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WHY WI-FI WANTS TO BE FREE

As the telecommunications industry wavers,
a global grassroots movement is building the
next-generation wireless network.

While wireless carriers around the world
have battled through the telecom bust, a
grassroots movement has quietly deployed
no-cost open wireless hotspots in cities
across the globe. In the process, these activists have transformed 802.11b wireless local area network (WLAN) technology from an indoor novelty for cable replacement to an outdoor amenity that transforms the urban landscape—key developments of this grassroots wireless movement are highlighted here. The community-based open wireless movement that has taken root in cities around the world in the last two years has demonstrated an alternative model for the widespread diffusion of wireless broadband networks. The experiences of early efforts in this area offer many insights

PUT SIMPLY, WIRELESS NETWORKS WANT TO BE FREE. BY "FREE," WE MEAN THAT HOMES, OFFICES, AND PUBLIC SPACES WILL INCREASINGLY BE EXPECTED TO PROVIDE HASSLE-FREE WIRELESS BANDWIDTH.

into the possible futures for wireless networking.

Like the Internet and Web, wireless LANs became a mass market technology due to open standards that unleashed powerful competitive forces and innovation. While many WLAN technologies were being sold throughout the 1990s, it was the establishment of the 802.11b standard by the IEEE, followed by Apple's aggressive launch of the Airport line of WLAN products in 1999 that set the stage for mass market development. After many other market entrants, by the summer of 2002 there were an estimated 15 to 18 million 802.11b networks [3].

Affectionately renamed "Wi-Fi" (for wireless fidelity) by a consortium of manufacturers, 802.11b quickly edged out competing WLAN standards. Even Intel ceded victory, abandoning the competing HomeRF WLAN standard in early 2001 and throwing its weight behind Wi-Fi. By fall 2002, Wi-Fi emerged as a serious threat to so-called "third-generation" cellular data networks, a long anticipated upgrade to wide area wireless networks [2].

The 802.11b standard was open, which allowed many manufacturers to quickly enter the WLAN market. In 1999, WLAN base stations cost as much as $1,000. Competition continually drove prices lower, and at the time this article was written the average price of a Wi-Fi base station was just $100. Client devices experienced similar rapid price declines, dropping to less than $50, and were quickly integrated as standard equipment in new laptops and handheld computers.

Building the Hotspots

As the number of Wi-Fi client devices and users grew during 2000–2002, a massive worldwide initiative began to deploy network infrastructure to support this new broadband medium. New and old firms were motivated to deploy infrastructure in places where early adopters would congregate. In South Korea, Japan, and Singapore, wireless carriers raced to deploy Wi-Fi hotspots at popular gathering places. These Asian hotspot networks leveraged high rates of mobile Internet use with the density of Asian cities to create a successful business model, typically charging the equivalent of $15–$20 for

unlimited Wi-Fi access throughout the network.

In the U.S., wireless hotspots were targeted toward business travelers and were deployed at locations frequented by business travelers, such as airport lounges, upscale hotels, and coffee-shop chains. However, unlike in Asia, cellular carriers did not directly own the U.S. hotspot providers. Consumers were slow to subscribe, driven away by average monthly fees of over $50, very limited network coverage, and the proliferation of free Wi-Fi hotspots. By summer 2002, one of the largest U.S. hotspot companies, MobileStar, was bankrupt. Not surprisingly, the company later re-emerged as a division of T-Mobile USA, a cellular carrier seeking early entry to the WLAN access market.

Hotspot providers (at least in the U.S.) had a challenging road to profitability in a world where unmetered Wi-Fi broadband was increasingly plentiful. Driven by the rapid drop in the cost of Wi-Fi hardware, no-fee wireless networks were popping up everywhere—in universities, offices, city parks, and homes. Dartmouth University's open network in New Hampshire alone boasted over 500 nodes covering many of the campus buildings and grounds [3]. By the fall of 2002, there was a good chance that anytime you walked onto a university campus or into a large office building, its owner would be offering free Wi-Fi connectivity as a basic amenity.

Thus while pay networks experienced slow subscriber growth, property owners and building managers moved quickly to provide the valuable amenity of wireless connectivity within their spaces. Like the Internet a decade earlier, the idea of a "wireless cloud" spread from universities into the broader market. Once it reached homes and businesses, taking it outdoors was the next step. This would be the province of the free wireless movement.

The Rise of the Open Network

As Wi-Fi spread quickly in 2000–2001, activists and hackers around the world began testing the limits of what could be achieved with this exciting new technology. The most novel of the resulting innovations was the redeployment of Wi-Fi to provide connectivity not only indoors in homes and offices (the

original design goal), but also outdoors in parks, porches, and plazas. These activists quickly found each other through email and Web connections, and began organizing volunteers and deploying cooperative public wireless networks.

The hotspots deployed by these grassroots wireless-networking groups were a dramatic departure from the pay hotspots set up by companies such as T-Mobile. Instead of requiring expensive usage fees, these networks would be open to all at absolutely no cost. Instead of extensive security layers designed to thwart eavesdropping, users would be expected to provide the desired level of security themselves using existing tools like SSH, SSL, PGP, and VPNs.

The spread of these free wireless networks was rapid. Most places where you would want wireless bandwidth already had wired bandwidth in abundance. Creating a hotspot was just a matter of installing a wireless base station, or access point, and advertising its presence through any of several means provided by the open wireless community.[1] For larger areas or outdoor spaces such as parks and plazas, directional antennas and amplifiers could be used to sculpt a coverage zone using the meager one watt of power permitted by the FCC for unlicensed operators in the 2.4GHz band.[2]

Individuals had many incentives to contribute to expanding the free network. First, there was a sense of mutual cooperation: "I will set up my free node in the hopes that others will too, and I will have access when I'm away from home." Second, similar to the open source software movement, there was a certain amount of prestige in the wireless networking community for those who were node operators rather than merely users. Finally, the utopian dream of completely undermining the stranglehold of cellular and landline telecommunications companies was an enticing goal.

After two years, the free network movement has established beachheads in every major American city, and throughout Europe and Australia. This free public hotspot network serves more varied locations than any commercial Wi-Fi network. From Manhattan's Bryant Park to Portland's Pioneer Square, in independent coffee shops and on the stoops of Brooklyn brownstones, the main database of open wireless networks lists over 300 hotspots in the U.S. alone (see the NodeDB Web site: www.nodedb.

com). In major cities, the open wireless network now rivals leading commercial WLAN networks. For example, at the time this article was written, in New York City the NYCwireless network (95 active nodes) was competing with the two main pay wireless LAN systems operated by T-Mobile USA (120 nodes) and Wayport (3 nodes) [9].

The free wireless movement's overall sustainability is being bolstered by expanding participation and partnership beyond the core group of individuals who started it. Spearheaded by NYCwireless' incorporation as a non-profit organization in April 2002, and resulting from collaboration with many existing businesses and government agencies, the constituency of support behind the idea of ubiquitous, free (to the user) wireless networks is rapidly growing. But why do free wireless networks have such widespread appeal?

It is the expert opinion of the authors that the popularity of open wireless networks is a combination of open standards and the benefits of mass-production and interoperability they bring, and the intrinsic value that a wireless "cloud" brings to the place in which it is located. Compared to the typical cost of waste disposal or powering the lights, bandwidth is inexpensive. For example, maintaining the Bryant Park Wireless Network and leasing its T1 backbone connection costs less than the park spends on trash bags![3] Thus it makes more economic sense for building owners, schools, and even entire neighborhoods to deploy their own open wireless infrastructure, rather than to contract this service out to a for-profit provider.

Put simply, wireless networks want to be free. By "free," we mean that homes, offices, and public spaces will increasingly be expected to provide hassle-free wireless bandwidth. Open wireless networks, which do not require users to log on or authenticate their identity, are already widely deployed and offer far easier and more uniform access to the Internet than any pay network might provide. Usage statistics support this conclusion as well—the authors' surveys of pay hotspots in Manhattan rarely find active users, while Bryant Park's network logs an average of over 50 users per weekday.

Dealing With Security Concerns
The most significant remaining obstacle to the proliferation of open wireless networks is security. Numerous articles (including several in this section) have detailed the many security risks of wireless

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[1]These included painting symbols on buildings or sidewalks (warchalking), word-of-mouth communications, local media, telephone hotlines, and the open wireless node and map at www.nodedb.com.
[2]The actual FCC Part 15 regulations governing power levels on unlicensed operators in the 2.4GHz band are more nuanced than a simple one-watt limit. For a thorough discussion, see Regulations Affecting 802.11 Deployment: www.lns.com/papers/part15.

[3]Personal communication, Jerome Barth, Park Manager, Bryant Park Restoration Corporation, Sept. 12, 2002.

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LANs, and great engineering effort is being exerted to address these additional risks. Rather than focus on these shortcomings, let us look at the very viable alternative approaches to wireless security that utilize currently available technology.

First, we must recognize the tools for securing communications over wired networks such as SSH, SSL, PGP, and VPN technologies are just as effective over a wireless medium and are far superior to any current or proposed wireless link layer encryption such as WEP or TKIP.

Second, we must recognize that no single implementation of security precautions will suit every user. In surveys of users of the Bryant Park wireless network, we find varying levels of demand for security in public WLAN situations. Corporate employees requiring the utmost security employ a VPN, while casual users continue to send email passwords in plain-text format even when informed of the risks. Put another way, the market is not demanding the level of security currently being debated and the result is an unnecessary holdup in the mass diffusion of wireless technology.

Third, while users should be responsible for securing their own communications at the desired level, Internet Service Providers should be providing the tools necessary to do so. Currently, we know of no commercial ISP in the U.S. offering individual consumers SSL/TLS-IMAP/POP/SMTP/WebMail-enabled email accounts, even though most of the client software supports all the features. As they develop the market for wireless networks and applications, ISPs should be expected to deploy the basic end-to-end security options their users require.

Free Wireless Groups Around the World

Combining legions of dot-com refugees and a wealth of new technology ripe for tinkering, local gatherings of wireless enthusiasts began organizing during 2000–2001 to confront the many challenges of realizing a free wireless network. While very different in origins and mission, these groups all advocated open standards and open networks in the deployment of Wi-Fi infrastructure.

By working together these activist groups have created a global movement much bigger than the sum of its parts. Each group reflects the unique social and physical characteristics of its community, and under the umbrella of FreeNetworks.Org they have synergistically combined these talents to develop the technology, philosophy, and economic framework of open networks. The hilly topography of the Pacific Northwest has helped shape Seattle Wireless's mission to build a fully independent wireless backbone in that city. In New York, where legal and accounting expertise are in greater abundance than technical know-how, NYCwireless has focused on developing the organizational and public relations infrastructure to grow and sustain a far-flung network of activists.

The grassroots wireless groups fall into three main categories, as defined by their main missions and activities:

- **Educators (Bay Area Wireless Users Group, Green Bay Packet Radio).** The Bay Area Wireless Users Group, BAWUG (www.bawug.org) spawned from PlayaNET, the non-Internet-connected wireless network of Burning Man, a community-based art happening held in the Nevada desert each August. These groups focus their efforts on educating members about wireless technology and providing a forum for discussion.
- **Networkers (Seattle Wireless, Madison Mesh, Consume, Madrid Wireless).** Disenchanted by corporate telecoms, these groups seek to create an open alternative to local telecommunications grids. The goal is to have a completely independent user-run wireless network that spans the metro area.
- **Philanthropists (NYCwireless, Personal Telco Project).** In the pedestrian-friendly cities of New York and Portland, wireless advocates have focused on installing open networks in public spaces like parks and plazas. NYCwireless' Bryant Park Wireless Network has become the city's most popular hotspot and an international symbol of the open wireless movement [1, 4, 8]. In Portland, the Personal Telco Project trumped Starbuck's costly hotspot by providing free access in adjacent Pioneer Courthouse Square [5].

These grassroots groups have shown the world the many possibilities of WLAN technology and

demonstrated that open wireless networks can be deployed in a more cost-effective, usable, and timely fashion than anyone in the technology community thought possible.

The Impact of the Free Wireless Movement

When electrification swept through American cities in the late 19th century it was impossible to predict the many uses that would be spurred by this new amenity (at the time, it was almost exclusively used to power Edison's incandescent light bulbs). It is rapidly becoming clear that wireless data connections, and the supporting networks, are evolving in a similar fashion. Not only will this new amenity be the medium for dozens of still-unrealized applications, but it will be as pervasive, as standardized, and as inconspicuous as electricity. Already, providing wireless connectivity is so inexpensive that charging for access is as counterintuitive as installing a pay phone in your kitchen.

As we realize the possibilities of widespread deployment of open wireless networks, technological changes in devices and network infrastructure will advance hand-in-hand with a variety of changing applications and user needs. Here, we take the liberty of anticipating some of the long-term trends in wireless data communications and the ways they are being challenged and affected by the free networks movement.

Devices

Zero Configuration. The popularity of the mobile phone is based on the century-old technology of the telephone. Signal strength indicators have replaced the dial tone, but the concept is the same—transparent network connectivity from any location. Expect operating systems to continue to refine the automatic wireless network detection features found in Windows XP and Mac OS X. By their nature free networks, which lack authentication procedures, are easier to configure than closed networks.

Ubiquity. Wi-Fi circuitry will get even cheaper, until it is embedded in all portable and handheld devices, even the disposable ones. How will your wristwatch log in to a closed wireless network? It won't have to if the network is open and free.

Mesh Networks. Serious technical problems still thwart the rollout of mesh networks, which replace the hub and spoke topology of current hotspots with a distributed relay system where the users become the infrastructure. A better alternative to this topology involves a hybrid model where

meshed relays extend the reach of wired base station networks, as free networks relay for each other across ever-longer chains.

Networks

The Wireless Amenity. Over the coming years as people experience free Wi-Fi in their homes and offices, on college campuses, at conference centers, and in public parks, they will inevitably come to expect the same easy and cost-free connectivity everywhere. Expect property owners to catch on quickly and take on the comparatively low cost of building out open Wi-Fi hotspots. Today it's impossible to lease Class A office space without a wired LAN infrastructure. In a few years it is inevitable that wireless LANs will complement this requirement. The wireless ISPs will quietly sell off their networks and disappear.

Hotspots Become Obvious. Today's hotspot operators rely on clunky interfaces to their rapidly changing coverage maps. The grassroots open networking groups have improved this scheme by setting up a telephone hotline that directs users to the closest hotspot. As Wi-Fi coverage continues to spread, look for hotspots to become increasingly obvious as property owners develop methods to advertise their wireless connectivity amenity in ways that people remember and seek out as they go about their daily routines or when visiting a new city.

A Hard Road For Hybrid Roaming. The emerging business model for cellular carriers is premised upon using WLAN hotspots to provide broadband connectivity in urban areas, and using dual- or tri-band wireless devices to switch over to wide-area 3G services when the user moves out of the hotspot. As has been noted previously in this publication, once users become accustomed to broadband they are not likely to go back to narrowband [6]. The bandwidth gap between WLANs and 3G data networks is similar in size to that between dialup access and wired broadband. We see a more likely scenario where users would rather travel to the closest hotspot than tolerate a comparatively slow connection. Already in dense urban neighborhoods like Manhattan's Greenwich Village, open hotspots are usually within a five-minute walk of any residence. Expect this kind of hotspot density to start cropping up in enough locations to threaten the revenue potentials of 3G data networks. Caching and automatic syncing based on network availability can eliminate the need for costly multi-band devices that support the wide array of 3G data transport mechanisms. Finally, the development of devices such as Vivato's wireless switch, an intelligent phased antenna array, further complicates

the rollout of 3G services by dramatically extending the range of low-power Wi-Fi devices.

Applications and Outcomes

Unpredictable Users. Just as no one could imagine the varied uses of electricity at the moment Edison lit the first incandescent bulb, users and developers will decide what uses future wireless networks are put to. For example, one of the first organized activities on the NYCwireless network was a wireless version of "Capture the Flag," a game called NodeRunner (www.noderunner.com). Combining the urban scavenger hunt with streaming media and open wireless hotspots, NodeRunner used wireless hotspots to merge virtual and physical worlds.

The Persistence of Place. Widespread open hotspots will reinforce existing face-to-face communities by allowing people to go to the places where they want to be rather than seeking out deskbound terminals. Location-based services will augment the value of interesting places. NYCwireless' Bryant Park Chat System has demonstrated how offline introductions often lead to real in-person get-togethers.

Enhancing Human Interaction. Imagine having every photo you ever took in your life available at a moment's notice during a conversation. Now apply that scenario to your company's entire set of financial records. Ad hoc networks will let us share digital media informally in face-to-face settings the way they are shared over peer-to-peer networks today. Apple's Rendezvous is just a glimpse of the possibilities of ad hoc personal area networks. **c**

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