Millennial Net

MeshScape™

Commercial- and Industrial-class Wireless Sensor Networks

RK-5409-5 Reference Kit

for 916 MHz MeshScape Systems

User's Guide

Document Number: DOC-0051
Revision: 01
Released: August 2005

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CAUTION

Initialization of the product should be performed only by a qualified systems administrator.

Compliance Statements

FCC Compliance

FCC compliance for Millennial Net's RK-5409-5 Reference Kit (916MHz, 5-3-1) consisting of the following models/components:

- EN-5409 end node
- MN-5409 mesh node
- MG-5409 MeshGate gateway

Compliance Statement (Part 15.19)

The Millennial Net RK-5409-5 Reference Kit complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada.

Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and

(2) 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.

Unlicensed Modular Approval (for OEMs)

The URM-G-916 complies with the FCC's 47CFR Part 15 rules and regulations as well as Part 15 Unlicensed Modular Approval as outlined in DA 00-1407. Compliance with the Modular Approval rules allows an OEM to integrate the URM-G-916 into other products without further FCC certification of the intentional radiator, but an OEM must still test their final product to comply with unintentional radiator requirements of 47CFCR Part 15.

Under the Modular Approval rules, an OEM must comply with the following when integrating the URM-G-916 into an end product:

1. The OEM must ensure that FCC labeling requirements are met. This shall include a clearly visible label on the exterior of the end product with the following nomenclature:

   Contains FCC ID: R8N-URM-G-916

2. The OEM must only use the reverse-SMA antennas listed below when integrating the device into an end product. These antennas have been tested and approved for use with the URM-G-916. Integrating the module using any other antenna will require testing to ensure compliance with FCC rules and regulations.

   Mobile Mark ½ wave Antenna Part Number: PSKN3-925RS

Nearson ½ wave Antenna Part Number: S467AH-915S

Linx ¼ wave Antenna Part Number: ANT-916-CW-QW

3. The OEM must use the same cable type and of the same length or longer than that defined below. Use of another cable type or of a shorter length will require testing to ensure compliance with FCC rules and regulations.

RF Cable type: RG174

RF Cable Length: 5.9" +/- 0.13"

Millennial Net Cable P/N: CBL-0008-01

Industry Canada Compliance Statement

This device has been designed to operate with an antenna having a maximum gain of 2.65 dB. Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 Ohms.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (EIRP) is not more than that required for successful communication.

OEM Integration

The module has the same requirements for integration into an OEM product for Industry Canada as it does for FCC. The only difference being the labeling nomenclature required on the exterior of the OEM product. The following must be clearly visible on the exterior of the OEM product:

Contains IC: 5127A-URMG916

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Information subject to change.

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About This Guide

This section provides information related to the content of the user guide:

- ‘Audience’ on page xvi
- ‘Using This Guide’ on page xvi
- ‘Symbols and Conventions’ on page xvii
- ‘Contacting Millennial Net’ on page xviii

Audience

This guide is intended for the following qualified service personnel who are responsible for installing, operating, and developing software to interface with the RK-5409-5 MeshScape Wireless Sensor Network Reference Kit:

- System installer
- Hardware technician
- System operator
- System administrator
- Software developer

Using This Guide

The sections of this guide provide the following information:

Section	Provides
Chapter 1, "Introduction"	General overview of wireless sensor networking and the MeshScape™ system.
Chapter 2, "Installing the MeshScape System"	Instructions for installing the components of the RK-5409-5 MeshScape Wireless Sensor Network Reference Kit (MeshGate, mesh nodes, end nodes) and MeshScape Network Monitor (GUI).
Chapter 3, "Running MeshScape Network Monitor"	Procedures for using MeshScape Network Monitor software to configure the MeshScape System nodes. Also includes information for attaching external I/O devices to an end node or mesh node.
Chapter 4, "Using the MeshScape API"	Information on the MeshScape API functions.
Appendix A, "Sample Application"	Procedure for running the sample application provided with the reference kit.
Appendix B, "Performing Firmware Upgrades and Configuring Device IDs"	Instructions for upgrading the firmware on MeshScape devices and reprogramming the group and device IDs.
Glossary	Defines terminology associated with wireless sensor networking and the MeshScape system.
Index	An alphabetical index of topics described in this manual.

Symbols and Conventions

This guide uses the following symbols and conventions to emphasize certain information.

Note: A note is used to highlight important information relating to the topic being discussed.

Caution

A caution means that a specific action could cause harm to the equipment or to the data.

Warning

A warning describes an action that could result in physical injury, or destruction of property.

Hazard

A hazard is a particular form of warning related expressly to electric shock.

Italics - Indicate the first occurrence of a new term, book title, and emphasized text.

1. Numbered list - Where the order of the items is important.

- Bulleted list - Where the items are of equal importance and their order is unimportant.

Contacting Millennial Net

World Wide Web

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www.millennialnet.com

Customer Support

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phone:
+1 781.222.1030

e-mail:
support@millennialnet.com

Technical Publications

Millennial Net is committed to providing you with quality technical documentation. Your feedback is valuable and appreciated. Please send comments, suggestions, and enhancements regarding this guide or any Millennial Net documentation to:

support@millennialnet.com

Please include the document title, number, and version in your email.

Additional Resources

To obtain additional resources and information about wireless sensor networking and the development and deployment of MeshScape-based applications, visit the resources page on our Web site at:

www.millennialnet.com/resources

There you will find links to:

- Application notes
- Articles
- Brochures and data sheets
- Case studies
- Industry notes
- Source book
- White papers

1

Introduction

This chapter provides an overview of the MeshScape system and Reference Kit. In this chapter you will find:

- 'Wireless Sensor Networking Overview' on page 1-2
- 'MeshScape System Overview' on page 1-6
- 'The MeshScape RK-5409-5 Reference Kit' on page 1-10

Wireless Sensor Networking Overview

This section provides you with a basic understanding of wireless sensor network concepts and components.

Defining Wireless Sensors Networks

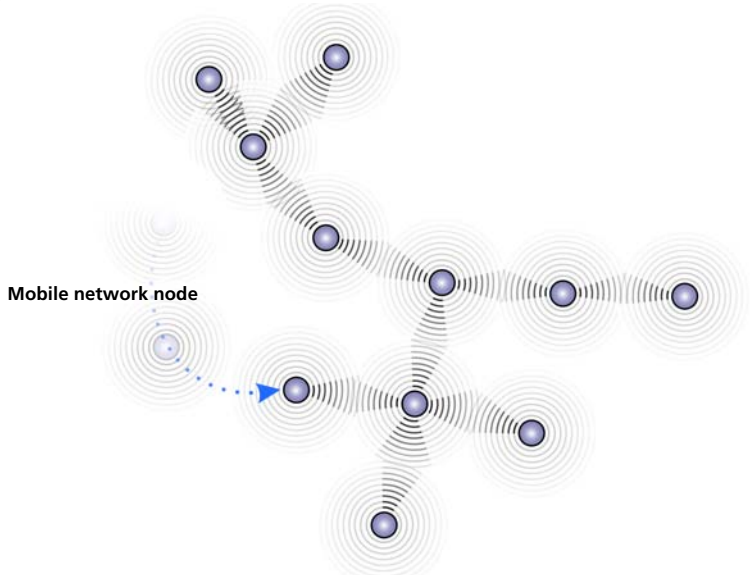
Until recently, networks designed for monitoring and controlling sensors or actuators on a network were limited in application and scope due to a major network design consideration—the cables required to connect the various sensors and actuators to a centralized collection point. In addition to the costs associated with installing and maintaining communication cables (fiber optic or copper), this type of network infrastructure prevents sensor mobility and severely limits the feasible applications of such a network.

Thanks to significant advances in low-power radio and digital circuit design, self-organizing wireless sensor networks are now a reality. Sensors of all types (temperature, motion, occupancy, vibration, etc.) can now be wirelessly enabled and deployed inexpensively and quickly.

Wireless sensor networks fundamentally change the economics of deploying and operating a sensor network, unlocking opportunities to achieve new efficiencies in production processes, building control, or monitoring, to name just a few. Wireless sensor networks also enable the development of a brand new class of applications and services not previously possible with wired sensor networks.

As illustrated in Figure 1-1, wireless sensor networks form what is called a wireless ad hoc network, which refers to a network's ability to self-organize and self-heal. This means there are no administrative duties associated with establishing and maintaining a wireless sensor network. By comparison, a wired infrastructure network, such as the LAN found in most office environments, requires a significant amount of overhead to install and maintain in terms of cabling and administrative time.

Figure 1-1. Untethered, mobile ad hoc network nodes



In an ad hoc network, sensor nodes consisting of a sensor attached to a wireless module can be randomly placed and moved as needed. If the network needs to scale up, additional sensor nodes are easily added. The new sensor nodes and surrounding network will do the work of discovering each other and establishing communication paths through single- and multi-hop paths. All this is made possible through the use of robust, efficient network protocols developed specifically for wireless sensor networks.

Wireless Sensor Network Components

This section describes the software and hardware that comprise a wireless sensor network.

System Software

The software required to integrate and operate a wireless sensor network resides as firmware in the system modules and in the application platform as a set of API functions or network monitoring system (NMS).

Module Firmware

Module firmware is a small, efficient piece of code that incorporates the module into a larger ad hoc network. It "drives" the module's operation as part of the larger ad hoc network.

The firmware is also responsible for packaging the analog and digital sensor data into digital packets and delivering them across the wireless sensor network.

API

An API, or application programming interface, is a set of commonly used functions for streamlining application development. Used by application developers, an API provides hooks to integrate the application platforms with the modules on the wireless sensor network.

API functions are grouped into "libraries." In wireless sensor networks, there are two different API libraries:

- High-level library: These functions are used to integrate the application with the gateway module.
- Low-level library: These functions are used to integrate the sensor/actuator with the end node module.

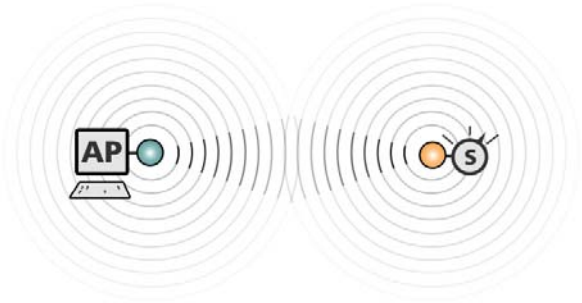
Network Monitoring System

A network monitoring system (NMS) is software used to interface with a particular wireless sensor network, eliminating the need for any programming. Through the NMS's graphical user interface (GUI), network operators are able to see the various nodes of their wireless sensor network. Depending on the type of network, control commands can also be issued through the NMS. For example, a pin on a digital interface between an end node and an actuator can be set to high to change the state of the actuator.

System Modules

The modules of a wireless sensor network enable wireless connectivity within the network, connecting an application platform at one end of the network with one or more sensor or actuator devices at the other end. As shown in Figure 1-2, the gateway and end node modules create a transparent, wireless data path between the application platform and sensor.

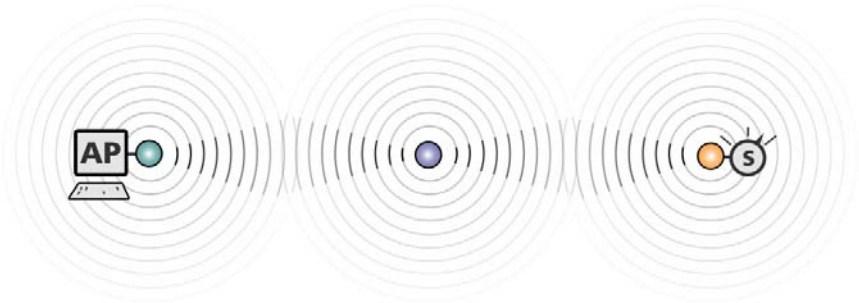
Figure 1-2. Basic wireless sensor network components



Exchange of analog or digital information between an application platform and one or more sensor nodes takes place in a wireless fashion. In this example, the data path between the gateway and end node is referred to as a *single-hop* network link.

To extend the range of a network or circumvent an obstacle, a wireless mesh node module can be added between a gateway and an end node as shown in Figure 1-3.

Figure 1-3. Adding a mesh node module



This particular example represents a multi-hop data path, in which data packets are handed off from one module to the next before reaching their destination (gateway-to-mesh node-to-end node and vice versa).

More elaborate network layouts are discussed later in Network Topologies," but for now, we'll take a closer look at each of the network components shown in Figure 1-3.

Application Platform

This is the network device (Network Controller, PC, handheld, etc.) used to monitor and control the actions of the various sensors and actuators that are connected to the wireless sensor network. The application platform is capable of making decisions based on the information it gathers from the network. Typically, the wireless sensor network will come with an API and/or a GUI used to interface with the wireless modules.

Gateway

The gateway is the interface between the application platform and the wireless nodes on the network. The gateway can be a discrete module, or it can be integrated onto a Flash card form factor for a handheld device, for example. All information received from the various network nodes is aggregated by the gateway and forwarded on to the application platform. In the reverse direction, when a command is issued by the application program to a network node, the gateway relays the information to the wireless sensor network. The gateway can also perform protocol conversion to enable the wireless network to work with other industry-standard network protocols.

Mesh Node Module

Considered full-function devices (FFD), mesh node modules (sometimes called routers) are used to extend network coverage area, route around obstacles, and provide back-up routes in case of network congestion or device failure. In some cases, mesh nodes may also be connected via analog and digital interfaces to sensors and actuators, providing the same I/O functionality of an end node module. Mesh nodes can be battery powered or line powered.

End Node Module

Considered reduced-function devices (RFD), end nodes (sometimes called endpoints) provide the physical interface between the wireless sensor network and the sensor or actuator to which it is wired. End nodes will usually have one or more I/O connections for connecting to and communicating with analog or digital sensor or actuator devices. End nodes are typically battery powered.

Sensor/Actuator

These are the devices you ultimately wish to monitor and/or control. An example is a sensor monitoring the pressure in an oil pipeline.

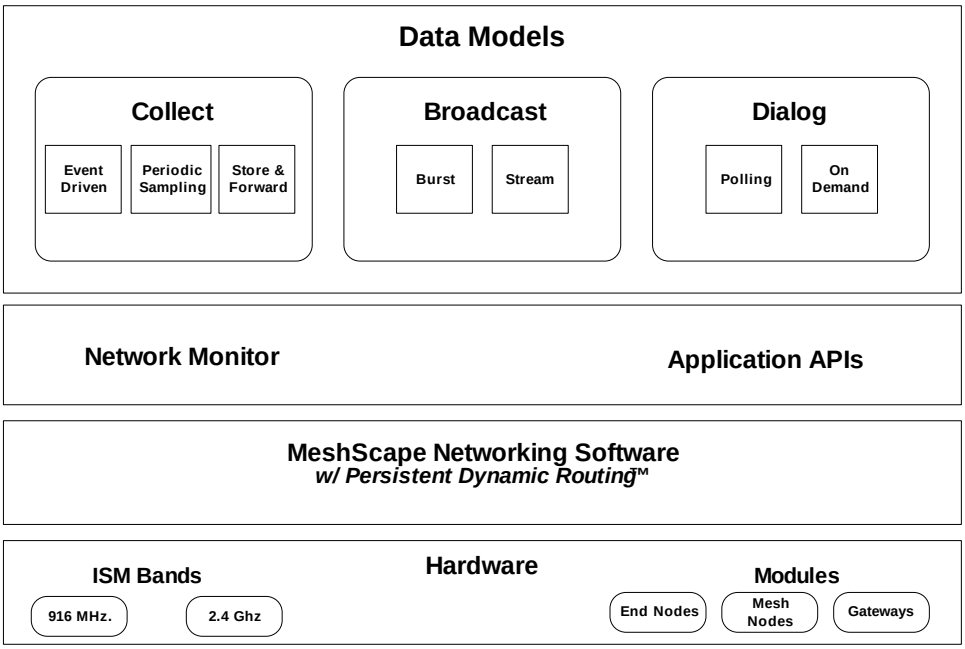
MeshScape System Overview

In order to realize benefits wireless sensor networking promises, the technology must be able to address several critical requirements: reliability of data transmission, responsiveness to adapt to dynamic environments, power efficiency, and scalability. The MeshScape™ wireless sensor networking system from Millennial Net delivers on all of these requirements. The MeshScape ready-to-embed hardware modules and assemblies support fast and cost-effective application development.

Core Elements of MeshScape System

The core elements of the MeshScape wireless sensor networking system are depicted in Figure 1-4 below.

Figure 1-4. MeshScape system core elements



MeshScape Networking Software

The ultra-efficient, highly scalable, self-organizing networking software is based on Persistent Dynamic Routing™ techniques. The networking software is delivered on the hardware modules described in this section. For volume applications, the MeshScape system software can also be licensed and integrated directly onto your sensor assembly.

Millennial Net has developed and optimized its protocol to address the unique characteristics and challenges associated with wireless sensor networking. The end result is a networking system and associated protocol that is highly scalable, ultra-efficient, and extremely responsive and resilient in dynamic environments. The MeshScape protocol for wireless sensor networks provides the industry's longest battery life at sensor nodes while delivering data over fault-tolerant links with end-to-end redundancy. The Millennial Net protocol is based on a set of

techniques including, Persistent Dynamic Routing for reliable and scalable wireless sensor networks. When forming an ad hoc sensor network, Persistent Dynamic Routing requires minimal overhead for requesting and establishing connectivity without relying on the bandwidth-consuming flooding technique.

MeshScape Network Monitor and Application APIs

The MeshScape system delivers the tools to view and control network dynamics. The MeshScape Network Monitor provides functions for monitoring and managing the network. Application APIs streamline development by providing input/output functions for sensor and application integration.

Hardware

The MeshScape system includes field-proven, "integratable" modules for fastest time to market. These ready-to-integrate end nodes, mesh nodes, and gateways support numerous application requirements and support various ISM bands for license-free operation around the world.

Data Models

The MeshScape system provides built-in support for data movement profiles to speed development including:

- data collection models
- bi-directional dialogue models
- broadcast models

These data models optimize the network for an application's specific data requirements and support a variety of classes for collection and bi-directional dialogue data models.

Data Collection Models

Data collection models describe monitoring applications where the data flows primarily from the sensor node to the gateway. The MeshScape system supports the data collection models described in this section.

Periodic Sampling

For applications where certain conditions or processes need to be monitored constantly, such as the temperature in a conditioned space or pressure in a process pipeline, sensor data is acquired from a number of remote sensor nodes and forwarded to the gateway or data collection center on a periodic basis.

The sampling period mainly depends on how fast the condition or process varies and what intrinsic characteristics need to be captured. In many cases, the dynamics of the condition or process to be monitored can slow down or speed up from time to time. Therefore, if the sensor node can adapt its sampling rates to the changing dynamics of the condition or process, over-sampling can be minimized and power efficiency of the overall network system can be further improved.

Another critical design issue associated with periodic sampling applications is the phase relation among multiple sensor nodes. If two sensor nodes operate with identical or similar sampling rates, collisions between packets from the two nodes is likely to happen repeatedly. It is essential that sensor nodes can detect this repeated collision and introduce a phase shift between the two transmission sequences in order to avoid further collisions resulting in optimal network operation and minimized power usage.

Event Driven

There are many cases that require monitoring one or more crucial variables immediately following a specific event or condition. Common examples include fire alarms, door and window sensors, or instruments that are user activated. To support event-driven operations with adequate power efficiency and speed of response, the sensor node must be designed such that its power consumption is minimal in the absence of any triggering event, and the wake-up time is relatively short when the specific event or condition occurs. Many applications require a combination of event driven data collection and periodic sampling.

Store and Forward

In many applications, data can be captured and stored or even processed by a sensor node before it is transmitted to the gateway or base station. Instead of immediately transmitting every data unit as it is acquired, aggregating and processing data by remote sensor nodes can potentially improve overall network performance in both power consumption and bandwidth efficiency. One example of a store-and-forward application is cold-chain management where the temperature in a freight container carrying produce or pharmaceuticals, for instance, is captured and stored; when the shipment is received, the temperature readings from the trip are downloaded and viewed to ensure that the temperature and humidity stayed within the desired range.

Bi-Directional Dialogue Data Models

Bi-directional dialogue data models are characterized by a need for two-way communication between the sensor/actuator nodes and gateway/application. The MeshScape system supports the bi-directional dialogue data models described in this section.

Polling

Controller-based applications, such as those found in building automation systems, use a polling data model. In this model, there is an initial device discovery process that associates a device ID with each physical device in the network. The controller then polls each device on the network successively, typically by sending a serial query message and waiting for a response to that message. For example, an energy management application would use a polling data model to enable the application controllers to poll thermostats, variable air volume (VAV) sensors, and other devices for temperature and other readings.

On-Demand

The on-demand data model supports highly mobile nodes in the network where a gateway device enters the network, automatically binds to that network and gathers data, then leaves the network. With this model, one mobile gateway can bind to multiple networks and multiple mobile gateways can bind to a given network. An example of an application using the

on-demand data model is a medical monitoring application where patients in a hospital wear sensors to monitor vital signs and doctors access that data via a PDA that is a mobile gateway. A doctor enters a room and the mobile PDA automatically binds with the network associated with that patient and downloads vital sensor data. When the doctor enters a second patient's room, the PDA automatically binds with that network and downloads the second patient's data.

Broadcast Data Models

Broadcast data models are characterized by a need for one-to-many communication between the gateway/application and sensor/actuator nodes. The MeshScape system supports the broadcast data models described in this section.

Burst

The burst data model is characterized by an uneven pattern of data transmission from the gateway/application to all sensor/actuator nodes on the wireless sensor network. The burst data model has been used with industrial lighting applications.

Stream

In the stream data model, the gateway/application sends data in a continuous stream to all sensor/actuator nodes on the wireless sensor network. The transport service guarantees that all data is delivered to the other end in the same order as sent and without duplicates. The stream data model is used when performing network upgrades.

Low-Power Configuration

Many sensors are dispersed over a wide area and must rely on batteries or solar cells for their power source. Consider the example of sensors taking measurements on a gas pad, it would be prohibitively expensive to network these sensors using cables, so a wireless sensor network is the perfect solution. However, to be useful in such an environment, the wireless sensor network must posses the following characteristics:

- Power: Low power consumption—sensor and node must be able to operate 10+ years on a singe battery
- Scalability: End nodes must be able to scale as sensor counts increase.
- Data Rate: Application/gateway must support a configurable sample rate.
- Range: End nodes must be able to communicate over distances of 60 to 80 feet and Mesh nodes must be able to communicate at distances up to 100 feet.
- Integration: The end nodes must be integrated with the sensor.

The MeshScape system possesses all of theses characteristics and uses configurable sleep and duty cycle intervals to minimize power consumption.

The MeshScape RK-5409-5 Reference Kit

Millennial Net's RK-5409-5 Reference Kit contains everything you need to set up a self-organizing, wireless star-mesh network. Once installed, you are able to observe the performance and operation of the network components and prototype your application.

The RK-5409-5 Reference Kit hardware includes:

- one MeshGate Gateway
- three mesh nodes
- five end nodes
- connecting cables

Reference kit software includes:

- MeshScape Network Monitor - the MeshScape system network monitoring tool and graphical user interface (GUI)
- MeshScape Programmer application - enables you to upgrade the firmware on MeshGate gateways and mesh nodes, and modify the group and device IDs of deployed mesh nodes and end nodes (see Appendix B, "Performing Firmware Upgrades and Configuring Device IDs")
- Application Program Interface (API) library - A complete API library is provided to streamline development using Windows Visual C/C++ on a PC. For applications where the MeshGate connects to a third-party controller, Millennial Net also provides libraries (pre-compiled Windows API library and Linux API library source), as well as source code examples.

The kit also includes:

- temperature sensor assembly - enables you to run a sample application (see Appendix A, "Sample Application").

Documentation for the reference kit includes:

- this user's guide - which describes how to set up the reference network, including connections to the host computer, power supplies, sensors, and other devices
- MeshScape Product Family Sheet
- technical specifications for MeshGate gateway, mesh node, and end node

For complete details on the contents of the reference kit, refer to 'Reference Kit Contents' on page 1-11.

MeshScape Network Monitor runs on MS Windows XP. MeshScape Network Monitor allows you to set network and device operating parameters and monitor the status of the network components and their inputs/outputs. The API software runs on Windows and Linux systems and can be easily incorporated into user application programs written in C/C++.

Major Features

Major features of the MeshScape RK-5409-5 Reference Kit include the following:

- Frequency band: 916 MHz
- Bi-directional/multiple-access communication
- MeshScape Network Monitor graphical user interface (GUI) for configuring the MeshScape system and evaluating its performance
- Application Programming Interface (API)
- End node and mesh node-specific features include:
  - configurable sampling interval
  - digital I/O - 4 channels
  - ADC input - 4 channels
  - UART input/output

Reference Kit Contents

The MeshScape RK-5409-5 Reference Kit contains the following components:

- (5) EN-5409 end nodes; each end node is mounted to a terminal board containing a battery. A 2-inch x 2-inch plastic housing is supplied for each end node.
- (3) MN-5409 Mesh Nodes (enclosed) with attached AC power adapters.
- (1) MG-5409 MeshGate gateway (enclosed) with an attached AC power adapter.
- (4) Antennas; one 1/2-wave antenna for each Mesh Node and one for the MeshGate.
- (3) Battery packs; one for each Mesh Node. Each battery pack requires two AA batteries (not included).
- (1) RS-232 serial cable for connecting the MeshGate serial port to the host PC. This is a DB-9, male-to-female, straight-through cable.
- (1) RS-232 serial cable for connecting the MeshGate console port to the host PC. This is a DB-9-to-mini-connector cable.
- (1) Temperature sensor assembly (for sample EN-5409 application). The enclosed temperature sensor assembly contains a terminal board (no End Node) and a battery.
- (1) CD-ROM containing support documentation and application software, including the MeshScape Network Monitor program, MeshScape Programmer application, and API software.

Warning

These electronic products are sensitive to electrostatic discharge (ESD). Permanent damage to these devices can result if subjected to high energy electrostatic discharges.

Proper precautions are recommended to avoid performance degradation or loss of functionality.

Host PC Requirements

The reference kit requires a personal computer (PC) for to run the supplied application software. The host PC must have the following minimal configuration:

- Microsoft Windows XP
- Processor: 1.0 GHz or greater
- 512 MB RAM
- RS-232 serial port
- CD-ROM drive for loading software
- Display with SVGA (800 x 600) resolution or greater
- 10 MB free disk space
- Microsoft Visual C/C++ for development purposes

Although the above platform is required to run MeshScape Network Monitor and other supplied applications, the supplied API library files are supported on both Windows and Linux platforms.

2

Installing the MeshScape System

This chapter provides the following MeshScape System installation information:

- 'Installing the MeshScape Wireless Sensor Network' on page 2-2
- 'Installing the Hardware' on page 2-3
- 'Installing MeshScape Network Monitor' on page 2-14

Installing the MeshScape Wireless Sensor Network

This section of the user's guide describes how to install the reference kit's hardware and software components. Installation should be performed in the following order:

1. MeshGate (see 'MeshGate Setup (MG-5409)' on page 2-3)
2. mesh nodes (see 'Mesh Node Setup (MN-5409)' on page 2-7)
3. end nodes (see 'End Node Setup (EN-5409)' on page 2-12)
4. MeshScape Network Monitor (see 'Installing Contents of Millennial Net's RK-5409 CD-ROM' on page 2-14)

Once the hardware is set up and the MeshScape Network Monitor software installed, you will launch MeshScape Network Monitor to verify that all hardware is detected and displayed.

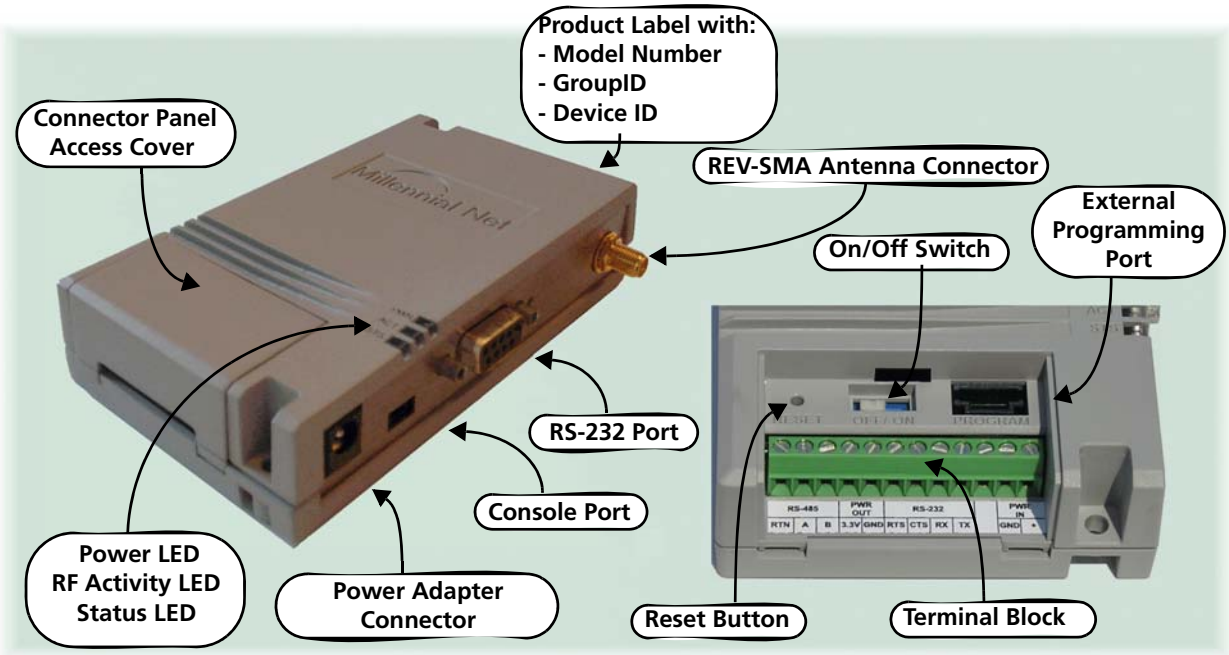
Installing the Hardware

The following procedures describe in order, how to install the various hardware components of the reference kit. When initially setting up the hardware, it is recommended that the MeshGate, mesh nodes, and end nodes be placed close to the host PC. This will make verifying proper network installation and operation easier when first establishing a session with MeshScape Network Monitor. The devices can then be moved away from the host PC as needed.

MeshGate Setup (MG-5409)

The MeshGate, model number MG-5409 (label with model number on bottom), is shipped enclosed in a case that provides access to the antenna, RS-232 data port, console port, and power connectors as shown in Figure 2-5. Additionally, a lift-off connector panel access cover on the case provides access to a 12-pin terminal block connector, a reset button, an on/off switch, and a 6-pin external programming port.

Figure 2-5. MeshGate components



The pin-out for the terminal block is as follows:

RS-485			PWR OUT		RS-232					PWR IN	
RTN	A	B	3.3V	GND	RTS	CTS	RX	TX		GND	+

During the setup procedure, refer to Figure 2-5 for location of the various MeshGate components.

To set up the MeshGate:

1. Attach one of the four included 1/2-wave antennas to the REV-SMA antenna connector. The antenna screws onto the connector.

Caution

When attaching the antenna, only hand-tighten the antenna to the connector. Using excessive force may damage the connector.

2. Connect the RS-232 cable between the MeshGate and the host PC.
3. Plug the supplied AC adapter into the MeshGate power connector and then into a 110 VAC power source.
4. Remove the connector panel access cover and slide the on/off switch to the ON position.
5. Replace the connector panel access cover.

   The MeshGate is ready to interface with the host PC and surrounding network nodes (mesh nodes and end nodes). For information on the behavior of the status LEDs, see Table 2-1.

Mounting options

There are three mounting options for the MeshGate:

- desktop
- wall
- DIN rail

Mounting the MeshGate on a Desktop

1. Choose a level, stable surface on which to rest the MeshGate.
2. Install one of the four supplied self-adhesive rubber feet in the round depression located in each corner on the bottom of the MeshGate chassis.

Mounting the MeshGate on a Wall

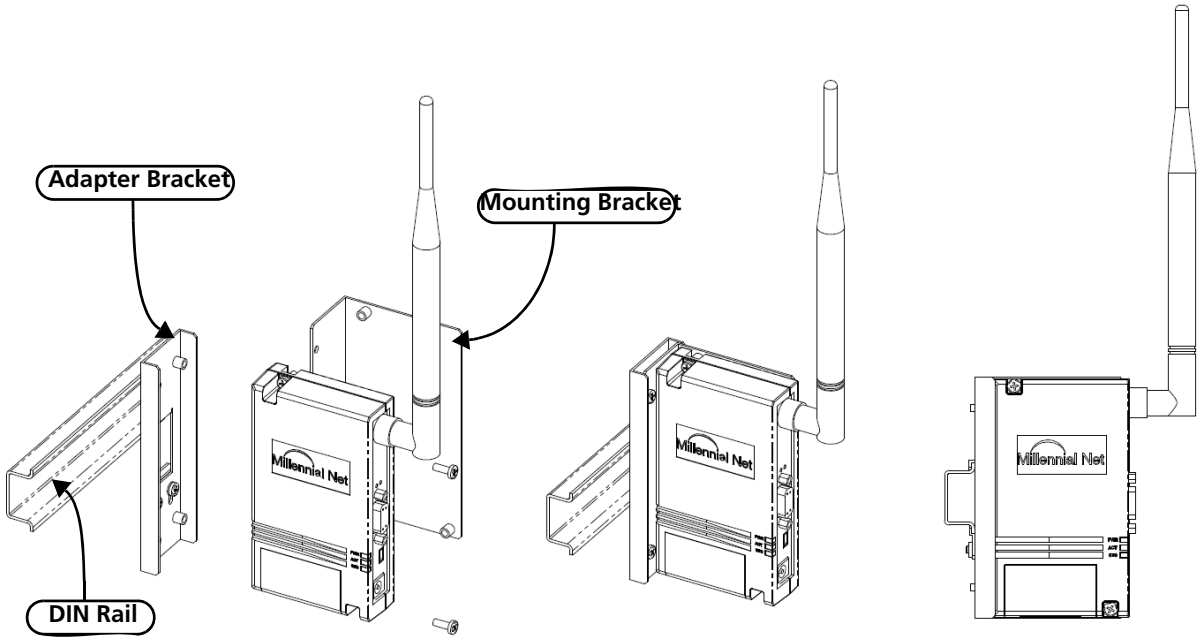
1. Place the MeshGate against the wall in the desired mounting location.
2. Mark the location of the two chassis screw holes on the wall.
3. Drill two screw holes in to the wall at the marked locations.
4. Mount the MeshGate to the wall using the two supplied screw anchors and screws.

Mounting the MeshGate to a DIN Rail

Millennial Net offers an optional DIN rail mounting kit (MG-DIN) to enable you to mount the MeshGate to a standard DIN rail easily and quickly.

To mount the MeshGate to a DIN rail using the supplied DIN rail mounting bracket and hardware, refer to Figure 2-6 and complete the following steps:

Figure 2-6. Mounting the MeshGate to a DIN rail



1. Using two of the supplied screws, secure the MeshGate chassis to the mounting bracket.
2. Mount the adapter bracket onto the DIN rail. Slide the adapter bracket's clamp up and then tighten its two screws to secure the adapter bracket in place on the DIN rail.
3. Using two of the supplied screws, secure the mounting bracket to the adapter bracket.

MeshGate status LED operation

Table 2-1 describes how the status LEDs on the MeshGate behave.

Table 2-1. MeshGate status LEDs

LED	Led State	Status
PWR	On	Connection with host device detected.
	Blinking	No host device detected or MeshScape Network Monitor not running.
	Off	Power has been removed.

Table 2-1. MeshGate status LEDs

LED	Led State	Status
ACT	Flashing	Gateway detects RF activity. The Activity LED will flash when detecting valid packets (packets destined for device) and may also flash when detecting invalid packets (packets destined for other devices) or environmental noise. Only valid packets are processed by the device.
	Off	No RF activity detected.
STS	*(Reserved for future use.)*	

MeshGate default settings

Table 2-2 lists the default settings for the MeshGate gateway.

Table 2-2. MeshGate default Settings

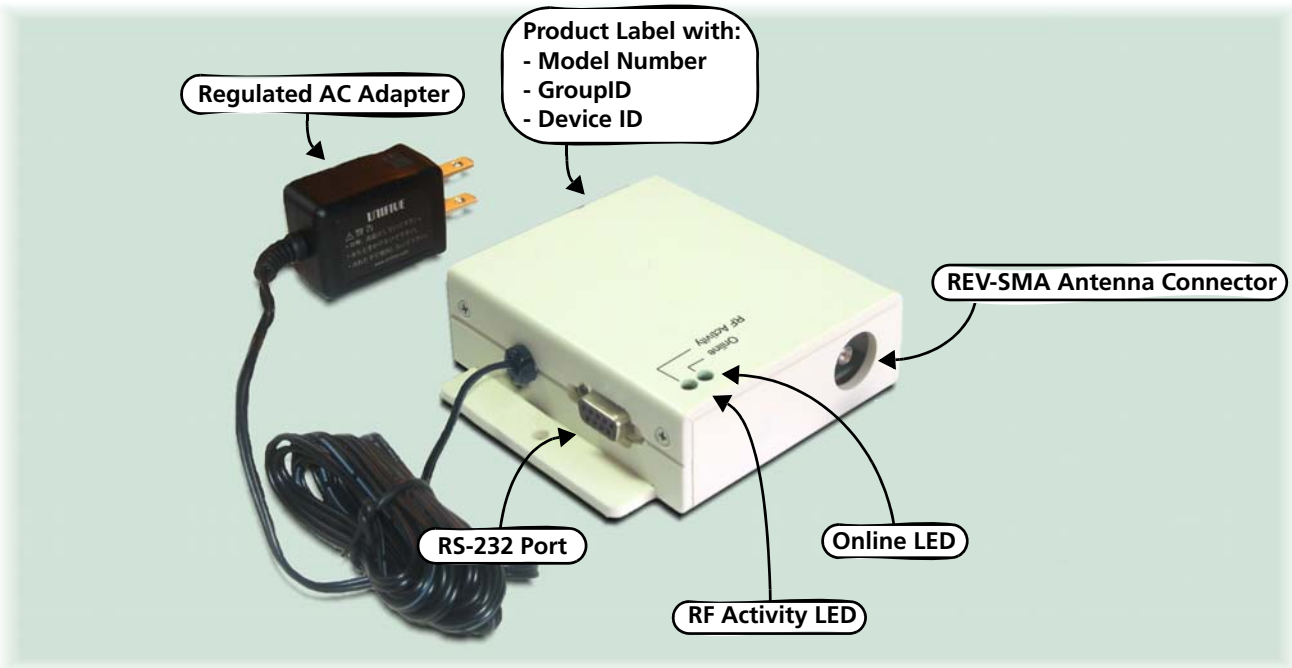
Variable *Description*	Default Value	Persisted?*
RS-232 Data Port Configuration	RS232 115,200 baud No parity No hardware flow control	Yes
Console Port	RS232 115,200 baud No parity No hardware flow control	Yes

* Persisted indicates value is retained after off/on power cycle.

Mesh Node Setup (MN-5409)

The mesh nodes, model number MN-5409 (label with model number on bottom), are shipped enclosed in cases that have openings for instant access to the antenna, and RS-232 connectors as shown in Figure 2-7.

Figure 2-7. Mesh node components



Installing antenna and applying power

To install a mesh node:

1. Attach one of the included antennas to the REV-SMA antenna connector. The antenna screws onto the connector.

Caution

When attaching the antenna, only hand-tighten the antenna to the connector. Using excessive force may damage the connector.

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2. Connect one of the following power sources supplied with the kit:
   - **Regulated AC Adapter** (recommended): Plug the regulated AC adapter into a 110 VAC power source.
   - **Batteries**: For applications where a 110 VAC power source is not available, the mesh node can be converted to a battery powered device. For instructions on installing one of the battery packs contained in the kit, see 'Converting to battery power' on page 2-9.

The mesh node is ready to operate as a router device (see note below). For information on the behavior of the status LEDs, see Table 2-3.

3. Repeat Steps 1and 2 for each mesh node in the kit.

Note: For information on accessing and using the mesh node internal I/O connections for interfacing with an external device see 'Accessing I/O connections' on page 2-10.

Mounting options

You may operate the mesh node while it is resting on a desktop or mounted to a wall. When mounting the mesh node to a wall, we recommend that you secure the mesh node in place using two #6 screws and screw anchors (*not supplied*) of the appropriate type for the mounting surface.

Mesh node status LED operation

Table 2-3 describes how the status LEDs on the mesh node behave.

Table 2-3. Mesh node status LEDs

LED	Led State	Status
Online	On	Online and in network.
	Blinking	Offline and searching.
	Off	No power.
RF Activity	Flashing	Mesh node detects RF activity. The RF Activity LED will flash when detecting valid packets (packets destined for device) and may also flash when detecting invalid packets (packets destined for other devices) or environmental noise. Only valid packets are processed by the device.
	Off	No RF activity detected.

Mesh node default settings

Table 2-4 lists the default settings for the MeshScape mesh node.

Table 2-4. MeshScape mesh node default settings

Variable *Description*	Default Value	Persisted?*
Sampling Interval *Defines the time interval between successive sensor samples sent from end node to MeshGate*	300 Seconds	No
A/D Converter Setup *Defines state of A/D converter sensor inputs*	Channels 0-3 disabled	No

Table 2-4. MeshScape mesh node default settings (continued)

Variable *Description*	Default Value	Persisted?*
DIO Setup *Defines state of digital I/O lines*	DIO<0:3> configured as inputs	No
Serial Data configuration *Defines configuration of serial data sensor input, options are:* ***Off*** *- DIO<0:3> configured as I/O lines* ***Digital UART*** *- DIO<0:3> configured as digital UART signals* ***RS-232*** *- 9600 baud, No parity, No hardware flow control* ***RS-485*** *- 9600 baud*	**Off** - DIO<0:3> defined as I/O lines	No
Label *Text label used to describe sensor*	<blank>	Yes (on Network Monitor host)
Group ID *Network ID used to identify members of the same wireless network*	Pre-programmed User re-programmable	Yes
Device ID *Device ID used to uniquely identify each node in a wireless network*	Pre-programmed User re-programmable	Yes

* Persisted indicates value is retained after off/on power cycle.

Converting to battery power

For applications where an AC power source is not available, the mesh node can be converted to a battery powered device.

To install an internal battery pack and batteries into an mesh node (see Figure 2-8):

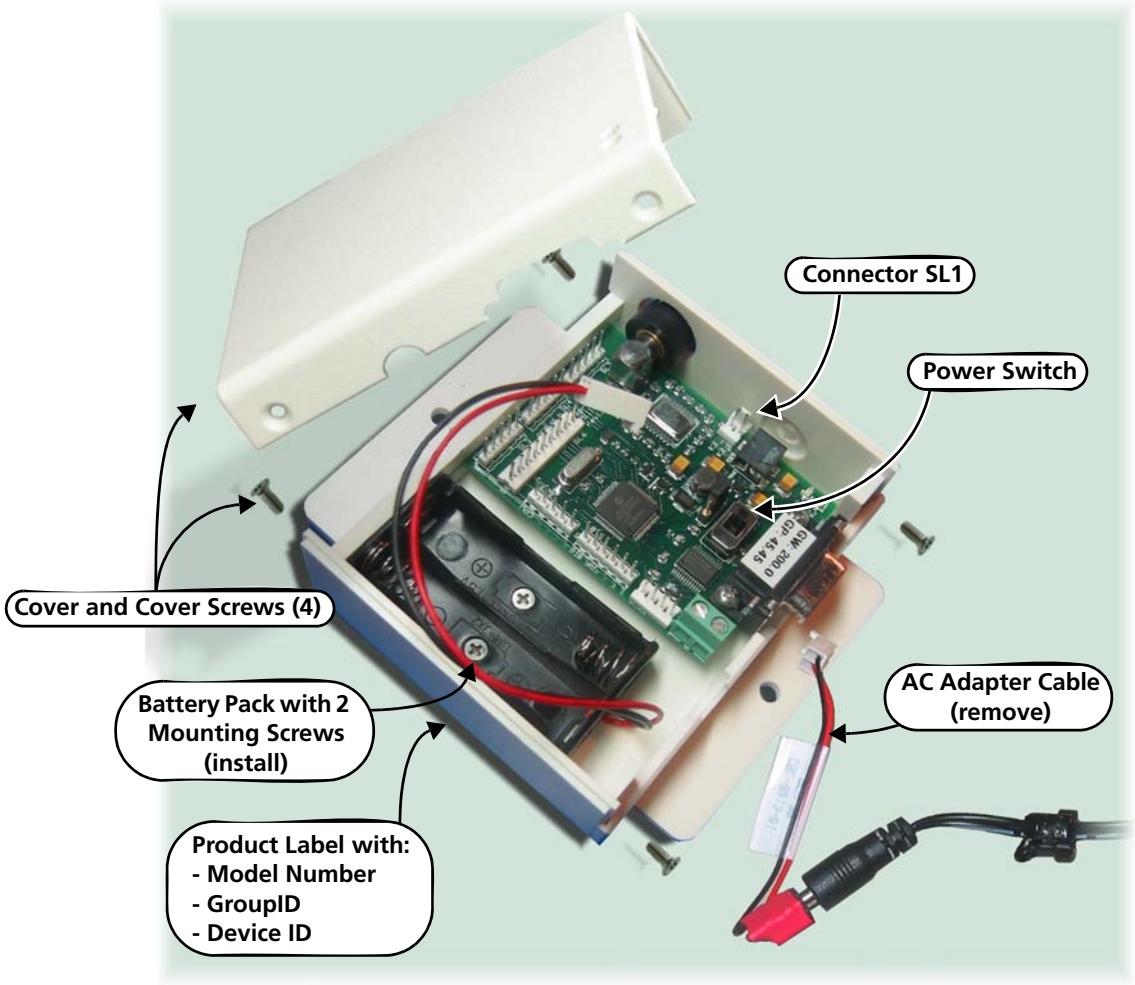
1. Remove the four philips head screws securing the cover to the base, then remove the cover.
2. Remove the AC adapter connector from **SL1** and remove the AC adapter assembly.
3. Turn the Power Switch **OFF**.
4. Mount one of the battery packs included with the kit to the back cover of the mesh node using the two mounting screws also included with the kit.
5. Observing polarity, install two AA batteries (not included in kit) into the battery pack.
6. Connect the battery pack to keyed connector **SL1**.

7. Turn the Power Switch **ON**. The mesh node is ready to operate as a router device (see note below). For information on the behavior of the status LEDs, see Table 2-3 on page 2-8.

8. Replace the cover and secure in place with the four philips head screws.

Note: For information on accessing and using the mesh node internal I/O connections for interfacing with an external device see 'Accessing I/O connections' on page 2-10.

Figure 2-8.Installing mesh node battery pack



Accessing I/O connections

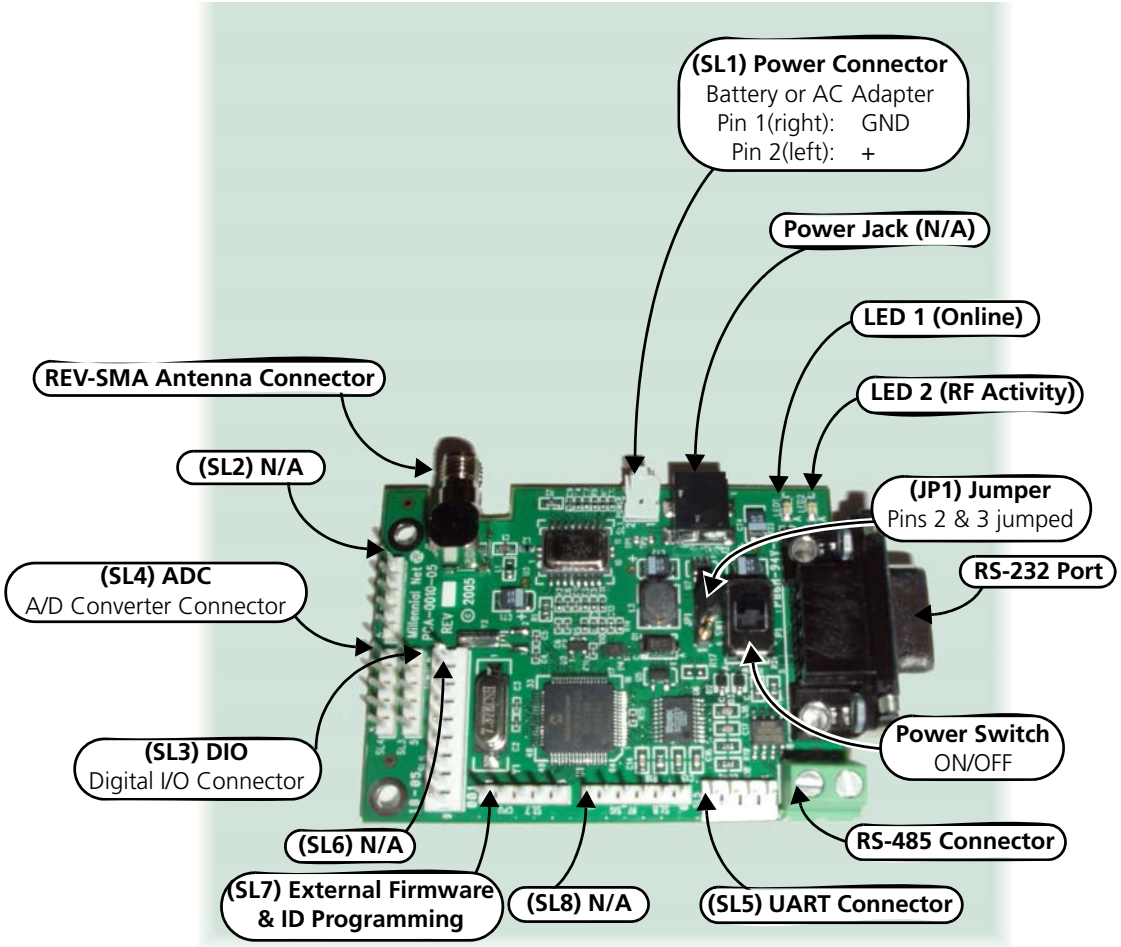
Figure 2-9 on page 2-11 provides a mapping of the various I/O connections available on the mesh node. To run a cable to an I/O connector, a punch-out is provided on the bottom of the case (to the right of the battery pack shown in Figure 2-8 above).

To access the mesh node's I/O connectors:

1. Remove the four cover screws that secure the top cover to the base as shown in Figure 2-8.
2. Lift the top cover off the base.

Note: Configuring and connecting an end node or mesh node to external devices via their digital or analog I/O connectors is discussed in Chapter 3, "Running MeshScape Network Monitor".

Figure 2-9. Mesh node components



Notes: 1. Callouts for **SL1–8** and **RS-485** point to pin 1 of each connector
2. Connectors labeled as **N/A** are reserved for future use.

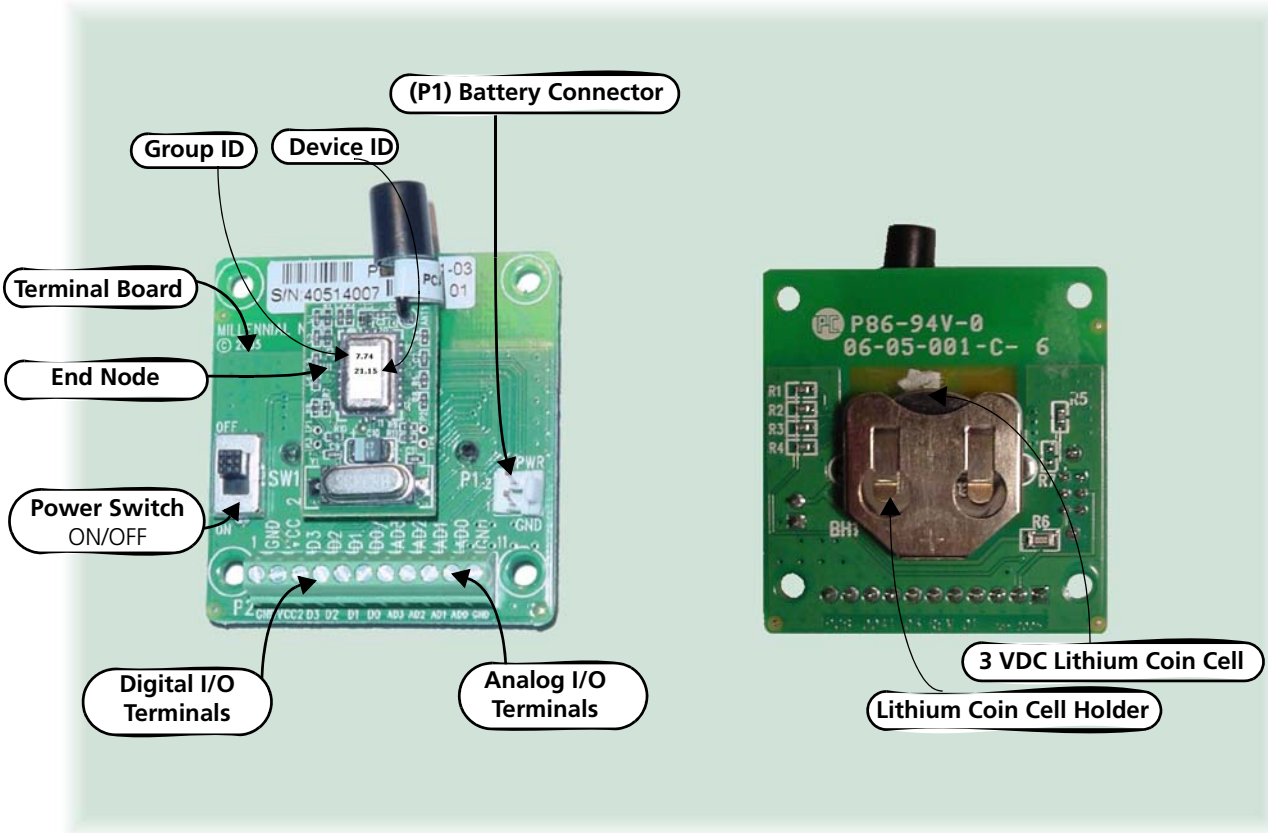
Caution

A jumper is factory-installed on JP1 that connects pins 2 and 3 together. Do not remove or change the position of this jumper as it will cause the device to malfunction.

End Node Setup (EN-5409)

The end nodes, model number EN-5409, are mounted to terminal boards as shown in Figure 2-10. A terminal board provides easy access to I/O connections and the power switch. The terminal board also contains a battery holder and battery for supplying power to the end node. The label on top of the end node contains the device and group IDs assigned to the end node.

Figure 2-10. End node and terminal board (top and bottom views)



To provide power to the end node, a 3 VDC lithium coin cell (CR2032 type) is provided and already installed in the battery holder on the back of the terminal board.

To activate an end node:

- Turn the terminal board's power switch **ON** (refer to Figure 2-10). The end node is ready to communicate directly or indirectly (through an mesh node) with the MeshGate. Repeat this step for each end node.

Note: Configuring and connecting an end node or mesh node to external devices via their digital or analog I/O connectors is discussed in Chapter 3, "Running MeshScape Network Monitor".

Mounting options

A 2-inch x 2-inch plastic housing is supplied with each end node and terminal board. You may operate the end node installed within its housing while it is resting on a desktop or mounted to a wall. When mounting the end node housing to a wall, we recommend that you secure it in place using two #6 screws and screw anchors (*not supplied*) of the appropriate type for the mounting surface.

Default settings

Table 2-5 lists the default settings for the MeshScape end node.

Table 2-5. MeshScape end node default settings

Variable ***Description***	Default Value	Persisted?*
Sampling Interval *Defines the time interval between successive sensor samples sent from End node to MeshGate*	10 Seconds	No
A/D Converter setup *Defines state of A/D converter sensor inputs*	Channels 0-3 disabled	No
DIO Setup *Defines state of digital I/O lines*	DIO<0:3> configured as inputs	No
Serial Data configuration *Defines configuration of serial data sensor input, options are:* ***Off*** *- DIO<0:3> configured as I/O lines* ***Digital UART*** *- DIO<0:3> configured as digital UART signals*	**Off** - DIO<0:3> defined as I/O lines	No
Label *Text label used to describe sensor*	<blank>	Yes (on PC where Monitor runs)
Group ID *Network ID used to identify members of the same wireless network*	Pre-programmed User re-programmable	Yes
Device ID *Device ID used to uniquely identify each node in a wireless network*	Pre-programmed User re-programmable	Yes

* Persisted indicates value is retained after off/on power cycle.

Installing MeshScape Network Monitor

The procedures in this section describe how to do the following:

1. Use the CD-ROM shipped with the reference kit to install the following Millennial Net items onto the host PC:
   - MeshScape Network Monitor
   - API software
   - EN-5409 End node Tech Sheet
   - MG-5409 MeshGate Tech Sheet
   - MN-5409 Mesh node Tech Sheet
   - RK-5409 MeshScape Users Guide
   - RK-5409-5 Kit Contents
   - IK-5409 Kit Contents
   - Reference Kits Tech Sheet
   - 5409 Family Product Sheet
   - 5409 MeshScape Release Notes
2. Open a MeshScape Network Monitor session.

The software installation procedure utilizes an InstallShield Wizard that will guide you through the installation process. When the process is complete, a MeshScape Network Monitor shortcut icon is also added to the host PC's desktop.

Installing Contents of Millennial Net's RK-5409 CD-ROM

To install the software contained on the CD-ROM:

Insert the *RK-5409 Reference Kit CD* into the host PC's CD-ROM drive. The Autorun feature launches the InstallShield Wizard. Follow the prompts to install the contents of the CD onto the host PC.

If Autorun is not enabled, drill down to the contents of the kit CD and double-click on **setup.exe**. The InstallShield Wizard is launched. Follow the prompts to install the contents of the CD onto the host PC.

Note: If a version of MeshScape Network Monitor already exists on the host PC, it will be detected during the installation process. A special prompt screen is then displayed, allowing you to modify, repair, or remove the existing files. You must select **Remove** to unistall the exiting version before installing the version contained on the CD.

Proceed to 'Launching MeshScape Network Monitor Using Windows' on page 2-15.

Launching MeshScape Network Monitor Using Windows

Using the standard application launching methods of Windows, the following procedure describes how to launch MeshScape Network Monitor and verify proper communication with the network nodes (see Figure 2-11):

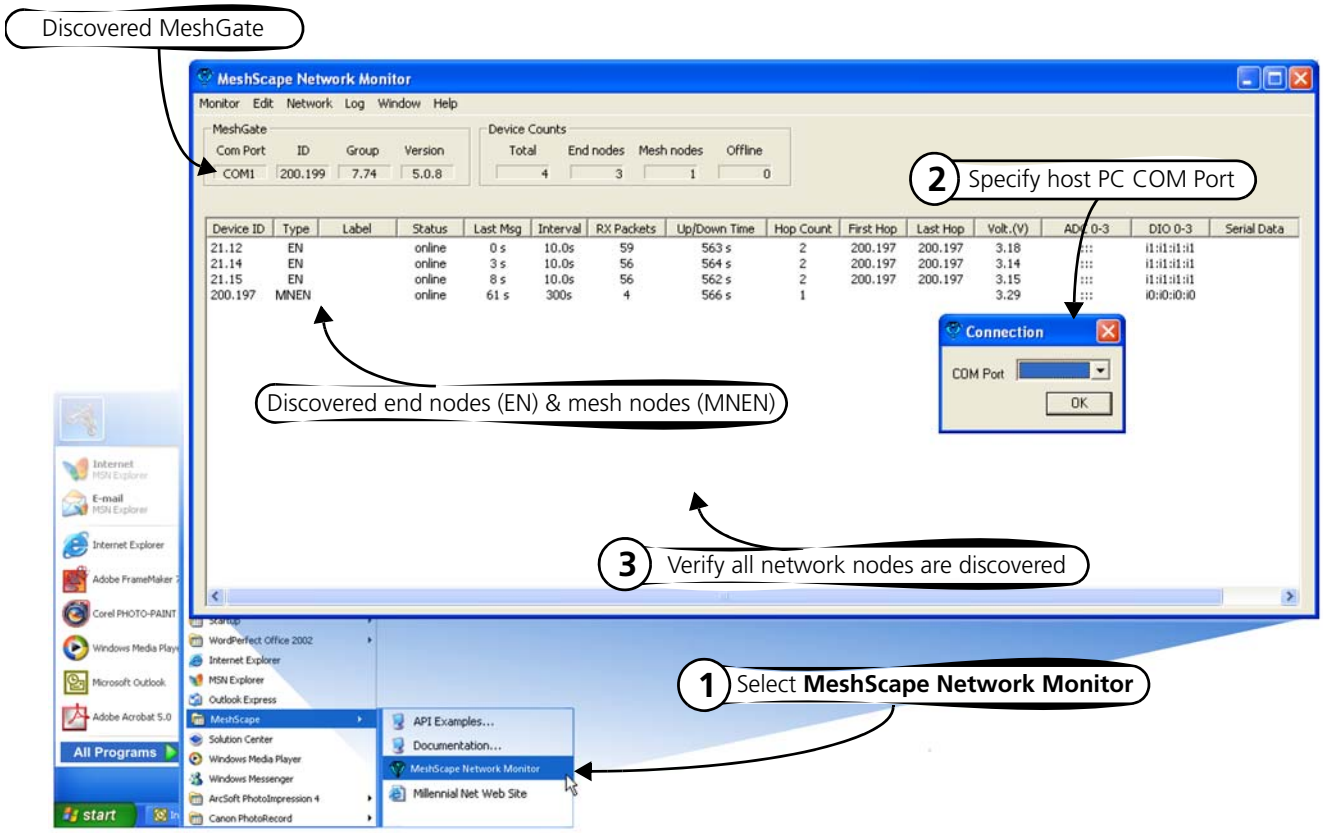
1. To launch MeshScape Network Monitor, do one of the following:

   – Double-click on the desktop's MeshScape Network Monitor icon.
   – From the Windows taskbar, select: **Start>All Programs>MeshScape>MeshScape Network Monitor**.

2. Enter the COM port on which the host PC is to communicate with the connected MeshScape.

3. Verify that all network nodes are discovered and displayed by MeshScape Network Monitor.

Figure 2-11. Using Windows' Start menu to launch MeshScape Network Monitor



Once proper operation of the MeshScape System has been verified, proceed to Chapter 3, "Running MeshScape Network Monitor" for an overview of the GUI and details on how to use it to configure the operation of your MeshScape System.

3

Running MeshScape Network Monitor

This chapter provides the following MeshScape Network Monitor information:

- 'MeshScape Network Monitor Overview' on page 3-2
- 'Configuring a Node's Operation' on page 3-6
- 'Labeling an End Node or Mesh Node' on page 3-19
- 'Configuring Persistence Attributes' on page 3-20
- 'Selecting a Com Port on the Host PC' on page 3-21
- 'Configuring Serial and ADC Data Formats' on page 3-22
- 'Turning Event Tracking On/Off' on page 3-23
- 'Broadcasting Data to All Nodes.' on page 3-24
- 'Creating an Event Log File' on page 3-26
- 'Viewing the Contents of an Event Log File' on page 3-27

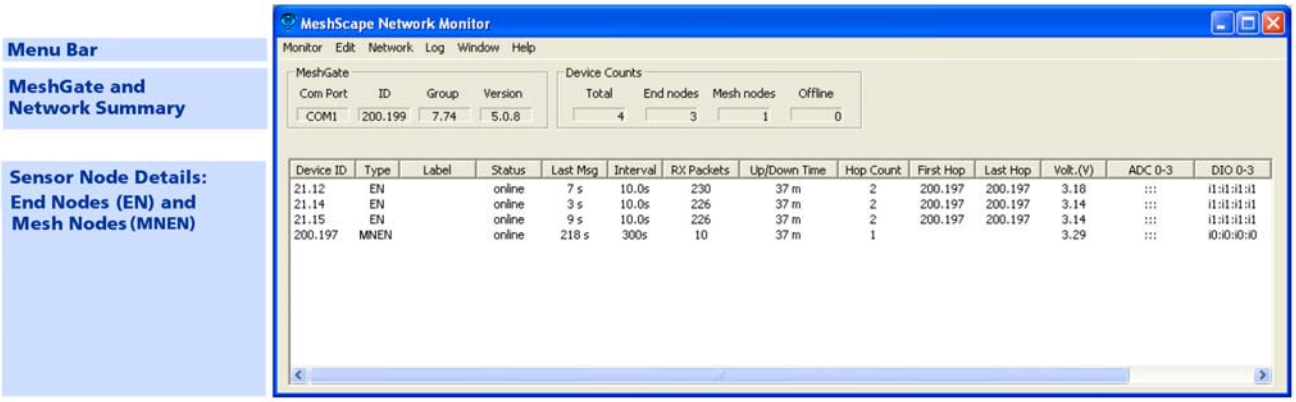
MeshScape Network Monitor Overview

Millennial Net's MeshScape Network Monitor is a monitoring and management system for MeshScape networks. This management tool will discover and display active mesh nodes in the vicinity of the MeshGate, and end nodes in the range of the MeshGate and mesh nodes as shown in Figure 3-12. MeshScape Network Monitor displays the *Group ID* and *Device ID* of the MeshGate and will display only end nodes and mesh nodes that have the same group ID as the MeshGate. (For information on opening a MeshScape Network Monitor session, see 'Launching MeshScape Network Monitor Using Windows' on page 2-15.)

Using MeshScape Network Monitor, a number of the monitoring features may be observed:

- **Any of the mesh nodes can be moved, and as long as they are within the range of an mesh node or the MeshGate, connectivity will be maintained seamlessly.** Any of the mesh nodes and even the MeshGate can be moved while operating, and all routes will automatically adapt to their new locations.
- **The MeshScape System Persistent Dynamic Routing™ routing protocol always seeks to route data using the most reliable RF links with the fewest hops.** The network protocol will change the route when an RF link in the route is deemed unreliable. This can be seen in the MeshScape Network Monitor. For example, the mesh node IDs used for the first and last hops may change from time to time even when the end node is stationary, due to environmental interference.
- **If any of the mesh nodes runs out of battery power or is turned off, all routes that went through that mesh node will be reconfigured—all end nodes communicating with that mesh node will still be connected to other mesh nodes without any disruption or loss of packets.** However, if an end node exceeds the range of the network due to the loss of an mesh node, then the end node will be displayed as Offline or removed from the display (depending on how the Persistence function is configured).

Figure 3-12. Sample MeshScape Network Monitor window



As shown in Figure 3-12, the main window is divided into the following sections:

Menu Bar

From the menu bar, system users access the following:

- **Monitor**

  This menu option provides access to the following functions:

  – **Exit**: Ends the session and closes MeshScape Network Monitor.

- **Edit**

  – **Labels:** Assign user-defined names to end nodes and mesh nodes on the network. For details, see 'Labeling an End Node or Mesh Node' on page 3-19.

  – **Persistence:** Stop monitoring/displaying offline end nodes and mesh nodes. For details, see 'Configuring Persistence Attributes' on page 3-20

  – **Data Format**: Configure the following I/O data formats:

    - *Serial Data Format*: Define format of displayed serial data (ASCII/Hex/Decimal)
    - *ADC Data Format*: Define format of displayed ADC data (Voltage/Raw Data)

    For details, see 'Configuring Serial and ADC Data Formats' on page 3-22.

- **Network**

  – **Connection**: Select serial port on Host PC to use for MeshGate connection. For details, see 'Selecting a Com Port on the Host PC' on page 3-21.

  – **All Sampling Intervals**: Configure all network nodes with the same sampling interval time. For details, see 'Configuring Sample Interval of all Network Nodes' on page 3-8.

  – **Events**: Turn event tracking on or off. Tracked events are included in the Event log file. For details, see 'Turning Event Tracking On/Off' on page 3-23.

  – **Broadcast**: Broadcast data to all nodes on your MeshScape system including the time to which all nodes will synchronize their clocks and Ultra Low Power (ULP) settings defining wakeup interval and duty cycle for all nodes. For details, see 'Broadcasting Data to All Nodes.' on page 3-24.

- **Log**

  – **Attributes**: Create a log file of reported network events, such as reported up/down events and changes to voltages or routes. For details, see 'Creating an Event Log File' on page 3-26.

  – **View**: Display contents of log file. For details, see 'Viewing the Contents of an Event Log File' on page 3-27.

- **Window**

  – **Watch:** Display the current status information relating to a node's interfaces. For details, see 'Using Watch Function to Display Configuration Information' on page 3-17.

  – **Statistics:** Open Monitor Statistics window, displaying RX/TX packet and byte information.

- **Help**

  – **About**: Displays MeshScape Network Monitor revision level information.

Gateway

This section displays the following information on the MeshGate connected to the host PC's RS-232 port:

- **Com Port**: Host PC's RS-232 port connected to MeshGate.
- **ID**: Device identifier assigned to the MeshGate. The ID consists of two octets (A.B), where each octet's value = 000 to 255.
- **Group**: Group identifier assigned to the MeshGate. All mesh nodes and end nodes with the same Group identifier will communicate with the displayed MeshGate.
- **Version**: Version of firmware loaded on the MeshGate.

Device Counts

This section displays the following information on the discovered network nodes:

- **Total**: Total combined number of discovered end nodes and mesh nodes.
- **End nodes**: Total number of end nodes currently online.
- **Mesh nodes**: Total number of discovered mesh nodes currently online.
- **Offline:** Total number of discovered end nodes and mesh nodes currently offline.

Sensor Node Details

This section displays the following information related to the end nodes and mesh nodes on the network:

- **Device ID**: Unique identifier assigned each node. The identifier consists of two octets (A.B), where each octet contains a value between 000 and 255.
- **Type**: This column lists all nodes discovered on the network that are assigned the same group ID as the displayed MeshGate. Nodes displayed here include end nodes (EN) and mesh nodes (MNEN).
- **Label**: User-defined name assigned to node.
- **Status**: Current status of the device:
  - **Online**: The node is communicating with the MeshGate.
  - **Offline**: The MeshGate can no longer communicate with the node.
  - **Refresh**: The node is being updated with a new operating state.
- **Last Msg**: Time elapsed since last packet was received from the node. Time is displayed in seconds (s).
- **Interval**: Time of the last message generated by a node. This value is synchronized with the sampling interval of the node. Time is displayed in either seconds (s) or minutes (m).

- **RX Packets**: Number of packets successfully delivered to MeshScape Network Monitor from a node since the node was detected by the MeshGate. The counter is reset if one of the following actions occur:
  - The node is powered down.
  - The MeshGate is powered down.
  - MeshScape Network Monitor program is restarted.
- **Up/Down Time**: Total time since the node was last detected on/off by the MeshGate.
- **Hop Count**: Number of network node hops taken by a packet delivered from a node to the MeshGate. For example: end node—MeshGate = 1 hop,
  end node—mesh node—MeshGate = 2 hops (each additional mesh node will add another hop).
- **First Hop**: Device ID of the first mesh node on the path used by a packet to get to the MeshGate. If no mesh node was used, then the field is blank, indicating the device is communicating directly with the MeshGate.
- **Last Hop**: Device ID of the last mesh node on the path used by a packet to get to the MeshGate. If no mesh node was used, then the field is blank, indicating the device is communicating directly with the MeshGate.
- **Volt**: DC voltage level of the node's power source in volts.
- **ADC Data**: Input voltages on pins used for analog-to-digital conversion operation.
- **DIO Data**: Digital information on pins used for digital I/O operation.
- **Serial Data**: Input serial data information when configured for serial operation.
- **Version**: Version of firmware loaded on the node.

Configuring a Node's Operation

To configure the operation of an end node or mesh node, double-click on the desired device from the list of discovered sensor nodes in the main display. The Device window is displayed, showing the current configuration of the selected device (see Figure 3-13).

The Device window is a modeless dialog that may be left open while you interact with other MeshScape Network Monitor features, windows, and dialogs. You can open multiple instances of the Device window—one per device as needed.

Figure 3-13. MeshScape Network Monitor's Device window

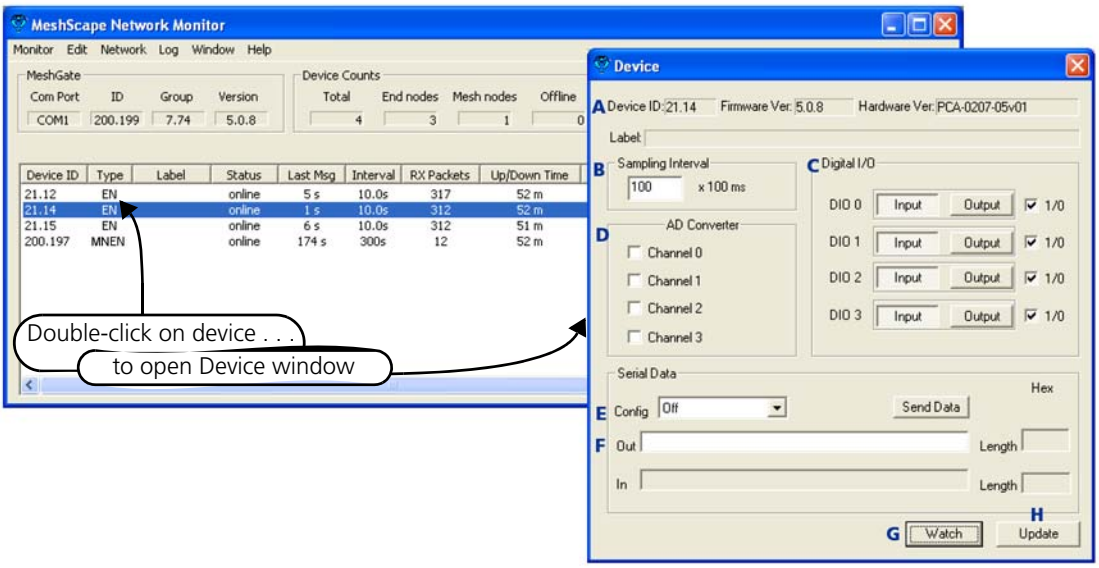


Table 3-6 describes the functions of the various sections of the window as shown in Figure 3-13.

Table 3-6. Device window functions

Item	Description	Function
A	Device ID	This is the device ID of the node currently selected for configuring.
B	Sampling Interval	This setting configures how often the node transmits a 'heart beat' data packet or any other data. For details, see 'Configuring Sample Interval of Single Node' on page 3-8.
C	Digital I/O	This panel is used to control the states of the I/O pins associated with digital I/O channels D0–D3. For details, see 'Configuring Digital I/O Operation' on page 3-9
D	AD Converter	This panel is used to control the states of the AD (Analog-to-Digital) Converter channels. For details, see 'Configuring AD (analog-to-digital) Converter Operation' on page 3-14.

Table 3-6. Device window functions (continued)

Item	Description	Function
E	Serial Data Config	This panel is used to select a serial I/O operation for a device: Digital UART, RS-232 (MN-5409 only), or RS-485 (MN-5409 only). Selecting serial operation disables digital I/O functionality because these operations share the same pins. For details, see the following: • 'Configuring UART Operation' on page 3-12 • 'Configuring RS-232 Operation (MN-5409 only)' on page 3-15 • 'Configuring RS-485 Operation (MN-5409 only)' on page 3-16
F	Serial Data Out	This panel, which is only used if the node is configured for serial operation, is used to send serial data to the node. For details, see the following: • 'Configuring UART Operation' on page 3-12 • 'Configuring RS-232 Operation (MN-5409 only)' on page 3-15 • 'Configuring RS-485 Operation (MN-5409 only)' on page 3-16
G	Watch	This option opens a new widow that displays information relating to the the node's various interfaces, including analog and digital I/O configuration states and packets received/sent. For details, see 'Using Watch Function to Display Configuration Information' on page 3-17
H	Update	Updates the selected device with any changes made to its configuration.

Configuring Sample Interval of Single Node

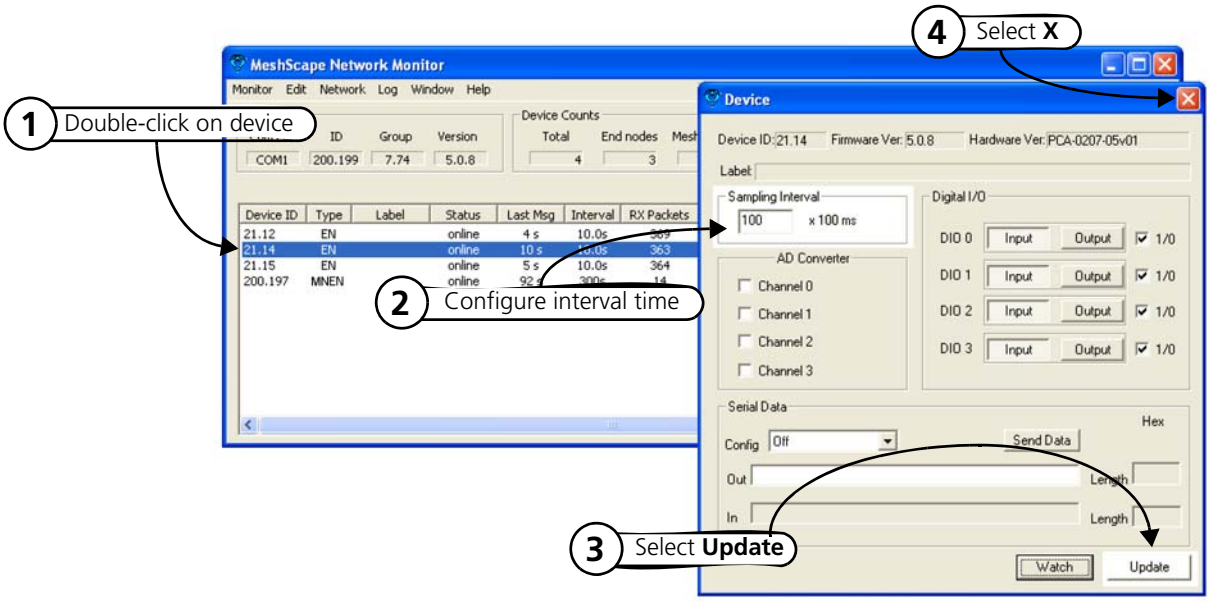
To configure the time interval between data packets transmitted by a node (see Figure 3-14):

1. Double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
2. Using the *Sampling Interval* panel, enter the interval sampling rate as a multiple of 100 milliseconds. For example, to configure a sampling interval rate of 10 seconds, enter a value of 100.
   minimum value: 1 (0.1 sec)
   maximum value: 65535 (109 minutes)
3. Select **Update**. The device's configuration is updated.

> ***Note:*** After you click Update, the MeshScape Network Monitor will display the 'Refresh' state for the device. Changes to the device configuration will show up after one sampling interval. You can use the Watch window to track configuration changes.

4. Select **X** to exit the Device window.

Figure 3-14. Configuring sample interval of single node



Configuring Sample Interval of all Network Nodes

> ***Note:*** It can take a long time to change the sampling interval for all network nodes.

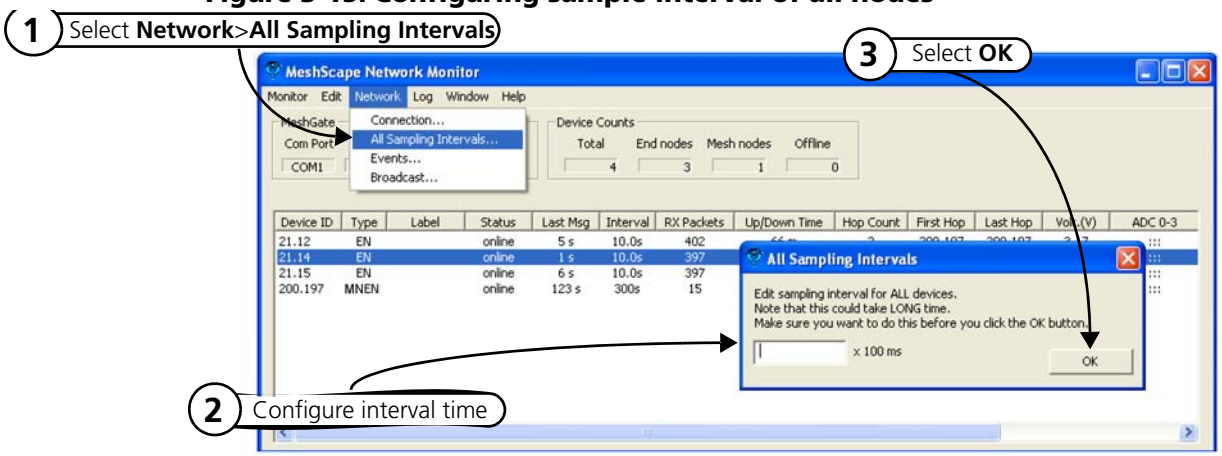
To configure all the network nodes with the same sampling interval rate (see Figure 3-15):

1. Select **Network**>**All Sampling Intervals**. The Edit Sampling Interval window is opened.

2. Enter the interval rate as a multiple of 100 milliseconds. For example, to configure a sampling interval rate of 20 seconds, enter a value of 200.

3. Select **OK**. All nodes on the network are configured with the sampling interval rate entered.

Figure 3-15. Configuring sample interval of all nodes



Configuring Digital I/O Operation

The following procedure describes the steps that need to be taken to set up the hardware and configure an end node or mesh node for digital I/O operation (see Figure 3-16).

Note: (*End nodes only*) The end node terminal board contains pullup resistors connecting its digital I/O pins to Vcc to prevent them from floating. If the I/O pins float, the current consumption of the end node could increase substantially and affect battery life. When using the end nodes with other hardware designs, be sure that all the unused digital I/O inputs are pulled up to Vcc and not left floating. Also, be sure that the inputs being used are compatible with the end node's digital I/O.

Digital Input Setup

1. Connect the digital source signals to the connectors (D0–D3) and Ground (GND) of:
   - end node's digital terminal block (P2 located on terminal board).
   - mesh node's terminal pins (connector SL3).

   See Figure 3-16 on page 3-11 for connector locations.

2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.

3. From the *Digital I/O* panel, select **Input** on each of the desired digital channels to use as inputs (DIO 0—DIO 3), then select **Update**.

   MeshScape Network Monitor displays the digital information for the node in the Digital I/O Data column, where **On** = output channel and **In** = input channel (n = 1 or 0).

Digital Output Setup

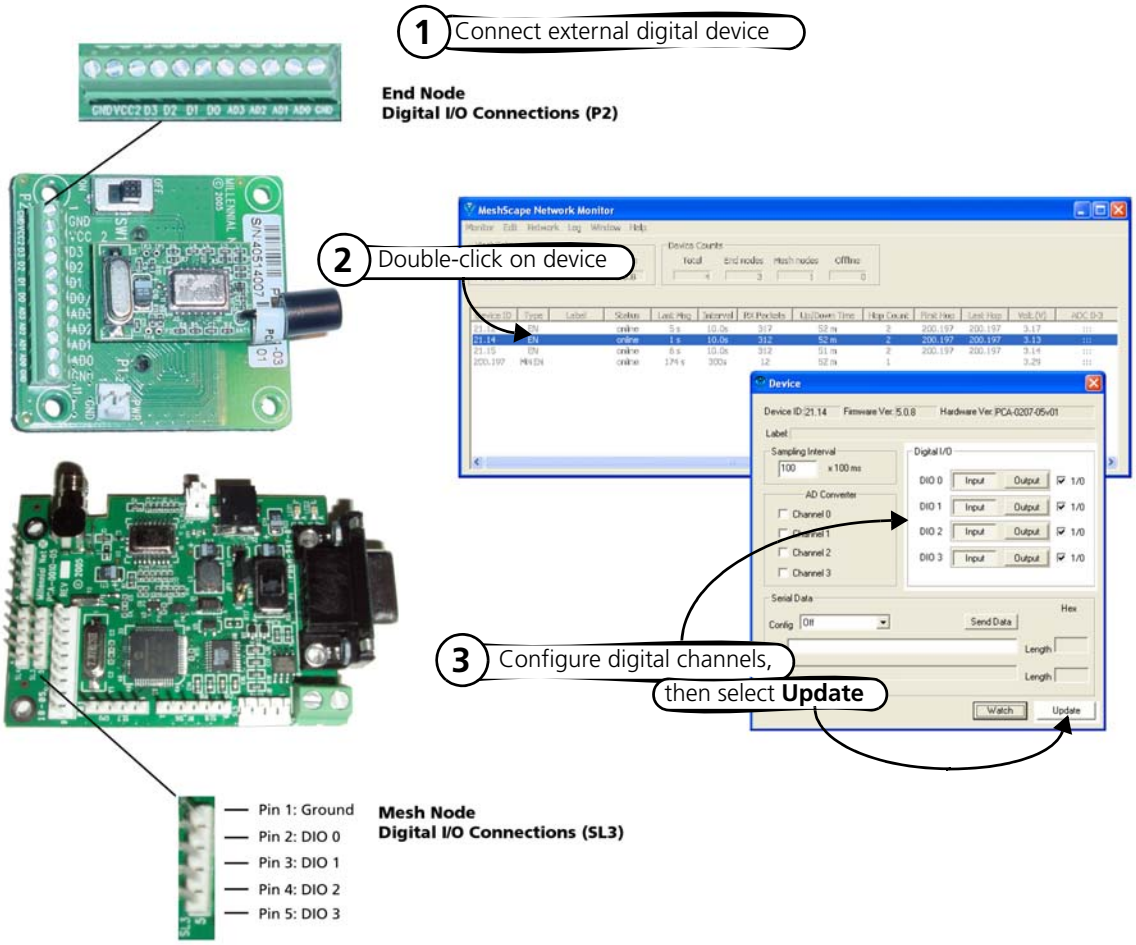
1. Connect the digital signal destination devices to the connectors (D0–D3) and ground (GND) of the following:
   - end node's terminal block (P2 located on terminal board).
   - mesh node's terminal pins (connector SL3).

   See Figure 3-16 on page 3-11 for connector locations.
2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
3. From the *Digital I/O* panel, select **Output** on each of the desired digital channels to use as outputs (DIO 0—DIO 3).
4. Set the output signal high or low using the **1/0** box located next to the desired **Output** button:
   - Selected = 1 (output is set high)
   - Not selected = 0 (output is set low)
5. Select **Update**.

   MeshScape Network Monitor displays the digital information for the node in the Digital I/O Data column, where **On** = output channel and **In** = input channel (n = 1 or 0).

Note: Input signals should not be applied when the end node is switched off. Since the node is an extremely low power device, it's possible that the input signal voltages will keep the microcontroller active, preventing it from resetting properly when switched back on. Also, when switched off, the terminal board will ground certain pins, which can cause excessive current drain for the external peripheral connected to it.

Figure 3-16. Configuring end node or mesh node for digital I/O



Configuring UART Operation

The following procedures describes how to use the end node's digital I/O connections or the mesh node's UART connector for serial/UART communications (see Figure 3-17). Refer to the technical specification sheets for the end node and mesh node for additional information required when using the device for serial communications.

Note: The end node supports the following serial communication parameters: 9600 bps, 8 data bits, no parity, 1 stop bits

The mesh node supports the following serial communication parameters: 9600 bps, 8 data bits, no parity, 2 stop bits

Serial data and digital I/O are mutually exclusive operations for end nodes.

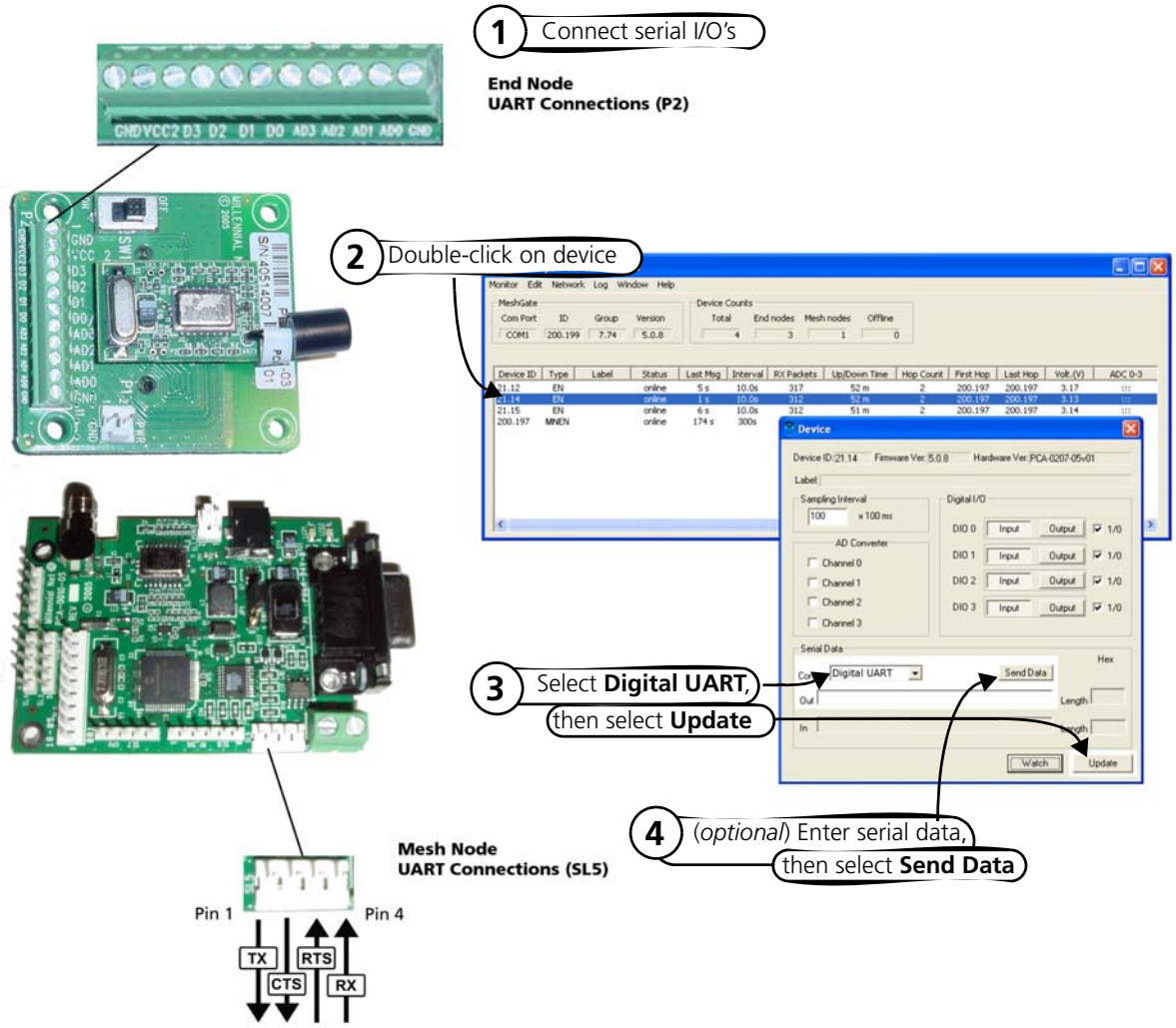
1. Connect to the following:
   - end node's P2 terminal block (pins D0–D3, GND).
   - mesh node's SL5 connector.

Caution

When making serial connections to an end node,
use an adapter to scale the RS-232 voltages to 3 volt digital logic.

2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
3. From the *Config* panel, select Serial Data: **Digital UART**, then **Update**. The UART terminal block is ready for UART operation (digital function is disabled).
4. (*optional*) To send serial data to the node, enter the data in the *Out* panel, then select **Send Data**.

Figure 3-17. Configuring end node or mesh node for UART operation



Configuring AD (analog-to-digital) Converter Operation

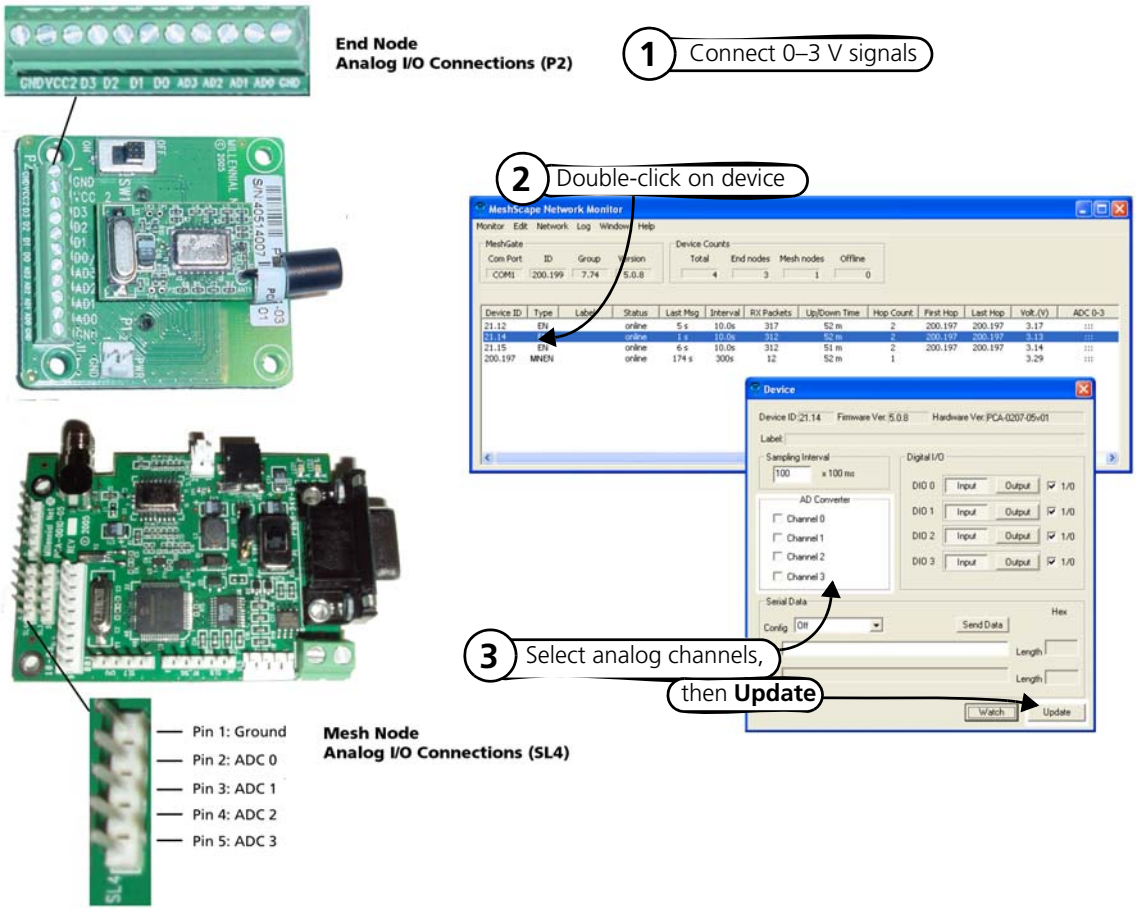
The following procedure describes the steps that need to be taken to set up the hardware and configure an end node or mesh node for AD Converter operation (see Figure 3-18):

1. Connect 0–3 VDC signals to the following A/D Converter connectors:
   - end node: Connect signal source ground to GND_CPU of the A/D Converter terminal block.
   - mesh node: Connect signal source ground to Pin 1 (Ground) of connector SL4.

   Use any or all of the A/D Converter channels (AD0–AD3/Pins 2–5) for connecting analog signal sources.
2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
3. From the *AD Converter* panel, select the AD Converter channels to which the external analog signals have been connected, then select **Update**.

   MeshScape Network Monitor displays the analog information for the node in the ADC (V) column.

Figure 3-18. Configuring end node/mesh node for analog I/O

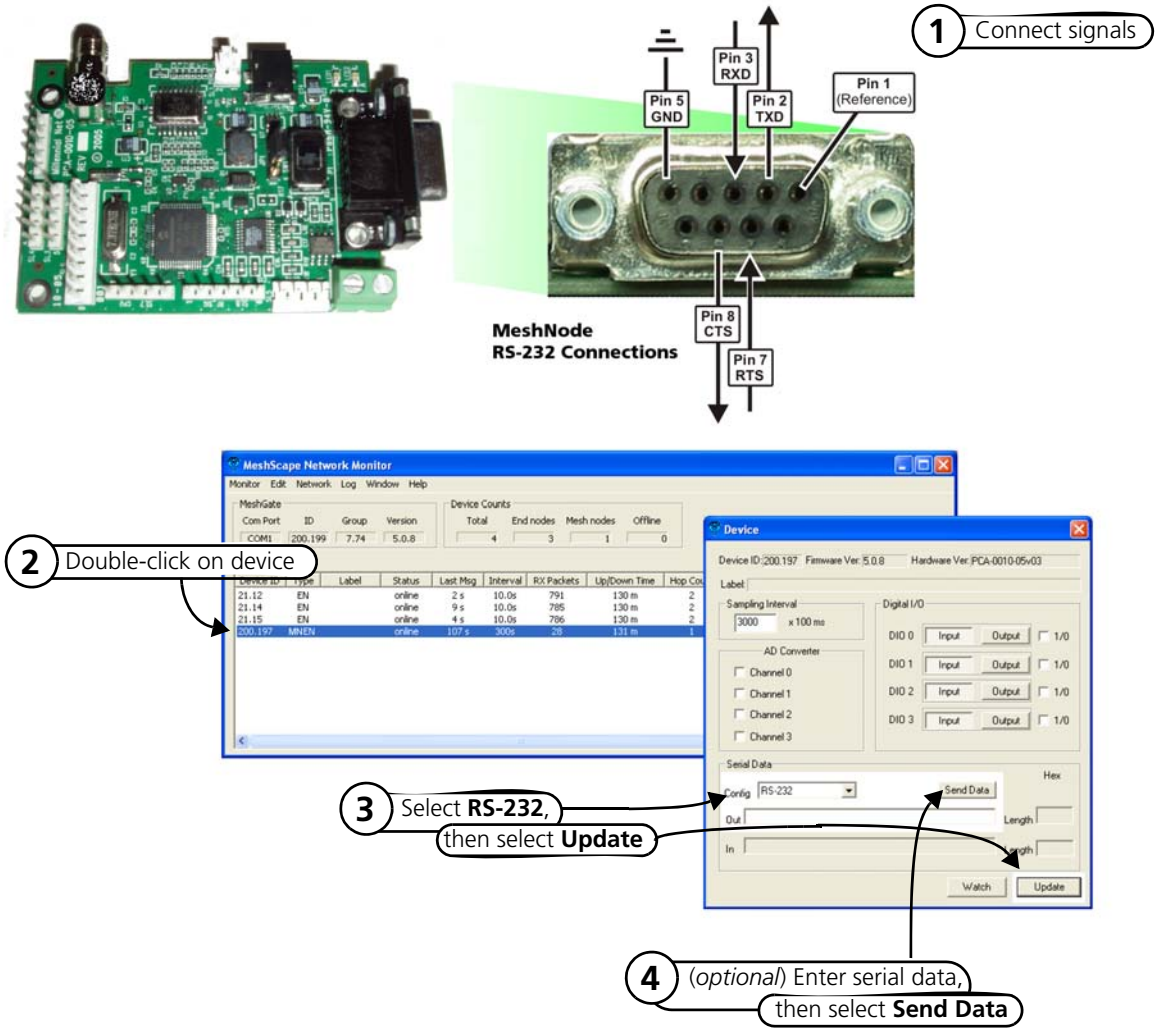


Configuring RS-232 Operation (MN-5409 only)

The following procedure describes the steps that need to be taken to set up the hardware and configure a mesh node for RS-232 operation (see Figure 3-19):

1. Use a DB-9 cable to connect the network device to the RS-232 female connector using the pinout information provided in Figure 3-19.
2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
3. From the *Config* panel, select Serial Data: **RS-232**, then **Update**. The RS-232 connector is ready for operation (digital function is disabled).
4. (*optional*) To send serial data to the mesh node, enter the data in the *Out* panel, then select **Send Data**.

Figure 3-19. Configuring mesh node for RS-232



Configuring RS-485 Operation (MN-5409 only)

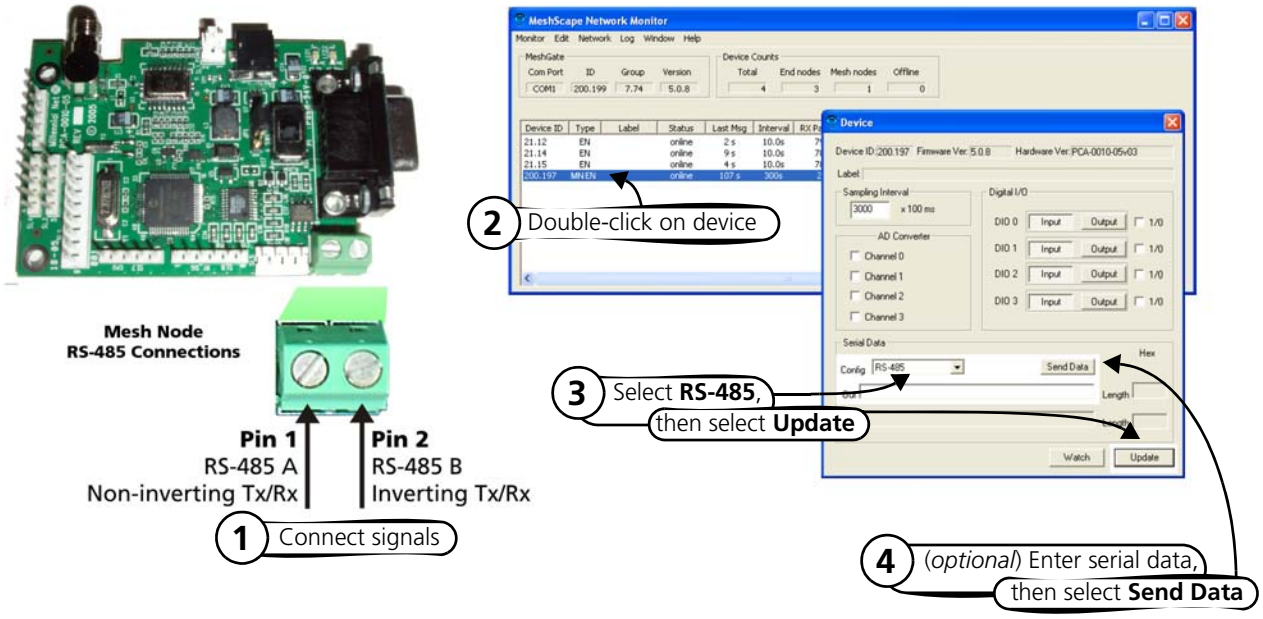
The RS-485 interface of the mesh node operates using the following parameters:

- Half-duplex mode
- 9600 baud
- Transmitting data: Maximum byte length for one request is 80 bytes
- Receiving data: Reception is terminated by the mesh node when the maximum input byte length is reached or there is no input for more than 20 ms. Once the input is terminated, the data is transferred to MeshScape Network Monitor.

The following procedure describes the steps that need to be taken to set up the hardware and configure a mesh node for RS-485 operation (see Figure 3-20):

1. Connect the network device to the standard 2-position RS-485 terminal block using the pinout information provided in Figure 3-20. The terminal block will accept 26 AWG to 16 AWG wire.
2. From MeshScape Network Monitor, double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
3. From the *Digital I/O* panel, select Serial Data: **RS-485**, then **Update**. The RS-485 connector is ready for operation (digital function is disabled).
4. (*optional*) To send serial data to the mesh node, enter the data in the *Serial Data* panel, then select **Send Data**.

Figure 3-20. Configuring mesh node for RS-485



Using Watch Function to Display Configuration Information

Use the Watch window to track changes to a device's configuration.

You may open multiple instances of the Watch window. The selected device's ID and label (if configured) are displayed in the Watch window title bar.

To display the current and desired configuration for a device (see Figure 3-21):

1. Double-click on the desired device from the list of discovered sensor nodes. The Device window is opened, displaying the device's current configuration.
2. Select **Watch**. The **Watch** window is opened, displaying the selected device's current and desired configuration information.
3. Select **X** to exit the Watch window.

Alternatively, click once on a device and then select **Window>Watch** to open the Watch window for that device.

Figure 3-21. Displaying I/O information using Watch function

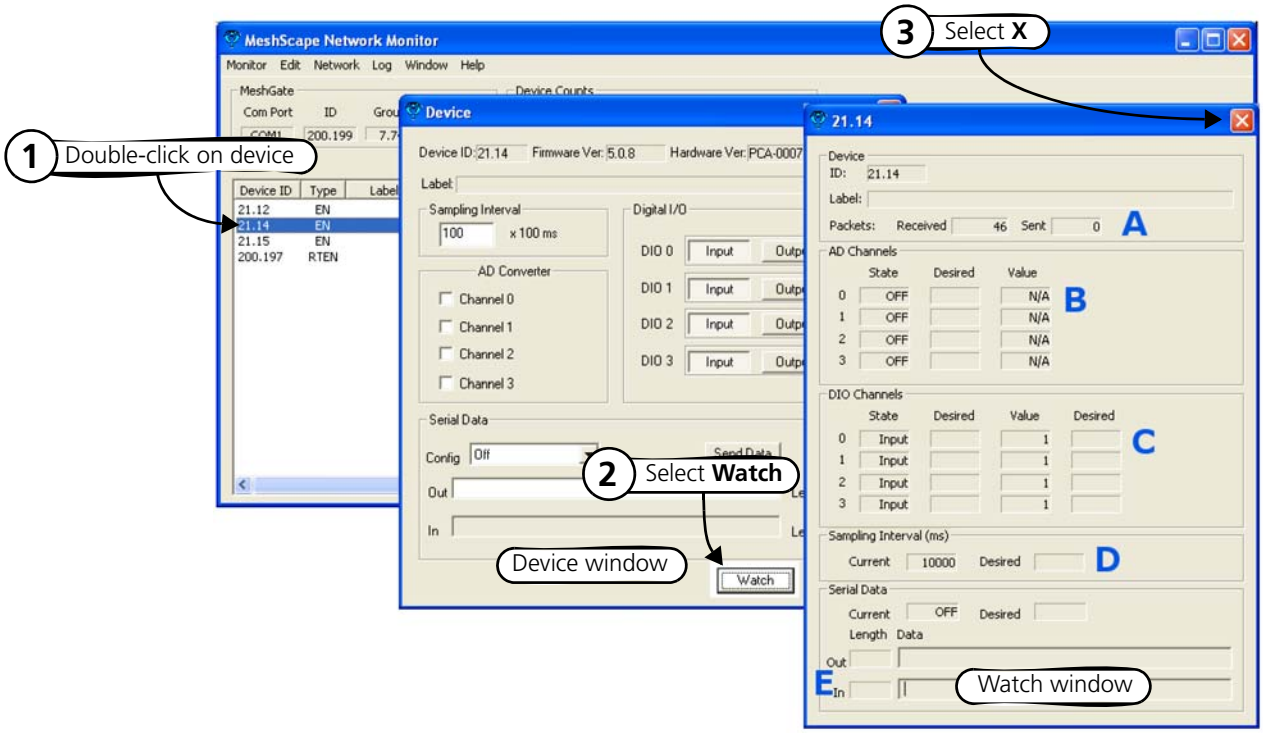


Table 3-7 describes the functions of the various sections of the Watch window as shown in Figure 3-21.

Table 3-7. Watch window functions

Item	Description	Function
A	Packets Received/Sent	Total packets received from or transmitted to the node.

Table 3-7. Watch window functions (continued)

Item	Description	Function
B	A-D Channels	This panel displays the following information for each analog-to-digital channel (0–3): • **State**: Current on/off state of the channel • **Desired**: Desired on/off state of channel, which can be changed using the **Device** window. • **Value**: Numeric values of the channel.
C	DIO Channels	This panel displays the following information for each digital channel (0–3): • **State**: Current input/output state of the channel • **Desired**: Desired input/output state of channel, which can be changed using the **Device** window. • **Value**: I/O values of the channel (1 or 0). • **Desired**: Desired I/O value of channel.
D	Sampling Interval	This panel displays the following sampling interval information: • **Current**: Currently configured setting. • **Desired**: Desired setting, which can be changed using the **Device** window (see 'Configuring Sample Interval of Single Node' on page 3-8).
E	Serial Data	This panel displays the following serial data information of data received from the node (In) or transmitted to the node (Out): • **Current**: Currently configured setting (Off, RS-232, RS-485) • **Desired**: Desired setting • **Length**: Length of string received/transmitted.

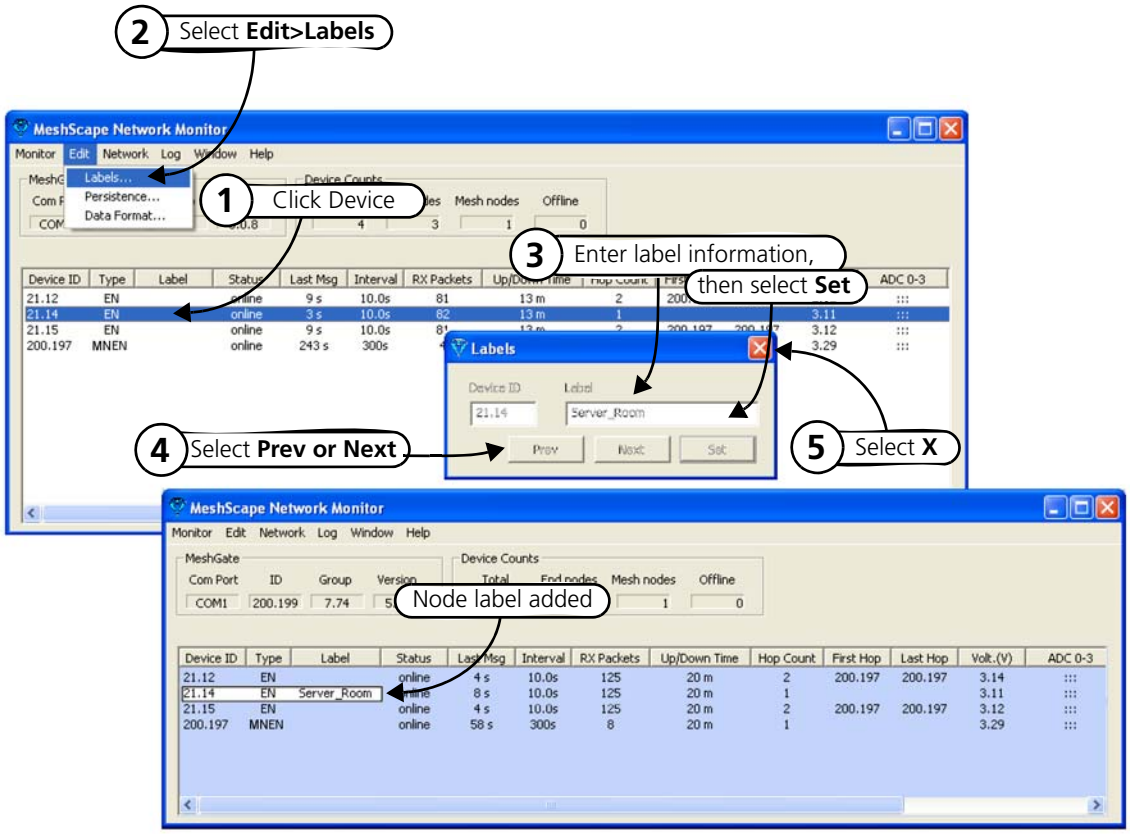
Labeling an End Node or Mesh Node

Labels are meaningful, persistent text strings used to identify network nodes beyond their group and device IDs.

The following procedure describes the steps required to assign a label to an end node or mesh node (see Figure 3-22):

1. From MeshScape Network Monitor, click on the desired device from the list of discovered sensor nodes.
2. From MeshScape Network Monitor, select **Edit**>**Labels**. The Edit Labels window is opened.
3. Enter the label to be applied to the node, then select **Set**. MeshScape Network Monitor displays the label in the *Label* column of the selected node.
4. Click **Prev** or **Next** to apply labels to other discovered sensor nodes.
5. Select **X** to exit the Edit Label window.

Figure 3-22. Labeling an end node or mesh node

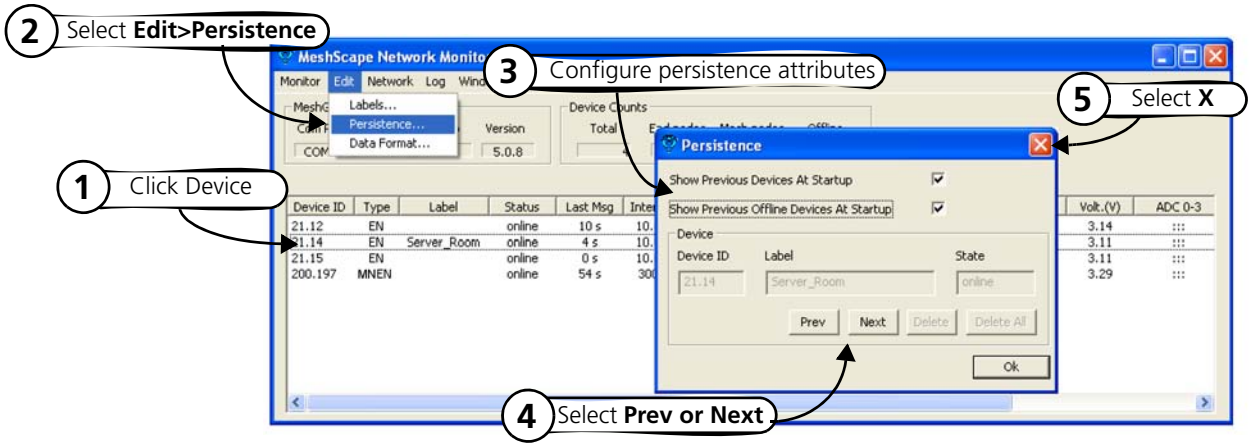


Configuring Persistence Attributes

The following procedure describes how to configure the persistence setting of the network's end nodes and mesh nodes (see Figure 3-23):

1. From MeshScape Network Monitor, click on the desired device from the list of discovered sensor nodes.
2. From MeshScape Network Monitor, select **Edit**>**Persistence**. The Edit Persistence window is opened.
3. Configure the following persistence attributes:
   - **Show previous devices at startup**: If selected, all online nodes will be displayed when MeshScape Network Monitor is started.
   - **Show previous offline devices at startup**: If selected, all online and offline nodes will be displayed when MeshScape Network Monitor is started.
   - **Delete**: Select the delete button to stop displaying the selected Offline node.
   - **Delete all**: Select this delete button to stop displaying any node with a status of Offline.
4. Click **Prev** or **Next** to apply persistence attributes to other discovered sensor nodes.
5. Select **X** to exit the Edit Persistence window.

Figure 3-23. Configuring node persistence attributes

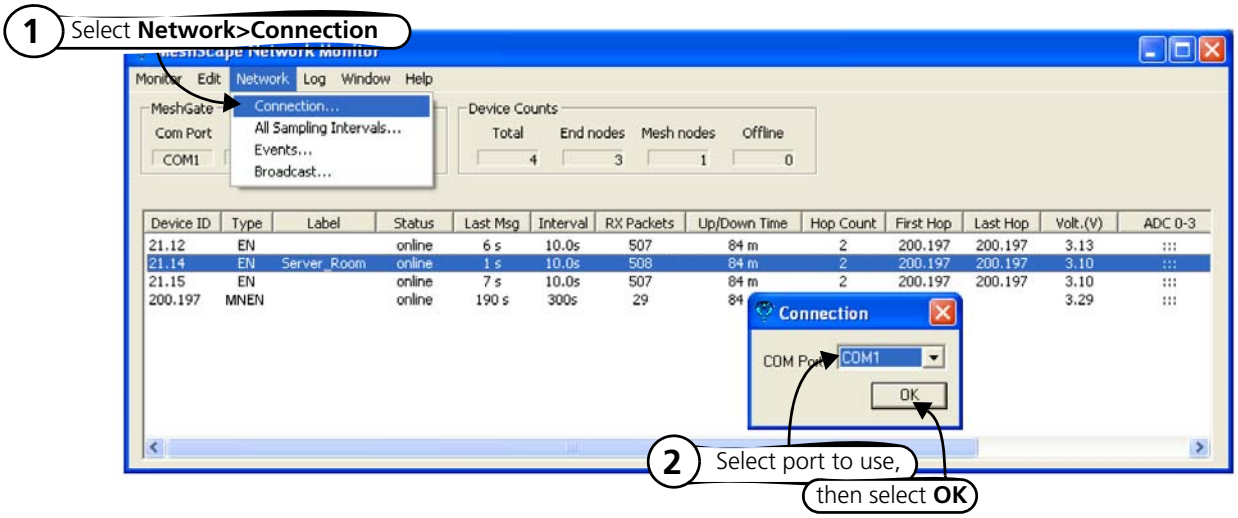


Selecting a Com Port on the Host PC

The following procedure describes how to select the RS-232 com port for MeshScape Network Monitor to use to communicate with the MeshGate (see Figure 3-24):

1. From MeshScape Network Monitor, select **Network>Connection**. The Connection window is opened.
2. Select the RS-232 com port to use from the drop down list of available ports, then select **OK**. MeshScape Network Monitor communicates with the MeshGate connected to the selected port.

Figure 3-24. Selecting com port on host PC

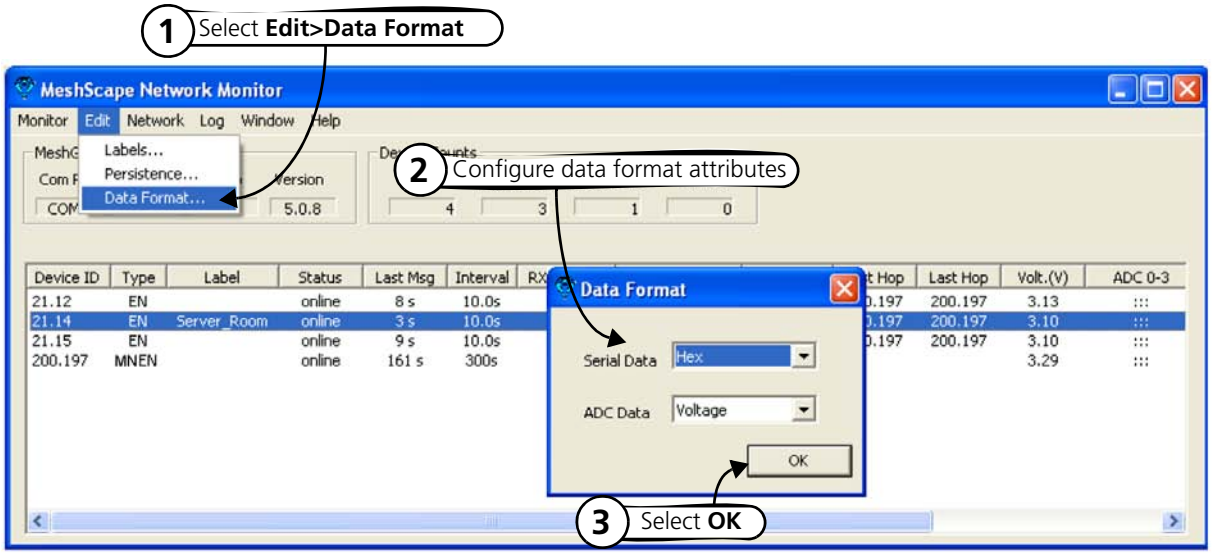


Configuring Serial and ADC Data Formats

The following procedure describes how to configure the format of displayed serial and ADC information (see Figure 3-25):

1. From MeshScape Network Monitor, select **Edit**>**Data format**. The Edit Data Format window is opened.
2. Configure the following network attributes:
   - **Serial data format**: Select the desired format for displaying serial data (ASCII/Hex/Decimal).
   - **ADC data format**: Select the desired format for displaying ADC data (Voltage/Raw Data).
3. Select **OK** to save the settings and exit the Edit Network window.

Figure 3-25. Configuring serial and ADC data formats



Turning Event Tracking On/Off

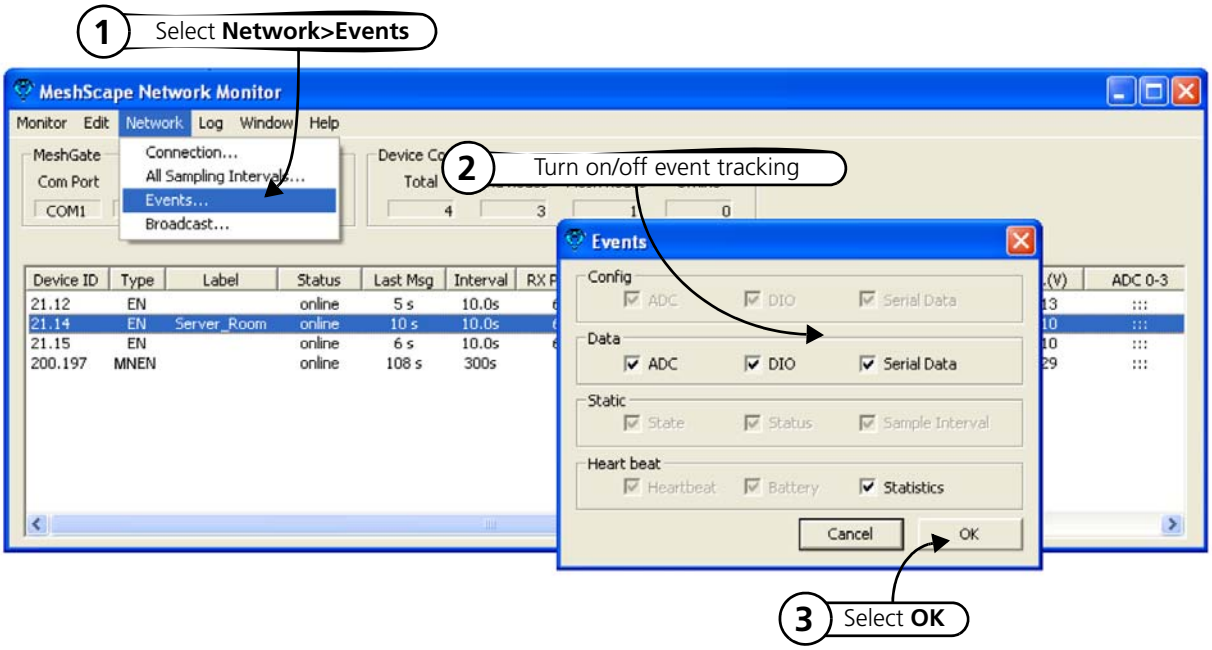
The following procedure describes how to turn event tracking on or off. Tracked events are recorded in the Event log file (see Figure 3-26):

1. From MeshScape Network Monitor, select **Network**>**Events**. The Events window is opened.
2. Configure the following event tracking settings:
   - **Configuration Events**: Display event tracking status for Analog-to-digital Converter, Digital Input/Output, and Serial configuration events.
   - **Data Events**: Turn event tracking on/off for Analog-to-digital Converter, Digital Input/Output, and Serial data events.
   - **Static Events:** Display event tracking status for device State, Status, and Sampling Interval events.
   - **Heartbeat:** Display event tracking status for device Heartbeat and Battery Level events. Display event tracking status for Statistical events.

Note: Events for which tracking cannot be turned off appear grayed out in the Events window.

3. Select **OK** to save the settings and exit the Events window.

Figure 3-26. Turning device event tracking on/off



Broadcasting Data to All Nodes.

Note: Broadcasting capabilities are available on your MeshScape only if you have enabled (i.e., unlocked) the ultra-low power feature.

You can broadcast the following data to all nodes on your MeshScape System:

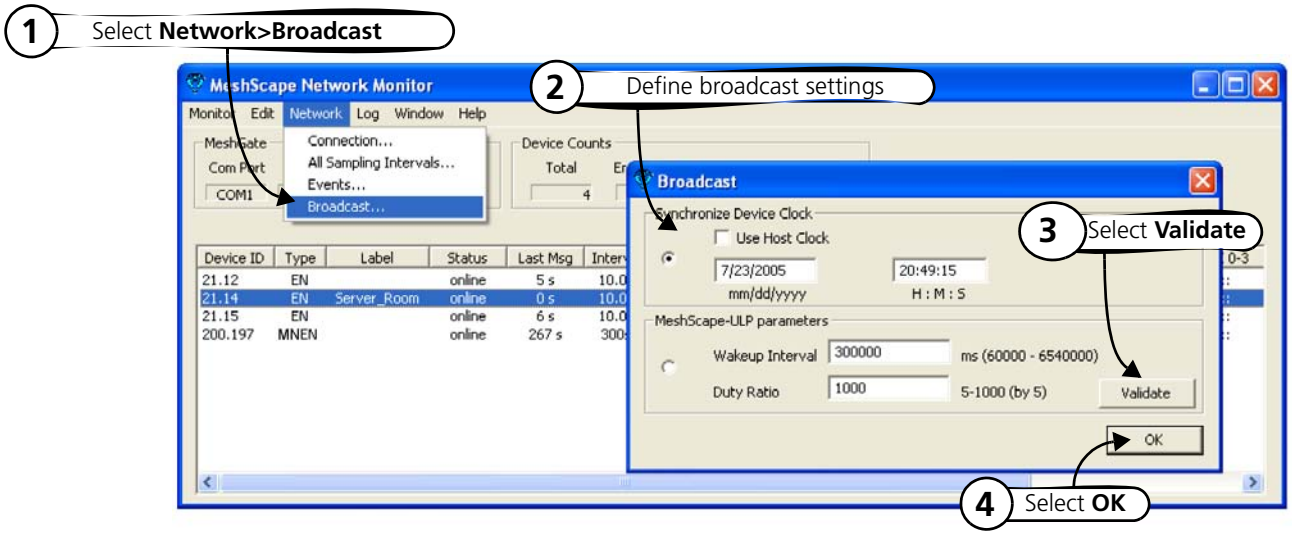
- The time to which all nodes will synchronize their clocks
- Ultra Low Power (ULP) settings defining wakeup interval and duty cycle for all nodes

The following procedure describes how to broadcast data to all nodes (see Figure 3-26):

1. From MeshScape Network Monitor, select **Network**>**Broadcast**. The Broadcast window is opened.
2. Configure the following broadcast settings:
   - **Synchronize device clock**: Set the time with which the node clocks are to synchronize. Mark the Use host clock check box to broadcast the time set on the host PC on which the MeshScape Network Monitor is running, or alternatively, enter the date and time to broadcast.
   - **Wakeup interval:** The wakeup interval determines the Mesh Node wakeup cycle. Minimum value for the wakeup interval is 60000 milliseconds, and the maximum value is 6540000 milliseconds.
   - **Duty ratio:** The duty ratio determines how long the Mesh Node stays awake and how long it sleeps during each wakeup interval. The duty ratio is defined as 100*(awake time)/(wakeup interval). Note that the wakeup interval = awake time + sleep time. The duty ratio has no unit.

     The units for specifying the duty cycle is tenths of a percent. The recommended Minimum value for the duty ratio is 5 (represent 0.5%), and the Maximum value is 1000 (represents 100.0%) set in increments of 5.
3. Select **Validate** to verify your ULP settings are valid and within range.
4. Select **OK** to save the settings and exit the Broadcast window.

Figure 3-27. Broadcasting data to all nodes



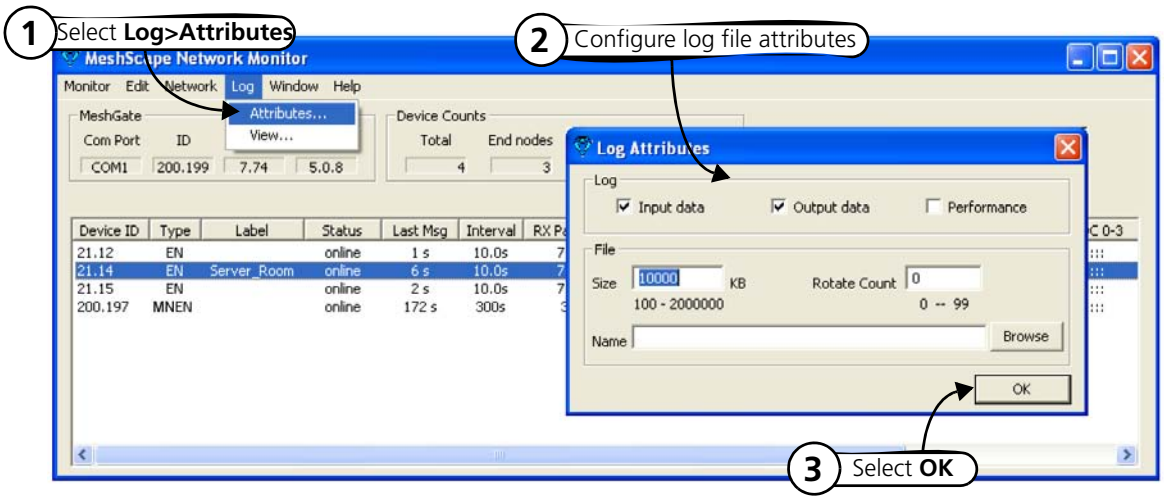
Creating an Event Log File

The following procedure describes the steps required to have MeshScape Network Monitor record reported network events to a log file (see Figure 3-28):

1. From MeshScape Network Monitor, select **Log**>**Attributes**. The Edit Logging Attributes window is opened.
2. Configure the following mesh node and end node log file attributes:
   - **Log data**: Record input/output/performance data.
   - **File size *n* KB**: Clear the log file and begin the recording process again when it reaches the designated file size and rotate count number.
   - **Rotate Count *n***: Number of history log files to maintain. Once this value is reached, files are written over.
   - **Name**: Assign a name to the log file and define where the file is saved.
3. Select **OK** to activate the logging process.

To view the contents of the log file, see 'Viewing the Contents of an Event Log File' on page 3-27.

Figure 3-28. Configure an event log file



Viewing the Contents of an Event Log File

The following procedure describes how to view the network event log file generated by MeshScape Network Monitor, which records node-generated events (see Figure 3-29):

1. From MeshScape Network Monitor, select **Log>View**. The log file window is opened, displaying the user-defined event log information (see also 'Creating an Event Log File' on page 3-26).
2. Select one of the following:
   - **Stop/Restart**: Select this toggle option to stop and restart a recording session.
   - **Clear**: Select this option to clear the information currently displayed and start a new recording session.

You can copy and paste event log data to the Windows clipboard.

To configure the events to track and include in the log file, see 'Turning Event Tracking On/Off' on page 3-23.

To configure the attributes of the log file that get recorded and displayed, see 'Creating an Event Log File' on page 3-26.

Figure 3-29. View contents of event log file

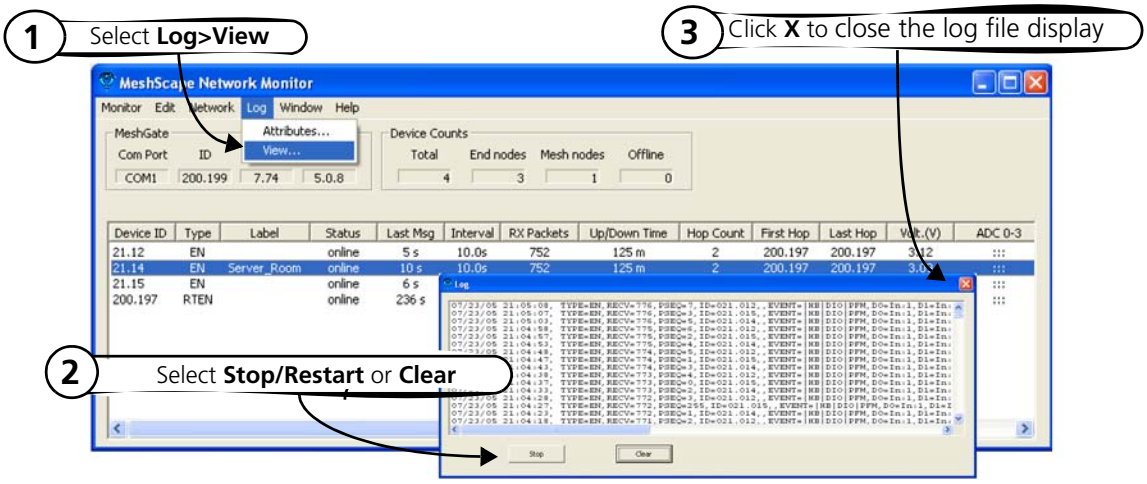


Table 3-8 describes the event keys (see example) displayed in the log file.

example: `04/22 11:00:42, Type=EN, RCV=100, PSEQ=28, ID=021.015, Event=|HB|DIO|PFM, D0=In:1, D1=In:1, D2=In:1, D3=In:1`

Table 3-8. Event log key definitions

Key	Key Meaning	Sub-Key	Sub-Key Meaning	Output to device example	Input to device example
A0 ... A3	ADC Channel 0 ... 3	En	Enabled	A0=En	A0=2.12
		Dis	Disabled	A1=Dis	

Table 3-8. Event log key definitions (continued)

Key	Key Meaning	Sub-Key	Sub-Key Meaning	Output to device example	Input to device example
D0 ... D3	Digital I/O Channel 0 ... 3	In	Input	D0=In	D0=In:1
		Out	Output	D1=Out:1	
EP	Endpoint	N/A	N/A	EP=001.001	EP=001.002
FH	First Hop Mesh Node	N/A	N/A	N/A	FH=001.002
HC	Hop Count	N/A	N/A	N/A	HC=3
LH	Last Hop Mesh Node	N/A	N/A	N/A	LH=002.003
RCV	Receive	N/A	N/A	N/A	RCV=200 (sequence number)
MNEN	Mesh Node	N/A	N/A	RT=200.001	RT=200.001
SER	Serial Interface	N/A	N/A	SER=12 34 56 13	SER=12 34 56 13
SI	Sampling Interval	N/A	N/A	SI=100.0	SI=200.0
SND	Send	N/A	N/A	SND=100 (sequence number)	N/A
ST	State	On	Online	ST=On	
		Off	Offline		
		Ref	Refreshing		

Viewing MeshScape Statistics

The following procedure describes how to view the network statistics recorded by MeshScape Network Monitor, which provides information on the packets received and transmitted by the network nodes (see Figure 3-30):

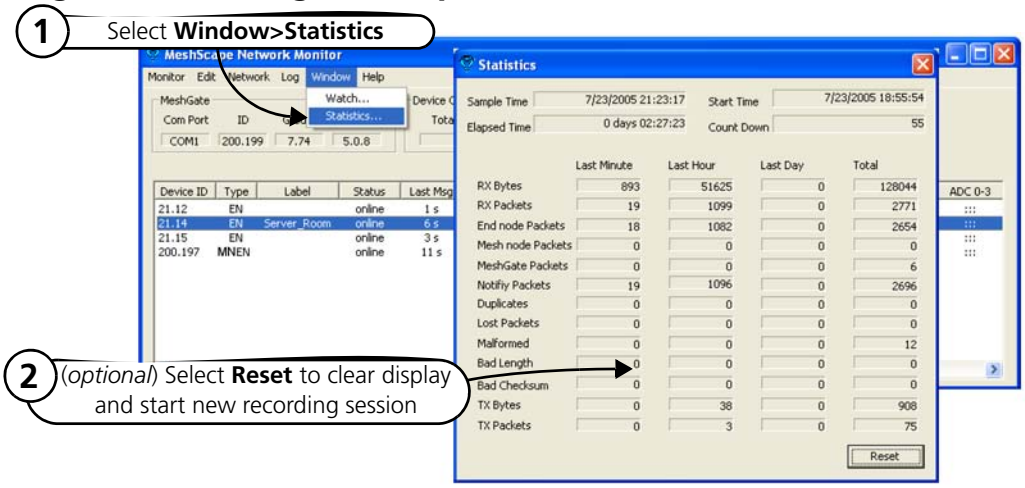
1. From MeshScape Network Monitor, select **Window**>**Statistics**. The Statistics window is opened, displaying the following information:
   - **Sample Time:** Current date and time.
   - **Start Time**: Date/time statistics recording session began.
   - **Elapsed Time**: Total recording time.
   - **Count Down:** Seconds before next sample is taken and window is refreshed.
   - **RX Bytes**: Total bytes received.
   - **RX Packets**: Total packets received.
   - **End Node Packets**: Packets received from end nodes.
   - **Mesh Node Packets**: Packets received from mesh nodes.
   - **MeshGate Packets**: Packets received from MeshGate.
   - **Notify Packets**: Packets sent from MeshGate to MeshScape Network Monitor for notification events.
   - **TX Bytes**: Total bytes transmitted.
   - **TX Packets**: Total packets transmitted.

Caution

Selecting **Reset** will remove all statistics collection history.

2. (*optional*) Select **Reset** to clear the information currently displayed and begin a new recording session.

Figure 3-30. Viewing MeshScape statistics



4

Using the MeshScape API

This chapter describes the following API functions:

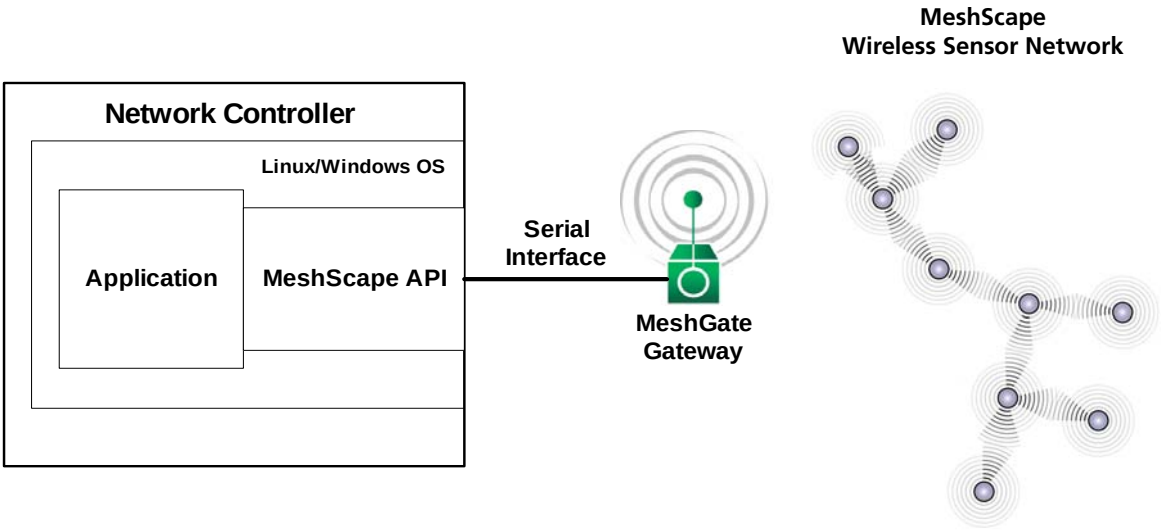
- 'Using the MeshScape API' on page 4-2
- 'MeshScape API Functions Overview' on page 4-5
- 'iBeanAPI.h' on page 4-7
- 'iBeanAPI_IO.h' on page 4-23
- 'iBeanAPI_Utils.h' on page 4-32
- 'iBeanAPI_LPR.h' on page 4-36
- 'iBeanAPI_performance.h' on page 4-39
- 'Example API Code' on page 4-42

Using the MeshScape API

Millennial Net's MeshScape™ API enables you to effectively use the features provided by Millennial Net's MeshScape wireless sensor network. You can develop custom applications that utilize the MeshScape API library on Windows- or Linux-based platforms such as Network Controllers, PCs, or PDAs.

The Millennial API provides a serial command set that enables a MeshScape MeshGate standalone gateway to communicate with user applications via a serial interface. The serial interface transports a byte stream-based protocol that provides MeshScape API equivalent functionality. The commands operate in both a query/response and an autonomous event notification manner.

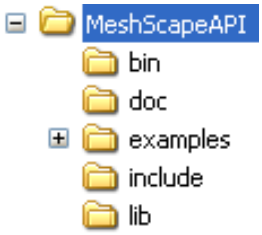
Figure 4-1. Using the MeshScape API



MeshScape API Directory Structure

The MeshScape API sub-directory contains five sub-directories which hold the API related files, including header files, dll and library files, and various compiled examples along with their source code listings. Figure 4-2 is a representation of the directory structure.

Figure 4-2. MeshScape API directories



The contents of each directory is described below.

bin Directory:

This sub-directory contains the iBeanAPI.dll file required for running API related applications. This dll file is compiled with Microsoft's Visual Studio .Net edition and therefore only supports Microsoft Visual C++ programming conventions.

doc Directory:

This sub-directory contains the MeshScape system user documentation in Adobe Acrobat (.pdf) format including:

- RK-5409-5 Reference Kit User's Guide (i.e., this guide)
- RK-5409-5 916 MHz MeshScape™ Reference Kit Contents & Getting Started Guide
- MeshScape Product Family Sheet
- Technical specifications for MeshGate gateway, mesh node, and end node
- Release notes

examples Directory:

This sub-directory contains the iMDLL5k.dll file along with pre-compiled API executables. These executables are compiled with Microsoft's Visual Studio .Net edition and are designed to run under Windows XP and Windows 2000. The source code along with sample Microsoft Visual Studio .Net solution file for these example applications can be found in the /src sub-directory. Here is a brief description of the API example applications:

- ListDevicesVC7.exe: This is a console based application that lists current online devices. For a detailed look at this example and its code, see 'Example API Code' on page 4-42.
- ReadSerialVC7.exe: This is a console based application that reads serial data received from any online device on the network that has serial interface enabled.
- SetSamplingVC7.exe: This is a console based application that changes the sampling interval of the online devices.
- TempMonitor.exe: This is a console based application that displays information from the Temperature Sensor Assembly.

– src Directory: This sub-directory contains the source code and their corresponding Microsoft Visual Studio .Net solution files. When these examples are built from these solution files, the executables are generated in the bin directory.

To access the different API examples available in the Examples directory, select the following:

Start>All Programs>MeshScape>API Examples

include Directory:

This sub-directory contains the MeshScape API header files required to build any API-based application. These header files are documented in this chapter.

lib Directory:

This sub-directory contains the iBeanAPI.lib file required to compile any API-based application.

MeshScape API Functions Overview

Table 4-1 provides a list of API functions associated with MeshScape system products.

Table 4-1. MeshScape API functions

iBeanAPI.h		Core API functions
	ibApi_Open() ibApi_Close() ibApi_GetApiVersion()	Session Management
	ibApi_GetNetworkList() ibApi_GetDeviceList()	Enumeration of network devices
	ibApi_GetDeviceInfo() ibApi_GetDeviceStatus()	Static and dynamic device attributes
	iBApi_GetDeviceState() ibApi_SetSamplingInterval() ibApi_GetSamplingInterval()	Universally supported device properties
	ibApi_WaitForDeviceEvent() ibApi_WaitForDeviceEvents() ibApi_SetEventMask() ibApi_GetEventMask() ibApi_GetDevicePacketSequenceNumber() ibApi_Block() ibApi_UnBlock() ibApi_RegisterEvent()	Event Notification
iBeanAPI_IO.h		Standard I/O peripherals
	ibApi_IO_GetDeviceCaps()	Static device attributes
	ibApi_IO_SetADCConfig() ibApi_IO_GetADCConfig() ibApi_IO_ReadADC()	Analog-to-Digital conversion
	ibApi_IO_SetDIOConfig() ibApi_IO_GetDIOConfig() ibApi_IO_WriteDIO() ibApi_IO_ReadDIO()	Digital input/output

Table 4-1. MeshScape API functions (continued)

	ibApi_IO_SetSerialConfig() ibApi_IO_GetSerialConfig() ibApi_IO_GetSerialBufferStatus() ibApi_IO_WriteSerial() ibApi_IO_ReadSerial() ibApi_IO_SetDeviceConfigAndData	Serial data interface (UART)
iBeanAPI_Utils.h		Supplementary functions
	ibApi_Utils_GetErrorDescription()	Obtain text descriptions for error codes
	ibApi_Utils_ConvertGroupIdToText() ibApi_Utils_ConvertTextToGroupId() ibApi_Utils_ConvertDeviceIdToText() ibApi_Utils_ConvertTextToDeviceId() ibApi_Utils_ConvertBatteryReadingToVoltage() ibApi_Utils_ConvertAdcReadingToVoltage()	Convert between ID structures and text representation
iBeanAPI_LPR.h		Ultra-Low Power Functions
	ibApi_LPR_SetClock()	Set the Coordinated Universal Time (UTC) clock for all devices
	ibApi_LPR_GetClock()	Retrieves the UTC clock value used for all devices
	ibApi_LPR_SetWakeupAndDutyRatio()	Sets the low power mesh node wakeup interval and duty ratio for all devices
	ibApi_LPR_GetWakeupAndDutyRatio()	Retrieves the wakeup interval and duty ratio for all devices
iBeanAPI_performance.h		Performance Statistics
	ibApi_GetStatisticData()	Retrieve statistical data for a given device.

iBeanAPI.h

Data Structures

1. **ibApi_APIHANDLE**

```
typedef ibApi_INT32 ibApi_APIHANDLE;
```

This handle represents an API session. It is created by `ibApi_Open()` and used by most of the other API functions.

2. **ibApi_RESULT**

```
typedef ibApi_INT32 ibApi_RESULT;
```

The API functions are standardized to return the value ibApi_RESULT, which is a signed 32-bit integer. If the integer is negative, then it is an error code such as ibApi_RESULT_ERR_INVALIDHANDLE or ibApi_RESULT_ERR_NOTPERMITTED. (See iBeanAPI.h for a full listing of error codes.) Otherwise, the result can be ibApi_RESULT_SUCCESS or a non-negative value specific to the particular function.

3. **ibApi_GROUPID**

```
struct ibApi_GROUPID_s {
  ibApi_UINT8 words[ibApi_GROUPID_SIZE];
};
typedef struct ibApi_GROUPID_s ibApi_GROUPID;
```

The group ID is a 32-bit address that is used to identify a specific network of i-Bean devices and is shared by all the devices within the network. (In the current implementation, each MeshScape System group can only have one MeshGate.)

The API functions are standardized to return the value ibApi_RESULT, which is a signed 32-bit integer. If the integer is negative, then it is an error code such as ibApi_RESULT_ERR_INVALIDHANDLE or ibApi_RESULT_ERR_NOTPERMITTED. (See iBeanAPI.h for a full listing of error codes.) Otherwise, the result can be ibApi_RESULT_SUCCESS or a non-negative value specific to the particular function.

4. **ibApi_DEVICEID**

```
struct ibApi_DEVICEID_s {
  ibApi_UINT8 words[ibApi_DEVICEID_SIZE];
};
typedef struct ibApi_DEVICEID_s ibApi_DEVICEID;
```

The device ID is a 64-bit address that uniquely identifies an i-Bean network component such as end node, mesh node, or gateway.

5. **ibApi_COMPARISON**

```
enum ibApi_COMPARISON_e {
  ibApi_COMPARISON_EQUAL            = (1<<0),
  ibApi_COMPARISON_LESSTHAN         = (1<<1),
  ibApi_COMPARISON_GREATERTHAN      = (1<<2),

ibApi_COMPARISON_NOTEQUAL         =
ibApi_COMPARISON_LESSTHAN|ibApi_COMPARISON_GREATERTHAN,
  ibApi_COMPARISON_NOTLESSTHAN      =
ibApi_COMPARISON_EQUAL|ibApi_COMPARISON_GREATERTHAN,
  ibApi_COMPARISON_NOTGREATERTHAN   =
ibApi_COMPARISON_EQUAL|ibApi_COMPARISON_LESSTHAN,
  ibApi_COMPARISON_BITMASK          = 0xf
};
typedef ibApi_UINT16 ibApi_COMPARISON;
```

This enum is used for the return value of functions that compare things. Note that these values are non-negative to enable casting as ibApi_RESULT.

6. **ibApi_IOMODE**

```
enum ibApi_IOMODE_e {
    ibApi_IOMODE_OUTPUT=0,
    ibApi_IOMODE_INPUT=1
};
typedef enum ibApi_IOMODE_e ibApi_IOMODE;
```

This is used by functions such as `ibApi_IO_SetDIOConfig()` for configuring channels for input or output.

7. **ibApi_DEVICETYPE**

```
enum ibApi_DEVICETYPE_e {
  ibApi_DEVICETYPE_ENDPOINT     = (1<<0),
  ibApi_DEVICETYPE_ROUTER       = (1<<1),
  ibApi_DEVICETYPE_ROUTERBEAN   = (1<<2),
  ibApi_DEVICETYPE_GATEWAY      = (1<<3),
  ibApi_DEVICETYPE_ANY          = 0x3f  /* used with filter */
};
typedef ibApi_UINT32 ibApi_DEVICETYPE;
```

This is used to identify the device type. The `ibApi_DEVICETYPE_ENDPOINT` and `ibApi_DEVICETYPE_ROUTERBEAN` implement various I/O interfaces, whereas `ibApi_DEVICETYPE_ROUTER` and `ibApi_DEVICETYPE_GATEWAY` do not.

8. **ibApi_DEVICEINFO**

```
#define ibApi_MAX_VERSION_STRLEN 32

struct ibApi_DEVICEINFO_s {
   ibApi_UINT16 struct_size;
   ibApi_DEVICETYPE device_type;
   ibApi_CHAR hardware_version[ibApi_MAX_VERSION_STRLEN];
   ibApi_CHAR firmware_version[ibApi_MAX_VERSION_STRLEN];
};
typedef struct ibApi_DEVICEINFO_s ibApi_DEVICEINFO;
```

This data structure is used by `ibApi_GetDeviceInfo()` to report static device attributes that are fixed at manufacturing time.

Structure Fields:

struct_size The value sizeof (`ibApi_DEVICEINFO`) should be assigned to this field prior to calling `ibApi_GetDeviceInfo()`. This allows future versions of the API to extend the struct without breaking binary compatibility.

device_type The type of the device (end node, mesh node, etc.).

hardware_version
firmware_version These two fields report the firmware and hardware version strings for various network devices, which are useful for diagnostic purposes. An empty string may be assigned if the device does not support version reporting.

9. **ibApi_DEVICESTATE**

```
enum ibApi_DEVICESTATE_e {
   ibApi_DEVICESTATE_OFFLINE,
   ibApi_DEVICESTATE_ONLINE,
   ibApi_DEVICESTATE_REFRESHING,
};
typedef ibApi_UINT16 ibApi_DEVICESTATE;
```

These functions are used with `ibApi_GetDeviceState()`. When a command is issued to modify a network device, a series of network communications must occur before the change will take effect. During this time period the said to be “refreshing”, and the actual device state may be different from values visible to the API. The refresh time depends on many factors such as sampling interval, traffic level, network topology, etc.

10. **`ibApi_DEVICESTATUS`**

```
struct ibApi_DEVICESTATUS_s {
    ibApi_UINT16 struct_size;
    ibApi_UINT16 hop_count;
    ibApi_DEVICEID first_hop_router;
    ibApi_DEVICEID last_hop_router;
    ibApi_FLOAT battery_level;
    ibApi_UINT16 seq_num;
    ibApi_GROUPID group_id;
};
typedef struct ibApi_DEVICESTATUS_s ibApi_DEVICESTATUS;
```

This struct is used by `ibApi_FUNC ibApi_GetDeviceStatus()` to report read-only device properties that change with time.

Structure Fields:

struct_size The value size of (`ibApi_DEVICESTATUS`) should be assigned to this field prior to calling `ibApi_GetDeviceStatus()`. This allows future versions of the API to extend the struct without breaking binary compatibility.

hop_count The hop count measures a device's topological distance from the gateway. If the device talking directly to the gateway (i.e., no mesh nodes), then the hop count is 1.

first_hop_router These fields store the device ID of the first and last router that the device's packets passed through on their way to the gateway. If the hop count is 1, then these fields are NULL.

last_hop_router These fields store the device ID of the first and last router that the device's packets passed through on their way to the gateway. If the hop count is 1, then these fields are NULL.

battery_level This reports the device battery level measured in raw data, not voltage. If battery information is unavailable, the value is 0.

Application can use ibApi_Utils_ConvertBatteryReadingToVoltage() to convert raw data to voltage.

seq_num The sequence number increments whenever an update occurs.

group_id This reports the group ID currently assigned to the device.

11. **ibApi_DEVICEEVENTTYPE**

```
enum ibApi_DEVICEEVENTTYPE_e {
  ibApi_DEVICEEVENTTYPE_ALL                 = 0xffffffff,
  ibApi_DEVICEEVENTTYPE_INFO_CFG            = 0x80000000,
  ibApi_DEVICEEVENTTYPE_STATISTIC           = 0x01000000,
  ibApi_DEVICEEVENTTYPE_NETWORK             = 0x00010000
  ibApi_DEVICEEVENTTYPE_SERVICE_CAPACITY    = 0x00020000,
  ibApi_DEVICEEVENTTYPE_HEARTBEAT           = 0x00008000,
  ibApi_DEVICEEVENTTYPE_SRR_DAT             = 0x00002000,
  ibApi_DEVICEEVENTTYPE_BATTERY             = 0x00001000,
  ibApi_DEVICEEVENTTYPE_DIO_DAT             = 0x00000800,
  ibApi_DEVICEEVENTTYPE_ADC_DAT             = 0x00000100,
  ibApi_DEVICEEVENTTYPE_DEVSTATE            = 0x00000080,
  ibApi_DEVICEEVENTTYPE_SER_CFG             = 0x00000020,
  ibApi_DEVICEEVENTTYPE_SI_CFG              = 0x00000010,
  ibApi_DEVICEEVENTTYPE_DIO_CFG             = 0x00000008,
  ibApi_DEVICEEVENTTYPE_ADC_CFG             = 0x00000001
};
typedef ibApi_UINT32 ibApi_DEVICEEVENTTYPE;
```

In this release it is possible to filter the events reported by ibApi_WaitForDeviceEvent() using a bitwise "OR" of event types defined in this enum.

Structure Fields:

ALL	All events unfiltered.
INFO_CFG	This event type will not occur in this release.
STATISTIC	Statistical data coming.
NETWORK	Network routing change.
SERVICE_CAPACITY	Network license or options exceeded.
HEARTBEAT	Heart beat received.
SRR_DAT	Serial data received.
BATTERY	Battery level report.
DIO_DAT	Digital IO data received.
ADC_DAT	ADC data received.
DEVSTATE	Device state change.
SER_CFG	Serial configuration change.
SI_CFG	Sampling interval change.
DIO_CFG	Digital IO configuration change.
ADC_CFG	ADC configuration change.

12. **ibApi_VERSION**

```
typedef ibApi_UINT32 ibApi_VERSION;
#define ibApi_MAKE_VERSION(MAJOR,MINOR,RELEASE)
   ((ibApi_VERSION)((MAJOR<<16)|(MINOR<<8)|RELEASE))
#define ibApi_GET_VERSION_MAJOR(VER)((VER>>16) & 0xff)
#define ibApi_GET_VERSION_MINOR(VER)((VER>>8) & 0xff)
#define ibApi_GET_VERSION_RELEASE(VER)(VER & 0xff)
```

The ibApi_VERSION type is used by functions such as `ibApi_GetApiVersion()` to encode version numbers as a 32-bit integer. Binary compatibility is only guaranteed when the major and minor components are the same. Note that this is a non-negative number to enable casting as ibApi_RESULT.

13. **ibApi_EXPECTED_VERSION**

```
#define ibApi_EXPECTED_VERSION
ibApi_MAKE_VERSION(5,0,11)
```

This macro encodes the API version number that the application was compiled with. It is passed to `ibApi_Open()` as a safeguard to ensure that the correct DLL file is being loaded by the application.

14. **ibApi_EXPECTED_VERSION**

```
#define ibApi_EXPECTED_MASC_VERSION
    ibApi_MAKE_VERSION(5,0,11)
```

This macro encodes the API version number that the application was compiled with. It is passed to `ibApi_Open()` as a safeguard to ensure that the correct DLL file is being loaded by the application.

Functions

1. **`ibApi_Open`**

```
ibApi_FUNC ibApi_Open(
   ibApi_VERSION       expected_version,
   ibApi_CONST ibApi_CHAR *server_type,
   ibApi_CONST ibApi_CHAR * connection_str
);
```

ibApi_Open() should be called to initialize the API before any other function is called. If the MeshScape Network Monitor software has not yet been started, this function starts the software and then connects to it. If MeshScape Network Monitor is already running, this function connects to it.

The “server_type” parameter specifies the MeshScape Network Monitor executable file path. The “connection_str” parameter contains starting MeshScape Network Monitor arguments.

Parameters:

expected_version: (input) Should always be ibApi_EXPECTED_VERSION.

server_type: (input) “[monitor path name]” path such as “..\\sagMon.exe”.

connection_str: (input) "[baud rate]"

baud rate: “-B115200”

Return Value:

An ibApi_APIHANDLE value if successful, error code (<0) if not.

2. **`ibApi_Close`**

```
ibApi_FUNC ibApi_Close(
   ibApi_APIHANDLE     api_hdl
);
```

This disconnects from the server and releases the API resources. This should be called before your application exits to avoid resource leaks.

Parameter:

api_hdl: (input) API handle returned from `ibApi_Open()`

Return Value:

An ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

3. **`ibApi_GetApiVersion()`**

```
ibApi_FUNC ibApi_GetApiVersion ();
```

This function returns the actual software version for the API, which can differ from ibApi_EXPECTED_VERSION if DLL's are mixed.

Return Value:

An IbApi_VERSION value if successful, error code (<0) if not.

4. **`ibApi_GetNetworkList()`**

```
ibApi_FUNC ibApi_GetNetworkList(
   ibApi_APIHANDLE     api_hdl,
   ibApi_GROUPID       networks[],
   ibApi_UINT32        networks_size
);
```

This retrieves a list of group ID's for the networks managed by the server.

Parameters:

param api_hdl: (input) API handle returned from `ibApi_Open()`

networks: (output) array of group ID's that is managed by the server

networks_size: (input) ibApi_INT32, maximum size for the network[]

Return Value:

The actual number of networks (which can exceed networks_size if the written data was truncated), or an error code (<0) if unsuccessful.

5. **`ibApi_GetDeviceList()`**

```
ibApi_FUNC ibApi_GetDeviceList(
    ibApi_APIHANDLE     api_hdl,
    ibApi_GROUPID       network,
    ibApi_DEVICETYPE    device_type
    ibApi_DEVICEID      devices[],
    ibAPI_UINT32        devices_size
);
```

This function retrieves the ID's of the devices in the network. The device_type parameter is a bitwise OR of the ibApi_DEVICETYPE constants that filters the result. (To retrieve all devices, use `ibApi_DEVICETYPE_ANY`.)

Parameters:

param api_hdl: (input) API handle returned from `ibApi_Open()`.

network: (input) Group ID of the network.

device_type: (input) Device type filter.

devices: (output) Pointer to an array of device IDs.

devices_size: (input) Maximum number of device IDs that the devices array can hold.

Return Value:

The actual number of devices (which can exceed devices_size if the written data was truncated), or an error code (<0) if unsuccessful.

6. **`ibApi_GetDeviceInfo()`**

```
ibApi_FUNC ibApi_GetDeviceInfo(
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_DEVICEINFO *  device_info
);
```

This function retrieves various static device attributes that are predetermined at manufacturing time. Thus, these values only need to be queried once for a particular device. See `ibApi_DEVICEINFO` above for details.

Note: To avoid memory corruption, the size of (`ibApi_DECVICEINFO`) must be allocated to the "struct_size" field prior to calling this function.

Parameters:

api_hdl: (input) API handle returned from ibApi_Open().

device_id: (input) ID of device to be accessed.

device_info: (output) Pointer to variable storing the result.

Return Value:

An ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

7. **`ibApi_GetDeviceStatus()`**

```
ibApi_FUNC ibApi_GetDeviceStatus(
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
   ibApi_DEVICESTATUS *device_status
);
```

This function retrieves various read-only device properties whose values can change with time. See `ibApi_DEVICE STATUS` above for details.

Note: To avoid memory corruption, size of (`ibApi_DECVICESTATUS`) must be assigned to the "struct_size" field prior to calling this function.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open().`

device_id: (input) ID of device to be accessed.

device_status: (output) Pointer to variable storing the result.

Return Value:

An ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

8. **`ibApi_GetDeviceState()`**

```
ibApi_FUNC ibApi_GetDeviceState(
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
);
```

This function queries the current state of a device in the network. See the `ibApi_DEVICESTATE` notes above for details.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open().`

device_id: (input) ID of device to be accessed.

Return Value:

An ibApi_DEVICESTATE if successful, error code (<0) if not.

9. **`ibApi_SetSamplingInterval()`**

```
ibApi_FUNC ibApi_SetSamplingInterval(
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
   ibApi_UNIT32        sampling_interval_ms
);
```

This function sets the sampling interval for the device. The sampling interval determines how frequently updates occur; lower values mean quicker response times, at the price of higher bandwidth and power consumption. Typically the current interval must elapse before the new interval will be programmed. When the update has completed, the device state will return from ibApi_DEVISESTATE_REFRESHING to ibApi_DEVICESTATE_ONLINE.

Note: The assigned value will be quantized to the nearest legal value supported by the device, which is typically a multiple of 100 ms larger than 300 ms.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of device to be accessed.

sampling_interval_ms: (input) New sampling interval (in ms).

Return Value:

An ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

10. **`ibApi_GetSamplingInterval()`**

```
ibApi_FUNC ibApi_GetSamplingInterval(
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
);
```

This retrieves the sampling interval for the given device, measured in milliseconds. See `ibApi_SetSamplingInterval()` above.

Return Value:

Sampling interval if successful, error code (<0) if not.

11. **`ibApi_WaitForDeviceEvent()`**

```
ibApi_FUNC ibApi_WaitForDeviceEvent(
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEEVENTTYPEevent_types,
    ibApi_INT32         timeout ms,
    ibApi_DEVICEID *    device_id
);
```

Note: This function is now obsolete and only retained for backward compatibility. Please use ibApi_WaitForDeviceEvents() instead.

This function implements the simplest form of event notification using the application thread content: It causes the calling thread to sleep until a network packet has arrived (i.e., the sequence number has incremented), and then returns the ID of the device that was updated. If multiple devices have changed since the last call, `ibApi_WaitForDeviceEvent()` will return their ID's in sequential round-robin order. If time timeout expires and nothing has changed, the return value ibApi_RESULT_ERR_TIMEOUT.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

event_types: (input) This parameter is reserved for a future feature allowing the wait condition to be restricted to a subset of the possible event types. In the current release, the parameter should always be `ibApi_DEVICEEVENTTYPE_ALL`.

timeout_ms: Number of milliseconds to wait before giving up (use -1 to wait indefinitely).

device_id: (output) ID of the device that changed.

Return Value:

An ibApi_RESULT_SUCCESS if a device changed, ibApi_RESULT_ERR_TIMEOUT if not, or an error code (<0) if unsuccessful.

12. **`ibApi_WaitForDeviceEvents()`**

```
ibApi_FUNC ibApi_WaitForDeviceEvents(
ibApi_APIHANDLE                     api_hdl,
ibApi_DEVICEEVENTTYPE               events_interested,
ibApi_INT32                         timeout_ms,
ibApi_DEVICEID *                    device_id,
ibApi_DEVICEEVENTTYPE *             events_happened
);
```

This function implements the simplest form of event notification using the application thread context. It causes the calling thread to sleep until a network packet has arrived (i.e. the sequence number has incremented), and then returns the ID of the device that was updated along with the event(s) that woke the sleeping thread up. If multiple devices have changed since the last call, ibApi_WaitForDeviceEvent() will return their IDs in a sequential "round robin" order. If time timeout expires and nothing has changed, the return value is ibApi_RESULT_ERR_TIMEOUT.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

events_interested: (input) This parameter allows the wait condition to be restricted to a subset of the possible event types.

timeout_ms: Number of milliseconds to wait before giving up (use -1 to wait indefinitely) A valid of zero means the thread will check for new events since the last call but will not wait.

device_id: (output) Pointer to ID of the device that changed.

events_happened: (output) The returned value is the subset of the events_interested. It indicates the event(s) that actually happened.

Return Value:

An ibApi_RESULT_SUCCESS if a device changed, ibApi_RESULT_ERR_TIMEOUT if not, or an error code (<0) if unsuccessful.

13. **`ibApi_SetEventMask()`**

```
ibApi_SetEventMask(
ibApi_APIHANDLE         api_hdl,
ibApi_DEVICEEVENTTYPE   event,
ibApi_DEVICEID          device_id
);
```

This function sets the event mask for the triggering of asynchronous events.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

event: (input) The event mask.

device_id: (output) ID of the device that changed.

Return Value:

An ibApi_RESULT_SUCCESS if a device changed or an error code (<0) if unsuccessful.

14. **`ibApi_GetEventMask()`**

```
ibApi_FUNC ibApi_GetEventMask(
ibApi_APIHANDLE         api_hdl,
ibApi_DEVICEEVENTTYPE * event,
ibApi_DEVICEID          device_id
);
```

This function gets the event mask for the triggering of asynchronous events.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

event: (output) The event mask storage location.

device_id: (output) ID of the device that changed.

Return Value:

An ibApi_RESULT_SUCCESS if a device changed or an error code (<0) if unsuccessful.

15. **`ibApi_GetDevicePacketSequenceNumber()`**

```
ibApi_FUNC ibApi_GetDevicePacketSequenceNumber(
  ibApi_APIHANDLE api_hdl,
  ibApi_DEVICEID device_id
);
```

This function Gets a device packet sequence number that is carried by a upstream packet sent from the device.

Parameters:

api_hdl: (input) API handle returned from ibApi_Open().

device_id: (input) The device id.

Return Value:

A 0 - 255 sequence number if successful, or an error code (<0) if failed.

16. **`ibApi_Block (void)`**

```
ibApi_FUNC ibApi_Block(void);
```

This function provides locking of shared data areas from within the application event callback. This function is to be called prior to accessing the data record returned to the callback function.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open().`

Return Value:

An ibApi_RESULT_SUCCESS if a device changed or an error code (<0) if unsuccessful.

17. **`ibApi_UnBlock (void)`**

```
ibApi_FUNC ibApi_UnBlock(void);
```

This function releases lock of shared data area from within the application event callback function. This must be called prior to exiting the application event callback if the ibApi_Block function was previously invoked.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open().`

device_id: (input) ID of the device to be accessed.

channel_index: (input) the channel index to access.

Return Value:

An ibApi_RESULT_SUCCESS if a device changed or an error code (<0) if unsuccessful.

18. **`ibApi_RegisterEvent()`**

```
ibApi_RegisterEvent(
ibApi_APIHANDLE          api_hdl,
ibApi_CALLBACK_FUNCTIONapi_callback)
;
```

This function registers a callback function to be called upon receipt of the specified asynchronous event.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

api_callback: (input) Callback function to register for asynchronous events as defined by prior call to ibApi_SetEventMask().

Return Value:

An ibApi_RESULT_SUCCESS if successful or an error code (<0) if unsuccessful.

iBeanAPI_IO.h

Data Structures

1. **`ibApi_IO_SERIALMODE`**

```
enum ibApi_IO_SERIALMODE_e {
  ibApi_IO_SERIALMODE_DISABLED = 0,
  ibApi_IO_SERIALMODE_UART,
  ibApi_IO_SERIALMODE_RS232,
  ibApi_IO_SERIALMODE_RS485
};
typedef ibApi_UINT16 ibApi_IO_SERIALMODE;
```

This is used by ibApi_IO_SERIALCONFIG to select the serial interface.

2. **`ibApi_IO_SERIALCONFIG`**

```
struct ibApi_IO_SERIALCONFIG_s {
   ibApi_UINT16 struct_size;
   ibApi_IO_SERIALMODE mode;
};
typedef struct ibApi_IO_SERIALCONFIG_s ibApi_IO_SERIALCONFIG;
```

Structure Fields:

struct_size The value size of (`ibApi_IO_SERIALCONFIG`) should be assigned to this field prior to calling `ibApi_IO_SetSerialConfig()`. This allows future versions of the API to extend the struct without breaking binary compatibility.

mode See `ibApi_IO_SERIALMODE` comments above.

3. **ibApi_IO_DEVICECAPS**

```
struct ibApi_IO_DEVICECAPS_s {
    ibApi_UINT16 struct_size;
    ibApi_UINT8 num_dio_channels;
    ibApi_UINT8 num_adc_channels;
    ibApi_UINT8 adc_resolution_bits;
    ibApi_UINT8 serial_input_buffer_depth:
    ibApi_UINT8 serial_output_buffer_depth
};
typedef struct ibApi_IO_DEVICECAPS_s ibApi_IO_DEVICECAPS;
```

This structure is used by `ibApi_IO_GetDeviceCaps()` to return various static device attributes that are predetermined at manufacturing time.

Structure Fields:

struct_size The value size of (`ibApi_IO_DEVICECAPS`) should be assigned to this field prior to calling `ibApi_IO_GetDeviceCaps()`. This allows future versions of the API to extend the struct without breaking binary compatibility.

num_dio_channels This is the number of DIO channels (i.e., the channel index passed to `ibApi_IO_ReadDIO()` must be less than this).

num_adc_channels This is the number of DIO channels (i.e., the channel index passed to `ibApi_IO_ReadADC()` must be less than this).

adc_resolution_bits This is the number of bits of resolution supported by the A/D converter, i.e. the maximum value for the raw data will be (1<<adc_rsolution_bits)-1.

*serial_input_buffer_depth*This is the number of input data packets slots for which packets can be pending to be read by the API-based application.

*serial_output_buffer_depth*This is the number of output data packet slots for which packets can be pending to be send by the monitor.

Functions

1. **`ibApi_IO_GetDeviceCaps()`**

```
ibApi_FUNC ibApi_IO_GetDeviceCaps (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_IO_DEVICECAPS *device_caps
);
```

This function retrieves various static device attributes that are predetermined at manufacturing time. Thus, these values only need to be queried once for a particular device. See `ibApi_IO_DEVICECAPS` above for details.

Note: To avoid memory corruption, size of (`ibApi_IO_DEVICECAPS`) must be assigned to the "struct_size" field prior to calling this function.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

device_caps: (output) Pointer to variable storing the result.

Return Value:

An ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

2. **`ibApi_IO_SetADCConfig()`**

```
ibApi_FUNC ibApi_IO_SetADCConfig (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index,
    ibApi_BOOL          enabled
);
```

This sets whether the specified ADC channel is enabled or disabled. The channel must be enabled before calling `ibApi_IO_ReadADC()`.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

enabled: (input) ibApi_TRUE to enable the channel.

Return Value:

An ibApi_RESULT_SUCCESS if successful, or an error code (<0) if not.

3. **`ibApi_IO_GetADCConfig()`**

```
ibApi_FUNC ibApi_IO_GetADCConfig (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index
);
```

This queries whether the specified ADCchannel is enabled or disabled.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

Return Value:

An ibApi_TRUE if enabled, ibApi_FALSE if disabled, or an error code (<0) if not.

4. **`ibApi_IO_ReadADC()`**

```
ibApi_FUNC ibApi_IO_ReadADC (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index,
    ibApi_FLOAT *       adc_value
);
```

This retrieves the value of the specified ADC channel, measured in volts. Note that this is computed by normalizing the raw reading relative to the battery voltage, and this calculation influences the precision of the result.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

adc_value: (output) Result of the ADC reading in raw data, not voltage. Application can use ibApi_Utils_ConvertBatteryReadingToVoltage() to convert to voltage.

Return Value:

An ibApi_RESULT_SUCCESSFUL if successful, or an error code (<0) if not.

5. **`ibApi_IO_SetDIOConfig()`**

```
ibApi_FUNC ibApi_IO_SetDIOConfig (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index,
    ibApi_IOMODE        io_mode
);
```

This sets whether the specified DIO channel is configured for input or output, which governs the interpretation of `ibApi_IO_ReadDIO()` and `ibApi_IO_WriteDIO()`.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

io_mode: (input) Input/output mode.

Return Value:

An ibApi_RESULT_SUCCESSFUL if successful, or an error code (<0) if not.

6. **`ibApi_IO_GetDIOConfig()`**

```
ibApi_FUNC ibApi_IO_SetDIOConfig(
  ibApi_APIHANDLE                     api_hdl,
  ibApi_DEVICEID                      device_id,
  ibApi_UINT8                         channel_index,
);
```

This queries whether the specified DIO channel is configured for input or output, which governs the interpretation of ibApi_IO_ReadDIO().

* and ibApi_IO_WriteDIO()

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

io_mode: (input) the new input/output mode

Return Value:

An ibApi_IOMODE value if successful, or an error code (<0) if not.

7. **`ibApi_IO_WriteDIO()`**

```
ibApi_FUNC ibApi_IO_WriteDIO (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index,
    ibApi_UINT8         dio_value
);
```

This sets the value of the specified DIO channel. Note that an error will result if the channel is not configured for output.

Note: In some product models, the DIO pins are shared with the serial data interface and will be disabled when it is active.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

dio_value: (input) New output level (0 or 1).

Return Value:

An ibApi_RESULT_SUCCESS if successful, or an error code (<0) if not.

8. **`ibApi_IO_ReadDIO()`**

```
ibApi_FUNC ibApi_IO_ReadDIO (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         channel_index
);
```

This reads the value of the specified DIO channel. If the channel is configured for output, it reads the current output value.

Note: In some product models, the DIO pins are shared with the serial data interface and will be disabled when it is active.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

channel_index: (input) Channel index to access.

Return Value:

Digital 0 or 1, or an error code (<0).

9. **`ibApi_IO_SetSerialConfig()`**

```
ibApi_FUNC ibApi_IO_SetSerialConfig (
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
   ibApi_IO_SERIALCONFIG *serial_config
);
```

This configures the serial "user data" interface. If these pins are shared with the DIO pins, the DIO will be disabled.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

serial_config: (input) New configuration.

Return Value:

An ibApi_RESULT_SUCCESS if successful, or an error code (<0) if not.

10. **`ibApi_IO_GetSerialConfig()`**

```
ibApi_FUNC ibApi_IO_GetSerialConfig (
   ibApi_APIHANDLE     api_hdl,
   ibApi_DEVICEID      device_id,
   ibApi_IO_SERIALCONFIG *serial_config
);
```

This retrieves the configuration for the serial "user data" interface.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

serial_config: (output) Variable to store the result.

Return Value:

An ibApi_RESULT_SUCCESS if successful, or an error code (<0) if not.

11. **`ibApi_IO_GetSerialBufferStatus()`**

```
ibApi_FUNC ibApi_IO_GetSerialBufferStatus (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_IOMODE        io_mode
);
```

For the given device, this function retrieves the status of the out going serial data buffer. The return value gives the number of empty packet slots in the buffer. A negative return value denotes an error and a zero return value means there is currently no out going empty packet slots.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

io_mode: (input) Data direction to be accessed.

Return Value:

The number of empty out going packet slots if successful, or an error code (<0) if not.

12. **`ibApi_IO_WriteSerial()`**

```
ibApi_FUNC ibApi_IO_WriteSerial (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         buffer[],
    ibApi_UINT16        buffer_size
);
```

This function writes buffer_size bytes pointed to by the buffer pointer to the specified device handle. Prior to use, the ibApi_FIELDID_USERDATAMODE field must have been configured for serial operation. The specific contents of the user data block and its maximum size are application defined but must be equal to or smaller than that the maximum payload size supported. Maximum payload size supported is returned when the function `ibApi_WriteSerialData()` is called with buffer_size=0.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

device_id: (input) ID of the device to be accessed.

buffer: (input) Pointer to packet to transmit.

buffer_size: (input) Number of bytes in user data packet to transmit.

Return Value:

Bytes sent if successful, or an error code (<0) if not.

13. **`ibApi_IO_ReadSerial()`**

```
ibApi_FUNC ibApi_IO_ReadSerial (
    ibApi_APIHANDLE     api_hdl,
    ibApi_DEVICEID      device_id,
    ibApi_UINT8         buffer[],
    ibApi_UINT16        buffer_size,
    ibApi_UINT8         seq_num
);
```

For the given device, this retrieves the user data packet that arrived most recently. The `ibApi_IO_SERIALMODE` setting must have been previously something other than `ibApi_IO_SERIALMODE_DISABLED`. The input buffer holds a single packet (i.e., an arriving packet overwrites the previous one). Lost packets can be detected by gaps in the sequence numbers, which increment whenever a packet is received. If no new data is available, then the return value is 0.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open().`

device_id: (input) ID of the device to be accessed.

buffer[ ]: (output) Buffer to store the incoming user data packet.

buffer_size: (input) Maximum size for buffer[ ].

seq_num: (output) Sequence number identifying this packet, or NULL if this information is not needed.

Return Value:

Error code or the actual size of the result (which could exceed buffer_size if the written data was truncated)

14. **`ibApi_IO_SetDeviceConfigAndData`**

```
ibApi_FUNC ibApi_IO_SetDeviceConfigAndData(
  ibApi_APIHANDLE api_hdl,
  ibApi_DEVICEID  device_id,
  ibApi_deviceSetConfigAndData *config_data);
```

This function is used to make several configuration and data requests to a device at one time.

Parameters:

api_hdl: (input) API handle returned from @link ibApi_Open()

device_id: (input) the ID of the device to be accessed

config_data: (input) User requested configuration.

iBeanAPI_Utils.h

Functions

1. **`ibApi_Utils_GetErrorDescription()`**

```
ibApi_FUNC ibApi_Utils_GetErrorDescription(
    ibApi_RESULT        error_code,
    ibApi_CHAR *        description,
    ibApi_UINT32        description_size
);
```

This function returns an English language interpretation for an API error code.

Parameters:

error_code: (input) ibApi_RESULT to be interpreted.

description: (output) Pointer to buffer storing the text.

description_size: (input) Maximum size of buffer.

Return Value:

Error code, or the actual size of the result including the terminating NULL (which could exceed description_size if the written data was truncated).

2. **`ibApi_Utils_ConvertGroupIDToText()`**

```
ibApi_FUNC ibApi_Utils_ConvertGroupIDToText(
    ibApi_CONST ibApi_GROUPIDgroup_id,
    ibApi_CHAR *        group_id_text,
    ibApi_UINT32        group_id_text_size,
    ibApi_UINT32        min_words
);
```

This renders a group ID as a text string, such as “1.2.3.4”. If the “min_words” parameter is less than 4, leading zeros will be omitted for brevity. For example, if min_words is 3, then “1.2.3.4” would be rendered as “2.3.4”.

Parameters:

group_id: (input) Group ID to convert.

group_id_text: (output) Pointer to buffer storing the text.

group_id_text_size: (input) Maximum size of buffer.

min_words: (input) Minimum number of digit groups.

Return Value:

Error code, or the actual size of the result including the terminating NULL (which could exceed group_id_text_size if the written data was truncated).

3. **`ibApi_Utils_ConvertTextToGroupID()`**

```
ibApi_FUNC ibApi_Utils_ConvertTextToGroupID(
   ibApi_CONST ibApi_CHAR *group_id_text,
   ibApi_GROUPID *     group_id
);
```

This parses a text string such as "1.2.3.4" and stores the result in the group_id structure. If fewer than 4 digit groups are provided, the result is left-padded with 0's.

Parameters:

group_id_text: (input) Buffer to be parsed.

group_id: (output) Structure to store the result.

Return Value:

ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

4. **`ibApi_Utils_ConvertDeviceIdToText()`**

```
ibApi_FUNC ibApi_Utils_ConvertDeviceIdToText(
   ibApi_DEVICEID      device_id,
   ibApi_CHAR *        device_id_text,
   ibApi_UINT32        device_id_text_size,
   ibApi_UINT32        min_words
);
```

This renders a device ID as a text string such as "1.2.3.4.5.6.7.8". If the "min_words" parameter is less than 8, leading zeros will be omitted for brevity. For example, if min_words is 4, then "1.2.3.4.5.6.7.8" would be rendered as "5.6.7.8".

Parameters:

device_id: (input) Device ID to convert.

device_id_text: (output) Buffer to store the text.

device_id_text_size: (input) Maximum size of the buffer.

min_words: (input) Minimum number of digit groups.

Return Value:

Error code, or the actual size of the result including the terminating NULL (which could exceed device_id_text_size if the written data was truncated).

5. **`ibApi_Utils_ConvertTextToDeviceId()`**

```
ibApi_FUNC ibApi_Utils_ConvertTextToDeviceId(
    ibApi_CONST ibApi_CHAR *device_id_text,
    ibApi_DEVICEID *    device_id
);
```

This function parses a text string such as "1.2.3.4.5.6.7.8" and stores the result in the device_id structure. If fewer than 8 digit groups are provided, the result is left-padded with 0's.

Parameters:

device_id_text: (input) Buffer to be parsed.

device_id: (output) Structure to store the result.

Return Value:

ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

6. **`ibApi_Utils_ConvertBatteryReadingToVoltage()`**

```
ibApi_FUNC ibApi_Utils_ConvertBatteryReadingToVoltage(
    ibApi_DEVICEINFO info,
    ibApi_UINT16 blRaw,
    ibApi_FLOAT *blFloat
);
```

This function converts a device's battery level reading from raw data to voltage.

Parameters:

info: (input) Device information.

blRaw: (input) Battery level reading in raw data.

blFloat: (output) Structure to store the battery level reading as a voltage.

Return Value:

ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

7. **`ibApi_Utils_ConvertAdcReadingToVoltage()`**

```
ibApi_FUNC ibApi_Utils_ConvertAdcReadingToVoltage(
   ibApi_DEVICEINFO info,
   ibApi_UINT16 adcRaw,
   ibApi_FLOAT *adcFloat
);
```

This function converts a device's battery level reading from raw data to voltage.

Parameters:

info: (input) Device information.

adcRaw: (input) ADC reading in raw data.

adcFloat: (output) Structure to store the ADC reading as a voltage.

Return Value:

ibApi_RESULT_SUCCESS if successful, error code (<0) if not.

iBeanAPI_LPR.h

Functions

1. **`ibApi_LPR_SetClock()`**

```
ibApi_FUNC ibApi_LPR_SetClock(
    ibApi_APIHANDLE     api_hdl,
    ibApi_GROUPID       network,
    ibApi_UINT32        utc_sec
);
```

This function sets the UTC clock for all devices. The UTC clock is used for the time synchronization purposes. The gateway will synchronize each device's clock through time synchronization process. The clock setting is a global attribute that applies to all devices in the network.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

network: (input) Group ID of the network.

utc_sec: (input) The UTC value in seconds, system clock is used if the value is zero.

Return Value:

ibApi_RESULT_SUCCESS if successful, or error code (<0) if not.

2. **`ibApi_LPR_GetClock()`**

```
ibApi_FUNC ibApi_LPR_GetClock(
    ibApi_APIHANDLE     api_hdl,
    ibApi_GROUPID       network,
    ibApi_UINT32 *      utc_sec
)
```

This function retrieves the UTC clock value (in seconds) used for all devices.

Note: After setting the network-wide clock by the method ibApi_LPR_SetClock(), it is necessary to wait at least 1 second before calling this function to allow the system to take on the new value.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

network: (input) Group ID of the network.

utc_sec: (output) UTC value in seconds.

Return Value:

The wakeup interval in ms if successful, or error code (<0) if not.

3. **`ibApi_LPR_SetWakeupAndDutyRatio()`**

```
ibApi_FUNC ibApi_LPR_SetWakeupAndDutyRatio(
    ibApi_APIHANDLE     api_hdl,
    ibApi_GROUPID       network,
    ibApi_UINT32        wakeup_interval,
    ibApi_UINT32        duty_ratio
)
```

This function sets the low power router wakeup interval and duty ratio for all devices. The wakeup interval and duty ratio are global attributes that applies to all devices in the network.

Changing of wakeup interval and duty ratio may have impact on the network stability, however, the worst case is to cause the network to reestablish itself entirely. Minimum value for wakeup interval is 60 seconds, maximum value is 6540 seconds (109 minutes).

Wakeup interval should be expressed in milliseconds. If too many digits of precision are used round off error can occur. Use ranges of 100's, 1000's, 10000's or 100000's of milliseconds rounded up to the nearest second to prevent round off error.

Minimum value for duty radio depends on minimum wakeup interval, and network size, radius (number of hops), currently it set to be 10%, maximum value is 100%. The 100% duty ratio means the router is no longer sleep.

Duty ratio can be set in 0.5% increments using the integer range 5-1000, with increments of 5. If (DutyRatio MOD 5) != 0, an error will be returned.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

network: (input) Group ID of the network.

wakeup_interval: (input) Wakeup interval in milliseconds.

duty_ratio: (input) the duty ratio (5 - 1000), in increments of 5.

Return Value:

Wakeup interval in ms if successful, error code (<0) if not.

4. **`ibApi_LPR_GetWakeupAndDutyRatio)`**

```
ibApi_FUNC ibApi_LPR_GetWakeupAndDutyRatio(
    ibApi_APIHANDLE     api_hdl,
    ibApi_GROUPID       network,
    ibApi_UINT32 *      wakeup_interval,
    ibApi_UINT32 *      sleep_interval,
    ibApi_UINT32 *      duty_ratio
);
```

This function retrieves the low power router wakeup interval and duty ratio for all devices.

Parameters:

api_hdl: (input) API handle returned from `ibApi_Open()`.

network: (input) Group ID of the network.

wakeup_interval: (output) Wakeup interval in milliseconds.

sleep_interval: (output) Sleep time in milliseconds.

duty_ratio: (output) the duty ratio (5 - 1000), in increments of 5.

Return Value:

ibApi_RESULT_SUCCESS if successful, ibApi_RESULT_ROUNDOFF if round off error detected or other error code (<0) upon failure.

iBeanAPI_performance.h

Data Structures

1. **`ibApi_PFM_PacketStats_s`**

```
struct ibApi_PFM_PacketStats_s {
    ibApi_UINT8 ctrlcode;
    ibApi_UINT16 packetTxCount;
    ibApi_UINT16 packetSearchCount;
};
```

Structure Fields:

ctrlcode	Control code.
packetTxCount	Number of transmissions and acks for this packet.
packetSearchCount	Number of search packets and responses caused by this packet.

2. **`ibApi_PFM_NodeStats_s`**

```
struct ibApi_PFM_NodeStats_s {
    ibApi_UINT8 ctrlcode;
    ibApi_UINT8 reportingFrequency;
    ibApi_UINT16 packetSearchCount;
    ibApi_UINT8 searchPacketTxCount;
    ibApi_UINT16 searchResponseRxCount;
    ibApi_UINT16 searchPacketRxCount;
    ibApi_UINT16 searchResponseTxCount;
    ibApi_UINT16 rejectedPacketCount;
    ibApi_UINT16 acceptedPacketCount;
    ibApi_UINT16 transmittedPacketCount;
    ibApi_UINT16 transmissionsCount;
    ibApi_UINT16 validInterrupts;
    ibApi_UINT32 totalInterrupts;  //2 -> 4
    ibApi_UINT8  numberOfAssociations;
};
```

Structure Fields:

ctrlcode	Control code.
reportingFrequency	
packetSearchCount	Number of search packets and responses caused by this packet.
searchPacketTxCount	Number of search packets transmitted.
searchResponseRxCount	Number of search packets received.
searchPacketRxCount	Number of search packets received.
searchResponseTxCount	Number of search responses transmitted.
rejectedPacketCount	Number of upstream packets rejected.
acceptedPacketCount	Number of upstream packets accepted.
transmittedPacketCount	Number of unique upstream packets.
transmissionsCount	Number of transmissions (excluding search packets and responses).
validInterrupts	
totalInterrupts	2 - 4
numberOfAssociations	

3. **`ibApi_PFM_Stats_s`**

```
struct ibApi_PFM_Stats_s {
    struct ibApi_PFM_PacketStats_s  packetStats;
    struct ibApi_PFM_NodeStats_s    nodeStats;
};
```

This structure is used by `ibApi_IO_GetDeviceCaps()` to return various static device attributes that are predetermined at manufacturing time.

Structure Fields:

packetStats	Packet statistics.
nodeStats	Node statistics.

Functions

1. **`ibApi_GetStatisticData`**

```
ibApi_FUNC ibApi_GetStatisticData(
  ibApi_APIHANDLE api_hdl,
  ibApi_DEVICEID device_id,
  ibApi_PFM_STATS *statisticData);
```

This function retreives the statistical data for the given device.

Parameters:

api_hdl: (input) API handle returned from ibApi_Open().

device_id: (input) the ID of the device to be accessed.

device_id: (output) the statistic data of the device.

Return Value:

An ibApi_RESULT_SUCCESS if successful, or an error code (<0) if not.

Example API Code

Millennial Net provides as part of the reference kit, several example API applications. This section examines in detail one of the API examples, ListDevicesVC7, including the code it uses. ListDevicesVC7 provides a list of all detected network nodes (MeshGate, Mesh Node(s), and End Node(s)).

ListDevicesVC7 Example

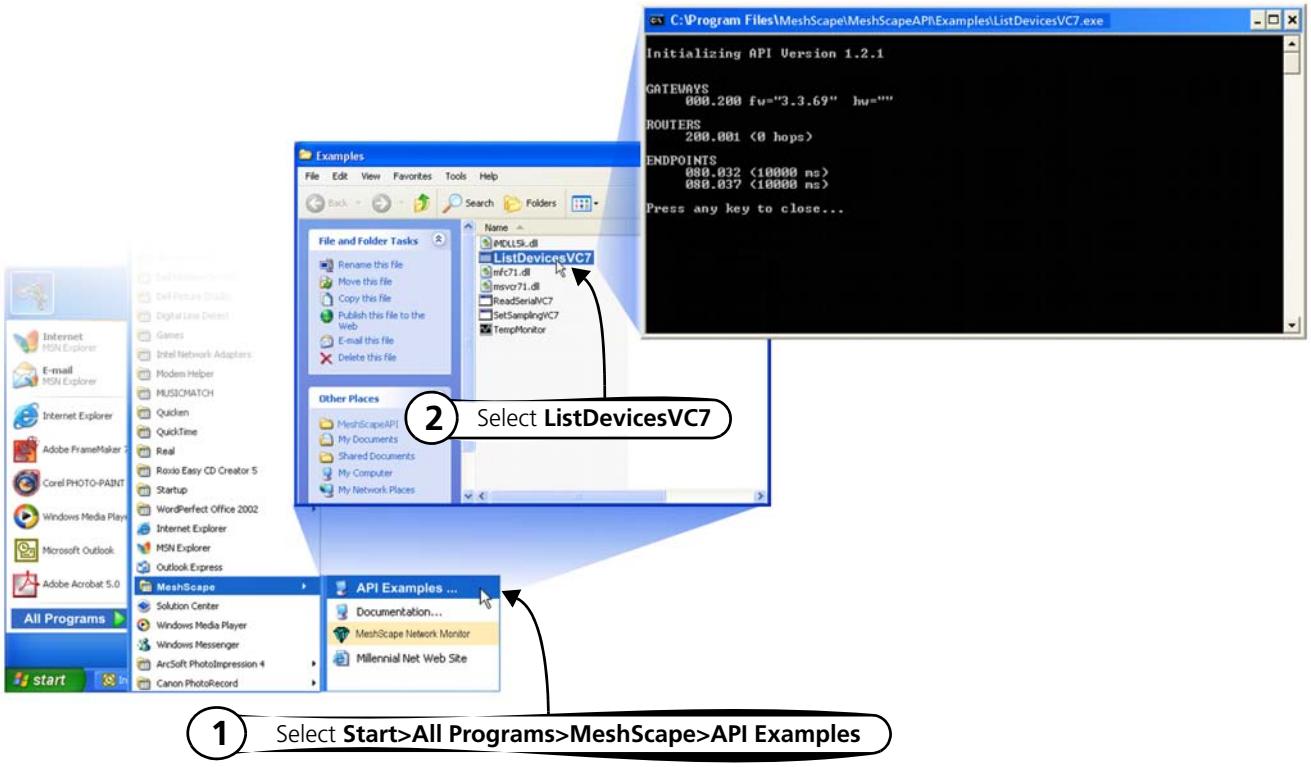
Note: Be sure that MeshScape Network Monitor is running before executing the following procedure.

To run the ListDevicesVC7 example (see Figure 2.):

1. From the Windows taskbar, select the following to open the Examples window: **Start>All Programs>MeshScape>API Examples**
2. From the Examples window, select **ListDevicesVC7**. The command window opens and displays the list of detected network nodes.

Proceed to "ListDevicesVC7 Code" to view the code used in this example.

Figure A-2. API example: ListDevicesVC7



ListDevicesVC7 Code

The C file containing the code shown here can be found in the Programs directory:

Programs\MeshScape\examples\src\ListDevices

```
/*
 * ListDevices.c
 *
 * Copyright (c) 2000-2005 Millennial Net, Inc. All Rights Reserved.
 * Reproduction or modification is strictly prohibited without express
 * written consent of Millennial Net.
 *
 * This example illustrates the basic operations of connecting to the i-Bean
 * API and obtaining basic information about the devices in the network.
 * It prints out the list of gateways, mesh nodes, and end nodes currently
 * participating in the network, along with some information about each
 * device.
 *
 * This project was built using Microsoft Visual C++ version 7.1, but should
 * be compatible with other similar compiler versions.
 */

#include <iBeanAPI.h>
#include <iBeanAPI_IO.h>
#include <iBeanAPI_Utils.h>
#include <stdio.h>
#include <stdlib.h>

#ifndef __GNUC__
#include <conio.h>
#else
#include <mingw/conio.h>
/*  #include <mingw/conio.h>  */
#endif

/*
 * This is the number of "words" in a network address.  For example, the
 * address "127.0.1" contains three words.  The i-Bean protocol supports
 * up to 8 words (64-bits), but the actual maximum is reduced in some
 * product releases to optimize the packet size.
 */
#define MIN_DEVICEID_WORDS 3
```

```
/*****************************************************************************/
void WaitForKey(void) {
  printf("\r\nPress any key to close...");
  _getch();
  printf("\r\n");
}

/*****************************************************************************
 * This is a simple wrapper for detecting and reporting API error return
 * values.  In C++, this function could throw an exception object.
 */
ibApi_RESULT CheckResult(ibApi_RESULT result) {
  char error_text[256];

  /*
   * Error codes always have a negative value.
   */
  if (result >= 0) return result;

  /*
   * For the purposes of this example, ibApi_RESULT_ERR_TIMEOUT is not a
   * fatal error.
   */
  if (result == ibApi_RESULT_ERR_TIMEOUT) return result;

  /*
   * This interprets the error code, writing the result to the error_text
   * variable
   */
  ibApi_Utils_GetErrorDescription(result,error_text,sizeof(error_text));

  printf("\r\nERROR: %s\r\n",error_text);

  /*
   * Technically, ibApi_Close() should be called before exiting, e.g. via
   * an atexit() handler.  (This is omitted in the example for simplicity.)
   */
  WaitForKey();

  exit(1);

  return 0;
}
```

```
/*****************************************************************************/
void ListDevices(ibApi_APIHANDLE api_hdl) {
#define DEVICEIDS_MAX 100
  ibApi_GROUPID groupid;
  ibApi_DEVICEID deviceids[DEVICEIDS_MAX];
  int deviceids_count;
  char deviceid_text[256];
  int sampling_interval;
  int i;
  ibApi_DEVICEINFO deviceinfo;
  ibApi_DEVICESTATUS devicestatus;

  /*
   * The ibApi_GetNetworkList() function returns a list of the groups
   * currently managed by the network.  If the gateway is not properly
   * connected to the monitor, then this list will be empty.
   */
  if (CheckResult(ibApi_GetNetworkList(api_hdl,&groupid,1) < 1)) {
    printf("The network is empty\r\n");
    return;
  }

  /*
   * List the gateways in the group, which typically should be
   * only one.
   */
  printf("\r\nGATEWAYS\r\n");
  deviceids_count = CheckResult(ibApi_GetDeviceList(api_hdl, groupid,
    ibApi_DEVICETYPE_GATEWAY, deviceids,DEVICEIDS_MAX));

  /*
   * If the buffer limit was exceeded, then display partial results
   */
  if (deviceids_count > DEVICEIDS_MAX)
    deviceids_count = DEVICEIDS_MAX;

  for (i=0; i<deviceids_count; ++i) {

    /*
     * Note that the struct_size must be assigned BEFORE calling
     * ibApi_GetDeviceInfo().  This allows compatibility with future API
     * versions that implement additional fields.
     */
    deviceinfo.struct_size = sizeof(deviceinfo);
```

```
  CheckResult(ibApi_GetDeviceInfo(api_hdl,deviceids[i],&deviceinfo));

  CheckResult(ibApi_Utils_ConvertDeviceIdToText(deviceids[i],
    deviceid_text,sizeof(deviceid_text),MIN_DEVICEID_WORDS));

  printf("  %10s fw=\"%s\"  hw=\"%s\"\r\n", deviceid_text,
    deviceinfo.firmware_version,deviceinfo.hardware_version);
}

/*
 * List the mesh nodes.
 */
printf("\r\nROUTERS\r\n");
deviceids_count = CheckResult(ibApi_GetDeviceList(api_hdl, groupid,
  ibApi_DEVICETYPE_ROUTER|ibApi_DEVICETYPE_ROUTERBEAN, deviceids,DEVICEIDS_MAX));

if (deviceids_count > DEVICEIDS_MAX)
  deviceids_count = DEVICEIDS_MAX;

for (i=0; i<deviceids_count; ++i) {
  /*
   * Note that the struct_size must be assigned BEFORE calling
   * ibApi_GetDeviceStatus().
   */
  devicestatus.struct_size = sizeof(devicestatus);
  CheckResult(ibApi_GetDeviceStatus(api_hdl,deviceids[i],&devicestatus));

  CheckResult(ibApi_Utils_ConvertDeviceIdToText(deviceids[i],
    deviceid_text,sizeof(deviceid_text),MIN_DEVICEID_WORDS));

  printf("  %10s (%i hops)\r\n", deviceid_text, devicestatus.hop_count);
}

/*
 * List the end nodes.
 */
printf("\r\nENDPOINTS\r\n");
deviceids_count = CheckResult(ibApi_GetDeviceList(api_hdl, groupid,
  ibApi_DEVICETYPE_ENDPOINT, deviceids,DEVICEIDS_MAX));

if (deviceids_count > DEVICEIDS_MAX)
  deviceids_count = DEVICEIDS_MAX;

for (i=0; i<deviceids_count; ++i) {
```

```
    CheckResult(ibApi_Utils_ConvertDeviceIdToText(deviceids[i],
      deviceid_text,sizeof(deviceid_text),MIN_DEVICEID_WORDS));

    sampling_interval = CheckResult(ibApi_GetSamplingInterval(api_hdl,deviceids[i]));

    printf("  %10s (%i ms)\r\n", deviceid_text, sampling_interval);
  }
}

/*****************************************************************************/
int main() {
  /*
   * This handle represents the current API session.
   */
  ibApi_APIHANDLE api_hdl;
  ibApi_VERSION api_version;

  api_version = ibApi_GetApiVersion();
  printf("\r\nInitializing API Version %i.%i.%i\r\n\r\n",
    ibApi_GET_VERSION_MAJOR(api_version),
    ibApi_GET_VERSION_MINOR(api_version),
    ibApi_GET_VERSION_RELEASE(api_version)
  );

  /*
   * ibApi_Open() is called to begin the session.  Your application
   * should ensure that ibApi_Close() is called to release the handle
   * before exiting.
   */
  api_hdl = CheckResult(ibApi_Open(ibApi_EXPECTED_VERSION,"local",""));

  ListDevices(api_hdl);

  CheckResult(ibApi_Close(api_hdl));

  WaitForKey();

  return 0;
}
```

A

Sample Application

This chapter contains information on how to perform the sample application included with the RK-5409-5 Reference Kit:

- 'Application Overview' on page A-2
- 'Application Setup & Operation' on page A-4
- 'Changing Temperature Sensor Battery' on page A-7

Application Overview

Millennial Net includes a sample application in the RK-5409-5 Reference Kit. This application demonstrates a real-world application of Millennial Net's end node peripheral interface and how it is used for monitoring and data collection purposes across a wireless network.

The RK-5409-5 Reference Kit includes a temperature sensor assembly with a 10,000 Ohm Kele sensor (Type 3) that changes resistance as its environmental temperature changes. The sensor can be used to measure temperatures from -35° to +240° degrees Fahrenheit, with ±5% accuracy.

The sensor's resistance change is measured via voltage change, measured by an end node's ADC channel 0, and converted by the TempMonitor application software (included with kit) to temperature. The sensor connection diagram is shown in Figure A-1 and process flow is shown in Figure 2.

Figure A-1. Temperature sensor assembly overview (cover removed)

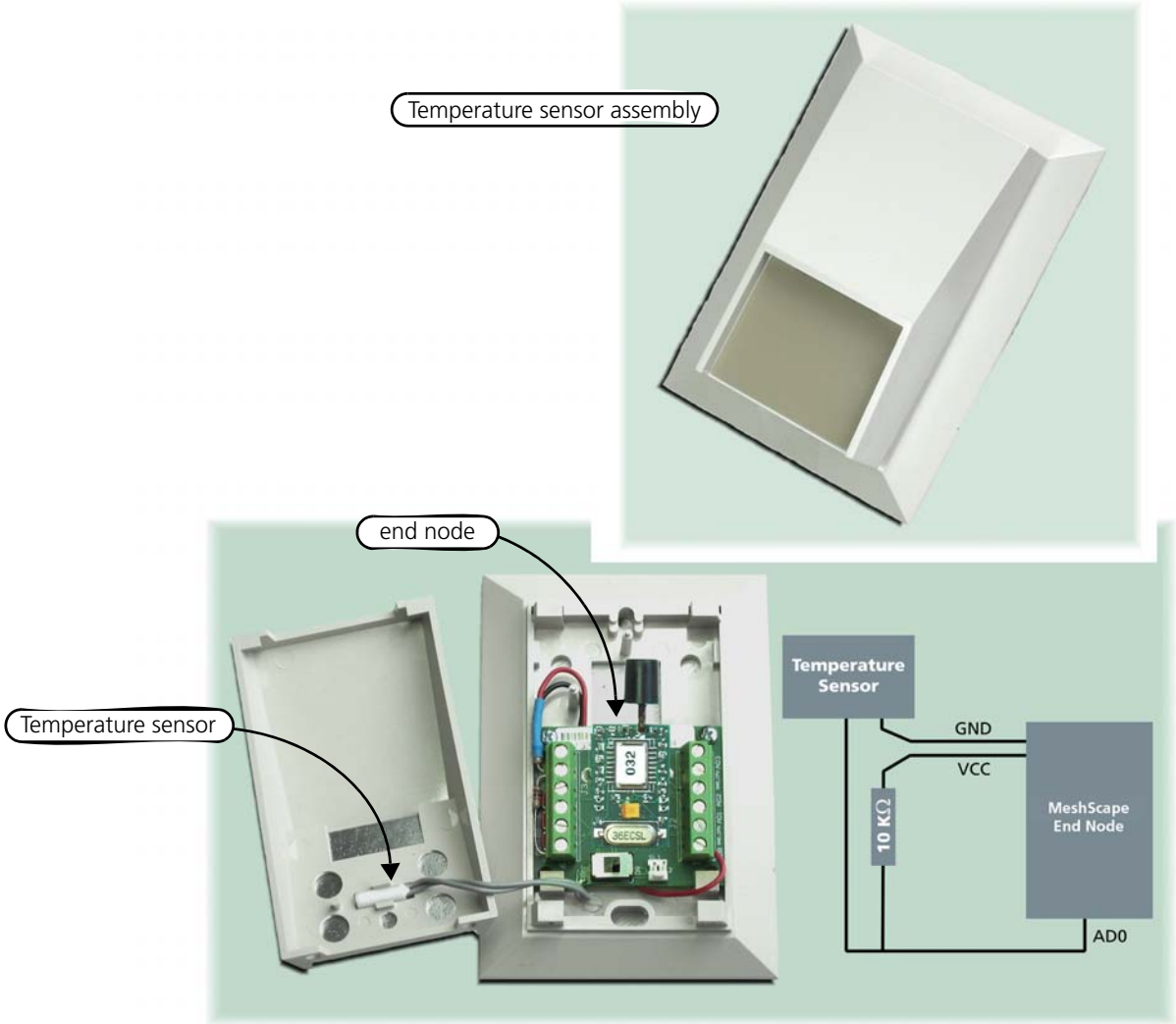
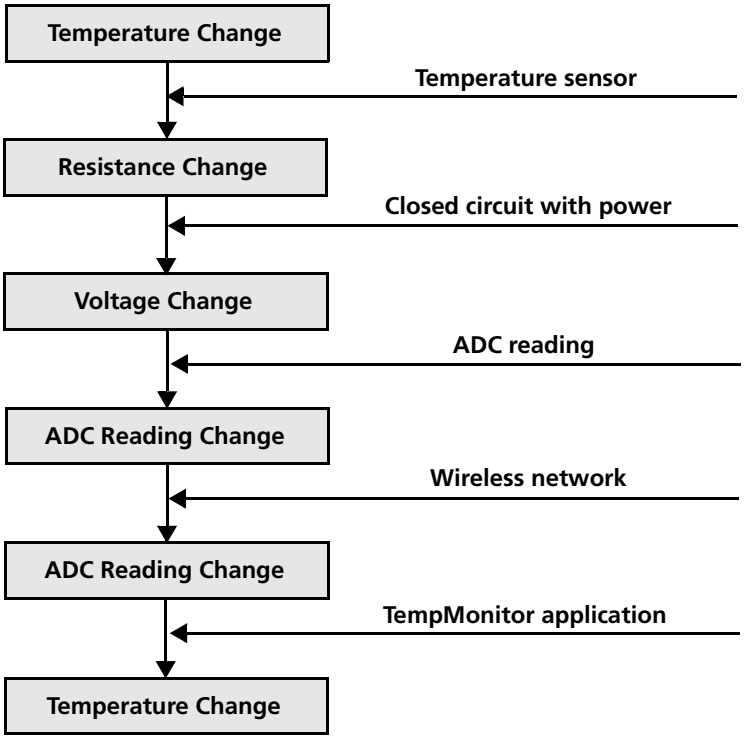


Figure A-2 describes the process flow.

Figure A-2. Process flow



Application Components

In addition to the MeshGate and MeshScape Network Monitor software supplied with the RK-5409-5 Reference Kit, the following items are included for the sample application:

- **end node** (removed from one of the kit terminal boards)
- **Temperature sensor assembly**: This assembly contains a factory installed terminal board and temperature sensor. The terminal board is also equipped with a factory-installed battery for providing power to the end node.

Note: Before using the temperature sensor assembly for this sample application, you will need to install an end node (see 'Temperature Sensor Assembly Setup' on page A-4)

- **TempMonitor application software** (automatically loaded on host PC when contents of kit CD are installed)

Application Setup & Operation

The following procedures describe how to set up the RK-5409-5 Reference Kit hardware and software for creating the Reference Kit's sample application.

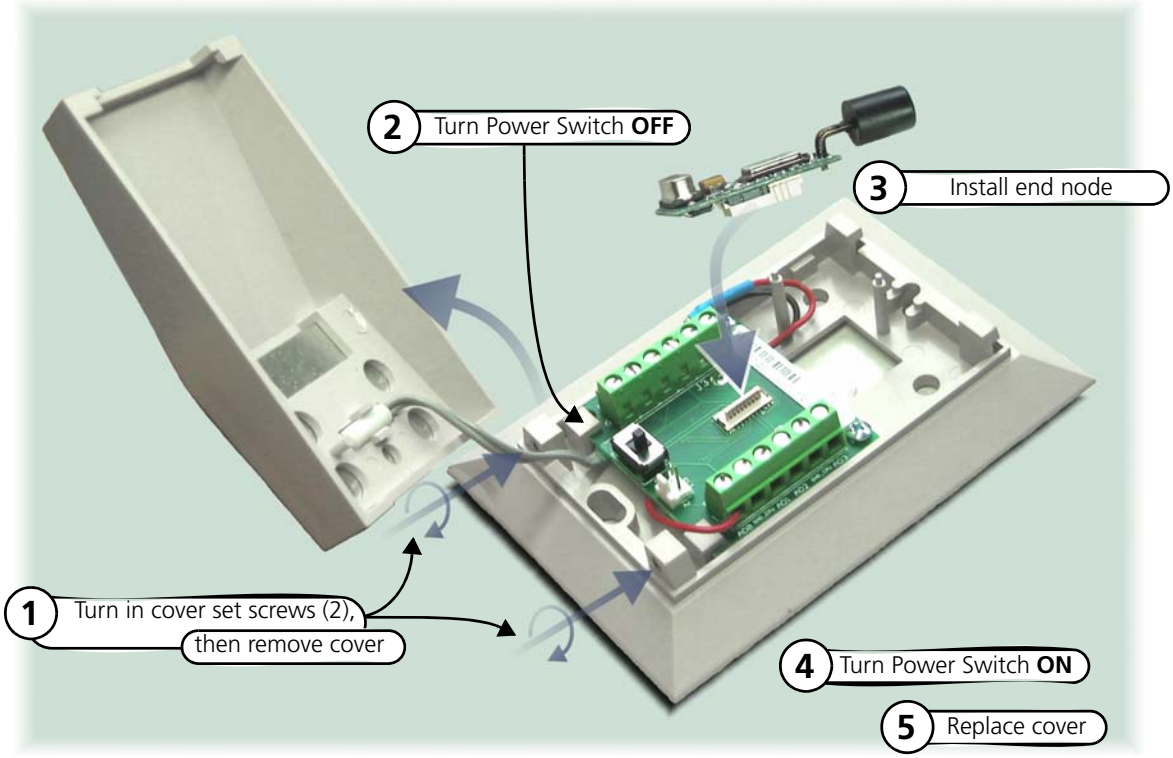
Note: Before this sample application can be executed, you must install the RK-5409 Reference Kit's hardware and software according to the instructions found in Chapter 2, "Installing the MeshScape System". *The MeshGate must be installed and powered on, and MeshScape Network Monitor must be running before proceeding.*

Temperature Sensor Assembly Setup

To install an end node in the temperature sensor assembly (see Figure A-3):

1. Use an Allen wrench to turn in the two set screws holding the cover to the base and remove the cover.
2. Turn the Power Switch **OFF**.
3. Remove an end node from one of the kit's terminal boards and install it on the terminal board located on the base of the temperature sensor assembly.
4. Turn the Power Switch to **ON**. The sensor is discovered and displayed by MeshScape Network Monitor.
5. Replace the cover and back out the two cover set screws to secure the cover in place.

Figure A-3. Installing end node in temperature sensor assembly

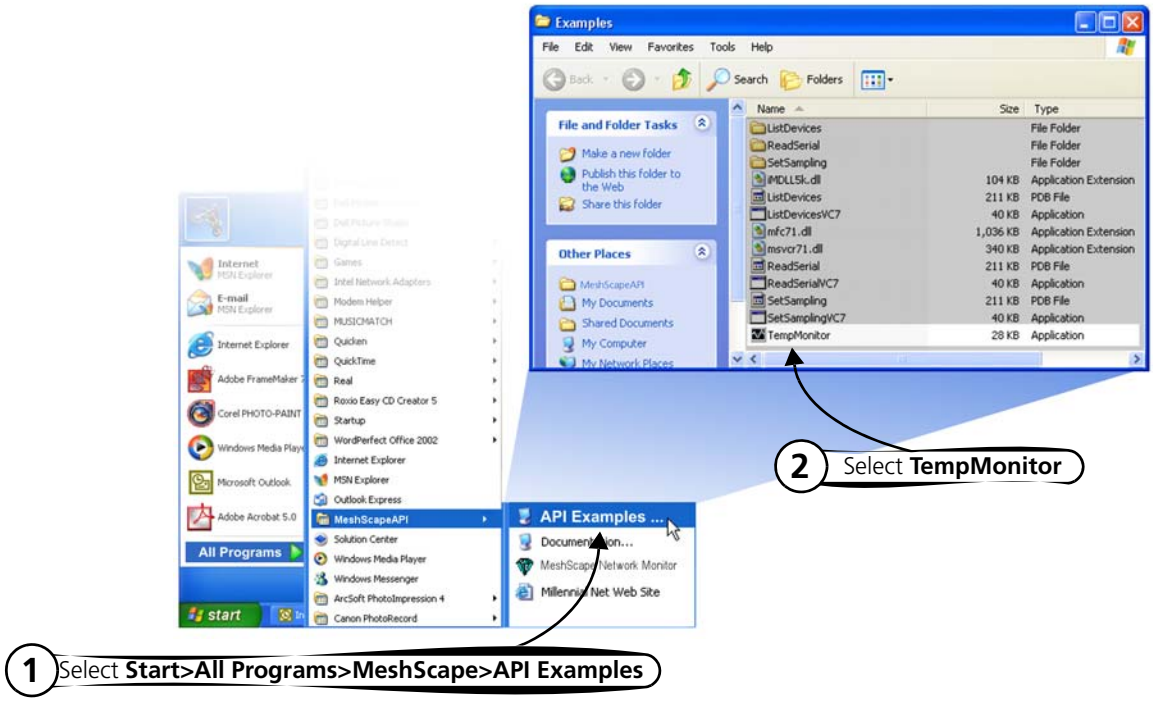


Launching TempMonitor Application

To launch the TempMonitor application (see Figure A-4):

1. From the Windows task bar, select **Star>All Programs>MeshScape>API Examples**. The Examples window opens with a list of options.
2. Select **TempMonitor** from the Examples window. TempMonitor launches.

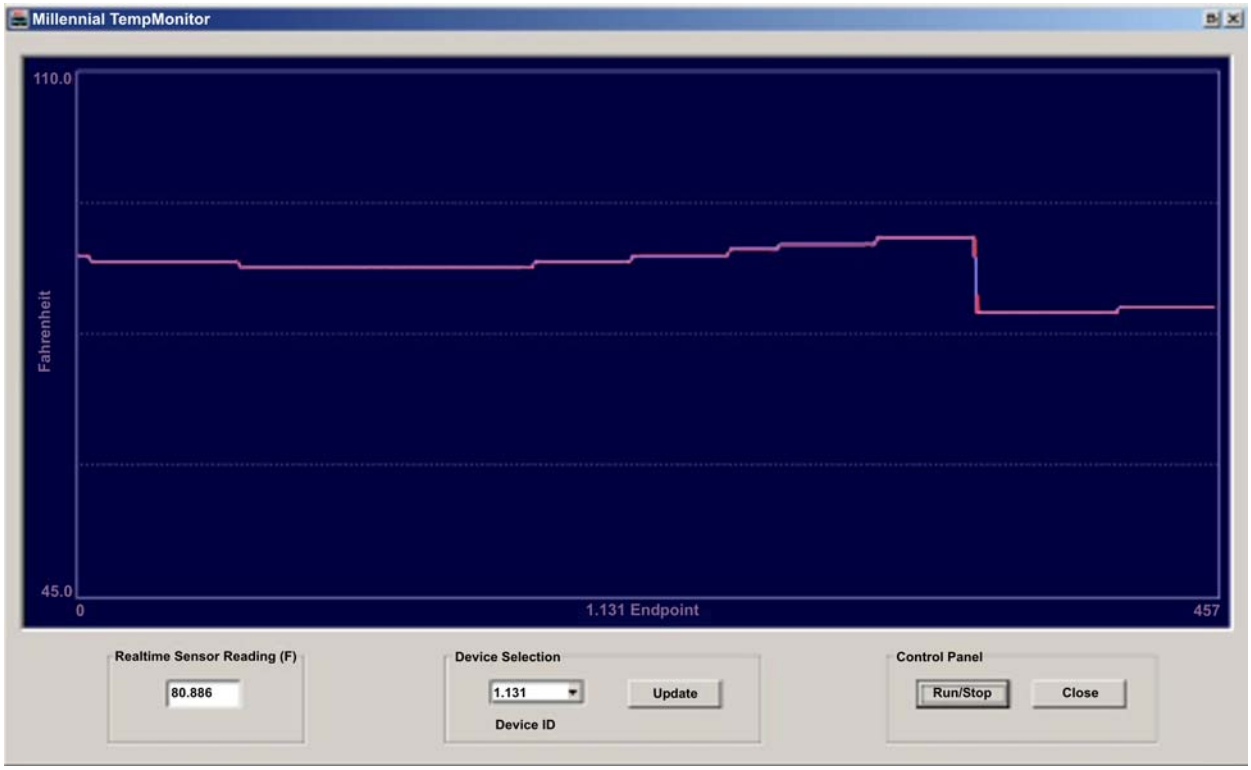
Figure A-4. Launching TempMonitor



TempMonitor Overview

The TempMonitor application displays temperature changes vs. time for one device only. Use the *Device Selection* area to select the end node with matching device ID, then click **Update** button to configure the device (enable ADC channel 1). The **Run/Stop** button is used to control the display curve updating; **Run** means continuously update the curve, **Stop** means to freeze the current curve. The precise reading can also be obtains from the *Realtime Sensor Reading(F)* area.

Figure A-5. TempMonitor display



You can change the environment temperature to observe changes to the graph's curve.

Changing Temperature Sensor Battery

The temperature sensor assembly comes with a factory installed lithium battery. The procedure below describes how to replace the battery when needed. Millennial Net recommends using the following replacement battery type:
DigiKey Part Number: **P189-ND**.

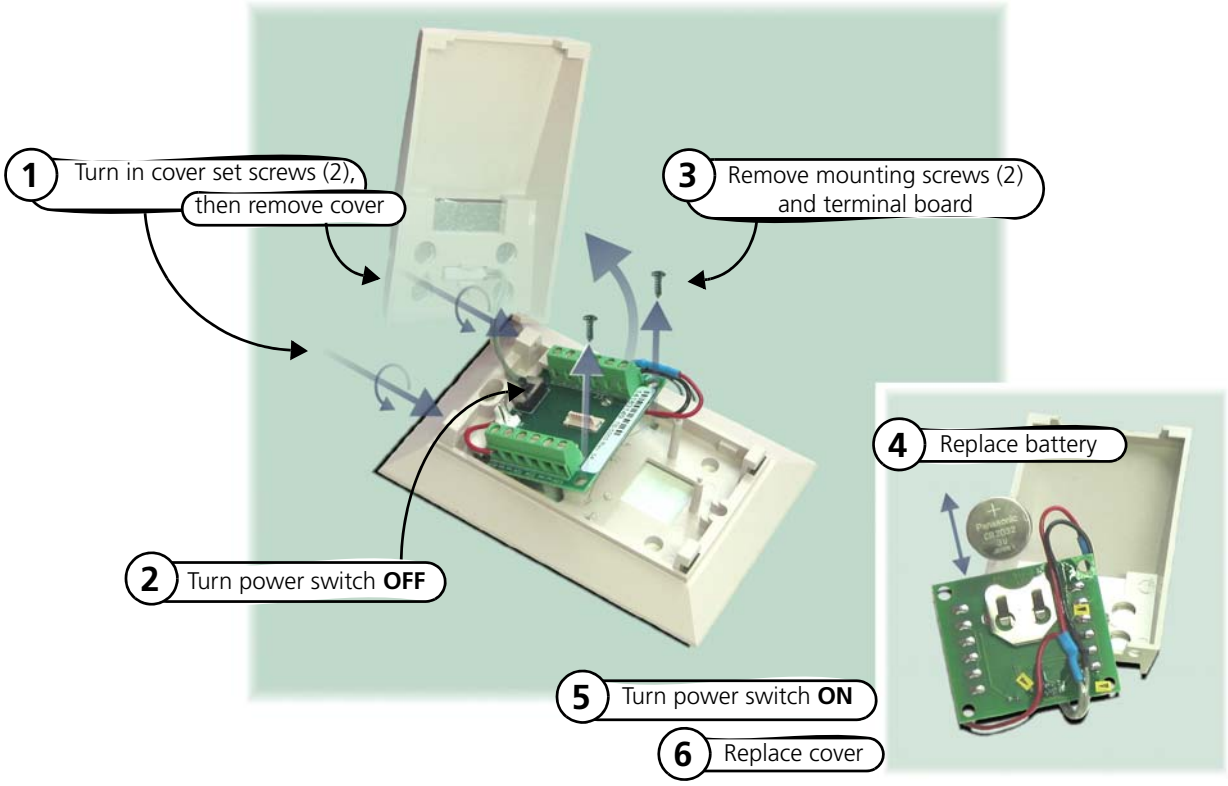
To replace the battery (see Figure A-6):

1. Use an Allen wrench to turn in the two set screws holding the cover to the base and remove the cover.
2. Turn the power switch **OFF**.
3. Remove the screws (2) securing the terminal board to the base and lift the terminal up and off the base.
4. Replace the battery—located on the bottom of the terminal board—with the recommended battery type, observing polarity (**+** side of battery to **+** side of holder).
5. Turn the power switch **ON**.
6. Reinstall the terminal board, replace assembly cover, and back out the two cover set screws to secure the cover in place.

Caution

Do not overtighten the terminal board mounting screws, which may damage the battery holder.

Figure A-6. Changing temperature sensor assembly battery



B

Performing Firmware Upgrades and Configuring Device IDs

The MeshScape Programmer application supplied with your RK-5409-5 Reference Kit enables you to upgrade the firmware on your MeshGates and mesh nodes, and re-program the group and device IDs on your MeshScape System. The supplied End Node Configurator enables you to program the group and devices IDs, default sample interval, and statistics reporting rate on end nodes. This chapter contains information on how to use the MeshScape Programmer and End Node Configurator applications and includes:

- 'Getting Started with MeshScape Programmer' on page B-2
- 'Performing MeshScape Programmer Operations' on page B-4
- 'Getting Started with End Node Configurator' on page B-8
- 'Performing End Node Configurator Operations' on page B-10

Getting Started with MeshScape Programmer

MeshScape Programmer is a feature-rich application that enables you to upgrade your MeshScape system by:

- re-programming the device flash memory
- unlocking firmware feature upgrades
- re-programming group and device IDs

To use MeshScape Programmer, you will need to:

- connect the target device that you wish to upgrade to your computer
- run the MeshScape Programmer application on your computer

Connecting the Target Device to Your Computer

You may upgrade the firmware on a MeshGate or a mesh node using MeshScape Programmer.

Connecting a MeshGate for Programming

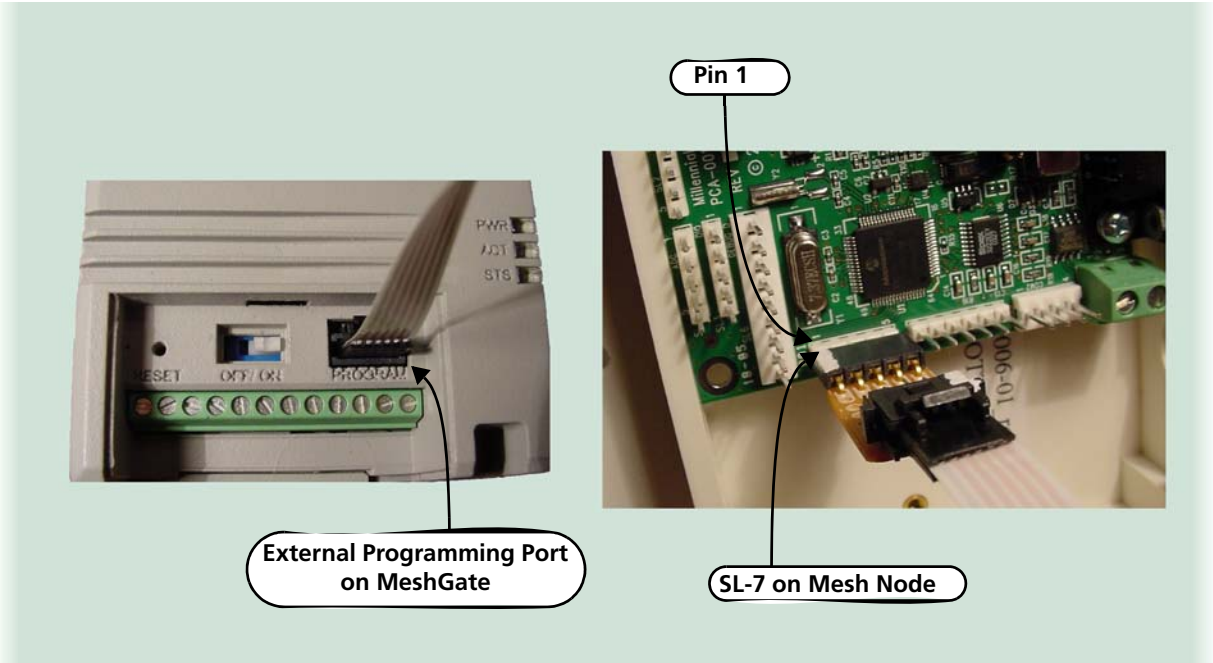
The MeshGate provides a console port equipped with a mini-connector to facilitate firmware upgrades.

Using the mini-connector-to-nine-pin serial connector cable supplied in your RK-5409-5 Reference Kit, connect the MeshGate console port to the serial port on your computer.

Connecting a Mesh Node for Programming

1. Connect a MeshGate to your computer as described above.
2. Remove the connector panel access cover from the MeshGate connected to the computer and remove the chassis cover from the target mesh node.
3. Referring to Figure B-1 and using the supplied MeshGate programming cable and MeshGate-to-mesh node adapter, connect the **external programming port on the MeshGate** to port **SL-7 on the mesh node**.
4. Replace the MeshGate connector panel access cover and mesh node chassis cover, and disconnect the programming cable after the firmware update is complete.

Figure B-1.Connecting MeshGate programming cable w/adapter to mesh node



Launching MeshScape Programmer Using Windows

To launch MeshScape Programmer, do one of the following:

- Double-click on the desktop's MeshScape Programmer icon.

- From the Windows taskbar, select:
  Start>All Programs>MeshScape Programmer>MeshScape Programmer.

MeshScape Programmer runs as described in the next section.

Performing MeshScape Programmer Operations

You may use MeshScape Programmer to:

- upgrade the firmware image on the target device
- unlock features on the target device
- re-program the device and group IDs on the target device

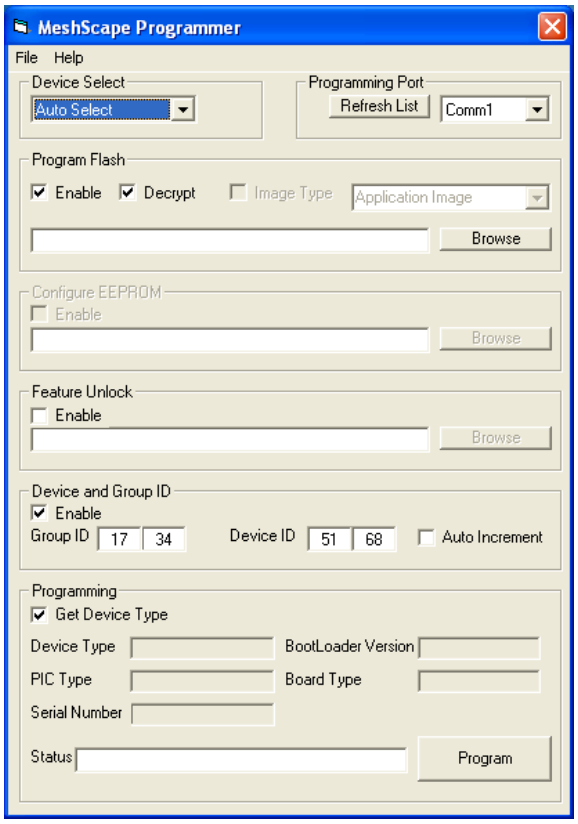
Upgrading Firmware on the Target Device

To upgrade the firmware on a MeshGate or mesh node using the MeshScape Programmer application:

1. Connect the target device to your computer and launch the MeshScape Programmer application as described in the previous section.

   The MeshScape Programmer main window appears as shown in Figure B-2.

Figure B-2.The MeshScape Programmer main window



2. Select the target device to program by selecting an option from the **Device Select** drop-down menu:
   - Auto-Select - Allow MeshScape Programmer to determine the connected device type (default).
   - MeshGate Application - Upgrade the firmware on the MeshGate's main application terminal board.
   - MeshGate RF - Upgrade the firmware on the MeshGate's RF daughter board.
   - External Device - Upgrade a mesh node connected to the MeshGate.
3. Select the PC serial port to use when communicating with the connected MeshGate from the **Programming Port** drop-down menu.

   If a required Comm port is being used by another application, close the application and then click **Refresh List** to make the Comm port available for use by MeshScape Programmer.
4. Select the firmware image file to load on the target device.
   a. Mark the **Enable** checkbox to enable the program flash operation.
   b. Mark the **Decrypt** checkbox to decrypt an encrypted image file. Encrypted image files are denoted by a .enc file extension.
   c. Click the **Browse** button, and select the firmware image file supplied to you from Millennial Net.
5. Upload the new image file to the target device.
   a. Mark the **Get Device Type** checkbox to display information about the target device in the Device Type field as the upgrade progresses.
   b. Click **Program** to initiate the firmware upgrade.

As the firmware upgrade progresses, you will see status messages posted to the **Status** field. Once the upgrade is completed, the status will be reported as Programming Complete.

Unlocking Features on the Target Device

To unlock features on a MeshGate or mesh node using the MeshScape Programmer application:

1. Connect the target device to computer and launch the MeshScape Programmer application as described on page B-2.

   The MeshScape Programmer main window appears as shown in Figure B-2.
2. Select the target device to program by selecting an option from the **Device Select** drop-down menu:
   - Auto-Select - Allow MeshScape Programmer to determine the connected device type (default).
   - MeshGate Application - Upgrade the firmware on the MeshGate's main application terminal board.
   - MeshGate RF - Upgrade the firmware on the MeshGate's RF daughter board.
   - External Device - Upgrade a mesh node connected to the MeshGate.

3. Select the PC serial port to use when communicating with the connected MeshGate from the **Programming Port** drop-down menu.

   If a required Comm port is being used by another application, close the application and then click **Refresh List** to make the Comm port available for use by MeshScape Programmer.

4. Select the feature unlock file to load on the target device.

   a. Mark the **Enable** checkbox to enable the feature unlock operation.

   b. Click the **Browse** button, and select the feature unlock file supplied to you from Millennial Net.

5. Upload the feature unlock file to the target device.

   a. Mark the **Get Device Type** checkbox to display information about the target device in the Device Type field as the upgrade progresses.

   b. Click **Program** to initiate upload of the feature unlock file to the target device.

As the feature unlock file upload progresses, you will see status messages posted to the **Status** field. Once the update is completed, the status will be reported as Programming Complete.

Reprogramming the Group and Device IDs on the Target Device

To reprogram the group and device IDs on a MeshGate or mesh node using the MeshScape Programmer application:

1. Connect the target device to computer and launch the MeshScape Programmer application as described on page B-2.

   The MeshScape Programmer main window appears as shown in Figure B-2.

2. Select the target device to program by selecting an option from the **Device Select** drop-down menu:
   - Auto-Select - Allow MeshScape Programmer to determine the connected device type (default).
   - MeshGate Application - Upgrade the firmware on the MeshGate's main application terminal board.
   - MeshGate RF - Upgrade the firmware on the MeshGate's RF daughter board.
   - External Device - Upgrade a mesh node connected to the MeshGate.

3. Select the PC serial port to use when communicating with the connected MeshGate from the **Programming Port** drop-down menu.

   If a required Comm port is being used by another application, close the application and then click **Refresh List** to make the Comm port available for use by MeshScape Programmer.

4. Enter the group and device IDs to set on the target device.

   a. Mark the **Enable** checkbox to enable the ID reprogramming.

b. Enter the new IDs in the **Group ID** and **Device ID** fields.

c. Optional. Mark the **Auto Increment** checkbox if you will be reprogramming the group and device IDs on multiple devices and wish to do so in sequence.

5. Upload the new group and device IDs to the target device.

a. Mark the **Get Device Type** checkbox to display information about the target device in the Device Type field as the upgrade progresses.

b. Click **Program** to initiate upload of the new IDS to the target device.

As the group and device ID reprogramming progresses, you will see status messages posted to the **Status** field. Once the update is completed, the status will be reported as Programming Complete.

Getting Started with End Node Configurator

End Node Configurator is a feature-rich application that enables you to upgrade your MeshScape end nodes by programming:

- group and devices IDs
- default sample interval
- statistics reporting rate

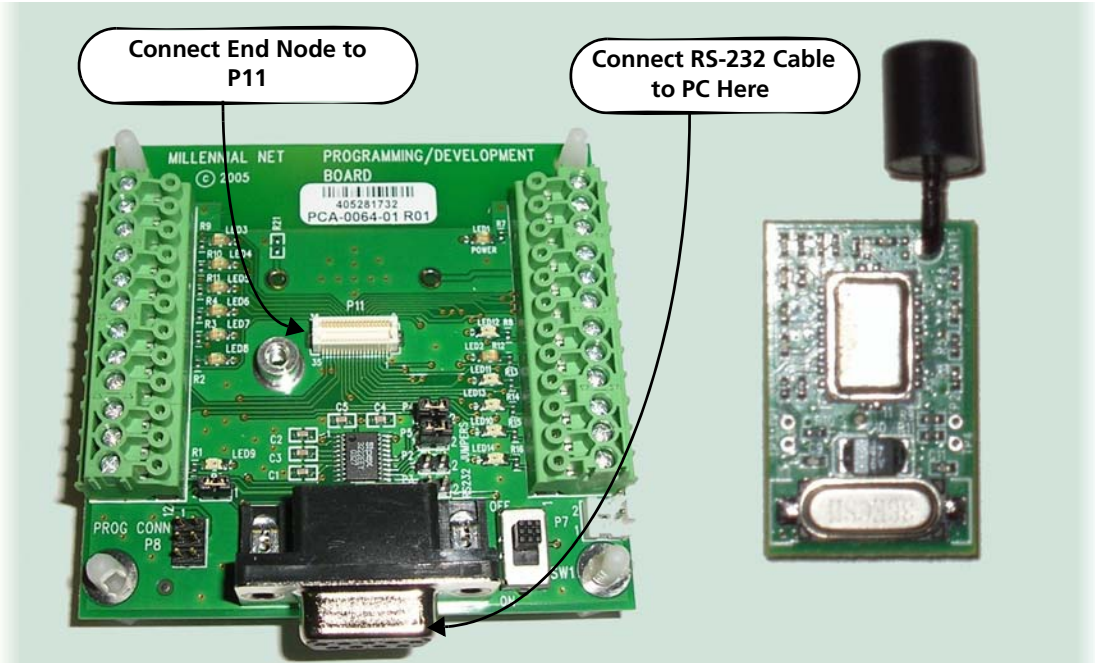
To use End Node Configurator, you will need to:

- connect the target end node that you wish to upgrade to your computer
- run the application on your computer

Connecting the Target End Node to Your Computer

A special terminal board equipped with an RS-232 serial port is included in your Reference Kit for programming end nodes. This end node terminal board is shown in Figure B-3.

Figure B-3.Connecting an end node to the programming terminal board



To connect an end node to your computer for programming:

1. Connect the end node to connector **P11** on the end node programming terminal board.
2. Connect the supplied RS-232 serial cable between the terminal board and the host PC on which you will be running the End Node Configurator application.

Launching End Node Configurator Using Windows

To launch End Node Configurator, do one of the following:

- Double-click on the desktop's End Node Configurator icon.
- From the Windows taskbar, select:
  Start>All Programs>End Node Configurator.

End Node Configurator runs as described in the next section.

Performing End Node Configurator Operations

You may use End Node Configurator to program an end node's:

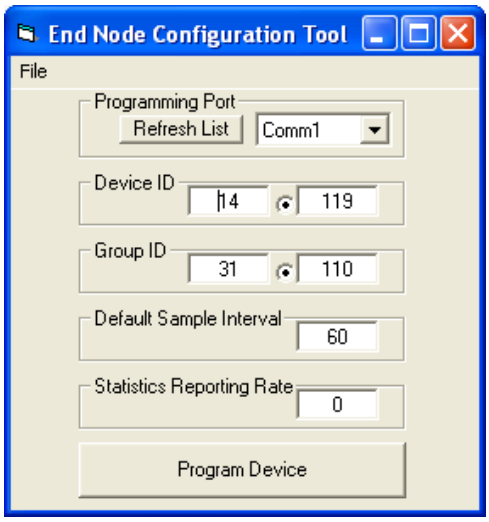
- group and devices IDs
- default sample interval
- statistics reporting rate

To use End Node Configurator:

1. Connect the target end node to your computer and launch the End Node Configurator application as described in the previous section.

   The End Node Configurator main window appears as shown in Figure B-4.

Figure B-4.The End Node Configurator main window



2. Select the PC serial port to use when communicating with the connected end node from the **Programming Port** drop-down menu.

   If a required Comm port is being used by another application, close the application and then click **Refresh List** to make the Comm port available for use by End Node Configurator.

3. Enter the device ID you wish to program on the end node in the **Device ID** field.

   The device ID is used to uniquely identify each device within a MeshScape system.

4. Enter the group ID you wish to program on the end node in the **Group ID** field.

   The group ID is the network ID used to identify members of the same MeshScape system.

5. Enter how often the end node transmits a 'heart beat' data packet or any other data in the **Default Sample Interval** field.

The default end node sample interval setting is 60 seconds.

6. Enter the rate at which the end node sends statistics in the **Statistics Reporting Rate** field.

   The Statistics Reporting Rate is the number of normal packets transmitted before performance statistics are added to a packet.

   A Statistics Reporting Rate of 0 means every packet has performance statistics added to it. A Statistics Reporting Rate of 1 means 1 normal packet is transmitted then performance statistics are added to a packet. A Statistics Reporting Rate of 2 would mean 2 normal packets are transmitted and the next packet has performance statistics added to it.

   The maximum Statistics Reporting Rate is 254.

   The default setting is 0—every packet has performance statistics added to it.

7. Click **Program** to program the end node with the entered settings.

Glossary

API

Application Programming Interface: A set of definitions of the ways in which one piece of computer software communicates with another. It is a method of achieving abstraction, usually (but not necessarily) between lower-level and higher-level software. One of the primary purposes of an API is to provide a set of commonly used functions-for example, to poll a wireless network for active network nodes (mesh nodes and end nodes). Programmers can then take advantage of the API by making use of its functionality, saving them the task of programming everything from scratch. APIs themselves are abstract: software that provides a certain API is often called the implementation of that API.

ad hoc network

A group of wireless sensors connected as an independent wireless network, communicating directly with each other without the use of a mesh node.

bandwidth

The amount of data that can be transmitted in a fixed amount of time. For digital devices, the bandwidth is usually expressed in bits per second (bps) or bytes per second. For analog devices, the bandwidth is expressed in cycles per second, or Hertz (Hz).

data model

As it pertains to wireless sensor networks, the data model characterizes and describes the way in which data flows through and is used in the network. Common data model categories include data collection models (periodic sampling, event driven, and store and forward) and bi-directional dialogue data models (polling and on demand).

DSSS

Direct Sequence Spread Spectrum: Spread spectrum method of spreading a narrow band signal. This method uses special pseudo noise codes to expand the narrow band signal out across a broad portion of the radio band. (See also *FHSS* and *spread spectrum*.)

duty cycle

The duty cycle of a module refers to the percentage of time the module is active versus inactive.

end node

The network module that provides the physical interface between the wireless sensor network and the sensor or actuator that it is wired to. Sometimes called a Reduced Function Device (see *RFD*).

endpoint

See *end node*.

FFD

Full Function Device: A term referring to a device that can act as an intermediate mesh node, passing data from other devices. (See also *RFD*.)

FHSS Frequency Hopping Sequence Spread Spectrum: Spread spectrum method of spreading a narrow band signal out across a broad portion of the radio band. This method "hops" the signal as a function of time. (See also *DSSS* and *spread spectrum*.)

gateway The network module that provides the interface between the application platform and the modules on the wireless sensor network.

IEEE Institute of Electrical and Electronics Engineers: Organization of engineers, scientists, and students that is known for developing standards for the computer and electronics industry.

IEEE 802.11.4 Standard developed by IEEE that defines the lower protocol layers (PHY and MAC) for low-data-rate wireless Personal Area Networks (PANs).

ISM The industrial, scientific, and medical (ISM) radio bands were originally reserved internationally for non-commercial use of RF electromagnetic fields for industrial, scientific and medical purposes. They are now also used for license-free error-tolerant wireless communications applications in the 900 MHz and 2.4 GHz bands.

latency In networking, the amount of time it takes a packet to travel from source to destination. Together, latency and bandwidth define the speed and capacity of a network.

mesh node The module on the wireless sensor network used to extend network coverage area, route around obstacles, and provide back-up routes in case of network congestion or device failure. The mesh node can also provide a direct physical interface to a sensor or actuator. Sometimes called a Full Function Device (see *FFD*).

mesh topology A wireless sensor networking architecture consisting of a gateway and mesh nodes that provides extended area coverage, routing around obstacles, and back-up data paths.

narrowband Radio signal that contains all of its power within a very narrow portion of the radio frequency band.

OSI Open System Interconnection: An ISO standard for worldwide communications that defines a networking framework for implementing protocols in seven layers. Control is passed from one layer to the next, starting at the application layer in one station, proceeding to the bottom layer, over the channel to the next station and back up the hierarchy.

packet A piece of a message transmitted over a packet-switching network. One of the key features of a packet is that it contains the destination address in addition to the data.

personal area network
A personal area network (PAN) is the interconnection of information technology devices within the range of an individual person, typically within a range of 10 meters.

protocol
The protocol defines a common set of rules and signals that devices (nodes) on the network use to communicate.

protocol stack
A set of network protocol layers that work together. The OSI reference model that defines seven protocol layers is often called a stack.

RFD
Reduced Function Device: A term referring to a device that is just smart enough to talk to the network (see also *FFD*).

router
See *mesh node*.

sensor node
A wireless sensor network node consisting of a sensor or actuator device attached to a wireless module. The wireless module provides the interface between the sensor device and the wireless network.

SNR
Signal-to-noise ratio: the ratio of the amplitude of a desired analog or digital data signal to the amplitude of noise in a transmission channel at a specific point in time. SNR is typically expressed logarithmically in decibels (dB). SNR measures the quality of a transmission channel or an audio signal over a network channel. The greater the ratio, the easier it is to identify and subsequently isolate and eliminate the source of noise. A SNR of zero indicates that the desired signal is virtually indistinguishable from the unwanted noise.

spread spectrum (wideband)
Technique for taking a narrowband signal and spreading it across a broader portion of the radio frequency band. Spread-spectrum signals are more resistant to interference than narrow band signals. The two basic methods for spreading a narrowband are direct sequence and frequency hopping. (See also *DSSS* and *FHSS*.)

star topology
A wireless sensor networking architecture consisting of a gateway and end nodes that is extremely power efficient for short-range networks.

star-mesh hybrid topology
A wireless sensor networking architecture consisting of a gateway, mesh nodes, and end nodes that optimizes range and power efficiency of the network.

topology
As it pertains to wireless sensor networks, the geometric arrangement of the modules (gateway, mesh nodes, and end nodes) within a network. Common topologies include star, mesh, and star-mesh hybrid.

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