

# Strategies for Stakeholders involved in the Emerging Wireless Broadband Networks

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## Abstract

*The broadband wireless access (BWA) market in the U.S. and around the world is expected to accelerate its growth in the next few years. WiMax is one promising technology expected to play an important role in the implementation of broadband wireless systems. However, many factors in addition to the technology choice contribute to the success of a BWA service provider. This study analyzes the environments and strategies for stakeholders involved in this nascent market. After providing an overview of the technology, the paper adopts the Industry Competitive Analysis methodology to analyze the external environments of both the incumbent cellular service providers and the emerging WiMax service providers. Then the balanced scorecard model is used to analyze the strategies considered by WiMax service providers. It is found that although WiMax is potentially a disruptive technology, new WiMax service providers may do well pursuing a niche strategy instead of directly competing with incumbent service providers. In addition, microeconomic analysis of wireless broadband networks for policy stakeholders also shows that niche areas, such as rural markets, may be where the greatest benefit can be obtained.*

## 1. Introduction

Broadband wireless access (BWA) and in particular WiMax is being implemented worldwide such as in South Korea (EETimes, 2006 ), and in Canada (ars technia, 2006). There are plans to build a nationwide WiMax service in France (Ovum, 2006), Australia (telecomasia.net, 2006) and even the U.S. (Telephony Online [2], 2006). In the U.S., Sprint already has plans to implement WiMax in Chicago and D.C. (Telephony Online [1], 2006). In January 2006, the WiMax Forum announced the first certification of products built to the IEEE 802.16-2004 and ETSI HiperMAN standards (ZD Net UK, 2006). The advent of these interoperable products is expected to stimulate rapid proliferation of the technology. IDC research (International Wireless Telecoms, 2006) has predicted the number of WiMax customer devices will grow from 1.6 million units in 2006 to 17.9 million units by 2010. There are several serious contenders for the hearts and pocketbooks of the broadband consumer. The competitive field and the potential strategy selected by each player will prove complex and be influenced by numerous factors. Municipalities and community based organizations will push for the hearts of the public consumer and provide services at very low costs or for free, and the telecomm giants (Sprint, Verizon, Cingular, and T-Mobile), large ISPs (Earthlink) or even small local ISPs will work to win over the consumer's pocketbook. Each provider will play a key role in providing BWA, but there are other supporting actors needed to provide the total service package. The other actors include: device manufacturers, content providers, application providers, payments agents, mobile network operators (MNO), and regulators (Camponovo & Pigneur, 2005).

This paper provides a strategic assessment, identifying the key factors that suggest the structure of the future WiMax industry, strategies available to service providers, and welfare analysis for policy maker. The paper is organized into the following sections: an overview of the WiMax technology and competing technologies, a cellular and WiMax industry analysis, and an in-depth look at WiMax company strategies, and the welfare analysis for WiMAX. Finally some conclusions are drawn in Section 6.

## 2. WiFi/WiMax Technology Overview:

There are several technologies to deliver broadband capabilities to fixed and mobile users. Table 1 below summarizes some of those key technologies and their characteristics (approximate values).

Technology	Specification	Frequencies	Data rate	Coverage	BTS	CPE
Wi-Fi	802.11	2.4/5.8 GHz	11-54 Mbps	100 m	\$75	\$75
WiMax - fixed	802.16-2004 Approved June 2004	2.5/3.5 GHz + other	75 Mbps per channel	1.5-6 miles	\$20-30K	\$300
WiMax - Mobile	802.16e – 2006 Approved December 2005	< 6 GHz	1.5 - 15 Mbps	1-3 miles	\$20-30K	\$300
HSDPA (based on GSM) (Cingular)	3GPP	1900 MHz	1.8-3.6 Mbps	1-5 miles	\$150K	\$300
EV-DO	3GPP2	450/700/80	1.8-3.1	1-6	\$150	\$300

Technology	Specification	Frequencies	Data rate	Coverage	BTS	CPE
(based on CDMA) (Verizon, Sprint)		0/1800/ 1900/2000 MHz	Mbps	miles	K	

Table 1: Broadband Wireless Access Technologies

Beyond the initial concerns over the true data rate and area of coverage, new WiMax service providers in the BWA industry will need to address numerous challenges. WiMax's technology uses Internet Protocols to transfer information in packets. It allows the user to obtain all the benefits of the Internet, but also inherit some of the risks. Security is a concern since the mobile user of WiMax will often be uploading and downloading corporate information. Fortunately the WiMax standard does address security concerns by providing the options to encrypt data with either DES3 or AES both of which are considered robust and secure (although bandwidth-intensive). Other concerns for a WiMax service provider are:

- Network management: will the system be efficiently tuned to meet the changing needs of customers on the network?
- Performance: will the customer obtain the expected throughput and be satisfied?
- Roaming: as customers drive through the network territory will their access devices switch seamlessly between base stations? When they exit the territory will other networks let them in (roaming agreements)?
- Interoperability: the WiMax Forum has designated certification centers to ensure interoperability of equipment and end user devices.
- Coverage: how much area should be covered by a base station given that coverage area is highly dependent on the terrain and the density of the population? Key factors affecting coverage are: frequency, base station transmit power, system balance, CPE transmit power, antenna gain, receiver sensitivity, CPE location, fade margin, in building attenuation, and data rate.
- Sustainability: how long will the investments last before the next superior technology arrives, and will it be backwards compatible?

Additional technical details on WiMax can be found in <http://www.wimaxforum.org/home/>. A typical WiMax network architecture is shown in Fig. 1.

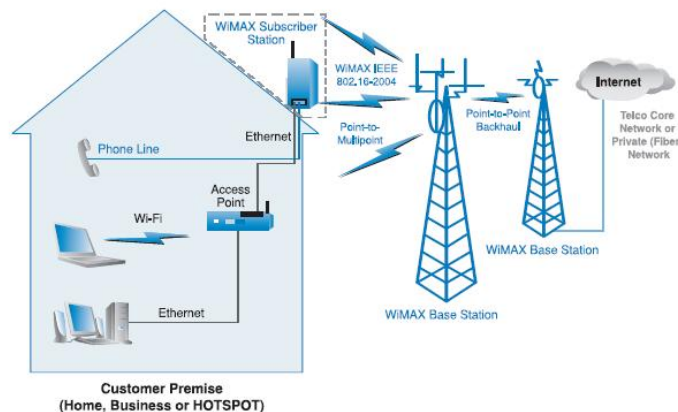


Figure 1: A typical WiMax network deployment

### 3. U.S. BWA Industry Analysis:

The United States BWA industry is still relatively nascent. Most of what we see are 2.5 and 3G offerings by the existing large cellular telecommunications companies such as Sprint (launched 2003, EV-DO), Cingular (launched in 2006, HSDPA), and Verizon (launched in 2003, EV-DO). However, with the recent approval of the WiMax mobile standards, the BWA industry is sure to see some changes. Sprint has already committed to a \$3 Billion investment in WiMax. The others may follow. The question is; will WiMax become a replacement for cellular technologies, an enhancement to them, or a niche competitor?

To understand what may follow, it is important to understand the structure of the current cellular telecom industry and how the growing WiMax industry may structure itself. The Industry Competitive Analysis methodology (Porter, 1979) is a common and frequently used process to assess the competitive structure of an industry. This process evaluates five factors that affect relationships and dynamics in a given industry. The following analysis will address the cellular telecom industry and then follow with the WiMax industry.

#### 3.1 Cellular Telecom: Competitive Industry Analysis

1) **Intensity of rivalry:** There is strong rivalry among the cellular telecommunications companies. Great effort is made to entice subscribers from other networks (churn) (Cingular: Financial Time, 2006; Sprint-Nextel: FierceWireless, 2006; Verizon: theStreet.com, 2006). There has been important industry consolidation (AT&T with Cingular, Sprint with Nextel, and GTE with Bell Atlantic to form Verizon) as each tries to obtain greater leverage and economies of scale.

2) **Barrier of entry to new competitors:** The rapidly maturing industry has undergone significant consolidation creating multi-billion dollar companies. The fierce competition and capitalization of the infrastructure make a barrier that is all but insurmountable – given the current technology. There is also a barrier associated with industry and operational knowledge. These large companies have databases about their subscribers and experience rolling out large scale technical infrastructures. This information and knowledge is hard to obtain other than through experience. Two additional barriers are the right of way in placing cell base stations and the limited available spectrum.

3) **Threat of new technologies:** The cellular industry has rapidly pushed the movement towards higher bandwidth technology realizing that a given percentage of their subscribers will eagerly find uses for it. WiMax represents a technology that can surpass the current cellular technologies bandwidth. Questions that need to be answered include whether it will be a replacement, enhancement, or a niche competitor. This “force” has great impact on sustainability of the cellular business model. In fact there are signs that people are availing VoIP over WiMax with tools such as Skype thereby eliminating the need for a cell phone altogether. The belief in the cellular companies’ ability to develop competing technologies with backward compatibility will prove important to the strategic decisions made today.

4) **Relative power of the buyers:** With just a few multi-billion dollar companies providing service in the cellular telecomm industry, they each have enormous purchasing power and influence. Suppliers who want to sell to these companies must be

willing to provide excellent pricing, service and customization. Since the current cellular phones are mostly bought through cellular companies, cellular companies effectively control access to the subscribers and thus obtain even further influence and control over the suppliers.

**5) Relative power of the sellers:** There are many products provided to the cellular telecommunication industry: cell phones, base stations, software applications, and content. For each of these product categories, there are a relatively wide variety of companies to provide each product and a high degree of competition. The infrastructure providers and cell phone manufacturing companies are in some cases large and influential companies, but they do not have as much say in shaping the industry as do the cellular phone service providers. However, recent trends among handset vendors to sell unlocked cell phones may increase the relative power of the sellers (Kharif, 2006).

This analysis shows an industry composed of a few highly competitive service providers who control and influence the entire industry including the suppliers. They have created an insurmountable barrier to entry to the industry – using the existing technology. However, the introduction of new technology could remove some of the barrier and allow new entries to the industry. WiMax may be such a technology. It will allow the provision of services capable of far greater bandwidth than the existing cellular technologies. The WiMax standards and interoperability testing will ensure that infrastructure suppliers of WiMax technology are motivated to rapidly minimize costs in their products. The infrastructure costs will shrink and with that, the capitalization cost of entry to the market. However, the cellular telecommunication companies will protect their market and be fierce competitors to any company perceived as a competitive threat. If the WiMax technology proves superior to cellular technologies for broadband delivery, then the cellular telecommunication companies' options will be to: rapidly build out the infrastructure to supply WiMax as an additional service or as a replacement to the existing infrastructure, purchase any company that proves a successful competitor, or do nothing. Sprint has already indicated its strategy by stating a \$3 Billion commitment to building a nationwide WiMax infrastructure (TelephonyOnline [2], 2006). Their strategy is to provide WiMax service as a complement to the existing cellular network and not as a replacement for it (WiMax Forum, 2006).

Another factor that may influence the timing and movement of the cellular telecommunication industry to WiMax is the development of new high bandwidth applications (e.g., IPTV or video-conferencing). The creation of new and compelling content may influence the rate at which consumers move to BWA and thus increase the incentive to the cellular telecommunication industry to provide the service.

This analysis implies that as WiMax technology proves itself and as demand for it grows, the cellular companies will either eagerly or reluctantly accept or proliferate it. Today's cellular market is largely controlled by Sprint, Verizon and T-Mobile (Cingular was recently acquired). However, even in this tightly controlled and highly competitive environment, there are independent cellular providers which have found sustainable niches (Maitland & Tapia, 2005). Until the cellular companies rush into the WiMax market, there will be opportunity for other players to roll out WiMax. Some companies may establish a strategy to create a regional, citywide (Philadelphia: Wi-Fi Planet, 2004; Atlanta: Mobile and Wireless, 2005), community (Broadband Wireless Exchange Magazine, 2006), or local WiMax service. Some of these companies will be consolidated over time into other WiMax industry leaders, but eventually the larger companies will be consolidated into a cellular telecomm company or just out competed by them.

Before reviewing the emerging WiMax industry, it is useful to look deeper at the Cellular Telecommunication Industry. Although there are only four dominant service providers in the industry, there are hundreds of smaller companies providing service as well (Maitland & Tapia, 2005). Some of their key findings related to these small service providers are:

- Although they lack buying power, capitalization, and any barriers to entry by the big four, they do continue to survive and some cases prosper.
- There seems to be great diversity in business models. Some are subsidiaries of larger providers, privately owned or established as a co-operative.
- The majority of them seem to have a narrow focus on providing only cellular services.
- Financial concerns are the largest difficulty. These companies seem to do well at responding to technological and policy related changes. Since they tend to be in areas with less subscribers or lower quality subscribers (higher churn rates), they tend to have uncertain revenue flows.
- These small service providers serve markets that the larger companies may not find economically worthwhile and they put a local face to the service.

Maitland and Tapia (2005) suggest several strategies that these small service providers may employ to remain competitive: 1) provide unique services such as foreign-language service and special international rates, 2) cooperate in lobbying for favorable policies and develop rural specialty services, and 3) be early adopters of new process or product innovations. Some of these small cellular companies may deploy WiMax as a means to remain competitive and provide new services. New companies may also form to provide WiMax services and face competition similar to that experienced by these small cellular telecomm companies. The experience faced by companies entering the emerging BWA industry will undoubtedly be reflective of that experienced respectively by the large and small cellular telecomm service providers.

### **3.2 The Emerging WiMax Industry**

The smaller WiMax companies (relative to the larger cellular providers) will lack the industry buyer power exhibited by the cellular telecomm companies. However, due to the establishment of WiMax standards and interoperability testing, the industry will at least initially have numerous suppliers of infrastructure offering competitive pricing. This should offset to some degree the lack of buyer power and allow entry of companies with less capital. With the barrier of high capital costs removed, even small locally developed service providers can enter the market.. Since these initial providers will be focused on regional, city and community footprints, the rivalry among competitors could be expected to be far less than for the cellular industry.

### **WiMax: Competitive Industry Analysis**

Although WiMax service is available in locations around the world, these implementations are mostly pre-WiMax standards. The industry's growth will substantially increase as more equipment manufacturers obtain certification to the approved standards and the equipment costs drop. As the industry grows, the five competitive forces will establish themselves and an industry structure will emerge. Following is an assessment of the five forces as they might be in the early growth phase of the industry and before large well capitalized companies enter: such as cellular telecoms.

1) **Intensity of rivalry:** Initially there is unlikely to be a high degree of rivalry. In the early stages of the industry, most companies will attempt to enter open niches rather than start out in head to head competition. They will look for an early mover advantage which has been demonstrated to be effective in some industries. However, the first movers will also experience a high equipment cost. Those who enter the market as little as a year later are likely to see significantly lower equipment costs providing them with a lower break even. As companies move into existing territories, the long term rivalry will not be based on infrastructure costs. It will be based on who can provide customer intimacy in terms of the best packages of service and value. At some point in the industry's growth, it will become a competitive concern to the cellular telecoms and they will enter to neutralize the challenge – and then the gloves come off. It is interesting to note the possibility that non-Telecom organizations such as enterprises and corporations could start WiMax networks and proliferate rapidly to create private voice & data networks.

2) **Barrier of entry to new competitors:** The costs to entry are low relative to cellular technology (see Table 1) and will continue to drop rapidly as more equipment manufacturers are certified. The barrier to entry due to infrastructure costs will be possible to overcome, encouraging ISPs, municipalities, and communities to implement networks. As the technology matures, the systems to support network monitoring and customer support will greatly improve, thus removing operations and support as a barrier. The real barrier to entry, however, will occur when large well capitalized companies form a large presence.

3) **Threat of new technologies:** The BWA industry is far from the final technology solution and as an industry it can count on new and better technologies becoming available. The questions will be: how soon? and will it be compatible? What is the service life of WiMax?

4) **Relative power of the buyers:** WiMax is now an approved standard with an established certification process to ensure interoperability (<http://www.wimaxforum.org/home/>). This will afford the initial service providers some degree of purchasing power. They can mix and match equipment from whatever supplier providing them with the right value. Equipment manufacturers will be under intense rivalry from the start and need to provide high value to the service providers.

5) **Relative power of the sellers:** The equipment suppliers are essentially producing a commodity (maybe with special features included, but the core functionality will be the same). The equipment sellers will have little power in this industry – even very large well capitalized and efficient ones.

The following Table 2 summarizes the BWA industry and the relative advantages some segments (cellular versus WiMax) may have over another.

	Rivalry	Barriers to entry	New technologies	Buyer Power	Seller Power
Cellular Companies	High among Sprint, Verizon and Cingular/ AT&T	High capitalization required. Some industry consolidation already completed	HSDPA, CMA2000-EVDO,  Future technologies that will be compatible? WiMax Technology is a possible replacement?	Very High – only a few large companies who buy tremendous amounts	Low to Moderate – cellular telecomm companies have several large handset manufacturers to choose from, providing for a fair degree of seller competition.
WiMax BWA Network providers	New players will have little initial competition, but significant competition from cellular telecoms if they become successful.	Barriers are far less than for cellular. Initial costs to create a footprint are not insurmountable.	WiFi (802.11g) WiMax (802.16-2004 and 802.16e-2005)  Future technologies that will be and not be compatible?	If cellular companies become WiMax network providers, then they will have very high buyer power. Until that happens, even the small network providers, will a fairly high level of buyer power.	Low: Many possible suppliers are being certified to the standards. As such, until industry consolidation occurs, there will be relatively less supplier power.

Table 2: Industry comparison of Cellular Telecomm and the nascent WiMax Industries

**4. Individual Entity Strategy: How will companies compete within the WiMax industry?**

The preceding analysis, using the industry competitive analysis model, looks at external forces affecting the structure of an industry. These external forces are outside the control of the organization. It is unlikely in most industries, that a single company will have the ability to affect the power structure between buyer and seller, create a significant barrier to new entrants, substantially change the competitive rivalry, or block the creation of any replacement technology. However, these forces which drive the industry’s structure have a profound impact on companies trying to enter into or survive within the given industry. Corporate strategies need to account for this structure, but they also need to look at the internal level: how an organization

focuses itself to provide for sustainability. Organizations must understand the external forces so they may strategically focus the internal processes (those under their control) to take advantage of the industry structure and to create competitive advantage. The internal view of strategy can be represented by use of the *balanced scorecard* strategy map (Norton & Kaplan, 2000).

The balanced scorecard is a process to map a coordinated set of strategies to improve an organization's competitiveness. This scorecard breaks the strategy mapping into four "perspectives": Financial, Customer, Internal Processes, and Learning and Growth. Organizations start the process by defining the overriding goal: shareholder value for profit companies, but the goal maybe something else for a non-profit entity. The mapping process flows from the defined corporate goal to the financial strategies established to support that goal, and from there to the customer based strategies that support those financial strategies, and so on down to the learning and growth strategies necessary to achieve all those above. The following four sections develop a strategy map for a WiMax company and show some of the factors that may drive a particular strategy.

**Financial Perspective:** This perspective is typically divided into a two-pronged approach to drive higher shareholder value: 1) Revenue growth, and 2) Productivity growth. Productivity growth probably will not be a major opportunity for sustainability. It is based on improving asset utilization and reducing operating costs. Assets are tuned and optimized at the time of initiating service, and although improvements can be made, they will not prove significant. Service providers in the WiMax industry, at least prior to any large dominant player emerging, will lack any significant buyer power and thus ability to derive a competitive advantage through a lower cost infrastructure. Thus, for the financial perspective, the strategic opportunity to gain advantage will be from developing solid revenue growth. A given service provider may move to a model of aggressive pricing to build a subscriber base rapidly or perhaps find ways to stimulate revenue by providing unique and valuable services. In a community or municipal based service, unique service could prove an effective strategy.

**Customer Perspective:** This perspective represents the organization's strategy to capture and retain the customer through providing: superior operating excellence, customer intimacy, or product leadership. WiMax companies will purchase interoperable equipment, the same as their competitors for much the same pricing. They will not likely be able to develop an operational strategy difficult to replicate. Product leadership might be represented by the initial configuration of the infrastructure that provides for superior bandwidth and connectivity as a customer moves around in the network footprint. Clearly this is important and should be accounted for and can provide a competitive advantage. However, this is established to a large degree at the time when the network is designed and competitors can gradually improve their network to the same level. Therefore, probably the strongest area for competitive advantage will come from a strategic focus on customer intimacy. This strategy has to do with understanding your customer needs. A WiMax service provider can produce various pricing packages for a variety of services. The service provider who can best match it's customer's needs by providing the correct service options and value will obtain the competitive advantage. Vigilant sensitivity to the customer base will allow for a hope of sustainable advantage. The effective application of the customer intimacy strategy will in turn drive greater revenues through increased subscription rates and from more purchased services. Thus it is in support of the financial perspective strategy.

**Internal Process Perspective:** This perspective represents the organization's strategies and competencies needed to successfully support the customer and financial perspectives. There are four key areas to consider when mapping out strategies: the organization's process of innovation, process of customer management, operational processes, and environmental

processes. All four areas are important to consider for a WiMax company's strategy. Innovation of new services will be key to maintaining customer intimacy. A strategy for innovation must look to supporting and improving how innovative services are identified and developed on a timely basis. The ability to accurately bill customers, identify service growth by appropriate customer segments, and target each segment efficiently will be key to the customer management area. A proper strategy to drive this area will support the higher level strategy of customer intimacy as well. The next area, operational processes, although important is probably not an area likely to score competitive advantage. Almost all WiMax infrastructure equipment will be interoperable and operationally similar. The component of the operational process that will vary is the systems to manage the network and customer access. The system monitoring software is readily available from third parties and thus unlikely to provide for competitive advantage. The last area of strategic internal process focus is environmental. This could be very important to some service providers in the WiMax industry. WiMax can operate over a very wide range of frequencies, some of which are regulated and some of which are not. There will undoubtedly be lobbying efforts to regulate unlicensed spectrum by those who have licensed spectrum (the cellular telecoms). It may not be much of a strategy, but maintaining a presence with WiMax service providers with similar frequency concerns will be important. This is more likely to be an issue for smaller service providers – unless they are situated in markets where the large providers are unwilling to enter.

**Learning and Growth Perspective:** This perspective formulates strategies based on employee competencies, information technology, and corporate culture. To achieve all the above strategies, a company will need to obtain and develop personnel with the right skill sets and abilities. There are information systems needed to monitor the network which was pointed out previously are probably not going to provide competitive advantage. Where information systems can play a strategic role is in the support of innovation and customer management (e.g., a well thought out knowledge management system.) A solid systems team will be able to identify the correct customer data to collect and then effectively mine for opportunities to innovate new services. They may also develop decision support systems to monitor and predict the best combination of services and pricing to maintain customer intimacy. Lastly, it is crucial for an organization to establish or shift a corporate culture to effectively support the above strategies. Not easy to do – but essential to ensuring that personnel know how to communicate and work together towards a clear common goal.

The balanced scorecard provides for a mapping of an organization's strategies to achieve a well identified goal. Sustainability of that goal should be of key concern to any entrant to the BWA industry. Not only do new entrants have to establish a financially sound model for the short term, but they need to be able to demonstrate how they will maintain profitability in the face of competition. The Resource Based View of the Firm Theory (RBV) (Barney, 1991) states that long term competitive advantage is derived from a company's control over rare or valuable resources that have low mobility, low substitutability, or low imitability. The knowledge and equipment associated with WiMax will be readily available and the equipment will be interoperable. The WiMax Forum and IEEE standard committees will ensure that competitive advantage from technology is limited or even absent. Thus companies cannot expect to obtain any sustainable competitive advantage by implementing the WiMax technology. As previously discussed, the barriers to entry for this industry will be low. Can a small WiMax service provider hope to formulate a strategy that provides any sustainable competitive advantage? In industries with low barriers to entry, it has been shown that there is a first mover advantage that seems to be sustainable (Makadok, 1998). Specifically, it has been empirically shown in the telecommunications industry that there can be a first mover competitive advantage derived from either the use of technology innovation or by a low cost strategy (Dowling & McGee, 1994).

However, the Dowling and McGee (1994) study looked at the equipment manufacturers and not the service providers. This paper looks at only the service providers and since the equipment they use is certified as interoperable, there will be little chance of an innovation by one manufacturer providing a competitive advantage to a service provider – especially when others can buy that equipment as well. That leaves the low cost option as a first-mover strategy. This strategy may prove correct, if the big telecommunications companies do not enter the BWA market with WiMax as well. Certainly, the studies support this strategy to some limited extent. However, all bets are off if the large telecommunication companies decide to move in. They will have the purchasing power to lower the capitalization costs and economies of scale. This along with their industry knowledge on how to market and manage a complex network will remove any potential for sustainable competitive advantage. The smaller service provider will either hope to be bought out or will find it difficult to stay in business.

This analysis does not close the door on all small WiMax service providers being able to sustain long term profitability. It does, however, close the door in markets where the large telecommunication companies decide to enhance their services with WiMax. What is left, is to operate a WiMax service in a marginal area where subscribers are few and perhaps less reliable with payments. In such an environment, a first-mover advantage is substantial and it would probably be unlikely a competitor would even attempt to enter

## **5. Strategy for policy makers**

### **5.1 Some Economic Foundations for Wireless Broadband**

#### **Network Effects**

Network externality is an important concept that has existed in telecommunication literature for decades and in the economics literature for well over a century. The basic idea is that when the number of users of a network increases, the value of the network to the other users changes (Liebowitz, 2002, Katz). In the context of telecommunication, positive network effects exist when an increase of network users raises the value of the network for other users. This is due to the complementary nature of the components of network (Liebowitz, 2002) and this is also the major reason for universal service advocates for telecommunications.

Many economics literature indicate that as the network size (an increase in the network users) gets larger, the benefit of a marginal network user will rise. However, if the bandwidth of a given network is limited and there is no technology advancement in a short run, as the number of network users grows above the threshold, the marginal benefit of an additional network user might decrease because of the network congestion. Therefore, Marginal Private Benefit (MPB) will rise initially but will decrease when network congestion gets worse (Figure 2).

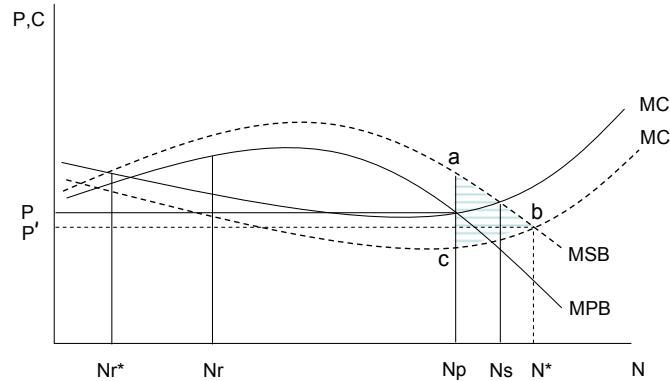


Figure 2: Network Effects and Impacts of Wireless Broadband

There is another important concept for the social welfare analysis of increased wireless broadband usage. The Marginal Social Benefit (MSB) includes direct and indirect benefits of network growth, such as economic development. Since MSB is equal to MPB plus any external benefits that it can create, MSB will be larger than MPB and the size of external benefit will grow as the network size increases.

With respect to the cost structure of broadband network, generally the Marginal Cost (MC) will slightly decrease initially because once the network infrastructure is installed, only network card and cable is required to the curb for an additional user to access the network. Moreover as the number of network user increases the prices of network equipments will decrease. But if the number of network user and network usage increase above a certain level, the network will require a major expansion and thus the MC will increase radically. By definition, when marginal benefit equals marginal cost ( $MB=MC$ ), the profit will be maximized. Therefore where private network providers can maximize their profits at MPB equals to MC ( $MPB=MC$ ) this will also be the appropriate network size,  $N_p$ , for private network providers.

For wireless broadband, the customer specific cost will be lowered since the network cable and the labor cost for laying the cable are not required. Therefore, if the wireless networks are installed, the cost structure will be  $MC'$ . Regarding the social welfare, if wireless broadband could be installed,  $N^*$  is the optimal size of network, since  $MSB=MC'$ .

Some economic theories indicate that  $N^*$  is difficult to achieve only by the actions of private market participants, because the private network providers cannot charge for their production of social benefit. In social welfare analysis, the  $\Delta abc$  will be the welfare loss, which can be restored by proper policy options, such as subsidy.

Rural areas are considered to be less attractive for telecommunications operators, because their geographic characteristics can lead to higher cost and lower revenue. Thus the benefits of wireless broadband mentioned above will help the increase of access to information and communication in these areas.

## 5.2 Welfare Analysis for Wireless Broadband Policy Options

There might be several scenarios for rural wireless broadband according to the combination of private business strategies and public options. However, to establish a simple decision model, we only consider the three basic models in this study: public, hybrid, and private model.

**Public Model.** A public entity deploys and operates a wireless broadband network using tax revenue and supplies free access to all subscribers. This model justifies the cost of the network as public goods for residents and visitors. This model can increase consumer benefit by providing broadband services free but also increase government cost and, as a consequence, consumer cost since the increase of government cost should be made up by additional tax revenue. Therefore, public inefficiency and lack of adaptability to rapidly changing network technologies could be sources of an increase in government cost within this model. Moreover, the open access network can reduce consumer benefit through network congestion by overuse. Therefore, the network supply amount of this model would be  $N_{pu}$  in figure 3(c).

**Hybrid Model (Partially Public Model).** Hybrid model can take many forms according to the combination of public instruments used by local governments. To make the decision model simple, in this study, a local government helps private firms to deploy and operate the wireless broadband network by allowing them to use community properties, such as traffic light poles and roads, in building their infrastructure. The private firms supply wireless broadband services, not for free but at the price that equals the marginal cost of network ( $P=MC$ ), for regular customers. For the disadvantaged residents, special network service programs, such as subsidies and free access, can be provided at the price under the marginal price ( $P<MC$ ) through subsidy or regulation. If this model can be adopted properly, the network supply amount of this model would be around  $N_{hyb}$  in figure 3(b).

**Private Model (Market Driven and No Public Policy).** This model is the case in which local governments do not intervene in telecommunications markets. The network supply of this model will be decided at the point that private marginal cost equals private marginal benefit as  $N_{pr}$  in figure 3(a).

For the purpose of simple analysis, figure 3(a), (b), and (c) show the same marginal benefit and cost structure where marginal benefits are decreasing and marginal costs are increasing. Except rural areas that do not require a large amount of wireless network bandwidth, most communities fall under the situation that figure 3(a), (b), and (c) describe.

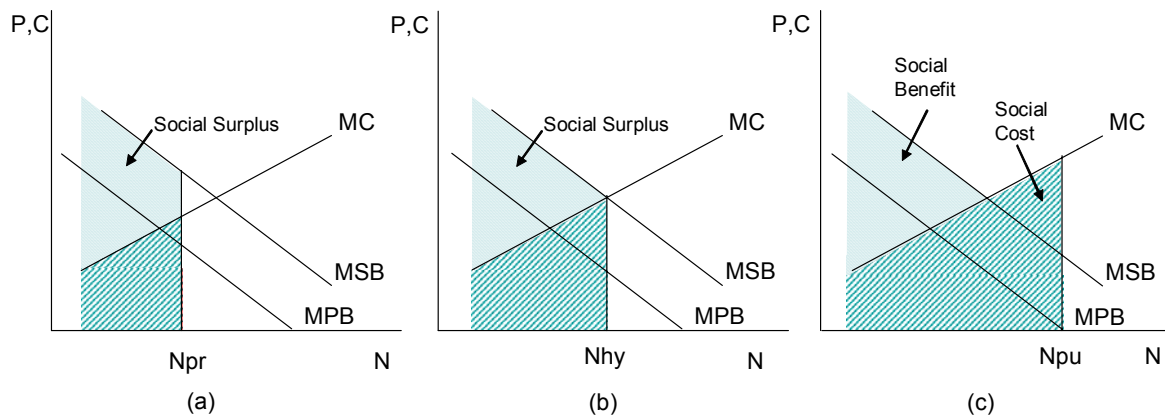


Figure 3: Social Surplus of Policy options

## **6. Summary of WiMax Strategy:**

The BWA industry is moving towards a key inflection point: will the WiMax technology prove superior to the roadmap for cellular technologies? The industry competitive analysis model presents five forces that influence the structure of an industry. The introduction of a substitutable technology is one of those. WiMax represents such a substitutable technology and as such we can expect to see a potential restructuring in the BWA industry. If WiMax does prove out, the cellular telecoms will need to embrace WiMax either as a replacement or enhancement to their existing infrastructure. Can the well capitalized telecoms out compete or absorb any companies entering the market in advance? If pure WiMax data providers leverage their first-mover advantage, can they sustain? This leaves the only viable non-telecom sustainable niches for a WiMax operator to be either in rural or low value markets with little interest to the large cellular telecoms, or municipal/community networks where service can be unique (customer intimacy) and subsidized.

It is difficult to predict what will happen. But our analysis in the papers lays out what can happen. It surely is an interesting future ahead for Broadband Wireless Access!

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