Lesson from WiFi Municipal Wireless Network

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ABSTRACT

Many U.S. metro cities' municipal wireless projects have been delayed or canceled. Cost forecasting, market penetration rates, and changing technologies are factors that contribute launch failure. Although larger cities have tried, smaller towns are more successful due to the lack of commercial competition. This paper takes the issues of price, cost, and market share of WiFi municipal wireless networks in the city of Philadelphia as an example. This paper finds that ignoring private broadband market providers, cost is underestimated and market penetration is overestimated, which leads to project contractors withdrawing from municipal projects where private competition is fiercest.

Keywords

WiFi, Pricing, Municipal Wireless, Market Analysis, Cost Analysis

INTRODUCTION

Compared to other developed countries in the world, deployment of broadband Internet access networks in the U.S. has been very slow. Even though the Federal Communications Commission (FCC) (2007) announced that as of June 2007 the number of broadband access lines (residential) were 65.9 million and that 99% of Zip Code areas were covered by broadband service providers, the U.S. lags with a ranking of 15th in the broadband penetration rate in the ITU report (2007). The phenomenon of slow network deployment has caused many localities to consider the development of municipal wireless networks as a form of utility service. For the last decade, WiFi technology has been successful on college campuses. The campus-wide WiFi network was the conceptual seed for a citywide WiFi network. Contributing to the concept was, T-Mobile, one of the mobile phone operators in the U.S. T-Mobile deployed a WiFi network, well-known for its public 'Hot Spots' and competes' with other 2.5G / 3G mobile internet providers. With several success stories of municipal wireless services in small and medium sized cities and with a possible success of WiFi technology in the commercial wireless market, big cities has shown interest in the WiFi based wireless service.

According to Daggett (2007), many U.S. cities are currently developing citywide wireless broadband networks, especially large cities such as Philadelphia, San Francisco, Minneapolis, Boston, Houston, and Seattle. Given the level of interest there is a strong possibility for municipal wireless to prevail in the U.S. as a preferred Internet access platform as well as a bridge to transit from e-government to m-government, which provides information and services both to citizens and city employees with wireless devices.

Philadelphia, Pennsylvania was a pioneer of the major U.S. cities to announce the development of a municipal wireless network using WiFi and is the focus of this article because Philadelphia is well known as one of the national public wireless access Hot-Spots. Earthlink was contracted to build the Philadelphia citywide WiFi wireless Internet access system, but the project has been delayed because of financial issues in 2008. Wireless Philadelphia project was available only in 15 square miles of Philadelphia without a fee. At the time of this writing, many municipal wireless projects have been delayed or canceled. One of the reasons is the business model used to justify the return on investment for municipal wireless projects. The business model for municipal wireless Internet access is different from that of commercial telecommunications Internet access providers. Commercial telecommunication providers build telecommunications infrastructure with an enormous upfront investment and sell telecommunication access and usage to their customers with an unlimited access monthly billing approach (low-cost-volume approach) (Daggett, 2007). This penetration pricing strategy helps offset the investments made upfront, and discourages, or at best, limits other competitors from entering the market. Municipal authorities, which are not-for-profit-entities, require a steady stream of revenue to maintain their business operation and have experienced real risk when encountering competition from commercial Internet service providers. Nevertheless, what is emerging as one of the most popular business models for municipal wireless systems is a hybrid (private-public) system in which the city owns the network infrastructure and a private company builds the network using city owned assets. The private company then operates the network with the city being one of the largest customers of the wireless service. In Philadelphia's case they used a low cost pricing strategy equivalent to traditional dial-up access monthly pricing. Accordingly, under this business model, an appropriate pricing level is one of the key factors for both the financial success of the municipal wireless service and the sensitive political issues for the governing municipal wireless authority. However, when the project forecasted the future market penetration rate, it omitted the need to compete with numerous other wired or wireless broadband services which are owned/operated by competing commercial companies. Scott (2005) also identified that municipal/public funded WIFI was expected to reduce the "digital divide" (the gap between those who can afford access to the Internet and those who can't) by providing inexpensive wireless Internet access and by the pressure of price competition to other wireless or wire line broadband providers, such as DSL and Cable providers.

In this paper, the authors analyze WiFi municipal wireless networks from various points of issue; (1) cost, (2) pricing, and (3) market share. It is our objective that this analysis will then provide both insight and the foundation to guide other municipalities considering citywide wireless Internet access service in their effort to transition from e-government to m-government.

CURRENT STATUS OF WIFI MUNICIPAL WIRELESS

In an effort to boost the city's economy, the City of Philadelphia in 2004 announced its intention to provide wireless Internet access service throughout the city. Using street lights as WiFi access points, the city wanted to offer a low-cost (dial-up Internet access price equivalent of $20/month). Ubiquitous broadband wireless connectivity to all points (every house and business) within the city of Philadelphia was their stated goal (Wireless Philadelphia Executive Committee, 2007). It was believed that the "Wireless Philadelphia" project would provide a competitive economic development advantage to the city of Philadelphia, while at the same time, reducing the city's telecommunication cost including 3G wireless service for field employees. According to the Wireless Philadelphia's web site (http://www.wirelessphiladelphia.org), 15 square miles of Philadelphia would be available for city wireless Internet in January 2007 within the Proof of Concept Zone. The Proof of Concept Zone encompasses a large section on North Philadelphia. Upon completion of the testing phase, the service provider Earthlink would build out the network to cover the entire city providing citywide WiFi service to all 135 square miles of the city by the end of 2007. However, by May 2008, Earthlink announced that it was out of the "Wireless Philadelphia" project.

The Census Bureau[1] in 2006 reported that there are 19,429 local municipal governments in the U.S. Of these, some 312 municipalities either have their own wireless network or in the process of building a city owned wireless network in the report of Muniwireless.com. (2007). While some municipalities like those in western Utah and Windom, MN (Daggett, 2007) have chosen fiber optic technology for their municipal broadband and Manassas, VA has chosen BPL (Broadband over Power Line) technology (City of Manassas, 2005), it is expected that many other municipalities will opt for WiFi technology when it is price competitive. The number of municipalities that have announced their intention to provide their own wireless networks is very small, representing only 1.6% of all municipalities. While public WiFi Internet service has not been very successful in larger metropolitan areas in the U.S., there are many successful stories in small town and cities U.S.A. The following table is the summary of U.S. cities which started their wireless municipal project by the end of 2006.

Citywide/region	City hot zones	Public safety only	Planned deployment	Total
79	48	36	149	312

Table 1 Number of U.S. cities of wireless Internet access (Source: Muniwireless, 2007)

BUSINESS MODEL

According to Daggett (2006), there are two business models for municipal wireless: the franchise model and the anchor tenant model. In the franchise model, a city grants the private company use of public assets for some period of time and a franchisee builds a network using the public assets and then operates the network paying a franchise fee to the city. In this case, the city is not the major customer. An example of this model is an agreement between Anaheim, CA and Earthlink. In the anchor tenant model, the city becomes a major customer and guarantees a minimum level of revenue to a contractor. An

[1] County and City Data Book: 2007 by U.S. Census Bureau (http://www.census.gov/statab/www/ccdb.html)

example of this model is an agreement between Minneapolis, MN and U.S. Internet. The city of Minneapolis guarantees $1.25 million annually over 10 years, while the contractor provides 5% of net revenues to a digital inclusion fund and provides free wireless Internet access in parks and technology centers. The City of Philadelphia chose the anchor tenant model. The city established a non-profit organization named Wireless Philadelphia. Wireless Philadelphia then entered into an agreement with the private company Earthlink, where they would construct and operate a citywide wireless network then sell access to the network for a “low wholesale fee” to seven ISPs (Scott, 2005). The city’s objective is to offer citywide wireless service to their residents and local businesses at a reasonable monthly subscription fee while at the same time offering subsidized WiFi service to lower income populations who could not otherwise afford broadband Internet access.

PRICING ISSUE

As we mentioned earlier, by the end of 2006, 79 U.S. cities had their own municipal wireless networks (Muniwireless.org, 2007). The authors visited 79 city’ web sites and reviewed the operations data of their respective municipal wireless networks. We found data for 69 municipal wireless services[2]. Among them are15 free access networks and two county wide subscription wireless networks. We excluded these 17 data and data for Philadelphia since they lie outside the definition of a subsidized, fee based municipal wireless system. The remaining 51 are fee-based city wireless networks. The authors classified the systems based on service area population; small town (less than 10,000 population), medium city (less than 100,000 population) and large city (more than 100,000 population). The following tables (2, 3 and 4) are per mega byte monthly price and a number of broadband providers of the 51 municipal wireless networks.

Category	Small Town	Population	Size (sq. miles)	Pricing/1Mbps	Number of BB provider
Small	Marshfield, VT	270	0.29	$39.95	5
Small	Westmore, VT	319	34.5	$78.00	7
Small	Tekonsha, MI	696	0.69	$128.00	8
Small	Island Pond, VT	849	4.18	$78.00	6
Small	Quincy, MI	1,630	1.28	$128.00	8
Small	Bronson, MI	2,308	1.36	$128.00	8
Small	Grand Isle, VT	2,324	16.5	$19.97	5
Small	Spring Lake, MI	2,362	1.06	$29.90	12
Small	Thomaston, ME	2,714	1.97	$26.60	6
Small	Ferrysburg, MI*	3,015	2.97	$29.90	-
Small	Princeton, MA	3,522	35.4	$39.95	6
Small	Vail, CO	4,628	4.54	$2.99	5
Small	Gladstone, MI	5,223	4.96	$79.90	5
Small	Adel, GA	5,389	7.87	$99.80	8
Small	Waupaca, WI	5,820	5.99	$24.95	10
Small	Jackson, WI	6,085	2.52	$6.65	6
Small	Rockland, ME	7,578	12.90	$23.90	9

[2] The other 10 cities do not provide information about their WiFi services in their web sites. Possibly they are not providing WiFi services anymore.

Small	Granbury, TX	7,753	5.54	$23.90	7
Small	Sandy, OR	8,286	2.63	$18.72	8
Medium	Grand Haven, MI	10,573	5.81	$29.90	10
Medium	Coldwater, MI	12,697	8.13	$128.00	8
Medium	Addison, TX	13,813	4.43	$29.99	13
Medium	Buffalo, MN	13,853	6.03	$42.61	11
Medium	Lebanon, OR	14,416	5.25	$26.60	7
Medium	Radford, VA	14,525	9.82	$19.95	7
Medium	Galt, CA	23,396	5.87	$6.24	7
Medium	Chaska, MN	23,736	13.7	$16.99	11
Medium	Sun Prairie, WI	26,429	9.55	$46.67	9
Medium	Foster City, CA	28,937	3.76	$19.95	16
Medium	Moorhead, MN	34,749	13.4	$19.95	3.67
Medium	Dublin, OH	36,565	21.1	$19.95	12.5
Medium	Pacifica, CA	37,327	12.6	$19.95	9
Medium	Lompoc, CA	39,883	11.6	$9.99	6.5
Medium	Southaven, MS	41,295	33.8	$30.00	7.5
Medium	Cerritos, CA	52,353	8.62	$81.90	10
Medium	Cupertino, CA	52,948	10.9	$19.95	15
Medium	Owensboro, KY	55,525	17.4	$59.98	10.5
Medium	Brookline, MA	57,107	6.79	$19.95	11.33
Medium	Rio Rancho, NM	58,534	73.4	$29.90	9.5
Medium	Longmont, CO	60,894	21.8	$19.95	13
Large	Santa Clara, CA	108,518	18.4	$19.95	12.25
Large	Concord, CA	122,204	30.1	$19.95	12.2
Large	Sunnyvale, CA	130,519	21.9	$19.95	12.75
Large	Tempe, AZ	169,172	40.1	$14.95	15.4
Large	Madison, WI	223,389	68.7	$24.95	10.86
Large	Lexington-Fayette, KY	270,789	284.5	$8.33	7.14
Large	Corpus Chrisiti, TX	285,267	154.6	$6.95	8
Large	Riverside, CA	293,761	78.1	$19.95	12
Large	Anaheim, CA	334,425	48.9	$6.95	13.14
Large	Tulsa, OK	382,872	182.6	$16.63	6.93
Large	Portland, OR	537,081	134.3	$19.95	13.58

Table 2 Population, Size, pricing, and number of broadband providers of City WiFi Network

* Data is not available in FCC document. (Zip: 49409)

Category of Cities	**Number of Cities**	**Average Population**	**Average Size (sq. miles)**	**Average Pricing / 1 Mbps**	**Average Number of Broadband Providers**
Small	19	3,725	7.7	$53.00	7.17
Medium	21	33,788	14.5	$33.26	9.88
Large	11	537,081	96.6	$16.23	11.30
Philadelphia	1	1,449,634	135	$21.95	11

Table 3 Summary of Population, Size, pricing, and number of broadband providers of City WiFi Network

Table 4 summarizes the statistics of the above table 3. The mean price of small city WiFi network is $53 per month, and the mean price of medium city WiFi network is $33.26 per month, and the mean price of large city WiFi network is $16.23 per month. The larger the city obviously has a correspondingly lower monthly city WiFi access price.

	Mean(μ_i)	Standard Deviation (s_i)	Sample Size (n_i)
Small City	53.00	42.52	19
Medium City	33.26	27.72	21
Large City	16.23	6.18	11

Table 4 Summary Statistics

The authors test the following three hypotheses:

- Hypothesis 1: the mean price of small town WiFi network is the same as that of medium city WiFi network. ($\mu_S = \mu_M$)
- Hypothesis 2: the mean price of small town WiFi network is the same as that of large city WiFi network. ($\mu_S = \mu_L$)
- Hypothesis 3: the mean price of medium city WiFi network is the same as that of large city WiFi network. ($\mu_M = \mu_L$)

Table 5 shows outputs of the above three tests. We can't say that the small town's WiFi access price is different from that of medium city but unequivocally, the large city's price is lower than both the small town and medium city. Apparently, one of the reasons for lower price of large city is the large number of competitors in the broadband market. There are many more competitors in the large cities are available than in the small towns.

	Test 1	Test 2	Test 3
Ho:	$\mu_S = \mu_M$	$\mu_S = \mu_L$	$\mu_M = \mu_L$
Ha:	$\mu_S > \mu_M$	$\mu_S > \mu_L$	$\mu_M > \mu_L$
V (degree of freedom)	18	18	20
α	0.05	0.05	0.05
to*	1.720	3.703	2.691
$t_{\alpha,v}$	1.734	1.734	1.725
Conclusion	Not reject Ho	Reject Ho	Reject Ho

Table 5 Hypotheses Test Output

It is difficult for municipalities to establish a price level for municipal wireless service because by its very nature it is a public-private partnership. From the public perspective, municipalities wish to maximize the wireless Internet access for its residents and businesses by offering the wireless service at the lowest possible price. From the private sector perspective, the wireless Internet partner requires a price that will not only provide break-even within an accepted period of time, but also offer competitive profit opportunities. Accordingly, the price should be high enough to pay for and maintain the city's wireless network while returning a reasonable profit to the Internet providing partner. At the same time the price should be low enough to allow as many citizens as possible to access the Internet and to benefit from the city wireless service. Setting a price level is a strategy that cannot succeed if wholly considered from the public perspective, but municipalities must take into account the private sector perspective of pricing in a competitive environment with choices available to the consuming market.

In our data, there are three categories based on population. However, a fourth city category could have been added; "metro city" where the population exceeds 1 million. Philadelphia is one of the metro cities whose population is 1.5+ million and covers 135 square miles. As we mentioned earlier, Philadelphia wanted to offer a low-cost (dial-up Internet access price equivalent of $20/month), at $21.95 per month. According to the FCC's statistics for a number of broadband providers, Philadelphia already has 19 broadband access providers. The city became the 20^{th} broadband provider. In addition, there are carrier level WiFi providers such as AT&T and T-Mobile. Their networks do not cover the whole city area, but their target area is in densely populated areas such as the airport, convention center, hotels, restaurants, and bookstores. Some DSL providers such as Verizon and AT&T allow their DSL customers free WiFi access. Therefore, competition level in the metro city is relatively fierce. Comparing the mean price of large cities ($16.23) and the trend of mean price of city WiFi network ($53-$33-$16), the price level of Philadelphia wireless seems slightly higher for the metro category.

The following table summarizes statistics of the number of broadband providers in the cities of table 2. These numbers are found in the FCC's statistics document[3]. The larger cities have more broadband providers, which infer that the competition level is more severe. If the quality of service provided by each broadband provider is not different it will lead to competition based on price, which probably explains the lower market price to users. We believe this is the primary reason explaining why large cities have a lower municipal WiFi price than the small cities in the data.

	Mean(μ_i)	Standard Deviation (s_i)	Sample Size (n_i)
Small City	7.17	1.92	18
Medium City	9.88	3.01	21
Large City	11.30	2.78	11

Table 6 Summary Statistics for a Number of Broadband Providers

COST ISSUE

Building a telecommunication network is capital intensive. A WiFi access network, however, is a relatively low cost technology compared to the FTTH (Fiber-to-the-Home) or BPL technology, which are used by some municipalities to provide Internet access service. Key components of the WiFi infrastructure are the WiFi access point and its backbone network. A fiber optic backbone network, for most cities, currently is the only cost effective solution. Therefore, whether a city has an existing fiber optic backbone network or not is a major factor when considering project cost. The size of the backbone network and the number of WiFi access points are based on the population, geographic size of the city, and topographical features such as rivers, mountains, and similar obstacles. In the St. Anthony Village, MN case (8000 population, 2.3 square miles), 35 access points are used per square mile and in the final report of municipal wireless for St. Paul, MN (2005), 20 access points (typically up to 20 users simultaneously per point limitations) are used per square mile. According to the Martin's web blog (Sauter, 2007), the average number of access points for municipal wireless is 25 access points per square mile. According to Gunasekaran and Harmantzis (2006), the final proposal to the City of Philadelphia was 30 access points per square mile. When Wireless Philadelphia stopped construction, the number of actual wireless access

[3] http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/hzip0606.pdf

points was 42-47 per square mile. (Breitbart, 2007). Typically the larger the city, the more dense the population, which means the greater the need for more access point per square mile. Taipei, the capital city of Taiwan, well-known for M-city, or Mobile-city, has 2.62 million people and is contained in 105 square miles. By the end of 2005, it had 10,000 access points for its city WiFi network, which provides 90% coverage. The average number of access points per square mile is 105.8 (10,000 / (105 sq. miles * 0.9)). Even if the official population of Philadelphia is 1.5 million, the population of the greater Philadelphia has 6.1 million people (Philadelphia.about.com, 2005), which makes it the fourth largest metropolitan area in the U.S. Compared to Taipei's 105.8 access points per square mile, Philadelphia's 30 access points per square mile in its final build was grossly underestimated. The following table shows the average population density of the above three city categories.

	Small City	Medium City	Large City	Philadelphia
Average Population Density (population / Size)	1,119 / sq. mile	3,204 / sq. mile	3,898 / sq. mile	10,738 / sq. mile

Table 7 Comparison of Population Density of Three City Categories

The rule of thumb in estimating WiFi municipal capital costs is $200,000 per square mile to cover 90% to 95% of homes and residents in a city (Daggett, 2007), which is based on 20 access points per square mile. Operating costs are the second largest cost after capital costs. Operating costs include the cost of operating the network full time (24 hours a day/7 days a week), pole attachment fees, electricity, hardware maintenance, software upgrades, and Internet interconnection fees. Operating costs for wholesale networks are estimated to be approximately 15% of the capital network annually. However, estimated operating costs for retail networks increases to around 30% including billing and marketing fees (Daggett, 2007). Whether municipal wireless is to be operated as a wholesale or retail venture is a non sequitur since the price which subscribers have to pay is the same. This is true whether the user access fees are paid to the city or paid to an Internet Service Provider. Accordingly, we assume operating costs at 30% of annual network capital cost in the model. The following table shows the cost assumptions of a WiFi municipal network in the first five years.

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Capital cost	$200,000 / sq. mile	-	-	-	-
Operating cost	$60,000 / sq. mile	$60,000 / sq. mile	$60,000 / sq. mile	$60,000 / sq. mile	$60,000 / sq. mile

Table 8 Cost assumption of WiFi municipal network

If we used the same scenario with a 100 access points per square mile, the following table gives us different numbers.

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Capital cost	$1,000,000 / sq. mile	-	-	-	-
Operating cost	$300,000 / sq. mile	$300,000 / sq. mile	$300,000 / sq. mile	$300,000 / sq. mile	$300,000 / sq. mile

Table 9 Modified Cost assumption of WiFi municipal network

MARKET ISSUE: SCENARIO-BASED FORECASTING

The profit function of this model is defined as revenue minus cost. The authors calculated profit based on annual revenue and cost. The revenue is defined by the number of subscribers (Q) times the monthly price (P) of the city WiFi service. The potential number of subscribers is assumed to be limited to the number of households (560,500) even though the City of Philadelphia has many visitors, both tourists and business (Scott, 2005). As noted earlier, in 2004 Philadelphia had a 15.7% broadband penetration rate with DSL and cable modem technologies (Scott, 2005). We further assume that WiFi operators in the City of Philadelphia should pay 5% of their net profits to a digital inclusion fund (that is a part of contract), which would be used to supply a digital package (hardware, software, and wireless Internet service) to low income households.

The following is the profit equation.

Profit = (1-0.05){P/month*Q* 12 Months} – {135 Sq. miles * $200,000/sq. mile + $60,000/year}* (Equation 1)

In the above model the profit is a one-time calculation using a static approach although it is assumed that the entire potential target market should take four to five years before reaching saturation. Such an approach is realistic, however, given that the adoption process for municipal wireless service should be similar to other related telecommunications services and will likely project a similar product life cycle. Most cities either have, or are contemplating a municipal wireless service and realistically target the 4^{th} or 5^{th} year as their breakeven year. According to the Wireless Philadelphia business plan (The Wireless Philadelphia Executive Committee, 2005), the following table presents the estimated market penetration rate which begins in the first year with 13.9% of the potential target market and increasing to 23.1% of the total potential target market in year 5.

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Penetration rate**	13.9%	19.3%	20.9%	22.2%	23.1.%
Number of residential subscribers	77.9 K	108.0 K	117.3 K	124.3 K	129.6 K*

Table 10 Change of profit with a market approach

K* = 1,000 subscribers, ** Based on the total households is 560,500

Source: The Wireless Philadelphia Executive Committee Report (2005)

Based on the above market penetration rate and $21.95 monthly pricing and cost assumption (table 7), the following table shows profit of 5 years, which is too rosy forecasting, which is not realistic when economy is bad.

Year	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue	1,624,410	2,252,070	2,445,998	2,591,966	2,702,484

Table 11 Revenue Projection

CONCLUSION

It is readily seen that realistic cost and revenue forecasts must be made if municipalities are to be successful in transitioning to an m-government model that also serves the digital-divide in our society. A secondary consideration is city size and market attractiveness for potential broadband suppliers. If your city is close to emerging to the next size category, other competitors have a greater likelihood of entering the municipality and competing using a pricing approach as they already do in the largest city category. Exacerbating the decision to move towards mobile government must also be tempered by economic and technology considerations. From an economic perspective, adoption rate and cost recovery may be hampered by a slow(ing) economy where customers may elect to forgo subscription and instead opt for pay as you go alternative services. Although more expensive by the minute, customers can control the usage amount by discretion. A confounding variable for municipalities is the process of creative destruction where the introduction of WiMAX may, after introduction, sweep customers away with superior technology.

To avoid the same problems as Wireless Philadelphia project, municipal governments, which plan to deploy a wireless network, should be careful in their analysis from the beginning. First of all, choosing a right business model is the most important. The private-public hybrid model is not easy to implement because it integrates two different entities which have different goals, the maximization of public welfare and the maximization of private companies' profit. Second, forecasting both cost and demand is not a one-time job, especially in the IT industry, whose technology and markets change very fast. From a time-involved dynamic situation, it may not be prudent to determine cost and demand in the early stage of a project. As in the case of Philadelphia, the city grossly underestimated cost and over estimated market penetration. In large metro city areas, with premium services offered at introductory regular rates as is the common strategy for companies to employ when entering markets to enable market penetration, Philadelphia was just not prepared to compete at such an intense level. Thirdly, pricing should be considered from the strategic point of view. It should be used to analyze a competitor's behavior against the selected pricing strategy chosen by the municipality. A thorough market study is a foundation to build a good pricing strategy. As illustrated earlier in this study, small towns also experience a certain level of competition in any market. There is no exception to competitive pressures in a free market economy even if the competitor in the market is a public entity. Municipal authorities should prepare to compete with commercial providers in the market. Last, in the IT industry, the IT service provider should watch for technology trends so as to minimize damage from a disruptive technology like WiMAX.

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