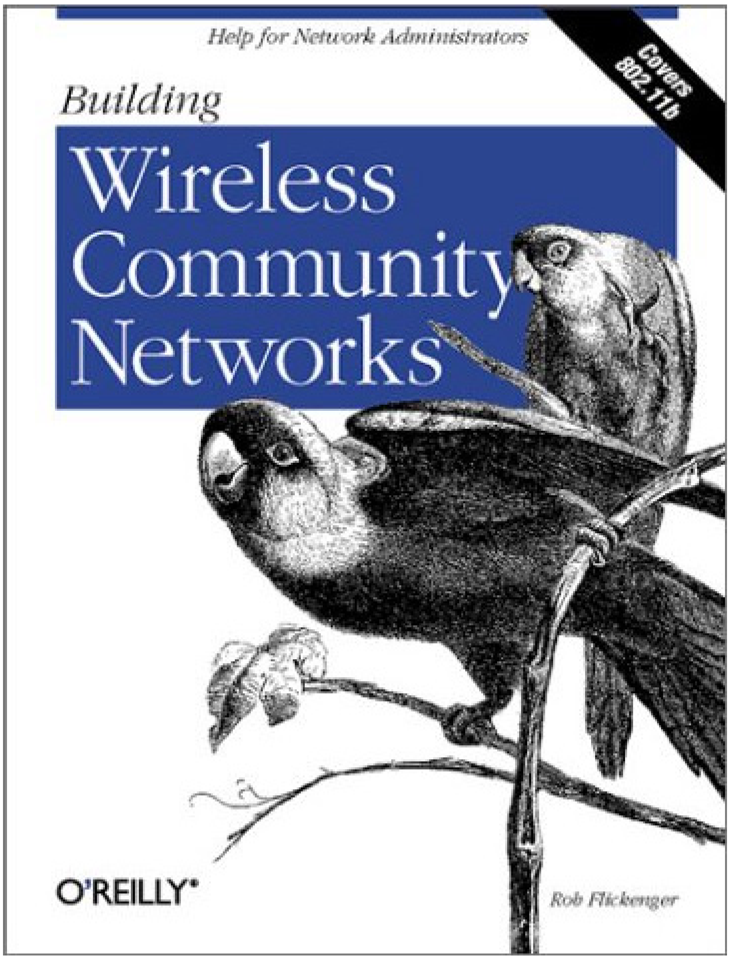

Building Wireless Community Networks

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Building Wireless Community Networks offers a compelling case for building wireless networks on a local level: They are inexpensive, and they can be implemented and managed by the community using them, whether it's a school, a neighborhood, or a small business. This book provides all the necessary information for planning a network, getting all the necessary components, and understanding protocols that you need to design and implement your network.

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Preface

Building Wireless Community Networks is about getting people connected to one another. Wireless technology is being used right now to connect neighborhoods, businesses, and schools to the vast, massively interconnected, and nebulous entity known as the Internet. One of the goals of this book is to help you get your community "unplugged" and online, using inexpensive off-the-shelf equipment.

A secondary but critical goal of this book is to come to terms with exactly what is meant by *community*. It might refer to your college campus, where many people own their own laptops and want to share files and access to the Internet. Your idea of community could encompass your apartment building or neighborhood, where broadband Internet access may not even be available. This book is intended to get you thinking about what is involved in getting people in your community connected, and it will demonstrate working examples of how to make these connections possible.

Audience

This book describes some solutions to the current (but rapidly changing) problem of building a wireless network for community use. It is *not* intended to be a design guide for wireless companies and ISPs, although I hope they find the information in it useful (and at least a little bit entertaining).

This book is intended for the technical user who is interested in bringing wireless high-speed network access to wherever it's needed. This could include extending Internet connectivity to areas where other access (such as DSL or cable) isn't available. It could also include setting up access at a school, where structures were built long before anyone thought about running cables and lines into classrooms. This book should also be useful for people interested in learning about how dozens of groups around the planet are providing wireless access in their own communities. The story of wireless network access is still in its infancy, but it is already full of fascinating twists and turns (never mind its potential!). I hope to communicate what I've learned of this story to you.

Organization

Early chapters of this book introduce basic wireless concepts and essential network services, while later chapters focus on specific aspects of building your own wireless network. Experienced users may prefer to skip around rather than read this book from cover to cover, so here's an overview of each chapter:

- *Chapter 1*, gives a brief history of the state of wireless connectivity and some ideas (and warnings) about how things might proceed.
- *Chapter 2*, is an overview of many important logistical considerations you will face in designing your own network; it describes some tools that may make your job easier.
- *Chapter 3*, provides a detailed description of critical network components that you will need to provide to your users. Network layout and security are also addressed.
- *Chapter 4*, details how to use wireless access point hardware effectively.
- *Chapter 5*, is a step-by-step guide to building your own access point using Linux, inexpensive PC hardware, and conventional wireless client cards.

- *Chapter 6*, is about extending your range. It looks at using topographic mapping software to evaluate long distance links, and it also examines the myriad antennas, cables, and connectors you are likely to encounter. It also provides a simple method for calculating the usable range of your gear.
- *Chapter 7*, investigates some really exotic (and useful!) applications of 802.11b. It includes practical pointers for setting up point-to-point links, some simple repeaters, assembling a 2.4GHz antenna from ordinary household objects, and lots of other fun hackery. It also includes an implementation of a dynamic "captive portal" firewall using open source software.
- *Chapter 8*, is a resource guide to some of the major players in the wireless network access revolution. Here you'll find out how people all over the globe are making ubiquitous wireless network access a reality, all in their free time.
- *Chapter 9*, is the (brief) history of my own experiences in setting up public wireless Internet access in Sebastopol, CA (and in meeting directly with the heads of some of the biggest community efforts in the U.S.).
- Finally, *Appendix A* provides a path loss calculation table, a reprint of the FCC Part 15 rules, and some other useful odds and ends.

Typographical Conventions

The following typographical conventions are used in this book:

Italic

Used to introduce new terms, to indicate URLs, variables or user-defined files and directories, commands, file extensions, filenames, directory or folder names, and UNC pathnames.

`Constant italic`

Used to show variables for which a context-specific substitution should be made.

	Indicates a tip.
	Indicates a warning.

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Chapter 1. Wireless Community Networks

In recent times, the velocity of technology development has exceeded "blur" and is now moving at speeds that defy description. Internet technology in particular has made astounding strides in the last few years. Where only a few short years ago 56Kb modems were all the rage, many tech heads now find themselves complaining about how slow their company's T1 connection seems compared to their 6Mb DSL connection at home.

Never before have so many had free and fast access to so much information. As more people get a taste of millisecond response times and megabit download speeds, they seem only to hunger for more. In most places, the service everyone is itching for is *DSL*, or *Digital Subscriber Line* service. It provides high bandwidth (typically, anywhere from 384Kbps to 6Mbps) over standard copper telephone lines, *if* your installation is within about three miles of the telephone company's CO, or central office (this is a technical constraint of the technology). DSL is generally preferred over cable modems, because a DSL connection provides guaranteed bandwidth (at least to the telephone company) and thus is not directly affected by the traffic habits of everyone else in your neighborhood. It isn't cheap, ranging anywhere from $50 to $300 per month, plus ISP and equipment charges, but that doesn't seem to be discouraging demand.

Telephone companies, of course, are completely enamored with this state of affairs. In fact, the intense demand for high-bandwidth network access has led to so much business that enormous lead times for DSL installations are now the rule in many parts of the country. In many areas, if you live outside the perceived "market" just beyond range of the CO, lead times are sometimes quoted at two to three years (marketing jargon for "never, but we'll take your money anyway, if you like"). Worse than that, in the wake of widespread market consolidation, some customers who were quite happy with their DSL service are finding themselves stranded when their local ISP goes out of business.[1]

One currently circulating meme for this phenomenon deems a stranded DSL customer "Northpointed," in honor of the ISP NorthPoint.net, which went out of business last March, leaving thousands without access.

What are the alternatives for people who want high-speed Internet access but aren't willing to wait for companies to package a solution for them? The telephone companies own the copper, and the cable companies own the coax.

Wireless networking now provides easy, inexpensive, high-bandwidth network services for anyone who cares to set it up.

Approved in 1997 by the IEEE Standards Committee, the 802.11 specification detailed the framework necessary for a standard method of wireless networked communications. It uses the 2.4GHz microwave band designated for low-power, unlicensed use by the FCC in the U.S. in 1985. 802.11 provided for network speeds of one or two megabits, using either of two incompatible encoding schemes: Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS).

In September, 1999, the 802 committee extended the specification, deciding to standardize on DSSS. This extension, 802.11b, allowed for new, more exotic encoding techniques. This pushed up the throughput to a much more respectable 5.5 or 11Mbps. While breaking compatibility with FHSS schemes, the extensions made it possible for new equipment to continue to interoperate with older 802.11 DSSS hardware. The technology was intended to provide "campus" access to network services, offering typical usable ranges of about 1500 feet.

It didn't take long for some sharp hacker types (and, indeed, a few CEO and FCC types) to realize that by using 802.11b client gear in conjunction with standard radio equipment, effective range can extend to more than twenty miles and potentially provide thousands of people with bandwidth reaching DSL speeds, for minimal hardware cost. Connectivity that previously had to creep up monopoly-held wires can now fly in through the walls with significantly higher performance. And since 802.11b uses unlicensed radio spectrum, full-time connections can be set up *without paying a dime in airtime or licensing fees.*

While trumping the telco and cable companies with off-the-shelf magical hardware may be an entertaining fantasy, how well does 802.11b equipment actually perform in the real world? How can it be applied effectively to provide access to the Internet?

1.1 The Problem

An obvious application for 802.11b is to provide the infamous "last mile" network service. This term refers to the stretch that sits between those who have good access to the Internet (ISPs, telcos, and cable companies) and those who want it (consumers). This sort of arrangement requires 802.11b equipment at both ends of the stretch (for example, at an ISP's site and at a consumer's home).

Unfortunately, the nature of radio communications at microwave frequencies requires *line of sight* for optimal performance. This means that there should be an unobstructed view between the two antennas, preferably with nothing but a valley between them. This is absolutely critical in long distance, low power applications. Radio waves penetrate many common materials, but range is significantly reduced when going through anything but air. Although increasing transmission power can help get through trees and other obstructions, simply adding amplifiers isn't always an option, as the FCC imposes strict limits on power. (See *Appendix A* for a copy of the FCC Part 15 rules that pertain to 2.4GHz emissions. We will return to this subject in detail in *Chapter 7*.)

Speaking of amplifiers, a related technical obstacle to wireless nirvana is how to deal with noise in the band. The 2.4GHz band isn't reserved for use solely by 802.11b gear. It has to share the band with many other devices, including cordless phones, wireless X-10 cameras, Bluetooth equipment, burglar alarms, and even microwave ovens! Using amplifiers to try to "blast" one's way through intervening obstacles and above the background noise is the social equivalent of turning your television up to full volume so you can hear it in your front yard (maybe also to hear it above your ringing telephone and barking dog, or even your neighbor's loud television...).

If data is going to flow freely over the air, there has to be a high degree of coordination among those who set it up. As the airwaves are a public resource, the wireless infrastructure should be built in a way that benefits the most people possible, for the lowest cost. How can 802.11b effectively connect people to each other?

1.2 How ISPs Are Attempting a Solution

Visions of license-free, monopoly shattering, high-bandwidth networks are certainly dancing through the heads of some business-minded individuals these days. On the surface, it looks like sound reasoning: if people are conditioned into believing that 6Mb DSL costs $250 per month to provide, then they'll certainly be willing to pay at least that much for an 11Mb wireless connection that costs pennies to operate, particularly if it's cleverly packaged as an upgrade to a brand name they already know. The temptation of high profits and low operating costs seems to have once again allowed marketing to give way to good sense. Thus, the wireless DSL phenomenon was born. (Who needs an actual technology when you can market an acronym, anyway?)

In practice, many WISPs[2] are finding out that it's not as simple as throwing some antennas up and raking in the cash. To start with, true DSL provides a full-duplex, switched line. Most DSL lines are asymmetric, meaning that they allow for a higher download speed at the expense of slower upload speed. This difference is hardly noticeable when most of the network traffic is incoming (i.e., when users are browsing the Web), but it is present. Even with the low-speed upload limitation, a full-duplex line can still upload and download data simultaneously. Would-be wireless providers that build on 802.11b technology are limited to half-duplex, shared bandwidth connections. This means that to provide the same quality of service as a wired DSL line, they would need four radios for each customer: two at each end, using one for upstream and one for downstream service. If the network infrastructure plan is to provide a few (or even a few dozen) wireless access sites throughout a city, these would need to be shared between all of the users, further degrading network performance, much like the cable modem nightmare. Additional access sites could help, but adding equipment also adds to hardware and operating costs.

Wireless Internet Service Providers. No, I didn't make that one up.

Speaking of access points, where exactly should they be placed? Naturally, the antennas should be located wherever the greatest expected customer base can see them. Unless you've tried it, I guarantee this is trickier than it sounds. Trees, metal buildings, chain link fences, and the natural lay of the land make antenna placement an interesting challenge for a hobbyist, but a nightmare for a network engineer. As we'll see later, a basic antenna site needs power and a sturdy mast to mount equipment to, and, preferably, it also has access to a wired backbone. Otherwise, even more radio gear is needed to provide network service to the tower.

Suppose that marketing has sufficiently duped would-be customers and claims to have enough tower sites to make network services at least a possibility. Now imagine that a prospective customer actually calls, asking for service. How does the WISP know if service is possible? With DSL, it's straightforward: look up the customer's phone number in the central database, figure out about how far they are from the CO, and give them an estimate. Unfortunately, no known database can tell you for certain what a given address has line of sight to.

As we'll see later, topographical software can perform some preliminary work to help rule out at least the definite impossibilities. Some topographical packages even include tree and ground clutter data. At this point, we might even be able to upgrade the potential customer to a "maybe." Ultimately, however, the only way to know if a particular customer can reach the WISP's backbone over wireless is to send out a tech with test gear, and try it.

So now the poor WISP needs an army of technically capable people with vans, on call for new installations, who then need to make on-site calls to people who aren't even customers yet. And if they're lucky, they might even get a test shot to work, at which point equipment can finally be installed, contracts signed, and the customer can get online at something almost resembling DSL. That is, the customer can be online until a bird perches on the antenna, or a new building goes up in the link path, or the leaves come out in the spring and block most of the signal (at which point, I imagine the customer would be referred to the fine print on that contract).

I think you can begin to see exactly where the bottom line is in this sort of arrangement. It's certainly not anyone's fault, but this solution just isn't suited to the problem, because the only entity with enough resources to seriously attempt it would likely be the phone company. What hope does our "wireless everywhere" vision have in light of all of the previously mentioned problems? Perhaps a massively parallel approach would help....

1.3 How Cooperatives Are Making It Happen

The difficulties of a commercial approach to wireless access exist because of a single social phenomenon: the customer is purchasing a solution and is therefore expecting a reasonable service for their money. In a commercial venture, the WISP is ultimately responsible for upholding their end of the agreement or otherwise compensating the customer.

The "last mile" problem has a very different outlook if each member of the network is responsible for keeping his own equipment online. Like many ideas whose time has come, the community wireless network phenomenon is unfolding right now, all over the planet.[3] People who have been fed up with long lead times and high equipment and installation costs are pooling their resources to provide wireless access to friends, family, neighbors, schools, and remote areas that will likely never see broadband access otherwise. As difficult as the WISP nightmare example has made this idea sound, people everywhere are learning that they don't necessarily need to pay their dues to the telco to make astonishing things happen. They are discovering that it is indeed possible to provide very high bandwidth connections to those who need it for pennies—not hundreds of dollars—a month.

GAWD, the Global Access Wireless Database, lists 198 public wireless access points at the time of this writing. Check out *http://www.shmoo.com/gawd/* to add your own or search for one.

Of course, if people are going to be expected to run a wireless gateway, they need access either to highly technical information or to a solution that is no more difficult than plugging in a connector and flipping a switch. While bringing common experiences together can help find an easy solution more quickly, only a relatively small percentage of people on this planet know that microwave communications are even possible. Even fewer know how to effectively connect a wireless network to the Internet. As we'll see later, ubiquity is critical if wide area wireless access is going to be usable (even to the techno über-elite). It is in *everyone's* best interest to cooperate, share what they know, and help make bandwidth as pervasive as the air we breathe.

The desire to end this separation of "those in the know" from "those who want to know" is helping to bring people away from their computer screens and back into their local neighborhoods. In the last year, dozens of independent local groups have formed with a very similar underlying principle: get as many people as possible connected to each other for the lowest possible cost. Web sites, mailing lists, community meetings, and even IRC channels