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17 October 2025

Dear Christina

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Cisco Press, Indianapolis, 2007. Shelf mark: YK.2007.b.1648**

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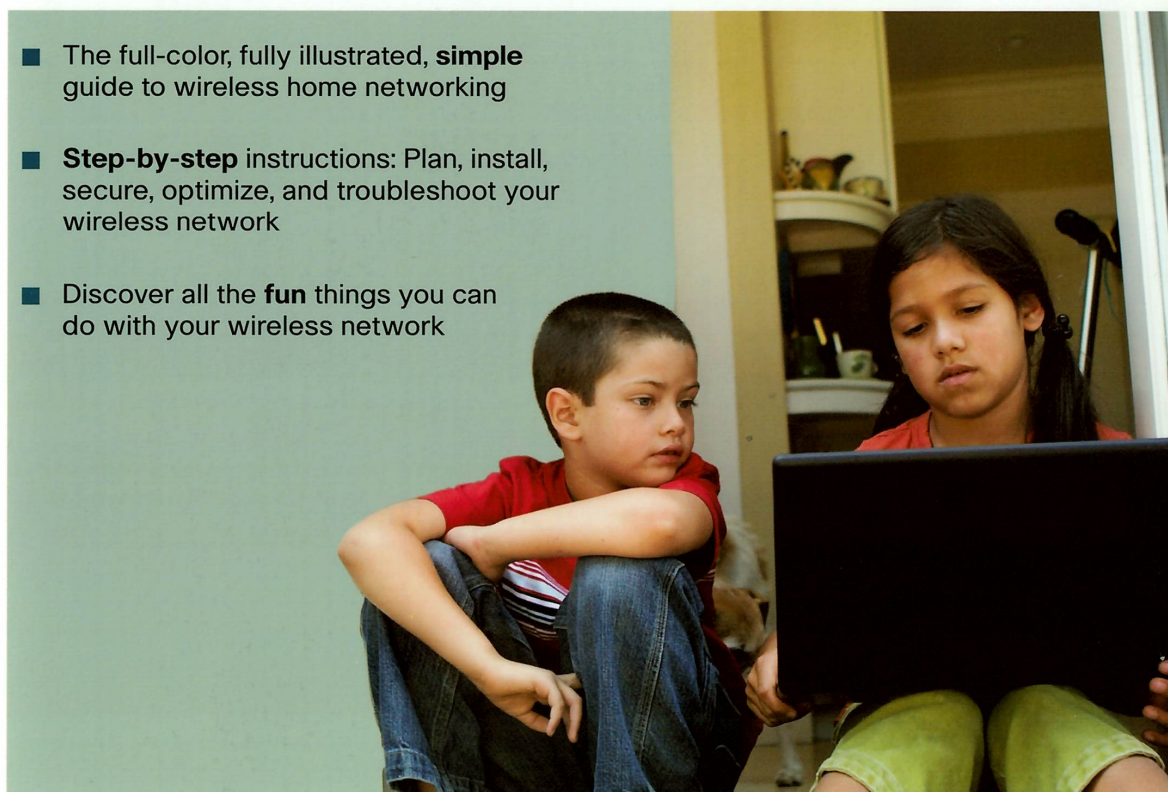
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# Wireless Home Networking **Simplified**

- The full-color, fully illustrated, **simple** guide to wireless home networking
- **Step-by-step** instructions: Plan, install, secure, optimize, and troubleshoot your wireless network
- Discover all the **fun** things you can do with your wireless network



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**Jim Doherty**  
**Neil Anderson**

# Wireless Home Networking Simplified

Jim Doherty and Neil Anderson

Copyright© 2007 Cisco Systems, Inc.

Published by:

Cisco Press

800 East 96th Street

Indianapolis, IN 46240 USA

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Printed in the United States of America 1 2 3 4 5 6 7 8 9 0

First Printing: December 2006

ISBN: 1-58720-161-5

## Library of Congress Cataloging-in-Publication Data

Doherty, Jim, CCNA.

Wireless home networking simplified / Jim Doherty, Neil Anderson.

p. cm.

ISBN 1-58720-161-5 (pbk.)

1. Home computer networks. 2. Wireless LANs. I. Anderson, Neil, 1965- II. Title.

TK5105.75.D66 2006

004.6'8--dc22

2006036500

## Warning and Disclaimer

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## Introduction

We assume that if you read the front cover you know what this book is about, but there's a bit more to it than that. With the explosion of popularity in wireless networking, there is a proportional number of people who do not understand the technology, and a similar number of people who think they understand it (but don't) and are all too willing to dispense advice. Usually it ends poorly, and you get stuck with a network that does not work.

This book is written for all of you out there who want to get the benefits of wireless networking but don't feel like you have the technical background to set it up yourselves. We are confident that if you read this book and follow the steps we lay out, you will have a much better understanding of the technology and, most importantly, a working wireless network. We will try to do this without you having to get a technical degree just to deploy your home network.

## What to Expect

We've divided this book into five parts, each of which describes a major part of the process of building and using a wireless network. These sections describe

- How wireless works
- What you need to know
- How to set it all up
- What to do if it doesn't work
- What other cool things you can do with it

Each section is described in greater detail in the following sections.

### Part I, "How Does It Work?"

Part I starts by explaining the basics in Chapter 1, "How Wireless LANs Work." We think it's worth mentioning that a basic working knowledge of wireless networking should be of interest to you if you are about to set up your own wireless network, and at a minimum it will help you make some better-informed decisions. In Chapter 2, "Wireless Standards: What the Letters Mean," we cover the main wireless standards. There are a number of choices with regard to the frequency, speed, range, and costs of each of the main standards, and we cover all of them here. We finish this section with Chapter 3, "Selecting the Right Wireless Standard for Your Network." There are a lot of choices out there. This chapter will help you cut through the confusion.

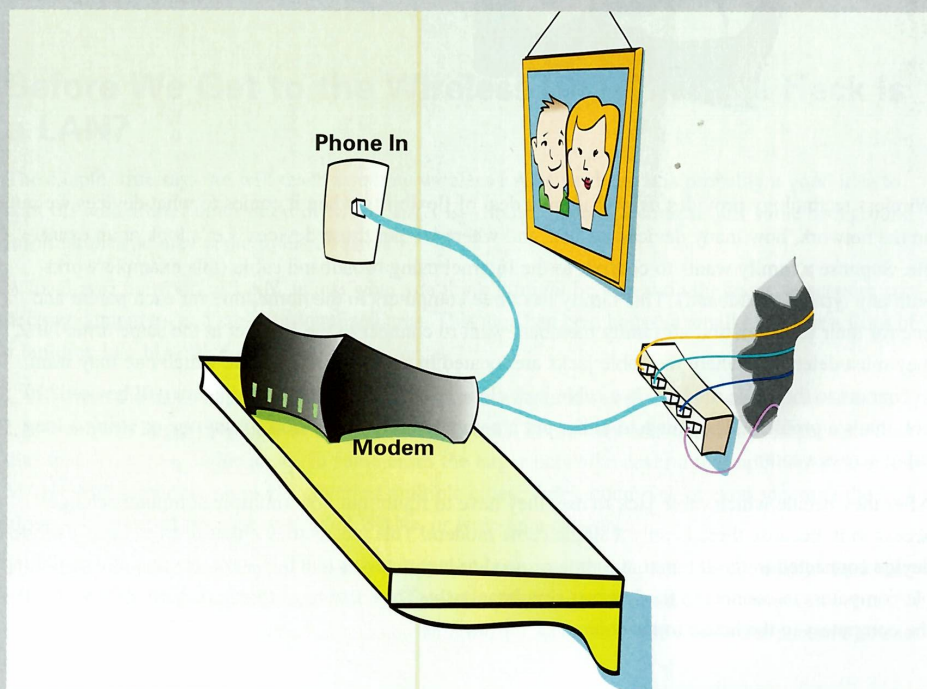
## How Wireless LANs Work

Albert Einstein was quoted as saying “You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat.”

That, in a nutshell, is how a wireless computer network works. In a wired network, data is sent and received between computers and routers using pieces of cable called *Ethernet*.

In a wireless network, air replaces the cables, and the same computer-to-computer communications are transmitted and received over the air using radio waves, very similar actually to how your mobile phone communicates.

This chapter discusses how wireless networks work and some of the challenges that had to be overcome to make them operate. If it gets too technical, just remember one thing: wireless networking is just a way to send stuff like web pages to and from your computer without a cable.



At this point, the family has some options:

- Run cables through the walls. If the family were building a new house, they could have it wired throughout for Internet access, but this can be expensive. If they live in an existing home, they could hire an electrician to run cables, but that is really expensive and messy. If they rent, neither of these is an option.
- String cables all through the house. This is cheap, but it's messy and the family members will be tripping over cables all the time.
- Move all the computers to where the router is. This is not a very practical option.
- Go wireless.

Now, some folks may be a little dubious about using a “new” technology, but the ability to provide wireless networking actually has been around for a long time. The reason you have heard about it only recently is that its use was never really necessary previously. The need to provide high-speed network access to multiple, somewhat mobile, computers only emerged with the widespread availability of broadband Internet and inexpensive computers.

The bottom line is that wireless networking is reasonably affordable and easy to install. If you were to build a wired network, by the time you purchased wired network adapters for all your computers, a router to connect them, and all the cables, the price would be close to what a wireless system would cost. Considering the convenience and the absence of clutter, the wireless network is a bargain. Keep in mind that with most wireless routers, you also get four ports for wired access, so with a wireless network you get the best of both worlds.

## **Before We Get to the Wireless Bit, What the Heck Is a LAN?**

The chapter title says we will teach you how wireless LANs work, so it is probably a good idea to start off with a brief description of what a LAN is—nothing overly technical, just some background information that may come in handy later.

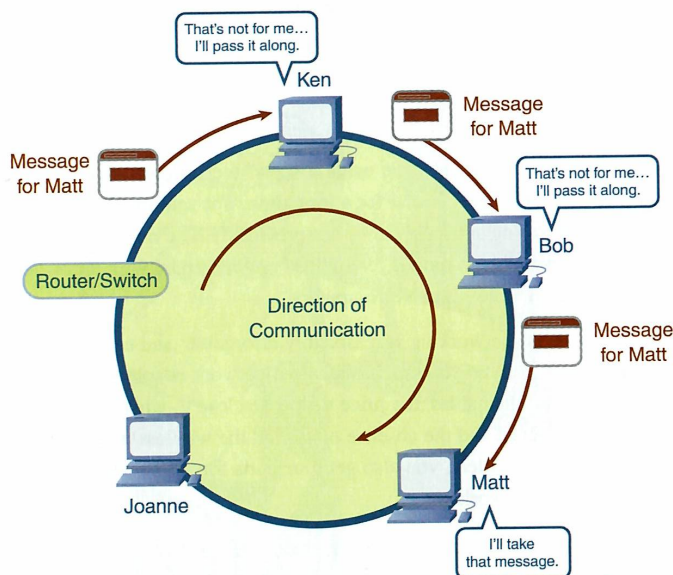
A local-area network, or LAN, is just what you think it might be, based on the name: a network connecting computers in a small or localized area. This area can be a house, a small office, or a floor of a building in a big office.

LANs form the basic building blocks of large-scale computer networks. LANs connect to other LANs to form larger corporate or institutional networks. These networks connect to larger networks that span large geographic areas. In some cases the larger networks cover a metropolitan area, called MANs. Still larger are networks covering multiple cities, states, countries, or even spanning the globe. Networks of this size are called WANs, or wide-area networks.

This structure provides a connection hierarchy that is very scalable. In fact, the Internet is the result of multiple WANs connected to each other, which in effect connects hundreds of thousands of LANs together along with the computers associated with those LANs. Think of your home network as one of those many networks.

When people first started connecting computers for networking, they used many different configurations and communication methods (or protocols). Some LANs were connected using a ring topology, where each computer is connected in a line, as shown in Figure 1-1. Communication from one computer to another is passed along the ring until it reaches the intended recipient.

**Figure 1-1 Ring Topology**



Other topologies included stars, meshes, dual rings, and buses. These configurations are illustrated in Figure 1-2.

Eventually, the topology that was (primarily) settled on was the bus topology. A bus topology has all the computers connected to a common cable, which is referred to as the bus. The common “cable” connecting all the computers today is located inside the router or switch, but it works the same way. Other topologies are still in use but most of the time LANs are connected using a bus topology.



**Note:** Routers and switches are similar in that they both provide a way to connect multiple computers together. The main difference is that switches typically connect only computers together, whereas routers additionally connect the home network to another network, such as the Internet. For a more thorough discussion on routers, switches, and other types of home networking equipment, pick up a copy of *Home Networking Simplified* (Cisco Press, 2005).

heavy fines for unauthorized transmissions. Because of this, wireless networks work on the “open” frequency bands, but this leads to a few other issues.

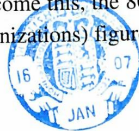
- **Interference**—Because many other devices use the open frequency bands (including cordless phones and baby monitors), anything using these bands is prone to interference from other devices.
- **Power and range**—The rules for the open frequency band limit the power of transmissions. The problem here is that the lower the power, the shorter the range. Engineers had to develop a way to make sure the range was wide enough to cover your house, to make going wireless worth the cost.
- **Data rates**—Data rate is another way of saying speed. People had become accustomed to the speed of broadband Internet. If switching to wireless meant that it would take an hour to download a single e-mail attachment again (as with dial-up), then no one was ever going to use it. So wireless had to be about as fast as wired.
- **Interoperability**—If seven different companies solve these problems in seven different ways, the technology will not be very usable or commercially viable. To ensure that everyone can make some money, standards are needed to make sure that stuff from different manufacturers works together.

## The Solution

The solution for wireless communication was something called 802.11, also known as Wi-Fi (pronounced “why fie”). We go into some detail about 802.11 in Chapter 2, “Wireless Standards: What the Letters Mean?” but for now just look at it as the name of the solution that some smart folks came up with that enables computers to communicate with each other over a wireless connection, without messing up the way computers were already talking to each other. We’ll look at this in two parts: first the wireless part, and second how it works with the wired Ethernet protocol.

For all its magic, the technology that drives wireless communication is no more than a fancy walkie-talkie in a really small package. The wireless device—whether it is a card you plug in or electronics that are built right into the computer—is a transmitter and receiver, sending and receiving radio signals. Unlike the kids’ walkie-talkies, however, these radios are capable of sending and receiving data at very high rates, from 10 Mbps at the low end to over 100 Mbps at the high end. Just a few years ago, these kinds of speeds were only possible using a cable to connect computers. The really good news is that the range of these wireless devices is good enough that you can put the wireless router in your home and provide access throughout most of your home and probably into areas of your yard. This is all done with minimal power consumption so that the battery on your wireless laptop does not drain too fast.

So now that we have computers that are capable of communicating over a radio link instead of a cable, let’s look at how the smart folks made it compatible with the existing wired Ethernet protocol. As it turns out, there was really no way to make wired Ethernet wireless without changing every existing network in the world. To overcome this, the 802.11 team (comprised of engineers from many companies, universities, and other organizations) figured out that the best way to solve the problem



was to take the bits of information being sent via Ethernet and stuff them into the wireless signal, which was then transmitted and received using the radio technology mentioned earlier. On the receiving end, the Ethernet packet was then pulled out of the wireless signal and passed onto the computer, at which point all the normal rules for Ethernet applied.

Let's look at this a different way. Imagine that you and your friend have developed a system for passing notes back and forth to each other during a class in which you sit next to each other. You have developed a shorthand system so that the notes are small but still contain all the information you need to communicate. Now imagine that you find yourselves in another class but you are now seated on opposite sides of the room. You still want to communicate with each other, but you really don't want to develop a new system with which to communicate (such as sign language) because using two methods would really be a pain. Your friend gets a great idea and cuts a hole into a tennis ball and stuffs the note into it. She then throws the ball to you. You catch the ball, pull the note out, and write a response. You then take your note and stuff it into the ball, which you then throw back.

This is basically what the wireless LAN (802.11) protocol does with Ethernet communication. 802.11 wireless LANs act as a way to carry the same wired Ethernet conversations that computers are used to, but over the air instead of over a cable. Pretty neat.

## Putting It All Together

Now, back to the network discussion. When computers are connected to a LAN, they are physically connected to each other, which is the basis for their association to that LAN.

With a wireless LAN, the computers have to find a way to connect, or associate, themselves to the LAN, because they are not physically connected. The way they do this is by tuning themselves to the wireless router using the name of the router (the wireless router's name is called the Service Set Identification number, or SSID). When you tell your computer to connect to an access point, the computer tunes to the access point's frequency and asks permission to join the LAN. If the access point is open, any computer asking to join the LAN will be allowed to do so. If the LAN has encryption security enabled, the computer needs to know the encryption key to even ask permission to join.



**Note:** In addition to *wireless router*, you may also see the terms *base station* or *wireless access point*, and all three pretty much mean the same thing in home networks. We'll stick with *wireless router* for the rest of this discussion.

Once a computer has connected, or associated, itself to the access point, it becomes part of the LAN. And, as we mentioned before, if a computer is on a LAN, it then has access to every bit of communication that takes place on that LAN. Now the computer can send and receive information to and from other computers on the LAN or to and from the Internet by transmitting over wireless to the wireless router (or access point). The wireless router acts as the central communication routing point, much like the wired cable in the LAN example earlier.

## Wireless Standards: What the Letters Mean

If you have already done some research about, or gone window shopping for, wireless networking stuff, you probably noticed that each piece of wireless gear has a letter (or letters) associated with it. The letters are usually A, B, G, N, or some combination such as A+G. In addition, the letters are usually prefaced by the words “wireless,” “wireless standard,” or “802.11.” So it is possible that while shopping for a router, you could see boxes that say any of the following:

- Wireless B
- 802.11g
- Wireless A+G
- Wireless Standard N

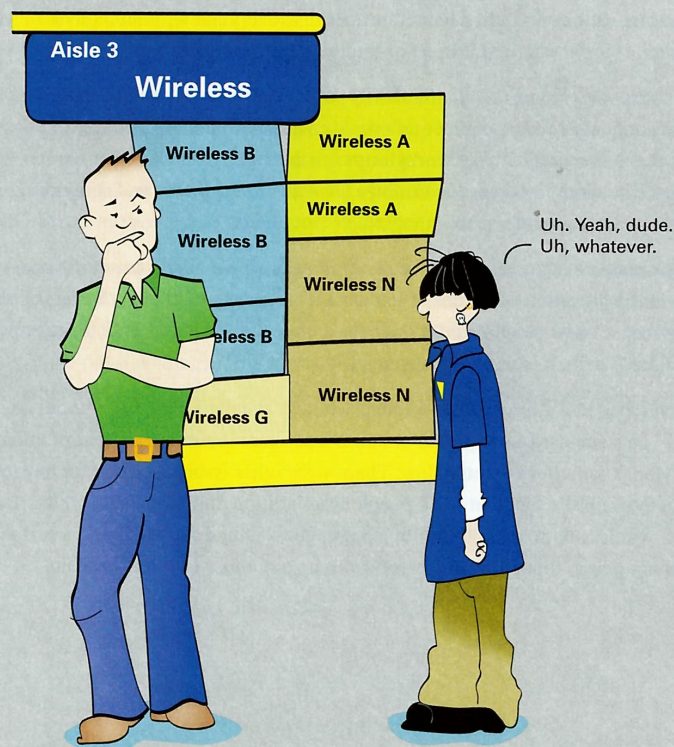


**Table 2-1 802.11a Summary**

| Feature       | Description                                                                               |
|---------------|-------------------------------------------------------------------------------------------|
| Frequency     | 5-GHz range                                                                               |
| Throughput    | 54 Mbps                                                                                   |
| Pros          | Fast<br>Less interference from other electronic devices such as cordless phones (for now) |
| Cons          | Range is limited<br>More expensive than B or G<br>Difficult to find compatible hotspots   |
| Compatibility | Not compatible with 802.11b, 802.11g, or 802.11n                                          |

## 802.11b

802.11b was developed at the same time as the A standard. Because it was less expensive to develop, 802.11b is the standard that most vendors first developed for home networking. As a result, 802.11b is also the first standard that enjoyed widespread adoption and is still widely used in home networking and Internet hotspots (Internet cafés and public wireless locations) today. This standard operates at 2.4 GHz and offers up to 11 Mbps of performance.

802.11b is the slowest of the main wireless standards but it is also the least expensive and most widely deployed. Keep in mind, though, that the speed of the B standard (11 Mbps) is still faster than most forms of high-speed Internet access, so the only limitation will be the applications you run within your network. So, although this standard would not work well for sending high-definition video over your wireless network within your home, it should be just fine for downloading video clips from YouTube ([www.youtube.com](http://www.youtube.com)).

802.11b has a range of about 150 feet (maximum) in open air before signal degradation becomes noticeable. The frequency used by the B standard is also unregulated, and you will find that many devices that use radio transmission (baby monitors, cordless phones, Bluetooth, and others) also use this frequency band and may interfere with your wireless router signal. We'll talk about this a bit more in Chapter 3, "Selecting the Right Wireless Standard for Your Network."

Table 2-2 provides a summary of the wireless B standard.

**Table 2-2 802.11b Summary**

| Feature       | Description                                                                                                 |
|---------------|-------------------------------------------------------------------------------------------------------------|
| Frequency     | 2.4 GHz                                                                                                     |
| Throughput    | 11 Mbps                                                                                                     |
| Pros          | Least expensive of the wireless standards<br>Most widely deployed<br>Range is good<br>Used by most hotspots |
| Cons          | Slowest of the wireless standards<br>Prone to interference from other devices                               |
| Compatibility | Compatible with 802.11g and 802.11n<br>Not compatible with 802.11a                                          |

## 802.11g

The 802.11g standard was developed in 2003 and borrowed from the best of the two previous standards (A and B). Wireless G offers the speed of the A standard (54 Mbps) but still operates on the unregulated 2.4-GHz frequency band, which provides the cost and range benefits of the B standard. Since its inception, the G standard has proven to be very popular and is very quickly replacing the B standard. The equipment cost for this standard is a bit more than for the B standard but less than for the A standard. The G standard is starting to become widely available in hotspots, and many computers that come with built-in wireless capabilities (which is most of them these days) come with G capability. This standard is also backward compatible with the B standard, so if you find yourself near a router using the B standard, your G-capable computer can communicate with it (the opposite is also true).

Some additional proprietary upgrades to the G standard make it even faster (up to 108 Mbps). Linksys has two flavors of speed enhancement. The first is called *Speed Booster*, which, as you might have guessed, boosts the speed (although Linksys only claims 54 Mbps+). The other enhancement is called *SRX*, which stands for Speed and Range eXpansion. Linksys claims that its top-of-the-line version of SRX provides 10x speed and 3x range enhancement. We have not done laboratory tests to measure this but the SRX routers do provide a noticeable improvement in both speed and range.



**Note:** We do not recommend buying and deploying such proprietary extensions of the 802.11g or other standards. They have several limitations, including two important ones:

- You do not get the additional performance unless your wireless router and wireless NICs are both using the proprietary scheme. Buying an SRX router, for example, and using plain old 802.11g wireless NICs means you get 802.11g performance and no SRX enhanced performance.
- Proprietary extensions can lead to incompatibilities with standard equipment.

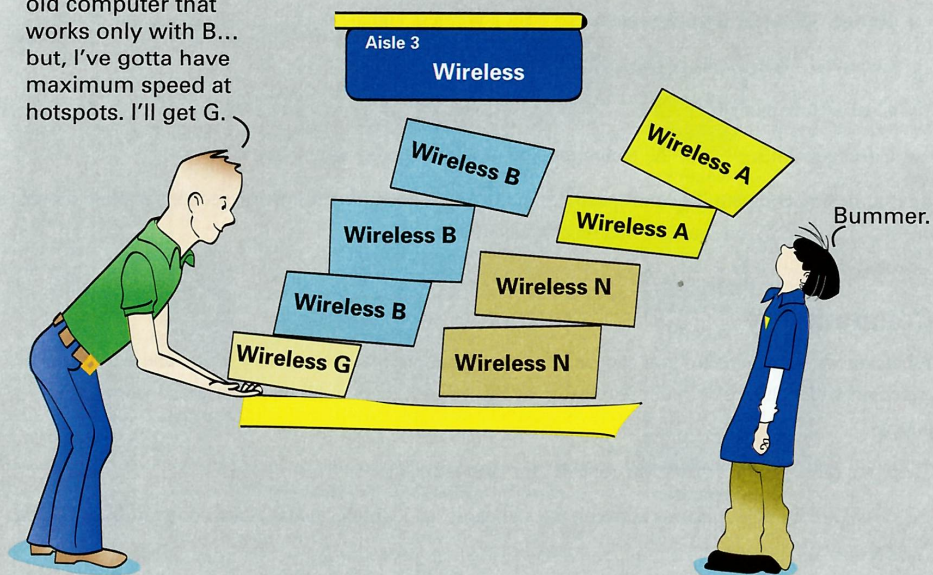
Therefore, we recommend you stick with one of the standards and be wary of proprietary manufacturer extensions.

## Selecting the Right Wireless Standard for Your Network

If you have looked around at your local technology store for wireless networking equipment, you probably noticed the array of wireless designations. With several broad-based standards available and even more vendor extensions, it's no wonder people leave the store confused and probably empty handed.

This chapter helps you choose which wireless standard is right for you. The decision does not have to be difficult at all. We try to boil the facts down and make it easy.

...cordless phone,  
old computer that  
works only with B...  
but, I've gotta have  
maximum speed at  
hotspots. I'll get G.



### Proprietary Extensions

The next complication is that some vendors provide proprietary extensions to their products to make them run even faster. For example, we mentioned in Chapter 2 that Linksys provides a Speed Booster version of its wireless G products that improves the transmission speed beyond the standard 54 Mbps. Linksys also provides an SRX series of wireless G products that doubles the speed to 108 Mbps. Other vendors have similar product extensions. You need to understand three things about such extensions:

- They are (or should be) backward compatible with the base standard.
- The extended speeds typically work only when you are using both that vendor's NICs and its routers with that particular extension. So, to get the benefits of SRX, you need to have both an SRX router and an SRX NIC.
- If you already own or intend to purchase a laptop with a built-in NIC, it most likely is not going to support such proprietary extensions.

Remember this when you are thinking of buying products with such extensions. Make sure they are compatible with the base standard, at a minimum. You should also make sure that you have the correct NIC for any manufacturer-based extensions. It would be a waste to pay the extra money for the Linksys SRX router, for example, if your NIC supports only the base G standard.

### Speed

The second consideration when choosing your wireless standard is resulting speed. Later in the chapter, in the section "Comparing the IEEE WLAN Standards," Table 3-2 gives an indication of the performance you will receive when you use a type of wireless NIC with a type of wireless access point/router. In general, the maximum performance the different wireless standards offer follows:

- **802.11a**—54 Mbps
- **802.11b**—11 Mbps
- **802.11g**—54 Mbps (up to 108 Mbps with extensions)
- **802.11n**—100 Mbps+

However, these speeds are the "stated" numbers, which are often only achieved in a lab setting. Once you have a router in your house, any number of factors can come into play that impact the speed you actually get. These factors include the distance between the router and the computer, the building materials in your home, interference from cordless phones and other devices, and, in some cases, even sunspots. Okay, that last one is pretty rare, but it can happen, and the basic point is that many factors—most of which are out of your control—affect the actual speed of the router.

Also, at the risk of being redundant, remember that the lower of the NIC and router speeds dictates the speed. For example, a NIC for the 802.11b standard will certainly function with a wireless router for the 802.11g standard, but it will only operate at the 11-Mbps rate, not the higher 54-Mbps rate of the G standard. Similarly, a NIC for the 802.11g standard will work just fine with a wireless router for the 802.11b standard. It will just operate at the slower 11-Mbps rate of the B standard.

## Planning Your Wireless Network

The first step in building your wireless network is to sit down and do some planning. Sure, it's fun to run out and start buying stuff, but a little time spent up front will save you a lot of frustration and rework time later.

### Wireless Network Topologies

Before laying out the wireless network, we need to discuss the basic concept of wireless network topologies. There are essentially two types of wireless networks:

- Peer-to-peer (also called *ad hoc*)
- Peer-to-access point (also called *infrastructure*)

A peer-to-peer (or *ad hoc*) wireless network does not have a central point of access or control. Every computer on an *ad hoc* network is considered an equal "peer," having the same rights and access as any other computer on the wireless network. In other words, all the computers communicate directly



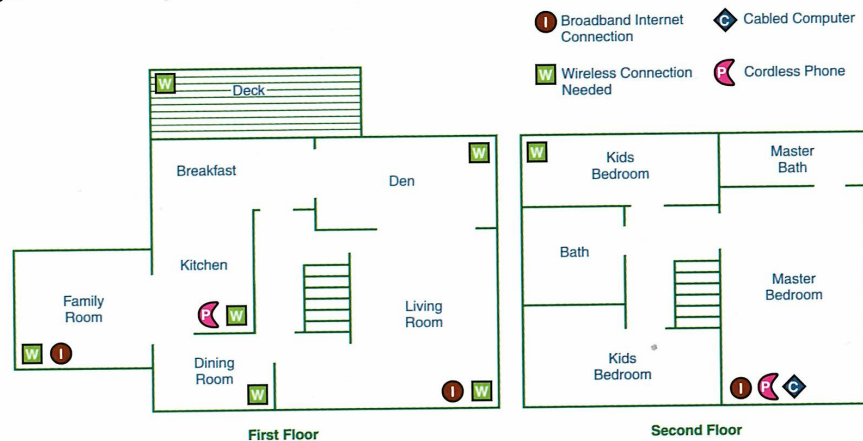
Next, put a mark in the rooms where you are likely to have a desktop computer, or other wired device such as a storage server, or network printer. In Figure 4-3, we used a blue diamond with a *C* in it to denote where we want to have a wired network connection, like a desktop computer.

Finally, put a mark in the rooms or areas where you can conceive of using a laptop computer and other wireless devices, including video cameras, printers, video game consoles, and so on. (This would include bathrooms, which we admit to using our computers in.)

In Figure 4-3, we used a green square with a *W* in it to denote where we want to have a wireless network connection, like a laptop.

In addition, if you have a cordless phone system that operates in the 2.4-GHz band (it should be written on the phone somewhere), you may want to mark the location of the phone's base station on the sketch. As we mentioned before, these phones can cause interference with your network if the wireless router is too close. In Figure 4-3, we used a pink moon with a *P* in it to denote where we currently have a cordless phone base station.

**Figure 4-3 Sample Sketch of a House**



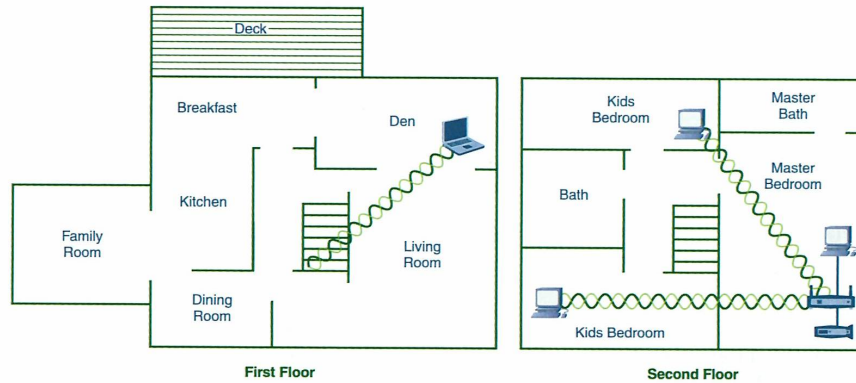
From the sketch, you can make some decisions about where you will put your wireless router, which computers will have wired connections, and which computers will have wireless connections.

Suppose, for example, that you have two desktop computers (a spouse's and a son's), one personal laptop (a daughter's), and one work laptop (yours). Suppose you also happen to have cable outlets in three areas of the house (master bedroom, living room, family room).

You need to have at least one computer with a wired connection (at least during initial setup and sometimes when changes are required). In this example, the family decides to have the high-speed broadband service installed to the outlet in the master bedroom. The wireless router can be placed next to the cable modem and the "Spouse" desktop computer. All three of these devices will be cabled together with Ethernet cables.

Because the daughter's laptop and the son's desktop computer are in other bedrooms of the house, and not easy to run Ethernet cables to, these computers will have wireless connections. The last computer is the work laptop, which is used primarily in the den, but could also be used in the living room, breakfast nook, and on the back deck. Wireless is definitely the way to go for this laptop as well. By jotting these requirements into the sketch, we have what's shown in Figure 4-4.

**Figure 4-4 Adding Wired and Wireless Computers to the Sketch**



For your network, determine the best location for the modem and wireless router based on your planned usage. Usually, the most central point of the house where you can set up a modem and router is the best option. If you live in a huge house, you may need a signal repeater or range extender, or a high-gain antenna. We will cover these types of devices in Chapter 6, “What to Buy,” and recommend that you try a basic router first to see if the performance is adequate.

Chapter 11, “Troubleshooting: I Can Connect Sometimes,” also contains some good advice on where to site your wireless router. We recommend reading that chapter before you finalize your network plan. By spending a little extra time up front understanding the trouble you could have, you could end up saving a lot of time and frustration later.

For now, mark the best available spot for your broadband modem and wireless router with an X. In this example, we chose the master bedroom because it has an available broadband connection jack, has a wired desktop computer (important for administration), and is fairly centrally located.

## Thinking Your Network Plan Through

One of the most common errors we see with friends and family setting up a network is that even when they do plan out the usage as shown in the previous section, they typically only consider how they will use the network the day it is installed. Consider, though, all the advances that have been made in both computing and networking in just the past few years. New capabilities are being added all the time, and what was considered “advanced” yesterday is pretty much the norm today, so much so that putting a network together without the new technologies seems odd. For example, a few years ago it was not really possible to have a wireless printer on your network. Now it's quite easy to set