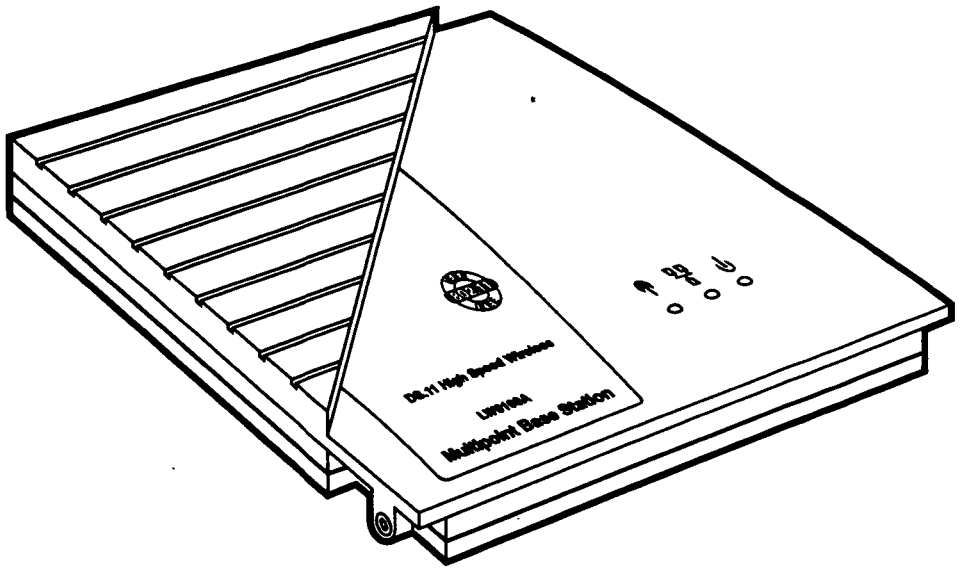
BLACK BOX
NETWORK SERVICES

JUNE 2000
LW0100A
LW0101A

11-Mbps Wireless Ethernet Bridges



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FEDERAL COMMUNICATIONS COMMISSION AND INDUSTRY CANADA RADIO-FREQUENCY INTERFERENCE STATEMENTS

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio communication. It has been tested and found to comply with the limits for a Class A computing device in accordance with the specifications in Subpart J of Part 15 of FCC rules, which are designed to provide reasonable protection against such interference when the equipment is operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be necessary to correct the interference.

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This digital apparatus does not exceed the Class A limits for radio noise emission from digital apparatus set out in the Radio Interference Regulation of Industry Canada.

Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de la classe A prescrites dans le Règlement sur le brouillage radioélectrique publié par Industrie Canada.

12. Precaución debe ser tomada de tal manera que la tierra fisica y la polarización del equipo no sea eliminada.

13. Los cables de la fuente de poder deben ser guiados de tal manera que no sean pisados ni pellizcados por objetos colocados sobre o contra ellos, poniendo particular atención a los contactos y receptáculos donde salen del aparato.

14. El equipo eléctrico debe ser limpiado únicamente de acuerdo a las recomendaciones del fabricante.

15. En caso de existir, una antena externa deberá ser localizada lejos de las lineas de energia.

16. El cable de corriente deberá ser desconectado del cuando el equipo no sea usado por un largo periodo de tiempo.

17. Cuidado debe ser tomado de tal manera que objectos liquidos no sean derramados sobre la cubierta u orificios de ventilación.

18. Servicio por personal calificado deberá ser provisto cuando:

    A: El cable de poder o el contacto ha sido dañado; u

    B: Objectos han caído o líquido ha sido derramado dentro del aparato; o

    C: El aparato ha sido expuesto a la lluvia; o

    D: El aparato parece no operar normalmente o muestra un cambio en su desempeño; o

    E: El aparato ha sido tirado o su cubierta ha sido dañada.

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1. Specifications

Compliance — EMI/RFI: FCC Part 15 Subpart J Class A, IC Class/classe A;
Electrical Safety: UL®, cUL

Standards and Data Rates— Wired LAN: IEEE 802.3 Ethernet v.2 CSMA/CD at 10 Mbps;
Wireless LAN: IEEE 802.11 TGb for 11 and 5.5 Mbps, IEEE 802.11 for 1 and 2 Mbps

Interface — Wired LAN: 10BASE-T

Protocols — Supports most major networking protocols including IP and IPX

Compatibility — Transparent to all network operating systems

Radio Type — Direct-sequence spread-spectrum

Radio Range — 15 miles (24 km)

Radio Transmit Power — +18 dBm or (for use with high-gain antenna) +2 dBm

Radio Frequency Range — 2.4 to 2.4835 GHz

Number of Channels — 13 (3 non-overlapping)

Radio Sensitivity — At 1 Mbps: –93 dBm;
At 2 Mbps and 5.5 Mbps: –90 dBm;
At 11 Mbps; –87 dBm;
Bit Error Rate (BER) is 1 x 10^{-5} or less at all data rates

User Controls — (1) Rear-mounted ON/OFF toggle switch;
Other functions controlled through included Windows based management utility or through SNMP

Indicators — (3) Top-mounted LEDs for wireless status/traffic, wired-network status/traffic, and power/firmware status

Connectors — All rear-mounted;
(1) Rear-mounted RJ-45 for 10BASE-T;
(1) Rear-mounted barrel jack for power;
(2) Side-mounted coaxial (proprietary SMA) for antennas

Temperature Tolerance — Operating: 32 to 104°F (0 to 40°C);
Storage: 23 to 158°F (–5 to +70°C)

Humidity Tolerance — Operating: 10 to 90% noncondensing;
Storage: 5 to 95% noncondensing

Power — From AC outlet through external power supply:
Input: 100 to 240 VAC, 47 to 63 Hz;
Output: 9 VDC at up to 1.67 A;
Consumption: Up to 9 VA (9 watts)

Size (Without Antennas) — 1.5"H x 7.9"W x 9.6"D (3.8 x 20.1 x 24.4 cm)

Weight — 1.7 lb. (0.8 kg)

2. Introduction

Depending on what types of antennas you use with it, the 11-Mbps Wireless Ethernet Bridge (11MWEB) system can wirelessly interconnect networks in adjacent buildings point-to-point or create long-range multipoint links. 11MWEB uses direct-sequence, spread-spectrum radio technology operating at a frequency of 2.4 to 2.4835 GHz, a part of the FCC's unlicensed Industrial, Science, Medical (ISM) band. Data is transmitted at rates up to 11 Mbps, providing network users with full 10BASE-T Ethernet speeds.

11MWEB is compatible with the following standards (and is interoperable with other IEEE 802.11 TGb-compatible, 2.4-GHz direct-sequence products):

- IEEE 802.11 TGb Wireless LAN
- IEEE 802.3 10BASE-T Ethernet
- IEEE 802.1Q support for Virtual LAN
- DHCP for automatic IP-address assignment
- SNMP for system management

In standard Ethernet LANs, network nodes are wired to a common bus: When one of the nodes sends a message, it assigns a destination address to the message and sends the message on the bus by transmitting it on the bus cable. All stations on the bus receive the message through the cable, but only the station with the intended address processes the message. If there are any areas in a site or between sites where you can't run cable, the regular LAN just can't go there.

The 11MWEB gives your network the ability to cross vast distances and/or reach tough-to-cable sites by transmitting messages by radio rather than over wire. Because 11MWEB is so flexible and runs at full 10BASE-T Ethernet speeds, you can use it to establish wireless connections that seem virtually transparent to users, creating high-speed connections between remote networks of all kinds. With the proper antennas placed in the right spots, it can go almost anywhere that it can reach.

There are two main components to the 11MWEB. The 11MWEB Base Station (our product code LW0100A) is an IEEE 802.11 TGb-compliant base-station bridge. It functions as the central unit for multipoint configurations and must form one end of any point-to-point configuration. The 11MWEB Client (our product code LW0101A) is the distributed bridge client at the other end of communication with the Base Station.

When a station on the local Ethernet LAN or workgroup sends a message that is not destined for another local station, the 11MWEB Client wirelessly forwards the message to the 11MWEB Base Station. Conversely, when the Base Station receives a message destined for a station on the Client's LAN or workgroup, the Base Station wirelessly forwards it to the Client. In this way, the 11MWEB Client and Base Station work together like a standard network bridge.

The first time each station on the Client's LAN sends a message, the station's address is registered by both the Client and the Base Station. The 11MWEB Clients and Base Stations can hold all the addresses necessary to support an entire LAN connected to a Client; each Client unit can be configured to handle as many as 1024 MAC addresses.

Figure 2-1 shows a typical 11MWEB installation. Figure 2-2 (on the next page) shows the rear panel shared by the Client and Base Station; below it is a description of what the controls and connectors are for.

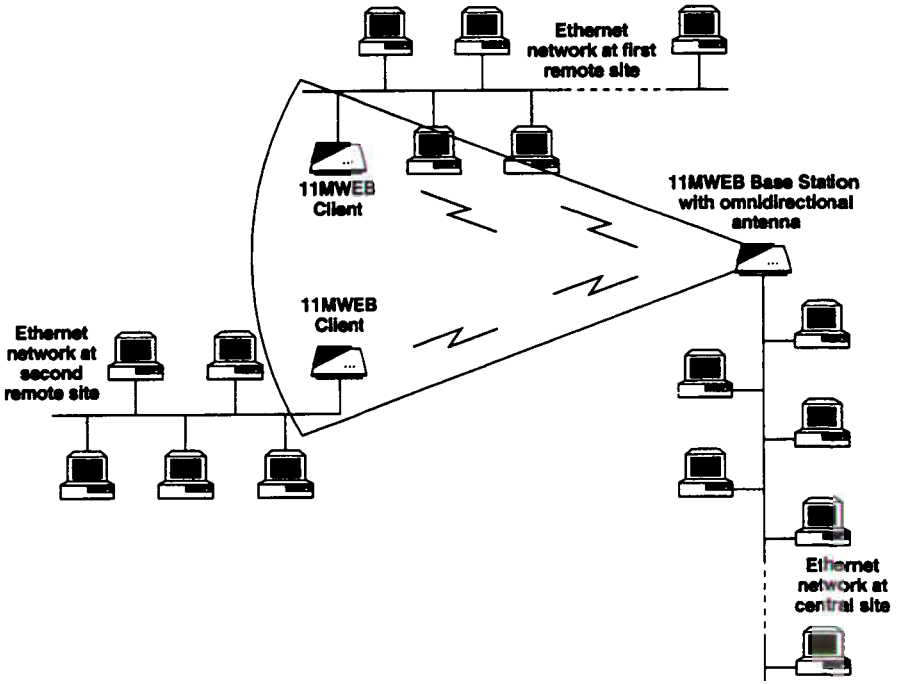

Figure 2-1. Typical 11MWEB installation (antennas not shown).

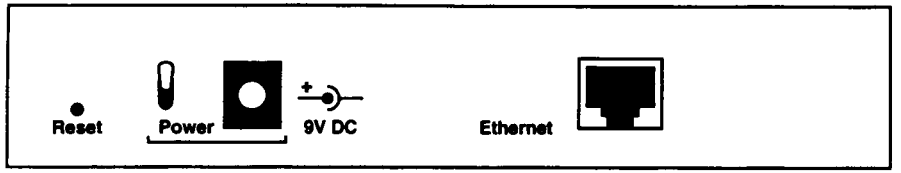

Figure 2-2. The rear panel of the 11MWEB Client and Base Station.

Name	Connector/ Control Type	Function
Reset	Recessed pushbutton (inside small hole)	Insert the end of a paper clip and press. Do this *while the unit is operating* to reset the unit, or *as you turn the unit on* to reload the unit's factory-default configuration.
Power	Pushbutton and matching barrel jack	Attach the output plug of the unit's power supply to this jack. After you plug the power supply or its input cord into a working AC outlet, press the button to turn the unit on and off.
Ethernet	RJ-45 jack	Attach the 10BASE-T cable from your device or wired network here.

3. Installation

3.1 The Basic Procedure

Take these steps to create a wireless LAN by installing 11-Mbps Wireless Ethernet Bridge (11MWEB) Base Station and Client units:

1. Check what you received against the packing list in **Section 3.2**.
2. **The most important part of getting your installation right:** Position the Base Station and Client units and their antennas in the most suitable locations, as described in **Section 3.3**.
3. Attach the power supplies to the units and plug them into working AC outlets, as described in **Section 3.4**.
4. Physically connect the units to your Ethernet LAN by running a 10BASE-T cable from their rear-mounted Ethernet jack to another device connected to the network. (This cable should be cross-pinned if the other device is a concentrator—hub, switch, router, etc.—or straight-through-pinned if the other device is a PC.)
5. Turn the units on. The 11MWEB wireless network will begin operating immediately. Observe the states of the units' LEDs as described in **Section 3.4**.

If you are content with the default settings of the Base Station/Client units—refer to **Chapter 4** for details—you can stop right here. But keep going if you'd like to add management options, assign different radio frequencies to each Base Station/Client pair, or impose any restrictions on the use of your wireless network.

6. To be able to manage the Base Station and Client units with SNMP, each unit needs a unique IP address. If you provide a DHCP or BOOTP service on your LAN (and have sufficient free IP addresses available), this will be taken care of automatically. If not, refer to **Section 4.2** for information on assigning IP addresses. (In general, use the 11MWEB Management utility, described in **Chapter 4**, to configure any of your 11MWEB units' network settings for your application.)
7. Select the radio channels of the Base Station and Client units according to your cell plan. See **Sections 3.3** and **4.6** for additional information. Add descriptive information about each unit for later reference.

3.2 The Packing List

These items should be included with your 11MWEB Base Station or Client package (please contact Black Box right away if any are missing or damaged):

- (1) 11MWEB Base Station or Client unit.
- (1) 9-VDC, 1.67-amp universal power-supply transformer and output cord.
- (1) Power-supply input cord suitable for your country or region.
- (1) 3.5" diskette containing the 11MWEB Management Utility.
- (1) Copy of this manual.

3.3 Unit and Antenna Placement

Each 11MWEB Base Station in your network will form the center of a wireless cell. The placement of Base Stations should be such that cells overlap slightly, to guarantee seamless wireless connectivity everywhere.

A design for optimum wireless coverage at a site is called a "cell plan." Creating a cell plan can be complicated, and is usually done by experts equipped with special measuring equipment. In general, though, neighboring Base Stations should preferably send and receive on different channels for maximum throughput.

The rest of this section describes various considerations to take into account when planning and performing an installation, including co-location; site selection; protection against lightning and spurious emissions; and antenna diversity, alignment, polarization, and sealing.

3.3.1 Co-Locating 11MWEB Units

Up to three Base Station or Client 11MWEB units can be co-located on the same building top or tower. (These should *not* be directly exposed to the elements, and you should *not* install equipment on a roof or tower yourself—see the notices at the start of **Section 3.3.2.**) Each unit should be assigned to one of the non-overlapping channels (1, 6, and 11).

When co-locating Base Station or Client units on the same building top or tower, the antennas should be mounted at least 2 feet (60 cm) apart if you're using 16-dBi unidirectionals (LW019A), 15 feet (5 m) apart if you're using 24-dBi unidirectionals (LW013), or 75 feet (23 m) apart if you're using 8-dBi omnidirectionals (LW0029A-R2). Co-locating omnidirectional antennas will reduce the maximum 11MWEB cell/link distance by up to 50%. So the farther you can separate them, the better the cell/link distance will be.

3.3.2 Site-Selection Factors

CAUTION!

Do *not* install the Base Station or Client units themselves fully outdoors where they are directly exposed to the elements. They can't tolerate temperatures more extreme than 0 to 40°C (32 to 104°F), and they aren't weatherproof. Install them indoors or in a protective cabinet and run cable from there to any antenna you're using.

WARNING—EXTREME HAZARD!

Tower or rooftop antenna installations are extremely dangerous! Incorrect installation, or any mistakes made during the process of installation or later maintenance, may result in damage, serious injury, or even death. Such installations *must* be performed by professional antenna installers only!

When selecting a location for antennas, take into consideration the following guidelines:

- Minimum distance between sites
- Maximum height above the ground
- Maximum line-of-sight clearance
- Maximum separation between antennas (antenna diversity)

Here are more details:

Path of Clearest Propagation

A "propagation path" is the path that signals traverse between the antennas of any Base Station/Client pair. You can think of this path as an imaginary straight line drawn between the two antennas. Any obstacles in the path of this line degrade the

propagation path. The best propagation path is, therefore, a clear line of sight with good clearance between the line and any physical obstacle.

Physical Obstacles

Any physical object in the propagation path can cause signal attenuation. Common obstructions for antennas installed outside are buildings, poles, towers, and trees; antennas installed indoors but pointing outdoors are also affected by any intervening windows or walls. Naturally, any mountains or other natural geographic features higher than the antenna and situated in the path between the two sites can constitute obstructions.

In general, if you're installing antennas outdoors, install them high enough to avoid any obstacles which might block the signal. If you're installing antennas indoors but pointing them outdoors for building-to-building communication, install them as close as possible to a window (or to wall if a window is not accessible) facing the required direction. Avoid metal obstacles such as metal window frames or metal-film anti-glare windows in the transmission path.

Minimal Path Loss

Path loss is determined mainly by several factors:

- **Distance between sites**—Path loss is lower and system performance better when distances between sites are less.
- **Clearance**—Path loss is minimized when there is a clear line of sight. The number, location, size, and makeup of obstacles determine their contribution to path loss.
- **Antenna height**—Path loss is lower when antennas are positioned higher. Antenna height is the distance from the imaginary line connecting the antennas at the two sites to "ground level." "Ground level" in an open area is the actual ground; in dense urban areas, it's the average height of the buildings between the antenna sites.

3.3.3 Antenna Requirements for Point-to-Point vs. Multipoint Applications

The 11MWEB can be used in point-to-point or multipoint configurations:

- A point-to-point link is based on the use of one Base Station and one Client, each equipped with one or two directional antennas. The necessary antenna gain depends on the required range and performance.
- Setting up a multipoint link requires a Base Station equipped with an omnidirectional antenna and at least two remote Client units equipped with high-gain directional antennas. High, isolated antenna locations help reduce problems in multipoint applications.

3.3.4 Antenna Diversity

In applications where no multipath propagation is expected, a single antenna is sufficient to ensure good performance levels. When this is all you use, check the labeling on the bottom of the unit to see whether you've attached the antenna to "antenna 1" or "antenna 2" and set the DS.11 Manager's "Transmit Diversity" option accordingly (see **Section 4.6**).

However, in cases where significant multipath propagation exists, you might want use two antennas per 11MWEB Base Station or Client. You can expect multipath propagation when there are potential reflectors in or near the line of sight between the Base Station and Client locations: buildings, airplanes, cars, and other things that signals can bounce off of. If the 11MWEB's radio signal does not all travel in a straight line, but is partially reflected or deflected by such objects, multiple propagation paths are created, which can reduce system performance. With two antennas, the system can compare the signals from each one on a per-packet basis and select the better of the two, every several milliseconds.

When you use two antennas, set the DS.11 Manager's "Transmit Diversity" option to "both" if it isn't already (see **Section 4.6**).

3.3.5 Antenna Installation and Associated Procedures

To install your antenna, a professional installer should take these steps:

WARNING!

Detached antennas, whether installed indoors or out, should be installed ONLY by experienced antenna-installation professionals who are familiar with local building and safety codes and, where applicable, are licensed by the appropriate government regulatory authorities.

Failure to do so might expose the end user to legal and financial liabilities. Neither the manufacturer, nor its resellers, nor its distributors shall be liable for expense, injury, damage, or violation of government regulations associated with the installation of detached antennas.

WARNING!

***Transmit antenna:* Regulations regarding maximum antenna gains vary from country to country. It is the responsibility of the end user to operate within the limits of these regulations and to ensure that the professional installer is aware of these regulations as well. The FCC in the United States and IC in Canada limit effective transmit power to 36 dBm. The maximum total assembly gain of the most powerful antenna/cable assembly we offer for use with the Bridges equals 19 dBi.**

Violation of government regulations exposes the end user to legal and financial liabilities. Neither the manufacturer, nor its resellers, nor its distributors shall be liable for expense or damage incurred as a result of installations which exceed local transmit-gain limitations.

1. Assemble the antenna according to the assembly instructions included with the antenna set.

2. Mount the antenna as high as possible.

3. *Check antenna polarization:* Make sure the antenna polarization is set as desired, keeping in mind that antenna polarization must be the same at both ends of the link. (In most applications, the preferred polarization is vertical, because above-ground propagation of the signal is better.) To verify antenna polarization, refer to the assembly instructions supplied with the antenna set.

4. Seal the antenna connectors against rain at the point where the cable enters the pole. Unsealed antennas are not suitable for use in outdoor installations.

5. *Take precautions against spurious radio-frequency emissions:* The regulations referred to in the second Warning notice above also specify maximum out-of-band radio-frequency emissions. If you are using a very long antenna cable—especially if it's routed near other equipment that's sensitive to radio-frequency emissions—you might want to install a filter (such as our product code LW0032) as close as possible to the 11MWEB's antenna connector.

6. *Take precautions against lightning:* Lightning protection is designed to protect people, property, and equipment by providing a path to ground for the lightning's energy. We strongly recommend that you use a "lightning arrestor" (also known as an "antenna discharge unit") such as our product code LW014 to protect your 11MWEB and the attached equipment. The arrestor will direct the energy of lightning strikes to ground through a deliberate and controlled path, so that the strike energy doesn't follow a much more destructive random path. (We recommend a lightning arrestor rather than simple surge protection because building-based lightning protection usually has much more voltage capacity than device-based surge protection. A building can withstand up to 100,000 volts, which is far more than most surge-protection devices can withstand, and electronic equipment might be damaged if just a few volts get through.)

   To install an arrestor, connect it between (a) the antenna cable and (b) the 11MWEB or its filter, or the cable running from the 11MWEB or its filter. Connect it as close as possible to the point where the antenna cable enters the building. *Make very sure* that the arrestor and the antenna mast (if the antenna is connected to one) are properly grounded.

   The professional installer who does this must be knowledgeable about lightning protection, and must install the lightning arrestor in a way that maximizes lightning protection.

7. If you're installing the antenna at the main site, connect its coaxial cable (or the cable from the filter, lightning arrestor, etc.) to the Base Station. If you're installing the antenna at a remote site, connect this cable to the Client at that site.

8. When all antennas are in place and fully connected, power ON your Base Station and Clients (see **Section 3.4**).

9. *Check antenna alignment:* Sometimes antennas need to be precisely aligned with each other. This isn't necessary with low-gain antennas because they have very wide radiation patterns. But high-gain antennas have a narrow beamwidth and often have to be aligned in order to optimize the wireless link.

   You can check the alignment of your antennas through software (see **Sections 4.3** and **4.7**): with the signal-quality bar in the Manager utility when using a Client, or by clicking on the RSSI tab when using the Base Station. Synchronize the Base Station and Client(s) by aligning the antennas at the main and remote sites until maximum signal quality is obtained.

   If the received signal quality is still lower than expected for this antenna/range combination, change antenna height and verify RF cable connections.

3.3.6 Suggested Maximum Distances

The maximum distance between a Base Station and its Client(s), and how you measure that distance, depends on whether the 11MWEB is being used in a point-to-point or multipoint application:

- In point-to-point applications, this measurement is referred to as the "maximum link distance." It is the greatest possible distance between the antennas of the Base Station and the single Client. For open outdoor areas with an unobstructed line of sight between the Base Station and the Client, the suggested maximum link distance is 15 miles (24 km), for which you'd use external 24-dBi antennas.

- In multipoint applications, this measurement is referred to as the "maximum cell size." It is the greatest possible distance between the antennas of the Base Station and the farthest Client. For open outdoor areas with unobstructed lines of sight between the Base Station and the Clients, the suggested maximum cell size is 4.3 miles (7 km).

For recommendations involving specific antenna models, refer to the range tables in **Section 3.3.7**.

3.3.7 Range Table

Antenna installations must have a clear line of sight. Solid obstacles such as buildings or hills prevent the establishment of a link. Partial obstacles such as trees or traffic can reduce range. Extending coaxial cables can cause an increase in assembly signal loss and a reduction in range.

Table 3-1 on the next page lists transmit/receive antennas that work well with the 11MWEB. (Keep in mind that antennas with "360°H"—360° horizontal—dispersion are "omnidirectional" models, while antennas with less horizontal dispersion are "directional" models.) For more specific range tables, guidelines, and information about extending cables, call Black Box Technical Support.

Table 3-1. Available Antennas and Antenna Kits for Use with the 11MWEB

Model	Ant. Gain	Cable Length	Kit Contains:	Ideal for:	Dispersion	Dimensions
LW0029A-R2	8 dBi	20 ft. (6.1 m)	Antenna w/ mounting hardware and cable	Establishing 360° coverage for multipoint links	360°H/13°V	Tubular, 17"H x 0.75" in diameter (43.2 x 1.9 cm), attachable to up to 2-ft. (0.6-m) mast
LW017A	11 dBi	30 ft. (9.1 m)	Antenna w/ mounting hardware and cable	ISPs, school districts, and campus area networks requiring wide dispersion patterns	75°H/28°V	11"H x 7.5"W x 3.5"D (27.9 x 19.1 x 8.9 cm)
LW018A	13 dBi	20 ft. (6.1 m)	Antenna w/ mounting hardware and cable	Medium-range multipoint links	46°H/28°V	11"H x 7.5"W x 3.5"D (27.9 x 19.1 x 8.9 cm)
LW019A	16 dBi	30 ft. (9.1 m)	Antenna w/ mounting hardware and cable	Medium- to long-range multipoint links requiring compact form factors	28°H/28°V	11"H x 11"W x 3.5"D (27.9 x 27.9 x 8.9 cm)
LW013	24 dBi	50 ft. (15.2 m)	Antenna w/ mounting hardware and cable	Long-range point-to-point links	6°H/10°V	24"H x 36"W x 15"D (61 x 91.4 x 38.1 cm)

3.4 Initial Operation

Once you've placed your 11MWEB Base Stations and Clients and mounted their antennas, you're ready to plug them in, attach them to your wired network, and power them up. Take these steps for each of your Base Station and Client units:

1. Get the unit's power supply and insert the barrel plug at the end of its output cord into the barrel jack marked Power on the unit's rear panel.
2. Plug the IEC 320 female outlet at the end of the power supply's input cord into the matching inlet on the power supply's transformer.
3. Plug the other end of the input cord into one of your site's AC-power (mains) outlets, or into a UPS (uninterruptible power supply) if you're using one.
4. Plug a 10BASE-T cable into the RJ-45 jack marked Ethernet on the unit's rear panel. Run this cable to another device on your wired network. (The cable should be straight-through-pinned if the other device is a concentrator—hub, switch, router, etc.—although these devices can usually autosense either type of pinning. The cable should be cross-pinned if the other device is a PC.)
5. Toggle the switch marked Power on the unit's rear panel. The unit will begin operating immediately; if a Base Station or Client at the other end of the unit's wireless link is also operating, the wireless link will become active.
6. When the unit powers up, observe its LEDs. Figure 3-1 on the next page shows the top-panel LEDs on the 11MWEB Base Station and Client; the table just below it describes what the LEDs mean.

If an 11MWEB Base Station or Client is receiving power but doesn't appear to be operating normally, here's how to reset it: While the unit is operating, insert the end of a paper clip in the hole marked Reset on the unit's rear panel. Press the clip inward. This will reinitialize the unit's firmware but won't change any of its configured parameters.

If neither resetting the unit nor turning it off and then on again seems to help, you can restore its factory-default configuration settings this way: Turn off the unit and insert the end of a paper clip in the hole marked Reset on the unit's rear panel. Press the clip inward *while you turn the unit on.* This will cause the unit to reload its original fresh-from-the-factory configuration, which you can then re-modify as required.

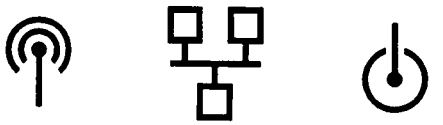

Figure 3-1. The LEDs on the 11MWEB Client and Base Station.

LED Picture	Name	Color	Meaning
Radiating antenna	Association/ Radio Traffic	Green	The Base Station is sending beacons at a rate of 10 per second. While it is scanning for its associated Client(s), the LED blinks irregularly until the link is synchronized (which usually takes no more than a moment or two).
Wired network segment	Backbone Traffic	Green	Data is being exchanged on the wired Ethernet network.
		Red	No network connection detected. Make sure that the 10BASE-T cable going into the unit is securely connected at both ends and is correctly pinned (straight if to a PC, crossed if to a hub/router/switch, etc.).
Circle and bar	Power and Firmware Status	Green	Unit is powered and firmware is operating normally.
		Red	Firmware did not start. Either the unit is not getting proper power or the firmware is wrong/corrupted.

4. Using the DS.11 Manager Utility

The Black Box DS.11 Manager, included on diskette with your 11-Mbps Wireless Ethernet Bridge, is a utility based on SNMP (Simple Network Management Protocol) that provides a consistent view of the 11MWEB wireless network. You can use the DS.11 Manager to control a large number of 11MWEB units—both Base Stations and Clients—from a single PC. Here are some of the the things you can do with it:

- Assign radio channels for optimal cell management;
- Program units with a specified IP address;
- Set the SNMP Read/Write Community strings;
- Verify the status of all units in the network;
- Perform a site survey;
- Select antennas and set their diversity;
- Configure other parameters;
- View counters; and
- Obtain general information about units.

To install the DS.11 Manager in an IBM® compatible PC running Microsoft® Windows® 95, Windows 98, Windows 2000, or Windows NT®, insert its diskette in the PC's floppy drive. Click the **Start** button on your desktop and scroll to **Run**. Type in "a:\setup" and press **Enter** to run the Manager's install program. Once this process is complete, you can run the DS.11 Manager at any time by double-clicking its icon on your desktop.

4.1 The Window Elements

The DS.11 Manager's single window consists of two main areas, as shown in Figure 4-1:

- In the **IP-address and community selection** area (on the left), you can select the community string and address of the unit you wish to manage or edit.
- The **tabs** area (on the right) consists of several tabs that correspond to groups of parameters required for managing the selected unit. The number of tabs displayed varies depending on the type of unit you're managing. When you switch between the tabs, the IP-address and community selection area continues to display the selected unit's address.

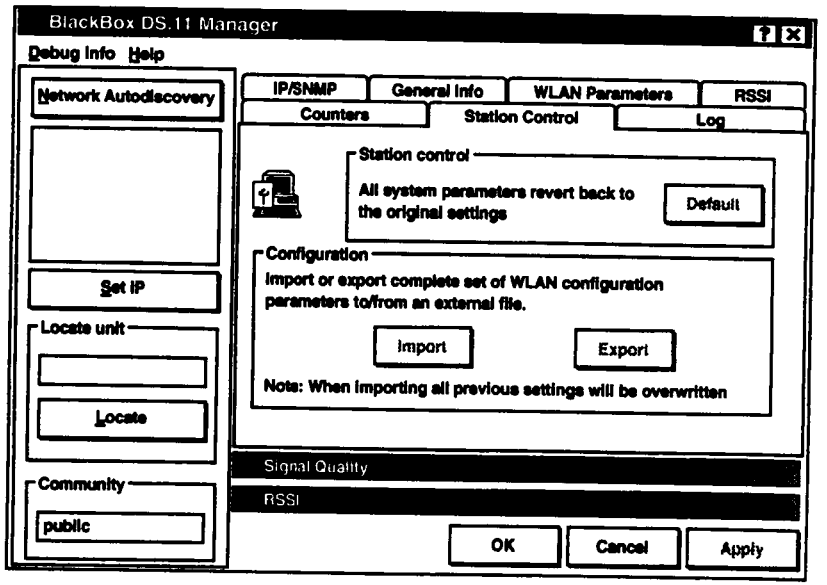

Figure 4-1. The DS.11 Manager's main window (shown with the Station Control tab selected).

These three standard buttons are at the bottom of the window:

- Click [OK] to implement any changes you made and close the window.
- Click [Cancel] to close the window without implementing any of the changes you made.
- Click [Apply] to implement any changes you made but leave the window open.

The rest of this chapter describes how to use the various options available through this window:

- See **Section 4.2** for how to use the [Set IP] button to manually assign and edit IP addresses.
- See **Section 4.3** for how to use the [Network Autodiscovery] and [Locate] buttons to select 11MWEB units.
- See **Sections 4.4 through 4.11** for how to use the options available under the different tabs.
- See **Section 4.12** for how to use the "Debug info" menu.

4.2 Set IP: Assigning and Editing IP Addresses Manually

When you select an 11MWEB Base Station or Client (see **Section 4.3**) and click the [Set IP] button in the DS.11 Manager's window, the Set IP dialog box is displayed, as shown in Figure 4-2.

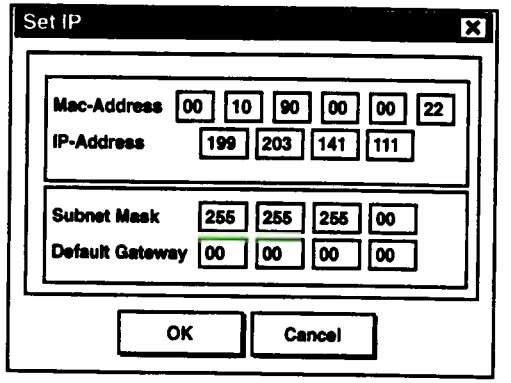

Figure 4-2. The Set IP dialog box.

Type the parameters in the appropriate fields and click OK. (If you haven't already recorded the unit's MAC address elsewhere, the MAC address is printed on a sticker on the bottom of the unit.) A message box is displayed notifying you when the changes are to take affect. This feature can be used only if the PC running the Manager is on the same Ethernet segment as the unit and not behind a router. (Be aware that if you assign the unit an IP address that isn't on the same IP subnet as the PC running the Manager, the Manager won't be able to "see" the unit any more.)

4.3 Autodiscovery and Locate: Selecting Units

In the DS.11 Manager's window, you can select an 11MWEB Base Station or Client unit to manage in either of two ways:

- Click the [Network Autodiscovery] button. The IP addresses of all of the 11MWEB units on the same subnet as the PC running the Manager are displayed in the list box underneath this button. Double-click on an address to select it. The default read community is public and the write community is private.
- If the unit is on the other side of a router, type the unit's address in the Locate field and click [Locate] to display its parameters.

If the unit you select is a Client, the Signal Quality and RSSI bars appear, as shown in Figure 4-3. The Signal Quality bar displays the signal quality between the selected Client and the Base Station communicating with it. The RSSI bar displays the signal strength.

Figure 4-3. The Signal Quality and RSSI bars.

4.4 The IP/SNMP Tab

When you click the IP/SNMP tab in the DS.11 Manager's window, the information shown in Figure 4-4 appears for the currently selected 11MWEB unit. As you can see, you can set some of the unit's IP, SNMP, and DHCP parameters here; these will become particularly useful when you download firmware to the unit using TFTP (see **Chapter 5**).

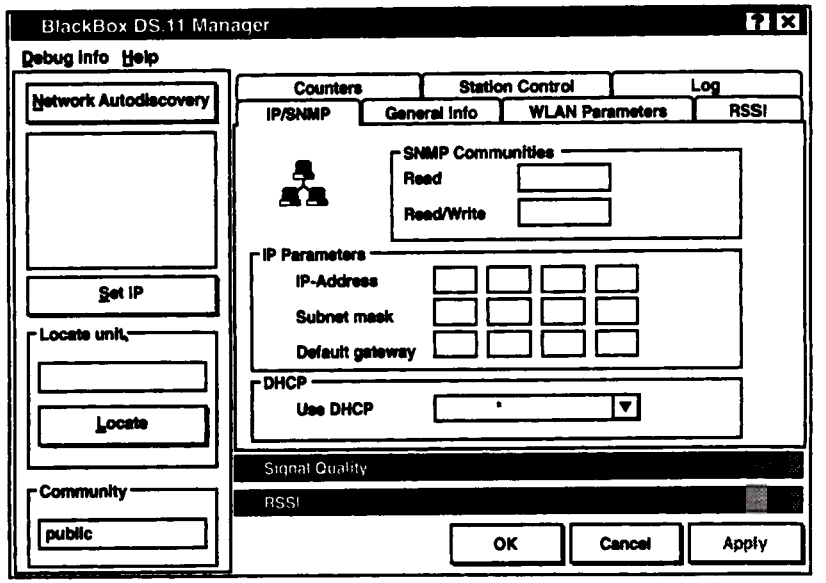

Figure 4-4. The IP/SNMP tab.

In the **SNMP Communities** area, you can set the "Read" (read-only) and "Read/Write" community strings for the unit. ("Public" is the default Read string and "Private" is the default Read/Write string.) In the **IP Parameters** area, you can set the unit's IP address, subnet mask, and default gateway. The **Use DHCP** setting determines the way your system utilizes Dynamic Host Configuration Protocol (DHCP, used for automatic IP assignment):

- **Always:** The system searches for a DHCP server each time the PC is turned on.
- **Smart:** This is the default value. The system searches for a DHCP server only if no IP address was assigned. If an IP address was assigned manually, the system will not search for a DHCP server.
- **Never:** The system never searches for a DHCP server.

4.5 The General Info Tab

When you click on the General Info tab in the DS.11 Manager's window, general information about the currently selected 11MWEB Base Station or Client is displayed, as shown in Figure 4-5.

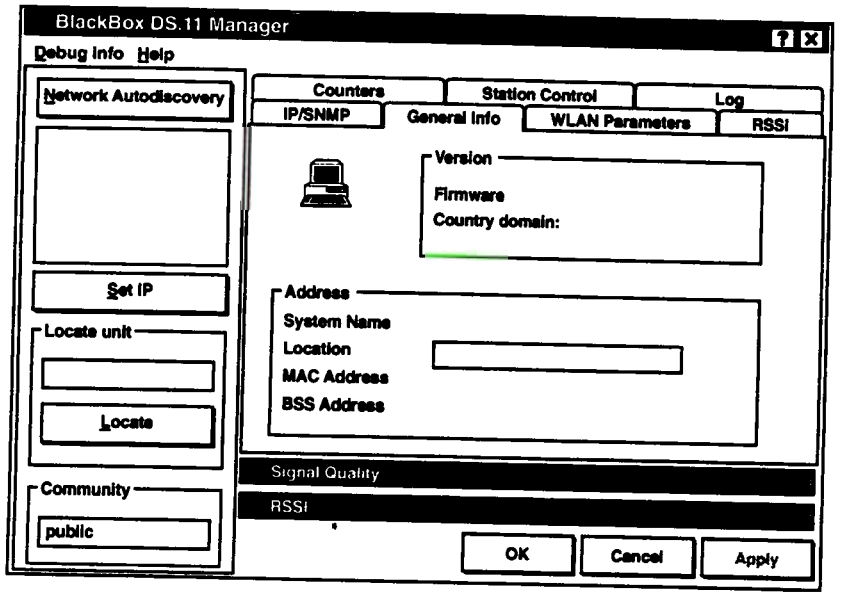

Figure 4-5. The General Info tab.

In the **Version** area, this information is displayed:

- **Firmware:** The firmware version that the unit is currently running.
- **Country domain:** The country/regulatory-agency standard(s) that the unit is factory-preset for. The value for these units will always be "US FCC"; this setting is correct for Canada also. This setting can't be changed.

In the **Address** area, this information is displayed:

- **System Name:** The unit's factory-preset name.
- **Location:** The unit's location; type in whatever description you find most useful.
- **MAC Address:** The unit's MAC address.
- **BSS Address:** If the unit's a Base Station, its MAC address (again). If the unit's a Client, the MAC address of the associated Base Station.

Remember that while you're viewing this tab you can switch between units, either by selecting the IP address from the list, or by typing it in and clicking [Locate].

4.6 The WLAN Parameters Tab

When you click the WLAN Parameters tab in the DS.11 Manager's window, the information shown in Figure 4-6 appears for the currently selected 11MWEB Base Station or Client.

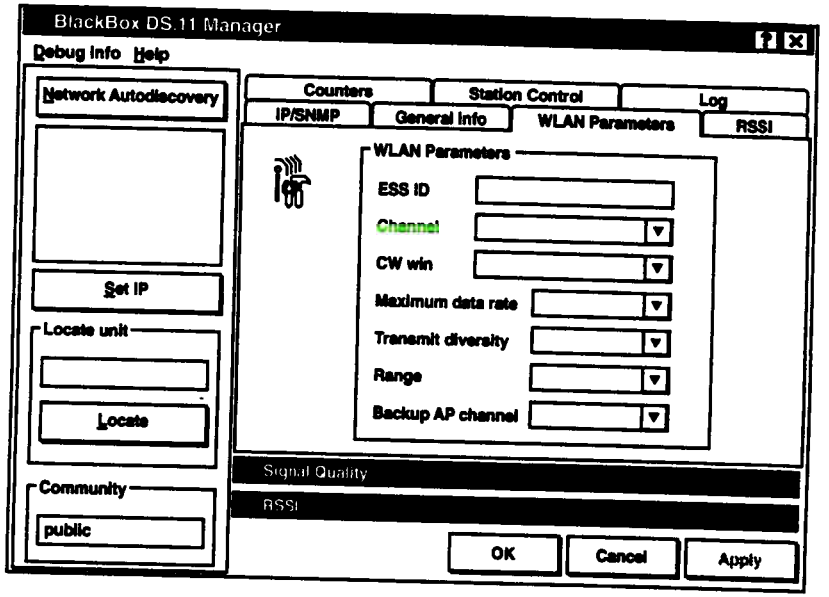

Figure 4-6. The WLAN Parameters tab.

Set any of these values as necessary:

- **ESS ID:** A case-sensitive ASCII string of up to 32 characters used to identify a WLAN (wireless LAN); this prevents the unintentional merging of two co-located WLANs. It is essential that the ESS ID be set to the same value in all Clients and Base Stations in the extended WLAN.

- **Channel:** Any specific channel, from 1 to 11, that you want the unit to use all the time; select it from this pulldown menu. Refer to Table 4-1 on the next page for a list of the frequencies that correspond to each channel.
  This step is not normally necessary: Under normal conditions, when each Client powers up, it automatically changes channels, searches ("scans") for its Base Station, and then synchronizes with the Base Station. But if the unit is in a WLAN that's co-located with one or more other WLANs, you might want the unit to stay on a specific single channel all the time; if so, choose that channel here.

Table 4-1. Channels and Matching Frequencies

Channel	Frequency
1	2412 MHz
2	2417 MHz
3	2422 MHz
4	2427 MHz
5	2432 MHz
6	2437 MHz
7	2442 MHz
8	2447 MHz
9	2452 MHz
10	2457 MHz
11	2462 MHz

- **CW Win:** The size of the "contention window"—either 7, 15, 31, or 63 time slots—that the unit will use. The contention-window backoff algorithm is a well-known method used to resolve contention between different Clients wanting to access the medium. Different window sizes are suited for different applications:
  - Use a window size of 7 slots for short range point-to-point links *only*.
  - Use 15 slots for traffic loads that tend to be unidirectional (that is, where most of the traffic flows across the wireless LAN in one direction) in order to improve performance.
  - Use 31 slots for heavy bidirectional traffic loads to minimize the packet error rate (PER).
  - Use 63 slots for large, long-range multipoint networks *only*.
- **Maximum data rate:** Each 11MWEB Base Station and Client adaptively selects the highest possible data rate for transmission. Under certain conditions—especially if you want the unit to transmit across greater distances than it would be able to otherwise—you might want to limit a unit's data rate . Possible values are 2, 5.5, or 11 Mbps; the default value is 11 Mbps.

- **Transmit diversity:** Select which antenna(s) you want the unit to use (the unit's "antenna diversity"): either "Antenna No. 1," "Antenna No. 2," or "both." "Both" is the default, so you'll have to set it to your chosen antenna connector for most applications. The antenna connectors are labeled on the bottom of the unit.
- **Range:** The operating range of your WLAN; select it from this pulldown menu.
- **Backup AP channel:** This option is not currently supported.

4.7 The RSSI Tab

The RSSI tab appears in the DS.11 Manager's window only if a Base Station is currently selected. Click this tab to view the signal quality of the Base Station's links to all of its associated Clients, as shown in Figure 4-7. (The Clients will be listed by their MAC addresses in the "Associated Stations" table.)

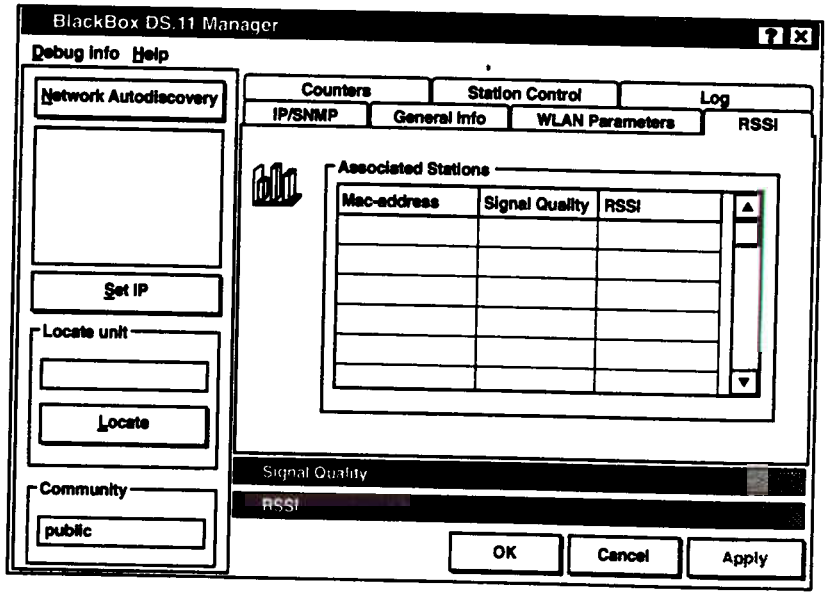

Figure 4-7. The RSSI tab.

4.8 The Counters Tab and the Graph Window

Click the Counters tab in the DS.11 Manager's window to see numeric and graphical representations of various WLAN-traffic statistics for the currently selected unit, as shown in Figure 4-8.

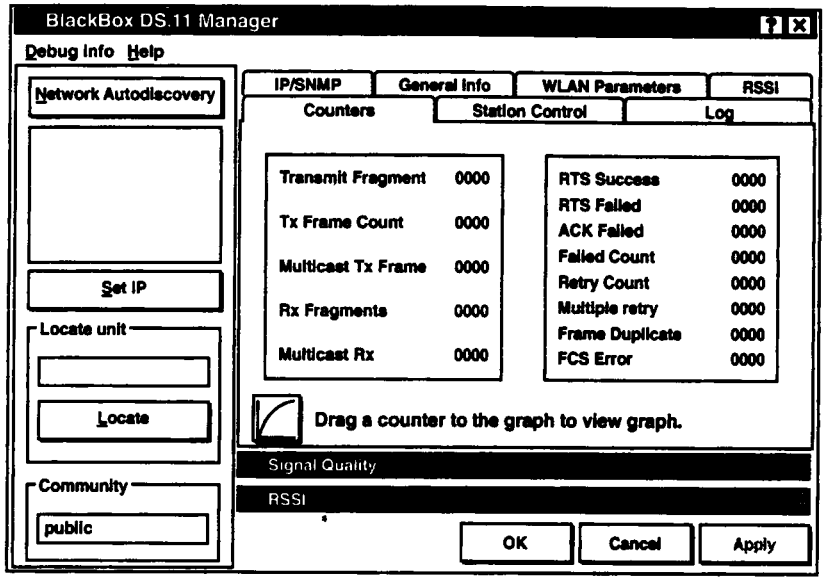

Figure 4-8. The Counters tab.

Select any of these counters and drag it to the icon to open the Graph window (see the next page) and view a graph of recent activity:

- **Transmit Fragment:** The number of transmitted frames. The count includes data, control, and management frames, including retransmissions of data frames. (For example, if the same data frame is retransmitted ten times, the count will increase by ten.)
- **Tx Frame Count:** The number of frames transmitted to the wireless media. The count includes the first transmission of data frames (*not* retransmissions), plus the numbers of control and management frames.
- **Multicast Tx Frame:** The number of transmitted multicast frames.
- **Rx Fragments:** The number of frames received, including data, control, and duplicate data frames.
- **Multicast Rx:** The number of received multicast frames.
- **RTS Success:** The number of successful Request To Send frames sent.

- **RTS Failed:** The number of failed Request To Send frames sent by the Client.
- **ACK Failed:** The number of times the Client stopped transmitting a frame after failing to receive an acknowledgment packet.
- **Failed Count:** (At the time of this writing, this counter is not meaningful.)
- **Retry Count:** The number of retransmissions.
- **Multiple Retry:** This counter is incremented when an packet is successfully transmitted after more than one retransmission.
- **Frame Duplicate:** The number of duplicate frames that were sent or received.
- **FCS Error:** The number of CRC errors.

When any of these counters is dragged to the graph, the window shown in Figure 4-9 appears. It will show how many of the counter events are occurring at any given moment; the graph will scroll slowly to the right as the system is monitored in real time.

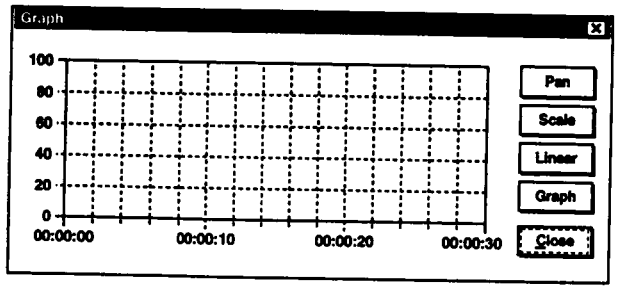

Figure 4-9. The Graph window.

- Click the Pan button and drag the cursor across the window to make the Graph window display more events or a longer time frame; it will become the Zoom button, which you can click to return to the standard display.
- If you're only getting one or two events at a time, click the Scale button to shrink the Graph window's Y-axis scale to display 0, 2, and 4 units. (To change this, you will have to toggle Linear and Log.)
- If you're getting large numbers of events, click the Linear button (you might have to toggle it several times) to expand the Graph window's linear Y-axis scale ten times, to display 0, 200, 400, 600, 800, and 1000 events. It will become the Log button; you can click this (again, you might have to toggle it several times) to display a logarithmic Y-axis scale of 0, 1, 10, 100, and 1000 events.
- Click the Graph button to display the counter as a blue line. It will become the Bar button; click this to display the counter as a bar graph.

4.9 The Station Control Tab

When you click the Station Control tab in the DS.11 Manager's window, you are presented with three configuration-control options for the currently selected 11MWEB Base Station or Client, as shown in Figure 4-9.

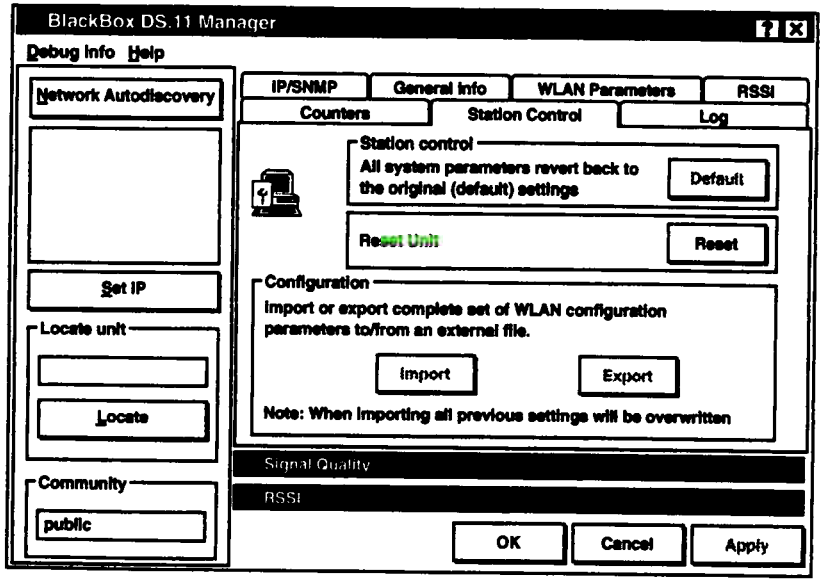

Figure 4-9. The Station Control tab.

You can either:

- Click the Default button to restore the unit's factory-default configuration settings—which can sometimes solve configuration-related problems, but will overwrite the unit's existing configuration;
- Click the Export button to save the unit's full configuration to an external file with the same name as the unit's "System Name" (see **Section 4.5**) in the Manager's folder; or
- Click the Import button to load a full configuration for the unit from a previously saved external file.

4.10 The Log Tab

When you click the Log tab in the DS.11 Manager's window, the Manager's trap settings will appear, as shown in Figure 4-10.

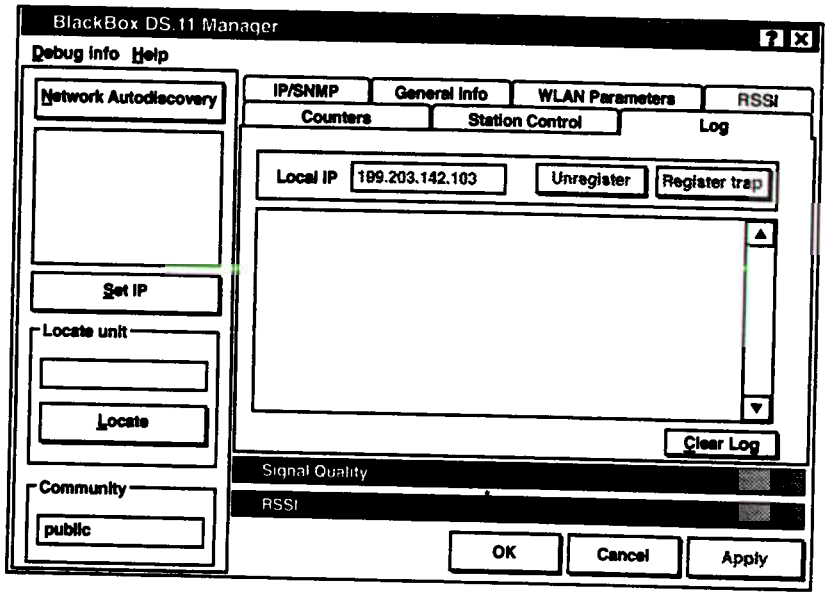

Figure 4-10. The Log tab.

If you want to trap events, first you need to use an SNMP client program to define one of your PCs—normally, the one running the DS.11 Manager utility—as a trap host. (Refer to the SNMP client's documentation for instructions for doing this.) Make sure that your Read community setting under the IP/SNMP tab is set to "private" (see **Section 4.4**), then select the 11MWEB units you want to trap events for, one after another, and click the Register trap button to register them as trapped addresses. (To turn trapping off for a given unit later, select the unit and click on the Unregister button.)

Once you have registered all of your desired traps, whenever an event occurs involving any of these units, a trap is sent to the defined trap-host address. When a registered unit is selected, the most recent trapped events will be listed in the main Log window, below the Local IP field. To clear the Log window, press the Clear Log button. (This will have no effect on the log being kept by the trap host; refer to the SNMP client's documentation for instructions on clearing/deleting the host's log.)

4.11 The Security Tab

When you click the Security tab in the DS.11 Manager's window, the Manager's authentication settings will appear, as shown in Figure 4-11. Currently only the Open System option is supported—which corresponds to "no authentication, any node in the WLAN can associate with a Base Station and receive and transmit data"—so there is nothing to set here.

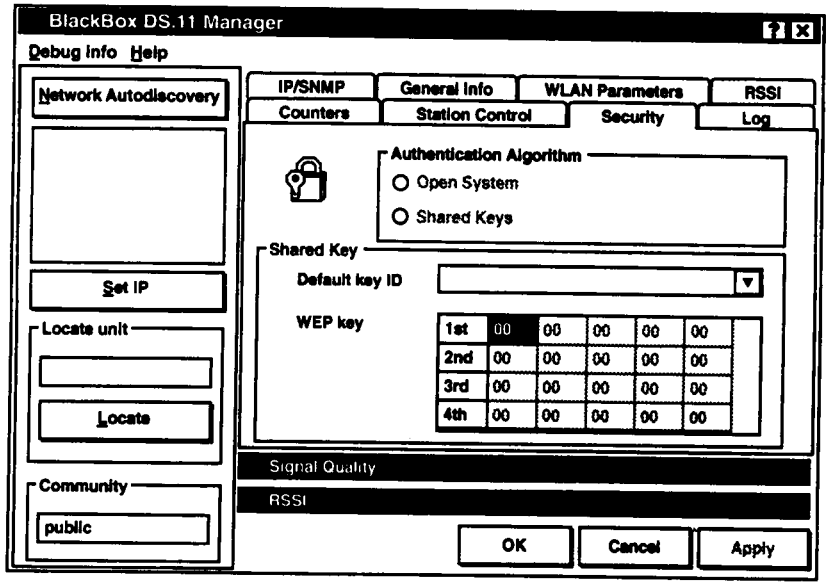

Figure 4-11. The Security tab.

4.12 The Debug Info Menu

If you ever have difficulty with your 11MWEB equipment, we might ask you to record a log of the system's behavior. Use the Debug Info menu in the DS.11 Manager's window to create a log file named "BreezeLog.log" in which the Manager will record information about system performance and events. This log file is always stored in the same directory as the Manager software.

To start recording, pull down the Debug Info menu and select "Start Log." When you finish recording (usually after 24 hours), pull down the menu and select "Stop Log," then email the log file to the Black Box technician who requested it. It might help us to diagnose your problem.

5. Upgrading 11MWEB Firmware

Occasionally we might introduce improved versions of the firmware for your 11-Mbps Wireless Ethernet Bridges. When this happens, here is the procedure you should use to download the new firmware and load it into an 11MWEB Base Station or Client:

1. Download the new firmware from the Black Box Web site, **www.blackbox.com**. At the time of this writing, the archive's filename will be "*x_y_z*.zip," where *x*, *y*, and *z* are the digits in the firmware version—for example, "2_5_7.zip" for version 2.57. (If you can't find the file, please call Black Box Tech Support for assistance.) Inside this archive, the filename of the firmware file itself should be "ap1100.arm" for Base Stations or "sa1100.arm" for Clients.

2. Set the unit's IP address using the DS.11 Manager utility that came with the unit (see **Section 4.2**), making sure to keep the unit on the same subnet as the PC running the Manager.

3. Ping the unit's IP address and make sure that you receive replies from the unit.

4. Run a TFTP utility on the PC running the Manager:

   Syntax: `tftp [-i] IP_address_of_destination_unit [put] name_of_firmware_file password`

   Example: `tftp -i 199.203.141.30 put ap1100.arm private`

   Download should be completed within two minutes, and a message of successful file transfer will be shown on the screen. The password will be the SNMP read/write community name (default is "private").

5. The unit will reset itself automatically.

6. Check the unit's LEDs to make sure there hasn't been a hardware failure (see **Section 3.4**), then run the DS.11 Manager utility to make sure that the firmware-version number that the unit reports is that of the file you just loaded into it (see **Section 4.5**).

NOTES

Do not disconnect any cables or try to stop the process before downloading is completed. If this occurs accidentally, reset the unit to its factory-default settings (see the last paragraph in Section 3.4) before retrying.

None of the configuration parameters you've set for an 11MWEB Base Station or Client will be lost or changed during the upgrade/download procedure, and there's no way you can corrupt the unit's firmware.

6. Troubleshooting

6.1 Common Problems

This section suggests possible causes of, and solutions for, some of the more common problems that might occur when installing and using an 11-Mbps Wireless Ethernet Bridge. Keep in mind that it is often helpful to check the 11MWEB's counters (see **Section 4.8**), even if the trouble you're having isn't listed here. If none of this helps, contact Black Box Technical Support as described in **Section 6.2**.

No power to 11MWEB Base Station or Client unit. Power LED is off.

1. The power switch on the back of the unit might be OFF. Try moving it to the opposite setting.
2. The power cords might not be properly connected. Verify that (a) the power supply's input cord is securely plugged into both the transformer and a working AC-power outlet, and (b) its output cord is plugged into the barrel jack on the back of the unit.
3. The power supply might be defective. Call us to get a replacement.

Failure to establish wireless link. Association LED is off and unit resets every few minutes.

1. The power supply to the affected 11MWEB units might be faulty. Verify that all of the affected units' power cords are properly connected, as described in item 2 under the "No power" issue above. Also make sure that your site isn't being hit with sags or other irregularities in AC power.
2. The Client units might not have the same ESS ID as the Base Station, or might be trying to use a different channel. Verify that all of the Clients in the affected wireless network have the same ESS ID, and are set to the same channel, as the Base Station they should be communicating with. See **Section 4.6**; remember that the ESS ID is case sensitive.

You might also want to check the antenna-cable attachment; antenna height, alignment, and polarization; line of sight; and the range between the antennas. But after you try the fixes in items 1 and 2, you can test the wireless link this way:

a. Set the Base Station and Client units side by side.

b. Power on each unit and see if a wireless link is established. (Even Clients without no antenna attached should establish a link if they're placed right next to the Base Station.)

c. If the units still fail to associate, resetting them to their factory-default configurations (see **Section 4.9**) might do the trick.

Wireless link established, but no Ethernet activity.
To check Ethernet activity as you try various fixes, watch the Ethernet LED indicator of the 11MWEB Base Station or Client and look over the unit's Ethernet counters (see **Section 4.8**).

1. The problem is probably with the 10BASE-T cable, the 10BASE-T port of the attached hub or other device, or the unit's Ethernet port. Check these things:
   a. Make sure that the 10BASE-T cable is securely plugged into both the 11MWEB Base Station or Client and the attached device.
   b. If the attached device has an "Association" or "Link" LED, is it solidly lit? If not, the port is probably inactive; try another port on the hub or swap in a known-good 10BASE-T cable.
   c. Ping the 11MWEB Base Station or Client to make sure that its Ethernet port is working.
   d. Make sure that the cable is a standard UTP cable carrying at least pins 1, 2, 3, and 6. Also verify that the cable is pinned straight-through (Pin 1 to Pin 1, 2 to 2, and so on) if it runs to a hub, switch, etc., or is cross-pinned properly (Pin 1 to Pin 3, 2 to 6, 3 to 1, and 6 to 2) if it runs to a PC or similar device.

2. The Client might be associated with a Base Station that is not connected correctly to the LAN. Make sure that there is no Base Station at your site that has the same channel and ESS ID as the Client, but is not connected to the LAN.

6.2 Calling Black Box

If you determine that your 11MWEB system is malfunctioning, *do not attempt to alter or repair any of your Base Station or Client units.* They contain no user-serviceable parts. Contact Black Box Technical Support at 724-746-5500.

Before you do, make a record of the history of the problem. We will be able to provide more efficient and accurate assistance if you have a complete description, including:

- the affected units' firmware version (see **Section 4.5**);
- the nature and duration of the problem;
- when the problem occurs;
- the components involved in the problem;
- any particular application that, when used, appears to create the problem or make it worse;
- the values of the counters (see **Section 4.8**) for the affected units; and
- the results of any testing you've already done.

To solve some problems, it might be necessary to upgrade the firmware of the affected units; see **Chapter 5** for a description of this procedure.

6.3 Shipping and Packaging

If you need to transport or ship an 11MWEB Base Station or Client unit:

- Package it carefully. We recommend that you use the original container.
- If you are shipping the unit for repair, please include all parts of its external power supply. If you are returning the unit, please include everything you received with it. Before you ship the unit back to Black Box for repair or return, contact us to get a Return Authorization (RA) number.

Appendix A: Radio-Signal Propagation

A.1 Introduction

This section explains and simplifies many of the terms relating to antennas and RF (Radio Frequency) that are used when dealing with an RF installation system.

Figure A-1 shows a typical radio system. In a radio system, information is given to a transmitter, which converts it into an RF signal. The RF signal is sent through an antenna, which converts it into an electromagnetic wave. The transmission medium for electromagnetic-wave propagation is free space.

The wave is intercepted by the receiving antenna which converts it back to an RF signal. (Ideally, this RF signal is the same as that originally generated by the transmitter.) The original information is then demodulated by a receiver back into its original form.

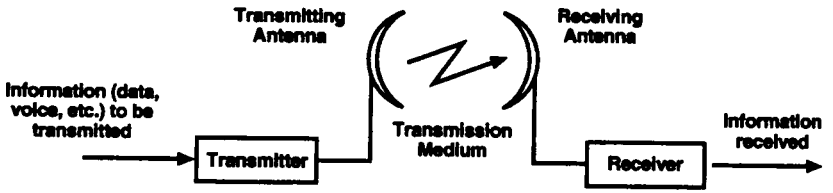

Figure A-1. A typical radio system.

A.2 RF Characteristics

dB

"dB" is an abbreviation for decibels, a logarithmic measurement of signal strength that corresponds to the relative power of the signal at different points.

RF Power Level

RF power level at either the transmitter output or the receiver input is measured in watts. It can also be measured in dBm (decibels referenced to one milliwatt). The relationship between dBm and watts can be expressed as follows:

$$P_{dBm} = 10 \times \text{Log } P_{mW}$$

For example, if the power of a signal is 1 watt (=1000 mW), $P_{dBm} = 10 \times \text{Log } 1000 =$ 30 dBm. If signal power is 100 mW, $P_{dBm} = 10 \times \text{Log } 100 = 20$ dBm, and so on. For calculating "link budgets" (the amount of power that one can afford to lose because of distance, connections, etc., and still have the communications link operate—see **Section A.4**), dBm measurements are more convenient than watts.

Attenuation

Attenuation (fading) of an RF signal is a type of power loss and can be computed this way: Where P_{in} is the input-power level at the attenuated input and P_{out} is the output-power level at the attenuated output, A_{dB} (attenuation in decibels) $= -10 \times \text{Log } (P_{out}/P_{in})$. For example: If, due to attenuation, half of a signal's power is lost ($P_{out}/P_{in} = 0.5$), attenuation in dB is $-10 \times \text{Log } (0.5) = 3$ dB. For more details, see the entry for *Attenuation* in **Section A.4**.

Path Loss

Path loss is a measurement of how much power an RF signal loses in the process of propagating (traveling) along a given pathway. It is expressed in dB. Path loss depends on:

- The distance between transmitting and receiving antennas;
- Whether there are any obstacles fully or partially blocking line of sight between the receiving and transmitting antennas; and
- Antenna height.

When the signal path is perfectly clear, path loss is equivalent to free-space loss (see the next entry).

Free-Space Loss
Free-space loss is a measurement of how much power an RF signal loses in the process of propagating (traveling) through open, unobstructed space. Where F_{MHz} is the RF frequency expressed in MHz and R_{km} is the distance in kilometers between the transmitting and receiving antennas, S_{dB} (free-space loss in decibels) = 32.4 + (20 x Log F_{MHz}) + (20 x Log R_{km}). At the 11MWEB's baseline frequency of 2.4 GHz (2400 MHz), this formula simplifies to S_{dB} = 100 + (20 x Log R_{km}). If you were transmitting across a distance of 8 km (5 miles), free-space loss at 2.4 GHz would be approximately 114 dB.

A.3 Antenna Characteristics

Isotropic Antenna
A hypothetical antenna having equal radiation intensity in all directions. Used as a zero-dB gain reference in calculating directed gain for a real antenna.

Antenna Gain
A measure of directivity. It is defined as the ratio of an antenna's radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated equally in all directions (isotropically). Antenna gain is expressed in "dBi" (decibels referenced to the isotropic baseline).

Radiation Pattern
A graphical representation, in either polar or rectangular coordinates, of the spatial energy distribution of an antenna.

Lobes
Areas in an antenna's radiation pattern where radio transmission or reception is stronger than others. Typically there's one "main lobe" where the transmission or reception is strongest and several somewhat weaker "side lobes."

Omnidirectional Antenna
An antenna that radiates and receives equally in all directions in azimuth (horizontally). Figures A-2 and A-3 show the radiation pattern of an omnidirectional antenna, including its side lobes, in polar form.

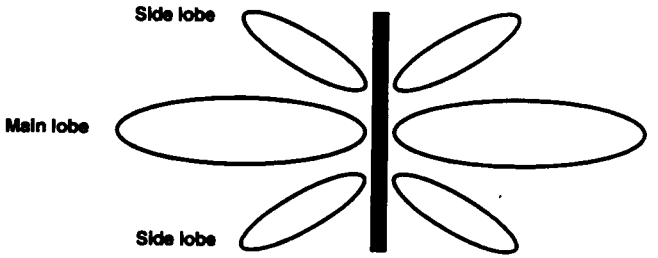

Figure A-2. Radiation pattern of an omnidirectional antenna (side view).

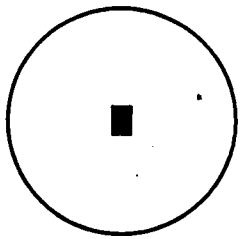

Figure A-3. Radiation pattern of an omnidirectional antenna (top view).

Directional (or Unidirectional) Antenna
An antenna that radiates and receives very strongly in one direction and much more weakly in all other directions. Figure A-4 shows the radiation pattern of a directional antenna, including its side lobes, in polar form:

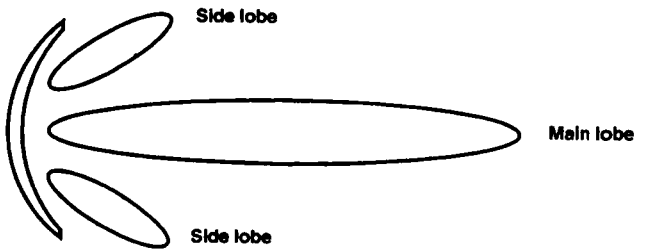

Figure A-4. Radiation pattern of a directional antenna (side view).

Antenna Beamwidth
How narrow or wide the "beam" of the main lobe of a directional antenna is. Defined as the angle between the two half-power (–3-dB) points on either side of the main lobe.

A.4 System Characteristics

Receiver Sensitivity
The minimum RF-signal power level required at the input of a receiver for certain levels of performance (Bit Error Rates, for example).

EIRP (Effective Isotropic Radiated Power)
An antenna's transmitted power. Equal to the transmitted output power minus cable loss plus the transmitting antenna gain.

Link Budget
The amount of transmit power minus the minimum necessary received power. This will yield a figure for the amount of power that one can afford to lose because of distance, connections, etc., and still have the communications link operate.

To calculate a link budget, one needs three main numbers: EIRP (see above), Ps (receiver sensitivity—see above—in dBm), and Si (received power level at the receiver input in dBm). To compute EIRP and Si, you'll need several other factors:

$EIRP = P_{out} - Ct + Gt$
where
P_{out} = Output power of transmitter in dBm
Ct = Transmitter-cable attenuation in dB
Gt = Transmitting-antenna gain in dBi
and
$Si = EIRP - Pl + Gr - Cr$
where
Pl = Path loss in dB
Gr = Receiving-antenna gain in dBi
Cr = Receiver-cable attenuation in dB

Here's an example:

If, for the 11MWEB system you'd like to install:

Frequency = 2.4 GHz
P_{out} = 4 dBm (2.5 mW)
Tx and Rx cable length = 10 m (32.8 ft.), and
attenuation of 0.6 dB/meter), so cable atte
Tx and Rx antenna gain (Gt and Gr) = 18 dB
Distance between sites = 3 km (1.9 mi.)
Data rate = 11 Mbps , so receiver sensitivity (

Assuming the path loss is equal to free-space loss (s
formula):

$Pl = 32.4 + (20 \times \text{Log } F_{MHz}) + (20 \times \text{Log } R_{km})$

Then the link-budget calculations work out this way

$EIRP = P_{out} - Ct + Gt = 4 \text{ dBm} - 6 \text{ dB} + 18 \text{ dBi}$
$Si = EIRP - Pl + Gr - Cr = 16 \text{ dBm} - 109.6 \text{ dB} +$

Because the absolute value of Si (input power at the
than that of the 11MWEB's Ps (receiver sensitivity, –8
theoretically work, especially because there is a 5.4-dB
between received signal power and sensitivity. (Margi
desirable in order to avoid intermittent reception pro
induced fluctuations in received power.)

Attenuation
Attenuation (fading) of the RF signal is caused by several factors:

- **Multipath propagation:** The transmitted signal arrives at the receiver from different directions, having traveled multiple paths of different lengths (as shown in Figure A-5), and so the separate parts of the signal have different attenuation and delay. The summed signal at the receiver might be much weaker than normal.

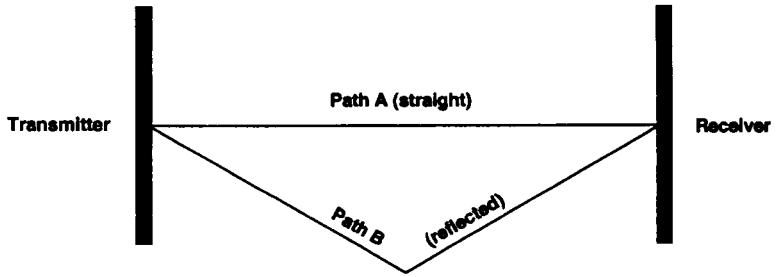

Figure A-5. Multipath propagation.

- **Bad line of sight:** There are radio-opaque or radio-reflective obstacles inside a certain area around the straight line between the Base Station and Client, the "first Fresnel zone." (See the "Line of Sight" entry on the next page.) The attenuation this causes will depend on how much of the zone is obscured.

- **Weather conditions (rain, wind, etc.):** At high rain intensity (0.6 inches or 15 mm per hour), the attenuation of an RF signal at 2.4 GHz may reach a maximum of 0.02 dB/km. Wind may also cause variable amounts of attenuation by causing the antenna to vibrate or sway.

- **Interference:** Interference might be caused by another 11MWEB system on the same frequency range, external noise, or other co-located wireless or radio equipment.

Line of Sight
An optical line of sight between two antennas exists if an imaginary straight line can be drawn connecting the antennas. A *clear* optical line of sight exists when no physical objects obstruct viewing one antenna from the location of the other antenna. A clear *radio-wave* line of sight exists if a defined circular area around the optical line of sight (the first "Fresnel zone," shown in Figure A-6 below) is clear of obstacles. Here's the formula for computing the radius (R) of a radio wave's first Fresnel zone:

$R = \frac{1}{2}\sqrt{(\lambda \times D)}$
where
λ = the wavelength of the signal in meters
and
D = the distance between the two antennas in meters

For example, if you're operating the 11MWEB at 2.4 GHz, the wavelength of the 11MWEB's radio signal is 0.125 meters. If the distance between your Base Station and Client is 16 km (10 miles), which is equivalent to 16,000 meters, the Fresnel-zone radius is one-half of the square root of (0.125 m x 16,000 m) = 22.4 meters (73.5 ft.).

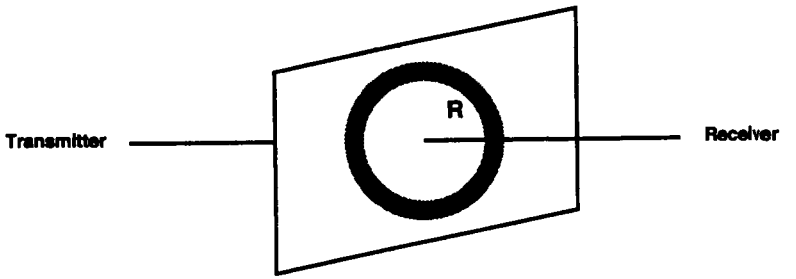

Figure A-6. The first Fresnel zone.

When at least 80% of the first Fresnel Zone is clear of obstacles, as shown in Figure A-7, propagation loss is equivalent to that of free space.

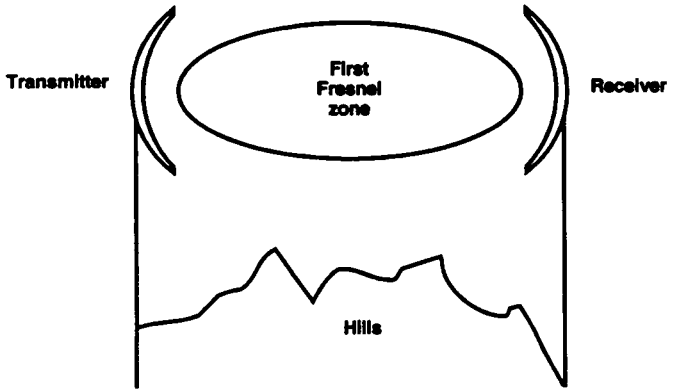

Figure A-7. A clear Fresnel zone.

Appendix B: Frequently Asked Questions

How many 11MWEB Base Station or Client units can be co-located on the same building roof or tower?
You can co-locate up to 3 Base Station or Client units on the same structure. Each unit must be assigned to one of the non-overlapping channels (1, 6, or 11).

What is the antenna-separation requirement for co-locating 11MWEB Base Station or Client units on the same building roof or tower?
The antennas should be mounted at least 2 feet (60 cm) apart if they're 16-dbi directional (our product code LW019A), 15 feet (4.5 m) apart if they're 24-dBi directional (LW013), and 75 feet (23 m) apart if they're 8-dBi omnidirectional (LW0029A-R2). When you co-locate omnidirectional antennas, the maximum cell size of each antenna is reduced by up to 50%. Greater separation will improve the cell size.

What is the throughput of the 11MWEB?
The typical performance of the wireless link between an 11MWEB Base Station and Client is 4.2 Mbps using TCP and 6.2 Mbps using UDP. For long-range links, the performance will drop about 5%.

Why are there 11 channels and only 3 usable?
The IEEE 802.11 specification calls out 11 selectable channels between 2414 MHz and 2462 MHz. Because of the transmission bandwidth of the DS modulation, only 3 channels are non-overlapping. Those are channels 1, 6, and 11; therefore, only 3 systems may be co-located.

The other channels are still usable, but if there's another 11MWEB at the same site using a nearby channel, the frequency ranges will overlap. This will cause the two 11MWEB systems to share the available bandwidth, which will slow them down.

When you've set an 11MWEB system to use a single channel, but you get in-band interference on that channel, you can try to get away from it by switching to a different nearby channel.

What if the 11MWEB link experiences interference?
If interference is affecting an 11MWEB link, you can switch the affected 11MWEB units to a different channel in order to try to avoid the frequency of the interference. Physically relocating the antennas might also help.

What is the typical latency of an 11MWEB link?
A point-to-point Base-Station-to-Client link would realize about 3 ms of latency.

Can the firmware of the 11MWEB Base Stations and Clients be upgraded?
Yes, the firmware in the Base Station and Client is stored in flash memory and is upgraded using the built-in TFTP server. See **Chapter 5**.

Can just anyone erase the firmware of my Base Station or Client or change their firmware?
No, the TFTP server in the Base Station and Client requires the SNMP write-community name (password) to perform an upgrade.

Can I corrupt my firmware flash when upgrading to a new version?
If the TFTP file transfer is interrupted during a flash update it is possible to corrupt the firmware. Fortunately, the 11MWEB has a backup flash, which contains the previous version of the firmware. If the primary flash becomes corrupted, the backup is automatically used to return the unit to an operating state.

When does the backup flash image get upgraded?
Even after completing a firmware upgrade, the backup flash containing the old firmware version is not overwritten with the new version until the unit is turned OFF and back ON again.

Can I downgrade my 11MWEB firmware?
Yes, an earlier version of firmware can overwrite a newer version.

Can I keep the previous version of the firmware?
Yes, but not in the 11MWEB Base Station or Client itself. You need to export it to the PC where you're running the DS.11 Manager software, from which you can import it later if you need to. See **Section 4.9**.

Does 11MWEB support 802.1Q VLAN?
Yes, but the support is limited to transparent operation: The 11MWEB does not take any action on 802.1Q frames, but will transparently pass them within a VLAN network.

Can I change the regulatory domain (country) of my 11MWEB?
No. The regulatory domain is factory-set and can't be changed.

How can I configure or manage my 11MWEB if I forget its SNMP community names?
Press the Reset button on the unit's rear panel with a paper clip. This will set the read and write community names back to "public" and "private," respectively.

How can I return an 11MWEB Base Station or Client to its factory-default settings?
There are two ways: Either click the Default button under the Station Control tab in the DS.11 Manager utility—see **Section 4.9**—or use a paper clip to press and hold the Reset button on the back of the unit while powering on the unit. Keep in mind that all current settings, including IP addresses, will be lost when you do this.

Can I place the Base Station and Client 11MWEB units outdoors?
No, not directly. The Base Station and Client are specified to operate at 32 to 104°F (0 to 40°C) and are not weatherproof. It is best to mount the 11MWEB indoors or in a protective cabinet.

What is the maximum number of networked PCs that the 11MWEB Base Station and Client can learn?
1024 network MAC addresses can be learned by the Base Station and Client.

Can the 11MWEB Base Station and Client be used for multipoint as well as point-to-point links?
Yes. The Base Station can support multiple Client units, creating a multipoint network.

How many Client units can one Base Station support?
The maximum number of associations is 128.

What is the practical limit to the number of Clients per Base Station? And what performance can I expect for a multi-point link?
This really depends on average throughput expectations. All clients would have the maximum throughput available for burst traffic; however, the overall average would depend on the utilization of the network. For example, in a heavily utilized network needing about 350 to 500 kbps average net throughput per site, 9 to 12 Clients would be the limit. For a moderately utilized network needing about 175 to 258 kbps average, 18 to 24 Clients could be used, and a lightly utilized network needing 32 to 48 kbps average net throughput per site could use up to 128 Clients.

What is the range of the 11MWEB Base Station and Client bridges?
15 miles (24 km) can be achieved using the 24-dBi directional (LW013) antenna kits for a point-to-point link. Consult Table 3-2 in **Section 3.3.7** for distances achievable with other antennas.

What are the specifications for the 11MWEB's power supply?
The 11MWEB power supply is rated for 100 to 240 VAC input (47 to 63 Hz) and 9 VDC at 1.67 A output. Polarity doesn't matter.

What management options are available on 11MWEB?
The Base Station and Client 11MWEB comes with a graphical DS.11 Manager utility that operates on any Windows based network-ready PC. With this utility you can configure and monitor every 11MWEB on your network. You can also use the 11MWEB's SNMP MIB on standard management platforms like SNMPc® and HP® Openview®.

Does the 11MWEB offer out-of-band management?
No, the 11MWEB does not offer out-of-band management (serial port, etc.). The 11MWEB is managed in-band only with the DS.11 Manager utility or SNMP.

What installation and site-survey tools are available for the 11MWEB Base Station and Client?
The 11MWEB comes with a Windows based DS.11 Manager utility. With this utility you can configure link parameters and monitor signal quality and RSSI (received signal strength indication). Optimizing antenna alignment is done using the signal quality and RSSI display. Any computer on the network can use this utility to manage Base Stations and Clients.

Is the 11MWEB compatible with other DS (direct sequence) equipment from other vendors?
Yes. However, interoperability can vary from vendor to vendor, and in some cases it may not operate if the manufacturer's implementation is not pure 802.11. The Base Station and Client can operate at 1 and 2 Mbps with legacy 802.11 DS equipment, and at 5.5 Mbps and 11 Mbps with 802.11b High Rate DS equipment.

Do the Base Station and Client 11MWEB support 802.1d spanning tree protocol?
No, the Base Station and Client do not support spanning tree. This is because the Base Station can also support roaming devices.

What is the normal PER (packet error rate) for the Base Station and Client 11MWEB?
The error rate will be about 4% to 6% (transmitted fragments vs. retry count). This is typical when operating in an interference-free environment at maximum range for bidirectional traffic loads. If the traffic load is more unidirectional, then the PER will be less.

What is the best value for the "CW win" parameter on the 11MWEB?
Setting the "CW win" (contention window) parameter to 31 slots for heavy bidirectional traffic loads will minimize the PER. Setting the CW win to 15 will improve performance for more unidirectional traffic loads. CW win 7 should only be used for short-range point-to-point links, and 63 should be used for large, long-range multipoint links. See **Section 4.6**.