ember

Ember Evaluation Kit User's Guide

Final

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28 May 2004

FCC Compliance for the CC1020 and EM2420 Ember Evaluation Modules

Compliance Statement (Part 15.19)
The Ember Evaluation Kit Module complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada.
Operation is subject to the following two conditions:
--This device may not cause harmful interference, and
--This device must accept any interference received, including interference that may cause undesired operation.

Warning (Part 15.21)
Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure (OET Bulletin 65)
To comply with FCC RF exposure requirements for mobile transmitting devices, this transmitter should only be used or installed at locations where there is at least 20 cm separation distance between the antenna and all persons.

FCC, Industry Canada, and CE certifications for the CC1020 and EM2420 Ember Evaluation Modules are pending.

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Document Purpose

This document describes the contents and use of the Ember Evaluation Kit, including equipment and software installation, EmberNet™ network setup, use of Ember Studio Lite, and the debugging, building, and uploading of applications.

Audience

The audience for this document is customers who have purchased the Ember Evaluation Kit. Customers are assumed to understand basic networking concepts and to be familiar with networking hardware and software.

Documentation Conventions

Notation	Meaning	Example
Italics	Identifies on-screen software menu options.	*Refresh Screen*
UPPERCASE	Identifies a keyboard key.	ENTER
Right-angle bracket	Delimits a series of software program menu options to be clicked.	*Open* > *Save*
`Courier`	Identifies software code and, in body text, variables.	`void Main(String[] argv)` the `buffer` variable
Angle brackets around a term	Delimits a placeholder to be replaced with the data indicated by the term.	<ipAddress>

Safety Symbols

Symbol	Meaning
	Signifies a warning about a potential personal safety hazard.
Caution!	Signifies a warning about a potential hazard to a piece of equipment.

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Purpose of the Evaluation Kit

Ember recognizes that you need to evaluate wireless solutions in your own environment before investing valuable resources to develop products centered on new technology. The Ember Evaluation Kit gives you everything you need to demonstrate a live wireless sensor network instantly and to begin to characterize the technology for your environment and application—for example:

- Observe the self-healing, self-organizing nature of an EmberNet network
- View and test real-time network traffic patterns
- Configure network parameters
- Send and receive several types of data over the network

The Evaluation Kit is not intended to be used for:

- Application development
- Resale
- Extended use or use in operating conditions exceeding those listed in Appendix B, "Ember Evaluation Module Technical Features."
- Any purpose other than evaluating Ember technology for business purposes

Evaluation Kit Contents

Your Evaluation Kit contains the following items:

Hardware	• 12 Ember Evaluation Modules • 12 external antennas • 2 AC power adapters with snap-on North American, European, United Kingdom, and Australian plugs • 2 serial adapter cables • 24 AAA batteries • 1 phillips screwdriver
CD	• Ember Studio Lite • Ember Chat • *Ember Studio Lite Release Notes,* Adobe PDF file • *Ember Evaluation Kit User's Guide,* Adobe PDF file (this document) • Datasheet for the radio chip that you purchased, Adobe PDF file: • Quick Start Guide: Ember Evaluation Kit, Adobe PDF file • Microsoft .NET Framework

Hardware and Software Requirements

The following hardware and software conditions must be in place before you can use your Evaluation Kit:

Hardware requirements	• Available RS-232 serial port or USB port
Software requirements	• Microsoft Windows 2000 or XP • Adobe Acrobat Reader (available free from www.adobe.com) • Microsoft .NET Framework, required for running the Ember Chat application (The Evaluation Kit includes a .NET Framework installer as a convenience for customers who do not already have .NET installed.)

Hardware Description

Ember Evaluation Module

The Ember Evaluation module (Figure 1-1) is a small device containing a low-power radio of your choice:

- CC1020 operating at the 868 or 915MHz band
- EM2420 operating at the 2.4GHz band

The radio has been designed to work with the supplied external antenna and will not perform as expected if a different antenna is attached to the module.

The module can operate on battery power or by an external electrical source (such as an electrical power outlet) via the supplied power adapter. See chapter 2, "Operating and Maintaining Evaluation Kit Components," for detailed operating instructions.

Modules are uniquely identified by their IEEE extended unique identifier (EUI), which appears on a label on the back of the module and in Ember Studio Lite (see "Accessing the EUI Number" on page 14).

Appendix B, "Ember Evaluation Module Technical Features," describes the technical features of the module.

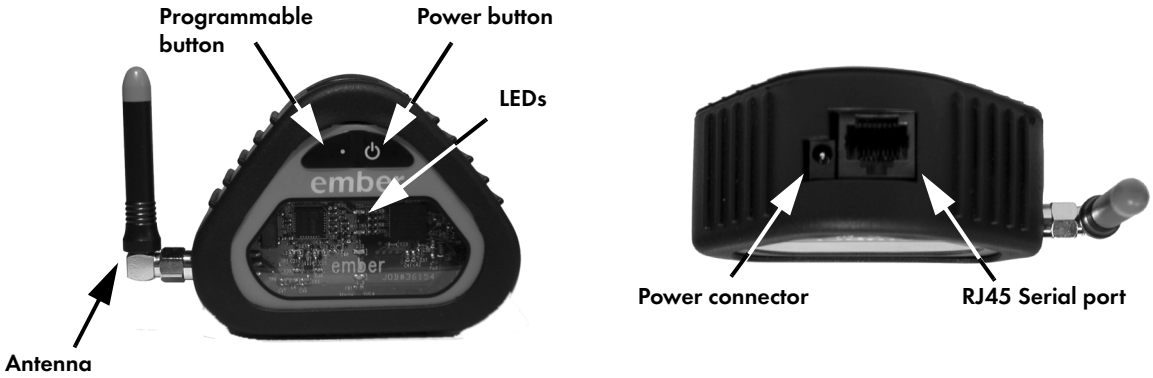

Figure 1-1: External features

Power Adapter Cable

Caution! Use only the power adapter cable provided in your Evaluation Kit. Using any other power adapter cable can severely damage the module microprocessor.

The AC power adapter cable (Figure 1-2) is a linear regulated wall plug power supply with 5.0VDC at 1600mA regulated output. It has a six-foot output cord and a power supply with four interchangeable snap-in input plugs (North American, European, United Kingdom, and

Australian). The cable in your Evaluation Kit has been approved by the correct regulatory agency for your location.

Figure 1-2: Power adapter cable

Serial Adapter Cable

Caution! Use only the serial adapter cable provided in your Evaluation Kit. Using any other serial adapter cable can severely damage the module microprocessor.

The serial adapter cable (Figure 1-3) is an Ethernet CAT-5E patch cable with RJ45 connectors. The RJ45-to-DB9S adapter attached to one end of the cable has been specially altered to work with Evaluation Kit modules.

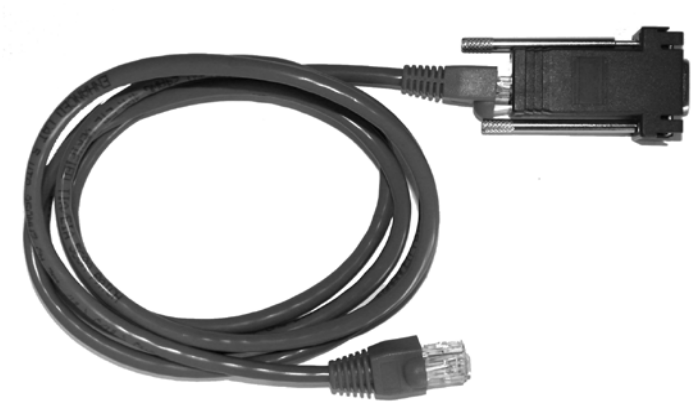

Figure 1-3: Serial adapter cable

Software Description

Note: The Evaluation Kit is not intended for application development. If you would like to develop applications, a complete EmberNet API is provided with the Developer Kit, along with comprehensive support services. Contact Ember for more information about this kit (see "Getting Help" on page 15).

Ember Studio Lite

Ember Studio Lite allows you to explore the capabilities of Ember radios running the EmberNet networking software:

- View a customizable real-time map of networked Evaluation Kit modules (see Figure 1-4).
- View network performance data.
- Run network tests (ping, trace route).
- Gather and display live temperature, orientation, and power data from sensors embedded in Evaluation Kit modules.
- View paired nodes in the network map.
- Configure network and module settings.
- Print the main window.

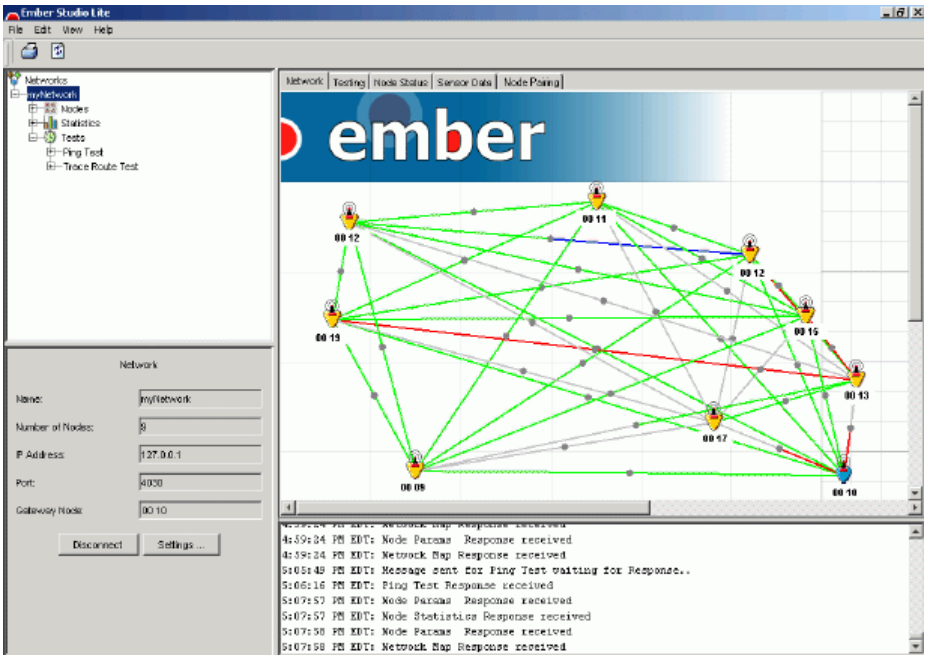

Figure 1-4: Ember Studio Lite main window

Ember Chat

Ember Chat is a sample application that demonstrates data transmission via the RS-232 port. For information about running Ember Chat, see "Using the Ember Chat Application" on page 33.

Accessing the EUI Number

A hexadecimal representation of the IEEE 64-bit EUI number for a module is printed on a label on the back of the module and is also visible in the Address64Bit field of the Node Properties window in Ember Studio Lite. See "Viewing Node Properties" on page 59 for information on opening this window.

Getting Help

If you have any questions about your Evaluation Kit, please contact your Ember account representative:

United States	313 Congress Street, 4th Floor Boston, MA 02210 Telephone: +1 617-951-0200 Fax:+1 617-951-0999 Email: support@ember.com
Europe	Unit 29 Science Park, Milton Road Cambridge CB4 0DW, UK Telephone : +44 (0) 1223 423322 Fax : +44 (0) 1223 423390 Email: support@ember.com

The Ember website contains information about the full range of Ember products and services and allows you to sign up for the support section of the site:

support.ember.com

CHAPTER 2

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Operating Evaluation Kit Modules

Positioning Modules

Warning! Position Evaluation Kit modules so that they are at least 20 cm away from users, to avoid exposing users to excessive radiofrequency emissions, as determined by the FCC.

You can position Ember Evaluation Kit modules in any spatial orientation (for example, horizontally, vertically, or upside-down), but for optimal performance all devices should be positioned with the antennas in the same orientation. When placing modules to set up a network, observe the operating temperature limits described in Appendix B, "Ember Evaluation Module Technical Features."

In general, objects near modules do not affect radio transmission. Very large solid objects such as walls and metal objects can diminish the radio range of modules positioned within a few inches of them. Placing a module within a metal box can completely isolate the module from the network. Repositioning the module 20 to 30 cm from any obstructions will usually restore full range. You can also reconfigure the network to work around a radio obstacle.

Modules operating in the 2.4Ghz spectrum will have the same restrictions as the lower frequency nodes, except that they are also likely to be significantly affected by being placed closely to water or objects containing large amounts of water.

Activating Modules

Modules are shipped in a shut-down state, without batteries and with a black plastic plug inserted into the power connector. To activate the modules, remove the black plastic plug and power them up by either inserting batteries (see "Inserting or Changing Module Batteries" on page 20) or connecting them to an external power source such as an electrical power outlet (see "Connecting Modules to an External Power Source" on page 18). The power indicator light will begin blinking in a pattern that indicates the power source that the module is using (see "Reading Module Lights" on page 18).

After modules have been activated, you can turn them on and off by pressing the power button. Note that battery-powered modules continue to consume power even after being turned off via the power button. For further information about this, see "Turning Modules On and Off" on page 17.

Note: Do not discard the black plastic plug. It it required to completely power down modules and should be reinstalled in the module when the module is not in use.

Turning Modules On and Off

To turn modules on and off, press the power button until the module beeps. When modules are turned on, their power indicator light blinks in a pattern determined by the power source (see "Reading Module Lights" on page 18). When modules are turned off, this light stops blinking.

Turning a module off does not necessarily fully power it down:

- Modules that do not have batteries inserted and that have been connected to an external power source **are fully powered down** when turned off.
- Modules containing batteries will **continue to use low levels of power** when turned off. This is true both for battery-operated modules and for modules containing batteries that are operating via external power.

■ **To fully power down a module that contains batteries:**

Insert the black plastic plug into the power connector.

Connecting Modules to an External Power Source

Caution! Use only the power adapter cable provided in your Evaluation Kit. Using any other power adapter cable can severely damage the module microprocessor.

To power a module by an external power source such as an electrical power outlet, snap the correct input plug into the adapter, connect the power adapter to the module (Figure 2-1), and plug the adapter into the power source. The power indicator light will begin to blink in the external power source pattern (see "Reading Module Lights" on page 18).

If the module contains batteries, unplugging the power adapter from the module will switch the module to battery power.

Figure 2-1: Module with connected power adapter

Reading Module Lights

Network Traffic Light

The network traffic light blinks whenever the module receives packet data.

Power Indicator Light

The power indicator light blinks in a pattern determined by the power source (■ = light on, — = light off):

Battery, full power	Quick flashes of light separated by lengthy pauses (■————■————■————)
Battery, low power	Two quick flashes of light separated by lengthy pauses (■–■————■–■————■–■————)
External power via power adapter	Long bursts of light separated by medium-length pauses (■■■■——■■■■——■■■■——)

Note: When a module begins blinking in the low-battery-power pattern, change the batteries as soon as is practical, because when battery power drops below a certain level, modules can behave in an erratic manner.

Connecting a PC to a Gateway Module

Caution! Use only the serial adapter cable provided in your Evaluation Kit. Using any other serial adapter cable can severely damage the module microprocessor.

Any module can serve as the gateway for the network, once it has been connected to a PC. Use the Evaluation Kit serial adapter cable to connect the gateway module to a PC (Figure 2-2).

If your computer only has a USB port, you can use any USB–to–RS-232 adapter to connect the serial adapter cable to the computer.

Figure 2-2: Module with connected serial adapter cable

Connecting and Positioning the Antenna

Caution! Before connecting the antenna to an Evaluation Kit module, make sure the module is completely powered down. Connecting an antenna to a module that is running on either battery or external power can damage the module's radio chip.

Use only the antennas supplied in your Evaluation Kit. Using different antennas will degrade the radio performance of modules.

- **To connect the antenna:**
  1. Make sure the module is completely powered down:
     - **Battery-powered module:** Insert the black plastic plug into the power connector.
     - **Module running on external power:** Unplug the module from the power source.
     - **Module running on external power but with batteries inserted:** Unplug the module from the power source, then insert the black plastic plug into the power connector.
  2. Connect the antenna to the module RP-SMA connector.
  3. Tighten the RP-SMA connector to finger-tightness only.
- **To position the antenna:**

  To obtain the best possible reception, point all antennas in a network in the same direction.

Maintaining Evaluation Kit Modules

Inserting or Changing Module Batteries

Caution! The circuit board inside the Evaluation Kit module is sensitive to electrostatic discharge. Follow electrostatic discharge (ESD) procedures when changing module batteries.

Change batteries when the power indicator light flashes in the low-battery-power pattern (see "Reading Module Lights" on page 18).

- **To change module batteries:**
  1. Remove and set aside the two screws holding the module's bottom plate in place. Lift the bottom plate off of the module and set it to one side (Figure 2-3). Avoid disconnecting the bottom plate from the module, particularly if you are working with more than one module at a time.

     Note: **The bottom plates of modules are not interchangeable.** The bottom plate carries a label showing the EUI number for the module to which the plate

belongs. If the wrong bottom plate is put onto a module, the label will no longer indicate the correct EUI number. If you suspect that the wrong bottom plate has been put onto a module, check the Address64Bit field for the module in the Ember Studio Lite Node Configuration window. The value in this field should be the same as the EUI number on the label. (For information on viewing the Node Configuration window, see chapter 7, "Managing Network Nodes.")

2. Insert or replace the batteries (use only AAA batteries). The module beeps to indicate that the batteries are working.
3. Replace the bottom plate and hold it in position as you replace the two screws.

Figure 2-3: Opened module

Storing Modules

When they are not in use, store modules in the Evaluation Kit carrying case, with the black plastic plug inserted into the power connector. This will protect the modules from damage and ensure that they are fully shut down when in storage.

Cleaning Modules

If the exterior of a module becomes dirty, wipe it lightly with a clean, damp cloth.

CHAPTER 3 Evaluating EmberNet Networks

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About EmberNet Networks

Ember technology gives you a plug-and-play networking solution. Using an EmberNet chip and network lets you concentrate on designing your data collection or control application by providing you with all the lower-level communications functions.

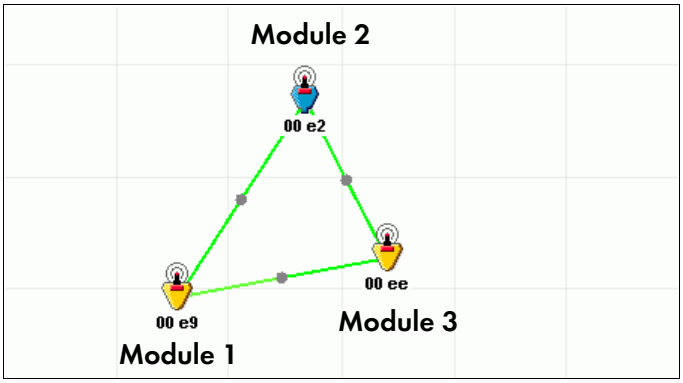
EmberNet networks gain their power from the following key features:

Automatic recognition	Modules discover each other without complex setup and configuration. In particular, modules discover and send data to the gateway module, providing automatic access to network status information.
Self-organization	Modules autonomously determine how to route data through the network to its proper destination.
Multihop routing	All modules can act as repeaters for other modules, to extend the range of communication.
Self-healing	An EmberNet network automatically reconfigures itself instead of breaking when a module fails or is removed.
Scalability	You can incrementally expand an existing EmberNet network by simply adding more modules to it.

Evaluating a Simple EmberNet Network

The following procedure takes you through the steps of evaluating a simple EmberNet network. The procedure demonstrates the key features of an EmberNet network.

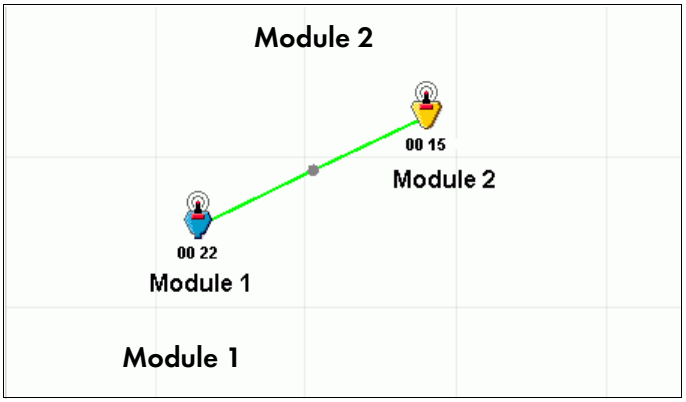
■ **To evaluate a simple Ember Network:**

Preparatory steps	Install Ember Studio Lite (see "Installing Ember Studio Lite" on page 42).
Set up a small network	Turn on three Evaluation Kit modules and connect one to the COM1 port on the PC, using the serial adapter cable provided in your Evaluation Kit. (The connected module is the network gateway.) We recommend operating the modules on battery power for this procedure. (For information on connecting and powering modules, see chapter 2, "Operating and Maintaining Evaluation Kit Components.")
Evaluate the ability of modules to **automatically discover each other** and **spontaneously organize into a network**	Double-click Ember Studio Lite and select *Create New Local Network* in the connection wizard. Enter a network name (can be anything). (For information on opening Ember Studio Lite and connecting to a network, see chapter 6, "Getting Started with Ember Studio Lite.") A network map resembling the following displays. If the link lines overlap, making the map hard to read, drag the node icons to new positions on the map. If your modules are hearing each other, the link lines in the network map will be green, blue, or red. For best results, try to change red lines to blue or green by moving modules. A red icon indicates that the module is not powered on or is offline for some reason.  The appearance of a network map showing three icons connected by green, blue, or red lines demonstrates that: • The modules discovered each other without requiring human intervention. • Modules 2 and 3 discovered the gateway module and sent network data to it. • All three modules spontaneously organized themselves into an EmberNet network. (For further information on reading the network map, see chapter 6, "Getting Started with Ember Studio Lite.")

Evaluate the network's ability to perform **multihop routing**

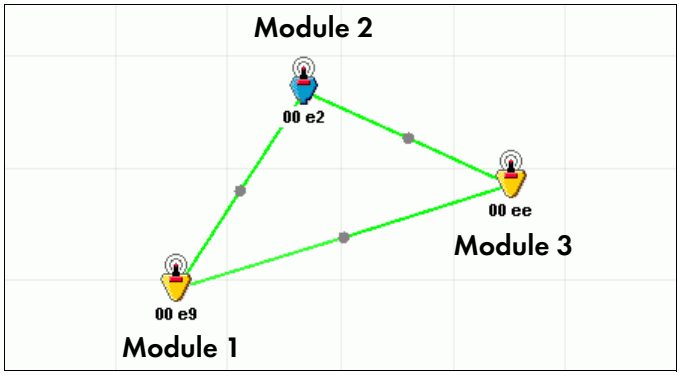
Carry module 3 approximately 100 feet away from modules 1 and 2.

When the network map updates (this may take a few minutes), it will no longer display module 3. (If module 3 still appears in the map, move it farther away.)



Now carry module 2 half of the distance between module 1 and module 3.

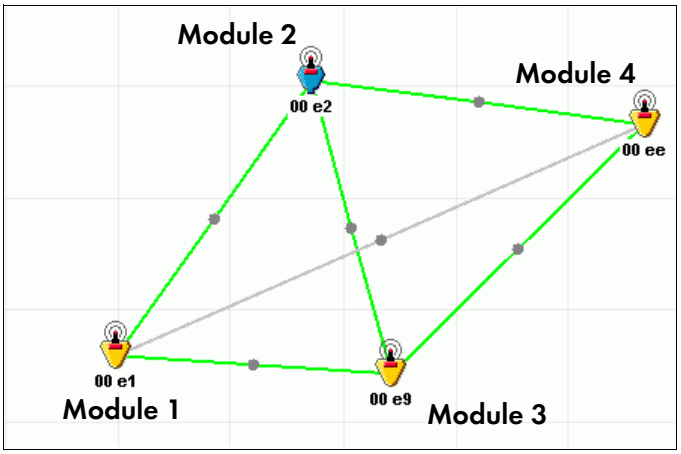
When the network map updates, it will again display all three modules.



The reappearance of module 3 in the network map demonstrates that module 2 acted as a repeater, enabling multihop routing for module 3.

Evaluate the network's ability to **route packets through multiple pathways**

Turn on a fourth module and add it to the network, but position it far enough away from module 1 that module 1 cannot hear it. When the network map updates, the link line between modules 1 and 4 should be gray or invisible.

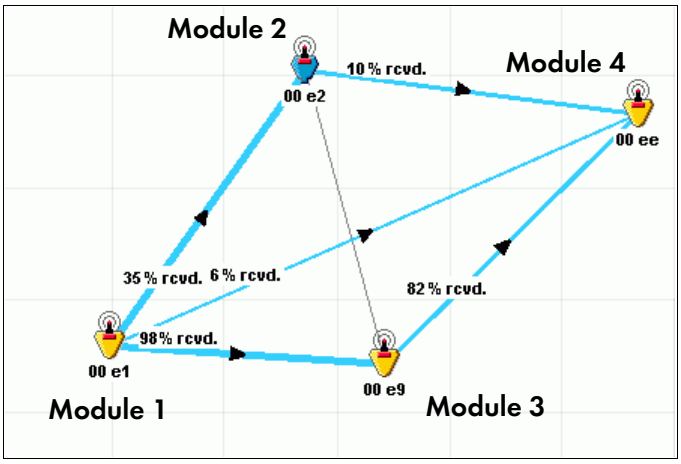


In Ember Studio Lite, click the Networks folder in the folder tree ( ), then click the Tests folder ( ). Click the Trace Route Test folder. The trace route test configuration window displays.

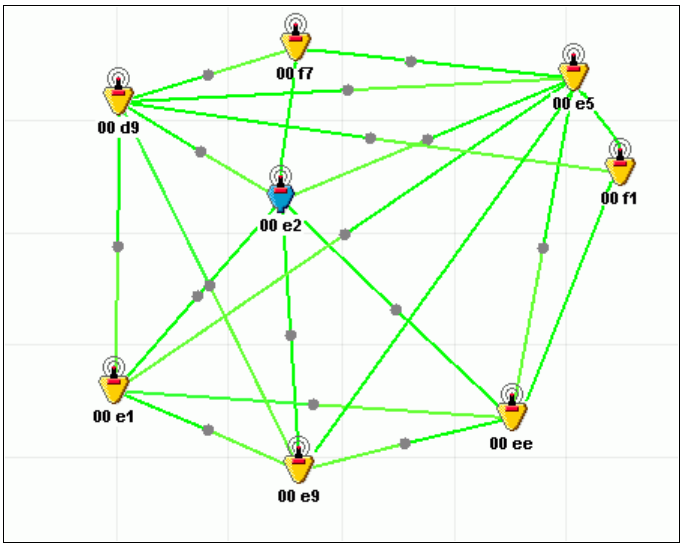
In the configuration window, click the Send Node field, then click the icon for module 1. Repeat for the Receive node field but click the icon for module 4. Do not change the default test parameters in the other window fields.

Click *Start* to run the trace route test. When the test finishes, a results folder named Test1 appears in the Trace Route Test folder.

Click the Testing tab, then click the Test1 folder. Ember Studio Lite displays the test results, which will resemble the following figure.



The test results demonstrate that the network routed packets to module 4 via both module 2 and module 3. (For more information on reading trace route test results, see chapter 8, "Testing the Network.")

Evaluate the **scalability** of the network	Add several modules to the network and refresh the network map. The map updates to show the new modules.  The network map demonstrates that the existing network has been quickly and automatically expanded.

Evaluating Complex EmberNet Networks

After you have put a simple network through its paces, you will be ready to set up networks that model real-life operating conditions. Some common situations include:

- Sensors located on multiple floors
- Metal-reinforced concrete walls creating radio-opaque corners around which the network must route
- Heavy metal machinery creating radio-opaque obstacles inside of a network
- Intermittent movement of vehicles or other obstructions through network paths
- Reflections created by the sudden intrusion of an obstacle into a network path

The specific challenges you will want to test depend on your application environment. In every case, though, EmberNet's key features will allow you to design an efficient network.

The Ember Evaluation Kit is optimized for mesh networking, using redundant pathways to ensure reliable data transfer. When designing test networks, we strongly suggest that you reduce potential single points of failure. Linear paths of nodes are not recommended. Gateway nodes should have multiple wireless connections to the network to ensure best data throughput.

Subdividing a Complex Network Via Radio Channels

When you advance to testing complex networks, you may wish to subdivide your network so that multiple people can work on sections of it without interfering with each other's work.

- **To subdivide a network:**
  1. Install Ember Studio Lite on each person's PC.
  2. Assign each person a specific radiofrequency channel. See Appendix C, "Module Radio Settings," for a list of available channels.
  3. Set different sets of modules in the network to the channels assigned to the people working on the network. For information on setting channels, see "Viewing Node Properties" on page 59.
  4. Have each person connect a module to his or her PC and then set the module to his or her assigned channel. This gives each person a gateway node that can see only network nodes set to the same channel that it is set to.

CHAPTER 4 Using the Evaluation Kit Sample Applications

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Available Evaluation Kit Sample Applications

The Evaluation Kit includes the following sample applications, which demonstrate selected commercial uses for Ember's wireless mesh networking technology:

Sensor data	Collect temperature, position, and battery life data from module sensors and view data in Ember Studio Lite.
Power management	Use Ember Studio Lite to cause a node to sleep (that is, enter low-power mode) except when reporting sensor data.
Node pairing	Pair nodes so that one can transmit control instructions to the other.
Ember Chat	Transmit data over the RS-232 port via a simple chat application.

Using the Sensor Data Application

The sensor data application allows you to sample module sensor data and then view real-time graphs of those data. You can simultaneously sample data from multiple modules. The application is run from Ember Studio Lite (see chapter 5, "Collecting and Viewing Sensor Data").

You must stimulate the module sensors to obtain viewable data. See "Obtaining Sensor Data" on page 30 for suggested methods.

The sensors acquire data at different rates, which makes them suitable for different types of demonstrations:

- The temperature and battery voltage sensors acquire data slowly and are best used to demonstrate the collection of sensor data over time.
- The acceleration sensors acquire data rapidly and are suitable for immediate demonstrations of the collection and display of sensor data.

Note: The sensors are not calibrated on the modules, so they do not provide exact temperature, battery, and acceleration data.

Available Sensor Data

Each Evaluation Kit module includes the following sensors:

Temperature	Ambient air temperature in degrees Celsius Range: -55°C to +130°C
Acceleration	Module orientation in space, in terms of acceleration in either the X or the Y axis (Figure 4-1) Range: + / -2*g*
Battery voltage	Charge (volts) remaining in module batteries (Fresh batteries have approximately 3.3V of charge.)

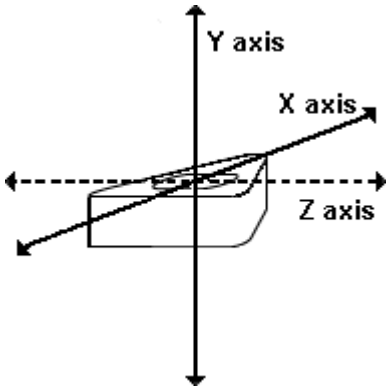


Figure 4-1: Accelerometer axes. The module is lying face up. The X-Z plane is horizontal to the module face, and the Y-Z plane is orthogonal to it.

Obtaining Sensor Data

Following are some simple strategies for stimulating module sensors to obtain data for the sensor application:

Temperature	• **To obtain temperature data over time:** Expose the module to cold or hot temperatures over a long period of time. For example, place the module in a very cold or hot room, inside a glass-sided refrigerator (a metal refrigerator will block radio transmissions), or beneath a hot light. • **To obtain (relatively) rapid changes in temperature data:** Expose the module to temperature extremes for short periods of time. For example, place the module in a refrigerator for approximately 10 minutes, then remove it to observe gradual sensor warming. **Caution!** Do not expose the module to temperatures outside of its operating temperature limits of 0°C to 70°C.
Acceleration	Grasp the module and tilt it from front to back or side to side. (Figure 4-1 illustrates the accelerometer's axes of movement.)
Battery voltage	• Plug the power adapter into the module, which produces a voltage change. • Run a module on battery power until the batteries begin to lose charge.

Using the Power Management Application

The power management application allows you to use Ember Studio Lite to instruct a module to enter a low-power sleep state except when it is transmitting sensor data. For information on enabling power management, see "Enabling Power Management" on page 40.

When power management is enabled for a module, it stops relaying packets and sleeps except when collecting and transmitting sensor data. The module processor and radio wake up at the specified sensor data report interval to collect sensor data and transmit it to the gateway node. Otherwise, the module does not respond to any network commands except sensor data commands. Turning a module off disables power management.

Note: When power management is enabled, Ember Studio Lite will not allow you to run a ping or trace route test, collect statistics, or reconfigure node properties.

Using the Node Pairing Application

The node pairing application allows you to pair modules such that one module (the "output" module) beeps when the other module (the "input" module) transmits accelerometer data to it.

To use the node pairing application, you must manually pair modules and then stimulate the accelerometer in the input module. Modules stay paired until you disable the pairing.

Note: Do not perform a ping or trace route test or use the sensor data application while using the node-pairing application. These tests increase network traffic, which can interfere with node pairing.

You can pair one input module with up to three output modules. You can also pair multiple input modules to a single output module. You can view a customizable map of paired modules in Ember Studio Lite, in the Node Pairing window.

- **To pair one input module with up to three output modules:**

  1. Press and hold the left button of the input module until it beeps twice in rapid succession. The input module is now in learning mode and can be paired with an output module.
  2. Press the left button of an output module. The output module and the input module both beep once, signifying that the input module heard the pairing message that the output module sent.
  3. To pair up to two more output modules to the input module, repeat the preceding step.
  4. Press the left button of the input module. The module rapidly beeps twice, signifying that it is no longer in learning mode and is now paired with the output module or modules.

- **To pair two or more input modules to one output module:**

  1. Press and hold the left button of an input module until it beeps twice in rapid succession. The input module is now in learning mode and can be paired with an output module.
  2. Press the left button of an output module. The output module and the input module both beep once, signifying that the input module heard the pairing message that the output module sent.
  3. To pair a second input module to the same output module, repeat the preceding steps, using a different input module.
  4. Repeat the preceding steps to pair multiple input modules to the output module.
  5. Press the left button of each input module. Each rapidly beeps twice, signifying that it is no longer in learning mode and is now paired with the output module or modules.

- **To use the node-pairing application:**

  Tilt an input module. Any output modules paired to it beep to indicate that control data passed from the input to the output module.

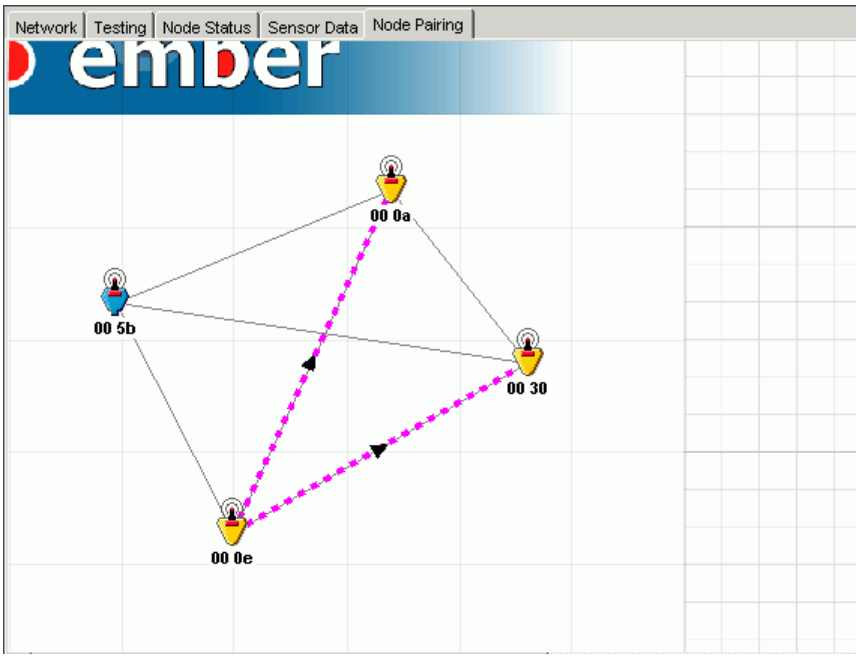
- **To disable node pairing:**

  Do one of the following:

  - Press the left button on the output module twice.
  - Turn off the output module. Note that this will cause the node to disappear from any network it participates in.

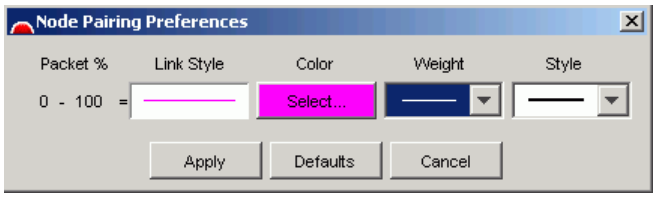
- **To view a map of paired modules:**

  In Ember Studio Lite, click the Node Pairing tab. The Node Pairing window displays. The window shows the network map with all link lines inactivated except for those between paired modules. The arrowhead superimposed on the pairing link lines points from the input module node icon to the output module node icon. You can set the color and weight of the pairing link lines.



- **To customize the pairing link lines:**

  1. Right-click the map and select *Node Pairing Preferences*. The Node Pairing Preferences window displays:



  2. Do one of the following:
     - Select a new line weight and style as desired from the drop-down menus.
     - Click *Defaults* to restore the default line preferences.
  3. Click *Apply*. The new preferences display in the map.

Using the Ember Chat Application

The Ember Chat application is a simple text entry application that allows two people to chat over computers connected anywhere on the network. It demonstrates the transmission of data to a computer via an EmberNet network gateway node's RS-232 port.

You can also write your own RS-232 data transmission applications with the Ember Serial Command Set. See Appendix D, "Ember Serial Command Set Reference," for complete documentation of these commands.

Setting Up to Run Ember Chat

Caution! Use only the serial adapter cable provided in your Evaluation Kit. Using any other serial adapter cable can severely damage the module microprocessor.

Before you can run Ember Chat, set up an EmberNet network (see chapter 2, "Operating and Maintaining Evaluation Kit Components"). Install the Ember Chat application on two computers (see "Installing Ember Chat" on page 33) and connect a module to each with the serial adapter cables provided in your Evaluation Kit.

Installing Ember Chat

Ember Chat requires Microsoft .NET Framework. The .NET Framework installer is provided as a convenience to you if it is not already installed on network-connected computers.

- **To install the Ember Chat application:**
  1. Place the Evaluation Kit CD into a PC.
  2. If you need to install the .NET Framework, click its installer on the Ember Chat CD (NET Framework Installer.exe) and follow the instructions.
  3. Click setup.exe to install the Ember Chat application. The installer writes the application files to C:\Program Files\Ember\EmberEvalChat, creates a desktop shortcut, and places Ember Chat in the Start menu.

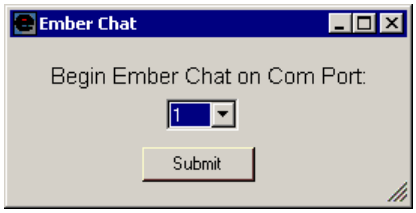
Opening Ember Chat

Note: Make sure that no one participating in the chat session is running Ember Studio Lite at the same time as Ember Chat.

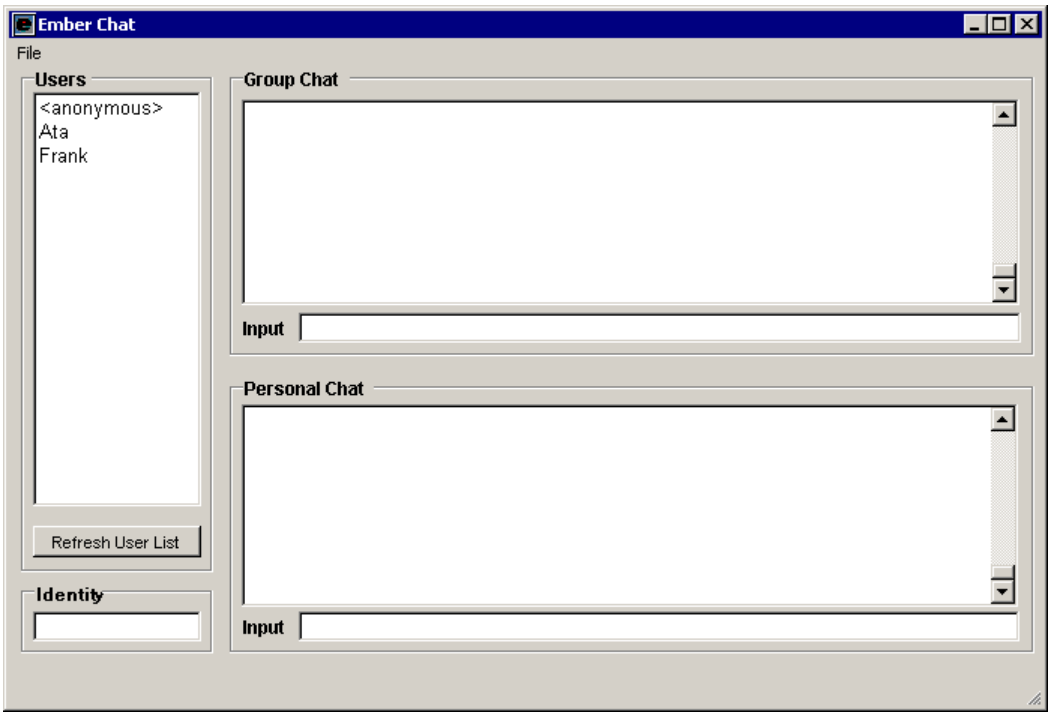
- **To open the Ember Chat application:**
  1. Start the application by doing one of the following:
     - Click the desktop shortcut.
     - Select the application in the Start menu.
     - Run the executable:

C:\Program Files\Ember\EmberEvalChat\EmberEvalChat.exe

The Begin Ember Chat window displays:



2. Select a COM port number and click *Submit*. The Ember Chat window displays:



The Users box lists the name of everyone currently logged into the network. The application refreshes this list every few seconds. To manually update the list, click *Refresh User List*.

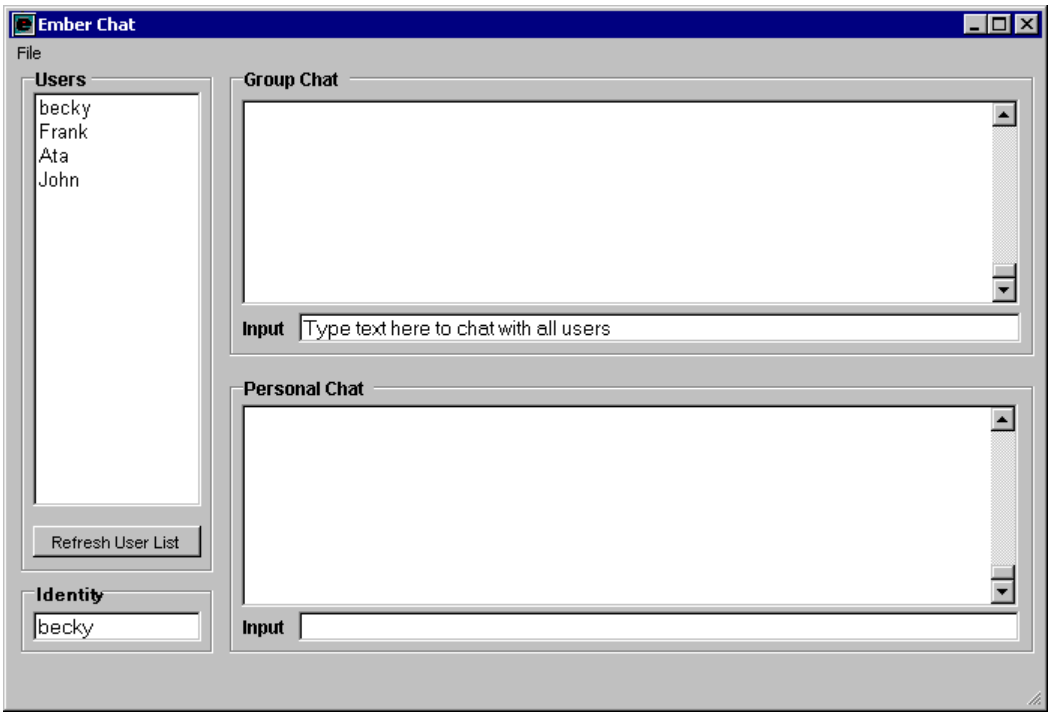
Using Ember Chat

After logging into the application, you can chat with everyone who is logged in or to a specific individual. Chatting with one person at a time can simplify communication, because you avoid all the crosstalk that occurs with group chatting.

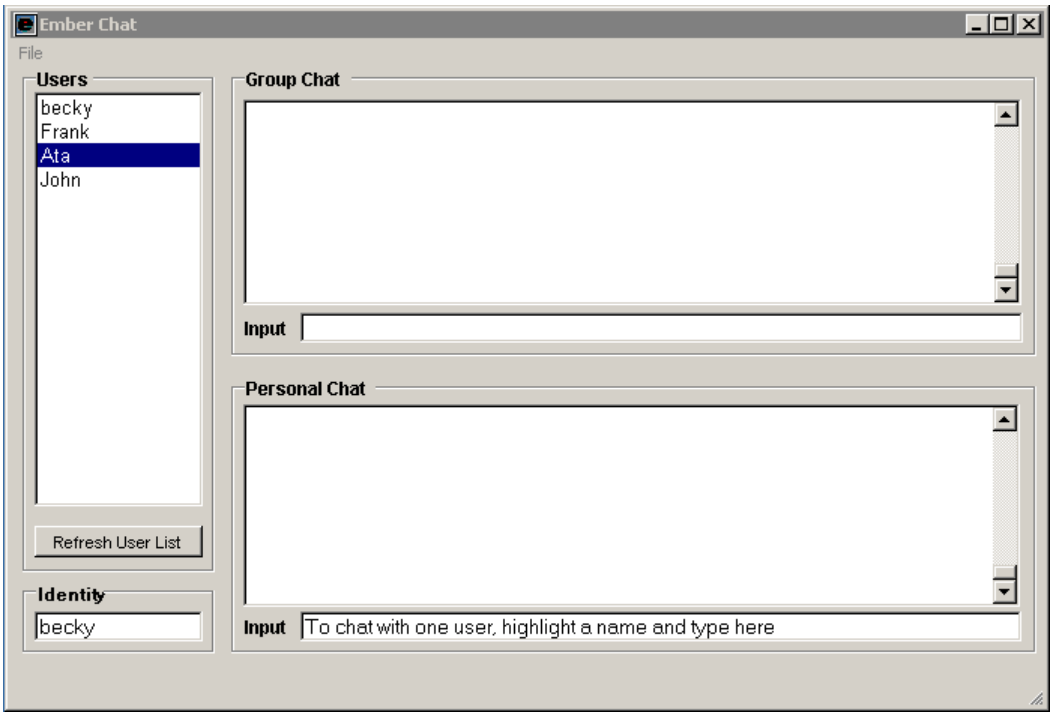
- **To chat over the network:**

1. Log into the program by typing a name for yourself in the Identity field and pressing ENTER. The name appears in the Users list. You can change this name at any time by entering a different name into the Identity field.
2. Enter text into one of the input fields. You can type up to 65 characters in a field at one time.

To chat with everyone, enter text into the Input field for the Group Chat box and press ENTER.



To chat with a single person, enter text into the Input line for the Personal Chat box and press ENTER.



Closing Ember Chat

To close the application, close the chat window.

Uninstalling Ember Chat

To uninstall the application, use the Add/Remove Programs utility in your PC's Control Panel.

CHAPTER 5 Collecting and Viewing Sensor Data

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Stimulating Sensors to Obtain Data

To obtain sensor data that you can collect and view with Ember Studio Lite, you must stimulate module sensors appropriately. See "Using the Sensor Data Application" on page 29 for information on module sensors and ideas for obtaining useful sensor data.

Collecting Sensor Data

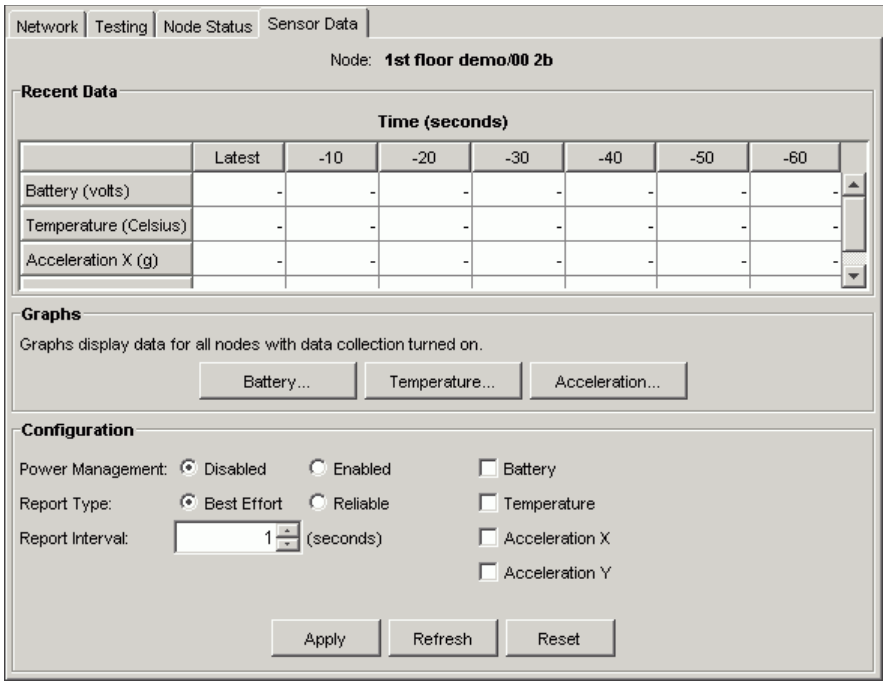
Use the Ember Studio Lite Sensor Data window to instruct modules to collect sensor data and report them to the gateway node at a specified interval. You can select from two sensor data transmission protocols:

- **Best Effort:** The module transmits sensor data reports without listening for acknowledgements from Ember Studio Lite. Reports are transmitted rapidly with this method but can be lost if collisions occur on the way to the gateway node.
- **Reliable:** The module transmits re-transmits reports until Ember Studio Lite acknowledges their receipt. Report transmission is slower with this method, but reports are never lost.

If you enable power management for nodes that are collecting sensor data, the nodes will enter and remain in a low-power sleep state except when they transmit sensor data (see "Enabling Power Management" on page 40). For information about the power management sample application, see "Using the Power Management Application" on page 30.

■ **To collect sensor data:**

1. Click the Sensor Data tab. The Sensor Data window displays. The window may display a node label and node ID:



2. Specify the node from which you want to collect data by one of the following methods:

   ◆ Click the Nodes folder in the folder tree, then click the folder for an individual node.

   Display the network map and click a node.

   The ID of the selected node appears in the window, and the window fields activate.

   If the node ID does not appear, click the Refresh button at the bottom of the Sensor Data window. If the node ID still does not appear, Ember Studio Lite cannot hear the node well enough. Try repositioning the node or increasing its transmission power setting. (See "Viewing Node Properties" on page 59 for information on changing the transmission power property.)

   If the window displays a message that the sensor data application cannot resolve the local ID, open the Node Configuration window and click the Refresh button. To open the Node Configuration window, double-click a node icon in the network map or the Nodes folder.

3. Select the checkbox for the data that you want to collect.

4. Select *Best Effort* or *Reliable*.

5. Specify a report interval.

6. Click *Apply*. After a few seconds, the window displays a message reporting that the module sensor has accepted the new data settings.

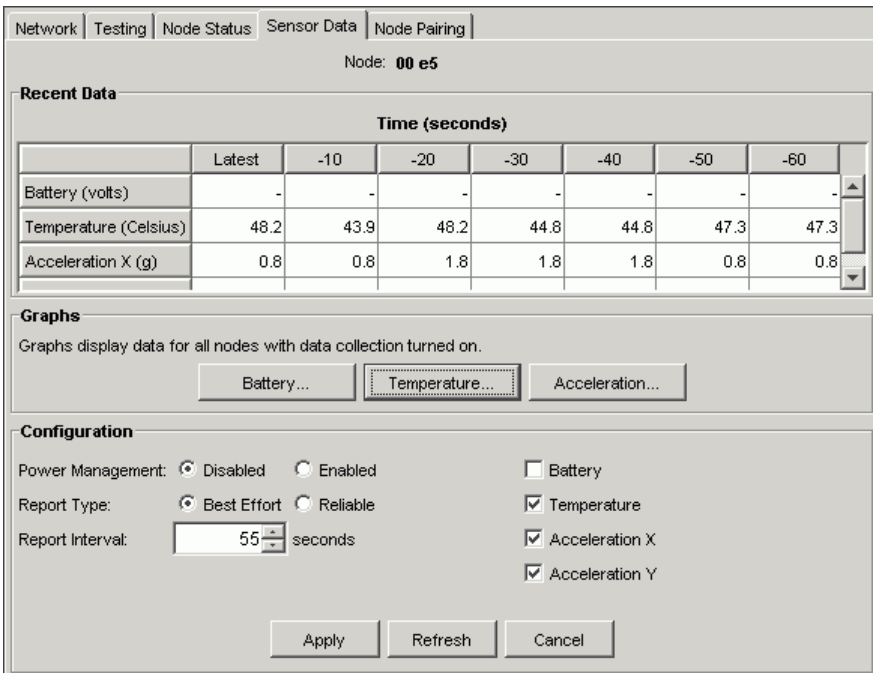
7. Stimulate the module sensor whose output you are collecting. For information on doing this, see "Obtaining Sensor Data" on page 30.

Viewing Sensor Data

Sensor data can be viewed in raw or graphed form.

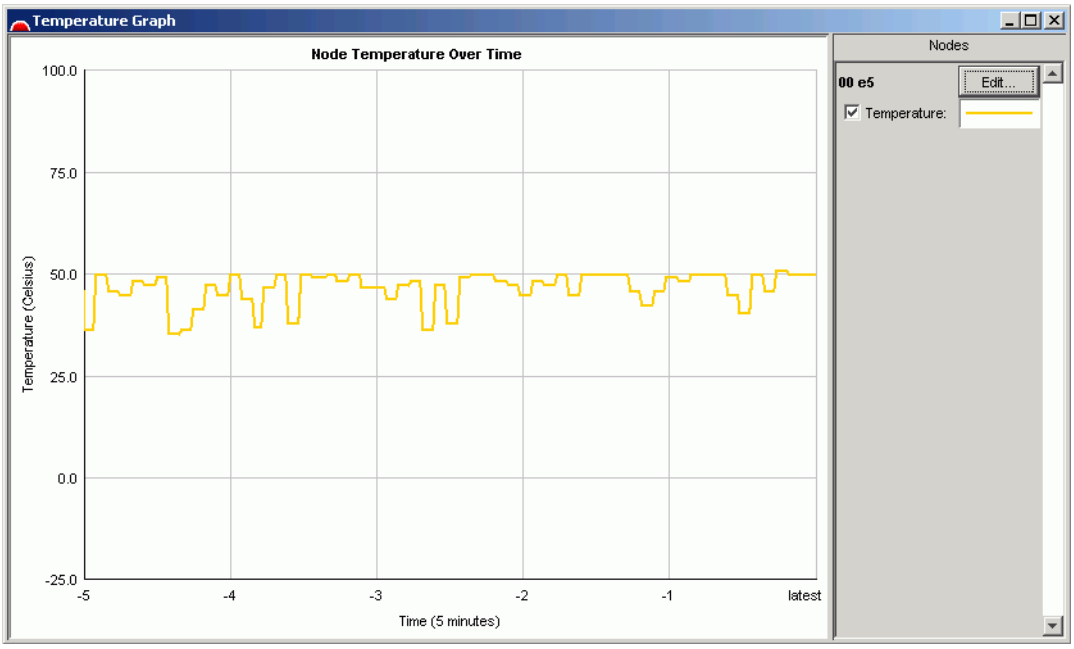
Viewing Raw Sensor Data

Raw sensor data are reported in the Recent Data section of the Sensor Data window. This section shows the most recent data value, plus old data back to 60 seconds before the latest report.



Viewing Sensor Data Graphs

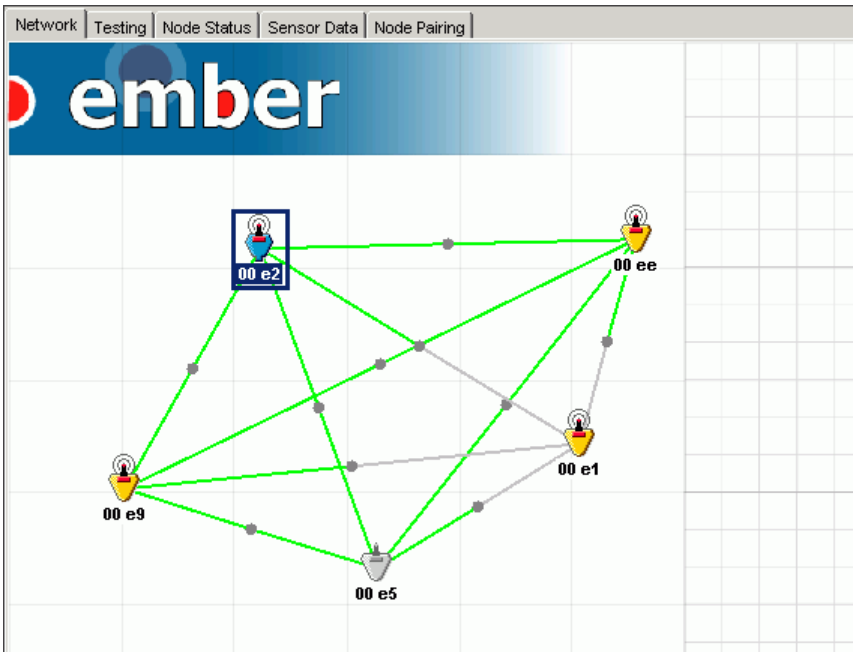
To view a sensor data graph, click a graph button in the Graphs section of the Sensor Data window. The selected graph displays in a new window.



Enabling Power Management

Use the power management sample application to instruct a module to enter a low-power sleep state except when it is transmitting sensor data. For an explanation of how power management works, see "Using the Power Management Application" on page 30.

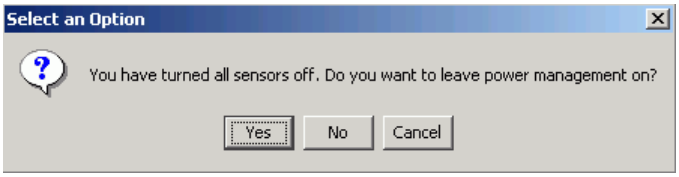
The network map displays the inactive node icon for sleeping nodes. In the following figure, node 00E5 is sleeping:



- **To enable power management:**

  Select the *Enabled* checkbox in the Configuration section of the Sensor Data window. The node enters a sleep-wake cycle, waking only to report the data it has been configured to report. For more information about how power management works, see "Using the Power Management Application" on page 30.

  If you attempt to enable power management without specifying sensor data collection, the following message displays:



- **To disable power management:**

  Use one of the following methods:

  - Deselect the *Disabled* checkbox in the Configuration section of the Sensor Data window.
  - Turn the module off.

  The node exits the sleep-wake cycle and begins participating in the network again.

CHAPTER 6 Getting Started with Ember Studio Lite

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Installing Ember Studio Lite

Insert the Evaluation Kit CD into your CDROM drive. The installation program should begin to run. If it does not, browse to the CDROM drive and double-click EmberStudioLiteInstaller.exe.

Opening and Closing Ember Studio Lite

To open Ember Studio Lite, click the Ember Studio Lite desktop icon:

The Ember Studio Lite main window and network connection wizard display. Use the wizard to connect to a network either remotely or locally (see “Connecting to a Network” on page 45).

To close Ember Studio Lite, click the Close button in the top right corner of the window, or select *File* > *Exit*.

Viewing Ember Studio Lite Help

Select *Help* > *Documentation* from the main menu to open a PDF help document. Click the Bookmarks tab to view the document table of contents.

About the Ember Studio Lite Main Window

The Ember Studio Lite main window allows you to:

- View the network or the results of network tests, in both graphic and text form.
- Perform network tests and network administration tasks.

The main window operates as described in Figure 6-1. The Tree View controls what displays in the other main window panes:

- **To see the network map:** Click *Nodes*.
- **To run a ping or trace route test or to view test results:** Click *Ping Tests* or *Trace Route Tests*.

To perform other Ember Studio Lite operations, such as refreshing the screen, select an option from the main menu or the toolbar. Available options and tools are documented elsewhere in this user guide.

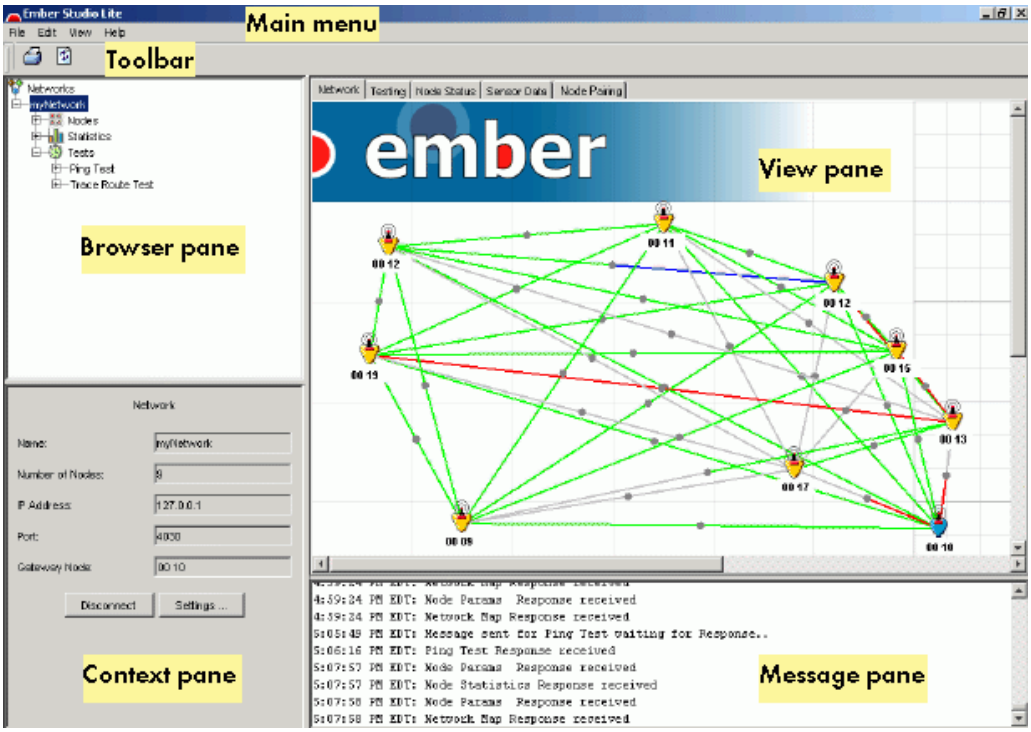


Figure 6-1: Ember Studio Lite main window

Table 6-1: Ember Studio Lite Main Window Regions

Main menu	Contains the File, Edit, View, and Help menus.
Toolbar	Contains the Print button ( )and the Refresh button ( ).
Browser pane	Displays a collapsible folder tree that provides information about the network and access to network management tools.
Context pane	Displays data entry windows or report windows.
View pane	Displays the contents of its tabbed windows: • **Network:** Graphical network map • **Testing:** Graphical view of test results • **Node Status:** Real-time node status data • **Sensor Data:** Module sensor data settings and graphs • **Node Pairing:** Graphical view of paired nodes
Message pane	Displays Ember Studio Lite status messages.

About the Folder Tree

Clicking folders in the folder tree gives you access to Ember Studio Lite tools and network data:

Networks folder		• Single-click the folder to view a window allowing you to connect to a network. • Right-click any network folder to delete it.
Nodes folder		• Single-click the folder to display a folder for each networked node. • Single-click a specific node folder to view parameters for the node. • Double-click the top-level Node folder to open the Node Configuration window.
Statistics folder		• Double-click to display the Statistics window.
Tests folder		• Single-click the folder to display the Ping Test and Trace Route Test folders. • Single-click a test folder to run a test or to view results of previously run tests. • Right-click the Ping Test or Trace Route Test folder to delete all tests. Right-click a single test folder to delete it.

About the Message Pane

Occasionally Ember Studio Lite prints an error message in the Message pane. Usually Ember Studio Lite will continue operating normally, and you can disregard the message. If Ember

Studio Lite seems to be malfunctioning when it prints an error message, record the message and contact Ember (see "Getting Help" on page 15). An Ember support engineer will use the message to diagnose the problem.

Printing the Main Window

To print the main window, click the print button on the toolbar ( ),or select *File* > *Print*.

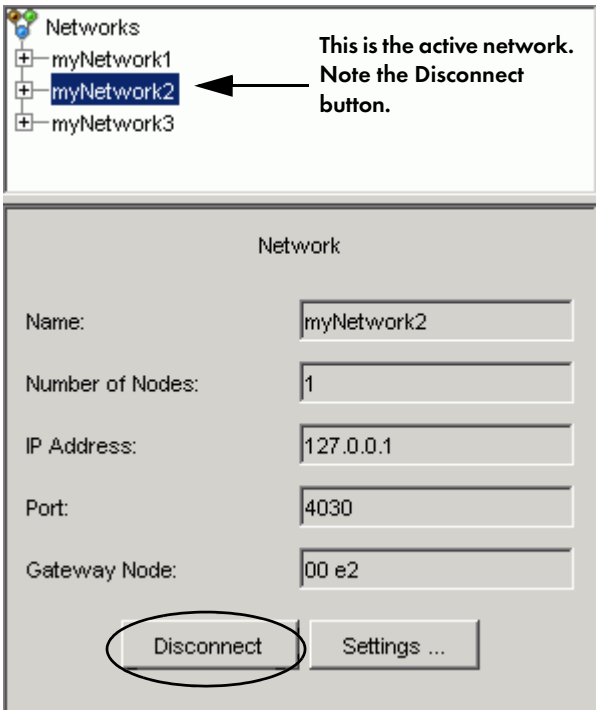
Connecting to a Network

You can connect to a network in two ways:

- **Locally** via the Ember Studio Lite gateway module connected to your computer.
- **Remotely** via Ethernet to a computer to which a gateway module is connected.

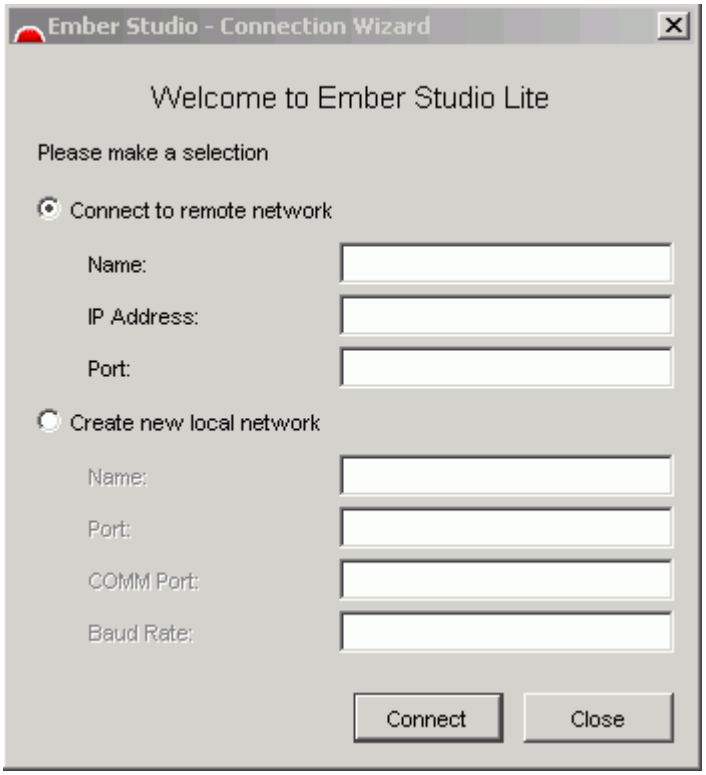
You can **serially** connect to any number of EmberNet networks. Each network connection that you open creates a network folder in the folder tree. Network folders persist, allowing you to switch connections easily, but you can delete them at will.

To determine which network is active, click network folders until you locate the one whose network window displays the Disconnect button:



Using the Network Connection Wizard

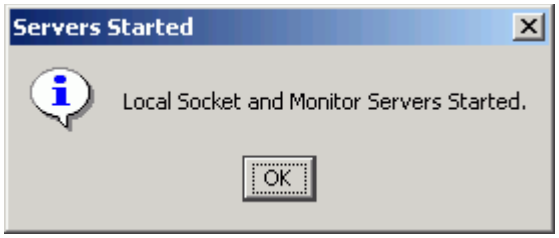
The network Connection Wizard automatically displays when you start Ember Studio Lite. You can also manually display it by selecting *File* > *Connection Wizard*.



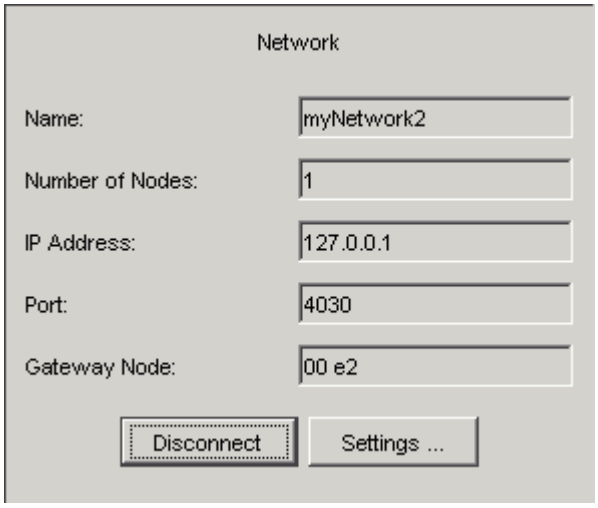
- **To connect via the Connection Wizard:**

1. Select *Connect to Remote Network* or *Create New Local Network*.
2. Enter values into the fields for the selected option.
   - **Name:** User-assigned name; will be used for the network folder in the folder tree. Can be any name you like (for example, Test, network123, My Test Network).
   - **IP Address:** IP address of the computer that is connected to the network. 127.0.0.1 is the default.
   - **Port:** 4030 is the default.
   - **COMM Port:** COM1 is the default.
   - **Baud Rate:** 19200 is the default.
3. Click *Connect*.

If you connected to a local network, Ember Studio Lite displays a confirmation window:



4. Click *OK* in the confirmation window. The Network folder displays in the folder tree, with three folders under it (Nodes, Statistics, Testing). The network map displays in the View pane (see Figure 6-1). The Network window displays in the Context pane, showing information for the new connection:

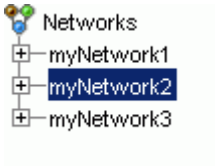


Switching to a Different Network

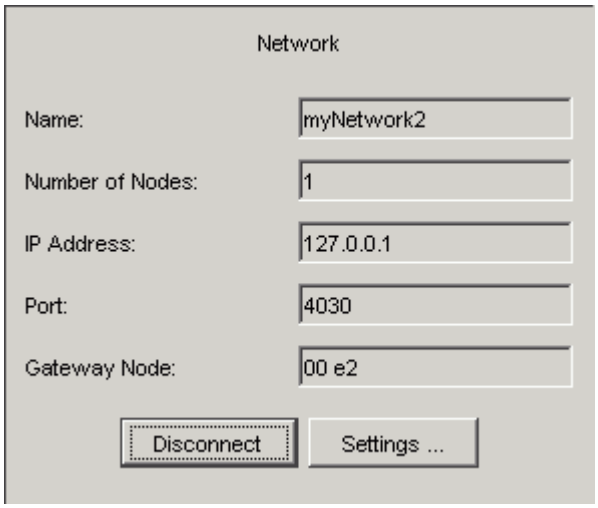
To switch to a different network, you must first disconnect from the active network.

- **To switch to a different network:**

1. Click the folder for the active network. The Network window displays in the Tree View:



The Network window displays, showing information for the active network:



The network window shares three fields with the Connection Wizard—Name, IP Address, and Port—plus the following two unique fields:

- **Number of Nodes:** Number of nodes in the network
- **Gateway Node:** Node ID of the network gateway, consisting of the last two bytes of the hexadecimal representation of the module's 64-bit EUI number. (To view the entire 64-bit number, open the Node Parameters window for the gateway; see "Viewing Node Parameters" on page 56.)

2. Click *Disconnect*. The Connect button replaces the Disconnect button, signifying that Ember Studio Lite is no longer connected to that network.
3. Do one of the following:
   - **To open a new network connection:** Follow the procedure in "Using the Network Connection Wizard" on page 46.
   - **To re-open a previously established network connection:** Click the network folder, then click *Connect* in the Network window. The Disconnect button replaces the Connect button, signifying that Ember Studio Lite is now connected to the network. The network map for the connection displays in the View pane.

Deleting a Network Connection

To delete a network connection, right-click the folder and select *Delete Network*.

Changing Network Settings

You can adjust the pace and intensity of network traffic by changing the following network settings:

- **Statistics Refresh Rate:** Time interval at which the statistics window refreshes itself.
- **Node Timeout Interval:** Time period over which Ember Studio Lite listens for a node to respond to a network ping.

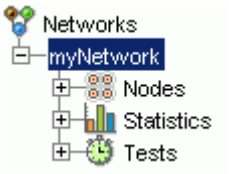
- **Node Ping Interval:** Time period at which Ember Studio Lite pings all nodes in the network and then updates the network map

The node timeout interval must be substantially greater than the node ping interval. Ember recommends making it three time greater. If it is not, nodes will suddenly go into and out of the error condition as their timeout periods are reached and Ember Studio Lite decides that they are offline. If you have turned off the display of error nodes, you will see nodes suddenly disappear from the network map and then reappear. What is happening is that Ember Studio Lite is pinging the network to discover all nodes less frequently than it is listening for nodes to time out. (For information on configuring the display of error nodes, see "Configuring Network Map Preferences" on page 52.)

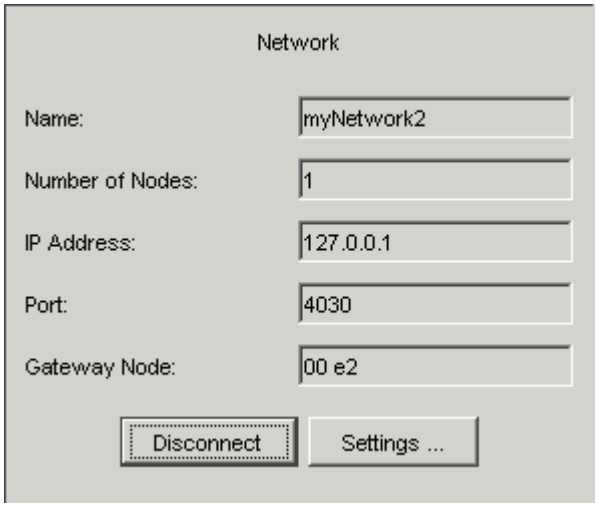
To decrease network traffic, enter large values for the statistics refresh rate and node ping interval.

■ **To change network settings:**

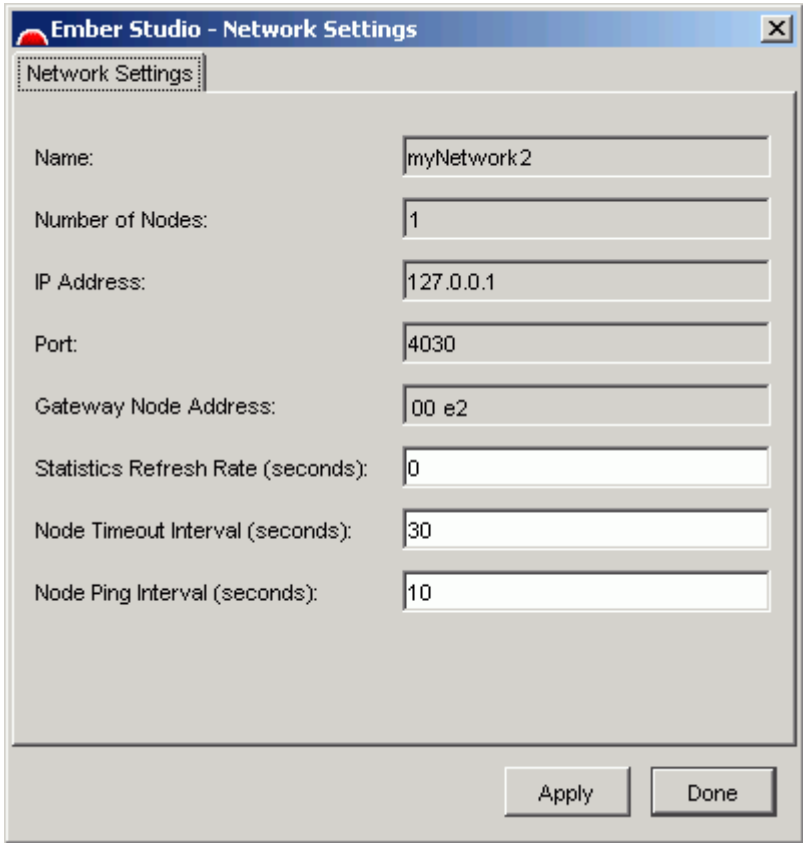
1. Click the active network in the folder tree:



The network window displays:



2. Click *Settings*. The network settings window displays:



3. Enter values into the configurable fields and click *Apply*.

Using the Network Map

The network map displays:

- **A logical representation of a physical network,** with icons representing nodes and lines representing links between nodes.
- **An indication of node status,** represented by the color of node icons.
- **An indication of link signal strength,** represented by the color, weight, and style of node link lines.

You can simulate the physical network on the network map by displaying a background image of the network environment (for example, a floor plan) behind the map and dragging icons to positions on the image. You can also customize the node icons and the link lines.

Network Map Elements

The network map contains the following elements (see Figure 6-2):

- **Node icons:** Represent the network status of Evaluation Kit modules. There are four types:
  - **Gateway icon:** Node (module) that is physically connected to a computer.
  - **Normal icon:** Normally operating network node.
  - **Error icon:** Node that is in an error state.
  - **Power management icon:** Node that is running the power management sample application (called "inactive" in the Node Preferences window).
- **Node IDs:** Consist of the last two bytes of the hexadecimal representation of the node's 64-bit EUI number. (The entire 64-bit number is visible in the Node Parameter window (see "Viewing Node Parameters" on page 39.)
- **Link lines:** Represent links between nodes. The color, weight, and style of the line drawn from a node to a gray dot signifies the strength of the link between that node and the node on the other side of the gray dot. Figure 6-2 shows the default preferences for link lines:
  - Green: Good signal strength
  - Blue: Fair signal strength
  - Red: Poor signal strength
  - Gray: Very poor signal strength

  If no signals are passing between two nodes, no link line will appear between them.

  In Figure 6-2 the line between 0022 and 0010 represents an internodal link. The signal strength represented by line segments A and B is strong. By comparison, 0010 hears only a fair-quality signal from 0013 and a poor-quality signal from 0007. All links between

0004 and its neighbors are gray because the node is in an error state, meaning that it hears almost nothing and transmits no data.

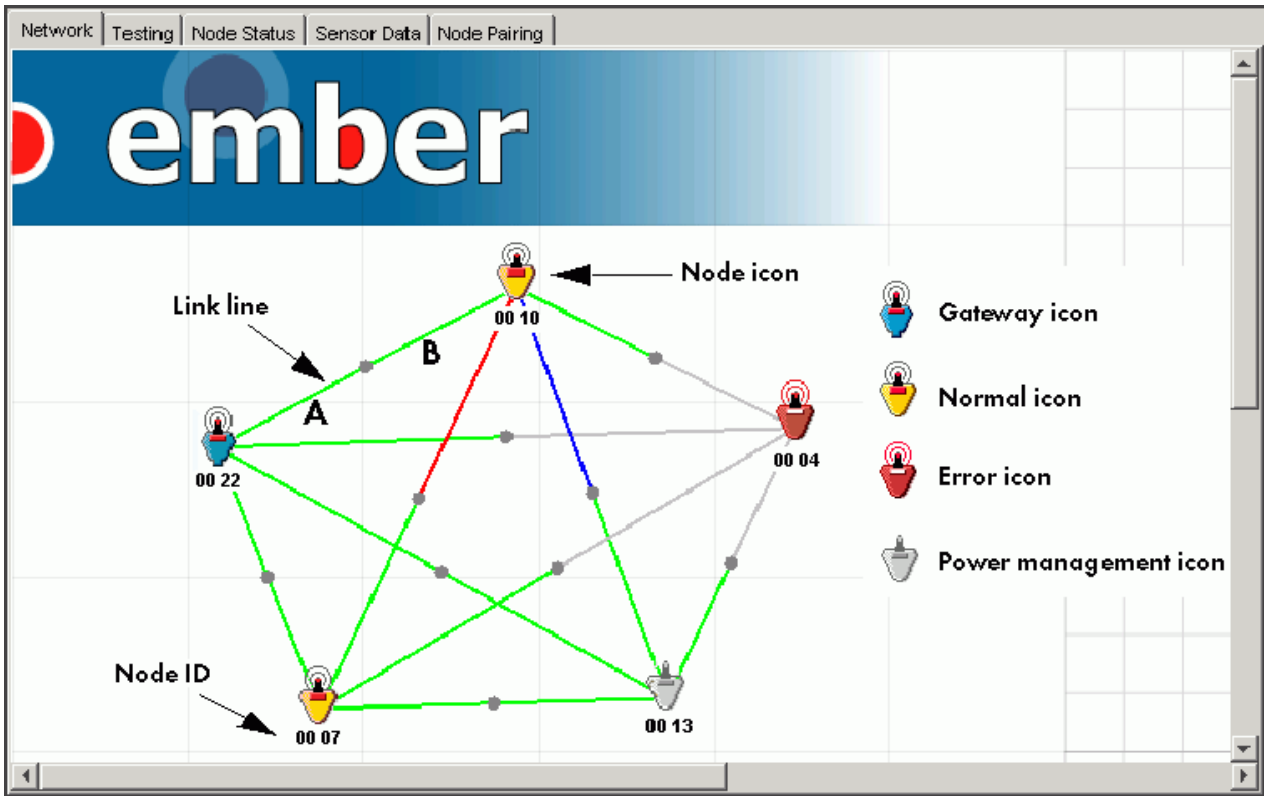


Figure 6-2: Network map elements

Refreshing the Network Map

To refresh the network map, click the Refresh button ( ) or right-click the map and select *Refresh*. After a short delay, Ember Studio Lite updates the map.

Moving Network Map Icons

To improve the readability of the network map or to position nodes on a custom background image, click and drag node icons to a new position.

When you click an icon, a black box displays around it, indicating that the icon has been selected.

Note: Rearranging node icons does not change the logical structure of a map.

Configuring Network Map Preferences

You can set preferences for the following network map features:

- Nodes
  - Display your own icons for gateway, normal, error, and power management nodes. (The power management node icon is termed "inactive" in the Node Preferences window.)

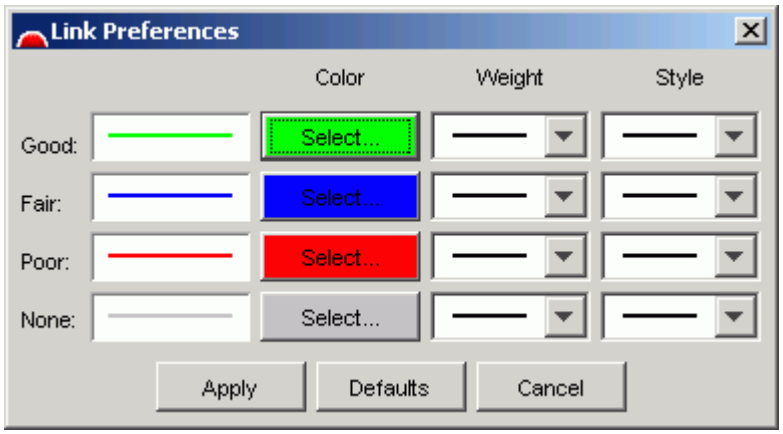
- Hide or display nodes that are in an error state.

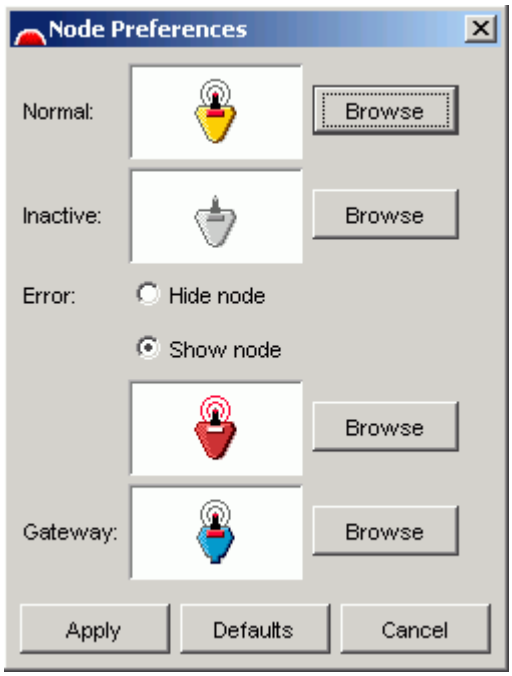
- Link lines
  - Specify line color, weight, and style.

You can also toggle the display of error nodes by selecting *View > Show Nodes With Error* from the main menu.

■ **To set network map preferences:**

1. Do one of the following:
   - Right-click anywhere in the map and select *Link Preferences* or *Node Preferences.*
   - Select *View > Preferences.*
2. The selected preferences window displays, showing the current link or node preferences.





3. Select preferences:
   - **To change the color, weight, or style of link lines:**

Select line weight or style from their respective drop-down menus. Click the color box, then select a color from the palette that displays.

- **To display custom node icons:**

  Browse to the folder containing the custom icons and select files.

- **To toggle the display of nodes in an error state:**

  Click the hide or show option.

4. Click *Apply*. After a short delay, the map displays the new preferences.

- **To restore map icons and link lines to defaults:**

  Display the node or link preferences window (see "Configuring Network Map Preferences" on page 52) and click the *Defaults* button. The default icons or link settings display in the map.

Displaying a Custom Background Image

You can replace the default network map background image with an image of your own design, such as a graphic of a floor plan, shop floor, or blueprint. Custom maps can be GIF or JPEG files.

- **To display a custom background image:**

  1. Right-click anywhere in the map to display the map preferences menu.
  2. Click *Set Background Image* and browse to the image you want to display.
  3. Click *Open*. The background image displays in the View pane.
  4. Drag node icons to their locations on the background image.

- **To remove a displayed background image:**

  Right-click the map and select *Remove Background Image*.

CHAPTER 7 Managing Network Nodes

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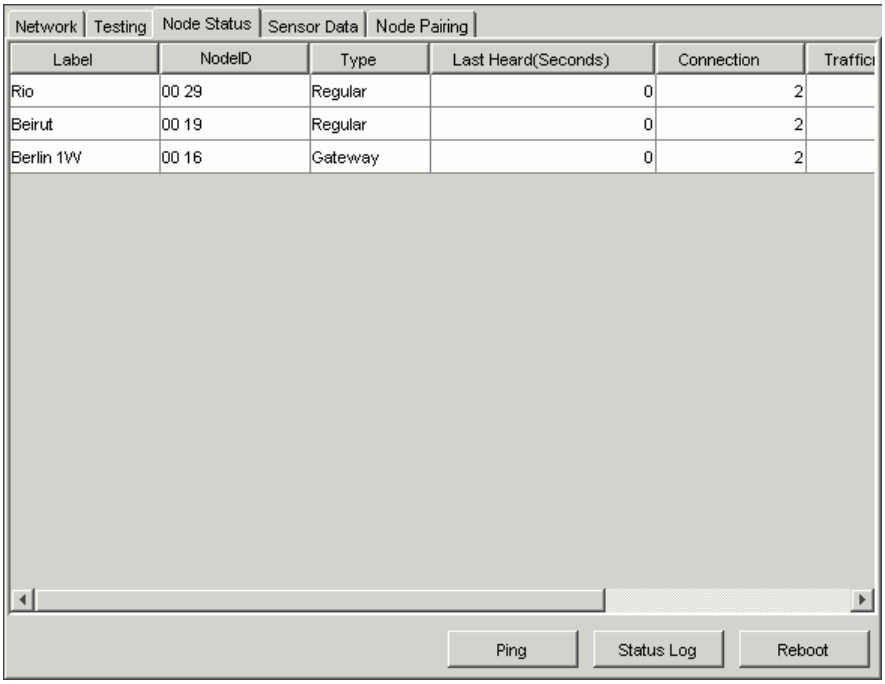
Viewing Node Status Information

The Node Status window displays real-time information about each active node.:

Label	User-defined label for the node, if one has been applied
Node ID	ID number consisting of the last two bytes of the hexadecimal representation of the node's 64-bit EUI number
Type	Type of node
Last Heard (Seconds)	Time since Ember Studio Lite last heard a ping response from a node
Connection	Number of links to the node
Traffic (Nos)	Number of messages that the node sent, received, or forwarded in the last polling cycle
Status	Operational status of the node

- **To view Node Status information:**

  Click the Node Status tab. The Node Status window displays:



- **To sort Node Status window columns:**

  Single-click a column head to sort the rows in ascending order by that column.

  Double-click a column head to sort the rows in descending order by that column.

- **To reorder Node Status window columns:**

  Drag a column to the left or right to change the order.

Viewing Node Parameters

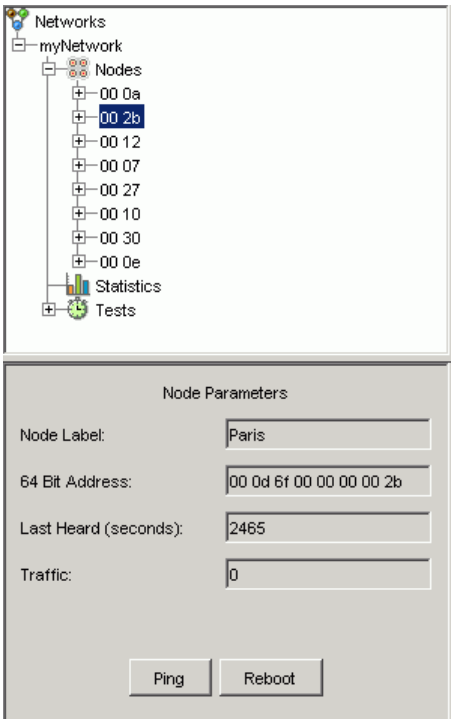
The Node Parameters window displays a subset of the node status data for a given node, plus the node's 64-bit EUI number. For definitions of the fields in this window, see "Viewing Node Statistics" on page 57.

Note that this window displays the complete hexadecimal representation of the node's 64-bit number and not just the last two bytes of it.

The window also includes the Ping and Reboot buttons for diagnosing node connectivity problems.

- **To view a node's parameters:**

  Click the Nodes folder in the folder tree, then click the folder for a node. The Node Parameters window displays in the Context pane:



Viewing Node Statistics

You can poll the network for the following node performance statistics:

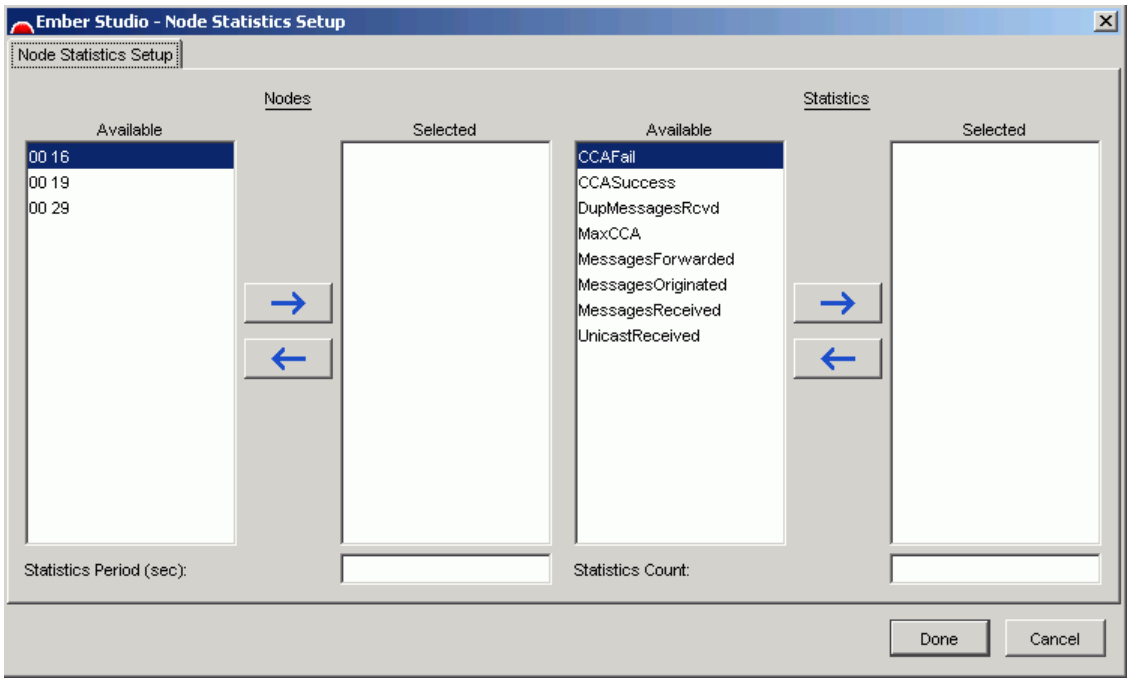
CCAFail	Total number of times clear channel assessment (CCA) failed. A CCA failure is not the same as a transmission failure, since the carrier sense multiple access (CSMA) algorithm retries CCA up to MAX_CSMA_RETRIES times before giving up.
CCASuccess	Number of times CCA succeeded in the media access control's (MAC's) CSMA algorithm. Equals number of transmissions.
DupMessagesRcvd	Number of duplicate messages received.
MaxCCA	Number of times a transmission failed because of a busy channel.
MessagesForwarded	Number of messages forwarded by node.
MessagesOriginated	Number of messages originated from node.

MessagesReceived	Number of messages received.
UnicastReceived	Number of unicasts received.

- **To view node statistics:**

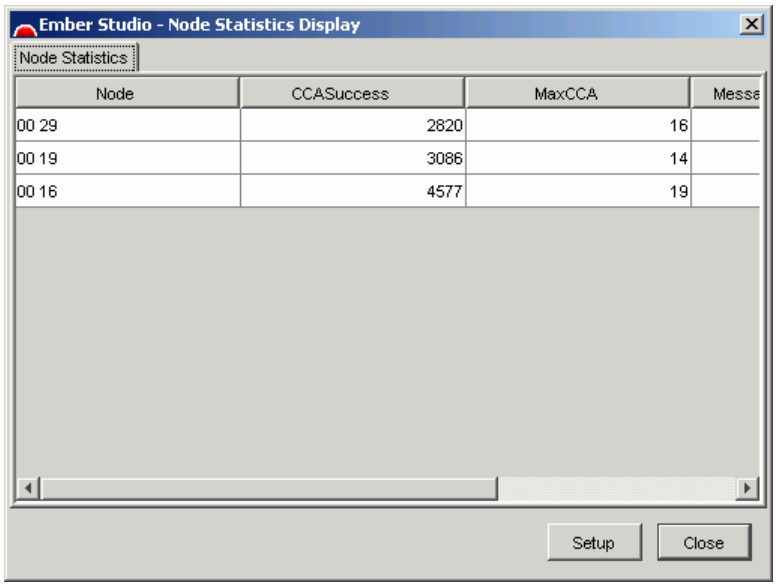
Note: Make sure power management is not enabled for the nodes that you poll (see "Using the Power Management Application" on page 30).

1. Double-click the Statistics folder in the folder tree. The Node Statistics Setup window displays:



2. Click a node ID, then click the right arrow. The node ID displays in the Selected box. Repeat to select additional nodes.
3. Click a statistic, then click the left arrow. The statistic displays in the Selected box. Repeat to select additional statistics.
4. Enter an integer into the Statistics Period field, to specify the polling frequency.
5. Enter an integer into the Statistics Count field, to specify the number of times to poll selected nodes.

6. Click *Done*. The Node Statistics Display window displays. Use the scrollbar to view all columns, or drag the right border to enlarge the window.



7. To collect different statistics or poll other nodes, click *Setup*. The Node Statistics Setup window displays again.

Viewing Node Properties

You can view values that have been set for each node's properties (Table 7-1)

Certain properties may not show if a node did not send its configuration information the last time it was pinged. Click the Refresh button to make the node send these values to the gateway.

Note: Ember Studio Lite will not let you configure the properties of a node for which power management is enabled (see "Using the Power Management Application" on page 30).

- **To view properties for a node:**

1. Double-click the Nodes folder in the folder tree. The Node Configuration window opens.
2. Click a node in the Nodes column. The properties in effect for the node display in the window's Key and Value columns. The Key column displays the properties, and the Value

column displays the property value. (If any properties are missing, click the Refresh button.)

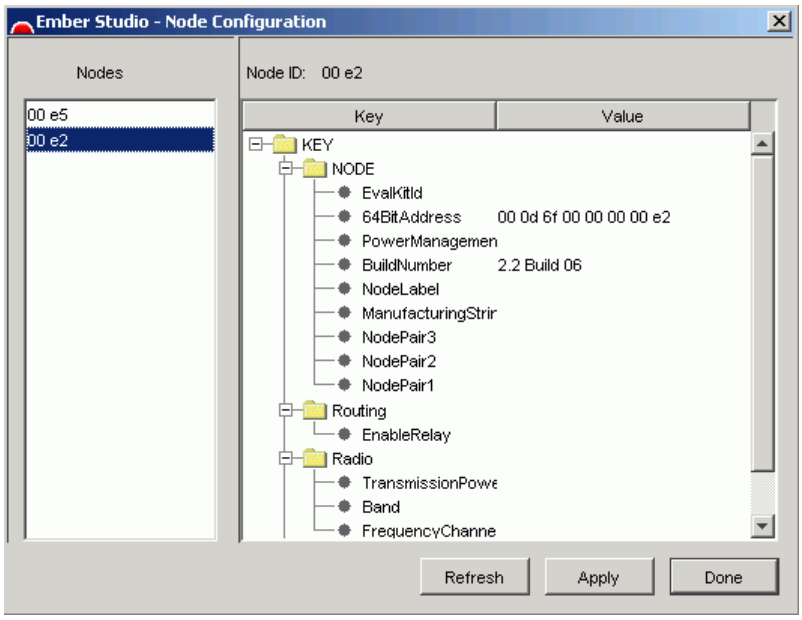


Table 7-1: Node Properties

Category	Property	Definition
Node	EvalKitId	Local ID for the node (that is, the RF communication module) (used only when running Ember Serial Command Set commands) **Note:** Do not change the value in this field unless you have purchased more than one Evaluation Kit and need to give all the modules consecutive local IDs. See "Resetting Local IDs" on page 101.
	64BitAddress	Hexadecimal representation of the 64-bit EUI number assigned to the module
	Power Management	Flag indicating whether power management has been enabled for the node true = enabled false = disabled
	BuildNumber	Ember stack build number
	NodeLabel	User-assigned node name

Table 7-1: Node Properties (Continued)

Category	Property	Definition
	ManufacturingString	Five-part number assigned by the node manufacturer. The parts are defined below with reference to the following sample number: 8473/0331/0060/01/A1 8473: Board number 0331: Lot code (31st week of 2003) 0006: Manufacturer's serial number 01: Manufacturing code A1: Board revision
	NodePair3	Either the EvalKitID for a node that has been paired to this node or "No Pair"
	NodePair2	Either the EvalKitID for a node that has been paired to this node or "No Pair"
	NodePair1	Either the EvalKitID for a node that has been paired to this node or "No Pair"
Routing	EnableRelay	A flag that determines whether the node relays messages
Radio	Transmission Power	Transmission power, in dB
	Band	Radio band
	FrequencyChannel	RF channel
Neighbor	Number of neighbors	Number of neighboring nodes
	[list of each neighbor node]	Value representing the quality of a node's link to each neighbor node. The range is 100 for the strongest possible link to 0 for no link.

Setting Node Properties

Table 7-2 identifies the properties that you can set and the values to input for each.

Table 7-2: Configurable Node Properties

Property	Parameters
NodeLabel	Any string. Whitespaces are allowed.
EvalKitId	Enter any integer that does not exceed the total number of nodes. **Note:** Be careful when changing the EvalKitId field. If two or more nodes are accidentally assigned the same local ID, their behavior will become erratic and networks including them will malfunction. See "Resetting Local IDs" on page 101.
Enable Relay	Select *true* or *false* from the drop-down list.
Transmit Power	Enter a value from Appendix C, "Module Radio Settings." .
Channel	Enter a channel from Appendix C, "Module Radio Settings." .**Note:** When resetting node channels, be sure to **change the network gateway's channel last.** When you change a node's channel, the node disappears from the network map because it is no longer set to the same channel as the gateway node. Therefore, if you change the gateway's channel first, you will be unable to see the nodes that still need to be changed. If you accidentally change the gateway's channel too early, change it back to the original channel so that you can see all the nodes still set to that channel.

- **To set node properties:**
  1. Display the Node Configuration window (double-click the Nodes folder in the folder tree and click a node in the Nodes column).
  2. Double-click the Value field for a property that you want to set. A selection box surrounds the property's value. Enter a new value for the property (refer to Table 7-2, and be sure to heed the special warnings about setting certain properties).
  3. Repeat the preceding step as needed.
  4. Click *Apply* to put the new property settings into effect.
  5. Click *Done* to close the window.

Pinging a Node

You can ping individual nodes from within the Node Status and Node Parameters windows.

Note: Do not ping a node for which power management is enabled (see "Using the Power Management Application" on page 30). Ember Studio Lite will display an error message if you attempt to do this.

- Node Status window: Click a node, then click the Ping button.
- Node Parameters window: Click the Ping button.

Rebooting a Node

You can reboot a node that seems to be stuck in an error state, to bring it back on line, from within Node Status and Node Parameters windows:

- Node Status window: Click a node, then click the Reboot button.
- Node Parameters window: Click the Reboot button.

Viewing Node Status Messages

You can view a log of Ember Studio Lite messages about a node from within Node Status and Node Parameters windows:

- Node Status window: Click a node, then click the Reboot button.
- Node Parameters window: Click the Reboot button.

CHAPTER 8 Testing the Network

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Available Network Tests

Ember Studio Lite includes the following network tests:

- **Ping:** Tests network performance between two nodes in a multi-node network that cannot hear each other (in this instance you may see multihop performance), or tests the strength of the radio link between two nodes that can hear each other.
- **Trace route:** Determines the statistical route that a series of packets traveled to get from one specified node to another.

How Ember Studio Lite Implements Network Tests

In the Ember Studio Lite ping test, the sending node ensures that it has a path to the receiving node and then sends unicast packets of a selected size at a selected delay. (Occasionally a node will send packets before establishing a route, in which case the ping test will fail.) The receiving node sends the packets back to the sending node. Both the sending and receiving nodes send packets through the network on a best-effort basis.

Ember Studio Lite implements trace route similarly to ping, except that the test is performed in one direction only. As part of the test setup, other nodes in the network are asked to count packets from a sender to receiver. Each node that receives a packet makes a forwarding decision based on the cost remaining to route the packet. If the node believes that it can forward the packet at the same or a lower cost indicated in the packet, it will try to forward the packet. However, if the node hears another node forward the packet while it is waiting to transmit, it will remove the packet from its transmit queue. Because of the nature of the mesh, link quality, and variations in timing between nodes, trace route shows that packets will take different paths through the network.

Ensuring a Successful Network Test

The quality of the results that you obtain from ping or trace route depend on the way the network is set up, traffic levels on the network, and the parameters supplied to the test, particularly packet size and packet delay. Best results are obtained when you observe the following guidelines:

- **Ensure that there are multiple paths of high-quality links from source to destination,** to provide alternate paths if a node is busy or subject to interference. The network does not operate well if there are traffic bottlenecks. Figure 8-1 shows an example of a well-formed test network.
- **Be careful about moving modules during the test.** Ember Evaluation modules are designed to support **portability, rather than mobility**. As in any network design, there is a trade-off between the network rediscovery rate and data throughput. Modules are designed to automatically discover and incorporate new modules into the network and to route around modules that are no longer responding. However, moving active modules during a test results in the modules' trying to use neighbors for routing that may no longer be present, and the alternate paths may also not be present. This could disrupt test packet routing. Moving a gateway module can result in the test initiation or test result messages not making it to the gateway. **To avoid this problem**:
  - Do not move modules during tests.
  - If you move a module between tests, reboot it so that its neighbors will rediscover it.
  - If you move the gateway module or it does not appear to be receiving network data, reboot the gateway module.
- **Run tests with small packet sizes and lengthy interpacket delays**. The smaller the packet, the quicker it travels through the network. The longer the packet delay, the more time the packet has to travel between source and destination.
- **Reduce network traffic during the test.** Tests run over a quiet network have a higher packet success rate than those run over a busy network that is, for example, gathering statistics at frequent intervals and running multiple concurrent tests. Nodes cannot transmit while they are receiving a packet or while one of their neighbors is transmitting. The network will attempt to retry packets that could not be sent because the network was busy, but after a set of unsuccessful retries the packet will be dropped by the intermediate nodes.

Ping Test Example

The data in Table 8-1 and Table 8-2, obtained during a series of ping tests run on the network depicted in Figure 8-1, provide an example of the effect of packet size, packet delay, and network traffic on the packet success rate. The network was configured to ping all nodes every 10 seconds to verify status and to poll selected nodes for statistics every 30 seconds.

Table 8-1 shows the result of (1) varying packet size while holding packet delay constant at 250 milliseconds and (2) varying packet delay while holding packet size constant at 25 bytes. Table 8-2 shows the result of varying network traffic (in this instance, the interval for statistics polling) while holding packet size and packet delay constant.

These data demonstrate the inverse relationship between packet size, packet delay, and network traffic and packet success rate.

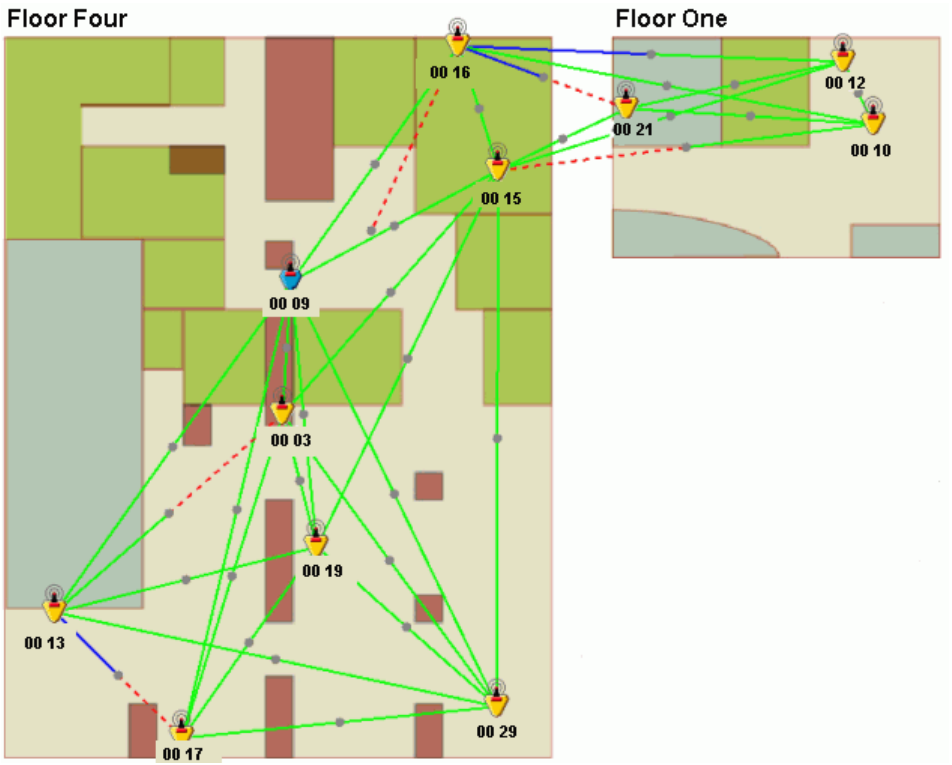


Figure 8-1: A well-formed test network

Table 8-1: Effect of Packet Size and Packet Delay on Packet Success Rate

Variable	Value	Success Rate for the Send-to-Receive Portion	Success Rate for the Receive-to-Send Portion
Packet size (bytes)	5	100%	100%
	10	100%	100%
	20	100%	100%
	40	100%	100%
	60	100%	95%
	80	100%	83%
Packet Delay	80	75%	60%
	120	99%	84%
	160	100%	97%
	200	100%	100%
	250	100%	100%
	300	100%	100%
	350	100%	100%
	400	100%	100%
	450	100%	100%
	500	100%	100%

Table 8-2: Effect of Network Traffic Level on Packet Success Rate

Statistics Interval (seconds)	Success Rate for the Send-to-Receive Portion	Success Rate for the Receive-to-Send Portion
30	98%	100%
10	100%	100%
5	100%	99%
2	91%	82%

Trace Route Test Example

Figure 8-2 and Figure 8-3 show the results of two trace route tests run on the network shown in Figure 8-1 and illustrate the effect of link quality and routing on the path a packet takes through the network.

In test 1, node 0017 was asked to send 100 packets to node 0012. Figure 8-2 shows the simple path that the data took in this test. Although node 0015 did not have a high-quality link from node 0017, it heard 98 of those packets. Since it had a low-cost route to node 0012, node 0017 forwarded the packets. Figure 8-2 shows the simple path that the data took in this test.

In test 2 the path for test 1 was reversed, with node 0012 sending 100 packets to node 0017. As Figure 8-3 shows, the results for this test were not quite as simple as those for test 1. Nodes 0016, 0015, and 0010 all heard and forwarded some of the packets. The weak link between 0015 and 0017 was used to eliminate a packet hop. But node 0009 acted as a repeater and forwarded the highest number of packets on to node 0017.

These two trace route tests illustrate how the asymmetric links typical in a wireless environment influence mesh-based routing in an EmberNet network. Node 0015 clearly hears node 0017 better than node 0017 hears node 0015. As a result of the variation in the link, what was a two-hop path in one direction requires on the return path requires two and three hops and takes many more paths.

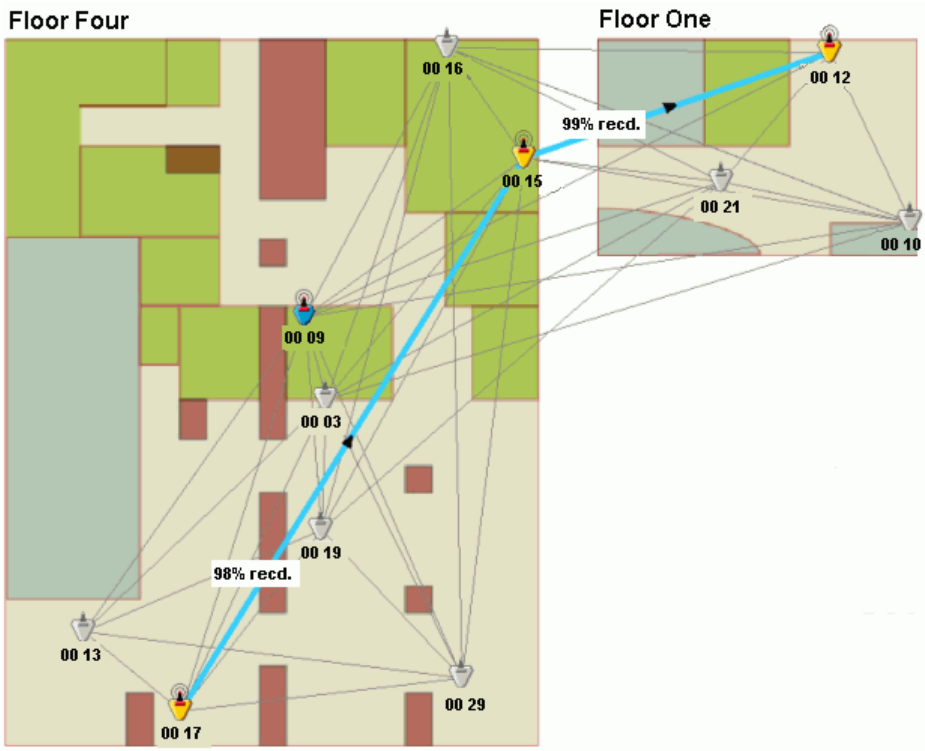


Figure 8-2: Trace route test 1 results

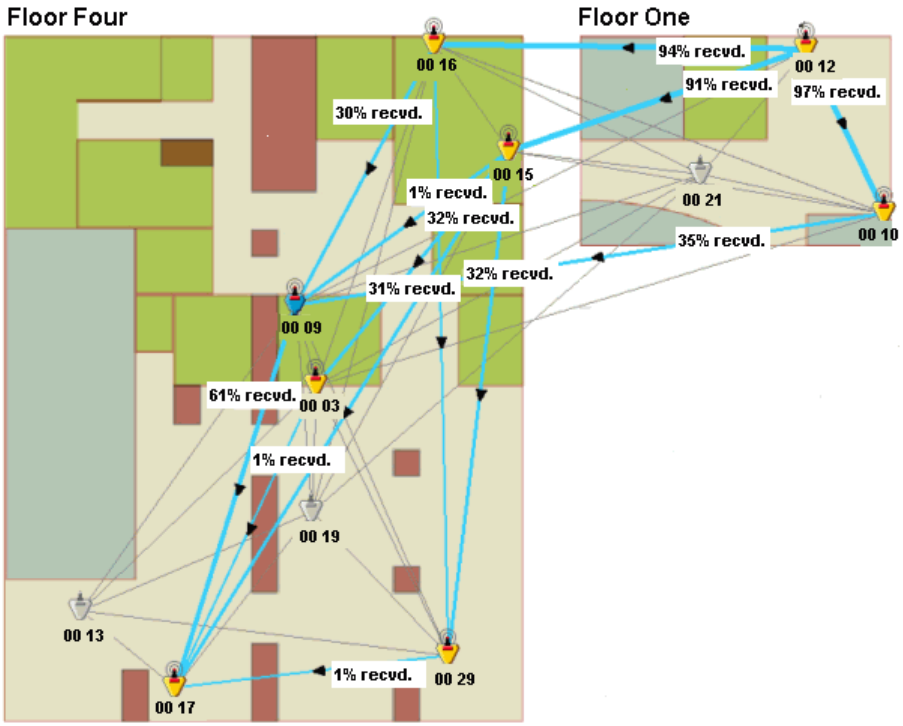


Figure 8-3: Trace route test 2 results

Performing a Ping Test

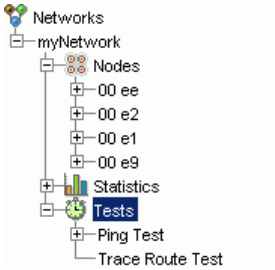
Running a Ping Test

For best results, observe the guidelines set out in "Ensuring a Successful Network Test" on page 65.

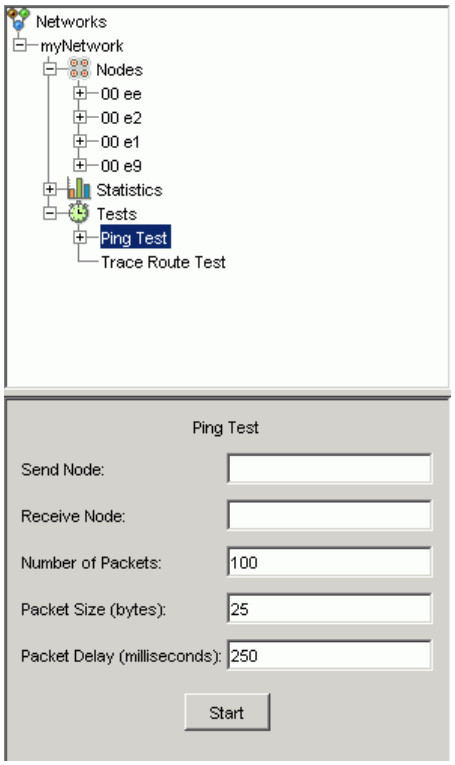
Note: Make sure power management is not enabled for the sender or receiver node in a ping test (see "Using the Power Management Application" on page 30). Ember Studio Lite will display an error message if you attempt to run a ping test on a node that is under power management.

- **To run a ping test:**

1. Click the Tests folder in the folder tree. The folder tree expands to list the Ping Test and Trace Route Test folders:



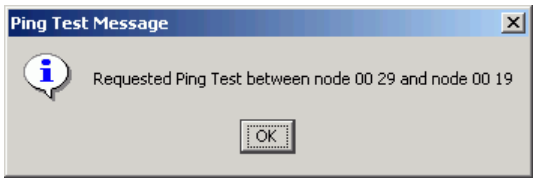
2. Click the Ping Test folder. A test setup window displays:



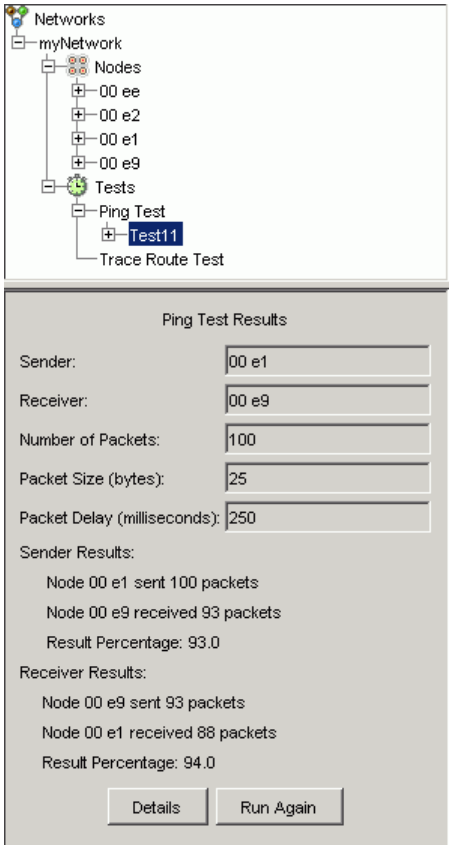
3. Enter parameters into the test setup window.

Send Node	Click the field, then click the send node in the network map, or enter the send node ID.
Receive Node	Click the field, then click the receive node in the network map, or enter the receive node ID.
Number of Packets	Enter a number from 1 to 999.
Packet Size (bytes)	Enter a number from 1 to 100.
Packet Delay (milliseconds)	Enter a number that, when plugged into the formula below, will result in a value of 5 minutes or less: Number of packets times number of milliseconds plus 20 seconds

4. Click *Start*. Ember Studio Lite displays a test initiation message:



5. Click *OK*. When the test finishes, Ember Studio Lite places the results in a numbered subfolder in the Ping Test folder.
6. Click the Testing tab, then click the numbered test result folder. Test results display in the View pane, superimposed on the network map, and the Ping Test Results window displays. See the following section for information on reading ping test results.



7. Optional: To re-run the test with the same parameters, click *Run Again*. To re-run the test with different parameters, enter new parameters into the Ping Test Results window and click *Run Again*.

Reading Ping Test Results

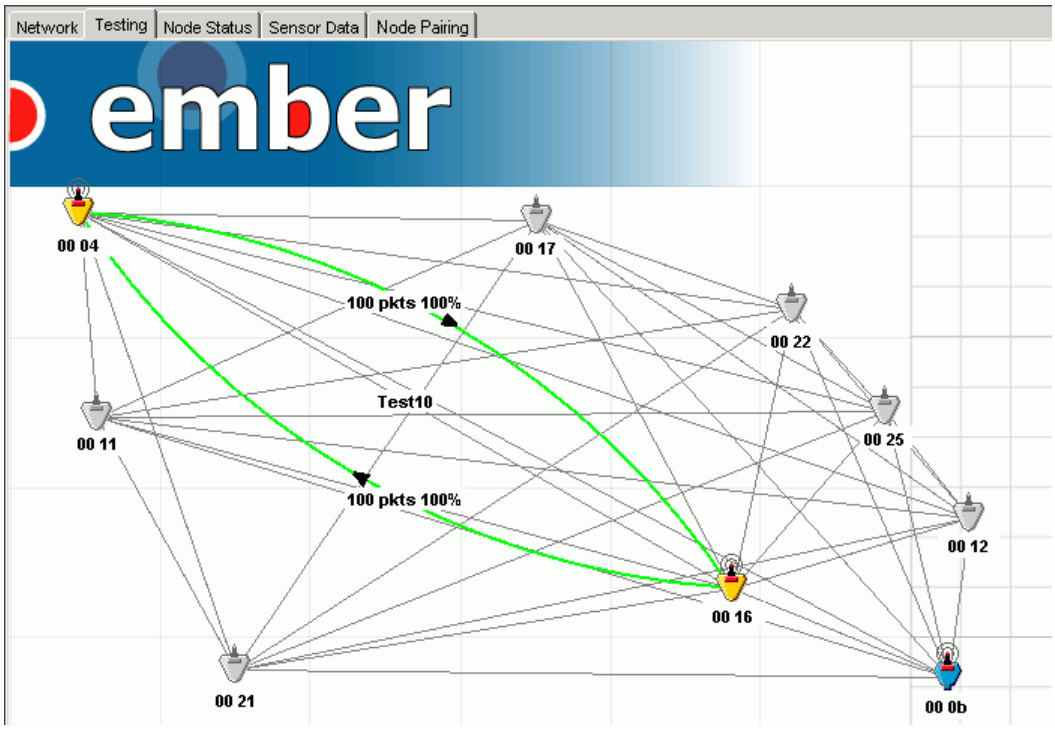
Interpreting the Ping Results Graphic

Ember Studio Lite displays the paths that ping packets traveled as lines superimposed on a ghosted version of the network map. The color, weight, and style of these lines can be configured to indicate the percentage of packets transmitted over a line (see "Configuring Ping and Trace Route Test Preferences" on page 79). The following table shows the default

ping display settings, which hold line weight and style constant and use only color to signify packet success rates:

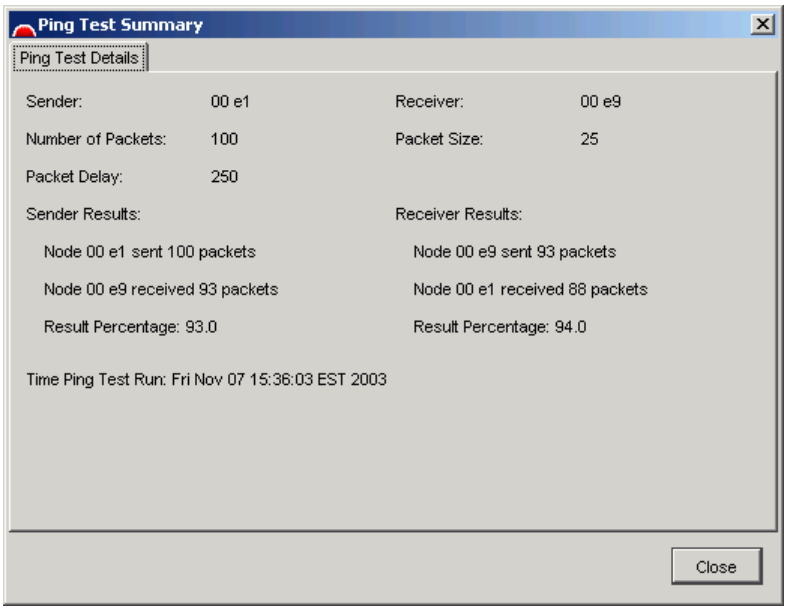
Color	Percentage of Packets
Green	76 – 100
Yellow	51 – 75
Red	26 – 50
Black	0 – 25

According to the default settings, the ping test depicted below had a 100 percent success rate, indicating a high-quality link between the two nodes.



Reading the Ping Test Reports

The Ping Test Results window provides an abbreviated report of the events in a ping test. To view a complete report, click *Details* to display the Ping Test Summary window.



Performing a Trace Route Test

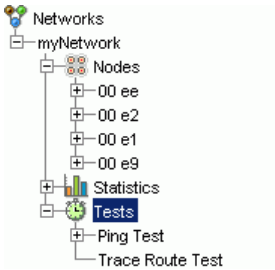
Running a Trace Route Test

For best results, observe the guidelines set out in "Ensuring a Successful Network Test" on page 65.

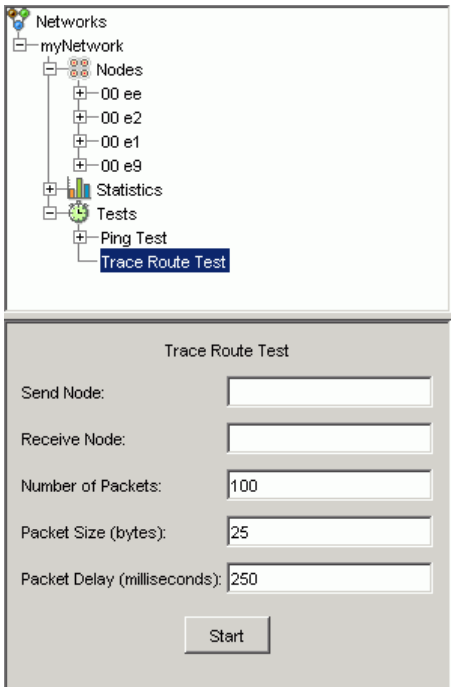
Note: Make sure power management is not enabled for the sender or receiver node in a trace route test (see "Using the Power Management Application" on page 30). Ember Studio Lite will display an error message if you attempt to run a trace route test on a node that is under power management.

- **To run a trace route test:**

1. Click the Tests folder in the folder tree. The folder tree expands to list the Ping Test and Trace Route Test folders:



2. Click the Trace Route Test folder. A test setup window displays:

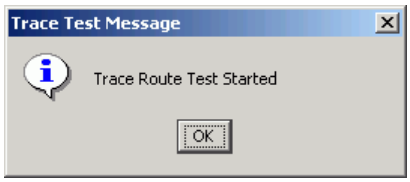


3. Enter parameters into the test setup window.

Note: Do not select the gateway node for the send or receive node.

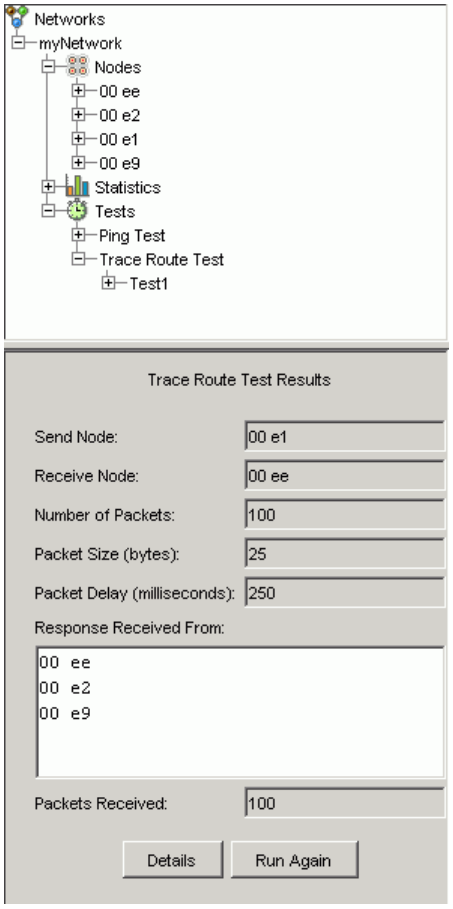
Send Node	Click the field, then click the send node in the network map, or enter the send node ID.
Receive Node	Click the field, then click the receive node in the network map, or enter the receive node ID.
Number of Packets	Enter a number from 1 to 999.
Packet Size (bytes)	Enter a number from 4 to 100.
Packet Delay (milliseconds)	Enter a number that, when plugged into the formula below, results in a value of 5 minutes or less: Number of packets times packet delay plus 60 seconds

4. Click *Start*. Ember Studio Lite displays a test initiation message:



5. Click *OK*. Ember Studio Lite displays the Trace Route Test Results window, which shows the progress of the test.

   When the test finishes, Ember Studio Lite places the results in a numbered subfolder in the Trace Route Test folder and the Trace Route Test Results window stops updating:



6. Click the Testing tab. Test results display in the View pane. See the following section for information on reading the test results.

7. Optional: To re-run the test with the same parameters, click *Run Again*. To re-run the test with different parameters, enter new parameters into the Trace Route Test Results window and click *Run Again*.

Reading Trace Route Test Results

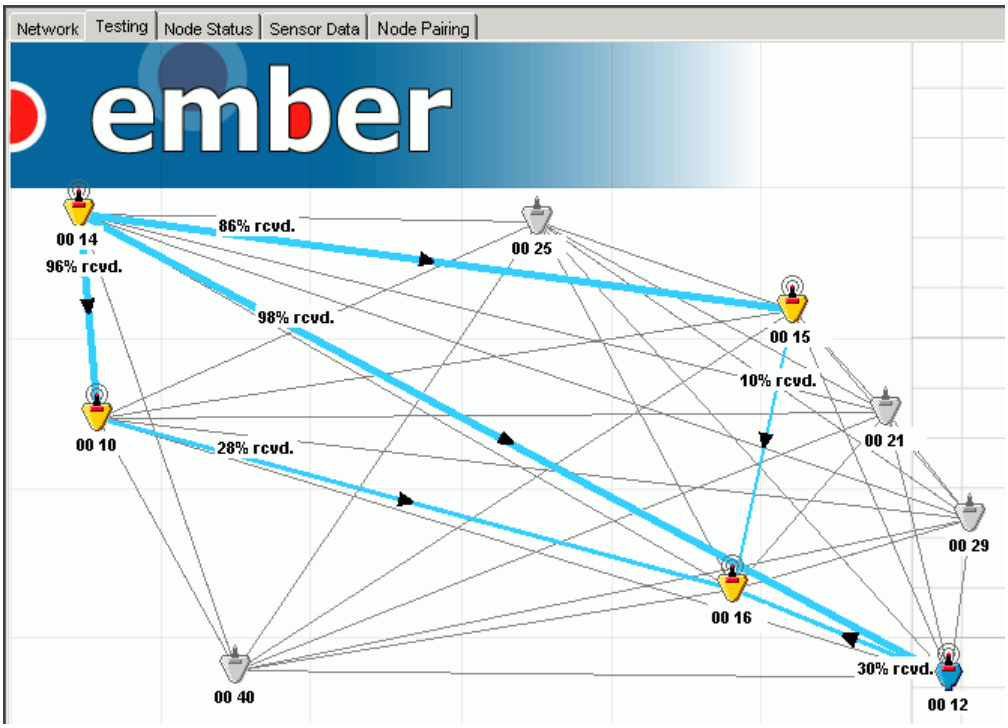
Reading the Trace Route Graphic

Ember Studio Lite displays the paths that trace route packets traveled as lines superimposed on a ghosted version of the network map. The color, weight, and style of these lines can be configured to indicate the percentage of packets transmitted over a line (see "Configuring Ping and Trace Route Test Preferences" on page 79). The following table shows the default

trace route display settings, which hold color and line style constant and use only line weight to signify packet success rates:

Line Weight	Percentage of Packets
▬	76 – 100
▬	51 – 75
▬	26 – 50
▬	0 – 25

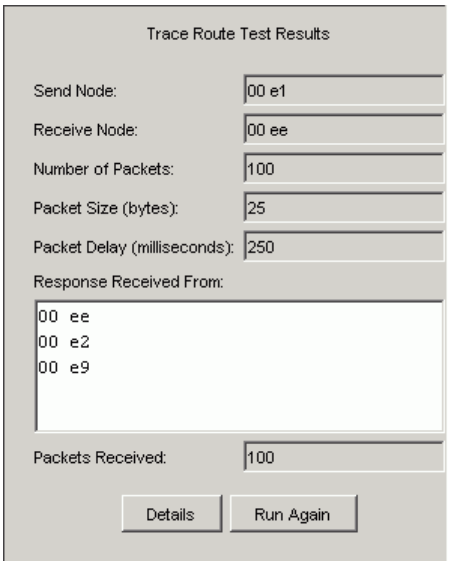
According to the default settings, during the test whose results are depicted below certain node links transmitted a higher percentage of packets than others, indicating variation in the quality of the links.



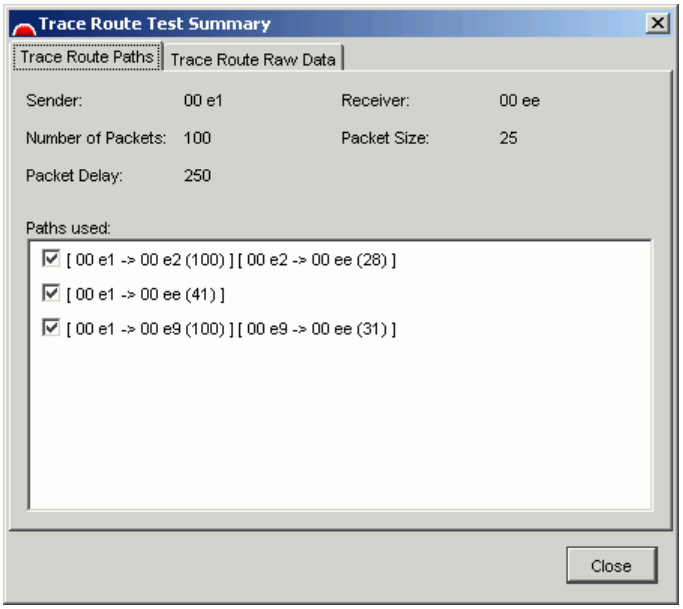
The depicted network is a simple one, and thus it is easy to discern all the paths that data took to move from the send to the receive node. If you are performing a trace route test on a complex network, the result lines may collide and be difficult to read. You can make such a confusing result graphic easier to read by selectively displaying lines; for information on doing this, see "Reading the Trace Route Test Summary" on page 77.

Reading the Trace Route Test Summary

The Trace Route Test Results window provides an abbreviated report of the events in a trace route test:



To see a complete report, click *Details* to display the Trace Route Test Summary window:

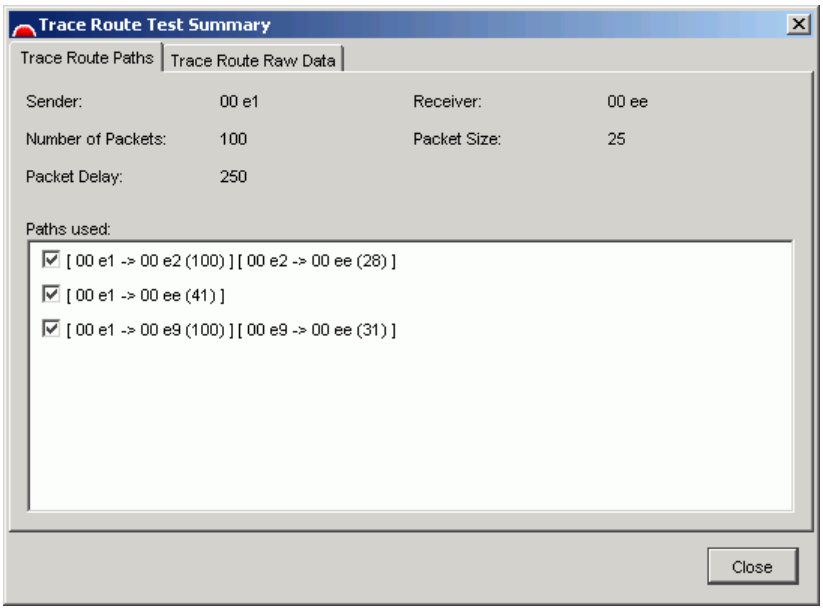


The tabs in this window provide different views of the test results:

- **Trace Route Paths:** Shows test results for each path and allows you to selectively turn paths on and off in the results map, to obtain a clearer view of a complicated test result pattern.
- **Trace Route Raw Data:** Displays raw test result data for either nodes on the trace route path or for all nodes.

- **To selectively display trace route paths in the test results map:**

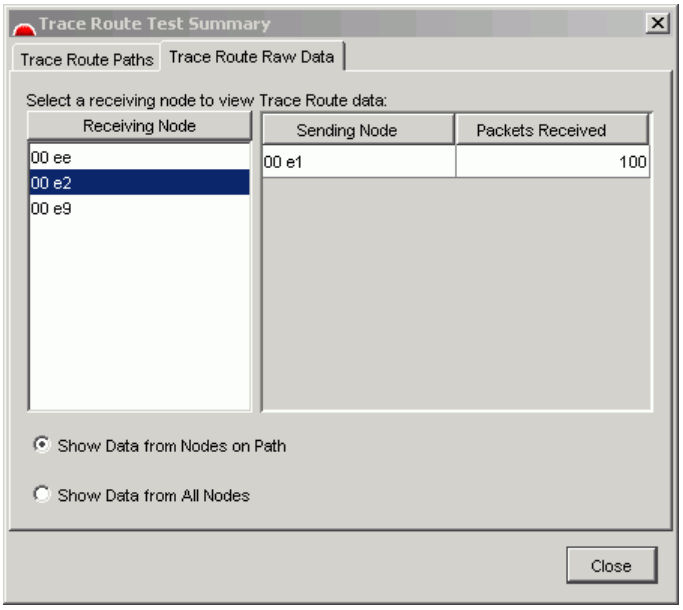
  Click the Trace Route Paths tab and select or deselect checkboxes to display or hide paths in the results map.



- **To selectively view raw data from nodes on the trace route path or from all nodes:**

  Click the Trace Route Raw Data tab, then:

  - Click a receiving node to see the nodes that sent packets to it and the number of packets sent.
  - Select whether to show data for all nodes or only nodes on the trace route path.



Viewing Results of Previously Run Tests

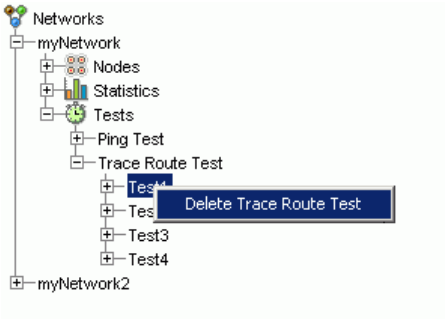
Click a test results folder, then click the Testing tab. The graphical and text results display.

Deleting Test Results

You can delete some or all test results. Be careful when deleting test results, because they cannot be recovered.

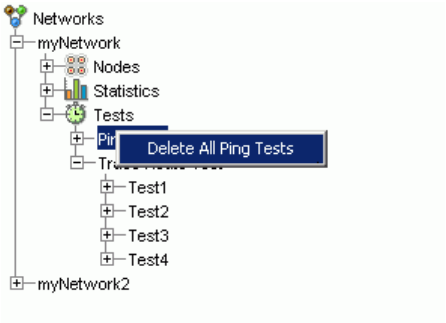
- **To delete tests results one at a time:**

  Right-click a test result folder and select the pop-up:



- **To delete all tests:**

  Right-click the Ping Test or Trace Route Test folder and select the pop-up.



Configuring Ping and Trace Route Test Preferences

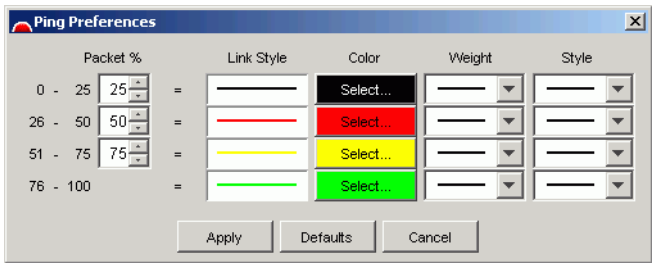
The color, line weight, and style of the lines in ping or trace route test results indicate the percentage of packets that traveled over a given leg of the test route. You can configure preferences for these display variables.

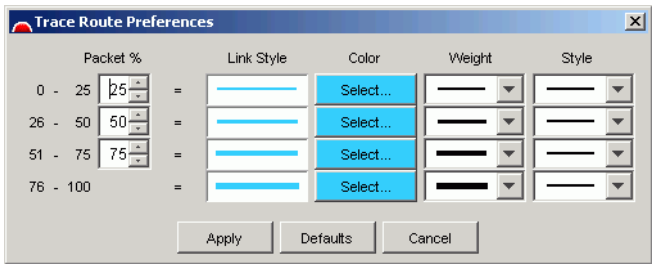
Note: We recommend using **one color and line style** for trace route test result lines. Using a single color and line style minimizes visual clutter on the screen when the results involve many lines. In most cases, the varying line weights are sufficient to visually distinguish the routes.

- **To change the color, weight, or style of test result lines:**

  1. Click the Testing tab.

2. Right-click anywhere in the Testing window and select *Ping Preferences* or *Trace Route Preferences*. One of the following windows displays:





3. Optional: Change the percentage of packets to which a given preference applies. By default the preferences are equally divided at 25 percent each.
4. Select a line style, color, and line weight from their respective drop-down menus. To configure color, click the color box, then select a color from the palette that displays.
5. Click *Apply*. The new settings take effect immediately.

■ **To restore the default ping or trace route preferences:**

To restore the defaults, display a preferences window as describe above, click *Defaults*, then click *Apply*. The default settings take effect immediately.

CHAPTER 9 Uploading EmberNet Upgrades

Obtaining EmberNet Upgrades 81
Uploading a New EmberNet Image to Modules 81

Obtaining EmberNet Upgrades

Ember will notify you when an EmberNet upgrade is available and upon your request will mail you a CD containing the binary.

Uploading a New EmberNet Image to Modules

Ember Studio Lite includes a wizard to help you to upload a new EmberNet image to your modules.

Note: You must upload the new image to **every module** in your kit. Failure to do so may cause Ember Studio Lite to behave in an unpredictable manner.

A module must be connected to the computer via a serial port before the image can be uploaded. If you are uploading via a serial port connected to a gateway node, the network will shut down when the upload begins.

Caution! When performing this procedure, use only the serial adapter cable provided in your Evaluation Kit. Using any other serial adapter cable can severely damage the module microprocessor.

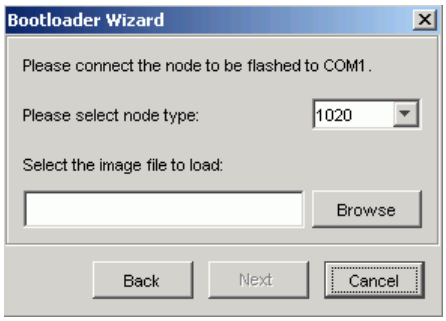
- **To upload a new EmberNet image to a module:**

1. Using the serial adapter cable that came with your Evaluation Kit, connect the module to a port on your computer that has been assigned to COM1. Turn the module on if necessary.

   Note: The module will not appear in the network map.

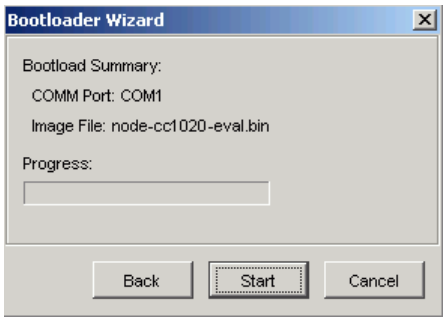
2. Select *Edit* > *Bootload Wizard*. The Bootload Wizard displays:

3. Enter a COMM port or accept the default and click *Next*. The next wizard window displays:

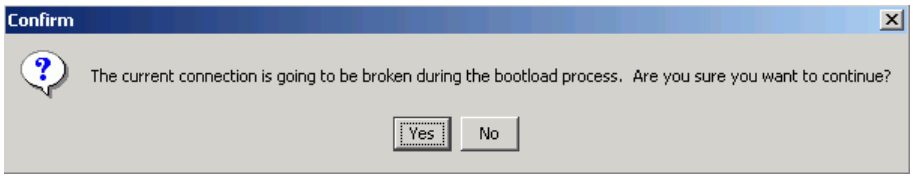


4. Select the node type according to the type of Ember Evaluation module you purchased (EM2420 or CC1020).

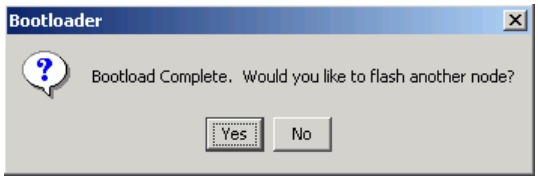
5. Browse to the image (.bin) file to be uploaded or enter the file into the textbox and press *Next*. The next wizard window displays:



6. Click *Start*. The wizard informs you that if you are using a serial port that is running a network, the network connection will close when the upload begins:



7. Click *Yes*. The wizard displays a progress bar as it uploads the image. When the upload is complete, the icon for the module appears in the network map, and the the following window displays:



8. Do one of the following:

   - Click *Yes* to upload the image to another module. The first window of the wizard displays. Repeat steps 2 to 6.
   - If your computer is providing the local connection for a network, reconnect the gateway node to the serial port, then click *No* to close the wizard. Otherwise, just click *No*. If you do not reconnect a network gateway to the serial port before closing the wizard, you will have to open the connection wizard to reconnect the gateway module to the network. (For information on using the connection wizard, see "Using the Network Connection Wizard" on page 46.

APPENDIX A Ember Studio Lite Quick Reference

Network Connections 84
Network Map 85
Node Management 86
Network Testing 86
Sensor Data 87
Node Pairing 88
General Tasks 88

Topic	To Do This	Perform These Actions
Network Connections	Connect to a new network	1. Click the folder for the network to which Ember Studio Lite is connected. 2. Click *Disconnect*. 3. Select *Connect to Remote Network* or *Create New Local Network*. 4. Enter values into the Name, IP Address, and Port fields. 5. Click *Connect*.
	Switch to a different network	1. Click the folder for the network to which Ember Studio Lite is connected. 2. Click *Disconnect*. 3. Click a different network in the folder tree. 4. Click *Connect*.
	Delete a network connection	Right-click the network folder and select *Delete Network*.
	Configure a network connection	For important information on configuring for optimum performance, see "Changing Network Settings" on page 48. 1. Click the network folder in the folder tree. 2. Click *Settings*. 3. Enter values in to the configurable fields. 4. Click *Apply*.

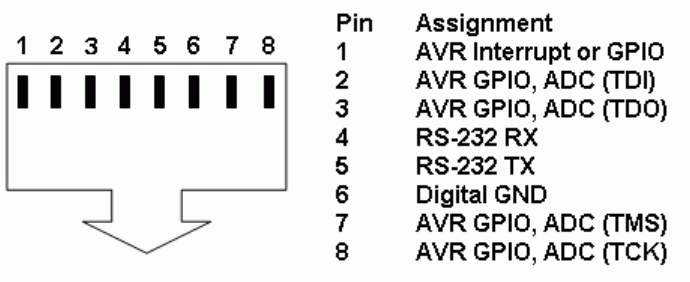
Topic	To Do This	Perform These Actions
Network Map	View the map	Click the Network tab.
	Refresh the map	Three methods: • Click the Refresh button in the toolbar. • Right-click the map and select *Refresh*. • Select *Edit* > *Refresh*.
	Rearrange map icons	Drag icons to new positions on the map.
	Zoom the map	Right-click the map and select a zoom value.
	Pan the map	Hold the mouse button down until the cursor changes to a pointing finger, then, with the mouse button down, move the cursor.
	Display custom node icons	1. Right-click the map and select *Node Preferences*. 2. Browse to locate new icon files. 3. Select one or more icon files and click *Open*. 4. Click *Apply*.
	Hide or show error nodes	Two methods: • In the main menu, select *View* > *Show Nodes With Error*. OR 1. Right-click the map and select *Node Preferences*. 2. Select *Hide node*. 3. Click *Apply*.
	Change the color, weight, or style of node link lines	1. Right-click the map and select *Link Preferences*. 2. Select color, line weight, and line style preferences. 3. Click *Apply*.
	Restore default preferences for node icons or link lines	1. Right-click the map and select *Link Preferences* or *Node Preferences*. 2. Click *Defaults*. 3. Click *Apply*.
	Display a custom background image	1. Right-click the map and select *Set Background Image*. 2. Browse to locate the new background image file. 3. Select the file and click *Open*.
	Display the default background image	Right-click the map and select *Remove Background Image*.

Topic	To Do This	Perform These Actions
Node Management	View node status	Click the Node Status tab.
	View node statistics	1. Double-click the Statistics folder in folder tree. 2. Enter a polling frequency in the Statistics Period field. 3. Enter number of times to poll network in Statistics Count field. 4. Select nodes to poll and statistics. 5. Click *Done*.
	View a node's parameters	Click a node folder in the folder tree.
	View properties for all nodes	Two methods: • Double-click a node in the network map. • Double-click the Nodes folder in the folder tree.
	Set node properties	See Table 7-2 for a list of configurable properties. 1. Double-click a configurable property. 2. Enter a new value and click *Apply*. 3. Click *Done*.
Network Testing	Run ping test	1. Click the Tests folder in the folder tree, then click the Ping folder. 2. Enter values in the Ping Test configuration window. 3. Click *Start*.
	Run trace route	1. Click the Tests folder in the folder tree, then click the Trace Route folder. 2. Enter values in the Trace Route Test configuration window. 3. Click *Start*. 4. To view results, click the numbered test result folder under Trace Route Test, then click the Testing tab.
	View test results	Click the numbered test result folder, then click the Testing tab. A test report displays in Context pane. To view an expanded report, click *Details*.
	Selectively display paths in trace route results map	1. Click *Details* in the Trace Route Test Result window. 2. Click the Trace Route Paths tab. 3. De-select checkboxes to turn off lines.

Topic	To Do This	Perform These Actions
	View and filter trace route raw data	1. Click *Details* in the Trace Route Test Result window. 2. Click the Trace Route Raw Data tab. 3. Select a node to view its raw data. Select a checkbox to view data from all nodes or path nodes only.
	Delete one test	Right-click the test result folder.
	Delete all tests	Right-click the Ping Test or Trace Route Test folder.
	Change the color, weight, or style of test result lines	1. Right-click the Testing window and select *Ping Preferences* or *Trace Route Preferences*. 2. Optional: Change the percentage of packets to which a given preference applies. 3. Select color, line weight, or line style preferences. 4. Click *Apply*.
	Restore the default preferences for ping or trace route result lines	1. Right-click the Testing window and select *Ping Preferences* or *Trace Route Preferences*. 2. Click *Defaults,* then click *Apply*.
Sensor Data	Stimulate module sensors	See "Obtaining Sensor Data" on page 30 for ideas.
	Collect sensor data	1. Click the Sensor Data tab. 2. Do one: ◆ Double-click a node in the network map. ◆ Click a node folder in the folder tree. 3. Select data checkboxes. 4. Select a report type. 5. Specify a report interval. 6. Click *Apply*. 7. Stimulate module sensors.
	View graphed sensor data	1. Click the Sensor Data tab. 2. Click a graph button.
	View raw sensor data	Click the Sensor Data tab.
	Turn on power management	Select *Power Management* in the Sensor Data window.

Topic	To Do This	Perform These Actions
Node Pairing	View map of paired nodes	Click the Node Pairing tab.
General Tasks	View help	Select *Help* > *Documentation*.
	Print the main window	Click the Print button in the toolbar, or select *File* > *Print*.

APPENDIX B Ember Evaluation Module Technical Features

Feature	Description	
Dimensions	Triangular shape, 6.35 cm on each side, 2.5 cm deep	
	0°C – 70°C	
Radio	CC1020 or EM2420 (For detailed specifications, see the datasheet.)	
	EM2420	**CC1020**
Operating frequency	North America and Europe: 2.400 – 2.483GHz	North America: 902–928MHz Europe: 868MHz
Power	0dBm – 25dBm	-25dBm to + 5dBm
Channels	16 channels	902 – 928MHz: 49 channels 868MHz: 4 channels
Antenna	North America and Europe: Tuned for 2.4GHz	North America: Tuned for 915MHz Europe: Tuned for 868MHz
	Omni-directional high-performance 1/4-wave monopole antenna with a right-angle RP-SMA female connector	
Processor	Atmega 128	
Data interface connector	RJ45 serial jack, not Ethernet compliant, with the following pin assignments:	
		
Power connector	DC power jack	

Feature	Description
Batteries	Two AAA batteries
Sensors	• Temperature sensor Range: -55°C to +130°C Maximum: +/- 5°C • Two-axis accelerometer (Y and X) Range: + / - 2*g* in any dimension Maximum: 3500*g*, 0.5 ms **Note:** Do not operate the module outside of the operating temperature limits described above.
Indicators	• Four LEDs (listed in order from top to bottom; the arrow in figure 1-1 points to the first LED): 1. Network traffic 2. Unspecified 3. Unspecified 4. Power/heartbeat • Programmable button • Piezoelectric buzzer
Software	EmberNet networking application
Certifications	FCC Part 15 compliant CE (EN 300 220-3 v1.1.1 and EN 301 489-3 v1.1.1) Industry Canada RSS-210

APPENDIX C Module Radio Settings

Transmission Power Settings 91
EM2420 91
CC1020 92
Radiofrequency Channel Settings 93
EM2420 93
CC1020, 868MHz 93
CC1020, 915MH 94

Transmission Power Settings

EM2420

Setting	Power
0	-13
1	-13
2	-11
3	-10
4	-10
5	-10
6	-8
7	-7
8	-7
9	-7
10	-6
11	-5

Setting	Power
12	-5
13	-5
14	-4
15	-3
16	-3
17	-3
18	-2
19	-2
20	-2
21	-2
22	-1
—	—

CC1020

Setting	Power	Setting	Power
0	-25	10	-15
1	-24	11	-14
2	-23	12	-13
3	-22	13	-12
4	-21	14	-11
5	-20	15	-10
6	-19	16	-9
7	-18	17	-8
8	-17	18	-7
9	-16	19	-6

Radiofrequency Channel Settings

EM2420

Channel	Frequency
0	2.405
1	2.410
2	2.415
3	2.420
4	2.425
5	2.430
6	2.435
7	2.440

Channel	Frequency
8	2.445
9	2.450
10	2.455
11	2.460
12	2.465
13	2.470
14	2.485
15	2.480

CC1020, 868MHz

Channel	Frequency
50	863.250
51	863.750
52	864.250
53	864.750

CC1020, 915MH

Channel	Frequency	Channel	Frequency
1	902.791	25	915.430
2	903.318	26	915.957
3	903.845	27	916.484
4	904.371	28	917.010
5	904.898	29	917.537
6	905.425	30	918.064
7	905.951	31	918.590
8	906.478	32	919.117
9	907.004	33	919.643
10	907.531	34	920.170
11	908.058	35	920.697
12	908.584	36	921.223
13	909.111	37	921.750
14	909.638	38	922.277
15	910.164	39	922.803
16	910.691	40	923.330
17	911.217	41	923.857
18	911.744	42	924.383
19	912.271	43	924.910
20	912.797	44	925.436
21	913.324	45	925.963
22	913.851	46	926.490
23	914.377	47	927.016
24	914.904	48	927.543

APPENDIX D Ember Serial Command Set Reference

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About the Ember Serial Command Set

You can use the Ember Serial Command Set to write small sample applications that you can run over your networked Ember Evaluation Kit modules. You can also directly address these commands to modules via a terminal emulator, such as Hyperterm or Tera Term, to immediately observe the transmission of data through the network.

Command Syntax

A Serial Command Set command consists of a single line listing the command name and followed by zero, one, or two whitespace-separated parameters:

```
command parameter parameter
```

Command parameters can consist of:

- Numbers (for local IDs)
- ASCII strings enclosed in quotation marks
- Binary messages enclosed in square brackets. For binary messages, the first byte must give the number of following bytes, not including the closing bracket.

The local ID is a number that uniquely identifies each module in an Evaluation Kit. Only Serial Command Set commands call modules by their local ID. To determine the local ID of a module, run the `local_id` command. Under certain circumstances, you may want to reset module local IDs (see "Resetting Local IDs" on page 101).

Commands

deliver

Repeatedly sends an unacknowledged message to a specified node, until the node returns an acknowledgment. (Abbreviation: `d`)

Parameters

Single integer consisting of a device ID
ASCII string in quotation marks *OR* binary message in square brackets (maximum length: 80 chars or bytes)

Example

```
deliver 2 "hello node 2"
```

broadcast

Broadcasts a message to all nodes. (Abbreviation: `b`)

Parameters

ASCII string in quotation marks *OR* binary message in square brackets (maximum length: 80 chars or bytes)

Example

```
broadcast "hello all"
```

local_id

Queries a device for its local ID number. (Abbreviation: `l`)

Parameters

None

Example

```
local_id
```

ping

Pings a specified node. (Abbreviation: `p`)

Parameters

Single integer consisting of a local ID

Example

```
ping 2
```

ping_all

Broadcasts a ping to all nodes. (Abbreviation: `a`)

Parameters

None

Example

```
ping_all
```

reset

Empties the message queue for a specified node and resets the connection. (Abbreviation: `r`)

Parameters

Single integer consisting of a local ID

Example

```
reset 1
```

set_channel

Sets the radio channel of the gateway node. (Abbreviation: none available)

Parameters

EM2420:

- Single integer with value of 0 to 15

CC1020:

- 915MHz radio: Single integer with value of 1 to 49
- 868MHz radio: Single integer with value of 50, 51, 52, or 53

Example

```
set_channel 3
```

set_local_id

Sets the local ID for a node. (Abbreviation: none available)

Be careful when resetting local IDs. See "Resetting Local IDs" on page 101 for important information.

Parameters

Single integer

Example

set_local_id 14

set_power

Sets the radio power of the gateway node to a specified value. (Abbreviation: none available)

Parameters

Single integer with value of 0, 1, or 2

Example

```
set_power 1
```

status

Queries a specified node for its channel and power settings. (Abbreviation: none available)

Parameters

Single integer consisting of a local ID

Example

```
status 2
```

Responses

Responses from Ember Serial Nodes have the same format as commands. Table D-1 lists some sample responses. Note that a status report is printed after every reboot.

Table D-1: Sample Command Responses

Response	Meaning
`datagram 3 "hello device 3"`	Response from node 3 to a send command
`unicast 3 "hello device 2"`	Response from node 2 to a deliver command
`broadcast 3 "hello everyone"`	Broadcast from node 3
`ping_reply 4`	Ping response from node 4
`local_id 2`	Node 2 reporting its local ID
`device 2 on channel 12 at power 0`	Status report for node 2

Error Messages

All error messages except for delivery errors consist of the word "error," a two-digit hexadecimal number giving the type of error, and a single parameter consisting of an ASCII string:

```
error hex_error_num string
```

Table D-2 lists all possible error messages.

Table D-2: Serial Command Set Error Messages

Message	Meaning
`error 01 "serial port error"`	The serial port detected an error, such as a parity error (if enabled) or a garbled byte. If you receive this message, check cables.
`error 02 "command processor busy"`	Commands were sent too fast for the processor.
`error 03 "no such command"`	A command contained one or more of the following mistakes: • Command was mistyped. **Example:** `sned` • Out-of-range value was specified. **Example:** `set_power 4`
`error 04 "incorrect command arguments"`	Illegal parameters were appended to a command. **Example:** `broadcast 3 "hello all"`
`error 05 "integer argument out of range"`	Out-of-range value was specified for command. **Example:** `send 1000 "hello"`, for a 5-node network
`error 06, "argument syntax error"`	Illegal value was specified for a numeric parameter. **Examples:** 2.2, O
`error 07, "message too long"`	String/binary parameter exceeded 80 characters or bytes. **Example:** `send 3 "on and on and ..."`
`error 08 "missing binary message terminator"`	Binary parameter to a command does not end with a closing square bracket ("]").
`error 09, "broken connection"`	Gateway node could not reach the device specified in command.
`error 0A, "outgoing message pipeline full" NUM` (where NUM is a device ID)	Message queue for the specified node is full.

Resetting Local IDs

If you purchased more than one Evaluation Kit and would like to write sample applications addressing any of your modules, you will need to reset the local IDs for all of your modules, because the modules in each of your kits have the same set of local IDs (1 to 12).

Note: **Be careful when resetting local IDs.** If two or more modules are accidentally assigned the same local ID, their behavior will become erratic and networks including the modules will malfunction. For this reason, do not reset local IDs unless you need to consecutively number the modules in two or more Evaluation Kits.

- **To reset a local ID:**

Caution! Use only the serial adapter cable provided in your Evaluation Kit. Using any other serial adapter cable can severely damage the module microprocessor.

1. Connect the module to a PC using the Evaluation Kit serial adapter cable.
2. Open a terminal emulator and configure it as described in "Configuring a Terminal Emulator for the Serial Command Set" on page 101. If you are working on a Microsoft Windows machine, we suggest that you use the built-in HyperTerminal program, which is available from the *Start* > *Programs* menu.
3. Identify the module's current local ID by running the `local_id` command.
4. Assign a new local ID to the module by running `set_local_id` command. Valid ID numbers are 0 to 255.
5. Optional: Physically label the module with its new local ID.

Configuring a Terminal Emulator for the Serial Command Set

Configure the terminal emulator being used to run Serial Command Set commands as follows:

- Terminal window:
  - Handle EOLs as CR/LFs
  - Echo typing, if desired
- Serial port:
  - Data rate: 19200
  - Parity: None
  - Stop bits: 1
  - Data bit: 8
  - Flow control: XON/XOFf