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Municipal Wireless: A Primer for Public Discussion

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MUNICIPAL WIRELESS:

A PRIMER FOR PUBLIC DISCUSSION

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The Debate Over Municipal Wireless

In recent months, numerous municipalities around the United States have publicly announced plans for the implementation of wireless broadband networks. As of March 2005, Muniwireless.com reported there were 42 deployed networks and hot-zones in the U.S., with another nine that have been announced or in deployment (Vos, *Report* 12). By my own count there have been at least a dozen additional new projects announced in the intervening four months, including the announcement that Philadelphia, PA will create its own network (*Wireless Philadelphia).*

Municipal wireless technology itself is new and complex, as are the social and financial issues surrounding the deployment of such networks. Unfortunately much of the public debate over these networks has occurred against a backdrop of public ignorance over their actual costs, abilities, benefits, and drawbacks. The purpose of this paper then, is not to further complicate this already contentious debate, but to provide a common backdrop of information in support of public debate of these issues.

Like the flame that draws forth the moth, the promise of community enrichment offered by wireless broadband networks has emboldened more than 42 communities and municipalities in the United States to bravely make the leap. Unlike the moth, it is not at all clear that anyone is getting burned by municipal wireless. In 2004 the President himself said, "We ought to have…universal, affordable, access for broadband technology by 2007, and then we ought to make sure as soon as possible thereafter, consumers have

got plenty of choices when it comes to [their] broadband carrier"(*Promoting Innovation and Competitiveness*).

Though the United States was one of the first countries to introduce commercial and residential broadband services by wire in the 1990's, and despite having 37 million broadband subscribers, the U.S. is ranked twelfth among industrialized nations with 12.8% of residents having broadband access. South Korea is at the top with nearly 25%, followed by the Netherlands, Denmark, Iceland, Canada, Switzerland, Belgium, Japan, Finland, Norway, and Sweden (OCED). Why has the United Stated fallen behind, when both of the last two White House administrations have cited broadband access as a national priority, vital to maintaining educational and technological competitiveness? Proponents of community and municipal wireless will say that existing broadband markets lack competition, that many U.S. markets are serviced by a single provider, and that even markets with multiple providers tend to be dominated by a single incumbent carrier (Feld, 3). To make matters worse, the same telecom companies have turned down proposals for projects to bring broadband to some rural and isolated communities, citing prohibitive Last mile (see below) costs.

In urban settings, it is argued that subscribers fees in excess of $35-$50/month have kept lower income families out of the market. Specific market research to support or contradict this contention, however, does not exist in the public domain. Since the federal deregulation of telecom companies in the 1990's, telecoms and incumbent ISP's have stopped publicly distributing information on demographics, though this information

is obviously still being collected and used internally. A few private, market-research entities like the Scarborough Research division of Arbitron have this information for sale by region (Arbitron).

In most cases these communities have been forced to reinvent the wheel in developing their implementation plans and networks. Missions, business models, deployment models, deployment scales, and the technologies for creating wireless networks are almost as diverse as the projects themselves, and innovations and experiments in each of these aspects of development occur on a monthly, if not weekly, basis.

Because of the newness of these projects, little public data exists as to the financial success or failure of the various approaches being tried. This dearth of concrete financial data is part of the reason the debate is ongoing. Both proponents and opponents have continued to make claims about the success and failure of various ventures, more often citing anecdotal or incomplete financial data. Proponents of some ventures have, for example, attempted to list advertising in their business models as a primary revenue stream, whereas few experts in either the ISP or wireless technology fields believe that is a reasonable expectation (Robinson).

Though there is great diversity and continuing innovation in municipal networks, a number of distinct technological and economic approaches have emerged that are common to virtually all municipal and community deployments. This paper will consider each major aspect of municipal wireless deployment in terms of how communities make

decisions about each of these elements. We will look first at some of the critical terms and technologies involved in this discussion, as well as the various concrete applications and benefits that wireless networks have to offer. We will then consider the various organizational and managerial approaches that have been implemented. Finally we will talk about the kinds of missions that are being taken on by groups running these networks.

The What and Why of WiFi

(The Language and Technology of Wireless Networks)

Wireless, WLAN, and Last Mile

While wireless network communication has existed for nearly 35 years, beginning as an experiment by the University of Hawaii in 1971 (Wikipedia *Alohanet*), the current set of standards known as 802.11 b & g (commonly called WiFi) have only arrived on the scene in the last five years. Wireless Local Area Networking, or WLAN, was originally conceived as part of a 'last mile" measure. If one imagines a data network as a circulatory system, bringing data to and from end users back to central line, the last links in that network, its "capillaries" so to speak, are the connections between the end user's computer and the network itself. Those connections are collectively called the "last mile," and just as a circulatory system has innumerable capillaries, so a data network may have innumerable last mile segments. In a data network the last mile segment is often its most expensive segment because of the large number of individual connections. WLAN was conceived to reduce the cost of the last mile, by eliminating the actual data wires and replacing them with a wireless connection instead.

Broadband

If you are confused by the term "Broadband," it's not you; it ***is*** confusing. Originally broadband was an engineering term referring "to data transmission where multiple pieces of data are sent simultaneously to increase the effective rate of transmission . . . where

two or more signals share a medium" (Wikipedia *Broadband*). In common usage, however, broadband is used to refer to data exchange speeds of anywhere to 256kbps (kilobits per-second) to 1.5 to 2mbps (mega bits per-second).

For the last ten years most residential broadband connections, like the Road Runner service from Time Warner, have been faster than what most applications would demand. In the last three years that has begun to change. The movement and sharing of audio and more recently, video files, has created a group of applications that is bandwidth hungry. Currently WiFi data transfer speeds are far in excess of the broadband speeds that most people can afford. My Road Runner connection provided by Time Warner (Rochester, NY) has a specified download speed of 5mbps. WiFi-b (802.11b) operates at 11mbps. And WiFi-g (802.11g) operates at 54mbps. WiMAX is likely to be around 70mbps.

WiFi

WiFi is a communication standard for residential and business WLAN's. The 802.11b and 802.11g standards, collectively known as WiFi, use the unlicensed and unregulated 2.4-gigahertz (GHz) band, along with "microwave ovens, cordless phones, and other appliances" (Wikipedia, *WiFi*). Working at an optimal range of less than 50 yards, WiFi was conceived not as a last mile measure at all but as way of eliminating hardwired Ethernet connections in business and residential networks ***indoors***.

Because WiFi technology works on an *unlicensed* radio frequency, however, people began to hack the various WiFi based consumer devices, especially routers, almost as

soon as they appeared on the market. One group in Boston hacked two Apple Airport routers to increase their range and create the Newbury Open Net, one of that city's first and most popular WiFi hotspots (Oh, *Boston WiFi Summit*).

Hotspots and WiFi Networks

The term "hotspot" or "hotzone" usually refers to a physical region, either indoors or outdoors or both, typically being serviced by a lone WiFi transceiver, providing broadband access to the Internet. Most commonly, the term implies that the access is provided is free of charge. If you set up a wireless router at home and do not secure it with a password or encryption, you have technically created a hotspot. Anyone in range of the signal of your wireless router, which unmodified is probably about a 150 yards, is in a hotspot you have created.

Community Wireless

The term "community wireless" is used interchangeably to describe both a business model and a form of wireless network deployment. Some cities have created programs to recruit businesses and community organizations to install their own hotspots, thereby creating an ad-hoc network of sorts. These are generally called WiFi networks or sometimes community wireless networks. Each node is privately owned by the sponsoring business or community organization, and each node has its own backhaul connection. A "backhaul" connection is where the wireless network is physically wired to Internet. If each node has a backhaul, it means that each node owner has to pay the cost of maintaining that connection. The municipality only has to promote the network to

the public, and recruit and assists sponsors with technical assistance and software support. Sponsors advertise "free" on the network—though as sponsors they must pay for all of the costs of their router-node. The public gets free access. Most, though not all, WiFi networks use a standard hardware set, but only some have networking software that offers any degree of interoperability between different nodes--i.e. the ability to move within the network without having to log in again and again as one moves from one wireless router to another. Buffalo, New York; Athens, Georgia; and Austin, Texas have all instigated wireless networks using this model. Sometimes these deployments are referred to as *wireless clouds.*

Mesh Networks

The hacking—altering a technology to serve a purpose beyond its initial intended use—of WiFi has not merely been limited to end users with WiFi routers. A number of WLAN equipment manufacturers (TROPOS, Camvera, Alvarion) have appeared on the scene in the last five years with an extension of wireless technology which permits the creation of extremely large networks (city-wide, county-wide or larger!) based on the same 802.11b & g standards. Called "mesh networks," these deployments use light-pole-mounted, wireless routers/repeaters, or "nodes." Wireless node transceivers are more powerful than standard residential wireless routers, and have an effective range of about 300 yards. TROPOS nodes have a RF (Radio Frequency) output of three watts; not much, but still 15 times the power output of a residential wireless router. Individual nodes exchange data between each other and are managed by software, such that only one router in ten or fifteen needs to have a "backhaul" connection, i.e. to be hardwired directly to the

Internet. Mesh networks therefore are like grids of "wireless stepping stones" which allow anyone within their coverage area to have broadband Internet access using the same 802.11a & g card in their computer that allows them to connect wirelessly at home.

Mesh networks have the added advantage of being extremely robust—far more so than most WiFi networks. Individual nodes in the network can be taken down without bringing down the entire network or even significantly reducing coverage (*Community Wireless Networks*). If a router supporting a hotspot, or within most community wireless networks, goes down, service is lost within that area that router serves. Furthermore, the advent of mesh networks has really transformed WiFi into a last mile technology—a role which was to be fulfilled first by the upcoming WiMAX technological standard.

It should be noted that at present, mesh networks represent the current technology of choice for large-scale deployments. Besides the above-mentioned advantages they are very quick and easy to deploy. A single bucket truck can install a single TROPOS node on a light post in a half hour. The same truck can then deploy enough nodes to cover an urban square mile in one to two days, installing the recommended 16-22 nodes (Robinson). If backhaul connections are available for the requisite number of nodes in the deployment, the network can begin service immediately. Similarly brief install times are cited for equipment manufacturers, Alvarion and Camvera. This ease of installation makes mesh networks the technology of choice for municipal (only) use, public-use and joint-use networks.

EVDO

Though dialup-speed wireless data networks have been available for law enforcement for more than a decade, recently Verizon Wireless has rolled out a broadband wireless service for the public in 50 markets around the United States. The service is currently priced at a personal monthly subscription rate of $80 and a startup fee for equipment of $80 to $200 depending on the equipment purchased. Verizon's data network is built as an addition to their existing cellular network, and makes use of their tower infrastructure. Called EVDO, which stands for "Evolution Data Only," this proprietary standard works at the 1.25 MHz frequency and operates at nominal broadband speeds of 500kbps, with a burst capability of 2mbps. The range of the system is about 15 miles, and Verizon has local coverage over most of Monroe County and along the NYS Thruway to Syracuse. Subscribers also have the ability to roam to any of the 50 markets where the program is operating and when not within one of those markets, can have data access at lower speeds whenever they are in range of a Verizon cellular tower.

WiMAX

WiMAX, which stands for "Worldwide Interoperability for Microwave Access," or 802.16, refers to a new set of wireless standards currently awaiting certification, which will allow faster (than WiFi) broadband communication over a range of 12+ miles. Claims about the actual effective range of WiMAX have varied widely from a low of seven to as many as 50 miles. The finished set of standards, which will allow

manufacturers to begin designing products to use them, were originally slated to be certified this past spring, are now scheduled for release in December of this year (2005).

One other difference between WiMAX and WiFi is that WiMAX may operate at least partially within licensed radio spectra. IEEE 802.16, specifies that WiMAX will operate in the 10 to 66 GHz range. The added specification 802.16a broadens WiMAX to access to the 2 to 11 GHz range (Wikipedia, *WiMAX)*. Some of the frequencies in those ranges are licensed, though most are not. Thus it is unclear how the technology's deployment will be managed. If it operates in licensed frequencies, it will presumably have to be managed geographically by the FCC issuing licenses, in much the same manner as television and radio stations are.

Some of the vendors currently involved in developing the technology standards for WiMAX have already begun to develop and install backhaul connections, which incorporate what they expect to be elements of the finished WiMAX standards (Robinson). WiMAX's long range of many miles and its high data rate makes it an ideal technology for creating wireless backhaul connections for WiFi networks. A WiFi network supported with WiMAX backhauls, instead of wired connections, might represent a significant savings in some applications.

When will WiMAX replace WiFi? It is as yet unclear whether it ever will. Although initially touted as a consumer technology like WiFi, it is yet unclear if WiMAX will become one, or instead evolve into a network support technology. Certainly, upcoming

applications, like streaming high definition video, will demand the kind of bandwidth that WiMAX can provide, but is WiMAX likely to take off without such applications? It took nearly four years from WiFi's introduction for the technology to be included in 100 percent of new computers, as it is this year (Robinson). We are probably at least that far away from seeing WiMAX becoming an ubiquitous component in new computers.

Why Are Cities Building Wireless Networks?

In “Wireless Broadband: The Foundation for Digital Cities,” Matt Stone writes, ”Visionary leaders at the local level are using wireless broadband to bridge the digital divide, strengthen economic development, and reduce the cost of government.” Cities are also using these networks to maintain a competitive profile with other municipalities, and to significantly improve the level of services provided to the public, primarily through improved data and communication services in support of police and firefighting efforts.

Municipal-Use vs. Public-Use

One of the first distinctions to be made between different types of deployments is whether the network is to be used exclusively by city employees—a municipal-use network, or whether the network is to also be open for use by residents—a public-use network. In a municipal-use network the total cost is borne by the city government, which may use grants, taxes, bond issues, or a combination of these sources to pay for it. Public-use networks may be funded in a variety of ways, through taxes, grants, bond issues, subscribers, or through support from coalitions of local businesses or community organizations. Some wireless deployments begin as municipal-use, and later expand to include public-use. Chaska, Minnesota used this strategy, which allowed the city to work out the kinks of its network management internally, before offering service to the general public (Robinson). Other cities, such as Corpus Christi, Texas, deployed a public-use

network at the outset, but only over a small "pilot" region of a dozen city blocks, in order to assess the viability of a larger, citywide deployment (*Call for Partnerships*, City of Corpus Christi).

Much of the dialogue about wireless networks has focused on the more superfluous benefits of having ubiquitous wireless access--that people can access the Web from a public park, or while waiting for a bus with a PDA. Such applications are incidental to primary use applications that are likely to drive and sustain a citywide network. With few exceptions, no single application is likely to be enough to justify building a network, but a wireless network fulfilling a set of political objectives, particularly bipartisan ones, can. Not surprisingly, Manhattan is building its municipal-use network on the basis of public safety and anti-terrorism (Brewin). Most cities have to match their own social and political needs with what is available on the WiFi menu, then craft a political strategy that reflects both local need and imperatives and realistic technological applications to be provided through the network. The first question then is, what's on the wireless menu? What kinds of applications can wireless networks provide?

Costs of, and Revenue from, Wireless Networks

One of the primary benefits that a wireless network can provide a city is revenue. Fee-based, public-use networks need not operate at a loss at all. Whether a city derives its fee income from wholesale ISP's--i. e. reselling wireless bandwidth to Internet Service Providers who manage individual retail and commercial accounts, or whether the city collects directly from end users—it seems feasible that user fees alone could pay for the

cost of building and operating a network, ***and still offer significantly reduced rates to the public***. A recent Jupiter Research report indicated, "the average cost of building and maintaining a municipal wireless network is $150,000 per square mile over five years." Figuring that the total average monthly cost of the network is $2,500/sq. mile, one can see that a mere 100 residential subscribers per sq. mile paying $25/month would meet the break-even point for the network.

Using currently available technologies, deployment figures for mesh networks in residential areas are likewise very reasonable. One of the largest equipment manufacturers, TROPOS, charges about $3,000 per router/node. 16 to 22 nodes are needed to cover a square mile. A utility bucket truck can install these, with backhaul connections, in two days at an additional cost of $5,000. Therefore, the deployment equipment costs range from $53,000-$71,000 per square mile.

A notable exception to this model occurs in urban areas where buildings commonly exceed heights of 60 feet. Above this height, interference from other RF sources, severely hampers WiFi data communication. Many more routers—even multiple routers per building—would be needed to service these structures, increasing the cost dramatically. Figures as high as 400 million to a billion dollars have been tossed out as estimates for high-rise cities like Manhattan.

As has been mentioned, advertising can and does provide an income stream in many wireless business plans, in the form of fees for splash pages, pop-ups, and referral and

linking fees from other sites and for web commerce. Although a few municipalities are trying to use advertising as a primary revenue source--Hermosa Beach, California for example--no accepted business model yet exists to justify this strategy (Burrell).

Applications and Benefits of Wireless Networks

As previously mentioned, many of the discussions around the benefits of wireless networks fail to nail down concrete applications of the kind that would justify a large-scale municipal deployment. What follows is a list of existing wireless applications and brief descriptions of each, segregated into two categories: municipal-use and public-use. It should also be noted that *all* of the municipal-use applications and many of the public-use applications would require a mesh network deployment in order to be practical.

Wireless Municipal-Use Applications

Police/Public Safety/National Security - Video

Mesh networks can and do provide police support in a variety of ways. Remote video monitoring stations can be quickly deployed and stationed either permanently or on mobile units. Data transmission from cameras occurs wirelessly through the network. Manufacturers like Axis Communications have been producing network-based video monitoring equipment for more than a decade. Video monitoring for traffic management can also be enhanced through lowered per-camera deployments costs, because the formerly wired, last mile connection is eliminated. The recent terrorist subway bombings in London have demonstrated the utility of police video monitoring of public spaces for identifying suspects (Stecklow); though the long-term effects of monitoring on rates of theft and violent crime is still in debate.

Mobile video cameras with onboard recording used in traffic stops and arrests have already demonstrated their usefulness in providing evidence against wrongful arrest and police abuse cases. Within a municipal wireless network, police vehicles can be equipped with live feed video equipment to monitor street officer activities and aid dispatchers and CO's in assessing risk situations.

Voice Communication

Currently most local and municipal police communications operate on proprietary and expensive analog "push to talk" radio networks developed in the 1940's and 50's. These

networks are expensive to build, operate, and maintain. Transitioning police communication to a wireless mesh network has a number of advantages. VOIP (Voice Over Internet Protocol) technology permits the Internet as well as wireless networks to carry spoken, telephone-style conversation with dramatically increased privacy and security. Mobile phones equipped with VOIP capable of operating on wireless networks have been available for the past year. Moving police communication onto these systems would eliminate the ability of the curious public and criminals to monitor police and fire operations via RF scanners. Police communications on the network would be encoded using WEP standards, which while not unbreakable, are far more secure than analog transmissions, and if need be, more robust encryption is also easily available.

Data Communication

But this is only the beginning. Ubiquitous broadband data and video transmission are also available through the network, and would not require proprietary equipment such as is currently needed for existing law enforcement data networks types like CDPD, 1XRTT, or GPRS, which also operate at dial-up speeds. Municipal wireless networks leave law enforcement agencies free to purchase appropriate laptop and palmtop devices equipped with 802.11b & g—any of which could access the network. A number of companies have integrated communication software packages to manage secure broadband wireless voice, video, and data communication for law enforcement and emergency personnel in the field. NIST, The National Institute of Standards and Technology, maintains a list of Public Safety Wireless Technology links on its webpage.

Washingtontechnology.com is another website specifically dedicated to developments in integrated government systems technology.

It should be noted that within public-use networks, police and emergency communications considered urgent can be flagged to get best use of the network, and to take priority over other data flowing over the network (Robinson). This is to insure speed and reliability in this vital communication.

Municipal-use law enforcement wireless applications can also be significant generators of revenue. A pilot municipal-use wireless project in Queens, New York, armed 1500 police with automated ticket issuing machines. In the pilot region the ticket writing error rate was 39%; this rate dropped to one percent under the program. It is estimated that if implemented citywide, the program would add more than $40 million annually by closing the gap of uncollected tickets due to handwriting errors. This application alone could pay for a citywide deployment in Queens. In 2003 New York City's Finance Department reported revenue of $429 million in parking fines (Koprowski). The Queens, NY project applies only to parking fines; certainly the same type of system could also be applied to the issuance of moving violations as well.

Lastly, regarding tickets, a handful of manufacturers are producing equipment to automate parking meters, so that drivers can pay their meter via credit card, the funds going directly into the city's coffers. City staff need no longer collect change from meters, and "meter maids" need no longer wander routes searching for expired meters, as

new wireless meters can automatically call for attendants themselves when a car runs over time. The City of Houston, Texas is currently implementing this scheme (Silverman). Other systems use video surveillance and vehicle tracking software to notify attendants when violations have occurred (Parking Eye).

Fire & Emergency Services

Fire and emergency response departments can benefit from many of the same measures taken for police, including the elimination and replacement of 'pushto talk" networks by VOIP. On-site data entry and retrieval can make vital information available to firefighting personnel, including access to CAD files of city buildings, schematics of municipal power, water and sewer lines, and databases of hazardous materials stored on-site. Mobile, truck-mounted video monitors can be used to provide the same kind of command and control information feedback that police would enjoy.

Utilities

City utilities, whether municipally owned or not, can benefit from ubiquitous wireless through the automation of gas, water, and electric meter reading, through the installation of 802.11 based wireless transceivers. Installation of these devices is limited only by the availability of power sources at the meter, and this too may shortly change. These devices would eliminate the need for people to read meters on foot. For municipally owned utilities, the savings through manpower reduction would go directly to the city. For privately owned utilities, the city could collect a fee from the utilities for use of the network in this manner.

Telemedicine

While we may not think of the cost of health care and emergency medicine as a cost borne by municipalities, certainly persons with Medicare, Medicaid, and other state-assisted health insurance, as well as the uninsured, place a burden on local health systems, much of which ends up being supported or supplemented with city and county funds. Although telemedicine has been in operation in some rural areas around the country for more than a decade, it had not been attempted in an urban setting until recently.

Telemedicine is the performance of remote medical diagnosis. It uses an on-site, trained facilitator, equipped with digital medical diagnostic equipment, and a broadband video and data connection, paired with a service-providing physician at an area hospital. Rochester, New York's Strong Hospital has been home to a pilot telemedicine project since 2001. This pilot project has demonstrated that telemedicine stations placed at daycare centers can vastly reduce the number of ER visits for children and consequently reduce rates of workplace absenteeism amongst parents and caretakers—without any reduction in quality of care (Shein, 5). The distribution of telemedicine access stations to schools, community centers, nursing homes, and managed-care facilities would dramatically reduce city-wide health care costs, improve health access to low-income families, and provide both relief and infrastructure support to overburdened emergency medicine departments. Currently it costs about $30,000 to equip a telemedicine station, but this price is dropping annually and will certainly continue to drop as more are sold

and installed. Since this is a relatively new application of this technology, any city taking advantage of it would most certainly enjoy increased national visibility as a result.

City Government

City government itself can see operating cost reductions from a wireless network, through the elimination/replacement of existing Ethernet networks and the consolidation of Internet access backhauls. For additional savings, a municipal government's phone access could be entirely replaced by a wireless network-based VOIP system such as has been discussed for police and emergency. City employees, such as building, health, and safety inspectors could dramatically increase productivity by filing reports digitally at the inspection sites themselves, rather than collecting information on paper forms and processing them back at the office.

Education

Finally, municipal education systems can benefit from wireless networks through the reduction or elimination of existing Ethernet networks and the elimination of onsite backhauls and ISP subscription fees, all while providing low- or no-cost access to city students both at school and at home. Expanded service can be made available to city students by offering free or reduced access to the network to enrolled students. Such applications of a wireless network would obviously go a long way towards addressing digital divide issues. Numerous grant opportunities also exist to provide training and hardware to economically disadvantaged end users.

One example of the numerous programs specifically designed to address digital divide issues is the Madison Park Development Corporation, a nonprofit community service organization in Roxbury, Massachusetts, which has built a community wireless network and is using grant funds to train and equip families to use the broadband access the network provides (*Technology Goes Home*).

All of the previous applications of municipal wireless networks, particularly mesh networks, are municipal-use applications, but a large number of tangible applications and benefits accrue to public-use networks as well. We will look first at the specific applications and then at some of the touted benefits of public-use networks.

Applications of Public-Use Networks

Concrete and specific applications of a public-use network include, city brand promotion, VOIP, outdoor access, mobile access, roaming access, emergency/crime reporting public access kiosks, and calendar event kiosks. There are likely to be a lot more, as increasing numbers of networks are deployed and cities find new uses for their networks, but this is a short list of currently available and tried applications.

Splash Pages & Branding

With a wireless network, municipalities have a unique opportunity for promoting their own brand. This is largely accomplished through a splash page, which is first thing that a user accessing the network will see. Every user accessing the network will see the splash page each time he or she goes to log in. The page will give new users a chance to purchase access or register for access, and is commonly used to promote whatever image of itself the city it wishes to present to the public.

VOIP

Use of VOIP—Voice Over Internet Protocol—need not be limited solely to municipal employees. VOIP over a municipal network offers a unique opportunity both to pass telecommunications savings on to subscribers, and for income generation. The City of Grand Haven, Michigan began offering this service to its citizenry through its appointed ISP operator, Ottawa Wireless, this summer, at rates ranging from $20-$30/month

(*Mobile WiFi Phone*). South Bend, Indiana has also begun offering similarly rated, inexpensive VOIP access through Michiana Wireless (*Michiana Voice Plans*).

Outdoor Data Communication

Of course another application of public-use wireless is outdoor access for data communication. People with a WiFi equipped device in parks or in any public space can access the network. Though someone opening up a laptop in a park on a sunny day is perhaps one of the most common mental images associated with municipal wireless networks, it is highly unlikely that this will be an important application of a network's capability. Cities like Boston and Rochester have weather incompatible with the outdoor operation of digital data devices for more than half of the year. There simply are no current applications (besides VOIP) that make outdoor use of ubiquitous wireless more than a novelty for most Northern American states. This is not to say that an application might come along at some point; there are just none right now. One such possible application would use a PDA equipped with wireless and GPS. Programmed tours of city hotspots with advertising, a "Zagat's Restaurant Walking Tour of Downtown" might be one such outdoor application, but this is merely a speculative idea of how the technologies might be combined into something useful.

For data communication outdoors, wireless is demonstrably useful and is used frequently in outdoor retail areas with lots of foot traffic and places to stop and sit. Its value in public parks and at bus stops is debatable, as the user must feel secure enough from theft to take out a laptop or PDA and use it in public. Individuals with wireless devices in cars

would have access to the network. This is a surprisingly useful convenience, one which I've experienced, not with a municipal wireless network, but by accessing hotspots created by unsecured wireless routers in residential neighborhoods from inside my car. Of course the availability of VOIP on a network would mean that people would use the network with their VOIP mobile phone wherever they were, and likely in most weather.

Public Information Displays

A municipality might further exploit its network through the creation of permanent or even mobile public information kiosks, at bus stops and high foot-traffic areas, that would promote city events and attractions, display weather forecasts and bus schedules, or even include advertising or underwriting support from local businesses, to drive revenue income.

Benefits of Wireless Networks

When we talk of benefits from a municipal wireless network, we are not talking about things that the network actually may do itself, but effects that its presence may have on the larger community.

Reduced Costs

Perhaps the single strongest argument for municipal wireless in any form is the effect that a wireless network has on the retail price for broadband access in a given market. Most American broadband markets are served by at most two or three incumbent carriers with little or no incentive to price their services competitively. Leaving aside for the moment how high prices limit broadband access to the wealthy, there is the simple notion that taxpayers and businesses appreciate lower prices in a marketplace subject to real competition pressures.

But a municipal wireless's relationship with incumbent ISP's need not necessarily be antagonistic. Depending on the business model used, incumbents can often be brought into partnerships with the new venture, either providing backhaul access for the network, or acting as a WISP and reselling broadband access services on the new network. The details of such models will be dealt with more closely in Business Models below.

Tourism

Wireless networks have often been touted as a great benefit to tourism. For vacation travelers this may well be true. For many the point of a vacation is to get away from devices like PDA's and laptops. The exceptions are mariners and small airplane pilots, wireless networks set up around marinas and private airports are getting heavy, if seasonal, use.

But for business travelers this is hardly the case. On a recent trip to London, which has very little in the way of open wireless Internet access, I found myself largely locked-out of the Internet, and prices at the few hotspots I was able to find ran about four to five pounds an hour ($8-$10). An open and free hotspot, or at least one at a reasonable rate, would have seemed a Godsend to me, particularly since my American cell phone was also initially unable to function in London.

The fact that wireless access has already arrived in many cities means that instead of being a promotional novelty, ubiquitous wireless access is becoming a standard by which the technological currency of municipalities is being judged by savvy travelers. Municipalities, which wish to position themselves as a technological leader to attract the technologically minded worker and business, need bear this in mind. Two years ago a municipal wireless network would have helped to position a city as a progressive, forward thinking, and "cool" place to live. Today a municipal WiFi network is not likely to attract young professionals by itself; it is, however, something that young professionals coming out of ubiquitously wireless college campuses are going to expect.

Dark Fiber

Many cities have quietly made significant investments in dark fiber deployments--i.e. installing unused optical fiber cables besides existing infrastructures such as water, gas, and sewer mains--in anticipation of later use. These dark fiber cable deployments have in some cases waited for over a decade for an appropriate application to make use of these significant taxpayer investments. Once lit and connected to the Internet, existing dark fiber deployments may well serve the backhaul needs of many municipal networks, both justifying the original expenditure and maximizing benefit from already expended taxpayer monies.

Benefits to Business

Businesses benefit from ubiquitous wireless through reduced access fees, the availability of new advertising venues, increased flow of professionals to retail hotspots, and increased productivity. As has been discussed, municipal wireless networks bring competition to the broadband marketplace. Businesses, whether connected to the new network or not, will benefit from competitive price reductions from incumbent ISP's. Under the community wireless business model, partnering businesses have unique advertising opportunities with network access splash pages. Retail businesses benefit from the increased flow of professionals attracted to the prospect of free or low-cost wireless access. This principal has been demonstrated internationally by the deployment of T-Mobile paid access hotspots in Starbucks worldwide. The last benefit, increased productivity, is perhaps the most variable of the benefits listed. Businesses with agents

operating within the confines of the network, such as delivery people, would have access to the network's inexpensive data and VOIP capabilities. Were a network to be demonstrated to be robust enough over time, for some businesses wireless VOIP might become the primary or even sole venue for voice telecommunications.

Business Models For Wireless Networks

The selection of a business model is critical to a wireless network deployment; the business model will link the organization's mission with a specific plan for revenue generation, which in turn will determine specific choices in wireless technology and deployment that will allow it to fulfill its mission goals. The type of founding organization--be it a municipality, a nonprofit or community group, a private consortium, or an association of disparate public and private entities interested in ubiquitous wireless--is not nearly as critical as getting a proper match between a number of competing factors, the group's mission, local and regional political imperatives, community needs, applications of the selected network type, and the network's means of revenue generation. The business model defines the operating structure of the network, its costs and capabilities, now and into the future, such that if you know the particular business model a deployment is using, you can often guess what its technology choices and deployment area will be. There are four basic business models for these networks, Community Network, Public Utility, Private Consortium, and Cooperative Wholesale. The different business models tend to arise out of different economic and political conditions, and each can result in very different types of deployments and technological choices. We will look briefly at the different models, citing a few communities that are working within each. For a more thorough treatment of the overall process of business plan selection and network implementation, see *Wireless Broadband The Foundation for Digital Cities* by Matt Stone.

Community Networks

First and foremost, community networks are meant to provide free broadband access to the public. It is often the case that community networks often become established because the founding organization(s) lacks the financial and political means to go another route, but not always. Community networks arise out of a common sense that wireless access should be free to the end-user. Sometimes this can arise out of a priority to use the network as a promotional tool--for downtown retail businesses for example. Other times a community network can arise out of a desire to address the digital divide as aggressively as possible—for example when such networks are founded by community support organizations.

Community networks have been deployed both as mesh networks and WiFi networks, and break into two general sub-types—those initiated by municipalities, and those initiated by non-profit or governmental organizations.

In the first type, a municipality builds the network using grants, donations, and taxpayer monies. Revenue comes through advertising on splash pages, and the city manages marketing and customer service itself. Since advertising revenues cannot hope to cover the actual costs of the network, one would expect that most municipalities taking this approach expect to justify their costs through, operational savings and streamlining opportunities created by the network, improved and streamlined services to the public (police & fire), promotional value for the community at large, and of course the free

access offered to those in the operational area. These are typically mesh networks, and Hermosa Beach, California has deployed a network using this model (Burrell).

In the second type, the municipality or non-profit organization gets grant money to promote the installation of WiFi hotspots by local businesses. These plans are almost universally dedicated to promoting urban downtown development. Each hotspot is owned and operated by the business that sponsors it--though with direction and technical support from the founding organization. In return, the sponsoring business gets access to advertising through a splash page that comes up whenever anyone accesses the network through its node. The individual hotspots form a patchwork, which is *unlikely* to develop into ubiquitous coverage. The network grows as new businesses are added to take on sponsorship of new individual network nodes, usually on-site. Most often these are WiFi networks, wherein each node has its own backhaul, but mesh networks can be deployed under this model as well, offering lowered operational costs to some sponsors. Buffalo, New York; Austin, Texas, and Athens, Georgia have built networks using this model. This is perhaps the least expensive means for deploying a network, since the city's role is merely promotional and organizational (Stone, 13).

Public Utilities

If the community wireless model is the model to accommodate the lightest municipal commitment, then the public utility business model represents the full commitment of a municipality's resources to a wireless project. As one would expect, this model entails the creation of a new division within city government dedicated solely to the planning,

deployment, and management of the wireless network. Marketing, billing and customer service is also handled by the municipality. The network is built entirely with city funds, gathered through federal grants, bond issues, or taxpayer revenue--just as other municipal utilities like sewer, water, gas, and electric are (Stone, 14). Public utility deployments seem to be a popular approach for regions where there is little or no incumbent broadband access. In most of these settings telecom companies have already said, "No thank you," and the municipalities have been forced to go it on their own (*Moorhead* (MN) *Public Service*) (*Owensboro* (KY) *Municipal Utilities*).

One exception to this is Chaska, Minnesota. Oddly enough five years ago Chaska was the first network to be deployed under the public utility or any model. Chaska instigated its program in response to a public call for reduced price, broadband, Internet access. Community residents and businesses felt that the longtime monopoly controlled by a single incumbent ISP was keeping broadband prices artificially high, and the city built its network to offer citizens a competitive low cost alternative. Residential wireless broadband access is now $15.99, and business access is $24.99 (Chaska.net).

Private Consortiums

According to this model, the primary operating entity for the wireless network is a private ISP or consortium of ISP's. The network is entirely built, owned, and operated by the consortium, and the municipality's involvement in the network is limited to ensuring the enforcement of whatever initial agreement the municipality made with the consortium. Structured like most private utility contracts, the municipality provides access to public

lands and infrastructure in exchange for specific public benefits to be provided by the consortium.

Ironically, if better business plans existed and more ISP's were building wireless networks to serve municipalities, this might become a moot discussion. Although the private consortium is the predominant model for *wired* telecommunications, of the four types of business models for *wireless*, this is by far the most rare. [I have only been able to locate a single ISP operator involved in deploying municipal wireless networks, though I expect there are at least a few others out there.] It is a risky proposition for a new business, and these operators seem uninterested in markets with incumbent broadband operators. Michiana Wireless has networks in smaller municipalities in Indiana, Michigan, and Pennsylvania. Residential access through Michiana starts at $39.99/month and business access is $99.99.

This business model seems appropriate for municipalities which for one reason or another cannot get private wired broadband access for its citizens, and which lack the means to instigate their own networks. For a municipality looking to reduce the cost of broadband access for its citizens, this is probably a poor choice. At present, it seems unlikely that private ISP's would accept many constraints on pricing when they are already bearing the financial risks of deploying and operating the network themselves. This might change very quickly if the few current operators begin to show some success, or better yet if a wireless ISP moves into an established market and competes successfully with incumbents.

Cooperative Wholesale

In this model, either a municipality has a network infrastructure built, or the community has one built through the efforts of a nonprofit organization. The deployment, operation and maintenance of the network are undertaken by a private company, operating in partnership with the founding entity. Bandwidth from the network is sold wholesale to a WISP or group of other operators who resell it to businesses and consumers through subscriptions.

For cities with incumbent ISP's wishing to create a wireless network, the benefits of this model are obvious. In the city-built version, the city is able to justify the cost of the network and realize savings by in-sourcing its telecommunication needs. Like the public utility model, virtually all wireless applications, both municipal-use and public-use, are available in this model. The municipality can first roll out the network as municipal-use—reaping all of those benefits--and later add public-use by offering excess bandwidth for sale through the WISP's.

In the other version of this scenario, the nonprofit obtains funds from grants and community support, including social and economic development programs, and contracts with the municipality for access to infrastructure, such as streetlight poles, much in the same way that private ISP's would (Stone, 14). Because the expenditure of taxpayer monies is avoided, the organization is free to pursue goals for network applications and benefits that might otherwise be viewed as politically partisan, such as bridging the

digital divide.

A Final Word on Mission

Just as the Internet has revolutionized our personal and business lives, municipal wireless has the potential to do the same. By mobilizing the power of the information on the Web, and by making that information ubiquitously available, wireless networks will create huge opportunities for economic growth and development. Some have been outlined here, undoubtedly there are many unforeseen applications and benefits out there. How individual communities decide to introduce and manage the known opportunities has been the subject of this paper. But we have not discussed what is perhaps most important element of any network deployment: mission. Precisely because wireless networks offer such a dizzying array of applications and benefits, a community considering a deployment must from the outset must exercise discipline in insisting that its network have a clear and concrete mission that is open and accepted by the community. The organizers of the network and the community must be clear about what their wireless network is being put in place to do, and why. Partnerships with business, educational institutions, community organizations, and even with incumbent ISP providers are essential to developing a set of social and economic goals that the community as a whole will embrace.

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