Wireless Broadband Networks: The U.S. Experience

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ABSTRACT: Corresponding to the rise and acceptance of the 802.11 b standard (Wi-Fi) in the United States, wireless local area networks (WLANs) that offer high-speed Internet access at numerous locations in markets that cover education, health care, manufacturing, retail, hospitality, government, and transportation are experiencing rapid growth. There has also been an active establishment of innovative business models to tap into the general demand for high-speed Internet access by creating wireless broadband networks based on clusters of WLANs. This paper outlines the key factors driving Wi-Fi growth and describes competing technologies. Using mini-cases, it explores the strategies of four organizations involved in developing wireless broadband networks (Boingo, Joltage Networks, Sputnik, and NYC Wireless). Although operating in the same market, these organizations offer significantly different access methodologies and services. The nature of possible future innovation in this domain is also examined.

KEY WORDS AND PHRASES: Broadband network innovation, business models, wireless infrastructure, wireless LAN, Wi-Fi, 802.11.

High-speed wireless access to the Internet has witnessed explosive growth in the U.S. market. Wireless local area networks (WLANs) are widely used in markets such as education, healthcare, and manufacturing, and increasingly in retail, hospitality, government, and transportation [7, 9]. Rapidly decreasing prices and home networks have fueled this growth [1]. In the last quarter of 2001, the sales of WLANs increased by 20 percent according to a study by Cahners In-Stat/MDR [3]. The growth in WLANs can be traced to the creation of 802.11b, the IEEE technical standard that enabled high-speed mobile interconnectivity. In 1990, the WLAN concept was created thanks to the efforts of the IEEE 802.11 Wireless Local Area Networks Standards Working Group. Subsequent research and development in this area led to the creation of the 802.11 standard adopted in 1997, and offered speeds of between 1 Mbps and 2 Mbps. In 1999, the IEEE ratified a new rate standard for standard WLANs, 802.11b, also known as Wi-Fi (Wireless Fidelity) upon certification by the Wireless Ethernet Compatibility Alliance (WECA) [33, 34].

Consumer demand for WLAN access, however, was a different matter until recently. It was mainly limited to small, isolated areas in homes or workplaces. A widespread, standardized infrastructure was nonexistent, and the range of local WLAN “hotspots” was limited to a few hundred feet. However, as the demand for wireless connectivity increases, entrepreneurial organizations are using novel methods to create fast-growing organic networks that cluster localized WLANs to develop a nationwide wireless infrastructure. Networks of this kind enable users to roam from one part of a city to another, and between cities, with continuous wireless access to the Internet. These organizations are trying to take WLANs to the next level to provide an alternative to digital subscriber lines (DSL) and cable modems for broadband Internet access for home and business users, and in some cases they use existing cable
and DSL infrastructure to increase the size of their network. This paper compares and contrasts the efforts of four such organizations as they race to gain market share in this exciting area: Boingo, Inc., Joltage, Inc., Sputnik, Inc., and NYC Wireless. These cases are early indicators of a marketplace phenomenon that will ultimately lead to larger players joining the race and perhaps dominating it.

Background

The explosive growth of WLANs can be traced to the creation of 802.11b, the Institute of Electrical and Electronics Engineers (IEEE) technical standard that enables high-speed mobile interconnectivity. The origins of the wireless LAN concept itself go back to the creation of the IEEE 802.11 Wireless Local Area Networks Standards Working Group in 1990. This group was charged with the task of developing a global standard for radio equipment and networks operating in the 2.4 GHz unlicensed frequency band for data rates of 1 and 2 Mbps [21]. What this standard did was to unify an extremely confusing wireless LAN marketplace that had relied on proprietary solutions. The 802.11 standard, adopted in 1997, offered speeds of between 1 Mbps and 2 Mbps. In 1999, the IEEE ratified a new rate standard for standard WLANs, 802.11b, also known as Wi-Fi. The formation of an industry alliance known as WECA, the Wireless Ethernet Compatibility Alliance, was instrumental in promoting interoperability among IEEE 802.11b networking systems. The alliance includes an impressive list of American technology leaders, such as IBM, Cisco Systems, Intel, and Microsoft, and, in addition, a European heavyweight, Nokia. Initially, wireless ISPs like Mobilestar and Wayport rolled out their services under the aegis of WECA [6]. Wi-Fi networks typically provide full network services to notebook PC and desktop PC users with transfer rates up to 11 Mbps at distances of up to 500 feet (152 meters). WECA has thus helped Wireless LAN technology to break loose and compete with access speeds over 1.5 Mbps. Over time, this initial effort led to vendor participation and adoption, the viral take-up of WLAN across consumer geographies, and the eventual success of cooperative industry bodies like WECA and the Wireless Ethernet Alliance (WLANA). The standard came with an array of attractive features, including a wide range of coverage (400 feet), seamless transition between performance levels, rapid scalability, and interoperability through the creation of the Wi-Fi certification process and the establishment of bodies like WECA and WLANA.

However, Wi-Fi has not developed in a competitive vacuum. HomeRF was an early and contemporaneous challenger to Wi-Fi. The new version of HomeRF (version 2.0) certified for use in the United States and Europe provides about 10 Mbps, about the same as 802.11b. Among other advantages, it provides higher-quality multimedia and is more compatible with Bluetooth devices. HomeRF is also less susceptible to interference because it constantly changes frequency through “frequency hopping.” However, Wi-Fi is advancing rapidly over HomeRF thanks to favorable momentum. The market share of HomeRF devices in the WLAN market was reduced from 45 percent in
2000 to 30 percent in 2001 [25]. Nonetheless, HomeRF has an impressive list of backers that expect to carve out a stable market niche in this area. Among them are Motorola, Nokia, AT&T, and Siemens.

Another overlapping technology, Bluetooth, was designed to exchange information across various types of appliances within a short range using a radio frequency. Bluetooth technology originated mainly through the efforts of Ericsson in 1994. The objective was to provide a low-power, low-cost interface between mobile phones and their accessories. Small-appliance makers, including handhelds, are now adopting Bluetooth. However, it has a limited data rate (725 Kbps) and is not capable of running data-intensive applications. Additionally, its short range of 30 feet requires the user to be very close to the access point. Bluetooth is considered a better substitute for the infrared standard (IrDA) but not for Wi-Fi. The deployment of both technologies is expected to continue to grow [5], and eventually they will merge in most commonly used appliances. Some industry observers posit that Bluetooth will be integrated with Wi-Fi to offer the benefits of both. Bluetooth, which seeks to simplify connectivity in the PAN (personal area network) space, is not an inherent competitor to 802.11b, but widespread adoption and rollout of the latter threatens the impact of Bluetooth per se. Therefore the industry might conceivably move toward a hybrid variation of 802.11b and Bluetooth. This, of course, would depend on vendor adoption, and on the types of product and service configurations that can be built using either or both of these standards.

Emergence of Wireless Broadband Networks

In the United States, WLANs are in an exponential growth mode. In 2001, 8 million WLAN chipsets were sold, an increase of 23 percent over the previous year. In 2002, 14 million chipsets were sold, giving an increase of 75 percent [8]. Overall, InfoDesign Corporation expects WLANs to grow at a compound annual rate of 41 percent for the next two years. The largest growth segment is homes and small offices. WLANs for the home and small businesses are expected to grow by 103 percent and for the enterprise by 32 percent [24]. By 2006, homes and small businesses will account for 58 percent of the total WLAN market.

This growth is partly fueled by a significant reduction in the price of equipment and home networks. Increasing numbers of households own more than one computer per household. Because computers are the primary gateway to the Internet, all the computer users in a household need simultaneous access to the Internet. The deployment of DSL and cable modems has provided broadband access to the Internet, but the computer users in a household cannot all access the Internet unless there is a home network providing the gateway. WLANs have targeted this rapidly growing need. If there is a WLAN in a household, every computer with a WLAN network interface card (NIC) is connected to the Internet without rewiring the house for network connections or spreading cables openly in hallways. The rapid reduction in the price of the hardware required for WLAN has enabled more households to set up WLANs. Today, a wireless LAN NIC can be purchased for less than $75 and access
points for about $150. Prices are still drastically dropping, providing general users with access to WLANs.

Along with the growth of private WLANs, public WLANs have emerged. Public WLANs provide wireless Internet access at public places, such as airports, hotels, cafes, libraries, malls, convention centers, and hospitals. It is expected that 21 million people in the United States will access public WLANs in the next five years. At the time of writing, there are 3,700 hotspot public access points in the United States. These are expected to increase to 41,000 in the next five years, generating $3 billion in service revenue [24]. When private and public WLANs are clustered, they create wireless broadband networks.

Two broad models have emerged in building large-scale wireless broadband networks [18]: (1) The top-down approach involves building a network in the traditional way with the network operator charging a fee for access. (2) The bottom-up approach involves loose federations of enthusiasts who offer free access to all [15]. Both models have advantages and disadvantages. The first model is planned, and involves methodical growth. But it requires a huge upfront investment before users will pay for access (and you can’t sell a network before you have built it). The second approach is spontaneous and driven by users, but it requires commitment and involvement of enthusiasts—otherwise, it could be highly fragmented to only few or local hotspots. Users tend to tap into freely available bandwidth in a free and ad hoc fashion, and they also riddle it with abuses. The organizations discussed in the next section have come up with four distinct hybrid models to reduce the problems with the two approaches.

**Wireless Broadband Network Business Models**

Four organizations actively involved in wireless broadband network rollout were chosen to outline the degree of inherent differentiation in market position, top-down or bottom-up type of innovation, and the role of the user/customer. Each organization has adopted a different strategy with respect to utilizing the underlying technology. Each organization provides a unique value proposition in attracting and retaining its customer base. Overall, these organizations represent four major business models employed by various players in building wireless broadband networks.

**Boingo**

Founded by Sky Dayton, the founder of Earthlink, a leading ISP, Boingo is one of the first companies to exploit the rapid growth of wireless LAN demand in the United States. Using a unique, organic model of wireless LAN take-up, the company is rapidly expanding its geographic coverage in the United States [2]. In this context, organic growth is defined in the conventional sense as driven mainly by investment in new products and facilities. Using 802.11b or Wi-Fi as the underlying standard, Boingo allows ultra-high-speed wireless Internet access from airports, hotels, cafes, and many other locations, includ-
ing retail and work-related settings. Users of the service download a piece of software that searches and connects to an available network in their immediate geography. The company has different levels of service and pricing to cater to various types of users. The Boingo Pro service is available for $24.95 a month and includes 10 Connect Days. A Connect Day provides unlimited access in a Boingo location for up to 24 hours, and includes the ability to disconnect and reconnect within each 24-hour period from the same location at no additional charge. Each additional Connect Day is just $4.95 with this plan. The Boingo Unlimited service is for frequent travelers and others who desire unlimited monthly usage, and costs $74.95 per month. Finally, the Boingo As-You-Go service is a pay-per-use facility priced at $7.95 per Connect Day. Other enhancements include centralized account management, a location directory for wireless hotspots, and customer service and support on a 24/7 basis. The company has teamed up with a number of wireless Internet service providers to extend network coverage. Current alliance partners include Wayport, Surf and Sip, Nomadix, RoomLinx, Air2Lan, Pacific Direct Connect, HereUAre, and AirPath [2]. Boingo also provides wireless broadband coverage in airports, including Austin-Bergstrom, Dallas/Ft. Worth, San Jose, Seattle-Tacoma, and Los Angeles (partial coverage), and hospitality chains, such as Hilton Hotels, Four Seasons, Sheraton Hotels, Ramada Hotels, Wyndham Hotels, Holiday Inn, Radisson Hotels, and Marriott Hotels.

Boingo’s business model is an example of top-down delivery of wireless access through a network of reliable service providers, with top-end infrastructure and coverage. This type of model is similar to current Internet access providers including dial-up ISPs and cable modem/DSL broadband service providers. Early on, Sky Dayton realized that the problem with Wi-Fi access was the difficult, if not downright unpleasant, customer experience, usually involving clumsy set-ups with the different PC cards or software that had to be used at different access points. Because there were multiple Wi-Fi operators, travelers had to have multiple Wi-Fi access accounts. A big downside of this situation was that customer service among the hundreds of Wi-Fi networks was virtually nonexistent. Seeing this market opportunity, Boingo collaborated with several (independent) networks and “stitched together a heterogeneous amalgamation or patchwork of different networks into a single, seamless experience for the end user” [17]. The underlying value proposition was to create a service directed at serious users who demanded reliability, service, and hassle-free access to the wireless Internet. While this model is attractive in the end, short-term growth is somewhat restricted by the ability to grow the network through partnerships. Interestingly, other models have evolved that capitalize on the organic network growth phenomenon by using the end-user as a partner in the network. A prime example is Joltage Networks, which is described below.

**Joltage Networks**

Joltage Networks, based in New York City, offers wireless Internet access using the 801.11b or Wi-Fi standard in an innovative delivery model that combines
the resources of network players and an organically growing user base. Here, the notion of organic growth refers to traditional investment-driven growth in parallel with community-driven network growth of users. These notions will be examined in detail in a later section. The parent company of Joltage is Organic Networks, Inc., which considers itself a wireless ASP and intends to develop the world’s largest network of public access, broadband wireless data hotspots [14]. A significant number of Internet users in the United States are connected through wired broadband services, including cable modem and DSL. By installing relatively inexpensive equipment at the site, they can convert their wired broadband environment into a wireless LAN environment and access it through wireless modems installed in their notebooks or handheld computers. The coverage can start from an area with a radius as small as 100 feet. The idea behind organic wireless ASPs is to get some of these users to share their network with other Joltage users, in return for reciprocal privileges elsewhere in the network, and to provide, for those who are so inclined, revenue-sharing possibilities based on the number of users they share their wireless access with. Thus, each wired broadband user can, in effect, become a Joltage provider by joining the network. The provider program enables users to download the Joltage free provider software and transform their access point and broadband connection into a Joltage hotspot. The Joltage Hotspot operates as a provider of high-speed wireless service to the public. Joltage tracks the wireless usage of the hotspot providers and pays them 50 percent of net revenues at the end of their payment period. This can be an attractive proposition to wired broadband users who do not use their access for extended periods. Another attraction is that Joltage does not charge a franchise fee. To turn a user location into a hotspot, the only cost incurred by the provider is that of a computer, an access point, and a broadband connection. For deployment of Joltage Wireless hotspots, Joltage provides a simple, downloadable, and free software application and Web site, which are seamlessly integrated with a comprehensive suite of back-end services, including accounting software, billing and payment software, and administration software. Together, these enable the Joltage Provider to launch and manage their hotspots.

In addition, much like the Boingo business model, Joltage offers users wireless Internet access at a fee. There are two simple pricing plans. One allows monthly access at $24.99 for up to 60 hours and 500 MB data download. The Pay As You Go plan is $1.99/hour, with a 1 hour minimum, billed at 15-minute increments thereafter. This service is targeted at users who want reliable, seamless wireless Internet access, and do not want to go to the trouble of joining the provider network. Like Boingo, Joltage offers a location finder, centralized account management, and customer support. Thus, through a combination of user-generated hotspots and company-driven network coverage, the Joltage Network hopes to deliver to consumers full, untethered, high-speed access to all Internet activities.

Sputnik

Sputnik, started by the co-founders of Linuxcare, builds its business model on the same open-source principles (Linuxcare offers paid technical support for
the open-source Linux operating system, plus a free searchable knowledge base and other resources. www.linuxcare.com). Based in San Francisco, Sputnik “envisions a world in which broadband wireless connectivity enables people to move about freely while maintaining connections to email, the Web, instant messaging, and all other Internet services” [29]. It expects to become a leading open platform for wireless applications and services, just like what Apache is for Web applications.

Sputnik provides its registered users with free access to its public Wi-Fi network, but expects to generate revenue through services, charging for the high-security corporate version of its software, and selling high-end Wi-Fi equipment to corporate customers. It sells Sputnik Enterprise Gateway software, which provides private, secure, Wi-Fi based WLAN for the enterprise. In addition to free access, another differentiating aspect of Sputnik is its unique software, Sputnik Gateway. Sputnik provides open-source-based software that anyone can download from its Web site. The software provides the user with free access to Sputnik’s network. In addition, users who have an Ethernet port can even create a local network with other wired users to provide them with Internet access. Governed under the General Public License and other open-source licenses, the software is continuously improved by a group consisting of more than 175 volunteer developers in addition to the company’s own developers. These developers are building additional modules for voice over WLAN, intrusion detection and protection, and VPNs.

The Sputnik network is built up through a combination of Sputnik’s own network and public gateways created by individual users (Sputnik Gateway Affiliates) using Sputnik Gateway software. Affiliates use the Sputnik software to share their bandwidth (through DSL/Cable) to the network and create a hotspot. Sputnik has more than 200 such hotspots in major cities like Detroit, Los Angeles, New York, the San Francisco Bay area, Seattle, and San Diego. The use of the network is free to all users. However, the company plans to eventually convert the network to a paid-subscriber basis for those who want to use the network but do not want to become affiliates. Affiliates and volunteer developers who have contributed to the development of the software will continue to receive free roaming access to the network. Taking a cue from Sputnik, competitors like Boingo have begun to support free community-access points where subscribers can make the service available to others free.

This model creates a community-based support system in which each member contributes money, bandwidth, or programming expertise to sustain the community.

**NYC Wireless**

NYC Wireless is a free public network that grew out of the New York City metropolitan area and was established with the objective of providing free wireless service in parks, coffee shops, building lobbies, and other public spaces [23]. Its approach to network building and development is centered on the notion of physical communities and neighborhoods. By developing these local-level NANs (neighborhood area networks), NYC Wireless also hopes to serve as a forum for idea exchange, education, and community enrichment.
In addition, the company also seeks to promote the research, development, and use of the next-generation of mobile ad-hoc wireless mesh networks. Through these activities, NYC Wireless hopes to build the world’s largest free, urban, public wireless Internet network.

Through on-line discussion groups, workshops, and meetings, NYC Wireless provides information about wireless Internet technology to individuals who wish to arrange their own wireless access points as well as developers of wireless technology. Over time, it expects to build a viable service model that allows environments like hospitals, malls, office complexes, and gated residential communities to operate their own wireless LAN networks.

NYC Wireless has an established presence in the New York metropolitan area (its main competitor being Joltage) as well as the Bay area in California and Seattle. NYC Wireless operates just like the Free Community Points Service offered by Boingo, except that it goes one step further and is free for everyone, including the hotspot provider. Its model is almost contrary to that of Joltage. Bryant Park in Manhattan is one of NYC Wireless’s well-known partners, but any real estate facility can become a partner free. Its wireless broadband service is already available in parks, coffee shops, and building lobbies in numerous Manhattan locations. NYC Wireless and similar community networks are springing up across the United States, aided mainly by generous Wi-Fi users and philanthropic organizations. Some comparable examples are Seattle Wireless (www.seattlewireless.com), NoCatNet (nocat.net), and the Personal Telco Project (www.personaltelco.net). These alternative networks may prove to be a major challenge to the top-down models of network deployment.

Discussion

After providing a brief theoretical background and comparative analysis that can be used to examine business models in the evolving domain of wireless broadband networks, this section presents several concerns that will be of importance in the future.

Theory-Grounded Comparisons

The rise of wireless broadband networks is a phenomenon that needs to be examined in the prior literature and in theory. Given the novelty of the phenomenon, there is little in the way of a concrete theoretical framework. However, some researchers have used frameworks from strategy and marketing literature to cast further light on the topic. An analytical approach grounded in scenario-based planning can be used to determine future evolutionary patterns in the industry. In particular, McClelland discusses how these scenarios can be progressively built using a network-centered view, an industry-structured view, a marketing and customer view, and then finally a more global and broad-based view [19]. The Infocom Research Project at Lund University in Sweden has identified several possible frameworks that might be of rel-
As the industry matures, one can also envision using Porter’s five forces framework to understand its competitive framework and to examine strategies for new entrants [26]. Herslow, Navarro, and Scholander propose the use of the Delta Model, which connects strategic position with the level of customer bonding and adaptive processes that links strategy to execution [13]. The Delta Model defines strategic positions that reflect fundamentally new sources of profitability, provides strategic alignment with the firm’s internal activities, and introduces adaptive processes that allow the firm to respond to uncertainties. These are all issues that new entrants in the wireless broadband sector have to deal with. Hamel proposes a closer examination and “unpacking” of the core business model for new and potentially revolutionary technologies [11]. These include examining aspects of the business model as they relate to core strategy, strategic resources, the customer interface, and the wider value network. Further insights can also be obtained from the marketing and e-business literature. In particular, the ideas of first-mover advantage, viral marketing strategy, and the role of user communities and open-source innovation can be used to examine specific aspects of the wireless broadband value proposition [10, 12, 16, 32].

The four wireless broadband providers described in the preceding section differ significantly from one another along a number of important dimensions. Using the business model typology outlined by Timmers, wireless broadband networks can be characterized by their high degree of innovation, in parallel to a high degree of functional integration [30]. It is important, therefore, to identify the elements of innovation and integration that contribute to this phenomenon. With the above theoretical perspectives as a background, these elements will be described briefly, and the providers will be compared and contrasted (see Table 1). This analysis is intended to provide a more comprehensive understanding of the market landscape in this emerging area. The three major areas along which these broadband wireless providers differ in respect to their innovative and integrative capacities are the nature of the network, the user experience, and the role of technology.

In the network area, several possible aspects can be differentiated. First, there is the type of network building involved in each business model. This could be a top-down model, as exemplified by Boingo, or a bottom-up model, as exemplified by Sputnik. Each of these network-building modes has its advantages and disadvantages. In the top-down model, the key objectives are reliability, stability, and predictable pricing policies and incentives. Large network operators with financial resources and an existing customer base in complementary areas are ideally suited to provide top-down coverage. In the bottom-up model, innovation and experimentation are the key operating modes. As a result, the range and quality of coverage are sometimes fragmented. However, in areas with a significant presence of technically sophisticated users, this type of network building model can grow and flourish.

The networks can be further classified based on their financial objectives. They may be commercially driven (like Boingo) or have more altruistic motivations (like NYC wireless). Associated with each network model is a set of costs to the end-user. In the case of NYC Wireless, for example, the cost to the end-user is zero (most cost-effective). On the other hand, commercial networks
like Boingo have low costs associated with their use. What is significant is that all of these networks are comparatively cost-effective to end-users as long as broadband access and wireless hotspots are widespread and on a growth curve. Another dimension along which one can categorize the network aspect is by looking at the locus of leadership at which the evolution of the network takes place (referred to here as the leadership role in network evolution). In the case of Boingo, the network operator takes the lead and is responsible for operational challenges like network rollout, and strategic issues like technology choice and integration. In the case of NYC Wireless, community leaders and volunteers take the initiative in charting the broader goals of the organization.

In the user area, these models differ on three major dimensions: user involvement, role of community, and openness to co-creation. User involvement is low to moderate in the Boingo and Joltage models, but high in the case of Sputnik and NYC Wireless. Similarly, the role of the community in determining policies and the code of behavior is high in community-oriented models like Sputnik and NYC Wireless, and low in commercial models like Boingo and Joltage. Commercial models have very rigid policies regarding co-creation with users. In most cases, these stem from the firm’s strategic decisions or strong desire to maintain the security and robustness of the network. By contrast, the other two types of models are a lot more flexible on the idea of co-creation with users.

In the technology area, technological robustness, network dependability, and incentive to technological upgrade are three dominating factors differentiating the models. A network is not one overall product, like a piece of software—it is a conglomeration of independent access points, like a chain with various individual links. Therefore, its strength and robustness lie in the technical capacity and robustness of the individual access points. Because net-

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### Table 1. Model Comparisons.

<table>
<thead>
<tr>
<th></th>
<th>Boingo</th>
<th>Joltage</th>
<th>Sputnik</th>
<th>NYC Wireless</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network</strong></td>
<td>Top-down</td>
<td>Mixed</td>
<td>Bottom-up</td>
<td>Bottom-up</td>
</tr>
<tr>
<td><strong>Type of network</strong></td>
<td>Commercial</td>
<td>Commercial</td>
<td>Semi-commercial</td>
<td>Nonprofit</td>
</tr>
<tr>
<td><strong>Cost effectiveness</strong></td>
<td>Low</td>
<td>Moderate</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td><strong>Leadership role in network evolution</strong></td>
<td>Network operator</td>
<td>Network operator</td>
<td>Individuals</td>
<td>leaders and volunteers</td>
</tr>
<tr>
<td><strong>User</strong></td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>Role of community</strong></td>
<td>None</td>
<td>Low</td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td><strong>Openness to co-creation</strong></td>
<td>Rigid</td>
<td>Rigid</td>
<td>Flexible</td>
<td>Semi-flexible</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
<td>Very low</td>
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<tr>
<td><strong>Technological robustness</strong></td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
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<tr>
<td><strong>Dependability</strong></td>
<td>Moderate</td>
<td>High</td>
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<td>Low</td>
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<tr>
<td><strong>Incentives to technological upgrade</strong></td>
<td>Moderate</td>
<td>High</td>
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</table>

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works based on commercial models are guided and operated through strict policies and administrative structures, they have a relatively high level of technological robustness. They are also more dependable than other models in terms of continuous availability of network services and backhaul capacity. On the other hand, community-oriented networks tend to be less robust and more prone to technical breakdowns, often because of incompatible technologies or misuse of the network.

Overall, each of these four business models provides a unique value proposition. Boingo offers hassle-free, high-quality, secure access to “professional” users. Joltage provides an additional source of income for small and medium-size enterprises that deploy WLAN for their own use. Sputnik targets both amateur enthusiasts and technically well-informed professional users with differentiated offerings. NYC Wireless offers a free public good that may contribute to efforts to reduce the digital divide.

**Emerging Concerns**

Each of the four organizations described in this article needs to pay close attention to several areas that could potentially affect its market performance and perception. Overall, each of these players faces seven major concerns:

- network effects
- security challenges,
- threat of commodization,
- value network innovations,
- industry consolidation
- innovation absorption capabilities, and
- technological evolution

**Network Effects**

Many information and communication technologies are affected by what economists call network externalities [28]. The value of a network to one user of the network depends on how many other users use it. As the installed base of users grows, the network becomes widely available, and more and more users will prefer to join it. Thus, supply directly affects demand and usage. Building critical mass is a key imperative for WBN survival and growth.

**Security Challenges**

Security is a key loophole of Wi-Fi networks that can be exploited by knowledgeable hackers. Although Wi-Fi automatically encrypts data during transmission, VPN is often added for access to corporate networks to add another layer of protection. Wired Equivalent Privacy (WEP) incorporated in WLANs uses either a 40-bit or a 128-bit RC4 encryption mechanism, typically implemented in the NIC’s hardware to minimize performance degradation [20].
Each of the service providers should deploy the best-of-breed security solution across its network and allow customers to choose their desired level of security. In the race to gain market share, this might seem like a costly investment at the outset, but attention to it could avoid problems with lawsuits down the road. Since community-based networks are more prone to security challenges, they will have to promote technological sophistication for their members/users and, in some cases, even provide basic training through community technical groups.

**Threat of Commodization**

Each of the four wireless access providers faces a severe threat of commodization in the end. As technology becomes cheaper and more widely accessible, access rates are bound to drop, just as they did with dialup ISPs. In the medium to long term, consumers will be looking for continuous and unlimited on-line access at flat-rate pricing. It is well known in the industry that the mobile customer is a “moving target” [22]. Mobile customers of the future will expect broadband connectivity at commodity prices. With subsequent improvements in the technological infrastructure, the access market is likely to move in that direction. There is considerable doubt whether the WISP model, with its high operating costs can be profitable in the end for current mobile operators. Some studies posit that the wholesale model, which connects large Internet, telecom, and media companies to network access points that in turn are passed on to end-users, shows more financial potential [31]. Beneficiaries of a wholesale WLAN take-up include hardware and networking providers like Cisco, Intel, Atheros, and Intersil.

**Value Network Innovations**

Despite the uncertainties, it is clear that the real value that can be created and delivered lies at the top of this infrastructure through innovations by the complementing value network. Complementing businesses and information providers need to provide customers with a unique mobile broadband experience through engaging and useful services, user-friendly integration, and unparalleled access to mobile multimedia content [27]. Only then will the true value of the technology be unleashed. At that stage, the service metrics that make the critical difference will include reliability, geographical network coverage, security, value-added services, and innovative alliances with compelling content providers. Therefore, each of these providers needs to figure out a sustainable competitive differentiation and positioning strategy.

**Industry Consolidation**

Another offshoot of growing competition will be industry consolidation across geographies. Consolidation will happen not only because of industry matu-
rity and price competition, but also because of the importance of universal access for end-users. Either smaller players will be acquired by large players, or equal players will develop a wider network that competes head-on with large competitors. Community-based models will add another twist to such consolidation, whereby a user may choose to join multiple networks to increase personal access. So community-based models, in effect, will consolidate through evolution.

**Innovation Absorption Capabilities**

The rise of Wi-Fi should be viewed against the background of the growing importance of the global networked enterprise, characterized by knowledge exchanges across organizational borders in an increasingly mobile domain. To ensure that the next layers of innovation can be built on top of the Wi-Fi standard, these industry participants not only need to exploit their individual competencies, but must also learn from the successes and failures of other firms across industries. Each of the competitors in this space will have to develop competencies in (1) the ability to gather market research insight into customer needs and adoption patterns, (2) rapid competitor and collaborator assessment, (3) understanding the rapidly changing mobile marketspace, and (4) the ability to integrate newer versions of the enabling technology.

**Technological Evolution**

Even as Wi-Fi gains widespread acceptance, the underlying technology is changing rapidly to provide more throughput to enable data-intense applications and multimedia experience on wireless. Efforts to set standards for the wireless technology began in 1990, but important standards did not emerge until 1997. The industry first embraced the initial 802.11 standard, followed by 802.11b. These two standards depend on older modulation technologies (Frequency Hopping Spread Spectrum and Direct Sequence Spread Spectrum), due to which they provide less throughput with the same bandwidth. Higher throughput needs prompted the development of orthogonal frequency division multiplexing (OFDM) and have given the rise to two new standards: 802.11a and 802.11b. Table 2 compares current and emerging standards in the WLAN area.

The 802.11a standard, approved by the IEEE at the same time as 802.11b, provides for data rates of up to 54 Mbps at 5-GHz frequency. This higher data rate makes 802.11a ideal for transmitting high-quality video signals and music. The technology is also less prone to interference than Wi-Fi, which shares its 2.4-GHz bandwidth with cordless phones, baby monitors, Bluetooth network devices, and microwave ovens. At the time of writing, 802.11a is available commercially, but it is more expensive and incompatible with 802.11b. The availability of multimode 802.11 NIC is expected to reduce the current problems in interoperability.

The 802.11g standard, now under development, operates on the same frequency as 802.11b. It is backward-compatible with 802.11b and similarly prone
to interference, but like 802.11a it provides much faster data speed. This new standard is expected to eventually replace the current Wi-Fi.

**Conclusion**

In the past year, the telecommunications and networking industry in the United States has witnessed an intriguing phenomenon. While the industry was focused on the next generation of cellular wireless networks, Wi-Fi based WLANs grew rapidly, but unexpectedly, to provide wireless broadband access to millions of people. Several small, entrepreneurial organizations took advantage of this unexpected opportunity to cluster WLANs to develop wireless broadband networks. While traditional wireless telecom companies, based on cellular technology, are bleeding from a combination of poor business judgment and misguided telecom policy, these new wireless network organizations are expanding their operations and networks exponentially.

This phenomenon is expected to continue in the near future, posing a significant threat to the parallel cellular wireless network. Cellular networks were designed for and cater to mobile phone users. Transmission of voice was the networks’ primary objective. As the data needs of mobile phone users grew with wireless access to the Internet and text messaging, cellular technologies improved over generations, per se 2G, 2.5G, and 3G. WLANs, on the other hand, were designed for wireless data needs. As voice and data technologies converge, wireless broadband networks will be able to provide voice over WLANs (VoWLAN) and thus will provide all of the functionalities of cellular networks—but more effectively. The VoWLAN market expanded from 20,000 handset shipments in 2001 to more than 80,000 shipments in 2002 and is expected to surpass half a million units by 2006 [4]. The current crisis in the telecommunications industry has affected the pace of innovation and the deployment of new infrastructure by cellular networks, thereby creating an opportunity for wireless broadband networks to catch up with them in terms of functionality and wider coverage. If early trends are any indication, broadband wireless access through Wi-Fi and its successor standards will take the lead over cellular networks in the United States in the near future.

In addition, WBNs may undermine the revenue and strategic position of traditional dialup ISPs and DSL/Cable modem operators, such as AOL, MSN,
Verizon, and Optimum Online. To a significant extent, WBNs provide the same services as the traditional players, with much more ubiquitous and convenient access. The cost structure of WBNs is much smaller in scale and more flexible.

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