aperto networks

PACKETWAVE

Fixed Broadband Wireless Access System

PACKETWAVE 1000 SERIES BASE STATION EQUIPMENT

Installation, Configuration, and Operation Manual

070-20000340-01
Rev. A, August, 2001

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REGULATORY INFORMATION

PART 15

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1) this device may not cause harmful electromagnetic interference, and
2) this device must accept any interference received including interference that may cause undesired operations.

FCC NOTICE: Radio and Television Interference

The PacketWave 100 Series Subscriber Equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used according to the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which is found by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment or device.
- Connect the equipment to an outlet other than the receiver's.
- Consult a dealer or an experienced radio/TV technician for assistance.

RF Exposure Notice

The installer shall mount all transmit antennas so as to comply with the limits for human exposure to radio frequency (RF) fields per paragraph 1.1307 of FCC regulations. The FCC requirements incorporate limits for Maximum Permissible Exposure (MPE) in terms of electric field strength, magnetic field strength, and power density.

CAUTION (5.8 GHz UNII)

To comply with FCC RF exposure requirements, antennas used for this device must be installed to provide a separation distance of at least 1.5m from all persons.

CAUTION (2.5 GHz MMDS)

To comply with FCC RF exposure requirements in section 1.1307, a minimum separation distance of 20 cm. is required between this antenna and all persons.

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CHAPTER 6. BSU AND SUBSCRIBER CONFIGURATION

CHAPTER 7. NETWORK CONFIGURATION AND START-UP

This manual is part of the documentation for the PacketWave fixed broadband wireless system for delivering high-speed subscriber services. The PacketWave documentation set includes:

- PacketWave 1000 Base Station Unit Installation, Configuration, and Operation Manual: *part number 070-20000340-0x*
- PacketWave 100 Series Subscriber Equipment Installation and Operation Manual: *part number 070-20000330-0x*

SCOPE OF THIS MANUAL

This manual documents Release 1, Phase 1 (R1P1) of the PacketWave System

This manual provides the following information:

- A *QuickStart* section for rapidly placing a PacketWave System in operation.
- A conceptual overview of the PacketWave System.
- Descriptions of the PacketWave hardware components, including base station and subscriber equipment.
- Descriptions of the PacketWave software components, including configuration programs, management interfaces, installation utilities, and monitoring/diagnostic functions.
- System and site planning information.
- Complete installation instructions for base station equipment.
- System configuration, management, and diagnostic procedures.

Installation and operating instructions for subscriber equipment (CPE) are provided in the *PacketWave 100 Series Subscriber Equipment Installation and Operation* manual.

CONVENTIONS USED IN THIS MANUAL

PacketWave manuals represent special kinds of text as follows:

- Files names and URLs are represented in italics, with variables described inside angle brackets. For example, if the URL *http://<IP address>/bsu.htm* is referenced, you will replace the variable *<IP address>* with the appropriate real IP address.
- Management interface text is represented by a bold font: for example, the **Generate Config File** button.
- Labels on equipment are represented in a bold sans serif font: for example, the **Control** connector.

WARNING: This format is used to indicate the possibility of personal injury or serious damage to equipment.

CAUTION: This format is used to indicate the possibility of system or equipment operation problems.

Items of special importance will be formatted and marked by a pointing-hand icon, as this paragraph is.

INTENDED AUDIENCE FOR THIS MANUAL

This manual is intended for system designers and planners, base station installers, system operators, and others requiring or desiring information about the PacketWave System. It provides information specific to the PacketWave system, but cannot and should not be considered a tutorial on relevant technologies and practices.

It is expected that system designers and planners are knowledgeable about radio communications, cellular communication systems, and IP networks. Tutorials on these subjects are beyond the scope of this manual, and are readily available in published and on-line materials.

Installation of radio equipment involves numerous factors, such as lightning and weather protection, requiring considerable expertise. It is assumed that equipment installers are professionals with knowledge of the principles and standard practices and procedures of cell site installation, with all relevant safety requirements, and with applicable local building codes.

GENERAL CAUTIONS AND WARNINGS

Observe the following when installing or operating any PacketWave System components.

All installation, including equipment mounting and cabling, should be performed by trained microwave radio technicians familiar with usual and customary practices and procedures.

Always use quality components—including cables, connectors, mounts, etc.—specifically rated for your particular environmental conditions and system performance requirements.

Always use appropriate tools, and follow the instructions of the tool manufacturers.

Observe all applicable local building codes.

Observe all customary and mandatory safety requirements when installing and operating PacketWave equipment.

Because Aperto cannot be responsible for improper installation or use of its equipment, failure to follow these and other published cautions and warnings may void your equipment warranty.

QUICKSTART GUIDE

This chapter outlines the basic procedure for installing a PacketWave System and putting it into operation. It identifies the minimal requirements for getting the system up and running.

WARNING: This QuickStart Guide assumes that installation procedures will be performed by qualified professionals following all safety and other requirements and acting in accordance with standard practices and procedures. Failure to meet safety requirements and/or non-standard practices and procedures could result in personal injury and/or damage to equipment.

All of the instructions presented in this chapter are discussed in more detail in subsequent chapters of this manual and in the *PacketWave 100 Series Subscriber Equipment Installation and Operation* manual.

PLANNING, SITE PREPARATION, AND CONFIGURATION

Before you begin installing the PacketWave equipment, make sure you properly plan the overall system and individual sites.

Step 1. Determine and Prepare Locations

A. Make sure that the base station is located such that it can communicate with subscribers.

- Cell sector width may be 60º or 90º, depending on the antenna chosen.
- Distance between base station and subscriber site may be up to 5 miles for line-of-sight or near-line-of sight communications, or up to 1 mile for non-line-of-site communications.

B. Make sure that the base station site includes a proper mounting structure for the radios and antennas, and an indoor location for the Base Station Unit. Maximum cable length is 165 feet (50 m) without dc insertion from an external source.

C. Make sure all subscriber sites have an appropriate radio/antenna support or mounting location. Maximum cable length between subscriber Indoor Units (bridge/routers) and Outdoor Units (radio/antennas) is 165 feet (50 m) without dc insertion from an external source.

Step 2. Define IP Networking

A. Each cell sector is served by a separate wireless subsystem (WSS) in the Base Station Unit. The WSS wireless interface will be the gateway for all subscribers it serves, which typically define a single subnet. Determine the WSS interface (gateway) address based on the available IP address space and desired subnetting.

NOTE: The PacketWave System supports VLSM.

B. The Base Station Unit requires a DHCP server from which it and subscribers receives IP addresses and other basic configuration information, and a TFTP server from which they download configuration files.

i. The DHCP server, or a DHCP relay agent pointing to it, must be on the same subnet as the BSU's backhaul interface for the BSU to locate the DHCP server.

ii. The address of the TFTP server is provided by the DHCP server, so may be any reachable IP address.

C. If SNTP (time), SMTP (mail), SNMP, and/or Syslog servers are to be implemented, their IP addresses will be required during BSU configuration.

Step 3. Create BSU Configuration File(s)

A. Load and run the WaveCenter Configuration Manager program (provided on CD).

> NOTE: The program can be run on the TFTP server or another computer from which the files can be downloaded to the TFTP server. The Configuration Manager runs on Windows 98, NT, or 2000 Professional; Linux; or Sun Solaris.

B. From the opening screen, click on the BSU icon to open the BSU Configuration Manager. For WSS 1:

i. Go to the **WSS — Multiple Subnets** menu and specify the **WSS IP Address** and **WSS Subnet Mask** (mandatory).

> NOTE: If multiple subnets are to be implemented for the WSS, click on the new instance icon and repeat the step above until all subnets are defined.

ii. Go to the **WSS — Channel** menu and specify the **Channel Center Frequency** (mandatory).

iii. If desired, configure any optional WSS parameters as described in Chapter 6 of this manual.

iv. Save the configuration by clicking the **Generate WSS Config** button and following the prompts.

v. For an additional WSS, click on the new instance icon on the **WSS — Multiple Subnets** menu, which will increment the WSS number (**Host ID**). Then return to step **i** above. When all WSS are configured, proceed to the step C.

C. Go to the **MAIN — General** menu and specify the Base Station Unit's **MAC Address.**

D. If desired, configure any optional BSU parameters (**MAIN**, **SNMP**, and **ALERTS** menus) as described in Chapter 6 of this manual.

E. When all configuration has been completed, generate the BSU configuration file by clicking on the **Generate BSU Config** button and following the prompts. Save the config file with a name uniquely linking it to the BSU; Aperto recommends the default format *bsc_<MACaddress>.cfg*.

F. Close the BSU Configuration Manager. If there are additional BSUs to configure, return to step B.

Step 4. Create Subscriber Configuration Files

A. From the WaveCenter Configuration Manager's opening screen, click on the subscriber Indoor Unit icon to open the subscriber (CPE) Configuration Manager option.

i. Go to the **System** menu and specify the **MAC address**, **CPE Mode** and **CPE Model** (mandatory).

ii. If the **CPE Mode** is **NAT**, you may go to the **NAT** menu and configure as desired. However, the defaults will work for basic operation.

iii. If the **CPE Mode** is **Router**, you may go to the **Router** menu and configure as desired. However, the defaults will work for basic operation. *(Standard routing is not supported in R1P1.)*

B. If desired, configure any other optional subscriber parameters as described in Chapter 6 of this manual.

C. When all configuration has been completed, generate the subscriber configuration file by clicking on the **Generate Configuration File** button and following the prompts. Save the config file with a name uniquely linking it to the subscriber Indoor Unit; Aperto recommends the default format *cpe_<MACaddress>.cfg*.

D. Close the CPE Configuration Manager. If there are additional subscribers to configure, return to step A.

Step 5. Configure the TFTP and DHCP Servers

A. Download all BSU and subscriber configuration files to the default TFTP directory on the TFTP server.

B. Configure the DHCP server for the following:

- IP address and subnet mask for TFTP server, and for other servers as desired.
- Range(s) of assignable addresses, with subnet masks and gateway addresses.
- BSU MAC address and the name of the corresponding configuration file to be found on the TFTP server.
- For each subscriber Indoor Unit, its MAC address and the name of the corresponding configuration file to be found on the TFTP server.

NOTE: If desired, different DHCP servers can be defined for the BSU and for subscribers.

C. Make sure that the DHCP and TFTP servers are running.

INSTALLING AND STARTING BASE STATION EQUIPMENT

The steps in this section outline the physical installation of the base station equipment. *(See Chapters 4 and 5 of this manual for details.)*

Step 6. Install Base Station Radios and Antennas

A. Mount the PacketWave radios and antennas on the antenna mast or other support structure using the mounting brackets supplied, or other brackets as required by the support structure. Observe minimum distances between antennas and maximum radio-to-antenna distances.

B. Connect the radio's RF jumper cables to the appropriate connectors on the antenna.

C. Install radio signal and control cables between each radio and the Base Station Unit location. Label the cable ends to prevent misconnections.

- Radio signal cable (RG6, 75 ohm, quad shield coaxial, male F connectors)
- Radio control cable (shielded outdoor Cat 5, male RJ45 connectors)

The **Radio Control** *interface on the Base Station has the same physical appearance as the* **10/100Base-T** *interface. Make sure you connect to the right one.*

Step 7. Install the Base Station Unit

A. Mount the Base Station Unit in an equipment rack, allowing for adequate air flow around and through the unit.

B. Connect the radio signal and control cables from the outdoor radios to the proper ports on the BSU front panel.

NOTE: No other connections to the front panel are necessary for a site with a single BSU. See Chapter 4 for discussions of optional connections and/or multiple BSUs.

C. Connect 120 V ac or -48 V dc to the rear panel connector, as appropriate.

Connecting power will cause the Base Station Unit to boot up, locate the DHCP server and obtain basic configuration information from it, then download its full configuration file from the TFTP server.

NOTE: If power is connected before the DHCP server is configured and the BSU's configuration file is available in the TFTP server, or if either of the servers is unreachable, the BSU will power up in standby mode. It will need to be rebooted when the servers are fully configured and reachable.

After the first successful loading of the BSU configuration file from the TFTP server, the configuration will be stored in nonvolatile memory on the BSU. Thus, if the BSU is rebooted when the TFTP server is unreachable, the BSU will operate with its existing configuration rather than going into standby mode.

INSTALLING AND STARTING SUBSCRIBER EQUIPMENT

The steps in this section outline the physical installation and initialization of equipment at the subscriber site. See the *PacketWave 100 Series Subscriber Equipment Installation and Operation* manual for details.

Step 8. Prepare for Installation

A. Before visiting the subscriber's site:

i. Make sure that the necessary system configuration has taken place, as described in the *PacketWave 1000 Base Station Unit Installation, Configuration, and Operation* manual.

ii. Make sure that the DHCP and TFTP servers are running.

iii. Verify that the subscriber configuration file has been created and saved on the TFTP server.

iv. Verify that the DHCP server has been configured with the subscriber's IP and MAC addresses and its configuration file name.

B. At the subscriber's site:

i. Identify the location for the Indoor Unit (bridge/router).

ii. Identify an appropriate location for mounting the Outdoor Unit, where it can be pointed at the base station with the least possible obstruction

iii. Determine the cable path between the Indoor Unit and the Outdoor Unit. Maximum cable length is 165 feet (50 m).

Step 9. Install the Outdoor Unit (Radio/Antenna)

A. If a mounting pole or other support is to be employed, install it in the chosen location, following standard procedures and local building codes.

The Outdoor Unit's mounting bracket accommodates diameters of 1.5 inches, 2 inches, or 5 cm.

B. Mount the Outdoor Unit to the support or to the building.

Step 10. Install the Indoor Unit (Bridge/Router)

A. To start, in most cases, the Indoor Unit should be temporarily placed close to the Outdoor Unit to facilitate antenna alignment process. When the installation of the-Outdoor Unit is complete, move the Indoor Unit to its permanent location.

Make sure the Indoor Unit is located near an electrical power outlet or power extension cord will be needed.

WARNING: For proper cooling, the Indoor Unit must be installed in the upright position, with adequate air flow around and through it.

B. Assuming that the Indoor Unit is located at a temporary location, run spare radio signal and control cables between the Outdoor and Indoor Units.

- Radio signal cable (quad shield coaxial, male F connectors) — **Radio RF** connectors on the Outdoor and Indoor Units.
- Radio control cable (shielded outdoor Cat 5, male RJ45 connectors) — **Radio Control** connectors on the Outdoor and Indoor Units.

The **Radio Control** *interface on the Indoor Unit has the same physical appearance as the* **10/100Base-T** *interface. Make sure you connect to the right one.*

Step 11. Initialize the Subscriber Equipment

A. Connect the power module between the Indoor Unit and a wall outlet.

B. Perform antenna alignment procedure (see the PacketWave 100 Subscriber Equipment manual, or the addendum on this subject).

C. If the Indoor Unit is located at a temporary location, move the Indoor Unit to its permanent location.

WARNING: For proper cooling, the Indoor Unit must be installed in the upright position, with adequate air flow around and through it.

D. Use the permanent radio signal and control cables to connect the Outdoor Unit to the Indoor Unit.

- Radio signal cable (RG6, 75 ohm, quad shield coaxial, male F connectors) — between **Radio RF** connectors on the Outdoor and Indoor Units.
- Radio control cable (shielded outdoor Cat 5, male RJ45 connectors) — between **Radio Control** connectors on the Outdoor and Indoor Units.

Step 12. Configure Subscriber Hosts

A. Connect the subscriber's computer(s) to the 10/100Base-T interface on the Indoor Unit, using a straight Ethernet cable for connection to a hub or a crossover Ethernet cable for connection directly to a computer.

B. Typically, the only other thing necessary to connect a subscriber host computer to the PacketWave network and beyond is to configure the host's TCP/IP to obtain its IP address using DHCP. Instructions should be available using the computer's online help

PACKETWAVE SYSTEM OVERVIEW

This chapter provides a description of the PacketWave Broadband Multiservice Wireless Access System, including system architecture, functionality, features, benefits, and hardware and software components.

CONCEPTUAL OVERVIEW OF THE PACKETWAVE SYSTEM

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Aperto Networks' PacketWave System is a next-generation fixed broadband wireless access solution that dramatically increases capacity and coverage while reducing deployment cost and time to market. It is a cellular system consisting of the

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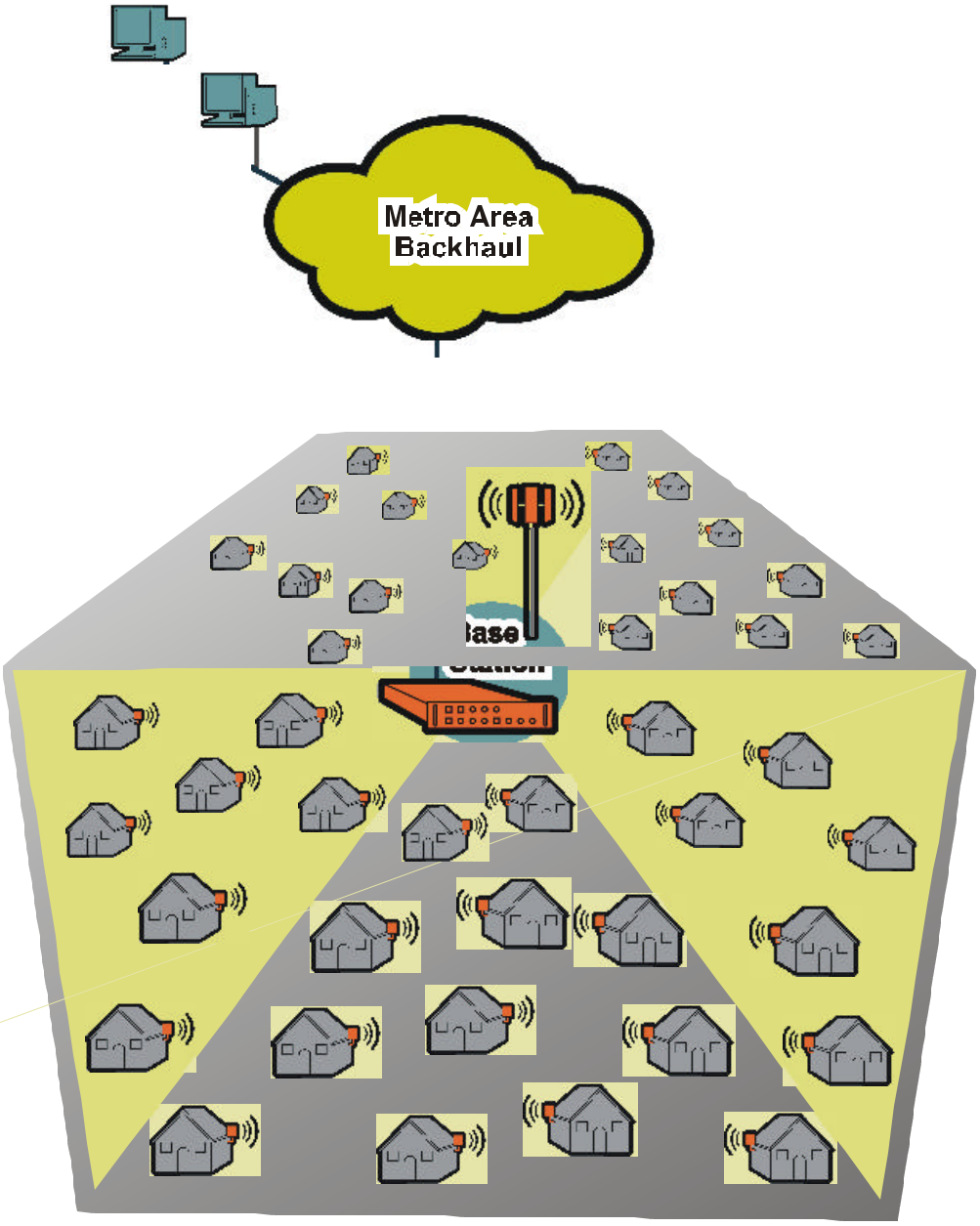


Figure2-1 PacketWave System Elements

Cell Size, Capacity, and Scalability

Aperto's advanced wireless technologies support a wide range of cell requirements, and make PacketWave an exceptionally scalable solution. PacketWave cell specifications include:

- Cell radius can easily reach 5 miles (8 km) with line-of-site transmission paths, or about 1 mile (1.6 km) with obstructed paths.
- Each Base Station Unit can support up to 250 subscribers per sector, with a maximum of six sectors.
- A cell can employ multiple Base Station Units. Thus, a single cell can serve thousands of subscribers.
- The bandwidth capacity for a Base Station Unit is 120 Mbps, based on a maximum raw bit rate of 20 Mbps per sector.
- Subscriber data rates can be individually configured from 384 kbps to 10 Mbps; with bursts to 20 Mbps.
- The ratio of downstream to upstream traffic can be adjusted between 90% downstream/10% upstream and 90% upstream/10% downstream.

The PacketWave System ensures that a wireless network can grow to thousands of subscribers in urban or suburban areas through high frequency reuse and dense multicell deployment. Combining high frequency reuse with advanced interference management and mitigation techniques, the PacketWave System conserves valuable spectrum by covering extensive geographical areas with a minimum number of channels.

As the number of subscribers and the bandwidth needs in a cell increase, new sectors can be added, and multiple PacketWave 1000 Base Station Units can be stacked to provide additional bandwidth using multiple channels per sector. To extend service offerings geographically, a service provider simply deploys additional cells.

Multiple Frequency Bands

The PacketWave System can be deployed in the standard frequency bands used variously throughout the world for licensed or unlicensed wireless broadband networking. The PacketWave 1000 Base Station Unit can support PacketWave radios and antennas operating in 2.5 GHz MMDS, 3.5 GHz FWA, 5.3 GHz, and 5.8 GHz U-NII bands with no physical or software reconfiguration. Similarly, any PacketWave 100 Series Subscriber Indoor Unit (bridge/router) can support the same range of frequency bands.

IP-Based System

The PacketWave System leads the industry in the implementation of advanced IP features and services. Packet filtering, DHCP snooping, and ARP snooping conserve bandwidth for subscriber traffic. Support for IP RIP routing, multiple subnets per sector, Variable-Length Subnet Mask (VLSM), and Classless Internet Domain Routing (CIDR) ensure complete control of IP address management and network configuration. PacketWave Series 100 Subscriber Indoor Units support bridging, IP routing, and NAT for flexible deployment.

Because the PacketWave System is based on IP end-to-end and IP networking skills and resources are relatively common, the PacketWave solution helps service providers to control costs, expand service options, expedite configuration, simplify connection to the Internet, and minimize time to market. The ubiquity of IP also allows native support for value-added Internet applications such as VPN, web hosting, and video-conferencing.

Range of Backhaul Options

The PacketWave 1000 Base Station Unit offers both flexible and cost-effective solutions to connect to backhaul networks. In its basic configuration, PacketWave 1000 supports 10/100 Mbps Ethernet. This enables the PacketWave 1000 to connect directly to an Ethernet-based MAN or, through an external router, to a variety of broadband network technologies. Through future plug-in modules, other backhaul options, such as ATM, will be directly supported. In addition, external optical or high-capacity wireless backhaul such as millimeter wave technology can be implemented. Where other backhaul options are not available, one of the Base Station Unit's wireless channels can provide a link to a backhaul network.

Whatever the backhaul option, quality of service (QoS) is maintained throughout the network using either IP Differentiated Services (DiffServ), ATM Service Categories, or MPLS.

Subscriber and Network Management

The PacketWave System simplifies subscriber and network management by using GUI-based tools, standard protocols, and industry-standard platforms. One of these tools is the highly-scalable, Java-based WaveCenter™ Configuration Manager, which automates the subscriber provisioning process. In addition to the WaveCenter Configuration Manager, the PacketWave System also includes Web-based and SNMP-compliant network management software for configuration, fault, performance, and security management.

Technological Innovations

At the heart of PacketWave's revolutionary performance are three innovative Aperto Networks technologies: *RapidBurst*™, *OptimaLink*™, and *ServiceQ*™.

RapidBurst

RapidBurst technology enables the PacketWave System to achieve exceptionally low latency and high spectral efficiency. Advanced Time Division Multiple Access (TDMA) burst mode ensures maximum flexibility and efficiency in both upstream and downstream transmissions. Adaptive Time Division Duplexing (TDD) allows operation in a single channel anywhere in the spectrum. Dynamic bandwidth allocation assigns time slots and packet sizes depending on specific traffic flows. With *RapidBurst*, the PacketWave System provides up to 120 Mbps of bandwidth per cell with one base station.

OptimaLink

OptimaLink technology individually optimizes the reliability and throughput of each Subscriber wireless channel by dynamically adjusting up to ten PHY- and MAC-layer parameters. The result is increased coverage, extending broadband services to subscribers who would otherwise be unreachable due to obstructed-line-of-sight or non-line-of-sight conditions.

ServiceQ

ServiceQ technology provides different quality of service (QoS) levels to subscribers on a flow-by-flow basis enabling differentiated service offerings and effective management of service level agreements (SLAs). Various service levels can be defined in three service classes—Constant Bit Rate (CBR), Committed Information Rate (CIR), and Best Effort (BE). The percentage of bandwidth allocated to each service class is adjustable depending on the mix of service offerings.

ServiceQ supports high-quality video and telephony applications. Each service flow can be associated with a specific host or application and can be assigned to any service class, so application-specific services with QoS can be offered.

BASE STATION (CELL SITE) EQUIPMENT

PacketWave base station equipment includes the PacketWave 1000 Base Station Unit and associated radios and antennas.

Base Station Unit

The PacketWave 1000 Base Station Unit, shown in *Figure 2-2*, is a single rack-mounting controller unit which supports any of the PacketWave System radio and backhaul options. There are two models, one with an ac power supply and one with a dc power supply.

Figure2-2 PacketWave 1000 Base Station Unit

In the basic configuration pictured, the PacketWave 1000 includes:

- Four built-in wireless interfaces for connection to radios and their associated antennas.
- A 10/100Base-TX Ethernet backhaul interface.
- Synchronization interfaces for multiple colocated Base Station Units.
- A local RS-232 craft management port.
- An external clock interface.
- A dry-contact relay which can be configured to operate a local alarm device or to control redundant equipment such as a backup radio and antenna.

- Two slots for plug-in modules.
  - One slot will support a dual wireless interface unit, allowing a total of six wireless interfaces in the Base Station Unit.
  - The second slot will support an alternative backhaul interface. Modules supporting additional backhaul options, including ATM, are under development.

Multiple Base Station Units

Subscriber density and bandwidth requirements may combine to exceed the capacity of a single Base Station Unit. Part of the scalability built into the PacketWave System is the ability to colocate and link multiple Base Station Units at a cell site. Through the use of different center frequencies within the system's frequency band, sectors can be overlaid within the cell to serve additional subscribers, providing a virtually unlimited growth path.

To coordinate the Time Division Multiple Access (TDMA) and Time Division Duplexing (TDD) on which the PacketWave wireless communication is based, it is necessary for all Base Station Units in a cell to be synchronized in terms of signal framing and time slot identification. Sync ports on the Base Station Unit allow all units to share the same framing, with inputs for a main and alternate BSU to provide the framing signal.

Base Station Radios and Antennas

PacketWave base station radios and antennas deliver the benefits of a single-source, thoroughly-tested base station package.

Radios and antennas are available for the following frequency bands:

- 2.5 GHz MMDS
- 3.5 GHz FWA
- 5.3 GHz U-NII
- 5.8 GHz U-NII

There are also different antenna models available for 60° and 90° sectors.

Radios and antennas are designed for mounting outdoors on tubular antenna masts or similar supports. Details are provided in Chapter 5.

SUBSCRIBER SITE EQUIPMENT

Figure 2-3 PacketWave 100 Series Indoor Unit and Radio/Antenna

PacketWave equipment installed at the subscriber site consists of an subscriber Indoor Unit (a bridge/router between the wireless subnet and the subscriber's computer or LAN), and an outdoor integrated radio/antenna unit. The two units are illustrated in *Figure2-3*.

There are four models of radios, for support of different frequency bands:

- 2.5 GHz MMDS
- 3.5 GHz FWA
- 5.3 GHz U-NII
- 5.8 GHz U-NII

Radio/antenna units vary in size, depending on the frequency band. Each subscriber Indoor Unit can support any of the integrated radio/antenna units. (Of course, the radio's frequency band must match that employed at the base station.)

The radio/antenna unit is usually installed on the subscriber's roof or under the eave, mounted either on a pole or to a flat surface. It is also possible to mount a radio/ antenna unit in a window if a suitable transmission path is available.

There are three models of the Indoor Unit: the PacketWave 110, 120, and 130. R1P1 supports only the PacketWave 130, which can function as either a bridge or a NAT router as illustrated in *Figure2-4*.

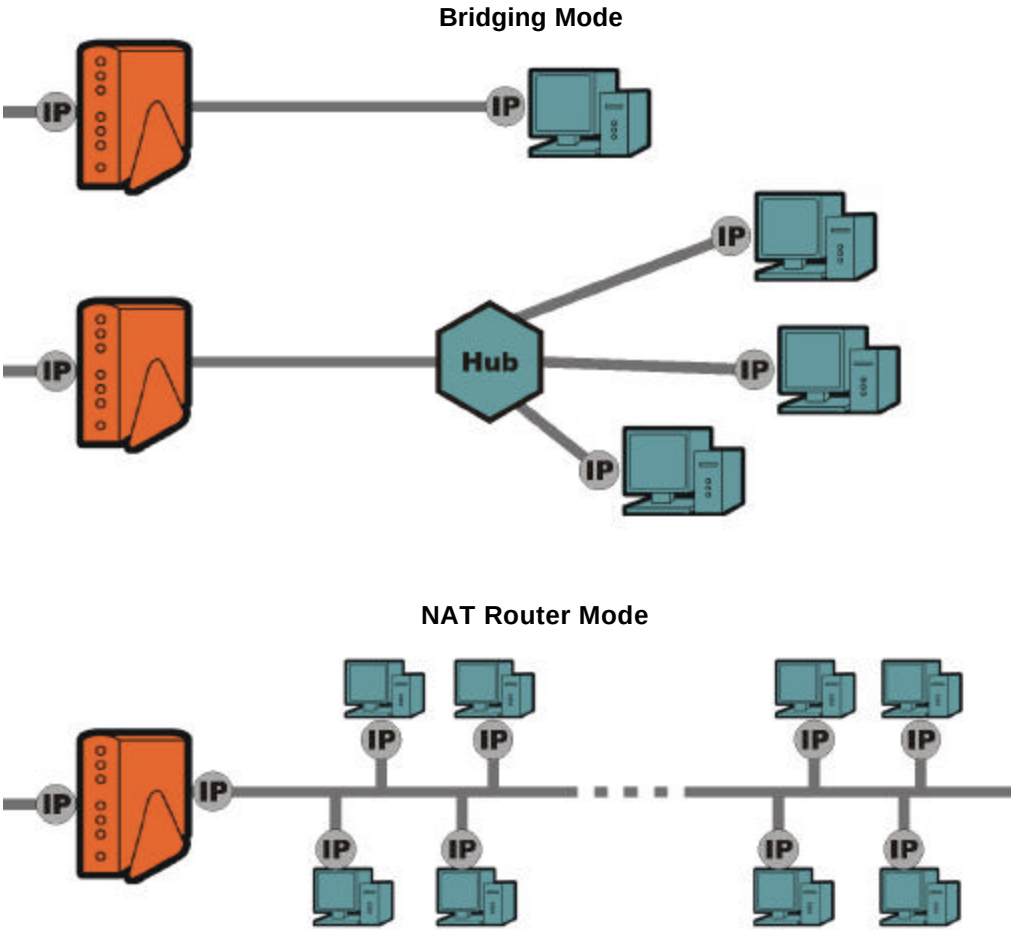


Figure2-4 PacketWave 100 Series Subscriber Indoor Units

THE PACKETWAVE SYSTEM'S IP NETWORK

The PacketWave System uses IP for the backhaul channel and the wireless channels. Overall, the system has the following network architecture, as shown in *Figure2-5*.

- The Base Station Unit's backhaul channel is part of a subnet which includes:
  - A gateway to the outside world (Internet or private network).
  - Access to a DHCP server (either the DHCP server or a DHCP relay agent must be on the same subnet as the BSU's backhaul interface).
  - Access to a TFTP server identified by the DHCP server.
- Each wireless interface is the gateway for a subnet comprising itself and the subscriber Indoor Units with which it communicates, and perhaps some or all of the hosts at the subscriber sites.

  NOTE: A wireless interface can be configured for multiple subnets, if desired. Also, two or more wireless interfaces can be "clustered" in the same subnet. These options are discussed in detail later in this section.

- Subnets may be implemented at subscriber sites. *Figure2-6* shows various options.

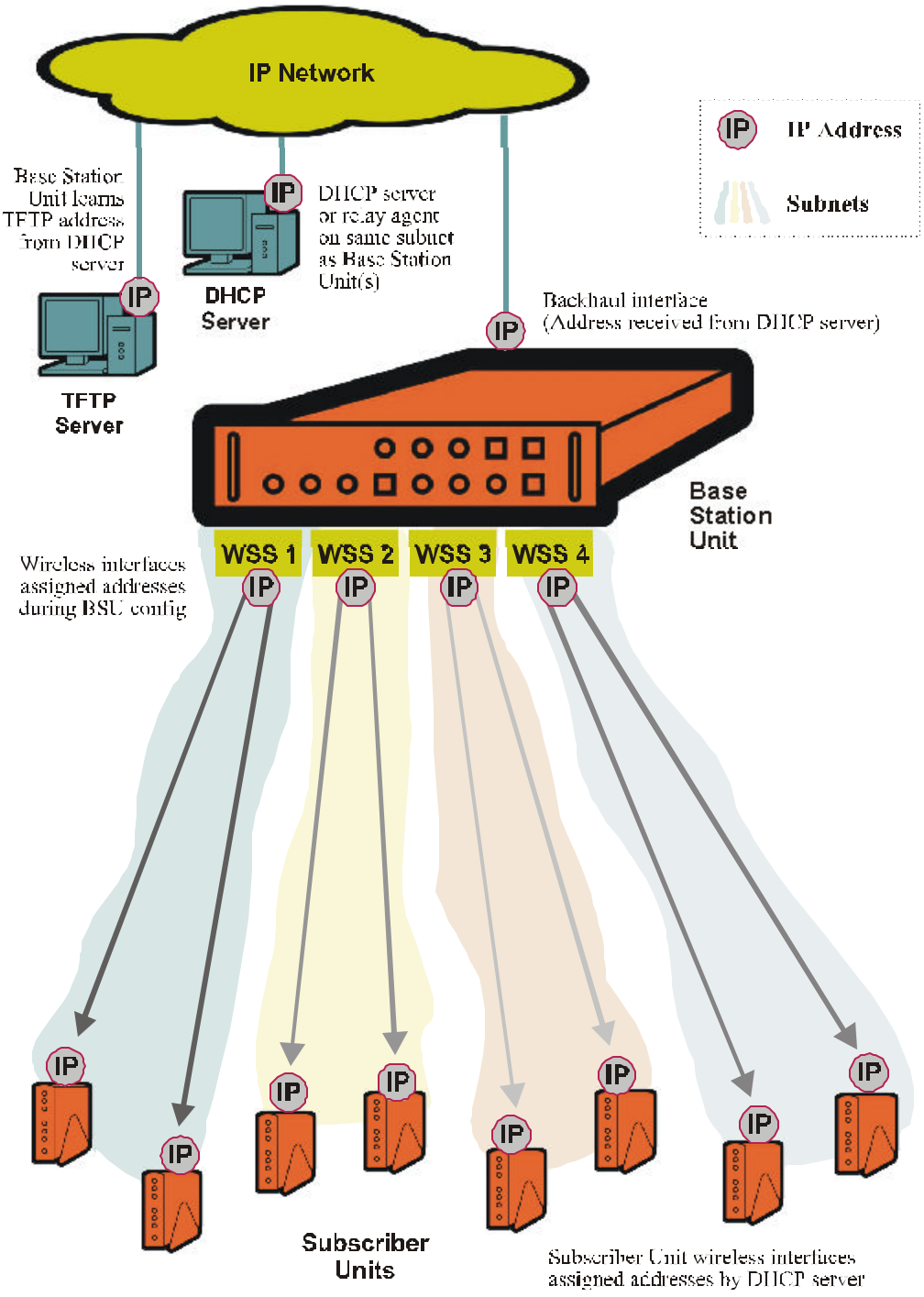


Figure2-5 PacketWave System IP Architecture

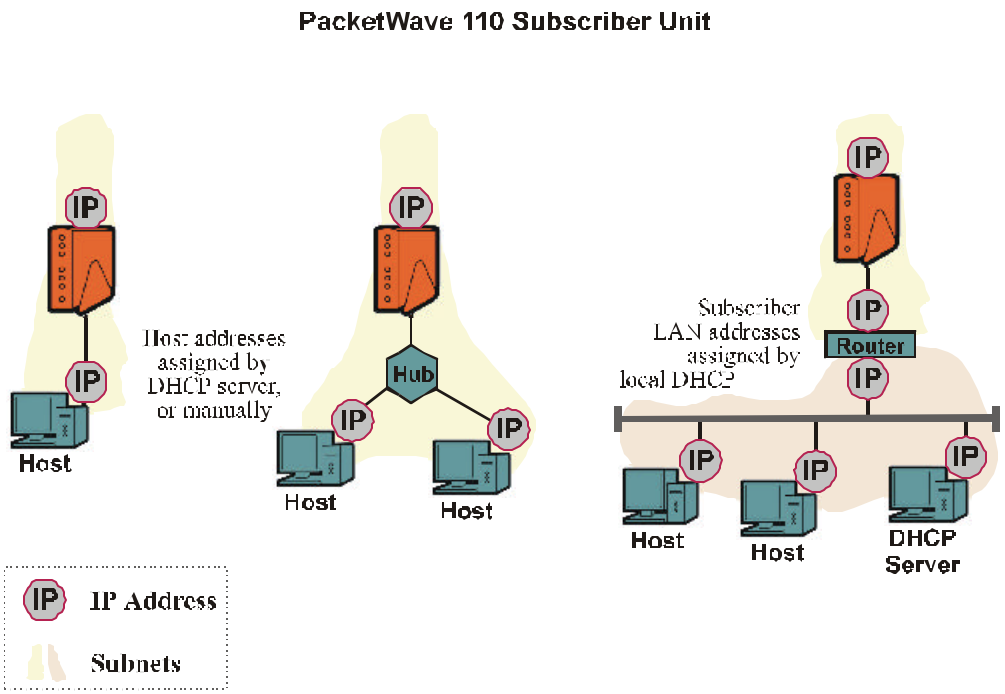


Figure2-6 PacketWave Subscriber Indoor Unit and Host IP Addressing

Address Assignment

The PacketWave System supports DHCP (Dynamic Host Configuration Protocol), which manages IP address assignment for most interfaces in the PacketWave network.

In the configuration of the DHCP server, the PacketWave System IP addresses must be fixed—i.e., reserved for the specific units; they cannot be dynamically assigned.

Specifically, PacketWave System IP addresses are distributed as follows:

- The Base Station Unit receives the IP address of its backhaul interface from the DHCP server for its subnet.
- The Base Station Unit's wireless interfaces (WSS) are assigned IP addresses as part of the BSU configuration (using the WaveCenter Configuration Manager).
- Subscriber Indoor Units receive the IP addresses of their wireless interfaces from the DHCP server, via a DHCP relay agent in the Base Station Unit.
- Subscriber hosts can receive IP addresses in a variety of ways (see *Figure2-6*):
  - From the BSU's DHCP server, via DHCP relay agents in the subscriber Indoor Unit and the Base Station Unit.
  - From a DHCP server included in the subscriber Indoor Unit.
  - From a DHCP server on the subscriber's subnet.
  - Using NAT (Network Address Translation), provided by the PacketWave Subscriber Indoor Unit or by a NAT router on the subscriber's subnet.
  - By manual entry at the hosts.

Clustering Wireless Interfaces

To enhance flexibility in the use of a particular IP address space, the PacketWave 1000 Base Station Unit allows multiple wireless interfaces to be assigned to the same subnet. This is done during BSU configuration using the WaveCenter Configuration Manager.

SU-to-SU Bridging

To make communication within the wireless subnets more efficient, the PacketWave 1000 Base Station Unit supports bridging between subscribers on the same subnet. SU-to-SU bridging is enabled or disabled during BSU configuration using the WaveCenter Configuration Manager.

Multiple Subnets on a Wireless Subsystem (WSS)

To enable one wireless interface to support subscribers for two or more service providers, the PacketWave 1000 Base Station Unit allows multiple subnets to be assigned to the same wireless interface. This is done during BSU configuration using the WaveCenter Configuration Manager.

Figure2-7 shows multiple subnets on a wireless interface. Note that when a subscriber Indoor Unit uses DHCP to request an address, neither the BSU (as DHCP relay agent) nor the DHCP server can determine from the request which subnet the SU should be assigned to. Therefore, IP and MAC addresses for all subscriber Indoor Units on the wireless system must be manually entered into the DHCP server.

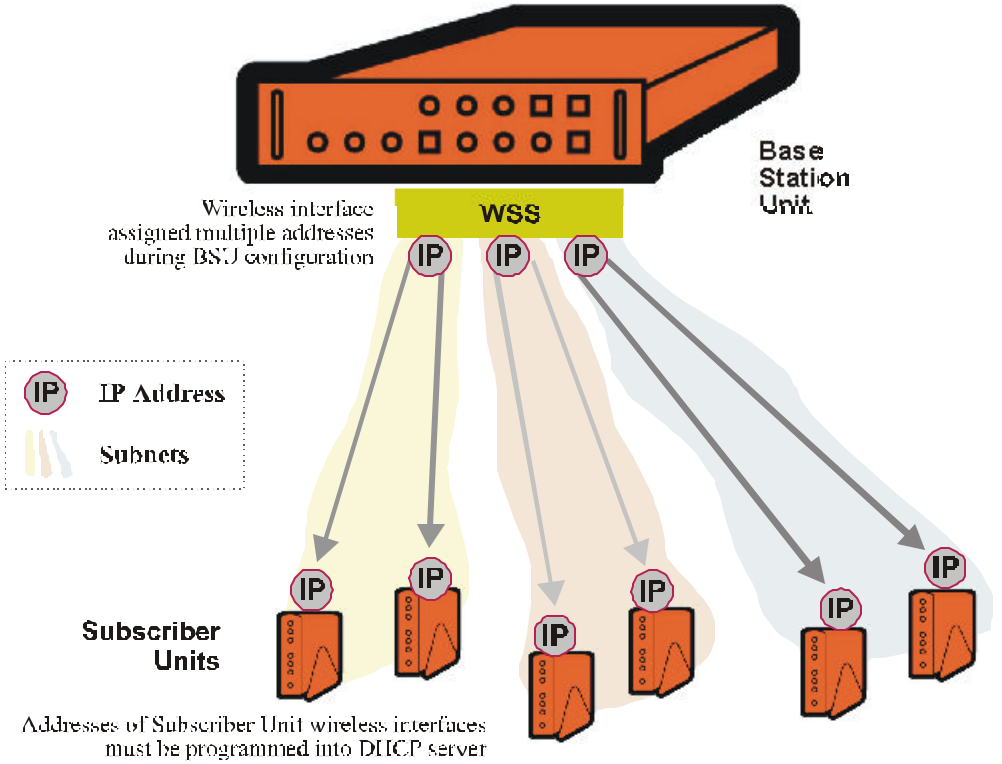
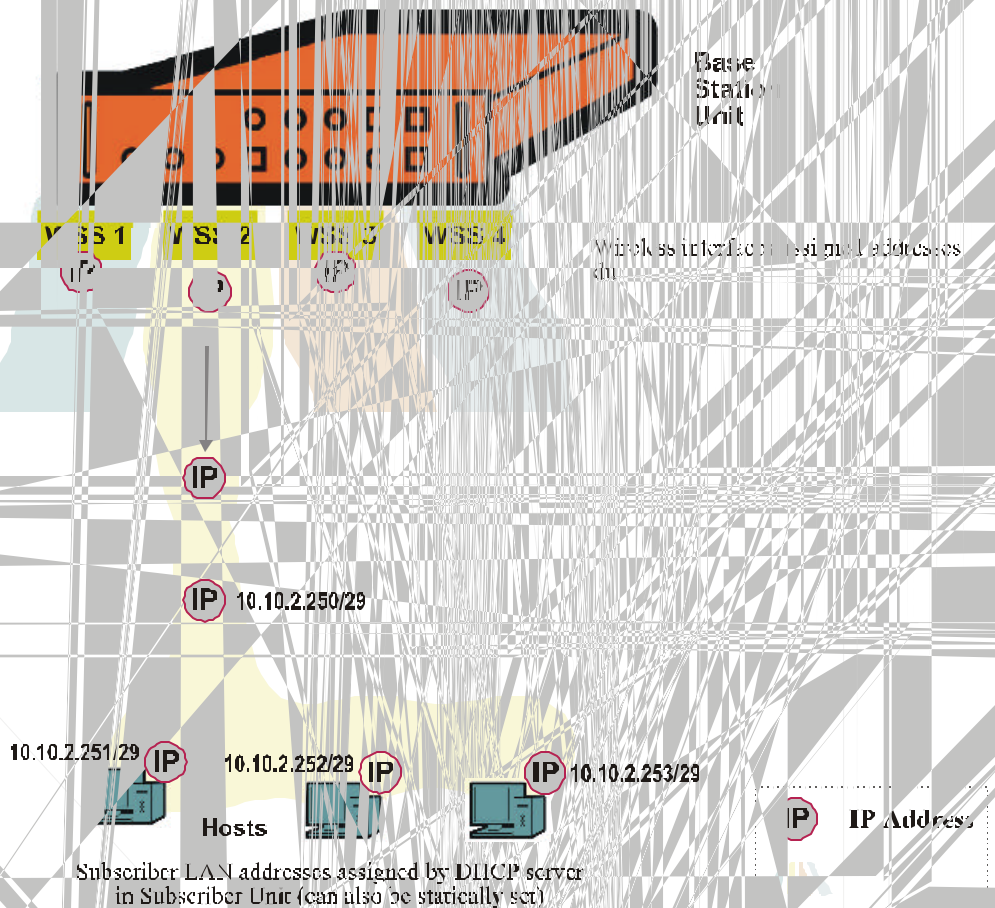


Figure2-7 Multiple Subnets on a WSS

ngth Subnets (VLSM)

e ketWave System supports Variable-Length Subnet Masking (VLSM). One ser characteristic of VLSM is that any number of contiguous final bits of an IP ddre can define a subnet, meaning that subnets need not be limited to Class A, B or C es. Using VLSM addressing techniques (such as recursive subnetting) can simp routing and allow more efficient use of IP address space.

Figu -8 show an example of VLSM addressing in a PacketWave network. A full discu n of VLSM is beyond the scope this manual, but detailed information can be foun numerous books and online sources.



e 2- M a PacketWave System

070-

Servers

Each Base Station Unit requires access to DHCP and TFTP servers to boot up properly. Access to additional servers is required for the support of specific features.

For additional information about PacketWave System servers, including the configuration of a DHCP server, see Chapter 7.

DHCP Server

The DHCP server assigns IP addresses to all of the PacketWave interfaces except the Base Station Unit's wireless interfaces. It also tells each Base Station Unit and subscriber Indoor Unit the name of its configuration file, its default gateway, and the addresses of other servers. Thus, the DHCP server is critical to the ability of PacketWave Base Station Units and subscriber Indoor Units to communicate with the rest of the Internet.

Because DHCP is based on a broadcast request from a client, and the Base Station Unit is a DHCP client, the DHCP server or a DHCP relay agent must be located on the same subnet as the Base Station Unit's backhaul interface.

TFTP Server

For the PacketWave System, the main function of the TFTP server is to store the system configuration files, and download them on request. Each Base Station Unit and subscriber Indoor Unit requests its configuration file on hardware or software reboot (cold or warm start).

Each Base Station Unit and subscriber Indoor Unit stores its configuration in non-volatile memory. When it reboots, it downloads the latest configuration from the TFTP server if it is able to, and then makes any changes to its configuration based on a comparison of the downloaded configuration with the stored configuration. If the device cannot successfully download its configuration from the TFTP server, it operates with its stored configuration.

The TFTP server is also used to distribute software updates to Base Station Units and subscriber Indoor Units as follows:

- The new software file is placed on the TFTP server.
- The configuration file for each unit to be downloaded is modified to specify the new software, and then re-saved on the TFTP server.
- Each unit to be downloaded is rebooted. During reboot, a unit gets its new configuration file, learns that a new software file is specified, and downloads the software from the TFTP server.

SNTP Server

The Base Station Unit typically derives the time and date from an SNTP (Simple Network Time Protocol) server identified by the DHCP server. The BSU includes time zone and daylight savings time parameters which it applies to the received time and date as appropriate.

NOTE: Alternatively, date and time can be set via the Web and SNMP interfaces.

Subscriber Indoor Units use the BSU as their time server.

DNS Server

The DHCP server should identify an DNS server to be used in the resolution of Internet domain names.

SMTP Server

The PacketWave Base Station Unit can use email to announce events. If this feature is to be used, an SMTP (Simple Mail Transfer Protocol) server must be specified.

System Log Server (Syslog)

If a Syslog server is identified either by the DHCP server or in the BSU configuration, the Base Station Unit will log all events to the specified server using the standard Syslog protocol.

SNMP Manager

PacketWave Base Stations and subscriber Indoor Units include built-in SNMP (Simple Network Management Protocol) agents. These agents can be accessed by SNMP managers as specified in the system configuration.

NOTE: PacketWave SNMP agents use SNMP v.2 syntax for objects.

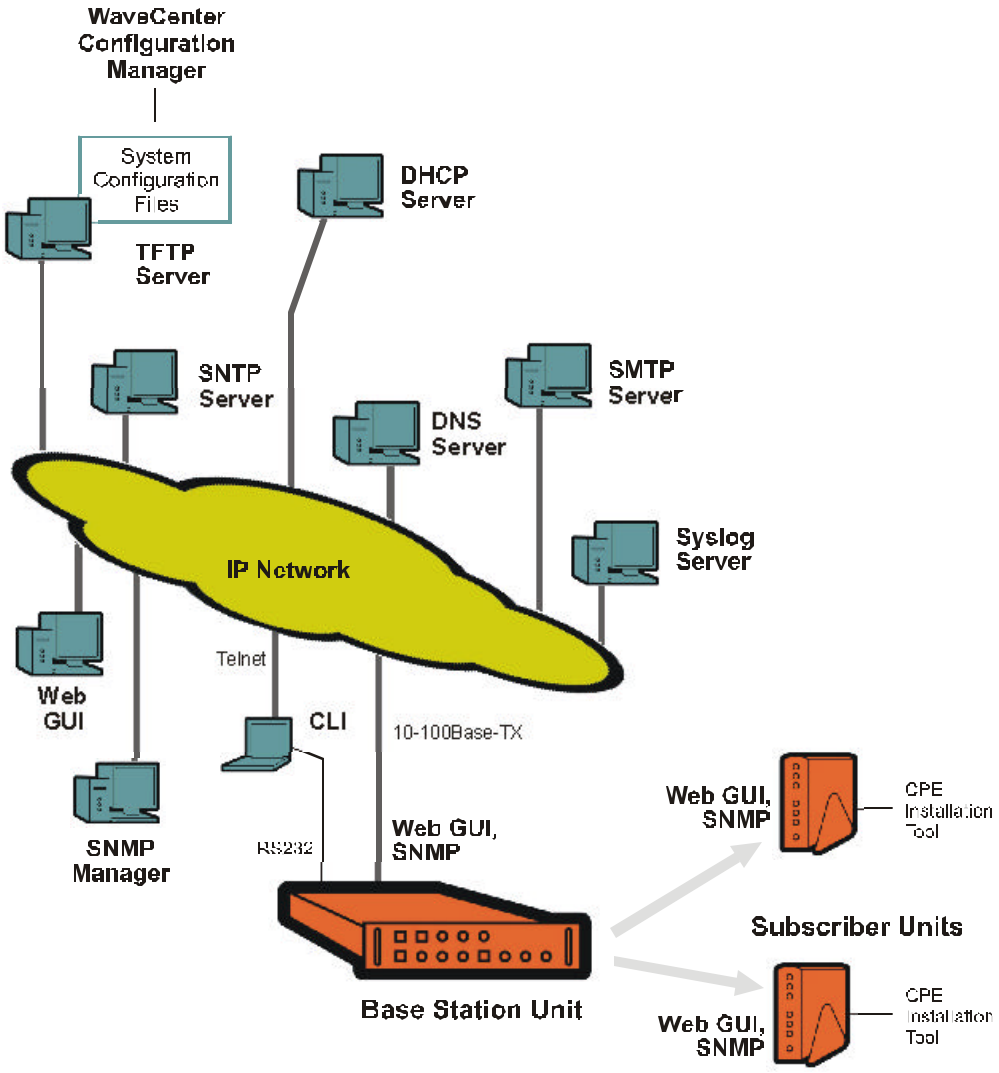


Figure2-9 PacketWave Servers and Management Access

CONFIGURATION AND MANAGEMENT SOFTWARE

The PacketWave System includes the WaveCenter Configuration Manager for developing and maintaining the system's configuration files. It also includes a browser-accessible Web GUI interface and an SNMP interface for real-time monitoring and management, plus a basic ASCII command line interface (CLI) for debugging/troubleshooting.

Figure2-9 shows the PacketWave System's management access.

Only configuration changes made using the WaveCenter Configuration Manager affect the PacketWave System's configuration data base. While some configuration can be performed via the Web and SNMP interfaces, these changes are lost if the configured equipment (Base Station or subscriber Indoor Unit) is rebooted.

WaveCenter Configuration Manager

The WaveCenter Configuration Manager (CM) is a Java-based application used to configure PacketWave base station and subscriber equipment. It runs on any of the following platforms:

- Windows 98
- Windows NT
- Windows 2000 Professional
- Linux
- Sun Solaris

NOTE: The platform on which the WaveCenter Configuration Manager is run must include the Java Runtime Environment (JRE). JRE is included on the WaveCenter distribution CD.

The Configuration Manager is used to create individual Base Station Unit and subscriber configuration files. These files are then stored on the system's TFTP server, from which they are downloaded automatically by Base Station Units and subscriber Indoor Units as part of their boot-up processes.

The PacketWave Configuration Manager has two parts: a Base Station Unit Configuration Manager and a Subscriber (CPE) Configuration Manager. Each consists of multiple menus which in combination allow full configuration of the PacketWave System components.

A complete description of the Configuration Manager and its use is given in Chapter 6 of this manual.

Web-Based GUI

For real-time monitoring and limited configuration of the Base Station Unit and all of its subscriber sites, the Base Station Unit supports a graphical user interface (GUI) accessible via the IP network using a standard browser (currently, Netscape 4.74 or Internet Explorer 5.0). The Web interface includes network views, performance graphs, and event logs.

Details of the Web interface are given in Chapter 8 of this manual.

SNMP Agents

For real-time monitoring and limited configuration, each Base Station Unit and subscriber Indoor Unit includes a built-in SNMP agent with trap support. (In R1P1, all SNMP parameters are read-only).

More information about SNMP capability in Chapter 8 of this manual.

Command Line Interface

An ASCII command line interface (CLI) provides a compact set of commands which are intended primarily for system troubleshooting by Aperto personnel or other qualified technicians. The CLI can be accessed via Telnet or directly through the Base Station Unit's front-panel RS-232 port.

An overview of the CLI is given in Chapter 8 of this manual.

SERVICE OFFERINGS AND QOS

The PacketWave System is designed to give service providers extreme freedom in the definition of multiple services and the specification of quality-of-service (QoS) levels. Before configuring individual subscribers, services and QoS parameters need to be identified. Factors involved include:

- Service Class, which may be:
  - Best Effort (BE)
  - Committed Information Rate (CIR)
  - Constant Bit Rate (CBR)
- Type of Service (TOS)
- Overall and peak bandwidths

Concepts of PacketWave Service Level Definition

The PacketWave quality-of-service (QoS) capability is based on sets of classifiers and service flows, and links between the two, as shown in *Figure2-10*.

- A classifier is one or more layer 2 and/or layer 3 parameters which will identify a particular traffic flow.
- A service flow is a set of parameters which will determine the performance characteristics (QoS) of traffic assigned to that flow.

When a classifier is defined, it is assigned to a specific service flow. Thus, any traffic meeting the classifier specifications will be transmitted according to the performance characteristics of its assigned service flow.

Assigning Service Levels

Service levels are assigned in the individual SU configuration files, allowing for maximum flexibility in differentiating service among subscribers.

Details of service level specification are provided in Chapter 6.

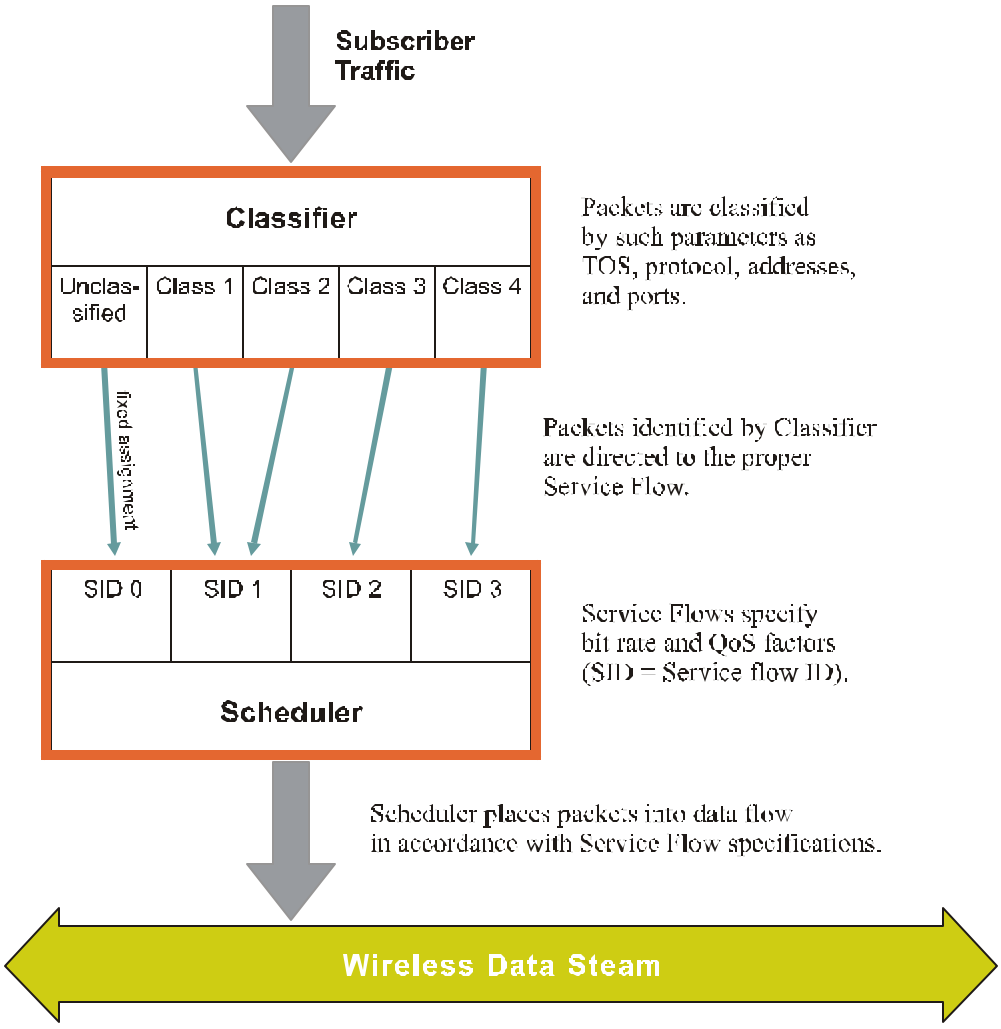


Figure2-10 PacketWave Service Levels

SYSTEM PLANNING

This chapter summarizes issues related to the planning of a PacketWave System.

CELL SITE CONSIDERATIONS

The planning of a wireless cell site is a complex task requiring the knowledge and skill of trained professionals. Location is of course a prime consideration, as are more technical factors such as interference management and lightning protection. Aperto expects that the cell site will be carefully thought out and professionally developed, and that recognized procedures and codes will be faithfully observed.

When planning a cell site, take into account the following characteristics of the PacketWave System:

- **Base Station Location** — While line-of-sight paths are not required between PacketWave antennas at the base station and subscriber site, performance is improved when transmission paths are unobstructed. Do whatever is practical to minimize actual or potential transmission obstructions.
- **Antenna and Radio Issues** — PacketWave base station antennas and radios are typically mounted on an antenna mast or tower, and include mounting brackets for attachment to tubular structures (pipes). If a mounting structure already exists, you will need to determine its suitability to the physical and radio characteristics of the PacketWave components. If no mounting structure exists or the existing one is not suitable, you will need to determine what type of mounting structure is appropriate, then obtain and install the structure. You will also need to determine the method by which antennas and radio will be mounted to the structure, and obtain appropriate hardware if the standard hardware included with the PacketWave components is not appropriate.

- **Base Station Enclosure** — The PacketWave Base Station Units must be located indoors, generally within 50 meters (165 feet) of the outdoor radios and antennas. (Greater cable lengths require insertion of dc from an external source.) Ensure that an adequate room or closet is available, that it meets the Base Station Unit environment specifications, and that sufficient power (120 or 220 V ac, or -48 V dc) is available.
- **Capacity and Equipment Requirements** — PacketWave System capacity—cell radius, sector and subscriber bandwidth, number of sectors, and number of subscribers per sector—is discussed in Chapter 2 and summarized in *Table3-A*. Use this information along with expected subscriber requirements to plan cell size, sectors, and base station equipment.
- **Radio Frequency Band** — Determine the frequency band in which the system will operate, and be sure that any required licences have been obtained. Make sure that all PacketWave radio receivers and antennas you order are for the proper frequency band.

Table3-A PacketWave System Capacities

Parameter	Capacity
Cell radius	Up to 5 miles (8 km) with line-of-site transmission paths and typical configuration, or 1 mile (1.6 km) with obstructed paths. Where even wider coverage is needed, the system can be configured to cover a radius of up to approximately 30 miles (50,000 m).
Sectors per BSU	1 to 6.
Sector width	60° or 90°.
Subscribers per sector	Typically up to 250.
Total bandwidth	20 Mbps per sector; 120 Mbps per BSU.
Maximum bandwidth per subscriber	Individually configured; from 384 kbps to 10 Mbps. Bursts to 20 Mbps.
Upstream-to-downstream bandwidth ratio	From 90% downstream and 10% upstream, to 90% upstream and 10% downstream.

SUBSCRIBER SITE CONSIDERATIONS

Locations of subscriber sites are determined by the subscribers, within the limits of the wireless cell. When implementing a subscriber site, consider the following:

- **Subscriber Indoor Unit** — Make sure the model chosen matches the subscriber's requirements for bridging/routing and host capacity.
- **Radio Frequency Band** — Make sure the PacketWave radio/antenna unit operates in the wireless cell's frequency band.
- **Cabling** — You will need to supply cables for connecting the subscriber Indoor Unit to the outdoor radio/antenna, and for connecting the subscriber Indoor Unit to the subscriber's computer or LAN. *Table3-C* identifies the cables that you will need to supply. (Cabling instructions are included in the *PacketWave 100 Series Subscriber Equipment Installation and Operation* manual.)

More complete planning instructions for the subscriber site are included in the *PacketWave 100 Series Subscriber Equipment Installation and Operation* manual.

Table3-C Subscriber Site Cable Requirements

Connection — Qty	Cable Type	Max. Length	Connectors
Ethernet (1)	Cat 5	330 ft (100 m)	RJ45 male
Radio Signal (1)	Coaxial, quad shield	165 ft (50 m)	Male F type
Radio Control (1)	Cat 5, ourdoor rated	165 ft (50 m)	RJ45 male

IP PLANNING: ADDRESSING AND SUBNETTING

When planning a PacketWave System, make sure you fully understand the system's IP networking principles and requirements as discussed in Chapter 2.

Plan the network carefully; then document the various subnets and the individual IP addresses. A topological diagram, while not required, will provide the most readily understandable network documentation.

Make sure that the network plan includes the following:

- Base Station Unit's MAC address (needed for DHCP configuration).
- Subnet and IP address for the Base Station Unit's backhaul interface.
- Default gateway for the Base Station Unit's backhaul interface.
- Servers accessible by the Base Station Unit.
- Wireless subnets, and IP addresses for the Base Station Unit's WSS interfaces.
- MAC addresses of individual subscriber Indoor Units, matched to subscriber site (needed for DHCP configuration).
- IP address for each subscriber Indoor Unit's wireless interface.
- Default gateways for subscriber Indoor Units (Base Station Unit WSS interfaces).
- Subscriber LAN subnets and IP addresses, as appropriate.

Instructions for configuring a DHCP server with the above information are provided in Chapter 7.

CONFIGURATION PLANNING

Each Base Station Unit and subscriber requires a separate configuration file which must be generated using the WaveCenter Configuration Manager. For basic operation, very simple configurations will suffice; the parameters which must be specified are:

- **Base Station Unit** — MAC address; WSS interface IP addresses and subnet masks; wireless channel center frequencies.
- **Subscriber Indoor Unit** — MAC address; mode (bridge, router, or NAT); model number.

However, there are numerous other parameters which can be specified to aid in network administration, to add features, or to adjust performance. Details are provided in Chapter 6 of this manual.

Determine the amount of configuration appropriate for your network, and the specific options to be selected. Document the configuration requirements for all Base Station Units and subscribers.

Service Level Planning

Management of multiple service level offerings requires careful thought and significant expertise in quality of service (QoS) issues and techniques. To maximize the flexibility with which service levels can be defined and managed, the PacketWave System includes extensive configuration options related to the establishment of specific types and levels of service.

If multiple service levels are to be offered, they must be defined in the Subscriber Unit (CPE) configuration files. Principles of service level definition and implementation are discussed in Chapter 2; configuration details are presented in Chapter 6.

INSTALLING BASE STATION UNITS

The Base Station Unit (BSU) is a rack-mountable control unit that links up to six radios and their antennas to the core network through a WAN backhaul channel. It must be mounted indoors, protected from precipitation and temperature extremes.

CAUTION: Make sure that the room in which Base Station Units are installed has temperature and humidity controls necessary to maintain the temperature between 32 and 104 °F (0 and 40 °C) and the humidity between 10% and 90% noncondensing.

MOUNTING

The Base Station Unit occupies two vertical rack units (3.5 inches) in a standard 19-inch equipment rack. It includes integral mounting ears as part of the front panel, handles on the front panel near the mounting ears, and drawer slides on the sides of the unit. Air flow holes are located on the sides of the enclosure, with a pair of cooling fans on the rear panel.

CAUTION: Make sure that the equipment is mounted so that adequate air flow around the BSU—particularly near the ventilation holes and fans—is not blocked.

Secure the front panel to the equipment rack using the appropriate hardware.

FRONT-PANEL CONNECTIONS

Other than the power connection, all connections to the Base Station Unit are made on the front panel, which is illustrated in *Figure4-1*.

Figure4-1 BSU Front Panel

Connecting the Radios to the BSU

Connections from the outdoor radios to the Base Station Unit are described in Chapter 5 of this manual.

Connecting the Backhaul Link

The standard backhaul connection for the Base Station Unit is a 10/100-BaseTX link. This can be used for a range of different backhaul implementations, as shown in *Figure4-2*.

To make the backhaul connection:

- Obtain or construct a Cat 5 cable of the required length, with a standard RJ45 plug on the BSU end and the appropriate connector on the other end.
- Insert one end of the cable with an RJ45 plug into the RJ45 socket labeled **100Base-T** on the BSU front panel, as shown in *Figure4-3*.
- Connect the other end as appropriate for the particular backhaul implementation.

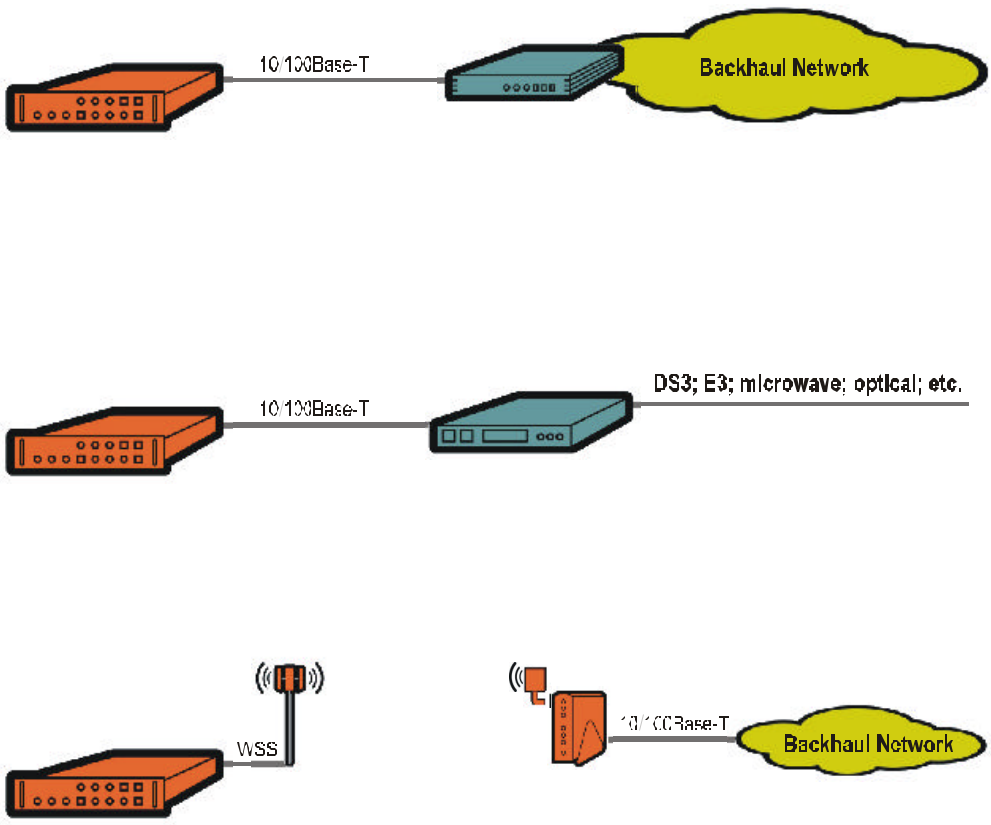


Figure4-2 Backhaul Channel Examples

Figure4-3 Backhaul Link Connection

Interconnecting Multiple BSUs at a Site

To properly identify wireless channel time slots, multiple colocated Base Station Units need to be synchronized to the same framing signal. This is done by interconnecting the units' **Sync** connectors, as shown in *Figure4-4*. When there are three or more Base Station Units, a main and alternate sync signal source for the framing signal should be chosen; with two Base Station Units, no alternate is necessary.

Any Base Station Unit can be the source of a framing signal. If it is not receiving a framing signal at one of its **Sync In** ports, a BSU will transmit a framing signal through its **Sync Out** ports. Thus, when the primary framing signal source fails, the alternate signal source can take over immediately.

To interconnect the multiple Base Stations:

1. Determine the Base Stations which will be the main and alternate sync signal sources.
2. For the main sync signal, construct a coaxial cable with a BNC connector at one end, a BNC T-connector for each Base Station Unit other than the main sync source, and a 50-ohm terminator at the other end.
3. For the alternate signal source, construct a coaxial cable with a BNC connector at one end, a BNC T-connector for each Base Station Unit other than the main and alternate sync sources, and a 50-ohm terminator at the other end.
4. Connect the **Main Sync Out** connector on the main sync signal source to the **Main Sync In** connectors on all other Base Station Units, as shown in *Figure 4-4*.
5. Connect the **Alt Sync Out** connector on the alternate sync signal source to the **Alt Sync In** connectors on all other Base Station Units *except the main sync signal source*, as shown in *Figure4-4*.

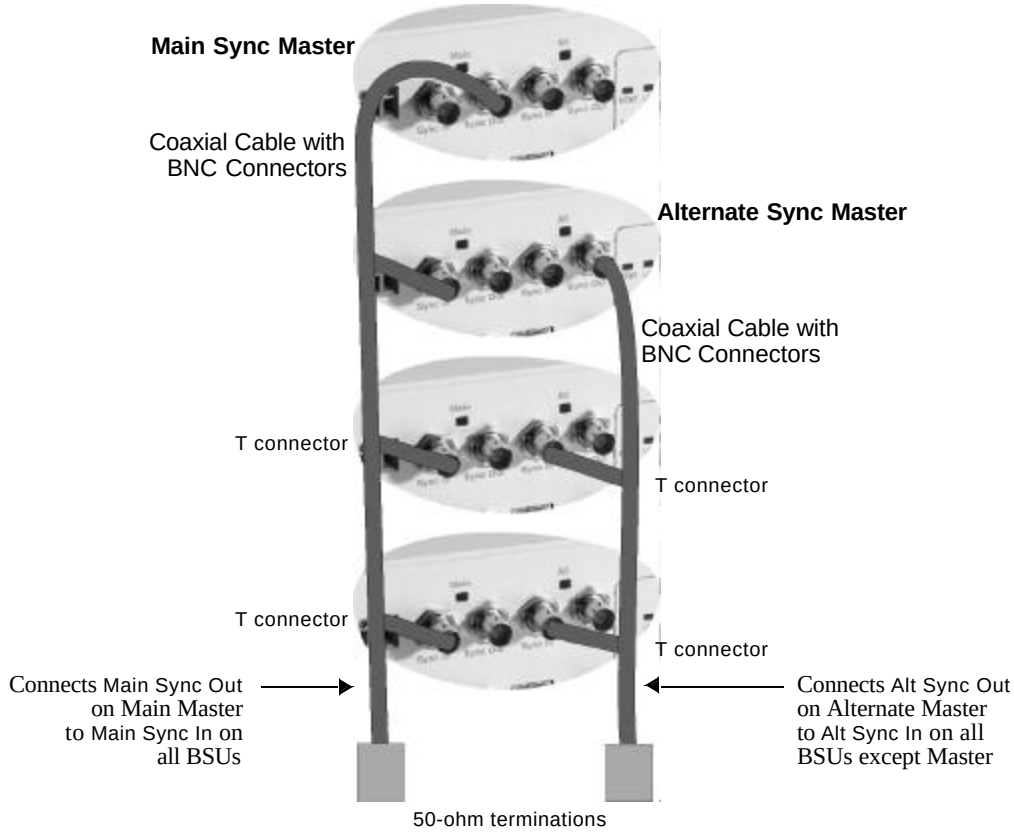


Figure4-4 Sync Connections for Multiple BSUs

Connecting an External Reference Clock

For timing, a Base Station Unit can use its own internal oscillator, or a 10 MHz signal from an external source. When multiple BSUs are colocated, it is a good idea to use an external source to facilitate synchronization.

To connect an external source:

1. If it is not already present, install the reference source per the manufacturer's instructions.
2. Construct a coaxial cable with a the required connector for the reference source at one end, a BNC T-connector for each BSU, and a 50-ohm termination at the other end.
3. Connect the cable to the reference source and to the **Ext Ref** connector on each BSU, as shown in *Figure4-5*.

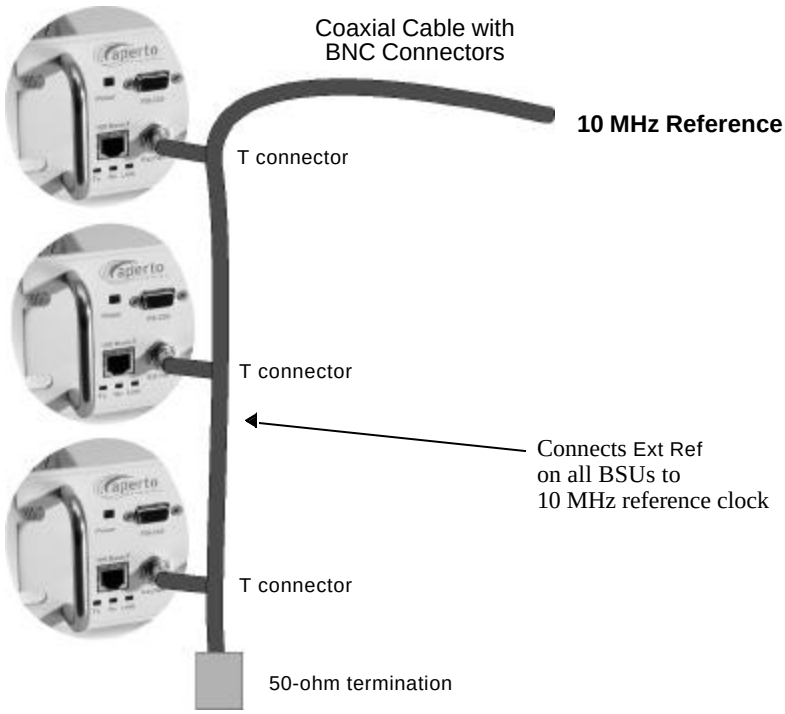


Figure4-5 Connecting an External Reference Clock

Connecting to the Alarm/Control Relay Switch

The **Relay Switch** connector on the Base Station Unit provides dry relay contacts for operating external equipment. It supports normally-open and normally-closed circuits, as shown in *Figure4-6*.

CAUTION: The alarm/control circuit connected to the relay switch should present a maximum current of 2 A at 30 V dc. It may be either normally open or normally closed.

To connect to the alarm/control switch relay:

1. Design and implement the desired external alarm or control circuit.
2. Use between 28 and 14 AWG wire (2.5 mm maximum diameter) for connection to the BSU. Wire may be solid, stranded, or stranded with ferrule.
3. Verify whether the alarm/control circuit is normally closed or normally open.
4. For a normally-closed circuit, connect the leads to terminals 1 and 2. For a normally-open circuit, connect the leads to terminals 2 and 3. Make the connections by:
   a. Loosening the screws above the wire holes, if necessary.
   b. Inserting the wires into the proper holes.
   c. Tightening the screws above the wire holes until the wires are held securely.

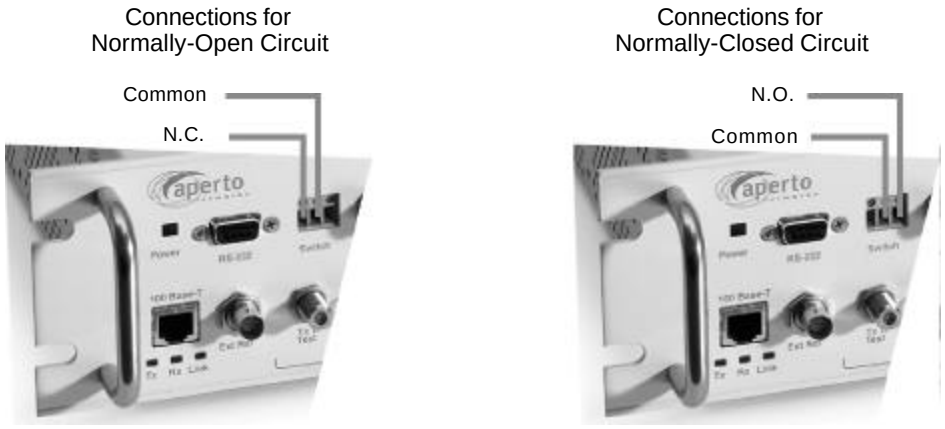


Figure4-6 Connecting to the Relay Switch

Connecting to the RS-232 Craft Port

The **RS-232** craft port on the Base Station Unit supports a direct serial connection to a PC, and is intended for temporary management and troubleshooting sessions using a command line interface (CLI). The port employs a DB-9 female connector and operates with the following parameters: 38.4K baud, 8 bits, 1 stop bit, no parity.

To use the CLI through the craft port, connect the computer to the BSU front panel as shown in *Figure4-7*, using a null-modem (crossover) cable up to 25 feet in length.

Operation of the CLI, which can also be accessed via Telnet, is discussed in Chapter 8 of this manual.

Figure4-7 Connecting to the RS-232 Craft Port

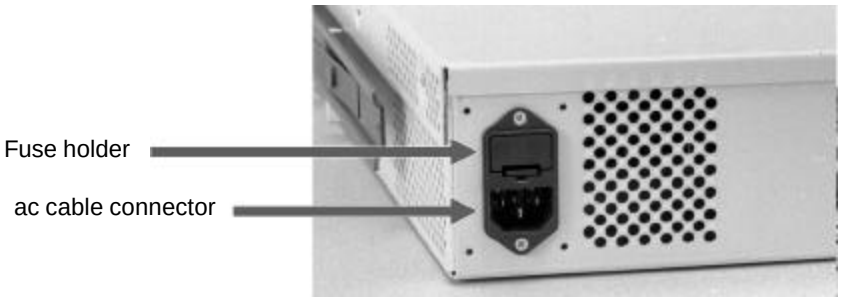
CONNECTING POWER

The Base Station Unit may come with either an ac or dc power supply. There is no on-off switch on either model, so disconnecting the power cable or wires is the standard way to remove power from the BSU.

Generally, it is a good idea to make power connections after all other connections have been made. However, *any front-panel BSU connection can be disconnected and reconnected while power is on.*

AC Power

An ac power cord is supplied with the Base Station Unit. To apply power to the BSU, simply plug the cord into the receptacle on the rear panel of the BSU (shown in *Figure4-8*) and then into a standard grounded wall outlet.



Rear of BSU, left corner

Figure4-8 AC Power Connection and Fuse Holder

Fuse

The ac power supply is protected by a fuse in a holder next to the power connector on the rear panel of the Base Station Unit, as illustrated in *Figure4-8*. For the US and other 120VAC power, the fuse is a 4 A, 250 V time-lag high-breaking fuse, 5 x 20 mm, such as the Schurter SPT 0001.2510.

Should this fuse blow, determine and correct the cause (if possible). Then replace the fuse as follows:

1. Disconnect the BSU's power cord.
2. Use a flat-bladed screwdriver to lever up the tab at the bottom of the fuse-holder and remove the fuse holder.
3. Remove the fuse from the clips that hold it, and verify that the fuse has blown.
4. Place a new fuse in the clips.
5. Snap the fuse holder into the opening in the rear panel.
6. Reconnect the BSU's power cord.

DC Power

The dc-power PacketWave 1000 includes dual terminal barrier connectors for redundant -48 V dc power connections, plus two 4mm ground studs at the bottom edge of the rear panel. You can connect to one or two power sources, as desired.

To connect to a dc power supply:

1. Use 12 AWG wire of no longer than 25 feet (8 m) for all power and ground connections. On the BSU end of each power and ground wire, install a crimp-style ring lug of 0.3 inches (7.5 mm) or less in diameter to fit between the terminal barriers. Make sure the wires are marked or color-coded to identify positive and negative connections.
2. Install a connecting wire from one of the **GND** lugs to a good earth ground.
3. Connect the positive (**+**) and negative (**-**) terminals of one of the BSU's dc power connectors to a -48 V dc power source, using a Phillips screwdriver to tighten the terminal posts on the ring lugs. Repeat for the other dc power connector and power source, if desired.
4. If a redundant power supply is to be employed, repeat steps 3 and 4 for the other power source, terminal block, and ground lug.

INSTALLING RADIOS AND ANTENNAS

The PacketWave base station antennas and radios are designed for mounting outdoors on common antenna masts, and include mounting brackets for such mounting. Different mounting hardware can be substituted as appropriate for your antenna support.

INSTALLING THE ANTENNA MOUNTING SYSTEM

Various antenna mounting systems can be used for the PacketWave base station. Choose a mounting system appropriate for your particular network and site, and follow the manufacturer's directions to install.

If the antenna mounting system has a directional aspect (for example, a six-sided antenna mast), be sure to consider the physical sector locations when installing.

CAUTION: Be sure that the antenna mounting system is appropriate for the weights and wind-resistance of all of the antennas and radios to be installed on it, and for local environmental conditions.

MOUNTING THE ANTENNAS AND RADIOS

Before mounting the antennas, you need to know the compass directions and elevation tilts appropriate for each sector. (The antennas have a beam width of 60° or 90° horizontal and 9° vertical).

There are several antennas which may be used in a PacketWave system. Because of their different sizes and weights, the antennas do not all use the same mounting accessories.

The base station radio includes a rear-mounted bracket as shown in *Figure5-1*; the bracket accomodates a pole diameter of 1.5 inches (3.8 cm), 2 inches (5 cm)

To mount an antenna:

1. Determine the mounting location for the antenna.
2. Orient the antenna vertically.
3. Using the mounting equipment provided, or other mounting hardware as desired, secure the antenna to the mast or other support.

To mount a radio:

1. Determine the exact location for the radio.
2. Loosen the pole clamp bolt and open the pole clamp.
3. Orient the radio so that the F and RJ45 connectors are at the bottom.
4. Close the pole clamp around the pole.
5. Adjust the direction and elevation of the radio/antenna unit.
6. Tighten the pole clamp bolt until the radio/antenna unit is secured in position.

Figure5-1 Base Station Radio Mounting Bracket

RUNNING THE RADIO CABLES

Connections to the radio include two “RF jumper” connections “up” to the antenna and two connections “down” to the Base Station Unit.

Radio to Antenna

The radio is connected to the antenna by two cables. One end of each is attached to the radio internally, and the other terminates with a male N connector, as shown in *Figure5-2*.

To connect the radio to the antenna:

1. Connect the cables from the radio to the appropriate connectors on the antenna.
2. Apply a silicone sealant or other weatherproofing to the connections as desired.

Radio to Base Station

There are two cables that connect each radio to its Base Station Unit: a radio signal cable (which also carries dc power) and a control cable. These cables run from outdoor radios to the indoor BSU, so a suitable cable run and building entry point must be identified, as discussed in Chapter 3. Connections to the BSU are illustrated in *Figure5-3*; Connections to the radio are illustrated in *Figure5-4*.

For these outdoor-to-indoor connections, the order of the steps in the installation procedure will vary depending on a number of factors, including site particulars and installers’ preferred practice. For example, in some cases it may be best to run unterminated cable and then attach connectors; in others it may be more efficient to attach one or both connectors to the cable before running it. Also, cable dressing at various locations may be best performed at different points in the procedure. Therefore, the procedures given for radio-to-BSU connections should be taken as a list of necessary steps and a suggested order, and modified as appropriate for your particular circumstances.

Figure5-2 Radio Cables for Connection to Antenna

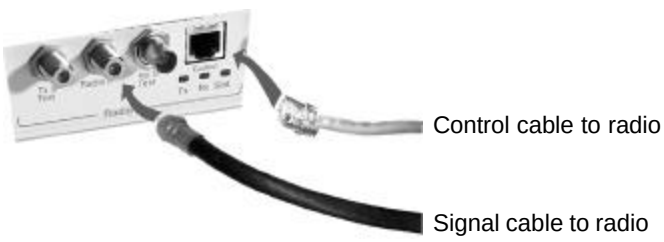


Figure5-3 BSU Radio Connections

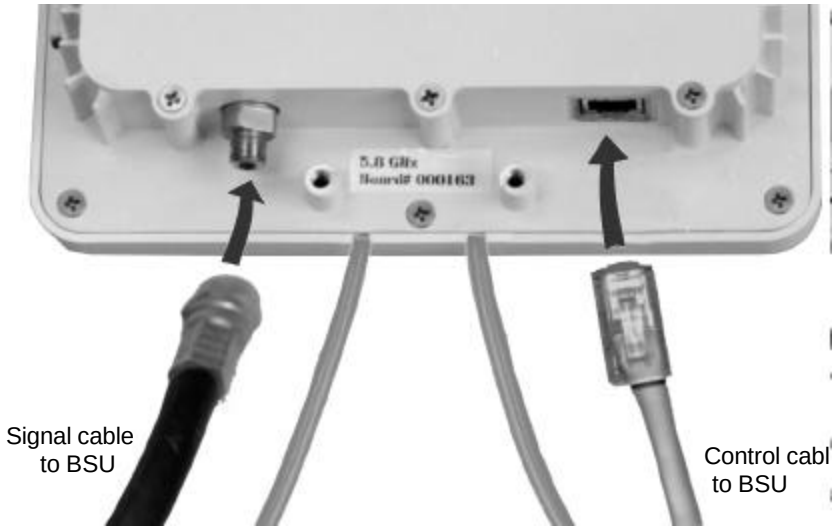


Figure5-4 Radio Signal and Control Connections

Radio Signal Connection

The radio signal cable should be outdoor-rated 75-ohm quad-shield coaxial cable with a maximum length of 165 feet (50 m) unless dc voltage is inserted from an external source. The cable terminates with a male F connector at each end.

To install the radio signal cable, perform the following steps:

1. Run an appropriate length of cable from the BSU to the radio. Include a service/ drip loop as appropriate.
2. Install a male F connector at the radio end of the cable.
3. Attach the cable to the female F connector on the radio, as shown in *Figure 5-4*.
4. Dress the outdoor portion of the cable as appropriate.
5. Install a male F connector on the BSU end of the cable.

If the cable is longer than 165 feet, replace step 7 with the steps in the section headed DC Voltage Insertion for Extra-Long Cables *later in this chapter.*

6. Attach the cable to the **Radio IF** connector for the appropriate **Radio** port on the Base Station Unit, as shown in *Figure 5-3*.
7. Dress the indoor portion of the cable as appropriate.

Control Connection

The radio signal cable should be shielded outdoor-rated Cat 5, and may be up to 165 feet (50 m) in length. It terminates with an RJ45 male connector at each end.

To install the radio control cable, perform the following steps:

1. Obtain an appropriate length of cable, and run it from the BSU to the radio. Include a service/drip loop as appropriate.
2. Place the supplied rubber boot over the radio end of the cable.
3. Install an RJ45 male connector on the radio end of the cable.
4. Plug the cable into the RJ45 socket on the radio, as illustrated in *Figure5-4*.
5. Put the rubber boot in position to protect the RJ45 connection and secure it in place with a cable tie. Make sure the longer side of the rectangular boot is parallel to the top lid of the rado.
6. Dress the outdoor portion of the cable as appropriate.
7. Install an RJ45 male connector on the BSU end of the cable.
8. Plug the cable into the **Control** connector for the appropriate **Radio** port on the Base Station Unit, as shown in *Figure 5-3*.
9. Dress the indoor portion of the cable as appropriate.
10. Seal the entry of the radio signal and control cables to the building as appropriate.

DC Voltage Insertion for Extra-Long Cables

If the radio signal cable is longer than 165 feet (50 meters), the power provided by the Base Station Unit via this cable will be attenuated to the point that it is insufficient to properly power the radio. In such a case, power must be inserted onto the radio signal cable using a bias tee and an external power source (18 V dc, 1.5 A) as illustrated in *Figure5-5*.

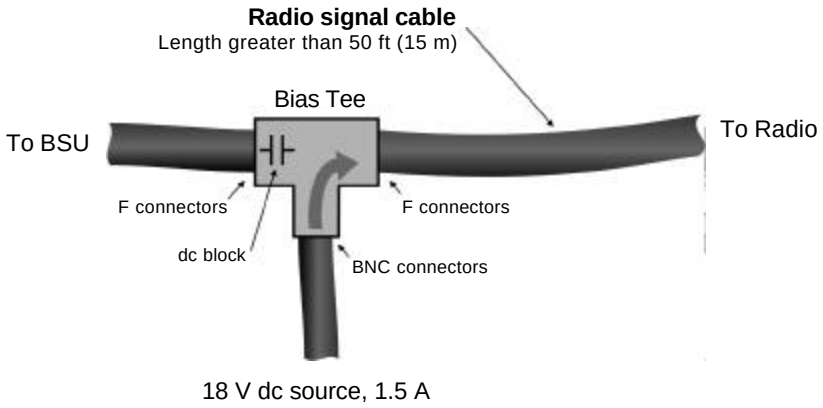


Figure5-5 DC Power Insertion for Radio

To insert dc voltage onto the radio signal cable:

1. Provide an 18 V dc power source capable of supplying 1.5 A, a coaxial bias tee with two female F connectors and one BNC connector, and a short coaxial cable with a male F connector at each end.
2. Connect the short coaxial cable to the **RADIO IF** connector on the Base Station Unit as illustrated in *Figure 5-4*.
3. Connect the other end of the short coaxial cable to the dc blocking side (female F connector) of the bias tee as shown in *Figure 5-5*.
4. Connect the radio signal cable from the outdoor unit to the other female F connector on the bias tee as shown in *Figure 5-5*.
5. Connect a cable from the 18 V dc power source to the BNC connector of the bias tee as shown in *Figure 5-5*.

BSU AND SUBSCRIBER CONFIGURATION

This chapter describes how to use Aperto's WaveCenter Configuration Manager™ to configure the base station and subscriber equipment in a PacketWave System.

Creating the BSU and subscriber (CPE) configuration files and placing them on the TFTP server is half of the PacketWave system configuration. The other half is the configuration of the IP network, including the DHCP server, described in Chapter 7.

INSTALLING THE WAVECENTER CONFIGURATION MANAGER

The WaveCenter Configuration Manager is provided on CD as part of the BSU package. You can load the WaveCenter Configuration Manager onto a computer running any of the following operating systems:

- Windows 98
- Windows NT
- Windows 2000 Professional
- Linux
- Sun Solaris

Whatever the platform, it will need to have the Java Runtime Environment (JRE) installed on it. If the JRE is not already present, it can be installed from the WaveCenter CD.

Depending on the particulars of your network, it may be a good idea to run the WaveCenter Configuration Manager on the same computer that provides the system's TFTP server. If you run the Configuration Manager on a different computer, you must be able to move the files created by the Configuration Manager to the TFTP server computer.

To install the WaveCenter Configuration Manager:

1. Place the CD in the CD-ROM drive and view the contents. Note that there is a *cm* folder/directory, which contains the Configuration Manager installation files, and a *jre* folder/directory, which contains the executable file for the Java Runtime Environment.
2. If the computer does not already have the Java Runtime Environment installed, open the *jre* folder/directory and run the executable file (*jre<version>.exe*).
3. Open the *cm* folder/directory; then open the appropriate folder/subdirectory for your platform and run the appropriate setup file. For example, for a Windows system open the *win32* folder and run *setup.exe*.
4. Follow the prompts in the installation wizard.
5. When installation has been completed, a WaveCenter Configuration Manager icon will have been placed on the desktop. Double-click this icon to launch the WaveCenter Configuration Manager.

HOW THE WAVECENTER CONFIGURATION MANAGER WORKS

The WaveCenter Configuration Manager is used to create a separate configuration file for each Base Station Unit and each subscriber in the system. Each base station unit and subscriber site (CPE) must have a valid configuration file in order to function.

BSU and Subscriber Branches

The WaveCenter Configuration Manager consists of separate Base Station Unit and subscriber (CPE) branches, accessed by clicking the BSC and SU (CPE) icons shown in *Figure6-1*. To configure a Base Station Unit, click on the BSC icon. To configure subscriber equipment, click on the subscriber Indoor Unit (CPE) icon.

Figure6-1 WaveCenter Configuration Manager Home Screen

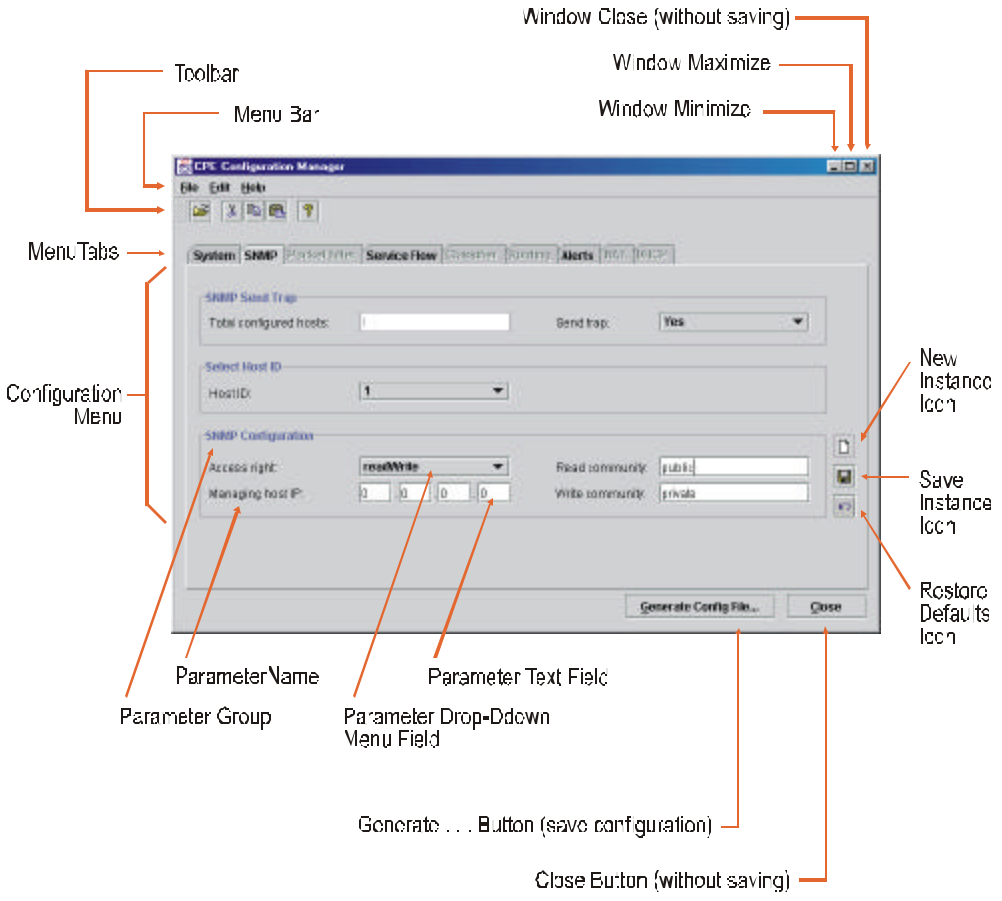


Figure6-2 WaveCenter Configuration Manager Screen Elements

Configuration Screen Formats

Each branch of the WaveCenter Configuration Manager (BSU and subscriber/CPE) consists of multiple configuration menu screens identified and accessed by tabs. *Figure6-2* shows a typical screen and its elements, while *Table6-A* defines the elements.

Table6-A Functions of CM Screen Elements

Screen Element	Function
Menu Bar: File	Allows opening and saving of configuration files, and exiting from (i.e., closing) the CM branch.
Menu Bar: Help	Opens CM help files (future).
Toolbar	Provides one-click access to open, cut, copy, paste, and help (same as corresponding Menu Bar functions).
Menu Tabs	Allow navigation among the various configuration pages.
Configuration Menu	Includes all configuration parameters for the tab.
Parameter Group	Description for a group of related parameters.
Parameter Name	Descriptive name for a single configurable item.
Parameter Text Field	Area where you configure a parameter by entering text.
Parameter Drop-Down Menu Field	Area where you configure a parameter be choosing from a menu.
New Instance Icon 	Used to open a new instance of the element being configured in this menu—for example, an additional SNMP manager.
Save Instance Icon 	Used to save a particular instance as configured on this menu—for example, an SNMP manager.
Restore Defaults Icon 	Used to restore factory defaults for the parameters on the page.
Generate BSC Config button	Used to create/save the BSU configuration file with parameters as currently specified on all pages. Similar to **File — Save As** menu option, except the **Generate BSC Config** button causes the CM to suggest a default file name of *bsc_<MACaddress>.cfg*.
Generate WSS Config button	Used to save a particular WSS configuration as part of the current BSU configuration. A WSS configuration file is created on disk as part of the process but need not be copied to the TFTP server.
Generate Configuration File button	Used to create/save the subscriber (CPE) configuration file with parameters as currently specified on all pages. Similar to **File — Save As** menu option, except the **Generate Configuration File** button causes the CM to suggest a default file name of *cpe_<MACaddress>.cfg*.
Close Button	Closes the CM branch window without saving the file (same as **File — Exit** menu option).
Window Close, Maximize, Minimize	The standard window controls.

Managing Configuration Files

Before using the WaveCenter Configuration Manager, be sure you understand the principles of configuration file management discussed below.

Opening and Loading Files

When you click on the BSU or subscriber Indoor Unit (CPE) icon on the WaveCenter Configuration Manager home screen, a new ("blank") configuration file is opened with the default parameters. You can then load an existing file by selecting **File — Open** from the menu bar, or the file open icon on the toolbar. The Configuration Manager will let you browse for the desired file.

> NOTE: Some screens have a new instance icon on the right side. This icon does not cause a new configuration file to be opened; rather, it causes a new instance to be opened, and is displayed only on pages which can be configured multiple times for multiple instances (such as multiple SNMP managers; see *Figure6-2*).

Saving Files

There are two methods for saving configuration files, as identified in *Table6-A*:

- Selecting **File — Save as** from the page menu line. The Configuration Manager will prompt for a file name**.**
- Clicking on the **Generate BSC Config** or **Generate Configuration File** (CPE) button. The Configuration Manager will prompt with the suggested file name in the format *bsc_<MACaddress>.cfg* or *cpe_<MACaddress>.cfg*, using the MAC address entered during configuration. See the discussion of file names below.

> NOTE: Some screens have a page save icon on the right side. This icon does not cause the configuration file to be saved; rather, it causes the current instance to be added to the configuration file which is being created or modified. The page save icon is displayed only on pages which can be configured multiple times for multiple instances (such as multiple SNMP managers; see *Figure6-2*).

File Names

Configuration files are required to have unique names so that each BSU and subscriber Indoor Unit can download the correct configuration file from the TFTP server. *Table6-B* identifies the naming convention suggested by Aperto, which uses MAC addresses to guarantee uniqueness. These are the default names used when you click on the **Generate BSC Config** or **Generate Configuration File** button, as described above.

While the naming convention identified in *Table 6-B* is recommended, it is not required. You can use any other format you wish, as long as the names are unique.

Table6-B Suggested Convention for Naming Configuration Files

Configured Entity	File Name Format	Example
Base Station Unit	*bsc_<MACaddress>.cfg*	*bsc_00013b0002e4.cfg* (for MAC 00:01:3b:00:02:e4)
Subscriber	*cpe_<MACaddress>.cfg*	*cpe_00013b00025d.cfg* (for MAC 00:01:3b:00:02:5d)

Storage Location

To be accessed by the Base Station Units and subscriber Indoor Units when they boot, the configuration files must be specified in the DHCP server's configuration file and stored in the default directory (typically, *\tftpboot*) of the TFTP server. You can save directly to that directory when creating the configuration files, or save to a different location and then transfer the files before booting the configured units.

Configuration Template Files

It will often be efficient to create generic configuration files which can be used as templates when adding new BSUs, WSSs, or subscribers.

You create and save a configuration template the same way you create and save a configuration file, but save it with a descriptive file name rather than a file name linking it by MAC address to a specific unit. Then, when you want to use the template as the basis for a new configuration file, you load the template, make any changes necessary, and save the file using the correct file name for the new unit.

> NOTE: Similarly, you can base a new configuration file on an existing configuration file by loading the existing file, editing it, and saving it using the proper file name for the new unit.

Downloading Configuration Files

After the configuration files have been created and stored on the TFTP server, the configured devices need to be booted up. (The Base Station Unit must be operational when a subscriber Indoor Unit is initialized, or the initialization will fail.) The booted device will then automatically download its configuration from the TFTP server.

Each Base Station Unit and subscriber Indoor Unit stores its configuration in non-volatile memory. When it reboots, it downloads the latest configuration from the TFTP server if it is able to, and then makes any changes to its configuration based on a comparison of the downloaded configuration with the stored configuration. If the device cannot successfully download its configuration from the TFTP server, it operates with its stored configuration.

USING THE WAVECENTER CONFIGURATION MANAGER

To configure a cell using the WaveCenter Configuration Manager, follow this general procedure:

1. Launch the WaveCenter Configuration Manager by clicking on the desktop icon. The program's home screen will be displayed, as shown in *Figure6-1*.
2. Click on the BSU icon. A BSU Configuration Manager window will open.
3. Configure the Base Station Unit as described later in this chapter, under the heading ***Base Station Configuration***.

   NOTE: If there are multiple BSUs, you may want to create and use a template file. See the section ***Managing Configuration Files*** earlier in this chapter.

4. When you are done, click on the **Generate BSC Config** button to save the BSU configuration.
5. Close the BSU Configuration Manager window. If there is another BSU to configure, return to step 2. If there is no other BSU to configure, go to step 6.
6. Click on the home page's subscriber Indoor Unit (CPE) icon. A subscriber CPE Configuration Manager window will open.
7. Configure the subscriber equipment as described in the section ***Subscriber Equipment Configuration*** later in this chapter.

   NOTE: You may want to create and use a template file. See the section ***Managing Configuration Files*** earlier in this chapter.

8. When you are done, click on the **Generate Configuration File** button to save the subscriber configuration.
9. Close the CPE Configuration Manager window. If there is another subscriber to configure, return to step 6. If there is no other subscriber to configure, go to step 10.
10. Exit from the WaveCenter Configuration Manager.
11. Copy all of the configuration files to the default directory for the system's TFTP server, typically *\tftpboot* (unless you saved them directly to that directory).

BASE STATION CONFIGURATION

To configure a Base Station Unit, including the wireless radio interfaces (WSSs, or wireless subsystems), click on the BSU icon on the WaveCenter Configuration Manager home screen (*Figure 6-1*). The BSU Configuration Manager will open in a new window, as shown in *Figure 6-3*.

*There are four required parameters for WSS/BSU configuration: WSS center frequency (***WSS — Frame** *menu); WSS subnet IP addresses and subnet masks (***WSS — Multiple Subnet** *menu); and BSU MAC address (***MAIN — General** *menu. All other parameters are optional.*

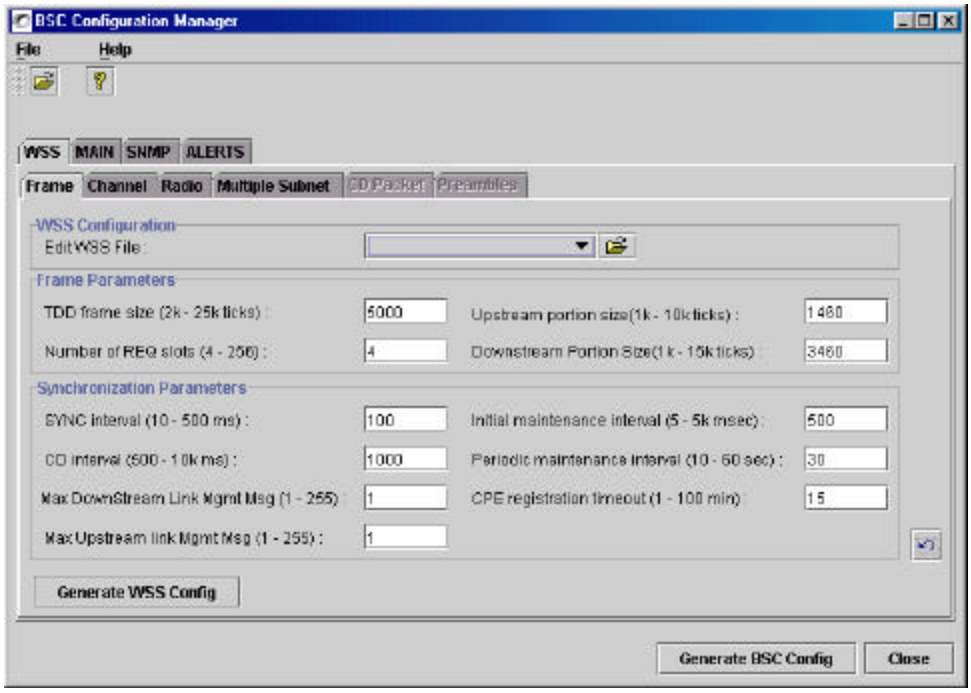


Figure6-3 Base Station Opening Menu (WSS — Frame)

There are four first-level menu tabs for BSU configuration, as shown by the upper row of tabs in *Figure6-3*:

- **WSS** — Used to configure each wireless subsystem (radio interface) on the Base Station Unit.
- **Main** — Used to specify various parameters for the Base Station Unit itself.
- **SNMP** — Used to configure the Base Station Unit for SNMP management.
- **Alerts** — Used to configure the Base Station Unit for email event alerts.

Configuring Wireless Subsystems (WSS)

Click on the **WSS** tab in the upper row. As the second row of tabs in *Figure6-3* shows, there are six menus for configuring a WSS:

- **Frame** — Used to specify how the wireless signal will be framed and synchronized.
- **Channel** — Used to configure the wireless communication channel.
- **Radio** — Used to configure the radio and antenna connected to the WSS.
- **Multiple Subnet** — Used to specify at least one subnet and mask per WSS.
- **CD Packet** —
- **Preamble** —

The **WSS Configuration — Edit WSS File:** *field on the* **Frame** *menu allows you to load an existing WSS configuration file, causing all of the WSS menus to display the current settings for that WSS file. You can then either modify that file, or save it under another name.*

You will need to create a separate configuration for each WSS. The basic procedure is as follows:

1. Start with the **WSS — Frame** menu (*Figure6-3*). If desired, use the **Edit WSS File** field to load an existing WSS configuration as a template.
2. Complete the other WSS menus as described on the following pages.
3. Click on the **Generate WSS Config** button, and specify the WSS you are configuring.
4. Repeat for all WSSs.