ZENA™ Wireless Network Analyzer User's Guide

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

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Trademarks

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

Microchip received ISO/TS-16949:2002 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona and Mountain View, California in October 2003. The Company's quality system processes and procedures are for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

ZENA™ WIRELESS NETWORK ANALYZER USER'S GUIDE

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ZENA™ WIRELESS NETWORK ANALYZER USER'S GUIDE

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the *"ZENA™ Wireless Network Analyzer User's Guide"*. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Development Systems Customer Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the ZENA Wireless Network Analyzer as a development tool to monitor and analyze wireless network traffic. The manual layout is as follows:

- **Chapter 1. ZENA Wireless Network Analyzer Overview** – This chapter introduces the ZENA Wireless Network Analyzer hardware and software, and briefly describes their capabilities.
- **Chapter 2. Getting Started** – This chapter describes how to install the ZENA software.
- **Chapter 3. ZigBee™ Protocol Tools** – This chapter describes how to use the ZigBee protocol tools provided by ZENA software. Both basic and advance monitoring techniques are shown.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use the ZENA Wireless Network Analyzer. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

Readme for ZENA Wireless Network Analyzer

For the latest information on using the ZENA Wireless Network Analyzer, read the `Readme_ZENA.txt` file (an ASCII text file) in the ZENA software installation directory. The Readme file contains update information and known issues that may not be included in this user's guide.

PICmicro® MCU Data Sheets and Family Reference Manuals

See the Microchip web site for complete and updated versions of device data sheets and related device family reference manuals.

Microchip 8-Bit PIC® Microcontroller Solutions (DS39630)

This document provides an overview of the features and functionality of the 8-bit PIC microcontroller product family. It highlights its powerful architecture, flexible memory technologies and easy-to-use development tools.

Microchip Stack for the ZigBee™ Protocol (AN965)

This application note describes how you can use the Microchip Stack for the ZigBee protocol to quickly build your application. To illustrate the usage of the Stack, working demo applications are included.

ZigBee™ Protocol Specification

See the ZigBee protocol web site for the complete and most recent revisions of the ZigBee protocol (http://www.zigbee.org).

PICDEM™ Z Demonstration Kit User's Guide (DS51524)

The PICDEM Z Demonstration Kit is designed to allow developers to evaluate and experiment with Microchip solutions for the ZigBee protocol. The PICDEM Z Demonstration Kit provides two ZigBee protocol nodes to create a simple, two-node network.

IEEE 802.15.4™ Specification

See the IEEE web site for the complete and most recent revisions of the IEEE 802.15.4 specification (http://www.ieee.org).

THE MICROCHIP WEB SITE

Microchip provides online support via our web site at www.microchip.com. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

DEVELOPMENT SYSTEMS CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at www.microchip.com, click on Customer Change Notification and follow the registration instructions.

The Development Systems product group categories are:

- **Compilers** – The latest information on Microchip C compilers and other language tools. These include the MPLAB® C18 and MPLAB C30 C compilers; MPASM™ and MPLAB ASM30 assemblers; MPLINK™ and MPLAB LINK30 object linkers; and MPLIB™ and MPLAB LIB30 object librarians.
- **Emulators** – The latest information on Microchip in-circuit emulators. This includes the MPLAB ICE 2000 and MPLAB ICE 4000.
- **In-Circuit Debuggers** – The latest information on the Microchip in-circuit debugger, MPLAB ICD 2.
- **MPLAB® IDE** – The latest information on Microchip MPLAB IDE, the Windows® operating system Integrated Development Environment for development systems tools. This list is focused on the MPLAB IDE, MPLAB SIM simulator, MPLAB IDE project manager and general editing and debugging features.
- **Programmers** – The latest information on Microchip programmers. These include the MPLAB PM3 and PRO MATE® II device programmers and the PICSTART® Plus and PICkit™ 1 development programmers.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://support.microchip.com.

DOCUMENT REVISION HISTORY

Revision A (April 2006)

- Initial Release of this Document.

NOTES:

Chapter 1. ZENA Wireless Network Analyzer Overview

1.1 INTRODUCTION

This chapter introduces the ZENA Wireless Network Analyzer hardware and software, and briefly describes their capabilities. The ZENA analyzer provides three main tools to develop IEEE 802.15.4 solutions quickly and efficiently with the free Microchip Stack for the ZigBee™ protocol. The ZENA analyzer enables developers to quickly modify and adapt the Microchip Stack for the ZigBee protocol to suit application requirements. The ZENA analyzer is also an IEEE 802.15.4 packet analyzer currently supporting the 2.4 GHz spectrum. The ZENA analyzer is capable of decoding ZigBee protocol v1.0 packets. The ZENA analyzer also provides ZigBee protocol network analysis support. The ZENA analyzer draws the network topology of the ZigBee protocol network as it is formed, allows users to watch packet transactions as they occur, record the packet transactions and play these packets back at variables speeds. These tools, combined, form a power tool in wireless development for the IEEE 802.15.4 protocol.

Note: The ZENA Wireless Network Analyzer board does not have to be attached to the computer to use the configuration tool or the playback functionality.

1.2 ZENA WIRELESS NETWORK ANALYZER KIT CONTENTS

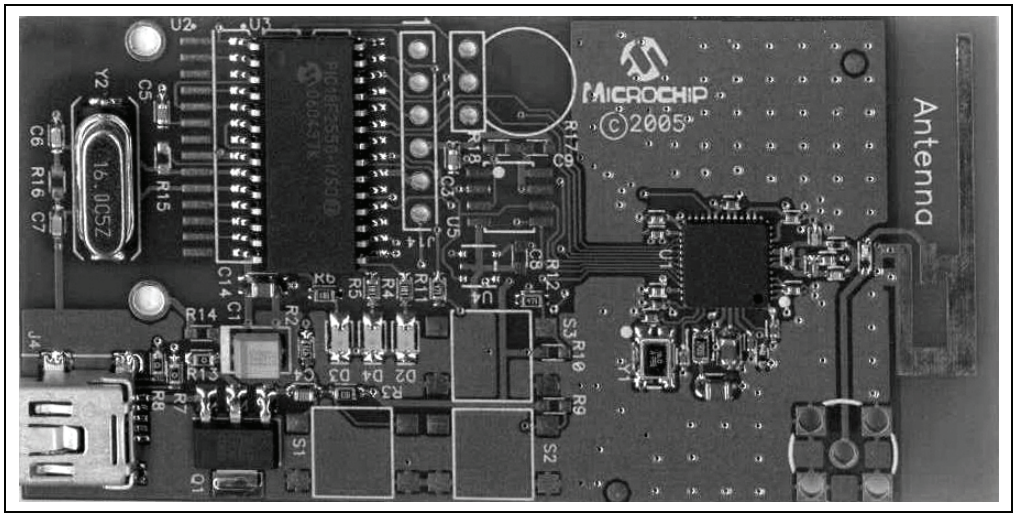
The ZENA Wireless Network Analyzer kit contains the following items:

- ZENA Wireless Network Analyzer
- USB mini-B cable
- ZENA Wireless Network Analyzer CD-ROM

1.3 ZENA ANALYZER OVERVIEW

The ZENA Wireless Network Analyzer board, seen in Figure 1-1, combines the PIC18LF2550 for full-speed, USB support with an IEEE 802.15.4 transceiver.

FIGURE 1-1: ZENA™ WIRELESS NETWORK ANALYZER BOARD



The ZENA Wireless Network Analyzer uses a USB mini-B cable to connect to the PC. The ZENA analyzer is powered by the USB bus. A PCB trace antenna receives the packets on the specified channel and sends the information over USB to the PC computer using the HID standard class.

Chapter 2. Getting Started

2.1 INTRODUCTION

This chapter describes how to install the ZENA Wireless Network Analyzer software.

2.2 INSTALLING ZENA SOFTWARE

Since the ZENA software can be used independently of the hardware, it is available from multiple sources, including the ZENA Wireless Network Analyzer CD-ROM and the installation for source files of *AN965, "Microchip Stack for the ZigBee™ Protocol"*. The version shipped with *AN965, "Microchip Stack for the ZigBee™ Protocol"* is a demo version, which provides Stack configuration and packet playback capability, but does not allow real-time network monitoring with the ZENA Wireless Network Analyzer hardware. The full version is shipped with the ZENA Wireless Network Analyzer board.

If you are installing the software from the ZENA Wireless Network Analyzer CD-ROM, insert the CD-ROM into your computer's CD-ROM drive. If the installation program does not start automatically, browse to the CD ROM directory and execute the `ZENAvn.nn.exe` program, where `n.nn` is the version number of the ZENA software. Follow the on-screen directions to install the ZENA software.

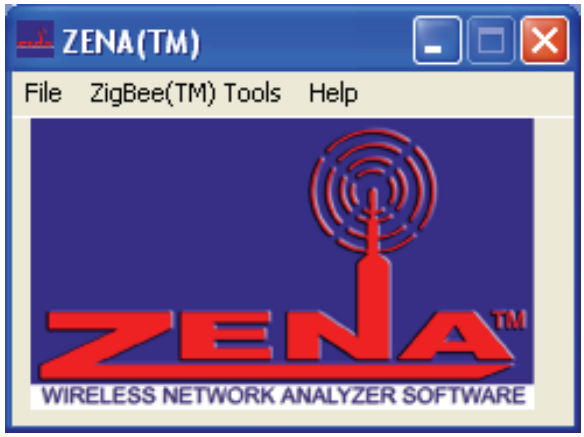
If you have installed the source code for one of the Microchip supported IEEE 802.15.4 protocols, the demo version of ZENA software is installed automatically in the root directory of the application source code. The demo version of ZENA software allows access to the Stack configuration and message playback features, but it will not communicate with the ZENA Wireless Network Analyzer hardware.

The ZENA Wireless Network Analyzer license agreement is presented. Read the agreement, then click **I Accept** to continue.

The ZENA Wireless Network Analyzer Readme file contains important information about the most recent release of the ZENA Wireless Network Analyzer, such as new features and known issues. The Readme file will change with each release.

Once the ZENA software is installed, use the desktop icon or Start Menu item to launch the ZENA software. The introductory screen appears as follows.

FIGURE 2-1: ZENA™ SOFTWARE MAIN WINDOW



NOTES:

Chapter 3. ZigBee™ Protocol Tools

3.1 INTRODUCTION

This chapter describes how to use the ZigBee™ protocol tools provided by the ZENA Wireless Network Analyzer. Both basic and advance monitoring techniques are demonstrated.

3.2 MICROCHIP STACK CONFIGURATION TOOL

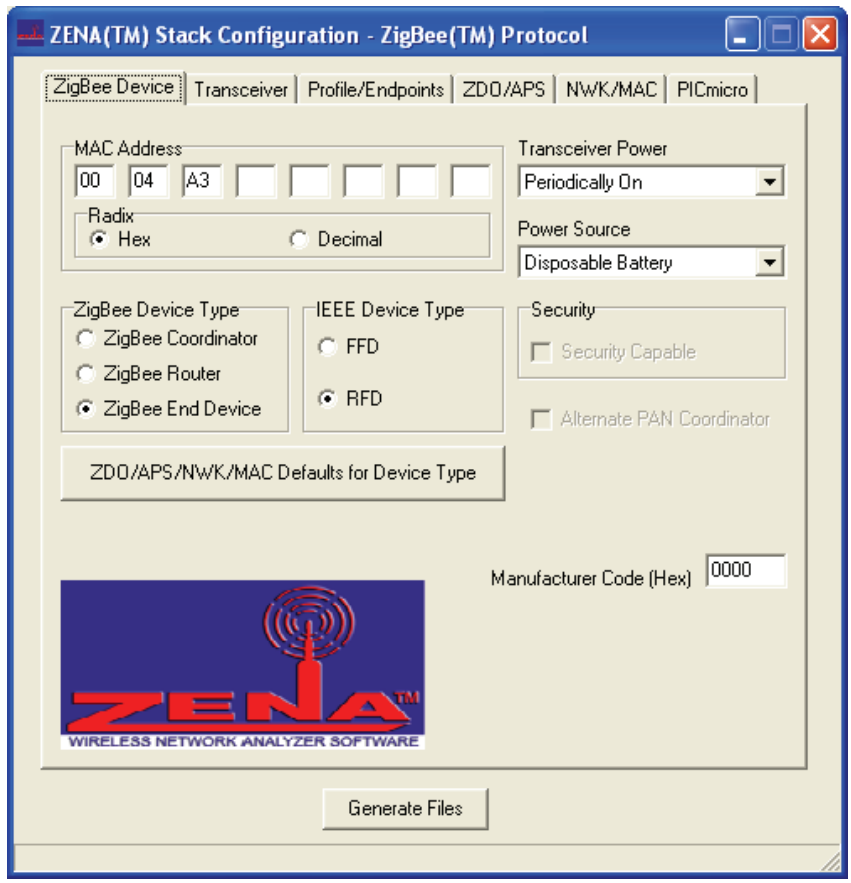
Microchip provides a freely available Stack as part of application note, *AN965, "Microchip Stack for the ZigBee™ Protocol"*. The application note and source code are available for download from the Microchip web site (www.microchip.com). After you have reviewed the application note and studied the demonstration projects, you will be ready to start your own ZigBee protocol application.

The ZENA analyzer will greatly assist you with configuring the Microchip Stack by automatically generating a portion of the source code for your ZigBee protocol application. Be sure to refer to *AN965, "Microchip Stack for the ZigBee™ Protocol"* for details about each ZigBee protocol configuration option. Select *ZigBee™ Tools>Stack Configuration* from the main ZENA™ Software Stack Configuration window. The ZENA™ Software Stack Configuration – ZigBee™ Protocol window will be displayed. Using the tabbed dialog, you can select all of the options required for your ZigBee protocol application. ZENA software will automatically enable and disable certain options depending on the selections you have made.

3.2.1 Specifying ZigBee Protocol Device Information

Select the **ZigBee Device** tab.

FIGURE 3-1: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, ZigBee™ DEVICE TAB



Using this window, you can configure the following items:

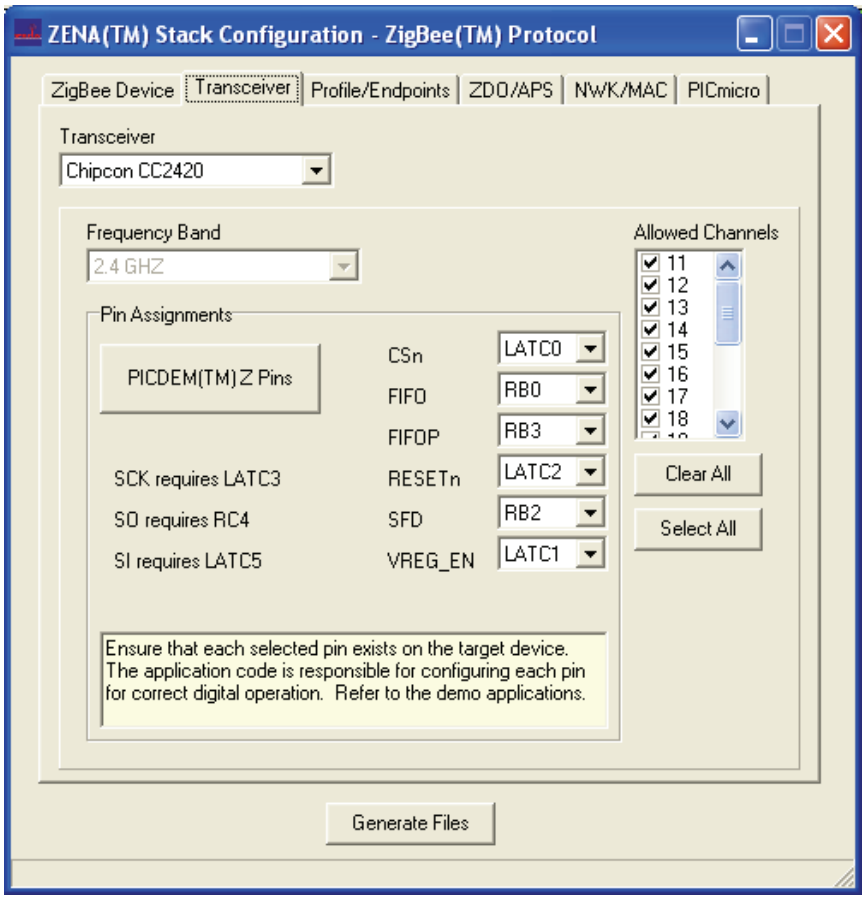
TABLE 3-1: ZigBee™ PROTOCOL DEVICE CONFIGURATION SELECTION

Configuration	Option Description
MAC Address	Each and every ZigBee protocol device must have its own, unique MAC address. The Microchip OUI is provided as a default for development purposes only. Please see *AN965, "Microchip Stack for the ZigBee™ Protocol"* for additional information.
ZigBee Device Type	ZigBee protocol defines three different types of devices. Select the device type of your application.
IEEE Device Type	Some ZigBee protocol devices have the option of selecting the IEEE device type. Select the appropriate IEEE device type for your application.
ZDO/APS/NWK/MAC Defaults for Device Type	When you change the device type, the ZENA™ analyzer will automatically set many options to their default settings unless you have altered them. If you have altered them and wish to restore them to their default values, click this button.
Transceiver Power	Offers transceiver power selection. Selects how the transceiver is powered.
Power Source	Offers power source selection. Selects your application's power source.
Security	This option is currently not supported by the Microchip Stack for ZigBee protocol.
Alternate PAN Coordinator	This option is currently not supported by the Microchip Stack for ZigBee protocol.
Manufacturer Code (Hex)	Each manufacturer of ZigBee protocol devices is assigned a manufacturer code by the ZigBee Alliance. Enter the four-digit hex value.

3.2.2 Specifying Transceiver Information

Select the **Transceiver** tab.

FIGURE 3-2: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, TRANSCEIVER TAB



Using this window, you can configure the following items:

TABLE 3-2: ZigBee™ PROTOCOL TRANSCEIVER CONFIGURATION SELECTION

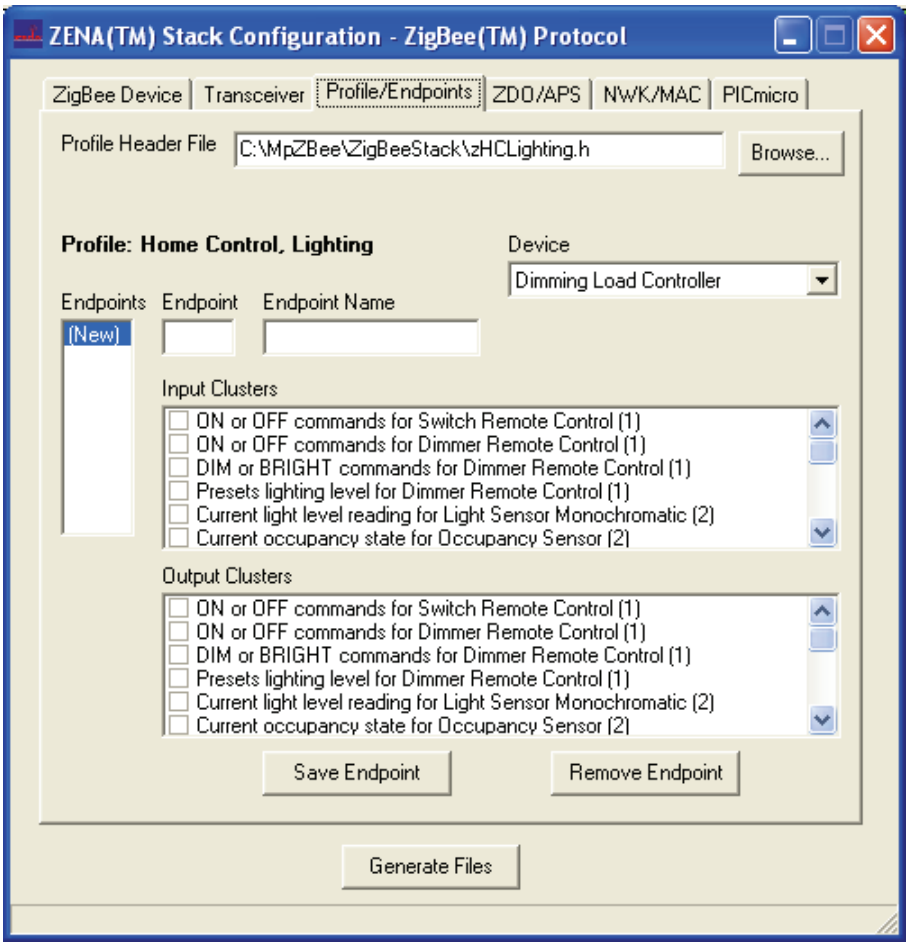
Configuration	Option Description
Transceiver	Select one of the transceivers supported by the Stack.
Frequency Band	This combo box shows the various available frequency bands of the selected transceiver. If the transceiver supports only one frequency band, that frequency will be displayed and the combo box will be disabled.
Pin Assignments(1)	This panel shows the required pins for the selected transceiver. The Stack allows you to change these pin connections to application-specific port pins.
PICDEM™ Z Pins	Click this button to restore the pin assignments to the connections used by the PICDEM Z Demonstration Board.
Allowed Channels	This area shows the channels that are supported by the selected frequency band. Selecting channels here will generate a label that can be used to specify the allowed channels for network formation and network discovery. Click **Clear All** to uncheck all channels, and click **Select All** to check all channels. Each channel can also be checked or unchecked individually by clicking on the checkbox that precedes the channel number.

Note 1: Ensure the pin exists on the target device. The application code is responsible for configuring the pin as a digital input or output as appropriate.

3.2.3 Specifying Profile and Endpoint Information

Select the **Profile/Endpoints** tab.

FIGURE 3-3: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, PROFILE/ENDPOINTS TAB



Using this window, you can specify the profile and endpoint structure that your application is using. See Table 3-3 for configuration options.

CAUTION
It is critical for ZigBee protocol interoperability that this section be accurate.

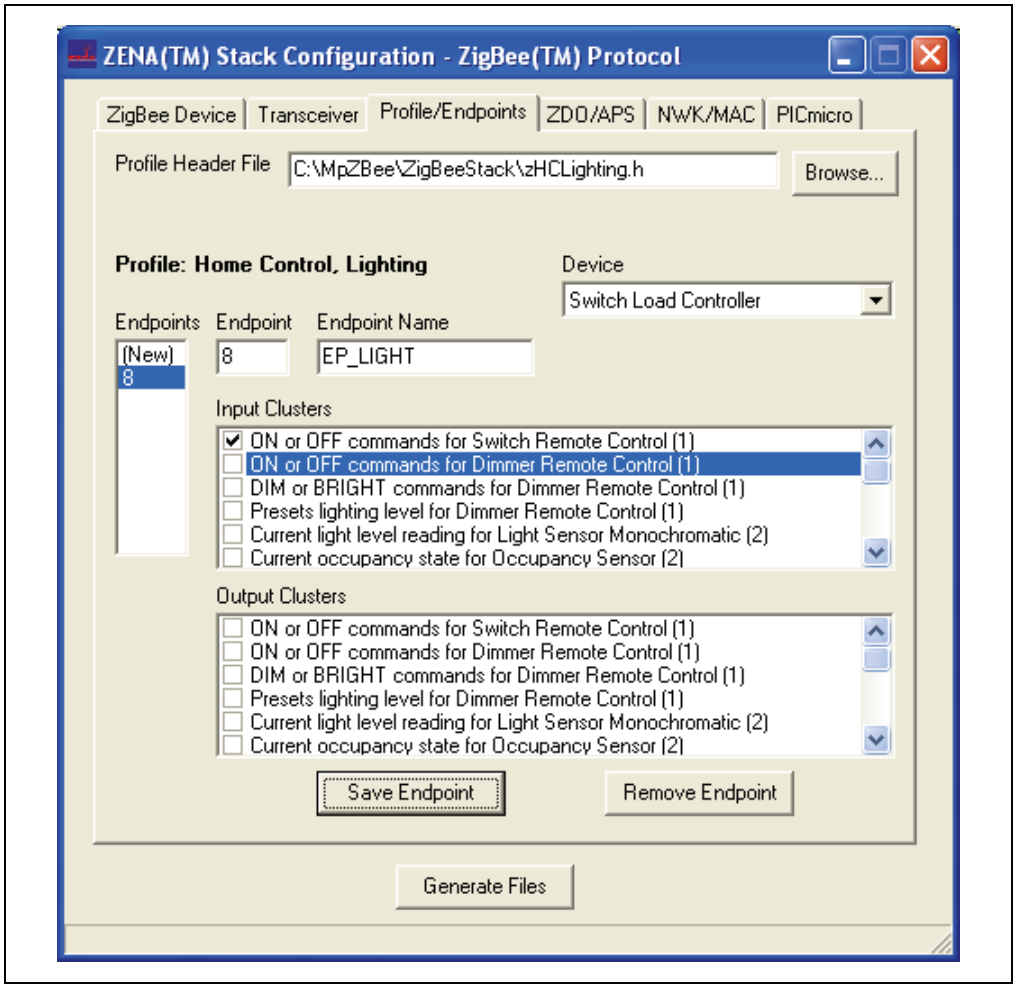
TABLE 3-3: ZigBee™ PROTOCOL PROFILE/ENDPOINTS CONFIGURATION SELECTION

Configuration	Option Description
Profile Header File	Click the **Browse** button to browse to and select the header file for the application's profile. This file has profile information in a specific format which the ZENA™ analyzer uses to configure many items, including: - Profile name - The list of devices supported by the profile - Allowable input and output clusters - Range checking for various parameters on other tabs
Device(1)	Select the profile device that describes the application.
Endpoints(2)	To define an endpoint: Enter the endpoint's numerical value (1-240) in the "Endpoint" edit box. In the "Endpoint Name" edit box, enter a valid C language label for that endpoint. Check all the input and output clusters that are supported by that endpoint under "Input Clusters" and "Output Clusters". Click **Save Endpoint** to save the endpoint. The endpoint number will be added to the "Endpoints" list box. To define another endpoint: Click on "(New)" in the "Endpoints" list box. All the endpoint information will be cleared. Enter the new endpoint's information and click **Save Endpoint**. To view a previously defined endpoint: Click on the endpoint number in the "Endpoints" list box. To remove a specified endpoint: Click on the endpoint number in the "Endpoints" list box and click **Remove Endpoint**.

Note 1: The ZENA analyzer does not confirm that all mandatory clusters are supported for the selected device.

2: Be sure to click **Save Endpoint** when you are finished defining an endpoint. If the endpoint information has been entered but not saved, the endpoint will not be included in the generated output files.

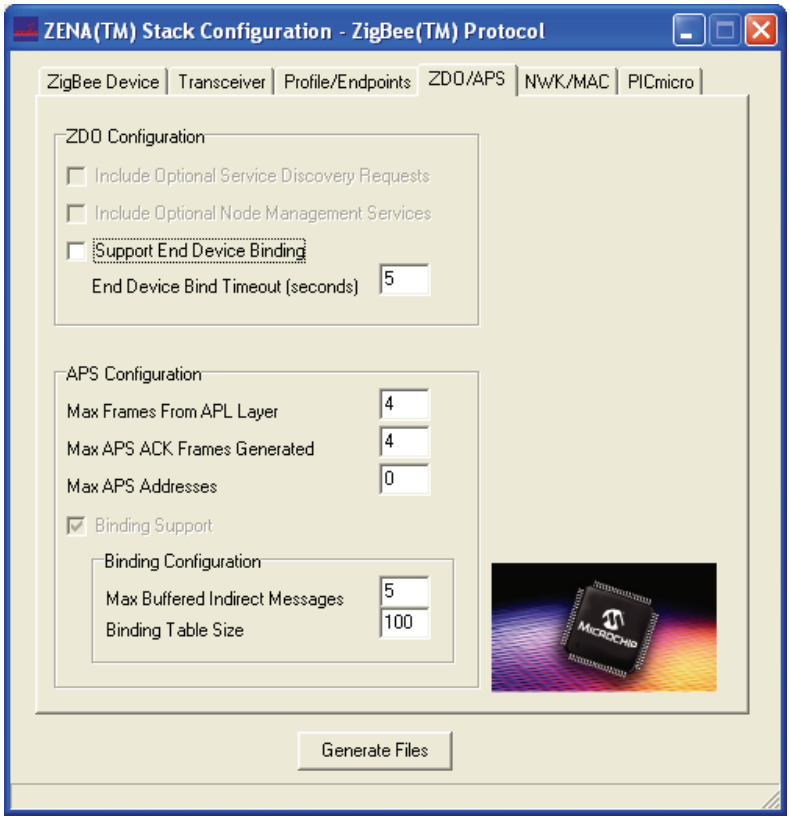
FIGURE 3-4: ENDPOINT SPECIFICATION



3.2.4 Specifying ZDO and APS Layer Information

Click on the **ZDO/APS** tab.

FIGURE 3-5: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, ZDO/APS TAB



This tab is used to configure the ZDO (ZigBee Device Object) and APS (Application Sub-Support) stack layers. Many options on this tab are enabled or disabled based on the “ZigBee Device Type” specified on the **ZigBee Device** tab.

Many of these options have a direct correlation to the amount of RAM or nonvolatile memory required by the application. To view the associated cost in the status bar at the bottom of the window, hold the mouse cursor over the appropriate edit box. This feature only functions if the edit box is enabled. See Table 3-4 and Table 3-5 for ZDO and APS option selections.

TABLE 3-4: ZigBee™ PROTOCOL ZDO CONFIGURATION SELECTION

Configuration	Option Description
Include Optional Service Discovery Requests	If checked, the application will support the optional ZDO service discovery requests. *This feature is not yet supported by the Microchip Stack.*
Include Optional Node Management Services	If checked, the application will support the optional ZDO node management services. *This feature is not yet supported by the Microchip Stack*
Support End Device Binding	This function is available only on ZigBee protocol coordinators. If checked, enter the “End Device Bind Timeout (seconds)” in seconds.

TABLE 3-5: ZigBee™ PROTOCOL APS CONFIGURATION SELECTION

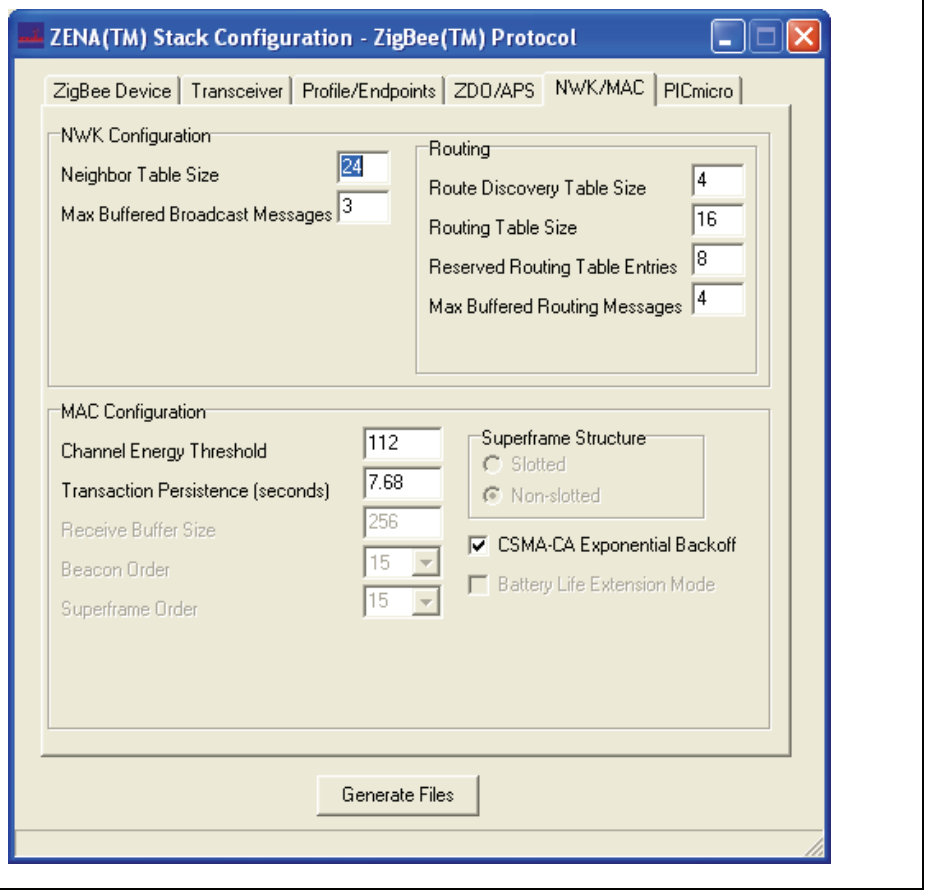
Configuration	Option Description
Max Frames From APL Layer	Each frame sent down from the Application layer must be buffered for retransmission on failure and for reporting back transmission confirmation status. Enter the number of frames that can be in the process of transmitting at the same time.
Max APS ACK Frames Generated	If messages are received from other nodes with APS-level Acknowledgement requested, the APS layer will automatically transmit the Acknowledge; but space is still required in the confirmation queue. Enter the number of APS-level Acknowledges your application is expected to be in the process of transmitting at the same time.
Max APS Addresses	ZigBee protocol allows the Application layer to specify a message destination using a node's 64-bit MAC address, rather than the 16-bit network address. If a 64-bit MAC address is specified, the APS layer searches an application maintained table for the corresponding 16-bit network address. Enter the size of that table in this field. If the Application layer will use only 16-bit network addresses to send messages, or the application is an IEEE Reduced Function Device, this value can be set to '0'.
Binding Support(1)	If the device will support bindings, check this box and enter the "Binding Table Size". If a device supports bindings, it must be able to buffer all incoming indirect messages for retransmission. Enter the number of indirect messages the application is expected to handle concurrently in the "Max Buffered Indirect Messages" edit box.

Note 1: Binding support is required for ZigBee protocol coordinators.

3.2.5 Specifying NWK and MAC Layer Information

Click on the **NWK/MAC** tab.

FIGURE 3-6: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, NWK/MAC TAB



This tab is used to configure the NWK (Network) and MAC (Medium Access Controller) Stack layers. Many options on this tab are enabled or disabled based on the “ZigBee Device Type” specified on the **ZigBee Device** tab.

Many of these options have direct correlation to the amount of RAM or nonvolatile memory required by the application. To view the associated cost in the status bar at the bottom of the window, hold the mouse cursor over the appropriate edit box. This feature only functions if the edit box is enabled. See Table 3-6 and Table 3-7 for NWK and MAC option selections.

TABLE 3-6: ZigBee™ PROTOCOL NWK CONFIGURATION SELECTION

Configuration	Option Description
Neighbor Table Size(1)	All ZigBee protocol devices contain a neighbor table where they store information about other nodes in the network.
Max Buffered Broadcast Messages	When a ZigBee protocol device initiates or receives a broadcast message, it must periodically retransmit that message until it hears all of its Full Function Device neighbors retransmit the message or the message times out. Enter the number of broadcast messages that the application is expected to process concurrently.
Route Discovery Table Size(1)	If the device supports routing, it must have a route discovery table.
Routing Table Size(1)	If the device supports routing, it must have a routing table.
Reserved Routing Table Entries(1)	If the device supports routing, it must reserve some of the routing table entries for route repair.
Max Buffered Routing Messages	If the device supports routing, it must be able to buffer messages while awaiting route discovery. Enter the number of messages that can be concurrently buffered awaiting route discovery.

Note 1: The minimum size of this item is specified in the selected profile. See **Section 3.2.3 "Specifying Profile and Endpoint Information"**.

TABLE 3-7: ZigBee™ PROTOCOL MAC CONFIGURATION SELECTION

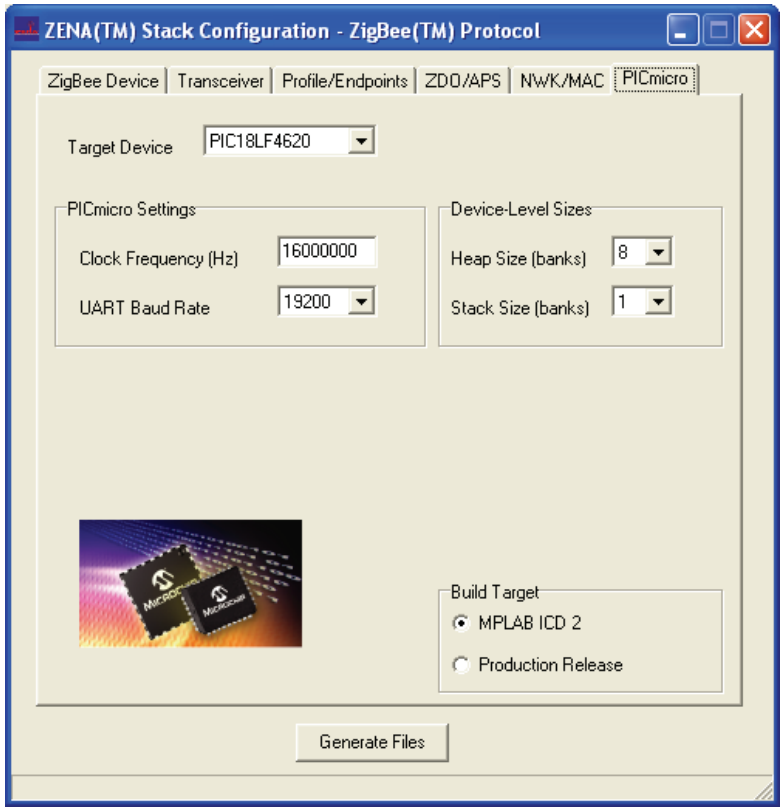
Configuration	Option Description
Channel Energy Threshold	This option is available for ZigBee protocol coordinators only. Enter the maximum amount of energy allowable for a channel to be selected for a new network.
Minimum Join LQI	This option is only available for devices other than ZigBee protocol coordinators. Enter the minimum link quality from a received beacon for that device to be selected as a potential place to join the network.
Transaction Persistence (seconds)	This option is available for devices with children whose receivers are off when the device is Idle and must buffer messages for those children until the children request them. Enter the amount of time in seconds that messages must be buffered before they can be discarded.
Receive Buffer Size	As bytes are received from the transceiver, they are buffered until an entire message is received and the application is finished processing the previous message. Enter the size of this buffer.
Beacon Order(1)	This value is fixed for non-beacon networks.
Superframe Order(1)	This value is fixed for non-beacon networks.
Superframe Structure(1)	Only non-beacon networks are supported; therefore, the superframe structure is non-slotted.
CSMA-CA Exponential Backoff	Check this box to use the IEEE exponential backoff.
Battery Life Extension Mode(1)	This feature is only used in beacon networks.

Note 1: The Microchip Stack for ZigBee protocol currently supports only non-beacon networks.

3.2.6 Specifying PICmicro MCU Information

Click on the **PICmicro** tab.

FIGURE 3-7: ZENA™ SOFTWARE STACK CONFIGURATION WINDOW, PICmicro® MCU TAB



This tab is used to configure basic PICmicro MCU options (see Table 3-8).

TABLE 3-8: ZigBee™ PROTOCOL STACK CONFIGURATION SELECTION

Configuration	Option Description
Target Device	Select the PICmicro® MCU device used by the target application. If the exact device is not available, select a similar device and refer to *AN965, "Microchip Stack for the ZigBee™ Protocol"* for information on modifying the linker script for the target device.
Clock Frequency (Hz)(1)	Specify the input clock frequency to the PICmicro MCU in Hertz. It is important that this value be accurate, as all internal ZigBee protocol timing will be based off of this value.
UART Baud Rate	If you are using the UART of the target device and you are using the interface code provided in *AN965, "Microchip Stack for the ZigBee™ Protocol"*, specify the UART baud rate. If your application does not use the UART, this value is irrelevant.
Heap Size (banks)	Specify the number of banks of heap space required by the application. Refer to *AN965, "Microchip Stack for the ZigBee™ Protocol"* for information on setting the heap size.
Stack Size (banks)	Specify the number of banks required for the C software Stack. Refer to *AN965, "Microchip Stack for the ZigBee™ Protocol"* for information on setting the Stack size.
Build Target	Select whether you want the linker script generated for a debug environment using MPLAB® ICD 2 or for a production build.

Note 1: The PICDEM™ Z Demonstration Board has a clock frequency of 16 MHz (16000000 Hz).

3.2.7 Generating the Configuration Files

When all of the options on all of the tabs are set appropriately, generate the Stack configuration files by clicking **Generate Files**. The ZENA Wireless Network Analyzer will first perform a validity check to ensure that all required fields have appropriate values and all profile-specific ranges are met. If no endpoints are specified, the ZENA analyzer will generate a warning, but will still generate the output files.

Note:	Many options, including endpoint specification, affect multiple output files. Therefore, it is recommended not to mix and match files from different ZENA analyzer sessions.

If the validity check passes, ZENA analyzer will prompt for an output directory for the configuration files. These files are:

- `zigbee.def` – Provides basic definitions for Stack configuration.
- `myZigBee.c` – Provides all ROM initialization for the Stack, including ZigBee protocol device descriptors.
- `zLink.lkr` – Project linker script.

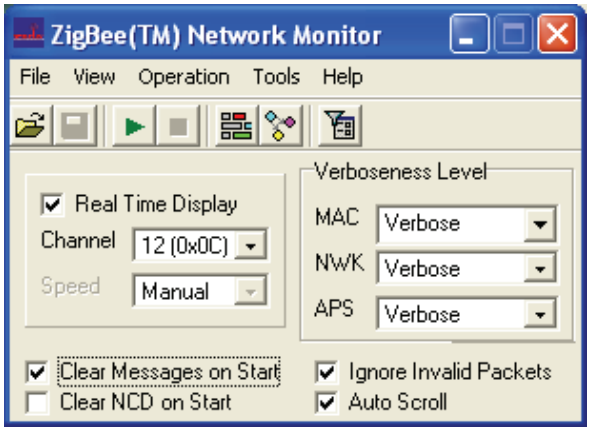
Each of these files has a time and date stamp included in the file. Refer to *AN965, "Microchip Stack for the ZigBee™ Protocol"* for more information about these files.

3.3 BASIC NETWORK MONITORING

The ZENA Wireless Network Analyzer hardware and software provide a powerful network monitoring tool for use from development through installation.

Connect the ZENA Wireless Network Analyzer hardware to the PC using the supplied USB mini-B cable. From the ZENA Software Main window, select *ZigBee™ Tools>Network Monitor*. The following window will open:

FIGURE 3-8: ZigBee™ PROTOCOL NETWORK MONITOR WINDOW



A blank Packet Sniffer window for displaying network messages will also open. If this window is closed, it can be reopened, either by clicking on the **Network Messages** button, or by selecting the *View>Network Messages* menu option.

The ZigBee™ Network Monitor window can be used to start and stop real-time network analysis, save and load data, and configure the display of the messages.

3.3.1 Real-Time Network Monitoring

Before initiating real-time monitoring, set the following options on the ZigBee™ Network Monitor window:

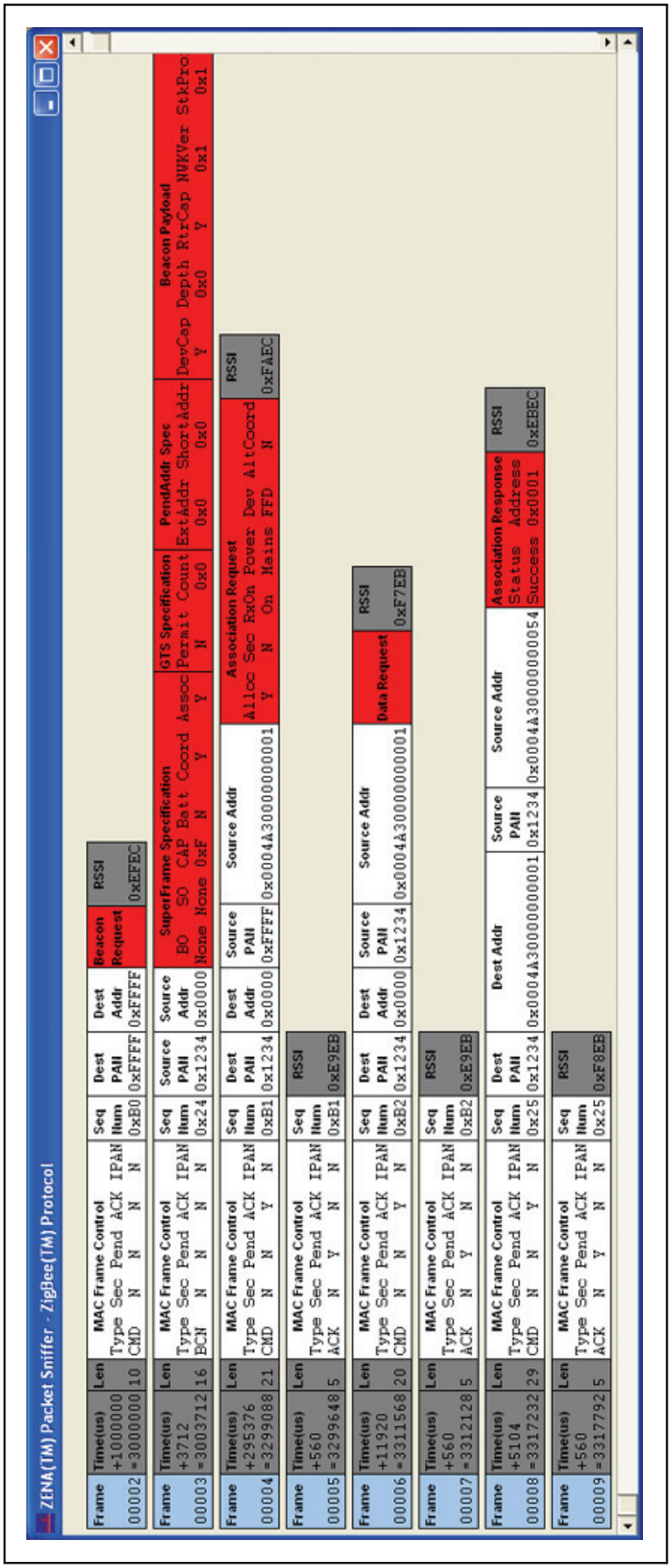
TABLE 3-9: REAL-TIME NETWORK MONITORING CONFIGURATION SELECTION

Configuration	Option Description
Real-Time Display	Check this box to display on-air messages that are received by the Network Analyzer hardware.
Channel	Select the desired channel to monitor. Note that if your application specifies more than one allowable channel to form or join a network, you may have to try multiple channels to find the network. This selection can be changed only while real-time monitoring is stopped.
Clear Messages on Start	If you want all previously displayed messages to be erased when you start monitoring, check this box. If you want the messages to be retained, uncheck this box.
Ignore Invalid Packets	If you want packets with invalid checksums to be ignored, check this box. If you want all network traffic and noise to be displayed, uncheck this box.
Auto Scroll(1)	If you want the Packet Sniffer window to automatically scroll, such that the newest message always appears on the bottom of the Packet Sniffer window, check this box.

Note 1: If “Auto Scroll” is checked, system response may slow. “Auto Scroll” can be disabled while real-time monitoring is in progress.

Click the **Play** button or select the *Operation>Start Sniffing/Playback* menu option to begin real-time monitoring. The received messages are then displayed on the Packet Sniffer window. Figure 3-9 shows a typical sequence of a new node joining a ZigBee protocol network.

FIGURE 3-9: ASSOCIATION REQUEST AND RESPONSE



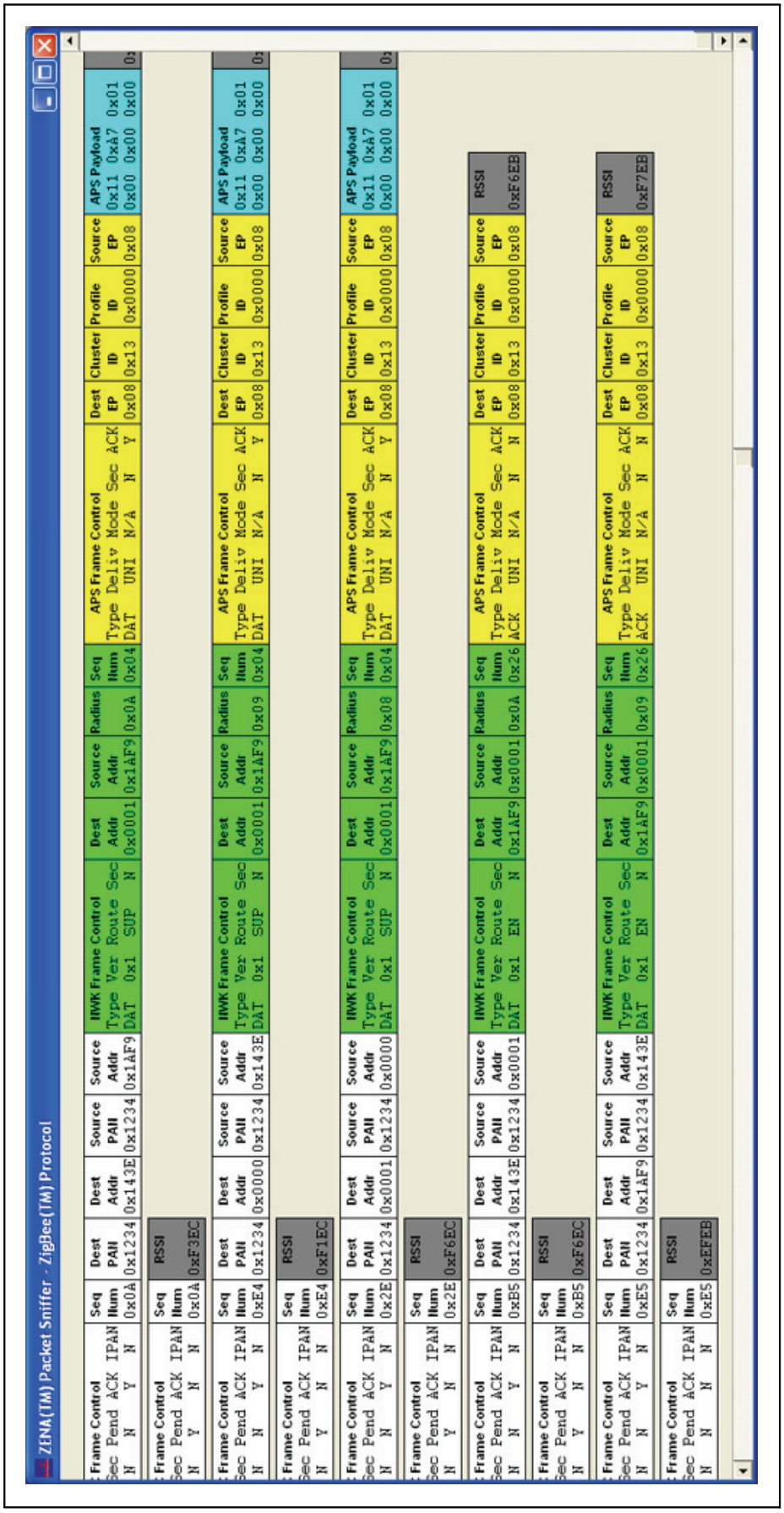
The various portions of the message are color coded for clarity.

TABLE 3-10: PACKET SNIFFER COLOR CODING

Field	Color
MAC Header	White
MAC Commands and Beacons	Red
NWK Header	Lime
NWK Commands	Fuchsia
APS Header	Yellow
APS Payload/Decoding	Aqua
Unknown	Olive

Figure 3-10 shows a message being routed from the originator to the final destination and an APS-level Acknowledge being routed back. Note that by using the ZENA analyzer, we can see that the first message is being routed along the network tree, while the Acknowledge is being routing more directly.

FIGURE 3-10: APPLICATION MESSAGE WITH APS-LEVEL ACKNOWLEDGE



Each message can contain a great deal of information, making it difficult to view on the screen. The Packet Sniffer window can be scrolled, but the ZENA analyzer also offers three different levels of viewing the MAC, NWK and APS-level information. Each layer can be configured separately on the Network Monitor window by adjusting the "Verboseness Level"; there are three levels offered (see Table 3-11).

TABLE 3-11: ZigBee™ PROTOCOL VERBOSENESS LEVEL CONFIGURATION SELECTION

Configuration	Option Description
Verbose	Headers for each field are provided with a description of the corresponding value below the header. Figure 3-10 shows all layers at the "Verbose" setting.
Numeric	Headers for each field are provided with the numeric value of that field below the header. Refer to Figure 3-11.
Condensed	No field headers are provided. All bytes of the field are represented numerically with the Least Significant Byte first. Refer to Figure 3-12.

FIGURE 3-11: APPLICATION MESSAGE WITH NUMERIC DISPLAY

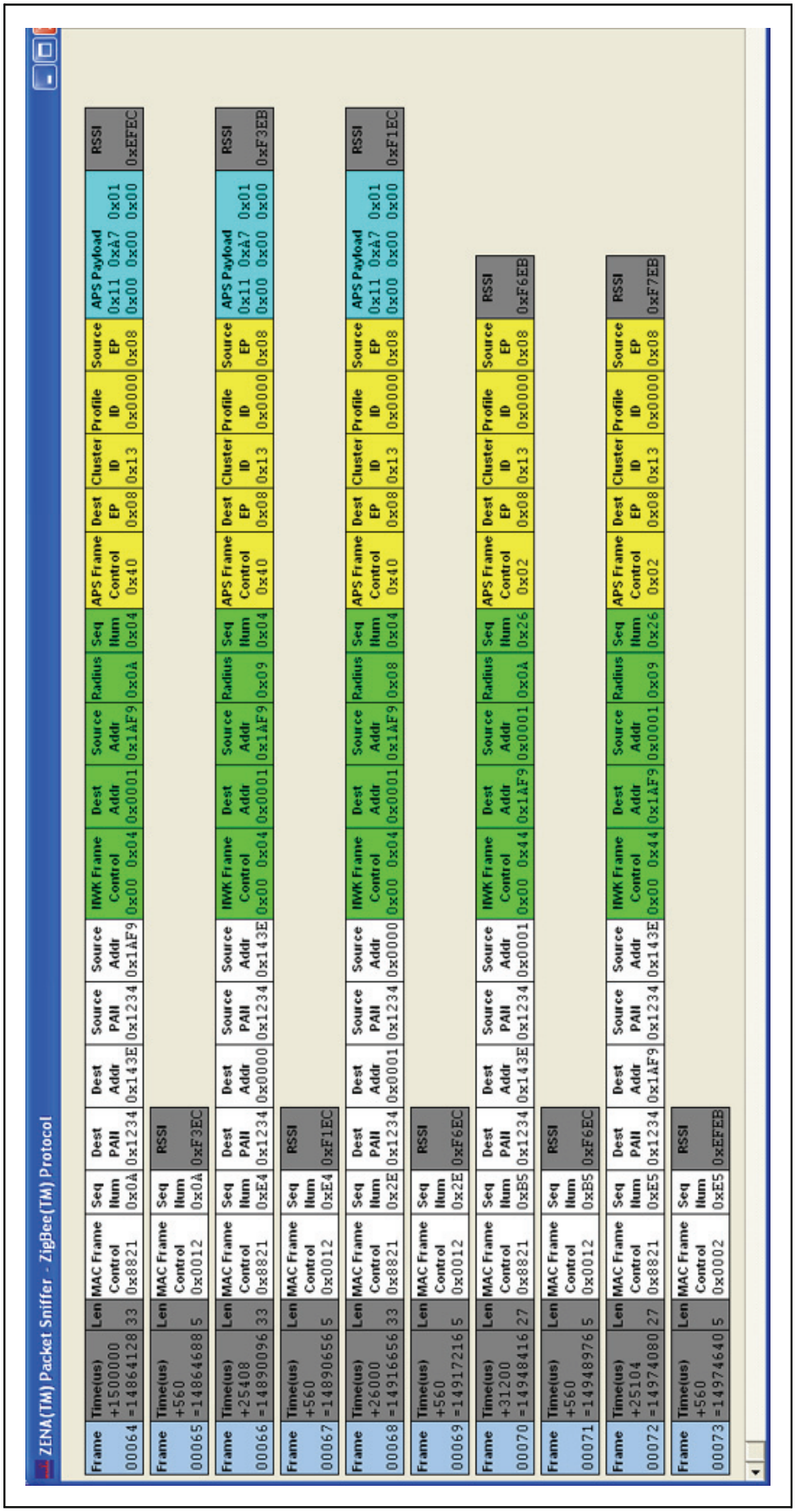
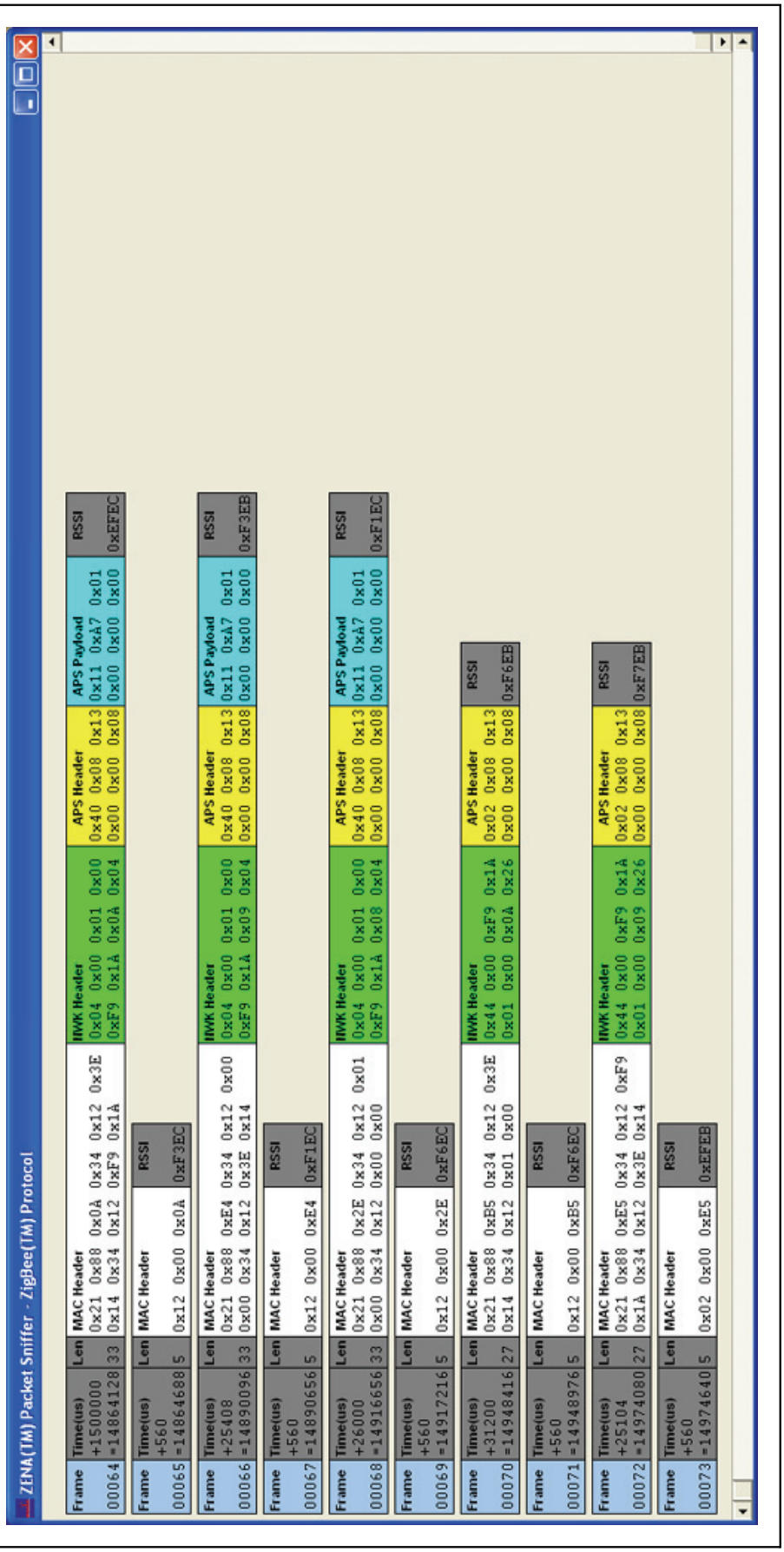


FIGURE 3-12: APPLICATION MESSAGE WITH CONDENSED DISPLAY



The data can be viewed and analyzed to some degree while real-time monitoring is in progress. For more advanced analysis, real-time monitoring must be halted by clicking the **Stop** button or selecting the *Operation>Stop Sniffing/Playback* menu option.

To save the data for analysis at a later time, click the **Save** button or select the *File>Save* menu option.

3.3.1.1 TIME-STAMPS

The displayed time-stamp is the time from the end of the previous message until the end of the current message. The time-stamp is displayed in micro seconds, and can represent up to 71 minutes before rolling over.

3.3.2 Analyzing Previously Captured Data

When real-time network monitoring is stopped, the ZENA Wireless Network Analyzer can be used to perform further analysis of the captured data. If real-time monitoring is in progress, halt it by clicking the **Stop** button or by selecting the *Operation>Start Sniffing/Playback* menu option. To analyze previously captured data, click **Open** or select *File>Open* and select the desired data file.

Uncheck the "Real Time Display" checkbox to enable the analysis capabilities.

3.3.2.1 PACKET PLAYBACK

Captured data can be played back as if it were being received in real time. Playback can begin at any point in the data. To select the first packet to play back, click on the desired packet in the Packet Sniffer window. The selected packet will then be outlined in red.

Note:	If playback is currently in progress (the **Start** button is disabled and the **Stop** button is enabled), a packet cannot be selected with a mouse click.

Select the desired playback speed using the "Speed" combo box. Available options are:

TABLE 3-12: ZigBee™ PROTOCOL PACKET PLAYBACK SELECTION

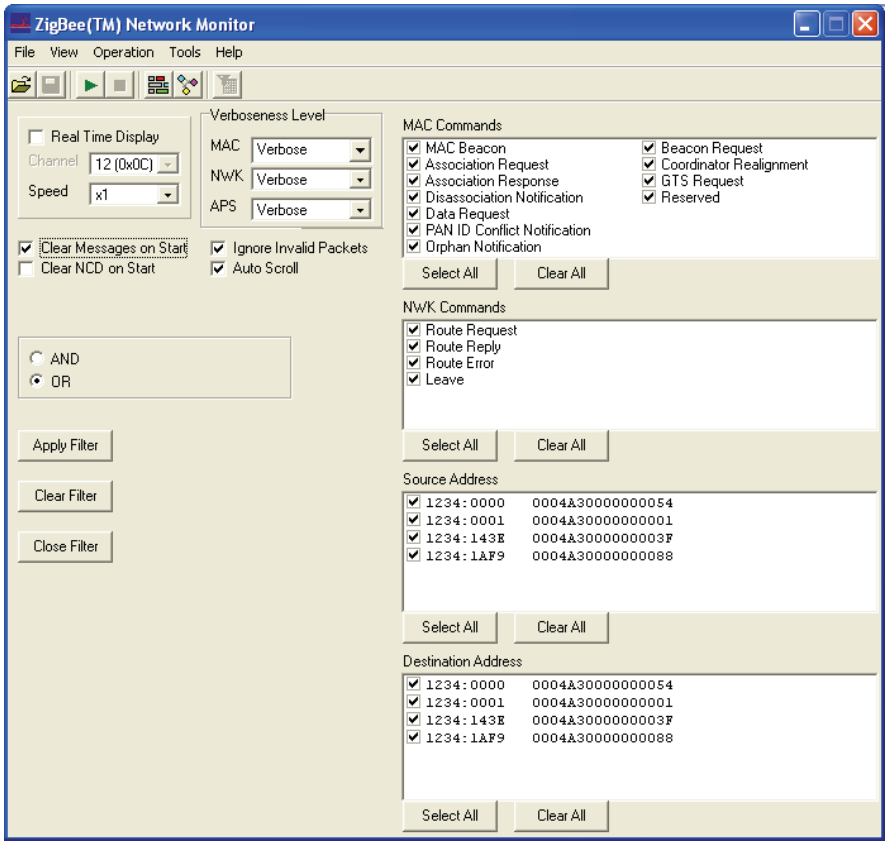
Packet	Option Description
x0.01	Packets are played back approximately 100 times faster than they were received.
x0.1	Packets are played back approximately 10 times faster than they were received.
x1	Packets are played back at approximately the same rate as they were received.
x10	Packets are played back approximately 10 times slower than they were received.
x100	Packets are played back approximately 100 times slower than they were received.
2 sec	Packets are played back at 2-second intervals between packets.
Instant	Packets are played back as quickly as possible.
Manual	Packet playback is controlled by the up and down arrow keys.

Packet playback is especially useful when using the filter option and performing more advanced network analysis.

3.3.2.2 USING THE PACKET FILTER

Click the **Filter** button or select the *Tools>Filter* menu option to enlarge the Network Monitor window and display the filter options.

FIGURE 3-13: NETWORK MONITOR WINDOW WITH FILTER

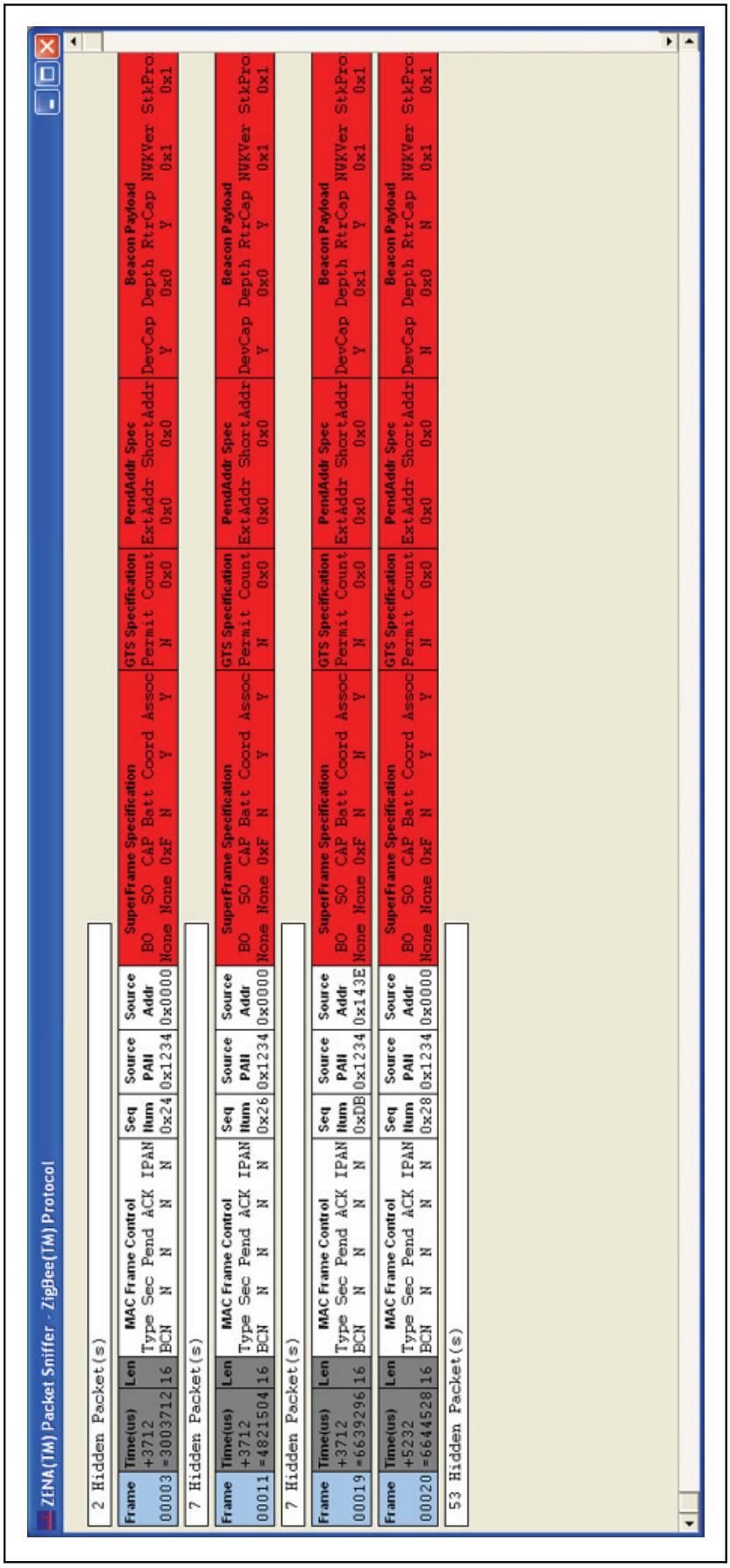


The filter is useful for displaying only selected packets in the Packet Sniffer window. For example, suppose we wish to see all beacons generated by our network. Set up the filter as follows:

1. Clear all “MAC Commands” checkboxes except “MAC Beacon”.
2. Clear all “NWK Commands” checkboxes.
3. Check all “Source Address” and “Destination Address” entries.
4. Select the “AND” option.
5. Click **Apply Filter**.

The Packet Sniffer window will then display all beacon packets and hide all others. Refer to Figure 3-14.

FIGURE 3-14: FILTERED BEACONS



Note: If the “Source Address” and “Destination Address” areas are empty and are needed for your desired filter, replay the network formation portion of the data. If you will be working with a network that maintains the same structure, you may want to save a captured data file that contains the network formation for populating these fields.

To redisplay all messages, click **Clear Filter**.

To close the filter and return the Network Monitor window to its original size, click **Close Filter**.

3.3.2.3 HIDING AND UNHIDING PACKETS

Packets in the Packet Sniffer window can be hidden in two ways:

- Using the filter function as described above
- Right clicking on a packet and selecting *Hide* from the pop-up menu

Note: Multiple packets can be selected for hiding by holding down the control key while clicking each desired packet. A range of packets can be selected by clicking on the first packet of the range, then holding down the shift key while clicking on the last packet of the range. Each selected packet will be outlined in red. When all desired packets have been selected, right click and select *Hide* to hide all selected packets.

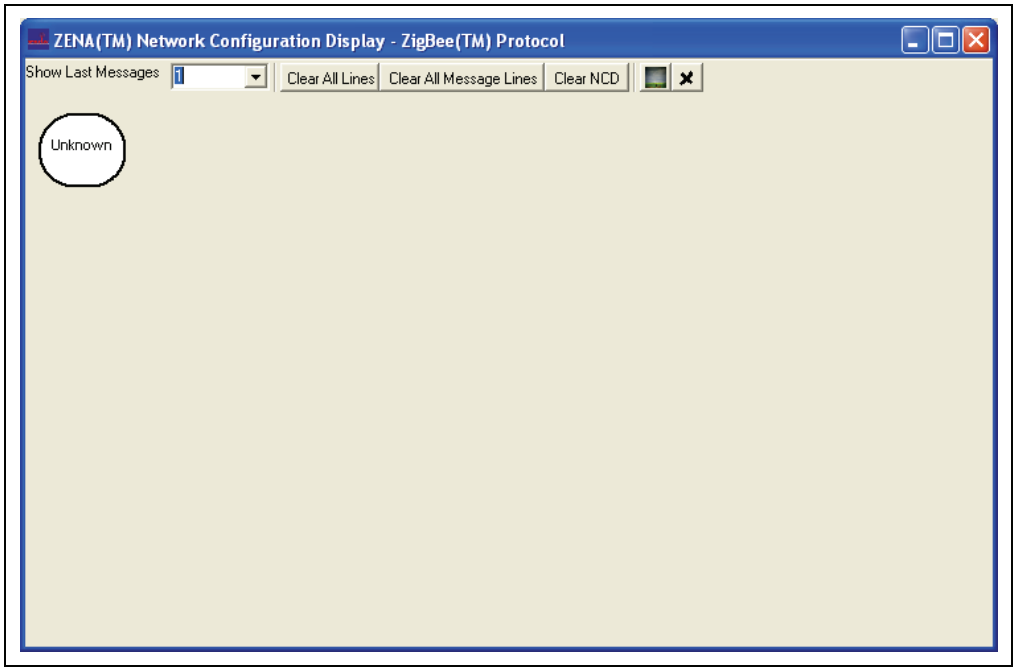
The hidden packets can be redisplayed by right clicking on the appropriate `X Hidden Packet(s)` box in the Packet Sniffer window and clicking *UnHide*.

3.4 ADVANCED NETWORK MONITORING AND ANALYSIS

3.4.1 Network Configuration Display Window

The ZENA Wireless Network Analyzer provides an extra level of network monitoring and analysis with the Network Configuration Display (NCD) window. Open the Network Configuration Display window by clicking the **Network Configuration Display** button or by selecting the *View>Network Configuration Display* menu option on the Network Monitor window.

FIGURE 3-15: NETWORK CONFIGURATION DISPLAY WINDOW



The NCD window can be used during both real-time network monitoring and packet playback. If the "Clear NCD on Start" checkbox on the Network Monitor window is checked, then the NCD window will be cleared when real-time monitoring is started. If you want the nodes to be retained, uncheck this box.

Note: Due to heavy system loading during real-time monitoring, the NCD window may not update properly during real-time monitoring, particularly if there is a lot of network traffic and if "Auto Scroll" is enabled. For best results, disable "Auto Scroll" if network traffic is heavy. The NCD window will update properly during packet playback.

When the ZENA analyzer receives a message from a device, it creates a node on the NCD window. The label for the node will be its 64-bit MAC address. To see the node's PAN ID and 16-bit network address, hold the mouse cursor over the node. If the ZENA analyzer monitors network creation, it can also color code the nodes according to device type.

TABLE 3-13: Node Colors

Node Type	Color
ZigBee™ Protocol Coordinator	Aqua
ZigBee Protocol Router	Fuchsia
FFD End Device	Lime
RDF End Device	Yellow
Unknown	White

When a message travels from one device to another, the NCD window will display a line from the source node to the destination node. If a device transmits a broadcast message, the NCD window will display a circle around the source node.

Note: Some messages, such as MAC Acknowledges, do not contain any address information. These messages are shown originating from the Unknown node.

Nodes can be hidden by right clicking on the node and selecting *Hide*. A new node, named "Hidden", will be created and all lines that would normally be drawn to the hidden nodes will be drawn to that node. To unhide all hidden nodes, right click on the "Hidden" node and select *Unhide All*.

When a device joins the network, the parent-child relationship of that device is shown by a silver line between the two devices. See Table 3-14 for NCD window controls.

TABLE 3-14: ZigBee™ PROTOCOL NCD CONFIGURATION SELECTION

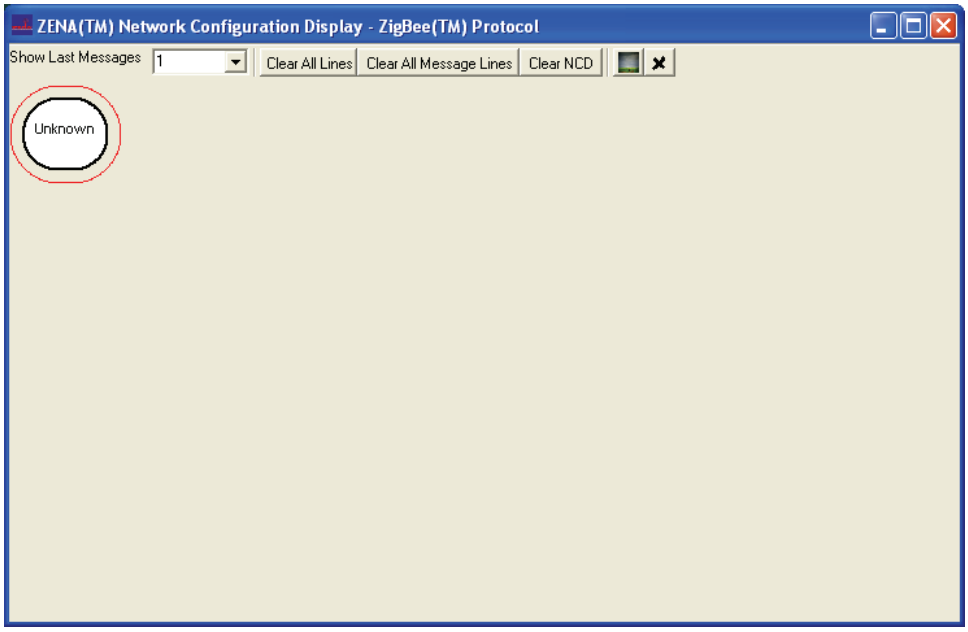
Control	Option Description
Show Last Messages	This combo box allows you to select how many message lines are displayed. When a new message line is drawn, the oldest line is removed. Several predefined options are available, or you may enter your own value. The silver network association lines are not affected by this setting.
Clear All Lines	Click this button to clear all message and network association lines. The nodes themselves are unaffected.
Clear All Message Lines	Click this button to clear all message lines. The network association lines and the nodes themselves are unaffected.
Clear NCD	Click this button to clear all message lines, all network association lines and all nodes.
Select Bitmap	Click this button to load a background image. This is described in more detail in **Section 3.4.4 "Customizing the Network Configuration Display Window"**.
Clear Background	Click this button to remove the background image.

3.4.2 Viewing Network Formation

The following sequence of figures shows how network formation appears on the NCD window.

First, the ZigBee protocol coordinator sends a beacon request.

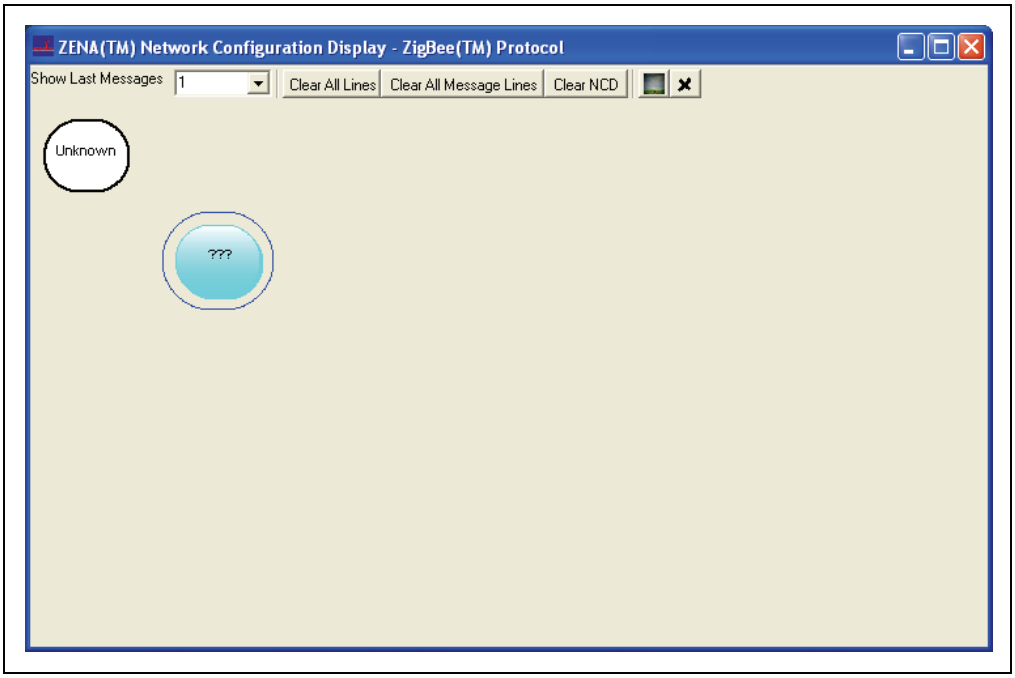
FIGURE 3-16: NCD BEACON REQUEST



Since there are no nodes on this channel, no beacons are received, and the ZigBee protocol coordinator forms a network.

Next, a ZigBee protocol router tries to find a network to join. It also emits a beacon request, which looks just like Figure 3-16, since the beacon request contains no source address information. Now, the ZigBee protocol coordinator responds with a beacon.

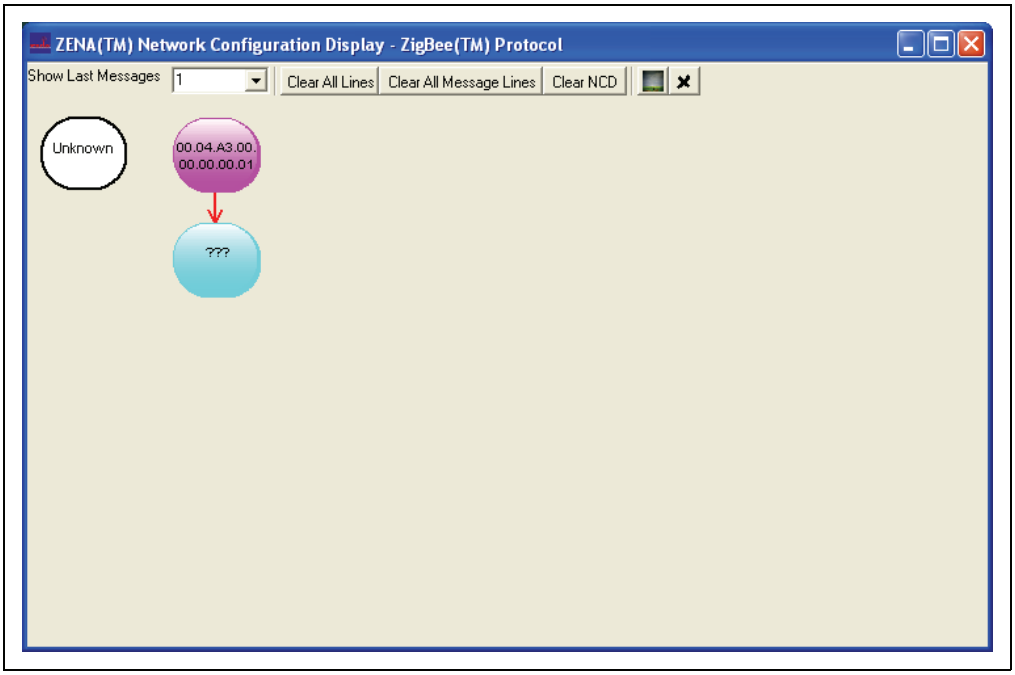
FIGURE 3-17: NCD BEACON



Note that the ZENA analyzer can tell from the beacon that this device is a ZigBee protocol coordinator, but it does not yet know its MAC address.

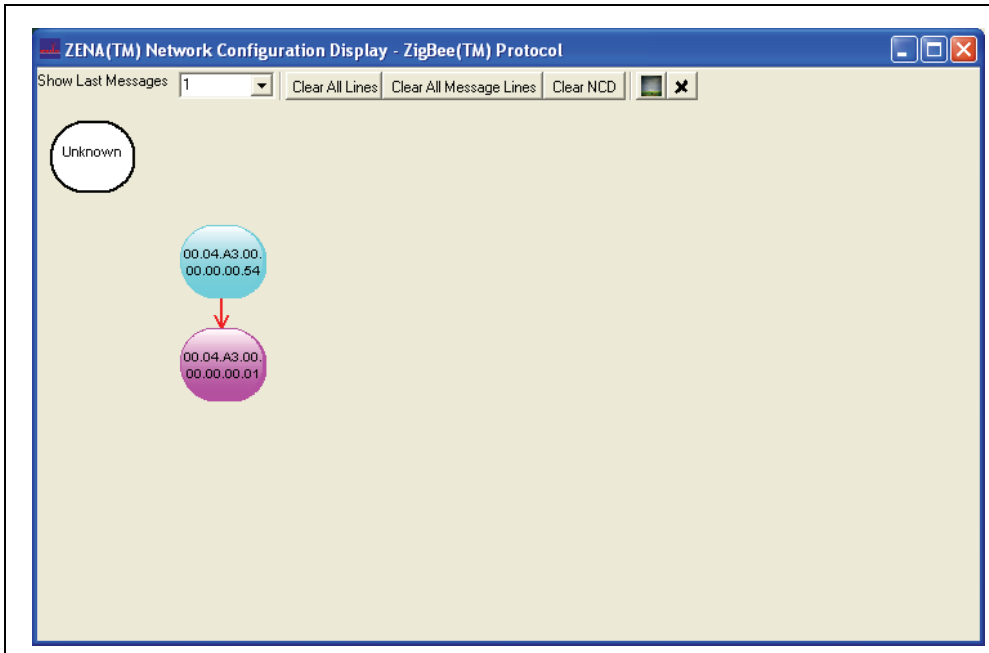
The ZigBee protocol router will now try to join the network by sending an Association Request. The ZENA analyzer can tell from the Association Request what type of device is trying to join the network.

FIGURE 3-18: NCD ASSOCIATION REQUEST



After a short time, the ZigBee protocol router will send a Data Request, asking for the Association Response. The ZigBee protocol coordinator will respond by sending the Association Response.

FIGURE 3-19: NCD ASSOCIATION RESPONSE



Now the device has joined the network. This relationship can be seen by clicking **Clear All Message Lines** to display only the network association lines.

FIGURE 3-20: TWO-DEVICE NETWORK

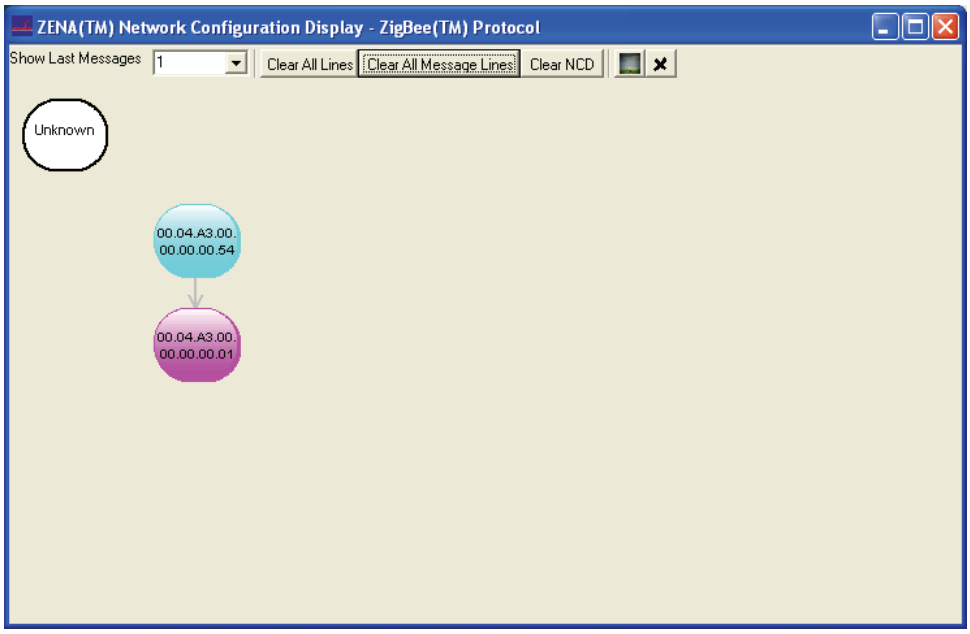
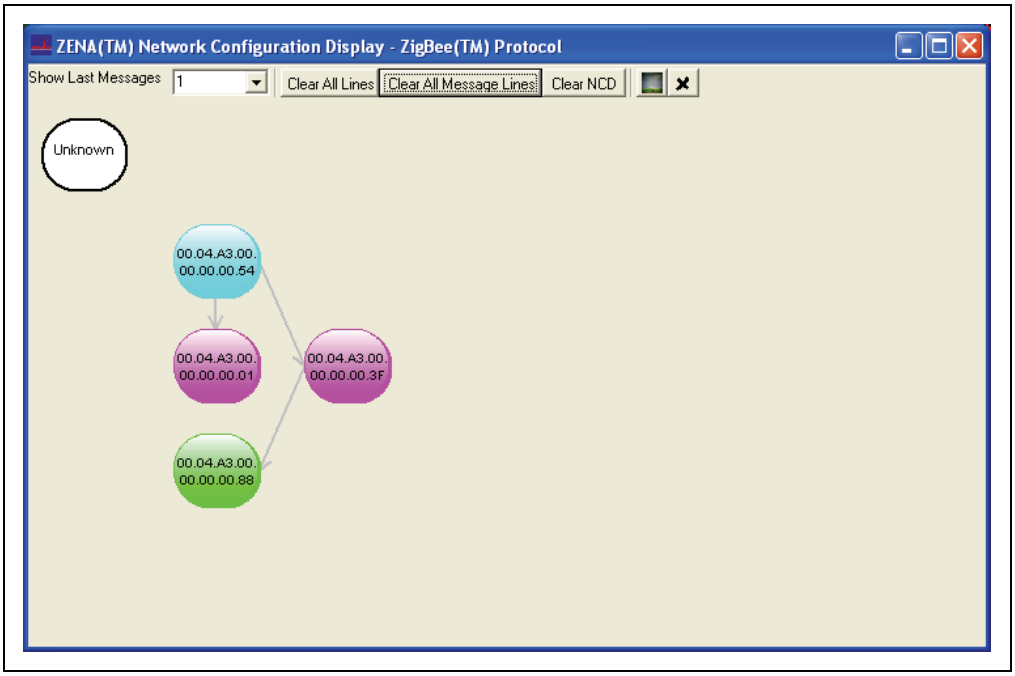


Figure 3-21 shows the NCD window after the creation of a four-device network.

FIGURE 3-21: FOUR-DEVICE NETWORK

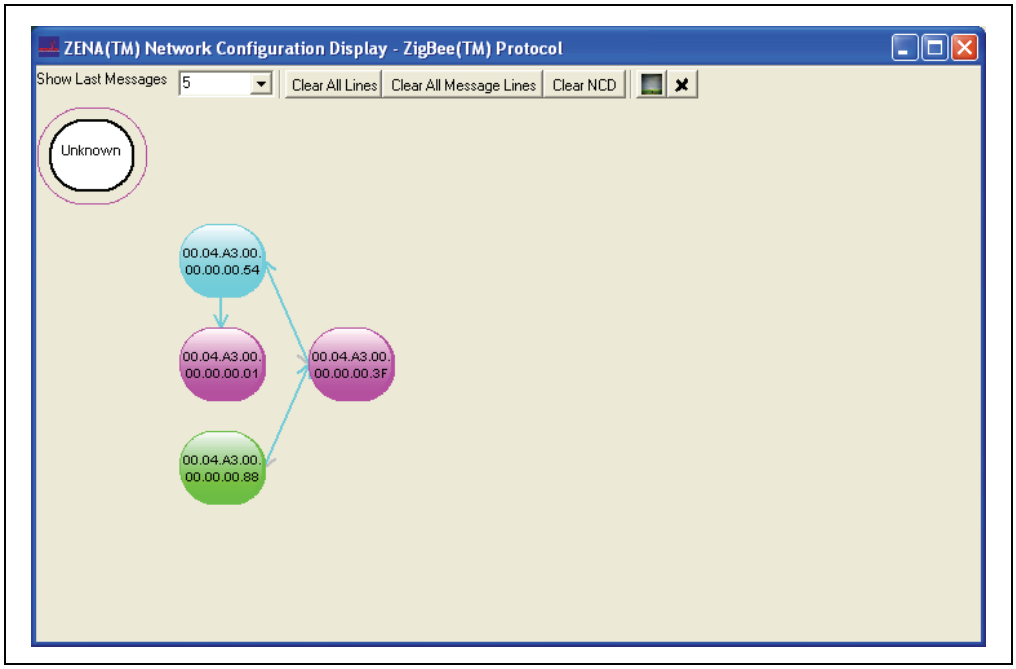


Note: If you will be working with a network that maintains the same structure, you may want to save a captured data file that contains the network formation. You can play back this file to establish the devices on the network, and then play back the various data files containing the network traffic you wish to monitor.

3.4.3 Viewing Network Traffic

After the network above was created, one of the devices attempted to send a message to another device. The path that the message followed is shown in Figure 3-22.

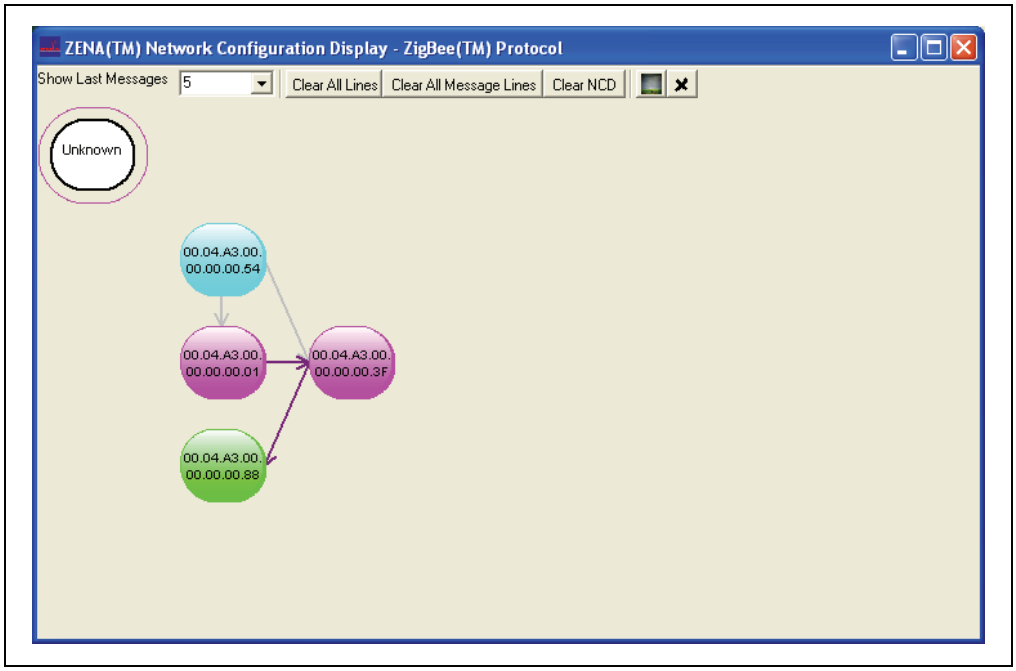
FIGURE 3-22: NCD MESSAGE PATH



The NCD window shows how the message went from device 00.04.A3.00.00.00.00.88 to device 00.04.A3.00.00.00.00.01, traveling through two other nodes.

This particular message requested an APS Acknowledge. Figure 3-23 shows the path of the APS Acknowledge. The ZENA analyzer illustrates that the APS Acknowledge followed a different route than the original message.

FIGURE 3-23: NCD APS ACKNOWLEDGE PATH

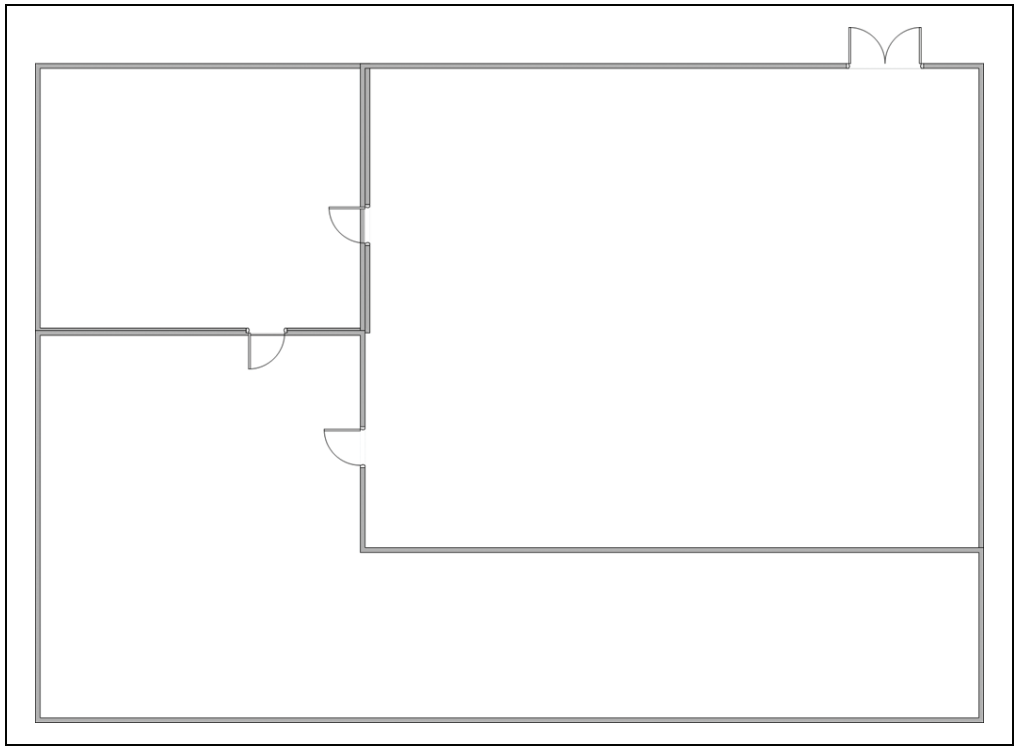


3.4.4 Customizing the Network Configuration Display Window

When analyzing network traffic, it is often helpful to understand the physical relationship between the devices. The ZENA analyzer allows you to select a bitmap as the background of the NCD window. The nodes can then be dragged so they match their physical location.

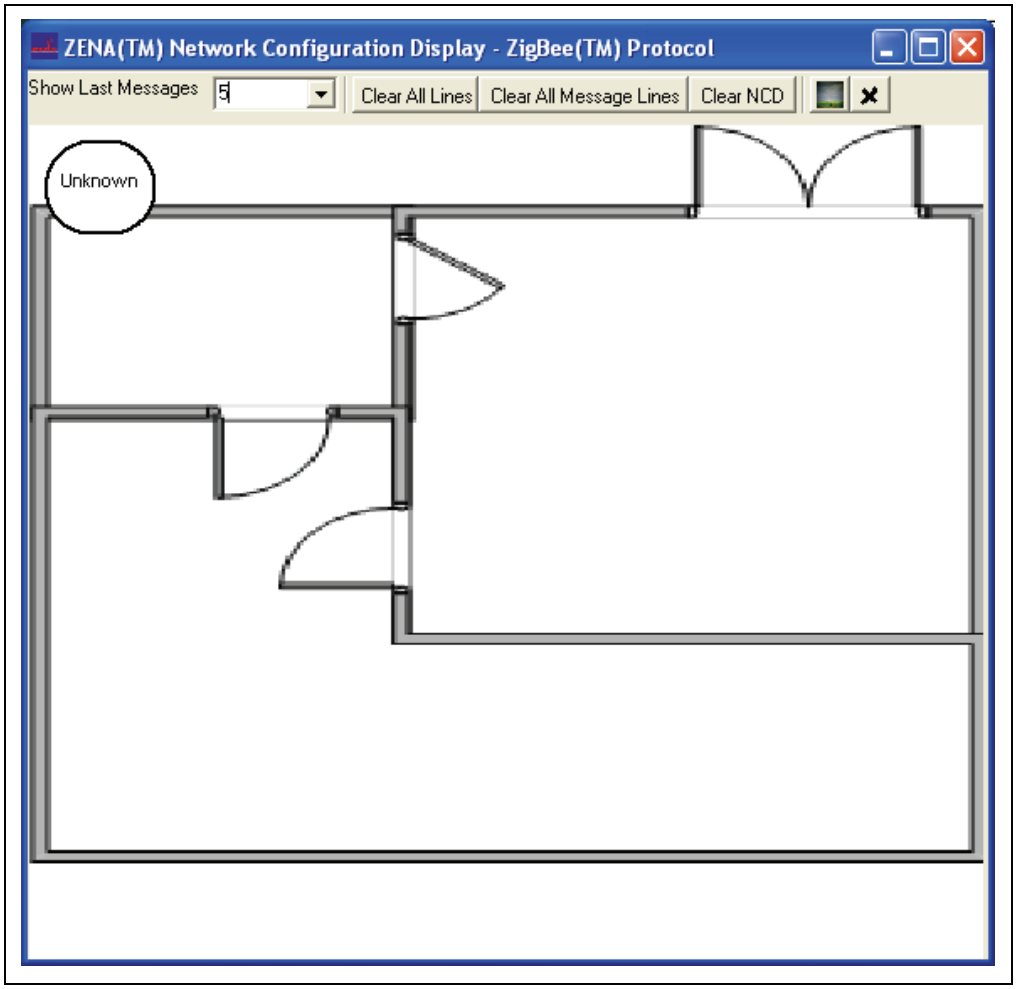
For example, Microsoft® Visio® drawing and diagramming software can be used to generate a simple floor plan. The floor plan can then be exported as a bitmap.

FIGURE 3-24: FLOOR PLAN BITMAP



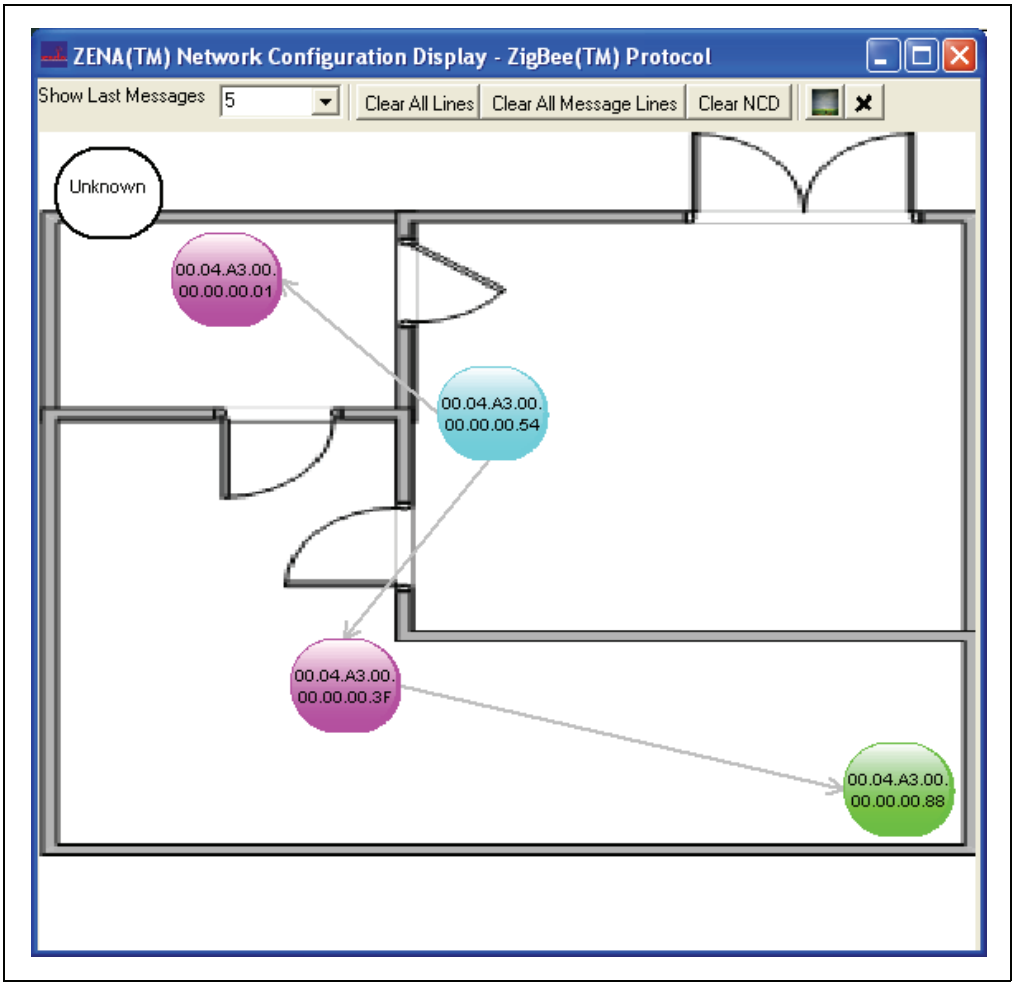
Load this floor plan as the NCD background by clicking the **Select Bitmap** button. The NCD window can be resized after loading the background to match the proportions of the bitmap.

FIGURE 3-25: NCD WINDOW WITH FLOOR PLAN BACKGROUND



When network formation is played back and displayed on the NCD window, the nodes can be moved to the location on the bitmap that represents their physical location.

FIGURE 3-26: FOUR-NODE NETWORK WITH FLOOR PLAN BACKGROUND



Repeating the above example, Figure 3-27 and Figure 3-28 show the application message and APS Acknowledge as they are routed through the network.

FIGURE 3-27: MESSAGE PATH WITH FLOOR PLAN BACKGROUND

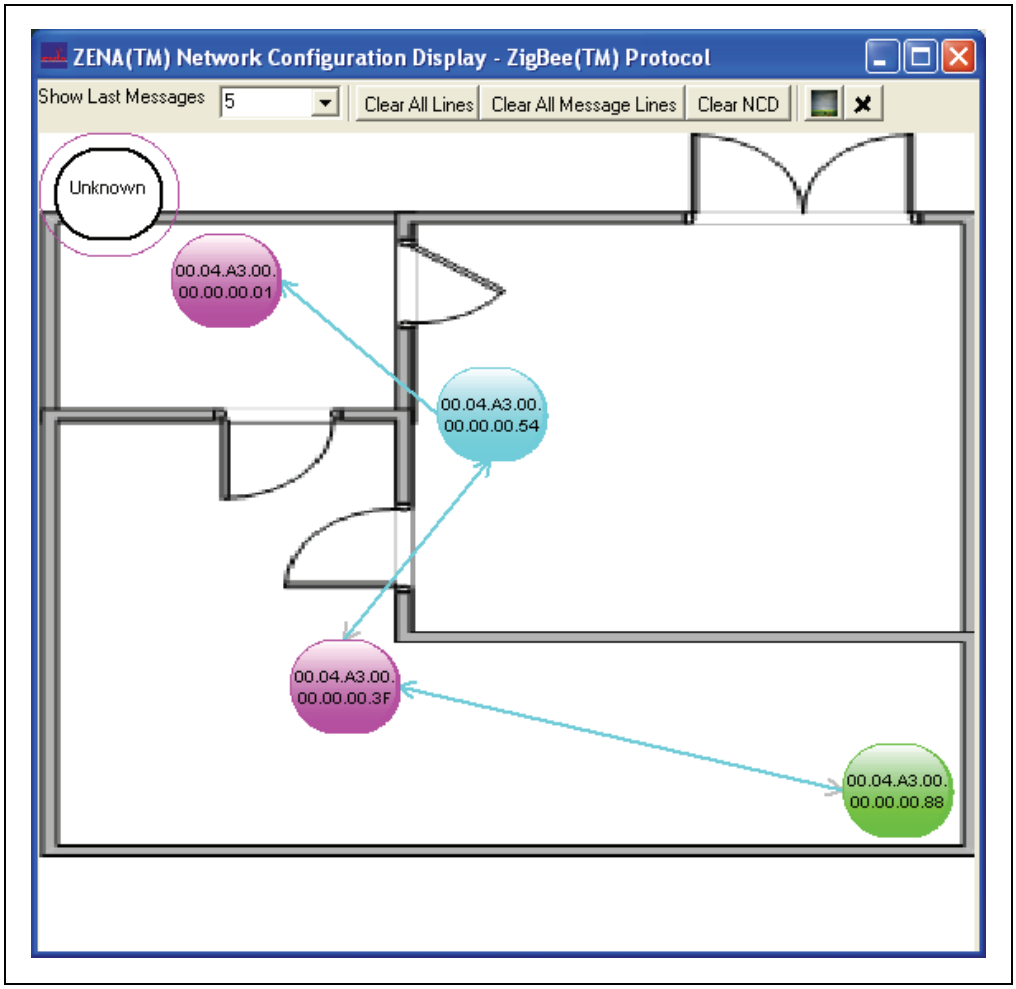
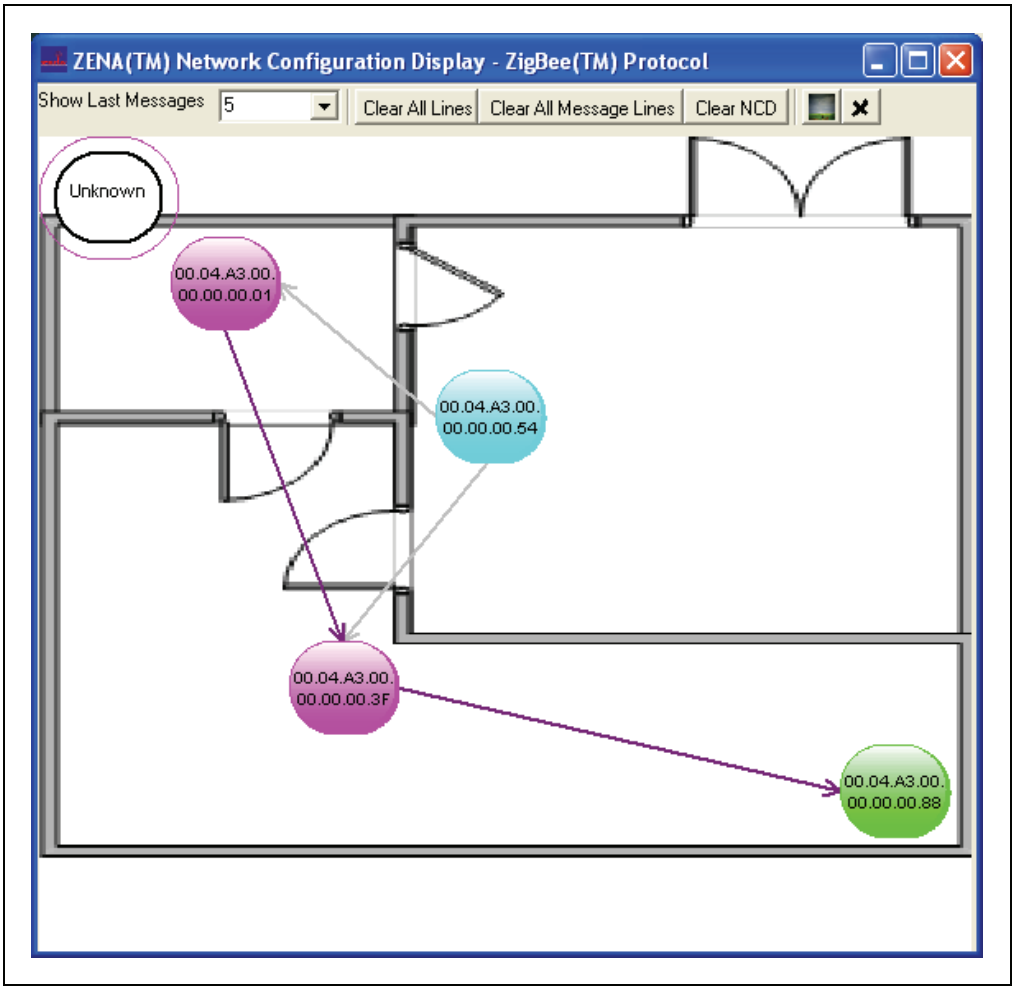


FIGURE 3-28: APS ACKNOWLEDGE PATH WITH FLOOR PLAN BACKGROUND



3.4.5 Analyzing Network Traffic

The ZENA Wireless Network Analyzer can provide a great deal of information about device and network operation. The Packet Sniffer window can be used to ensure that messages are appearing on the air as expected, and that the messages have the correct format. The NCD window can be used to ensure the network is formed in the correct manner.

The ZENA analyzer can show how messages propagate through the network. In the examples above, we see by using the NCD window that the application message is routed along the network tree, while the Acknowledge is routed more directly. Using the Packet Sniffer window, we can determine if the message was sent with routing suppressed, or if routing was requested but a node in the path did not have routing capacity.

The ZENA analyzer can also provide insight as to physical barriers that are affecting the system. In the previous example, we can see that physical barriers are probably preventing two nodes from talking directly.

With a larger scale network, the ZENA analyzer can also help determine if device layout needs to be optimized for the system's required network traffic. If the ZENA analyzer indicates that a great deal of traffic is being routed through a single device, that device may be getting overloaded. An alternate arrangement of devices might generate more balanced network traffic.

3.4.6 Exporting Data

In some cases, it may be necessary to export the raw message data to another tool for further analysis. To export raw data, select the desired packets in the Packet Display window, right click on the packets and select *Copy To Clipboard*. The raw packet data will be exported to the clipboard in ASCII format, each packet on a new line, with a space after each byte. Approximately 21000 bytes of packet information can be exported at one time.

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China - Xian
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ASIA/PACIFIC

India - Bangalore
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India - New Delhi
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India - Pune
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Japan - Yokohama
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Fax: 81-45-471-6122

Korea - Gumi
Tel: 82-54-473-4301
Fax: 82-54-473-4302

Korea - Seoul
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Fax: 82-2-558-5932 or
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Malaysia - Penang
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Fax: 60-4-646-5086

Philippines - Manila
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Taiwan - Hsin Chu
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