Millennial Net

MeshScape™

Commercial- and Industrial-class Wireless Mesh Networks

RK-5424-5 Reference Kit

for 2.4 GHz MeshScape Systems

User's Guide

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NOTICE

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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-5424-5 Reference Kit (2.4GHz, 5-3-1) consisting of the following models/components:

- EN-5424 end node
- MN-5424 mesh node
- MG-5424XL MeshGate Extra Long Range gateway

Compliance Statement (Part 15.19)

The Millennial Net RK-5424-5 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.

Note (Part 15.105(b))

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

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Unlicensed Modular Approval (for OEMs)

The URM-G-2400 and URM-M-2400 comply 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-2400 and URM-M-2400 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-2400 and URM-M-2400 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-MG5424XL

2. The OEM must only use the reverse polarity-SMA (RP-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-2400 and URM-M-2400. Integrating the module using any other antenna will require testing to ensure compliance with FCC rules and regulations.

   Centurion ½ wave Antenna Part Number: WCR2400SMRP

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-0018-01

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 modules have 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: 5172A-MG5424XL

For countries not covered by FCC Part 15, Industry Canada RSSS-210, or CE

The RK-5424 -5 Reference Kits are to be used solely by professional engineers for the purpose of evaluating the feasibility of low-power wireless data communications applications. The user's evaluation must be limited to use of an assembled Kit within a laboratory setting which provides for adequate shielding of RF emission which might be caused by operation of the Kit following assembly. In field testing, the assembled device must not be operated in a residential area or any area where radio devices might be subject to harmful electrical interference. Distribution and sale of the Kit is intended solely for use in future development of devices which may be subject to FCC regulation, or other authorities governing radio emission. This Kit may not be resold by users for any purpose. Accordingly, operation of the Kit in the development of future devices is deemed within the discretion of the user and the user shall have all responsibility for any compliance with any authority governing radio emission of such development or use, including without limitation reducing electrical interference to legally acceptable levels. All products developed by user must be approved by the authority governing radio emission prior to marketing or sale of such products and user bears all responsibility for obtaining the approval as needed from any other authority governing radio emission. If user has obtained the Kit for any purpose not identified above, including all conditions of assembly and use, user should return Kit to Millennial Net, Inc. immediately.

Trademarks

Information subject to change.

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About This Guide

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

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-5424-5 MeshScape Wireless Mesh 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 mesh networking and the MeshScape™ system.
Chapter 2, "Installing the MeshScape System"	Instructions for installing the components of the RK-5424-5 MeshScape Wireless Mesh 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, "Running the Demo Application"	Procedure for running the sample application provided with the reference kit.
Appendix B, "Using MeshScape Programmer"	Instructions for using the MeshScape Programmer application to upgrade the firmware on MeshScape devices, reprogram the group and device IDs, and select the channel on which the devices operate.
Appendix C, "Setting Up the Digi One SP"	High-level configuration procedures for the Digi One SP Ethernet-to-serial adapter when used to provide an Ethernet connection for the MeshGate.
Appendix D, "Accessing the MeshGate CLI"	Describes how to access the MeshGate command line interface (CLI) to verify and configure the MeshGate serial port settings.
Glossary	Defines terminology associated with wireless mesh 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

Millennial Net maintains a site on the World Wide Web where information on the company and its products can be found. The URL is:

www.millennialnet.com

Customer Support

For answers to your technical questions, Millennial Net's Customer Service department can be reached at:

phone:
+1 781.222.1030

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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 mesh 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 Mesh Networking Overview

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

Defining Wireless Mesh Networks

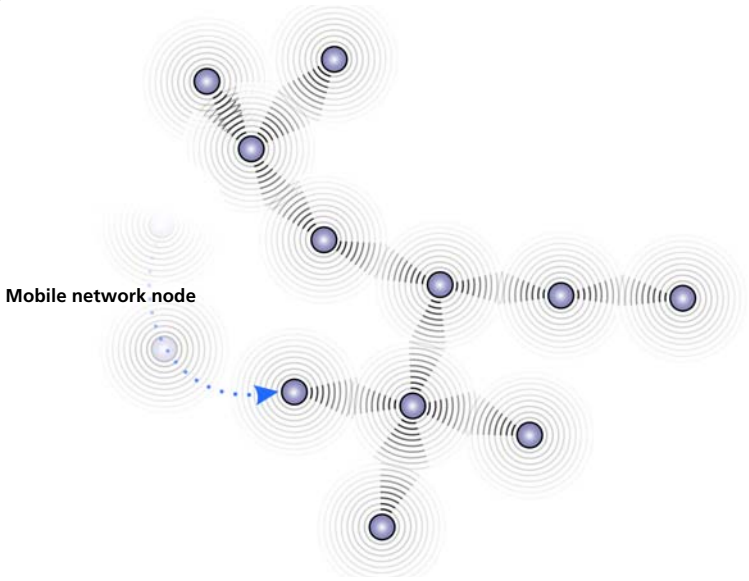
Until recently, networks designed for monitoring and controlling sensors or actuators on a network were limited in application and scope due to a major network design consideration—the cables required to connect the various sensors and actuators to a centralized collection point. In addition to the costs 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 mesh 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 mesh networks fundamentally change the economics of deploying and operating a sensor network, unlocking opportunities to achieve new efficiencies in applications such as production processes, building control, or monitoring. Wireless mesh 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 mesh 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 mesh 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 mesh networks.

Wireless Mesh Network Components

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

System Software

The software required to integrate and operate a wireless mesh 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 mesh network.Firmware is pre-programmed onto every MeshScape component. However, you have the opportunity to modify certain network parameters for each component. See Appendix B for more information.

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 mesh network.

API functions are grouped into "libraries." In wireless mesh 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.

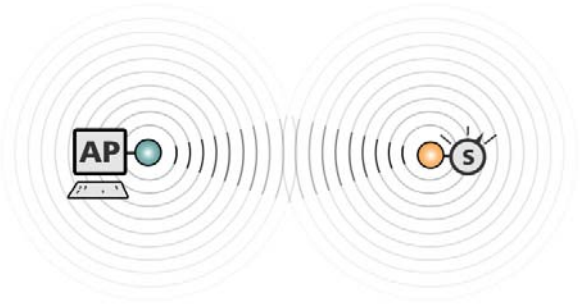
Network Monitoring System

A network monitoring system (NMS) is software used to interface with a particular wireless mesh 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 mesh 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 mesh 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.

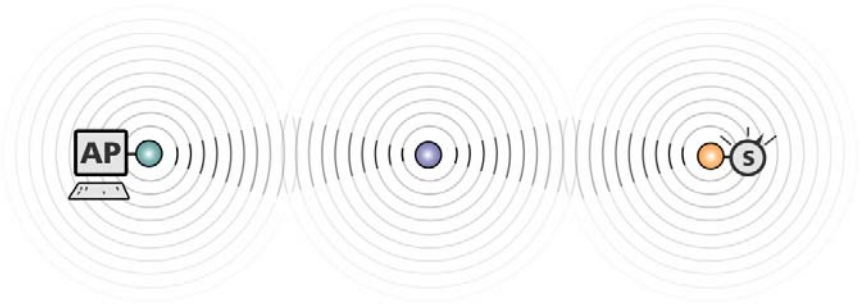
Figure 1-2. Basic wireless mesh network components



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 mesh network. The application platform is capable of making decisions based on the information it gathers from the network. Typically, the wireless mesh 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 use in, for example, a handheld device. 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 mesh 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 mesh 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.

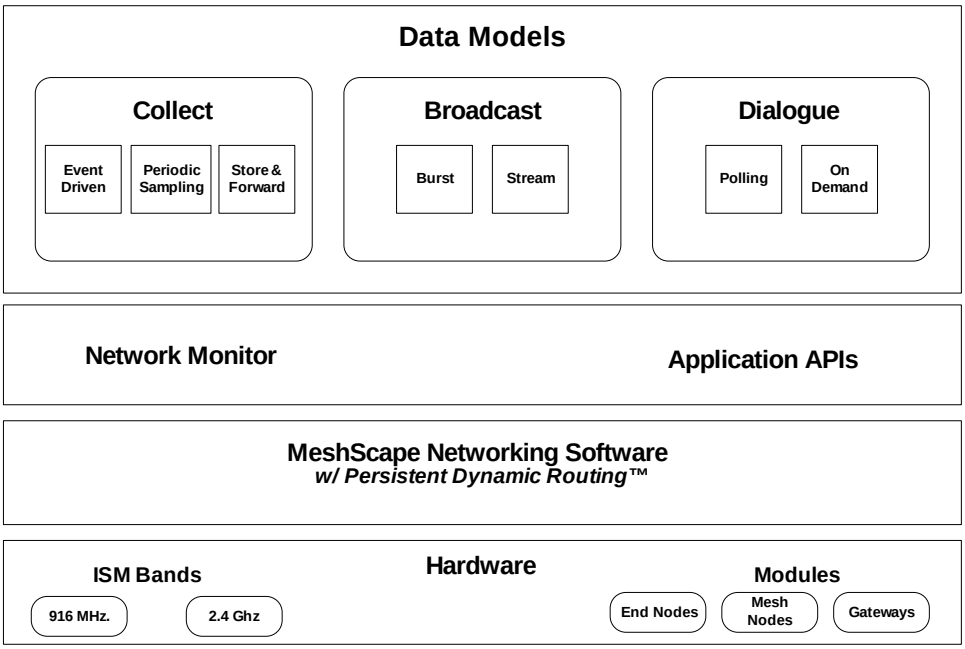
MeshScape System Overview

In order to realize benefits wireless mesh 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 mesh 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 mesh 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 mesh 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 mesh 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 mesh 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.

MeshGate Extra Long Range Connection Options

The MeshGate Extra Long Range gateway is equipped with an RS-232 serial port that enables the gateway to connect to a Windows XP host PC running the MeshScape Network Monitor application, or to a Linux- or Windows-application platform (network controller, PDA, PC, etc.) running a MeshScape API-based application.

Use one of the following options to establish a connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range:

- Establish a direct serial connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range using the supplied RS-232 cable.
- Establish a TCP/IP connection from the Network Monitor host PC to a MeshScape Serial Proxy Server that has a direct serial connection to the MeshGate Extra Long Range. The MeshScape Serial Proxy Server that runs on a Linux or Windows XP host is supplied with your MeshScape RK-5424-5 Reference Kit software.
- Establish a TCP/IP connection from the Network Monitor host PC to an Ethernet-to-serial adapter connected to the MeshGate Extra Long Range.

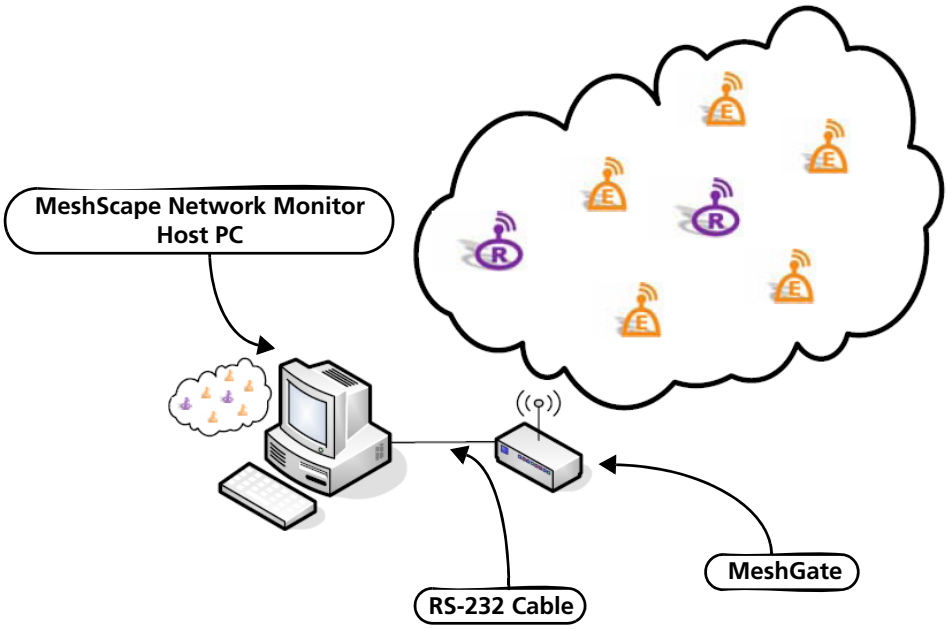
These MeshGate Extra Long Range connection options are described and depicted in the following sections.

Regardless of which of the following serial connection options is used, the MeshScape Network Monitor or other MeshScape API-based application can only access and monitor a single MeshScape, i.e., a single instance of MeshScape Network Monitor cannot monitor multiple MeshScapes.

Direct Serial Connection

Figure 1-5 shows a local direct serial connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range using the supplied RS-232 cable.

Figure 1-5. Direct serial connection to the MeshGate



In this topology, only one MeshScape API-based application running on the host PC can access the MeshScape.

TCP/IP Connection to the MeshScape Serial Proxy Server

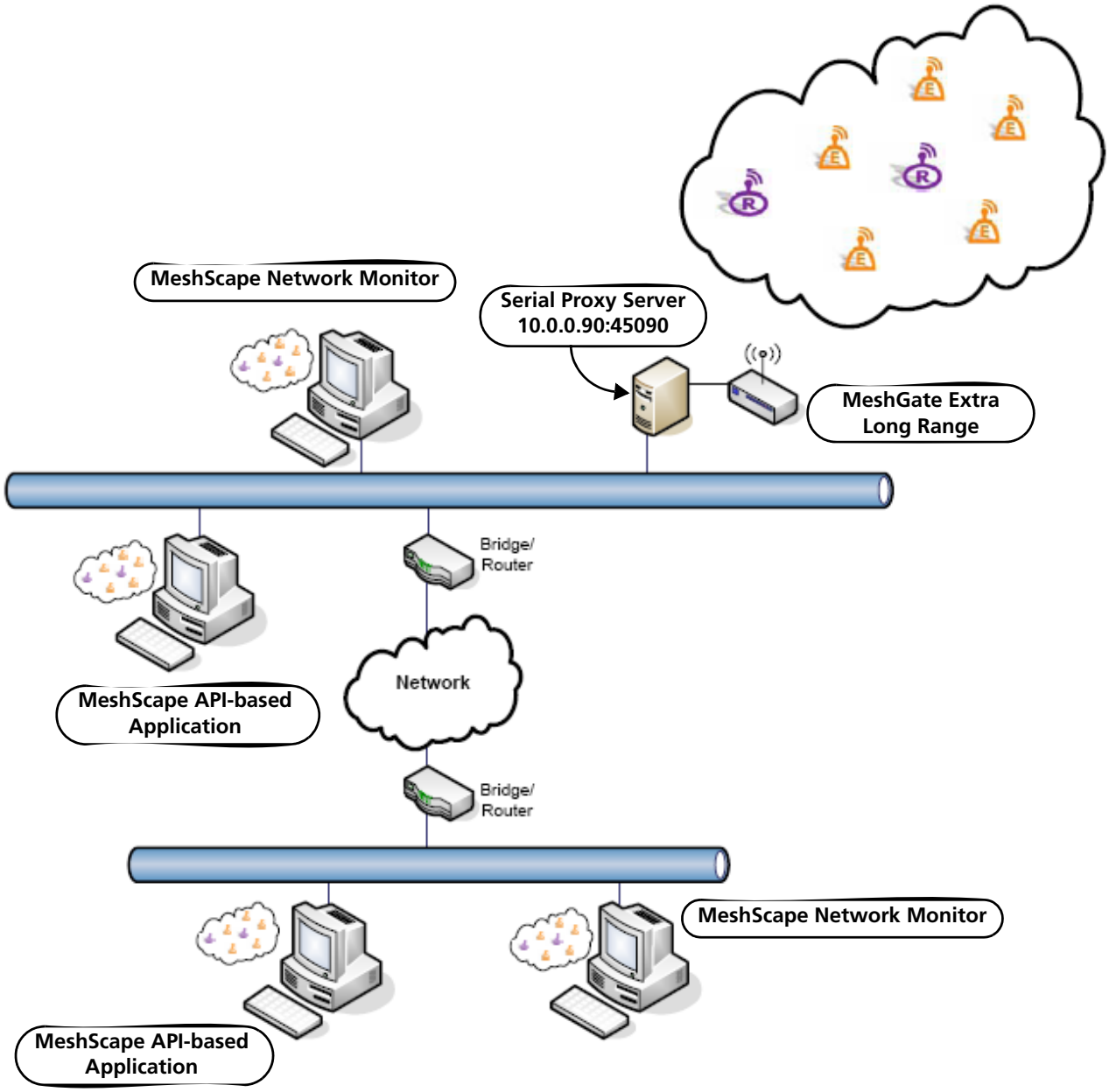
Figure 1-6 shows a PC that is running the MeshScape Serial Proxy Server and is connected to the MeshGate Extra Long Range via the PC's serial port.

A MeshScape API-based application functions as a serial proxy client by changing its lowest level serial interface to a TCP/IP interface. The MeshScape API TCP/IP serial proxy client interface opens a connection to the MeshScape Serial Proxy Server by connecting to its well advertised port.

Local and remote MeshScape API-based applications including MeshScape Network Monitor access the MeshScape data on the MeshGate Extra Long Range by connecting to the MeshScape Serial Proxy Server at IP address 10.0.0.90 on port 45090.

Although Figure 1-6 does not show any MeshScape API-based applications running on the PC, any number of MeshScape API-based applications could be running on the same PC host as the MeshScape Serial Proxy Server. The MeshScape Serial Proxy Server supports up to ten client connections.

Figure 1-6. Connection to the MeshGate via the MeshScape serial proxy server



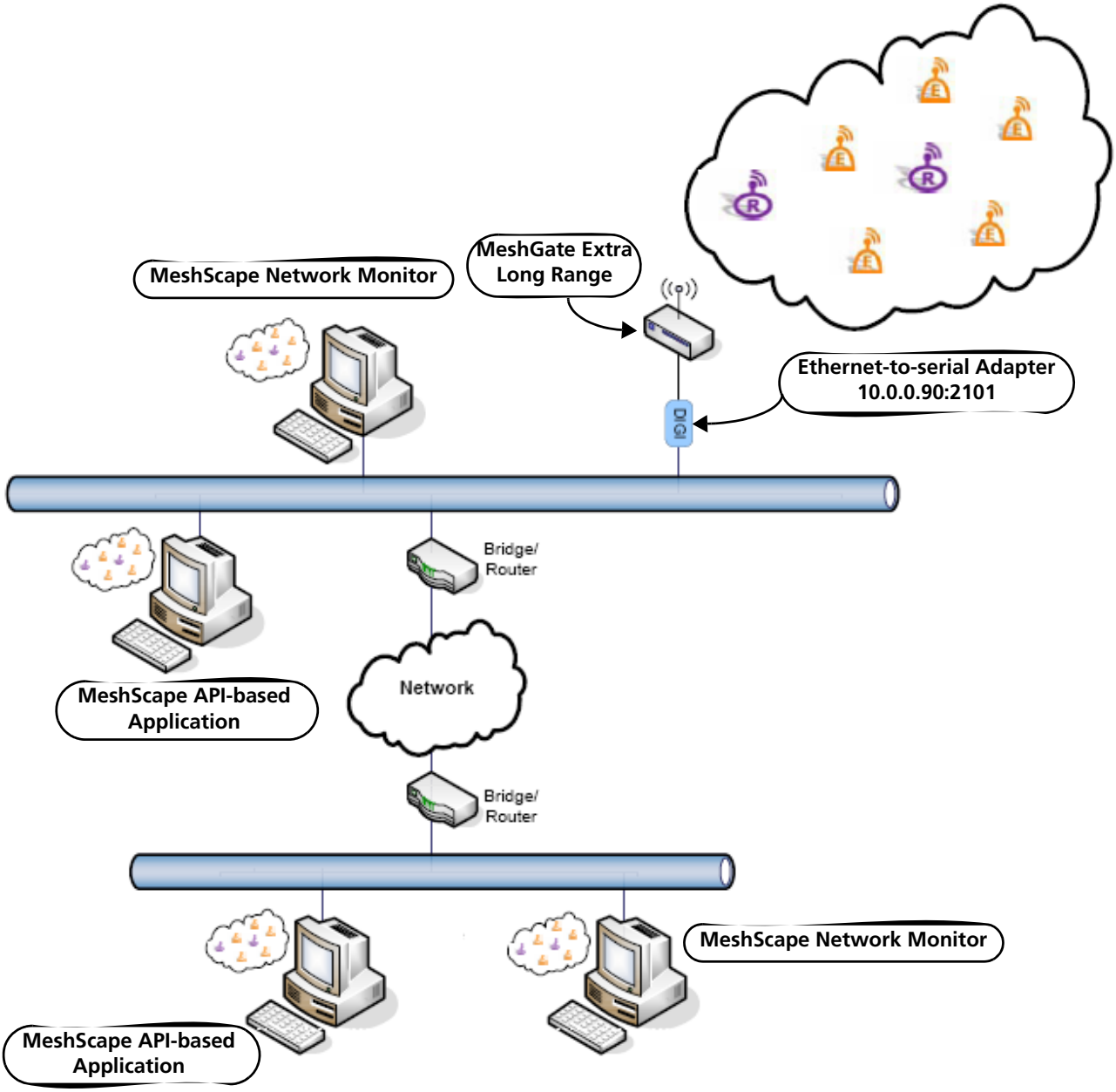
TCP/IP Connection to an Ethernet-to-serial Adapter

Figure 1-7 shows a MeshGate Extra Long Range connected to an Ethernet network using an Ethernet-to-serial adapter. The Ethernet-to-serial adapter has both an RJ-45 Ethernet connector and a DB-9 serial connector. The device accepts TCP/IP packetized serial data from the Ethernet, extracts the raw data, and forwards it out the serial port. The reverse operation is performed in the serial-to-Ethernet direction.

Local and remote MeshScape API-based applications including MeshScape Network Monitor access the MeshScape data on the MeshGate Extra Long Range by connecting to the MeshScape Serial Proxy Server at IP address 10.0.0.90 on port 2101.

Millennial Net has qualified the Digi One SP Ethernet-to-serial adapter for use with MeshScape wireless mesh networks. Appendix C of this user's guide presents a high-level configuration procedure for the Digi One SP Ethernet-to-serial adapter when used to provide an Ethernet connection for the MeshGate Extra Long Range.

Figure 1-7. Connection to the MeshGate via Ethernet-to-serial Adapter



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 rate 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 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 mesh 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 mesh 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 mesh network is the perfect solution. However, to be useful in such an environment, the wireless mesh 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 node 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 (18 to 24 meters) and Mesh nodes must be able to communicate at distances up to 100 feet (30 meters).
- 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-5424-5 Reference Kit

Millennial Net's RK-5424-5 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-5424-5 Reference Kit hardware includes:

- one MeshGate Extra Long Range 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 Extra Long Range gateways, mesh nodes, and end nodes, and modify the group and device IDs of deployed mesh nodes and end nodes (see Appendix B, "Using MeshScape Programmer")
- Application Program Interface (API) library - A complete API library is provided to streamline development using *MS Visual C++.NET* on a PC. For applications where the MeshGate Extra Long Range 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, "Running the Demo Application").

Documentation for the reference kit includes:

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

For complete details on the contents of the reference kit, refer to 'Reference Kit Contents' on page 1-15.

MeshScape Network Monitor runs on MS Windows XP and allows you to set network and device operating parameters, and monitor the status of the MeshScape 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++.

Major Features

Major features of the MeshScape RK-5424-5 Reference Kit include the following:

- frequency band: 2.4 GHz
- 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-5424-5 Reference Kit contains the following components:

- (4) EN-5424 end nodes; each end node is mounted to a terminal board equipped with a battery.
- (1) EN-5424 end node mounted to a terminal board equipped with a battery and a Kele temperature sensor for use with the supplied sample MeshScape application.
- (3) MN-5424 Mesh Nodes (enclosed) with AC power adapters.
- (1) MG-5424XL MeshGate Extra Long Range gateway (enclosed) with an AC power adapter.
- (4) antennas; one 1/2-wave antenna for each Mesh Node and one for the MeshGate Extra Long Range.
- (1) RS-232 serial cable for connecting the MeshGate Extra Long Range 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 Extra Long Range console port to the host PC. This is a DB-9-to-mini-connector cable.
- (1) MeshGate programming cable
- (1) MeshGate-to-end node programming adapter
- (4) International power outlet adapter kits for supplied power adapters
- (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) to run the supplied application software. The host PC must have the following minimal configuration:

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

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.

Microsoft Visual C++ .NET is recommended for development purposes on Windows platforms.

2

Installing the MeshScape System

This chapter provides the following MeshScape system installation information:

Installing the MeshScape Wireless Mesh 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 Extra Long Range (see 'MeshGate Extra Long Range Setup (MG-5424XL)' on page 2-3)
2. Mesh Nodes (see 'Mesh Node Setup (MN-5424)' on page 2-12)
3. End Nodes (see 'End Node Setup (EN-5424)' on page 2-16)
4. MeshScape Network Monitor (see 'Installing Contents of Millennial Net's RK-5424 CD-ROM' on page 2-19)

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

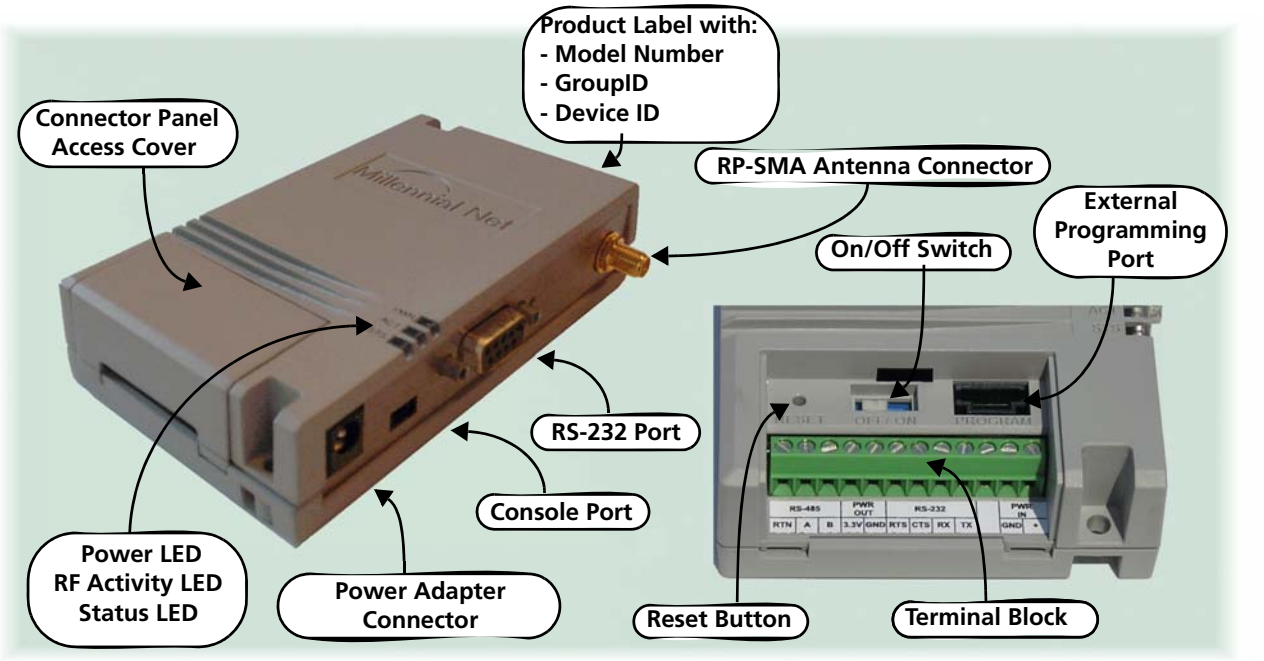
Installing the Hardware

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 Extra Long Range, 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 Extra Long Range Setup (MG-5424XL)

The MeshGate Extra Long Range, model number MG-5424XL (label with model number on bottom), is shipped enclosed in a case that provides access to the antenna connector, RS-232 data port, console port, and power connectors as shown in Figure 2-8. 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 2-8. MeshGate Extra Long Range components



The pin-out for the MeshGate Extra Long Range terminal block is as follows:

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

The function of each MeshGate terminal block pin is described as follows:

Table 2-1. MeshGate terminal block pin assignments

Pin	Label	Input/Output	Function
1	RTN	Reference	Reference connection for RS-485
2	A	I/O	RS-485 signal +
3	B	I/O	RS-485 signal -
4	3.3V	Output Power	3.3V output power
5	GND	Power	Digital ground
6	RTS	Input	RS-232 Request to Send
7	CTS	Output	RS-232 Clear to Send
8	RX	Output	RS-232 Receive Data
9	TX	Input	RS-232 Transmit Data
10	N/A	N/A	Not used
11	GND	Power	Digital Ground
12	+	Power	Input power (4.5V to 30V)

Mounting options

There are three mounting options for the MeshGate Extra Long Range:

- desktop
- wall
- DIN rail

Mounting the MeshGate Extra Long Range on a Desktop

1. Choose a level, stable surface on which to rest the MeshGate Extra Long Range.
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 Extra Long Range chassis.

Mounting the MeshGate Extra Long Range on a Wall

When mounting the MeshGate Extra Long Range to a wall, we recommend that you secure the MeshGate in place using two #6 screws and screw anchors (*not supplied*) of the appropriate type for the mounting surface.

1. Place the MeshGate Extra Long Range 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.

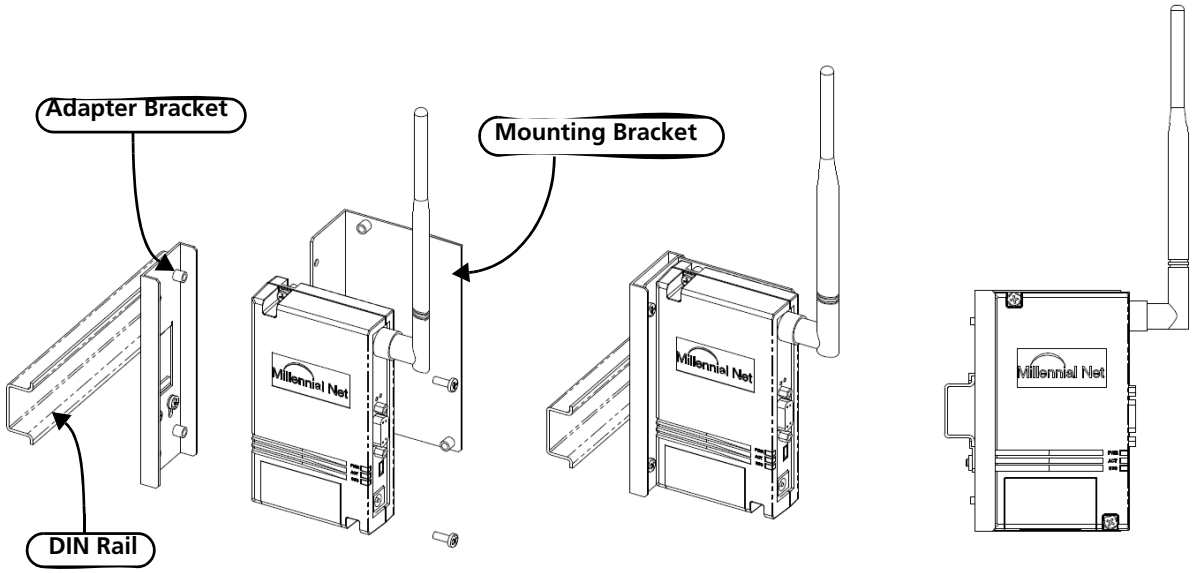
4. Mount the MeshGate Extra Long Range to the wall using two #6 screws (not supplied).

Mounting the MeshGate Extra Long Range 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 Extra Long Range to a DIN rail using the supplied DIN rail mounting bracket and hardware, refer to Figure 2-9 and complete the following steps:

Figure 2-9. Mounting the MeshGate Extra Long Range to a DIN rail



1. Using two of the supplied screws, secure the MeshGate Extra Long Range 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.

Connection options

The MeshGate Extra Long Range is equipped with an RS-232 serial port that enables the MeshGate Extra Long Range to connect to a Windows XP host PC running the MeshScape Network Monitor application, or to a Linux- or Windows-application platform (network controller, PDA, PC, etc.) running a MeshScape API-based application.

Use one of the following options to establish a connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range:

- Establish a direct serial connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range using the supplied RS-232 cable.

- Establish a TCP/IP connection from the Network Monitor host PC to a MeshScape Serial Proxy Server that has a direct serial connection to the MeshGate Extra Long Range. The MeshScape Serial Proxy Server that runs on a Linux or Windows XP host is supplied with your MeshScape RK-5424-5 Reference Kit software. See page 2-20 for information about installing and running the MeshScape Serial Proxy Server.
- Establish a TCP/IP connection from the Network Monitor host PC to an Ethernet-to-serial adapter connected to the MeshGate Extra Long Range.

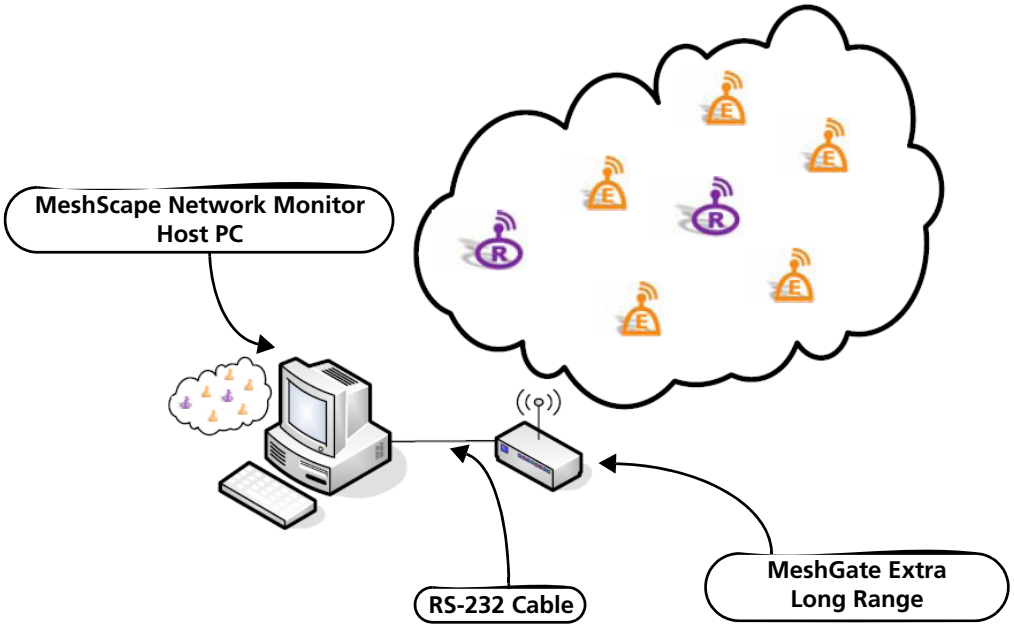
These MeshGate Extra Long Range connection options are described and depicted in the following sections.

Regardless of which of the following serial connection options is used, the MeshScape Network Monitor or other MeshScape API-based application can only access and monitor a single MeshScape, i.e., a single instance of MeshScape Network Monitor cannot monitor multiple MeshScapes.

Direct Serial Connection

Figure 2-10 shows a local direct serial connection between the MeshScape Network Monitor host PC and the MeshGate Extra Long Range using the supplied RS-232 cable.

Figure 2-10. Direct serial connection to the MeshGate Extra Long Range



In this topology, only one MeshScape API-based application running on the host PC can access the MeshScape.

TCP/IP Connection to a Serial Proxy Server

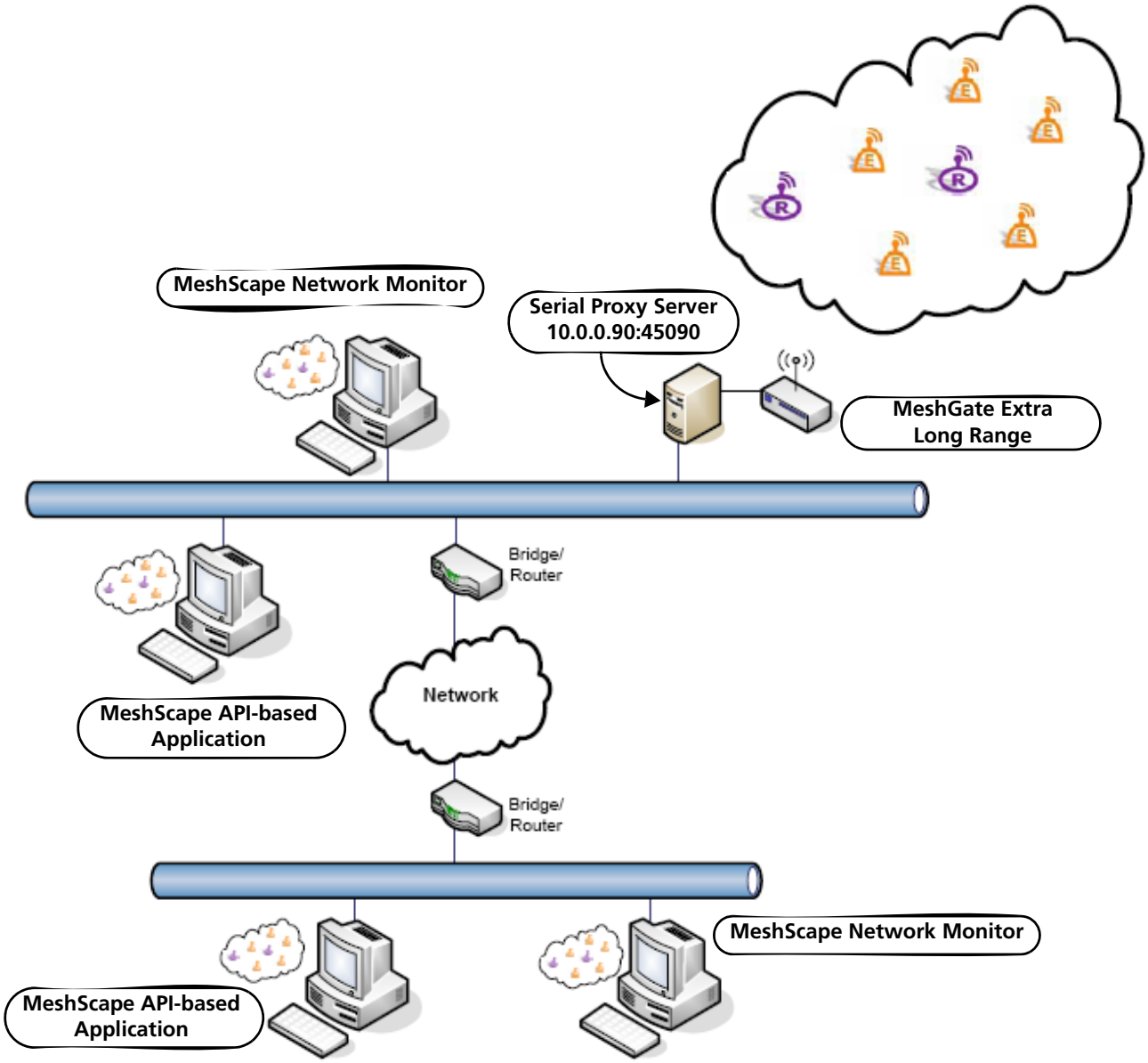
Figure 2-11 shows a MeshGate Extra Long Range connected to a PC running the MeshScape Serial Proxy Server via the PC's serial port.

A MeshScape API-based application functions as a serial proxy client by changing its lowest level serial interface to a TCP/IP interface. The MeshScape API TCP/IP serial proxy client interface opens a connection to the MeshScape Serial Proxy Server by connecting to its well advertised port.

Local and remote MeshScape API-based applications including MeshScape Network Monitor access the MeshScape data on the MeshGate Extra Long Range by connecting to the MeshScape Serial Proxy Server at IP address 10.0.0.90 on port 45090.

Although Figure 2-11 does not show any MeshScape API-based applications running on the PC, any number of MeshScape API-based applications could be running on the same PC host as the MeshScape Serial Proxy Server. The MeshScape Serial Proxy Server supports up to ten client connections.

Figure 2-11.Connection to the MeshGate via the MeshScape serial proxy server



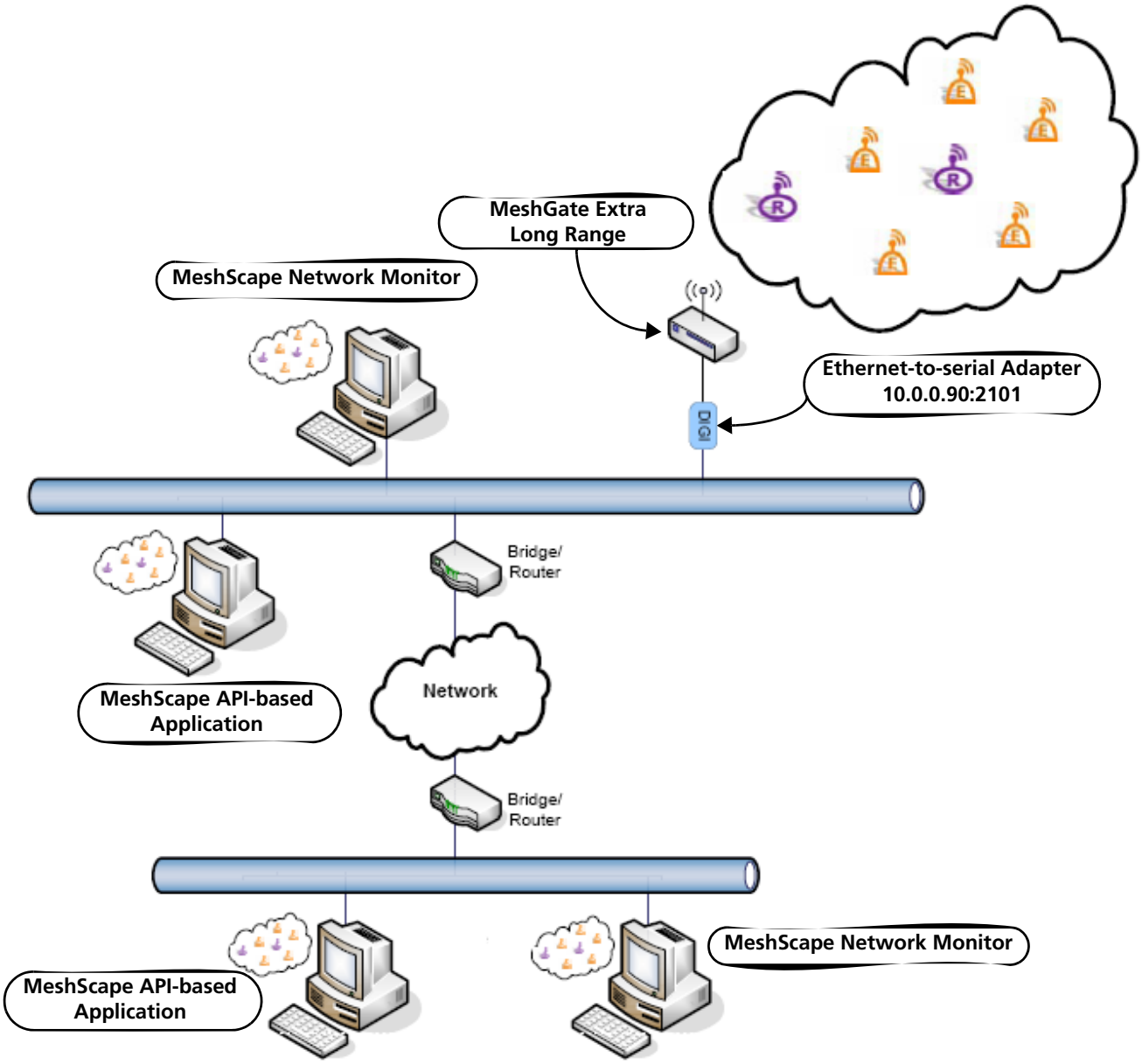
TCP/IP Connection to an Ethernet-to-serial Adapter

Figure 2-12 shows a MeshGate Extra Long Range connected to an Ethernet network using an Ethernet-to-serial adapter. The Ethernet-to-serial adapter has both an RJ-45 Ethernet connector and a DB-9 serial connector. The device accepts TCP/IP packetized serial data from the Ethernet, extracts the raw data, and forwards it out the serial port. The reverse operation is performed in the serial-to-Ethernet direction.

Local and remote MeshScape API-based applications including MeshScape Network Monitor access the MeshScape data on the MeshGate Extra Long Range by connecting to the MeshScape Serial Proxy Server at IP address 10.0.0.90 on port 2101.

Millennial Net has qualified the Digi One SP Ethernet-to-serial adapter for use with MeshScape wireless mesh networks. Appendix C of this user's guide presents a high-level configuration procedure for the Digi One SP Ethernet-to-serial adapter when used to provide an Ethernet connection for the MeshGate Extra Long Range.

Figure 2-12. Connection to the MeshGate via Ethernet-to-serial Adapter



Console Port

The MeshGate Console Port is a mini-serial connector that provides access to the MeshGate command line interface (CLI). You can connect to the MeshGate CLI to verify and configure the MeshGate serial port settings as described in Appendix , "Accessing the MeshGate CLI".

Setup procedure

To set up the MeshGate Extra Long Range:

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. Establish a connection from the MeshScape Network Monitor to the MeshGate Extra Long Range by completing one of the following:
   - Connect the supplied RS-232 cable between the MeshGate's RS-232 port and the MeshScape Network Monitor host PC's serial port.
   - Connect the supplied RS-232 cable between the MeshGate's RS-232 port and the serial port on a PC running the MeshScape Serial Proxy Server. You can then establish a remote TCP/IP connection from the MeshScape Network Monitor host PC to the Serial Proxy Server. Installing and running the MeshScape Serial Proxy Server is described on page 2-20.
   - Connect the supplied RS-232 cable between the MeshGate's RS-232 port and an Ethernet-to-serial adapter (*not supplied*) connected to an Ethernet network. You can then establish a remote TCP/IP connection from the MeshScape Network Monitor to the Ethernet-to-serial adapter. Millennial Net has qualified the Digi One SP Ethernet-to-serial adapter for use with MeshScape wireless mesh networks. Appendix C of this user's guide presents a high-level configuration procedure for the Digi One SP Ethernet-to-serial adapter when used to provide an Ethernet connection for the MeshGate Extra Long Range.
3. Plug the supplied AC adapter into the MeshGate Extra Long Range power connector and then into a 110/220 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 Extra Long Range 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 2-2.

MeshGate Extra Long Range status LED operation

Table 2-2 describes how the status LEDs on the MeshGate Extra Long Range behave.

Table 2-2. MeshGate Extra Long Range 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 2-2. MeshGate Extra Long Range 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 Extra Long Range default settings

Table 2-3 lists the default settings for the MeshGate Extra Long Range gateway.

Table 2-3. MeshGate Extra Long Range default Settings

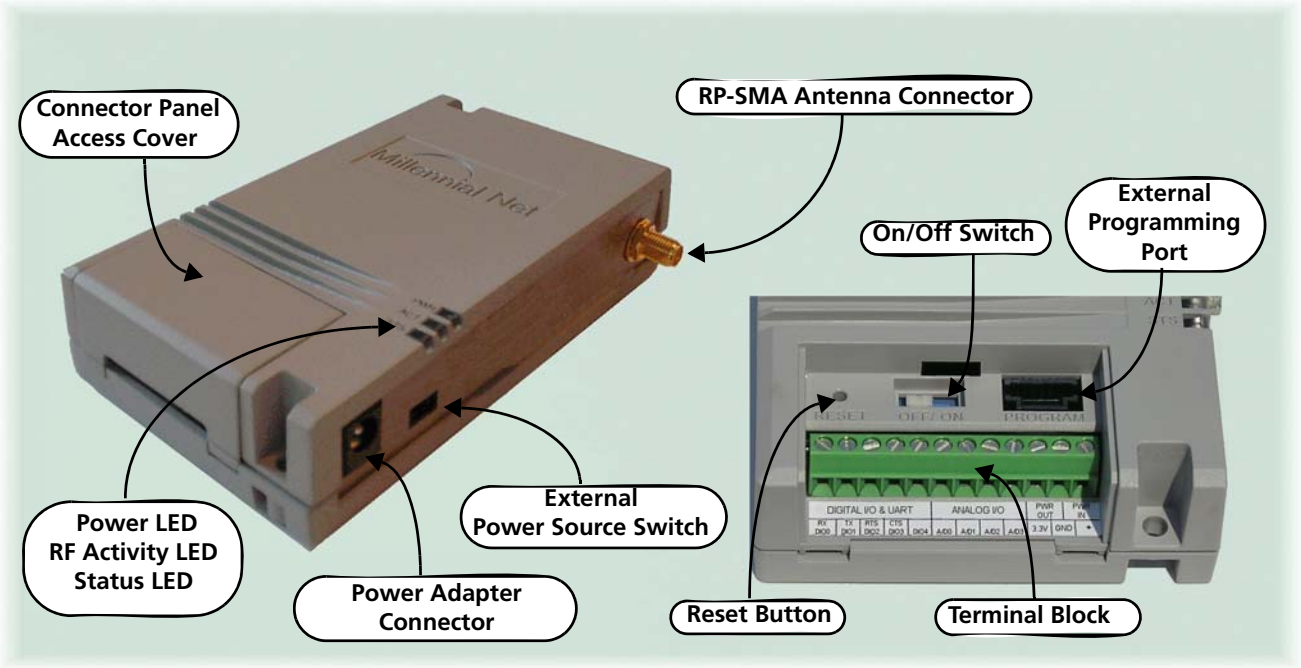
Variable ***Description***	Default Value	Persisted?*
RS-232 Data Port Configuration	RS232 115,200 baud No parity No hardware flow control	Yes
Console Port	RS232 115,200 baud No parity No hardware flow control	Yes

* Persisted indicates value is retained after power cycle.

Mesh Node Setup (MN-5424)

The Mesh Nodes, model number MN-5424 (label with model number on bottom), are shipped enclosed in cases that provide: RP-SMA antenna connector, three-position external power source switch, and a connector for the supplied power adapter as shown in Figure 2-13. 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 six-pin external programming port.

Figure 2-13. Mesh node components



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

DIGITAL I/O & UART					ANALOG I/O				PWR OUT		PWR IN
RX DIO0	TX DIO1	RTS DIO2	CTS DIO3	DIO4	A/D0	A/D1	A/D2	A/D3	3.3V	GND	+

The function of each Mesh Node terminal block pin is described as follows:

Table 2-4. Mesh Node terminal block pin assignments

Pin	Label	Input/Output	Function
1	DIO0/RxD	I/O or Output	Digital Input/Output 0 or UART RX
2	DIO1/TxD	I/O or Input	Digital Input/Output 1 or UART TX
3	DIO2/RTS	I/O or Input	Digital Input/Output 2or UART RTS (in)
4	DIO3/CTS	I/O or Output	Digital Input/Output 3 or UART CTS (out)