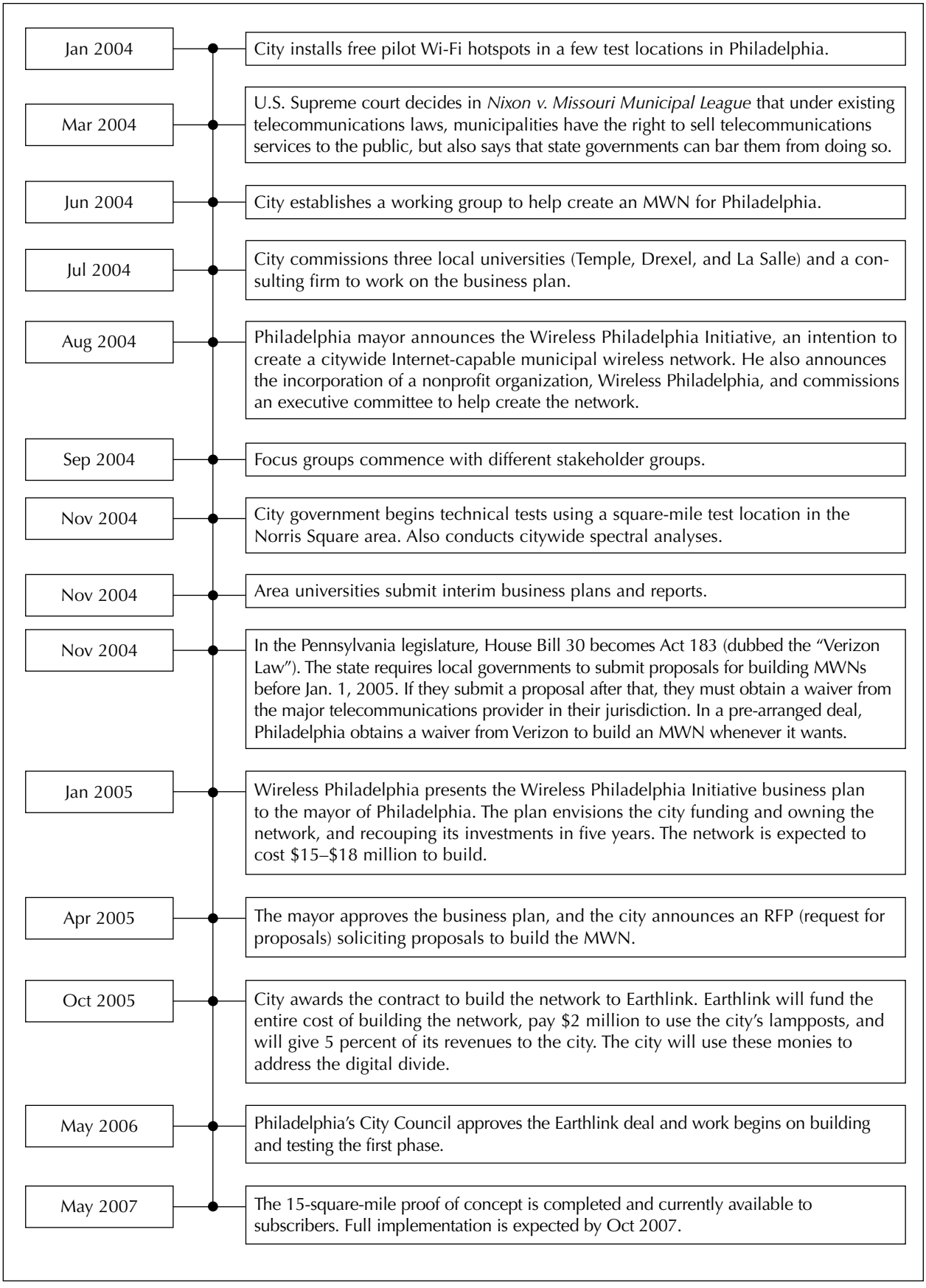
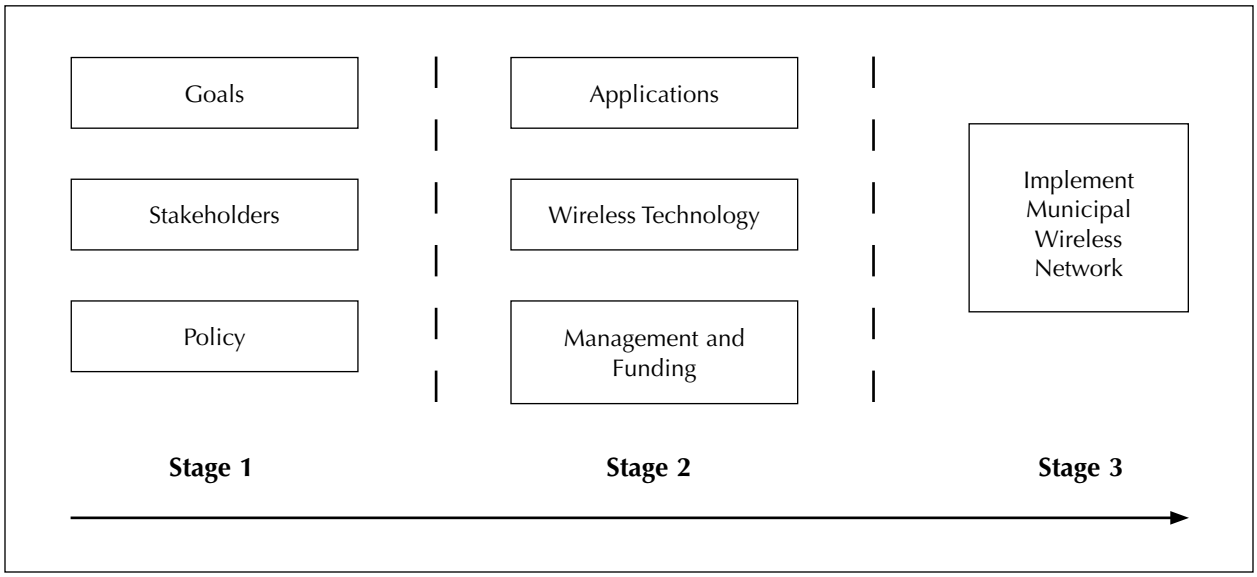


Figure 4: MWN Development Framework



Source: *Mandviwalla et al., forthcoming.*

Stage 2, Wireless Philadelphia decided on the kinds of applications that the MWN would support, what technologies would be used to build the network and support these applications, and what sort of management and funding arrangement would be used to build and operate the network. In the final stage, the actual network would be built. The stages are rough milestones and serve to retrospectively illustrate activities that were often carried out in parallel and with considerable overlap.

Stage 1: Goals, Stakeholders, and Policy

Goals

In August 2004, Wireless Philadelphia announced its mission and objectives:

Mission

Wireless Philadelphia aims to strengthen the economy and transform Philadelphia's neighborhoods by providing wireless Internet access throughout the city. Wireless Philadelphia will create a digital infrastructure to help citizens, businesses, schools and community organizations make effective use of this technology to achieve their goals while providing a greater experience for visitors to the City.

Objectives

- To spur economic development
- To enhance community neighborhoods
- To help overcome the digital divide
- To reduce the cost of government

It was assumed and hoped that the MWN would lead to improvement in the overall socioeconomic scenario in a locale, leading to urban renewal where needed. This would lead to improvement in citizens' quality of life and, subsequently, economic competitiveness of the community. The intent of the cost-savings goal was that the municipality could save on internal communication costs by using its own network to enable Internet access for its employees, instead of relying on an ISP. Several secondary goals were also discussed by the city in its interaction with citizens and the media:

Secondary Goals

- Providing business and government users with ubiquitous Internet to supplement their internal networks, so that field staff could access the Internet while in the field.
- Expanding the potential market for e-government services.
- Improving the attractiveness of the community for business visitors and tourists.

- Giving local entrepreneurs a chance to participate in building the network, lowering barriers to entry for them to enter such a market.
- Empowering citizens to participate electronically in the political process.

Stakeholders

Members of the Executive Committee of Wireless Philadelphia indicated four main areas of interest and concern with regard to the MWN: innovation, adequate leadership, a reliable network, and structures that are responsive to user needs. The Executive Committee was also concerned with sustainability. Sustainability involved issues such as organizational and governing modes, performance measurement, funding, financial viability, end-user training, and customer support. The Executive Committee identified the key stakeholders of the project as follows:

- City residents with access to and knowledge of the Internet and computers
- City residents without access to and knowledge of the Internet and computers
- City government of Philadelphia
- Business community (large and small)
- Nongovernmental organizations (NGOs) and nonprofit organizations
- Healthcare community
- Academic community (higher education and public schools)
- Business visitors and tourists

More than a dozen focus groups were conducted with over 120 participants from the above list (see Table 3 on page 24 for sample stakeholder comments). It became evident that stakeholders had contrary expectations and interests. For instance, some stakeholders believed that the city government should own the MWN, while others believed that it should be owned by the private sector. Similarly, some stakeholders believed that lower-income users should be allowed to use the service for free, whereas others believed that everyone should be made to pay for it. In addition to the focus groups, a town-hall-type public forum was held that involved a discussion of issues similar to those explored in the focus groups. We believe that the focus on understanding the needs of stakeholders was very helpful. It elicited important issues and requirements from many different local groups, and helped create a positive and inclusive atmosphere about the project in the city. We strongly recommend that newer projects follow a similar strategy.

Policy

In parallel with goal setting and stakeholder analysis, Wireless Philadelphia was also grappling with state policy. In March of 2004, the Supreme Court reached its decision in *Nixon v. Missouri Municipal League* supporting municipal involvement in MWNs and allowing states to decide whether municipalities in their jurisdiction could offer MWNs. Bolstered by this decision, a number of municipalities seriously began to look into MWNs. However, a fairly well-accepted viewpoint was that the business of Internet access should be left to the private sector ISPs, and that municipalities should not get involved with offering access to network services. A strong lobbying effort from telecommunications companies led to a number of states banning all municipalities within their jurisdictions from building MWNs. In the state of Pennsylvania, Verizon was the predominant telecommunications company. According to media reports, Verizon exerted heavy lobbying pressure on the state government to bar MWNs in the state. Meanwhile, Neff, with help from the mayor, championed the cause of Philadelphia's MWN to state legislators and to the governor. In parallel, it was also reported that Neff negotiated with Verizon to change the terms of their demands.

During this time, Wireless Philadelphia also grappled with other policy challenges related to the legal implications of building and operating an MWN, such as responsibility for data security and related liabilities. During the stage 1 period, the CIO was very visible in the community and the media as a strong champion of the MWN. At that time, there had been considerable concern about various city government budget shortfalls, and there was a view that instead of focusing on a risky new project, the city should focus on restoring funds to various programs. The CIO assuaged those fears by asserting that the city government was not interested in acquiring monopoly rights over the project, and was instead interested in private sector participation and eventual complete ownership and management by the private

Table 3: Examples of Stakeholder Comments from Focus Groups

Positive Comments from Stakeholders
It would be a matter of pride for Philadelphia to be the first major city with a citywide MWN.
It would help address the digital divide and improve the socioeconomic potential for residents of the city.
It would help businesses become more connected and competitive.
Government field workers (e.g., police, parking authority, meter readers) would be able to access records and information while out in the field.
More city government workers would use the Internet, thereby giving the city an e-government edge.
Case workers of NGOs and nonprofit organizations would be able to access records and files while out in the field.
Healthcare workers would be able to implement e-health initiatives and be able to access information while out in the field.
It would enhance the telecommuting possibilities in the city.
Universities and colleges would benefit by expanding connectivity beyond on-campus wireless networks. Also, the attraction of the MWN could help colleges increase enrollment from students outside the city.
Schools could make study materials available online and thereby benefit students at home. Students could benefit from participating in virtual field trips. Parents could develop closer contact with teachers and school administrators via the Internet.

Negative Comments from Stakeholders
If skills training was not managed adequately, individuals with non-existent or minimal computer literacy skills could fall further behind others, thereby exacerbating the digital divide.
The MWN should be a win-win deal for all concerned. Private sector ISPs should not suffer economically because of the network; that could mean a loss of jobs in the city.
The system must stay up-to-date with evolving technical standards and technology. It should not be allowed to become obsolete. It should be made future proof.
The privacy and security of users of the network must be guaranteed.
The network should not only be accessible from outdoors, but also should be available indoors.
Whereas it was OK for the government to build it, the government must eventually divest itself of day-to-day operations of the network, and hand that responsibility to the private sector.
The MWN should be cost neutral to the city, and should not cost too much to subscribe to. It should cost less to subscribe to than other competitive options offered by private ISPs. Also, there should be a sliding-scale cost structure so that lower-income users can subscribe for less.
Quality and reliability should be given a strong priority. Customer support should be adequate.
Publicity and promotion programs must be used to raise awareness among potential users.
Local community leaders must play an active role in communicating the potential of the MWN.

sector. Secondly, she avowed that the MWN would be built at a neutral zero cost to the city.

Despite the initial success in Philadelphia and other similar projects around the world, we believe that newer projects will continue to face significant policy challenges. It will remain critical for new projects to have strong, vocal, media-savvy, and politically and legally connected champions.

Stage 2: Applications, Technology, and Management and Funding

Applications

At the time of the project, a number of communities around the country were experimenting with new kinds of applications to run on MWNs, such as providing police squad cars with Internet-connected laptops, and installing utility meters with wireless technology so they could be read remotely. However,

it was decided that the initial focus of Philadelphia's MWN would be to provide reliable, quality Internet access to the city's population, with particular emphasis on underserved low-income residents. Further, the city government would become an anchor tenant. That is, the MWN would be assured support and usage from the city government. It was decided that radical applications, if any, would be considered at a later stage. Given the timeframe of the project, and the unique demographics and politics of Philadelphia, focusing initially on low-cost Internet access was a good decision. It allowed the project to focus on a concept that was relatively easy to explain, defend, promote, and implement. However, as the technology matures, and the cost of Internet service continues to decline, it may be progressively harder to focus only on "digital inclusion."

Wireless Technology

Given the available options, the most suitable technical infrastructure for the city was Wi-Fi mesh technology, with WiMAX backhaul. Problems with this technology included: (1) it had not been tested in such a large-sized network, (2) it was likely to be outdated soon, and (3) mesh technology was available only in proprietary form, with many different vendors offering incompatible solutions. However, the technology was low cost enough that it could be replaced if it became outdated, and industry-wide activity was under way that would soon create open standards for mesh technology.

Given the uncertainty surrounding the use of the technology on a large scale, between November 2004 and January 2005 the city conducted extensive technical feasibility tests. RF Spectral Analysis was conducted to assess the extent of current unlicensed band usage and to predict the likelihood of future interference. The city used handheld spectrum analyzers to analyze the RF band usage in 50 locations spread across the city. The results of this analysis showed that it was feasible to use the 2.4 and 5.8 GHz unlicensed RF for the MWN. This was an important step in ensuring the technical feasibility of the project because the unlicensed RF spectrum is subject to interference from many different devices including cordless phones and microwaves.

Additional analysis and simulations indicated that to achieve adequate MWN availability, Philadelphia would need a mesh network that consisted of 18 mesh nodes per square mile, transmitting at 1 watt per node, with nodes installed at a height of 45 feet from ground level. A test network was created with these specifications over a square mile area. The tests revealed that signal strength parameters were within acceptable ranges and Internet access speeds ranged from 1 to 11 Mbps. As expected, the factors that most affected signal strength were proximity of the client device to a mesh network node, and the amount of obstruction in the path between the client device and the closest mesh network node. The overall pattern of RF propagation matched the pattern predicted by the simulation.

Such extensive testing will likely continue to be required by new projects in the conceivable future. Each city or area has unique electromagnetic, topographical, and geographical properties that can dramatically influence the number of nodes required, reliability, and the speed of access. The results of such testing will significantly impact the actual cost of implementation and the feasibility of certain applications. For example, on the cost issue, a different topography of buildings and natural structures may require significantly more or less nodes. Another example related to applications is that if the MWN will provide the backbone for handheld wireless devices that will read city utility meters, then how will that application deal with "dead" (high interference/low signal) zones?

By March 2007, the Philadelphia project had completed a pilot proof of concept implementation covering 15 square miles of the city. The eventual goal is 135 square miles. Still, even 15 square miles is a very large area for a densely populated northeast city. The results of the pilot will likely be very useful to other cities that are interested in creating an MWN. The early indications are that the pilot will be successful and that the technology is sufficiently mature to continue scaling upward.

Management and Funding

This part of the planning process included determining responsibility for funding the network and managing the implementation and operations. This process is inherently controversial. For example, the project included a social consciousness dimension to address the city's digital divide. It is difficult to gauge how and to what extent such social aims can

be adequately addressed by the private sector and, therefore, to estimate how much government sector involvement is desirable or necessary. Many different kinds of funding and management models are possible for MWNs. For instance, Lehr et al. (2006, p. 7) have identified five distinct models, as follows:

Retail service model: "the municipality offers retail services to consumers over infrastructure that it owns and operates."

Wholesale service 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."

Franchisee model: "the municipality contracts with a private firm to build and operate the facilities."

Real estate 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."

Coordination model: "the municipality can provide a nexus for demand aggregation (e.g., buyer groups) or for coordinating efforts of community networking (Wi-Fi cooperatives)."

Each of the funding models listed above has differing levels of government and private sector participation, resulting in various advantages and disadvantages depending on one's point of view. For instance, increased municipality participation is likely to lead to increased emphasis on the social consciousness aspects of the project, but may crowd out private sector participation. Wireless Philadelphia explored the following related but different funding and management models:

Public community: The city would fund the deployment and operation of the MWN and provide free access to all subscribers.

Private consortium: Private telecommunications companies would fund the deployment and operation of the MWN. The city would provide access to assets such as lampposts for a fee and would act as an anchor tenant. However, the city would also regulate the service in favor of economically disadvantaged subscribers.

Wholesale cooperative: The city would fund the deployment and operation of the MWN. Further, the city would sell network capacity to private ISPs to resell on a value-added basis.

Public utility: A public utility would fund the deployment and operation of the MWN and sell access like any utility.

Nonprofit: Nonprofit organizations would fund the deployment and operation of the MWN via grants and donations. Access to the network would be sold on a nonprofit basis.

The above discussion of models is generic and applicable to other contexts (see Table 4). The debate over the most appropriate model was constrained and contextualized by issues that were specific to Philadelphia. First, the concept of public access TV in Philadelphia had been disastrously executed during the 1980s and 1990s, and for the most part this was blamed on city government interference in policy and infrastructure creation. There was considerable concern that Philadelphia could have a similar management failure with the MWN.

Second, the city government had been running budgetary deficits for a while, and Philadelphia was already considered one of the most highly taxed cities in the nation. There was concern that if there were unanticipated cost overruns in building the MWN, this could further break the city's budget and raise taxes.

Third, most of Philadelphia already had potential broadband Internet access. Comcast had the capability to supply cable Internet to 75 percent of the city's population, and Verizon had the capability to supply DSL over telephone lines to 95 percent of the city's population. There was already pre-existing underutilized capacity. What if the MWN were built and nobody came to use it?

In response to the specific concerns above, it was argued that beyond simple availability of broadband Internet, the issue was that of future potential. The city was simply trying to lay a foundation for basic wireless infrastructure that could be as important to the city as paved roads were a century earlier. The

Table 4: Sample MWN Business Models Worldwide

Business Model	City	Description
Public community	St. Cloud, Florida; Hermosa Beach, California	City owned and operated. Free access to all. Taxpayer-funded access.
Public utility	Chaska, Minnesota; Lompoc, California	City owned and operated. Low-cost, fee-based access.
Wholesaling cooperative	Corpus Christi, Texas	City owned and operated network primarily built to support local government applications and functions. Excess network capacity sold on wholesale basis to ISPs, who resell network access on retail basis.
Wholesaling cooperative	Västerås, Sweden	Network's main artery provided by city. Groups such as tenant and housing associations build their own capillary networks, tap into the main artery, choose the services they want, and pay for usage.
Private consortium	Silicon Valley, California	Privately owned and operated. Network capacity sold on wholesale basis to other ISPs. Basic, lower-grade service offered free. Premium, higher-quality service offered for a fee.
Private consortium	Tempe, Arizona	Privately owned and operated. Access offered for a fee. Access available free for a couple of hours each day.
Private consortium	Mountain View, California	Privately owned and operated (by Google). Access is free and supported via advertising revenue.
Private consortium	Taipei, Taiwan	Privately owned and operated. Access available for a fee via an ISP. No particular focus on digital inclusion.

MWN was not an end in itself but a means to an end, in which the end was a universally Internet-literate population that could take advantage of the digital economy and contribute to the city's future. The technology and installation costs were low enough that it would be negligent of the city government not to invest in the network. Moreover, current broadband Internet access was expensive and there were no associated services or products offered by commercial providers to help people use the Internet. Wireless Philadelphia contended that the city government was not interested in the business of providing Internet access, and was more interested in acting as a catalyst to build capacity in a way that was managed by the private sector. Finally, Pennsylvania had a goal to ensure universal broadband access by 2015, and Wireless Philadelphia and its champions argued that this would be impossible to achieve unless radical and drastic new techniques were attempted to increase Internet access.

In November 2004, interim business plans were submitted by partner universities, and Wireless Philadelphia started the process of finalizing the business plan. At the end of November, in the Pennsylvania legislature, House Bill No. 30 became Act 183. The bill gave state government authority to require all municipalities in the state to submit proposals for MWNs for approval before January 1, 2005. If they submitted proposals on or after that date, the municipalities would first have to get a waiver from the major local telecommunications provider. In Philadelphia (and in most of Pennsylvania), the major provider was Verizon. However, because the CIO and the mayor had negotiated with state legislators as well as with Verizon, there was an understanding that Philadelphia would be exempt from this act. Soon after Act 183 was passed, Verizon officially granted Philadelphia a waiver. This allowed Philadelphia to submit a proposal for the MWN whenever it wanted, even after January 1, 2005.

Stage 3: Implementation

In February 2005, Wireless Philadelphia submitted its final business plan to the mayor. A hybrid business model was proposed after evaluating the candidate business models on their ability to support the following criteria:

- Free service in parks and public spaces
- Low cost or free for disadvantaged

- Cost neutral for city
- Generate return/profit for city
- Universal access/coverage
- Revitalize communities
- Respond to technology change
- Wide range of service offerings

The hybrid model was a cross between the nonprofit model and the wholesale cooperative model. Accordingly, Wireless Philadelphia proposed a plan whereby the city government would invest $10 million toward building the network. The network would be built by a private sector entity and owned by a nonprofit organization, namely Wireless Philadelphia. The city would guarantee a line of cheap credit to Wireless Philadelphia toward operational costs, and network capacity would be sold on a wholesale basis to private sector ISPs.

The ISPs would resell network access on a retail basis to end consumers. The city would be an anchor tenant, i.e., it would be an assured customer of the network. Based on what it considered conservative subscription estimates, the business plan predicted that the city government would recover its investments in less than five years; therefore, the network would, in effect, be cost-neutral to the city after five years. The network would be available throughout the 135-square-mile area of the city.

In April 2005, the mayor approved the business plan for the Philadelphia Wireless Initiative and announced an RFP (request for proposals) to solicit proposals to build the MWN. The "fixed price required" RFP included detailed technical, coverage area, service level, and network management specifications. The network was to support a diverse set of users including low-income residents (see Tables 5 and 6), and it was to be built so that other service providers could easily resell the capacity. The RFP was a watershed event in that it clearly established that (1) the network would be built by a professional private contractor; (2) by requiring discounted service for low-income subscribers and coverage in specific low-income areas, the city was staying true to its original vision of digital inclusion; and (3) by requiring support for different types of users, the city was creating room to realize the economic development aspects of its vision. The RFP also provided respondents with the opportunity to propose their own funding, ownership, and management models. An open process was created to make the RFP easily available to all potential respondents, and eventually Wireless Philadelphia evaluated 12 complete proposals.

In October of 2005, Philadelphia announced an agreement with Earthlink to build the MWN. The final agreement, effective February 21, 2006, included the following key elements:

- Earthlink would undertake the entire cost of building and operating the network over the 135-square-mile radius of the city. Upon completion in about two years, the network was expected to require more than 4,000 nodes and 24 towers to cover the city, and provide access using industry standard 802.11b and 802.11g technologies.
- The network would be owned by Earthlink, and the agreement allowed Earthlink to directly sell retail access to end consumers, as well as sell capacity on a wholesale basis to other potential service providers.
- A key element of the final network would be the provision of full-service Internet access accounts subsidized by Earthlink. These accounts would be made available to qualified low-income and disadvantaged persons in the city for $9.95 per month.
- Earthlink would also provide a complete set of network management, maintenance, support, and upgrade services. In parallel, the city empowered Wireless Philadelphia to manage the agreement with Earthlink, oversee the build-out of the network, and assume responsibility for championing the digital divide goal.
- Earthlink would initially pay $2 million over two years for the right to build the network and use the city light poles to install its equipment. The $2 million would be paid in installments tied to the proof of concept, with the largest payment to be made in the second year. After the second year, Earthlink would pay 5 percent of its revenues to Wireless Philadelphia and also pay a per pole usage fee.
- Wireless Philadelphia would use the above funds to serve the needs of low-income residents by providing personal computers to low-income residents as well as nonprofit organizations,

Table 5: Different Types of Proposed Services and Subscribers

Service Types	Definition	Examples
Residential and Low-Income Fixed and Nomadic Service	Access for a single device, provisioned for primary use at a residence, with access throughout the city. Service features include basic Internet access to support service provider applications such as e-mail and web access.	Residential user with single desktop or single laptop, with support for roaming throughout the city; discounted service for low-income subscribers.
Standard Business Fixed Service	Access for multiple devices, provisioned for primary use at a business location. Service features include basic Internet access to support service provider applications such as e-mail, web access, VPN, etc.	Businesses with less than 20 employees are target customers
Educational Institution Fixed & Nomadic Service	Same as Residential Fixed and Nomadic service	Bulk purchase resident and non-resident student access, with comparable features as Residential Fixed & Nomadic
Premium Business Service	Same as Standard Business service plus optional service provider services such as VPN, firewall, etc.	Businesses with more than 20 employees are target customers
Occasional Use Nomadic Service	Basic Internet access for a daily or weekly fee	Tourists, business travelers
Secure Private Business Portable	Roaming access across city with service features such as VPN & firewall	Business customer employees, field workers
Secure Government Portable	Mobile access by city agency users using mobile computing devices	Inspectors, public safety officers, meter readers, surveyors, etc.
Secure Government Fixed	Fixed access for city agency locations (T-1 like service alternative)	Municipal office locations

Source: *Wireless Philadelphia Request for Proposal (2005).*

Table 6: Subscriber Projections

Subscriber Analysis	Anticipated Subscribers (thousands)				
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Residential & Low-Income	77.9	108.0	117.3	124.3	129.6
Standard Business	0.8	2.1	3.4	4.8	5.3
Premium Business	0.1	0.2	0.3	0.3	0.3
University & Distance Learning Fixed	16.6	18.1	20.0	21.9	22.8
Occasional Use—Nomadic	3.6	3.6	3.6	3.6	3.6
Secure Government Portable	0.3	1.0	1.7	2.4	3.0
Secure Government Fixed	0.1	0.1	0.2	0.2	0.3
Total Subscribers	**99.4**	**132.9**	**146.5**	**157.5**	**162.2**

Source: *Wireless Philadelphia Request for Proposal (2005).*

conducting training programs, providing website development and online marketing assistance to small businesses, and raising awareness.

The above arrangement required no investment from the city, and on the surface seems like a win-win for all. The city created an entity, Wireless Philadelphia, to lead the social consciousness elements of its vision and, with the Earthlink agreement, provided Wireless Philadelphia with the continuing funding and authority to have a chance at realizing this vision. By outsourcing all the key technical, service, and management elements of the project, the city stayed away from activities that are typically outside its scope of expertise. Essentially, what the city government did was to monetize its passive assets such as lampposts and other rights-of-way properties. It had created a new source of income without investing anything.

The agreement generated considerable goodwill in various quarters, including the media. Nevertheless, the agreement still needed to be approved by the Philadelphia City Council. During this time, a couple of high-profile incidents brought attention to MWNs. Hurricane Katrina had laid waste to telecommunications networks in New Orleans, and a makeshift MWN had been created to help workers involved in the relief and rebuilding efforts. This received considerable attention, particularly because the state of Louisiana had banned MWNs, and the local telecommunications providers petitioned to shut down this new MWN. However, relief agencies spoke out strongly in favor of the network because of how much it was helping them do their work. For instance, because of this network, New Orleans city inspectors were able to increase inspections from less than 40 a day to over 500 a day (Jackson, 2006). Private sector telecommunications companies eventually backed down from protesting against the MWN to allow relief work to continue uninterrupted. This incident had a positive effect on public opinion regarding MWNs.

Another incident had a negative impact. The city of Taipei, the capital of Taiwan, had built what was then the largest MWN in the world. However, it was deemed to have failed because of lack of subscriptions. Built with an expectation of hundreds of thousands of potential subscribers, it acquired barely a few thousand in the first few months of operation. The principal reason for its perceived failure was that there were a plethora of Internet access options available before it was built, and over 80 percent of the city already had Internet access connections and was not interested in switching to the MWN. This raised many questions about when and under what conditions it was prudent for a city to build MWNs.

After considerable debate and, according to media reports, pressure from both sides of the fence, the Philadelphia City Council eventually approved the Earthlink deal in March 2006. Work on building the network started immediately afterward. Wireless Philadelphia hired key staff during the spring and summer of 2006, including Greg Goldman as the first permanent CEO. Goldman's background included experience with both the private and nonprofit sectors. His initial focus was to oversee the deployment of the 15-square-mile proof of concept, which was completed by March 2007.

In summer and fall 2006, Goldman worked on creating the relationships and infrastructure needed to market the $9.95 "digital inclusion" accounts. One key element was establishing relationships with existing community and nonprofit groups who could both market the accounts and handle payments. The current status of the project in May 2007 is that the proof of concept deployment was completed and rolled out to subscribers. Citywide implementation is expected by October 2007.

Lessons Learned and Recommendations

The Philadelphia initiative is one of the largest and most ambitious wireless projects in the world, and the city was one of the first to announce and start working on an MWN. Governments have great power to act as catalysts for introducing changes in society. The city government of Philadelphia intervened to accelerate the availability of low-cost, reliable wireless Internet access throughout the city. This may be considered a low-level goal, a means to an end, but there was also a much higher-level goal. The city government's intervention can be framed as the use of technology by government to promote social change and reduce disparity. When any organization attempts to introduce change among its stakeholders, it faces a number of challenges that need to be managed. However, when governments attempt to introduce change, they face more complex challenges related to the socio-politico-economic context.

When the city government of Philadelphia announced its wireless initiative, it faced strong opposition from stakeholders who objected on the grounds that the city was in poor financial condition and that such projects were better addressed by the private sector. Nevertheless, the city was undeterred; it succeeded in acting as a catalyst among various stakeholders and in engaging citizen support to help solve a major public challenge. The city government acted as a catalyst by taking on various roles, such as champion, facilitator, steering committee, policy maker, partner, coordinator, consultant, project manager, referee, regulator, and capacity builder. It removed barriers to resources and provided incentives and a legislative framework to give stability to the new infrastructure. In summary, the Philadelphia case demonstrates that government's role as catalyst can indeed work. However, municipalities will continue to face challenges and barriers similar to the ones faced by Philadelphia. The following discussion of short-term recommendations and longer-term sustainability considerations should prove helpful to municipalities contemplating an MWN.

Short-Term Planning and Implementation Recommendations

1. **A strong champion is required.** From 2004 to about the middle of 2006, the original champion of the project was Dianah Neff, CIO of Philadelphia. Since the summer of 2006, Greg Goldman, CEO of Wireless Philadelphia, has taken on a leadership role. Both Neff and Goldman championed the MWN

Short-Term Planning and Implementation Recommendations

1. A strong champion is required.
2. Diverse stakeholder interests must be managed.
3. Private and public interests will need to be balanced.
4. The "application" of the municipal wireless network must be identified.

Long-Term Sustainability Considerations

1. The digital divide is a tenable justification over the short term but faces long-term challenges.
2. Municipal wireless networks need insulation from unpredictable, large-scale external forces.
3. The technology of municipal wireless networks will change.

in the media and in the community, and when it was needed they mounted a vigorous defense of the project. They had to work extremely hard to rationalize competing visions and maintain public interest, while simultaneously staying current with technological developments. The champion of a project of this nature is subject to a large number of external and internal forces and competing claims; the champion must handle pressure from different constituents while remaining conscious of the socio-political context and complexity.

2. **Diverse stakeholder interests must be managed.** The city government had to manage the demands and challenges of different stakeholders, including telecommunications companies, civic leaders, community groups, the media, the state government, city politicians, and the public. For instance, when both Verizon and state legislators appeared to be against MWNs, the city government coordinated a solution whereby Philadelphia could be excluded from anti-MWN legislation. To put pressure on them to exclude Philadelphia, the city government facilitated communications by various activist groups and NGOs to communicate the message that the digital divide problem in Philadelphia could not be addressed solely through private sector efforts.

   From a different perspective, to unite Philadelphians around the project, the city tapped into their civic pride and nostalgia about the city's past greatness. It told different stakeholder groups what they wanted and needed to hear. When dealing with corporate leaders it emphasized how the MWN would enhance the city's image, whereas when dealing with community groups it emphasized how it would address the digital divide. To further increase community support, the project leaders started discussions with the powerful Philadelphia school district about how the network could address various problems facing the district. Earlier, the city had partnered with area universities to generate the business plan. In this way, the effort became a credible public-private partnership, with representatives of government, the private sector, and academia involved with evaluation and generation of the project plan.

   The leaders of future projects will need to play different roles and wear multiple hats to respond to the demands and challenges from extremely diverse and often powerful stakeholders. Even though Philadelphia was able to manage its diverse stakeholders, some costs were involved. The time taken for approval was very long, and there were some stipulations that may prove difficult to implement. For example, according to the agreement with the city, Wireless Philadelphia should also "improve parental involvement in student education."

3. **Private and public interests will need to be balanced.** With planning and creative thinking it is possible to create structures that can optimize the interests of both the public and private sectors. In Philadelphia, a nonprofit organization (Wireless Philadelphia) will lead the social consciousness goals of the project, while a large, well-known for-profit organization (Earthlink) will lead the technical and management aspects of the project.

   By creating a nonprofit with the mission to lead the digital divide elements of the city's vision—and by providing the nonprofit with the authority and sustainable funding to take action—Philadelphia seems to have at least, in the short term, created a viable structure for realizing its social consciousness goals. By partnering with Earthlink to build the network, the city has avoided involvement in activities where it had little experience and credibility. It has also, to some extent, made moot the philosophical and political challenges to the role of government in building MWNs.

   In addition, by currently working actively with local small businesses to deliver other services such as training and website development to the community, the city is creating a sense of opportunity for the private sector. However, it is still too early to say if the optimization of public and private interests in Philadelphia is sustainable. For example, if the expected higher-paying retail customers do not materialize in the long term, it would not be unusual for a for-profit firm such as Earthlink to try and restructure the agreement or back out completely.

4. **The "application" of the municipal wireless network must be identified.**
   A question that has been asked of MWNs is, "If you build them, will they come?" Setting up the infrastructure will not guarantee success, and enabling access is not synonymous with adoption or an effective application. In Philadelphia, the decision was to focus on Internet access as the main "application"; other cities have focused on more tangible applications such as wireless meter reading. Yet even with simple Internet access, Philadelphia will face challenges in ensuring adoption and effective use. The current efforts of Wireless Philadelphia to connect with and use existing community groups to distribute the $9.95 digital inclusion accounts is one positive first step to ensure adoption.

   Taipei's experience shows that MWNs may be unadvisable when (1) a population has a plethora of pre-existing Internet access options, (2) there are no efforts to identify and provide ongoing support to specific constituents, and (3) there are no specific compelling applications. As Internet access becomes more and more easily available, newer MWN projects will likely face a higher bar for success and will need to include formal social programs such as training or tangible cost-effective applications such as wireless meter reading to ensure adoption and eventual success.

Long-Term Sustainability Considerations

1. **The digital divide is a tenable justification over the short term but faces long-term challenges.**
   The principal method by which Philadelphia was able to minimize opposition to the MWN project was by calling attention to Philadelphia's considerable digital divide. This indicates that government involvement with MWNs may not be advisable in the absence of a compelling social rationale. The existence of such a rationale gives government the moral confidence to pursue radical measures and encourages stakeholders to support these measures. However, the danger is that projects based on the digital divide may not be able to deliver measurable success.

   The digital divide cannot be resolved overnight. Digital divides arise from deep-seated socioeconomic causes related to education, income, culture, and attitude toward technology. Simply providing low-cost access to the Internet is not going to make much of a difference in the short term. However, this is a "chicken and egg" argument, and this criticism can be countered with an analogy. Take the case of a village in the developing world that has no access to electricity. Providing this village access to electricity will not transform its economy overnight. However, it does lay the basic foundation to enable it to exploit this resource in the future. Moreover, without electricity, it has no hope of competing and participating in the global economy.

   Similarly, ubiquitous Internet access will not transform a digitally divided city, such as Philadelphia, overnight. Nevertheless, it will lay a foundation that may enable the city to make strides toward eliminating the digital divide. Even if projects like Wireless Philadelphia are successful in providing low-cost Internet access and even if they follow up with training, low-cost or free computers, and community support and involvement, it will still take a long time to show discernable change. This problem is further exacerbated because there are no reliable measures for gauging the true social and economic impacts of MWNs.

2. **Municipal wireless networks need insulation from unpredictable, large-scale external forces.**
   MWN projects are subject to unpredictable and large-scale social and political forces. For instance, in the U.S., most projects are vulnerable to the four-year election cycle. If the process of building an MWN is currently under way, and new community leadership is elected, there is no telling how the new leadership may choose to act with regard to the MWN.

   Similarly, a country's or region's political environment can have a significant impact on attitudes toward MWNs. What is acceptable at the community level may not be so at the state or national level. For instance, 10 MWN projects in the Netherlands were investigated by European Union commissioners for receiving "illegal state

subsidies" (Taaffe et al., 2005). In Philadelphia, the insulation from external forces was partly achieved by creating Wireless Philadelphia as a nonprofit that has its own funding source and management and is separate but yet accountable to the city. However, per its management agreement with the city, Wireless Philadelphia still has to submit its budget to the city for approval and comment.

3. **The technology of municipal wireless networks will change.**
   A recent new development, called Broadband over Power Lines (BPL), allows Internet access to be supplied via power connections. Because buildings are typically already wired for power, this technology could remove the cost advantages of deploying wireless networks. In addition, approximately 90 percent of the telephone lines in the U.S. are currently DSL capable (Hearn, 2006). DSL prices are falling rapidly, with a connection currently available at around $15 per month. Lower-income consumers are typically more price conscious, and if the cost of DSL falls below the cost of wireless connectivity, consumers will likely go with the cheaper solution. A change in technology does not necessarily remove the underlying rationale for MWNs. Future projects will need to plan around such developments and create structures that are focused on the underlying need of the municipality rather than the capabilities of the specific technology. It is unclear if the structures created in Philadelphia would survive a change in technology and if Wi-Fi-based wireless technologies will be in use 10 years from today.

Final Reflections

In this final section, we reflect on three basic questions: Was the wireless project in Philadelphia a good idea? Did Philadelphia do a good job? Should other cities consider similar projects?

The answer to all three questions is yes. The project was a good idea for the city because the digital divide issue is real, the technology is feasible and cost-effective, and the private sector was not moving fast enough. The project also seems to have improved the image and civic pride of the city. We expect that the imperatives in other municipalities will be different given different geographic, demographic, political, and historical contexts. Overall, the city did do a good job in getting the project approved and implemented.

The digital divide perspective was the right perspective for Philadelphia and, to its credit, the project has remained true to that original orientation. However, the project took much longer than expected to start implementation. We expect planning and implementation to go much faster in other municipalities.

Finally, we strongly believe that other municipalities should consider similar projects. The time is right, the technology works, and even though the issues that Philadelphia faced will be different for other cities, the possibility for meaningful social and economic impact remains.

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ABOUT THE AUTHORS


Abhijit Jain


Munir Mandviwalla

Abhijit Jain is an Assistant Professor at the Cisler College of Business, Northern Michigan University. His teaching interests include strategy, human-computer interaction, e-commerce, database analysis and design, and enterprise systems. He has written papers on various subjects including e-government and municipal wireless networks.

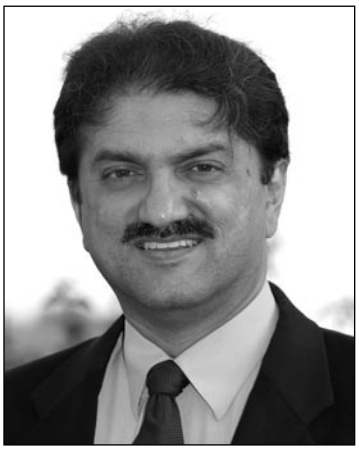
Dr. Jain received a bachelor of science degree from Nagpur University, India, concentrating in computer science; an MBA from the University of Delhi, India; and a Ph.D. from Temple University, concentrating in business administration. For two years during his Ph.D. at Temple University, he was appointed a University Fellow, which conferred the highest research grant accorded to Ph.D. students there.

Munir Mandviwalla is Associate Professor, founding chair of the Management Information Systems Department, and Executive Director of the Irwin L. Gross Institute for Business and Information Technology, Fox School of Business, Temple University. Dr. Mandviwalla's current research interests include communication technologies, globalization, and the use of prototyping for theory development. His teaching focuses on information systems management.

Dr. Mandviwalla has published more than 40 articles in scholarly journals and international conferences including *Management Information Systems Quarterly, ACM Transactions on Computer Human Interaction, Journal of Organizational Computing and Electronic Commerce, Decision Support Systems,* and *Information Systems Journal*. He is also on the editorial board of several international journals and served as the program chair of an international conference on the information technology workforce.

His work has been supported by grants totaling approximately $2 million from the National Science Foundation (NSF), Bell Atlantic, IBM, Microsoft Corporation, CIGNA Corporation, Advanta Corporation, Lotus Development Corporation, and Lilly Endowment, Inc. In 2000, IBM selected him for their Faculty Partnership Award in recognition of contributions to e-business teaching and research. In 2002, the Claremont Graduate University recognized him with its Alumni Hall of Fame award.

Dr. Mandviwalla holds a bachelor of science in systems engineering from Boston University, an MBA from the Peter F. Drucker School of Management at Claremont Graduate University, and a Ph.D. in management information systems from the Programs in Information Science at Claremont Graduate University.


Rajiv D. Banker

Rajiv D. Banker is the Merves Chair and Director of the Center for Accounting and Information Technology at the Fox School of Business, Temple University. Previously, Dr. Banker served as the Anderson Chair and Dean at the Anderson School of Management at the University of California, Riverside. He also held distinguished professorial and endowed chair positions at the University of Texas at Dallas, Carnegie Mellon University, and the University of Minnesota.

Dr. Banker is internationally recognized as a leader in interdisciplinary research in management. He has received numerous awards for his research, including awards for Notable Contribution to the Management Accounting Literature and Notable Contribution to the Governmental Accounting Literature by the American Accounting Association, and best paper awards at international conferences in information systems and in accounting. He has published more than 100 articles in prestigious research journals including *Management Science, Accounting Review, Journal of Accounting and Economics, Journal of Accounting Research, Operations Research, Manufacturing & Service Operations Management, MIS Quarterly, Information Systems Research, Communications of ACM, IEEE Transactions in Software Engineering, Academy of Management Journal, Strategic Management Journal,* and *Econometrica*.

His research articles are cited over 100 times each year by other researchers in a wide range of disciplines. One of his papers is ranked fourth highest in citations in the 50-year history of *Management Science*. He is recognized by the Institute for Scientific Information *(Web of Science)* as one of only 243 most highly cited researchers in economics and business worldwide that have made fundamental contributions to the advancement of science and technology.

Dr. Banker's research interests range from analytical modeling to statistical analysis of data collected from different companies to address complex or emerging problems of importance to managers. His research on information systems explores issues of e-business competitive strategy, investments in information technology, software productivity and quality metrics, and management of software development and maintenance. His research in accounting addresses questions pertaining to performance measurement, incentive compensation, strategic cost management, and public accounting industry analysis. His research in management science includes the development of new analytical methods for productivity and efficiency evaluation. His research has been supported by the National Science Foundation, the Financial Executives Research Foundation, the Institute of Management Accountants, and several leading corporations.

Dr. Banker has supervised many doctoral students placed at prestigious research universities. Six of his doctoral students have won awards for best dissertations and three others have received runner-up awards. He has been the recipient of three teaching awards voted by graduate and undergraduate students.

Dr. Banker received a bachelor of science degree with highest honors from the University of Bombay, concentrating in mathematics and economics. He received a doctorate in business administration from Harvard University, concentrating in planning and control systems.

KEY CONTACT INFORMATION

To contact the authors:

Abhijit Jain
Assistant Professor
Cisler College of Business
Northern Michigan University
305 Cohodas Hall
Marquette, MI 49855
(906) 227-2707

e-mail: ajain@nmu.edu

Munir Mandviwalla
Chair and Associate Professor
Executive Director, Irwin L. Gross Institute
for Business and Information Technology
Fox School of Business
Temple University
210 Speakman Hall
1810 North 13th Street
Philadelphia, PA 19122-6083
(215) 204-8172

e-mail: Munir.Mandviwalla@temple.edu

Rajiv D. Banker
Merves Chair in Accounting and
Information Technology
Fox School of Business
Temple University
210 Speakman Hall
1810 North 13th Street
Philadelphia, PA 19122-6083
(215) 204-2029

e-mail: banker@temple.edu

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For additional information, contact:
Jonathan D. Breul
Executive Director
IBM Center for The Business of Government
1301 K Street, NW
Fourth Floor, West Tower
Washington, DC 20005
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