2.4 GHz ZigBee™ Demonstration User's Guide

1. Introduction

The Silicon Laboratories 2.4 GHz ZigBee Development Kit includes all hardware and software to demonstrate and design a six-node ZigBee network. The hardware includes six development boards, each with a Silicon Laboratories C8051F121 microcontroller, CP2101 USB interface, Chipcon CC2420 2.4 GHz 802.15.4 transceiver, and antenna. Each includes a variety of pushbutton switches, LEDs, and a trimpot for demonstration applications, as well as a programming interface compatible with the Silicon Laboratories serial and USB debug adaptors.

This document describes installation and operation of the 2.4 GHz ZigBee Demonstration application. Refer also to "AN222: 2.4 GHz 802.15.4/ZigBee Development Board Hardware Users Guide" for a hardware description of the development board.

2. Hardware and Software Installation

This section describes the first-time software and hardware installation procedure.

2.1. Install Software

Insert the CD, which will automatically launch the installer shown in Figure 1. Click *802.15.4 / ZigBee Kit Tools* to install the demonstration software.

The software can be launched by the desktop shortcut or from the *Start → All Programs → Silicon Laboratories → 2.4 GHz ZigBee Demonstration* menu after installation.

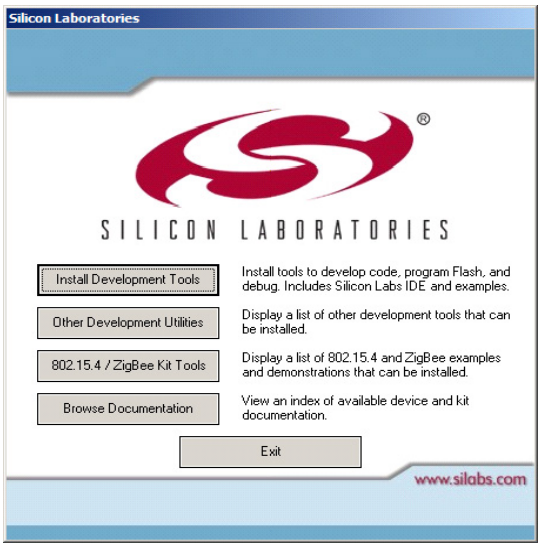

Figure 1. Installer

2.2. Set up Hardware and PC Interface

Before first use, each node must be individually configured and installed as a new Windows USB device as follows:

1. Attach the supplied antenna to the SMA connector on the PCB. Orient the antenna upright and perpendicular to the board.
2. Connect the development board to the PC's USB interface. This interface provides both communication to the GUI and power for the board.
3. Install the USB drivers. The Windows "Found New Hardware Wizard" will automatically start when the board is connected. The Wizard will run twice for each new development board: first to install the USB driver and second to install a virtual COM port driver. Follow the default settings for both as shown in Figure 2.

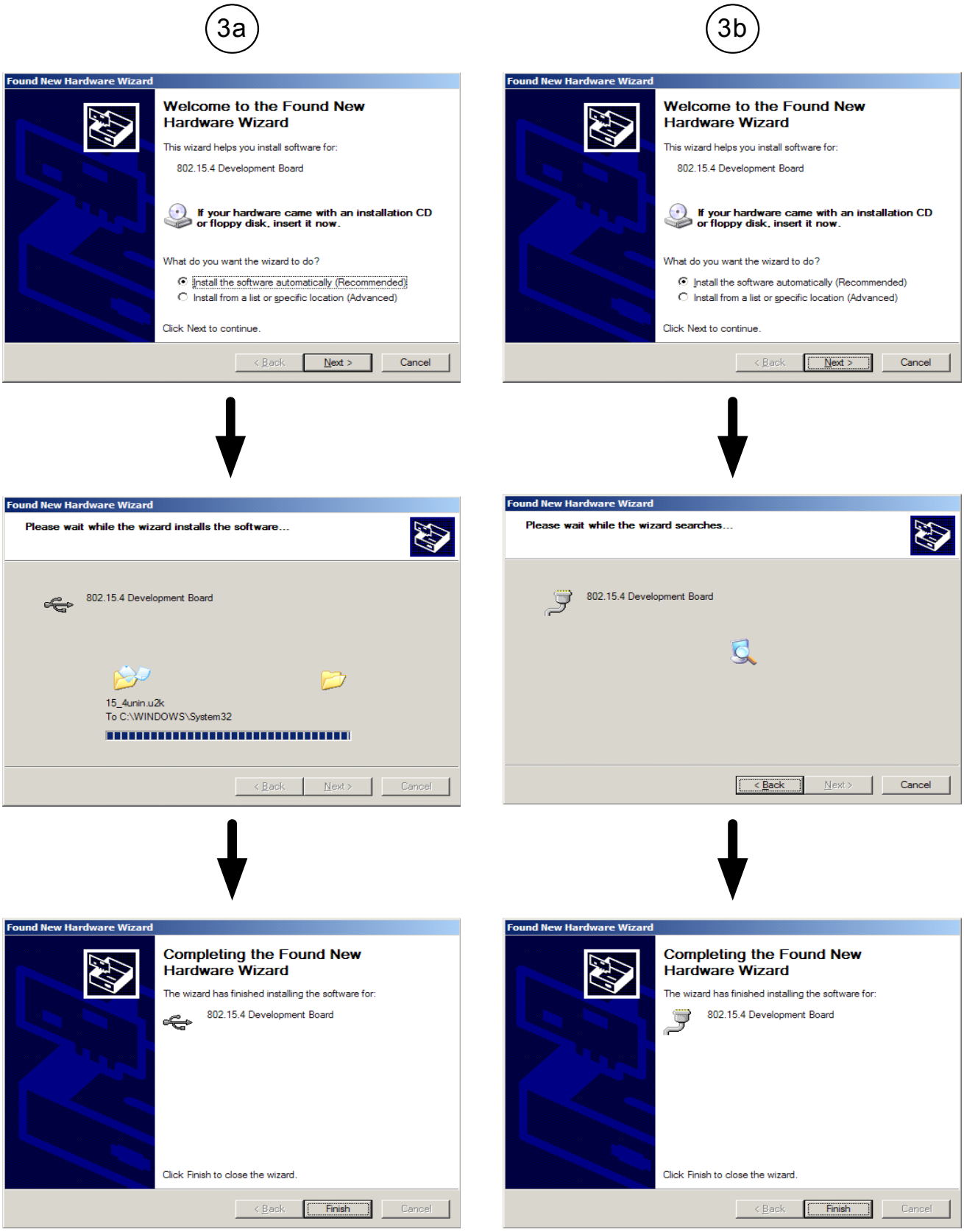

Figure 2. USB Installation

4. Determine the COM port assigned to the development board. This assignment is unique for each development board on each PC. The COM port assignment may be determined by the following steps:
   - Connect and install the development board as described above.
   - Open the Device Manager:
     - Right click on the My Computer desktop icon:
     - Select Properties.
     - Select Hardware.
     - Select Device Manager tab.
   - Open the Ports subsection, find the attached 802.15.4 Development Board device (assigned to COM4 in this example; see Figure 3.)
   - Note the COM port assignment for future reference. It may prove useful to label this information on each board.

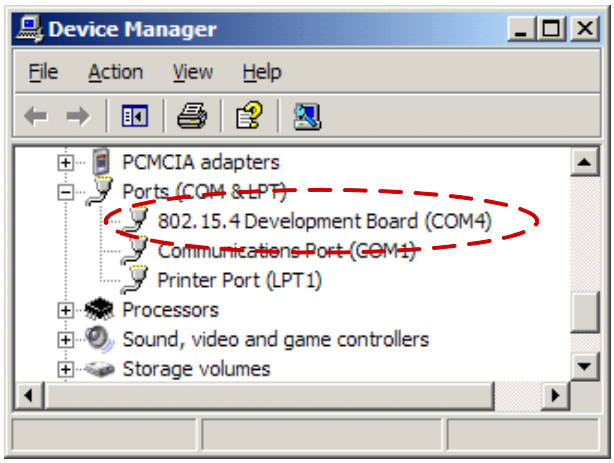

Figure 3. Determining COM port from the Device Manager

5. Disconnect the board and repeat for the remaining boards.

2.3. Configure Nodes

The development kit contains several preconfigured network topologies. These topologies are predefined and downloaded to each node via USB.

While the ZigBee protocol utilizes ad-hoc networking, this demonstration uses preconfigured topologies. These topologies are designed to allow the user to experiment with various cluster, star, and linear multi-hop networks within the confines of one's desk or laboratory bench.

Each node must be individually configured before initial use through the USB port. Once configured, the network may be changed over the air as described in later sections of this document. Configure each node as shown in Figure 4 and the steps on the following page.

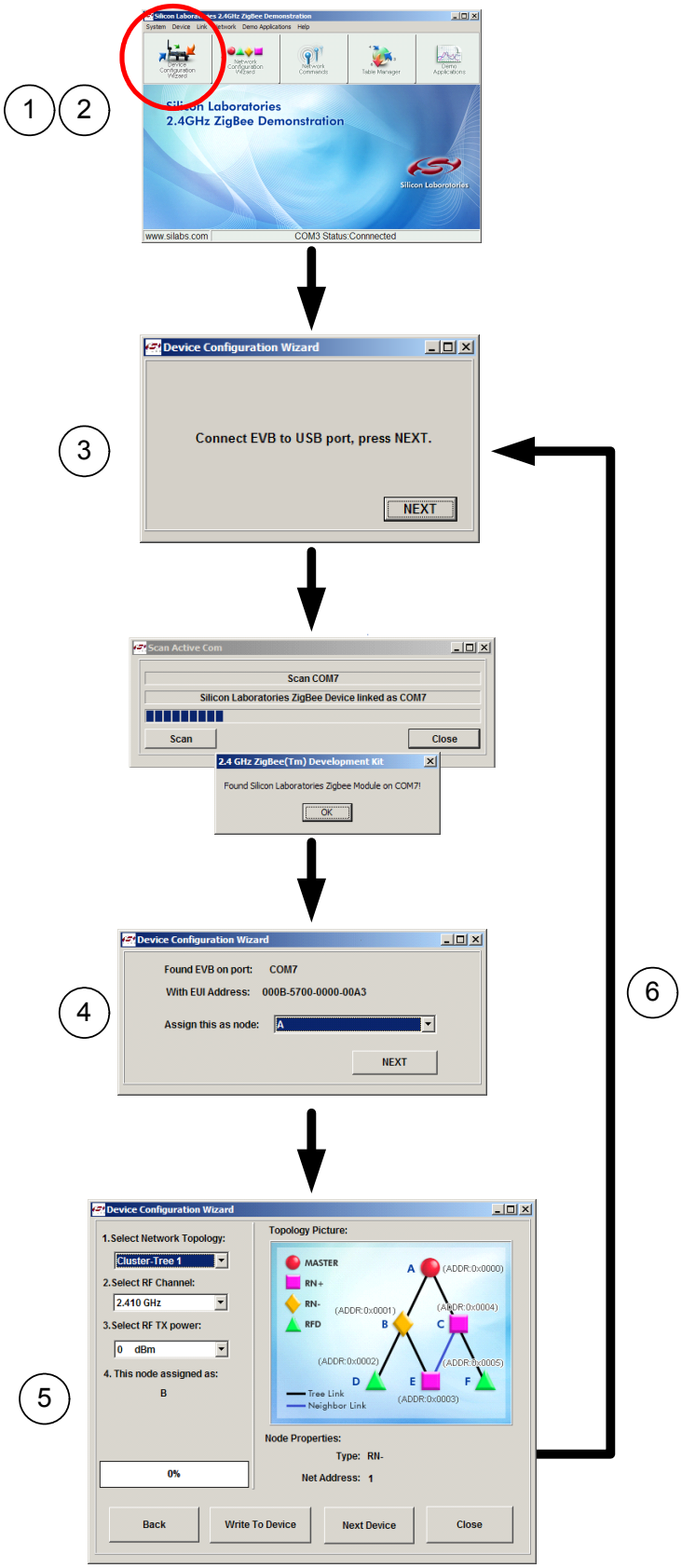

Figure 4. Device Configuration

1. Start the 2.4 GHz ZigBee Demonstration Software from the *Start → All Programs → Silicon Laboratories → 2.4 GHz ZigBee Demonstration* menu or use the desktop shortcut.
2. Launch the Device Setup Wizard from the main window.
3. Connect the development board to the PC USB port, then press the *Next* button. The utility will scan all COM ports, stopping at the first one with a Silicon Labs 802.15.4 Development Kit board.
4. Assign an identifier to the board. While the 802.15.4 specification includes a unique Extended Unit Identifier (EUI) for each board, it is cumbersome to use within the context of a demonstration. Instead, the Demonstration GUI assigns a "shortcut" lettered identifier for simplicity. This step associates a letter with each EUI.

   Node A is the designated master in the various network topologies. Other nodes are Full-Function Device (FFD) routing nodes or Reduced Function Device (RFD) terminal nodes, depending on the network topology selected.

   Select the desired node letter identifier, then click *Next*. Ensure that each development board is assigned a unique lettered identifier. Lettered labels are included in the kit for convenience.
5. Download the module's network personality. This personality includes MAC and network addresses, neighbor information, node type, and the network's radio channel.

   The network topology and frequency are selected only once for the Master node A. These selections become the default settings for nodes B and greater.

   Click *Write to Device* to download the information to the module via USB. A "Setup Device Successful!" message will appear to confirm the download.
6. Disconnect the development board then press *Next Device*. This will prompt the user to connect the next board and repeat the process above. Assign the remaining boards as nodes B through F.

Only the Master node (node A) needs to be connected to the PC once configuration is complete.

3. Basic Operation

This section describes how to establish a basic ZigBee network and collect data over the air using the included demo applications. Advanced features are described in the following sections.

3.1. Start ZigBee Network

First, connect the Master node to the PC USB port and start the 2.4 GHz ZigBee Demonstration utility.

Second, power up the remaining five nodes. Either insert a 9 V battery and slide SW2 to the “ON” position or connect an external 9 V_{DC} supply to the coaxial power jack.

The development boards will now be networked together using the topology defined during configuration.

The network topology may be displayed in a separate window for convenience. Open this diagram through the *System → Preferences→ Display* menu.

3.2. Communicate with Each Node

Once the network is established, it is a good idea to exchange a simple message with each node to ensure connectivity. The simplest way to do this is to send an inquiry from the Master to each remote node using the Network Commands utility.

First, ensure that the Master node is connected to the USB port of the PC. Next, open the *Network Commands* window from the main toolbar. Select the remote node letter, then click *Send Cmd*.

Figure 5 shows a MAC address request from Node C which is useful as a simple ping test. If connected, the node will respond and the background will be green. The background will turn red or yellow if an error occurs.

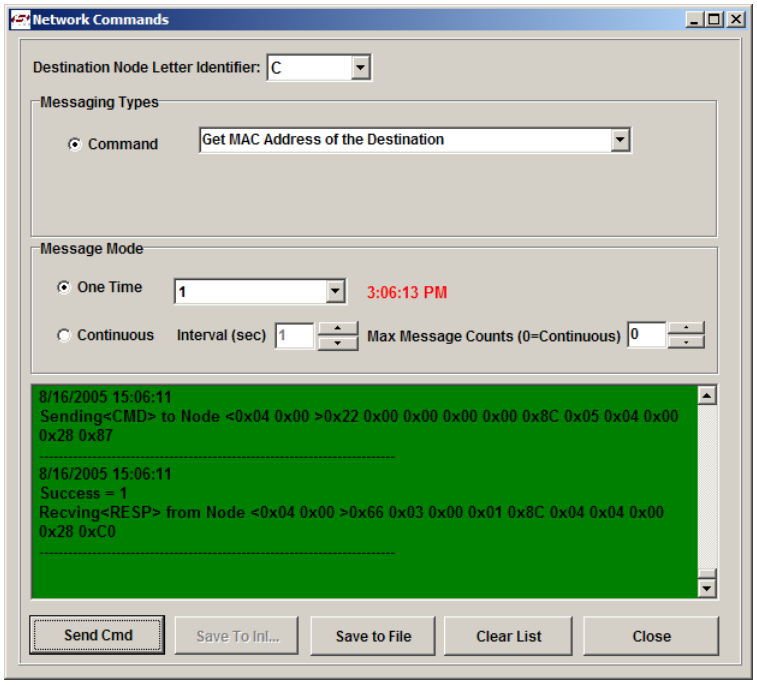

Figure 5. Ping Test to Node C

3.3. Measure Over Network using Demo Applications

The Master can read temperature, ADC input, and Received Signal Strength Indication (RSSI) values from any of the remote nodes. Data is relayed between the various nodes to the Master through the network as defined during configuration.

Launch the Applications window by clicking the *Demo Applications* button from the main toolbar. A menu with choices for *Potentiometer*, *RF Received Signal Strength,* and *Temperature* will appear.

3.3.1. Potentiometer Application

This application demonstrates a typical ADC data acquisition application. The Master periodically requests a value from a remote node's ADC as shown in Figure 6. A potentiometer sets the analog input voltage for this demo. Values range from 0 to 4095, the 12-bit ADC's full-scale value.

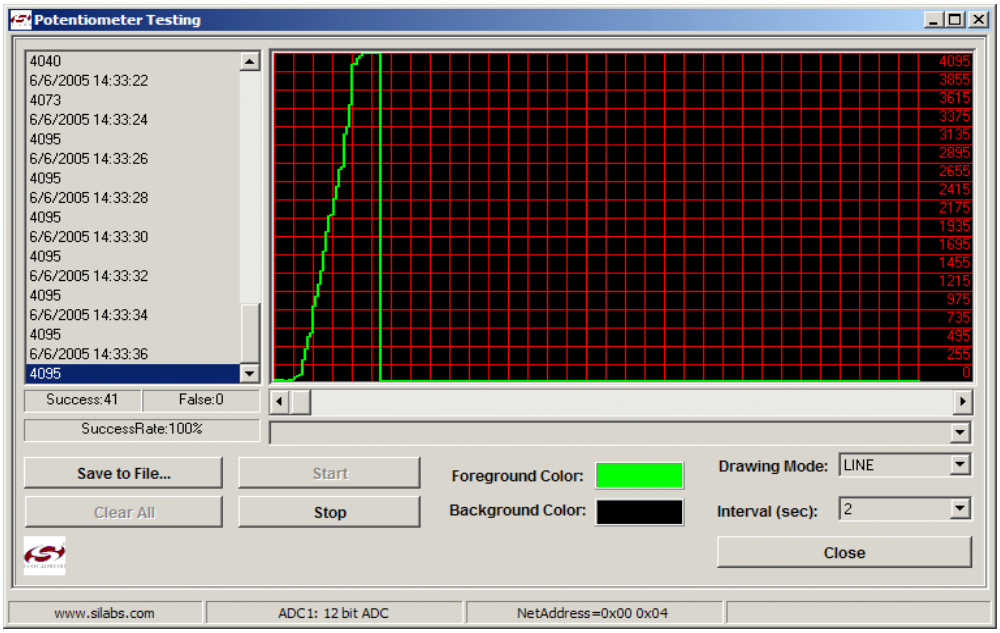

Figure 6. ADC Potentiometer Measurement Application

3.3.2. RF Received Signal Strength (RSSI) Application

Similar to the Potentiometer Application, the RSSI utility periodically reports a node's RF received signal strength back to the Master as shown in Figure 7.

The RSSI value in dBm is measured by the CC2420 receiver, then communicated to the microcontroller via the SPI interface. Note that this value is the received signal strength from the parent node, not necessarily from the master node.

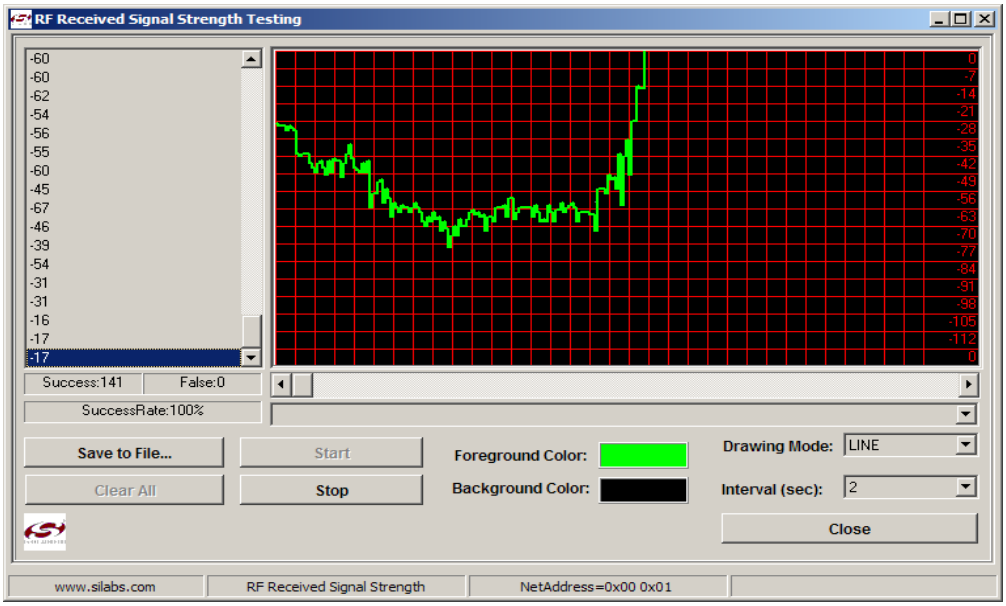

Figure 7. RSSI Measurement Application

3.3.3. Temperature Application

The temperature application shown in Figure 8 periodically polls a node for its temperature. The temperature is measured directly by the C8051F121 microcontroller's on-chip temperature sensor.

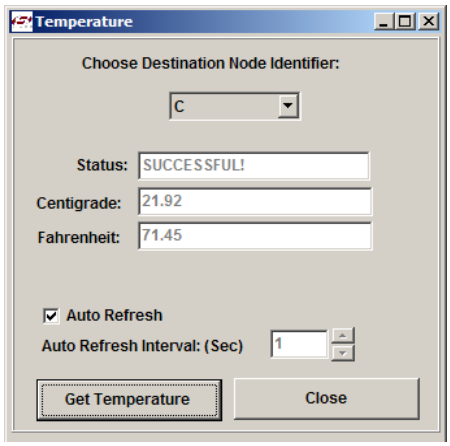

Figure 8. Temperature Measurement Application

3.4. Reconfigure Network

The network topology may be reconfigured over the air from the Master node by the following steps:

1. Ensure that the Master node is linked to the GUI. (Master node is connected to PC via USB and the correct COM port is selected.)
2. Click the *Network Configuration Wizard* button to open the window shown in Figure 9:

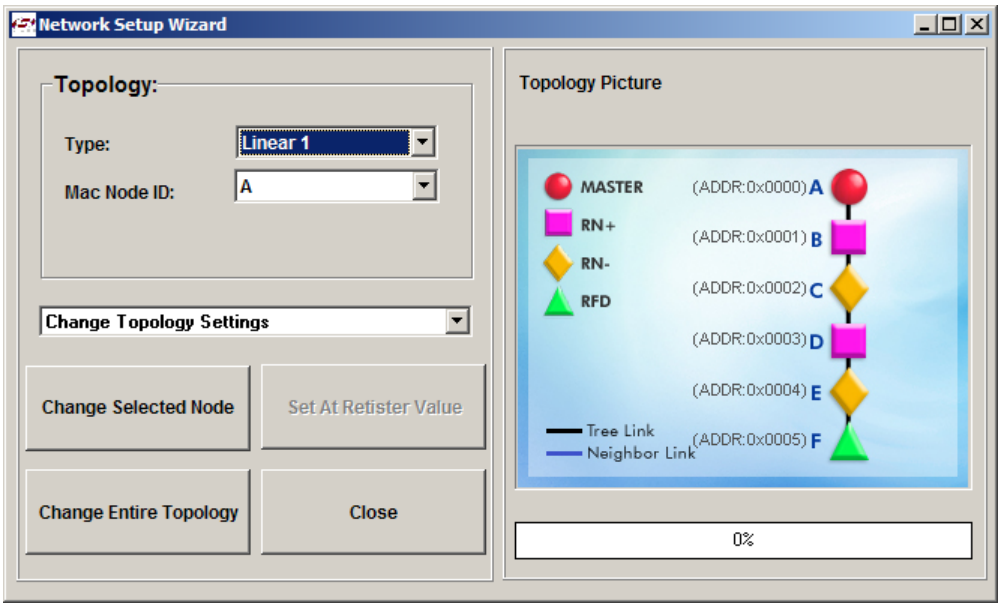

Figure 9. Network Configuration Wizard

3. Select the new network topology ("Linear 1" topology in this example)
4. Ensure that all nodes are within reception range.
5. Click *Change Entire Topology* button.
   After a brief delay, a dialog box will appear either indicating success or a failure. If failed, the GUI will cease configuration and indicate the failed node. In the example shown in Figure 10, nodes A and B were successfully configured, but node C configuration failed

   Troubleshoot a configuration problem by checking the following:
   - Ensure that all development boards are powered.
   - Ensure that all boards are within radio reception range of node A.
   - Verify that all nodes had the same network topology before reconfiguration.
6. If reconfiguration is still not successful, reset each board individually to the new network topology using the Device Configuration Wizard.

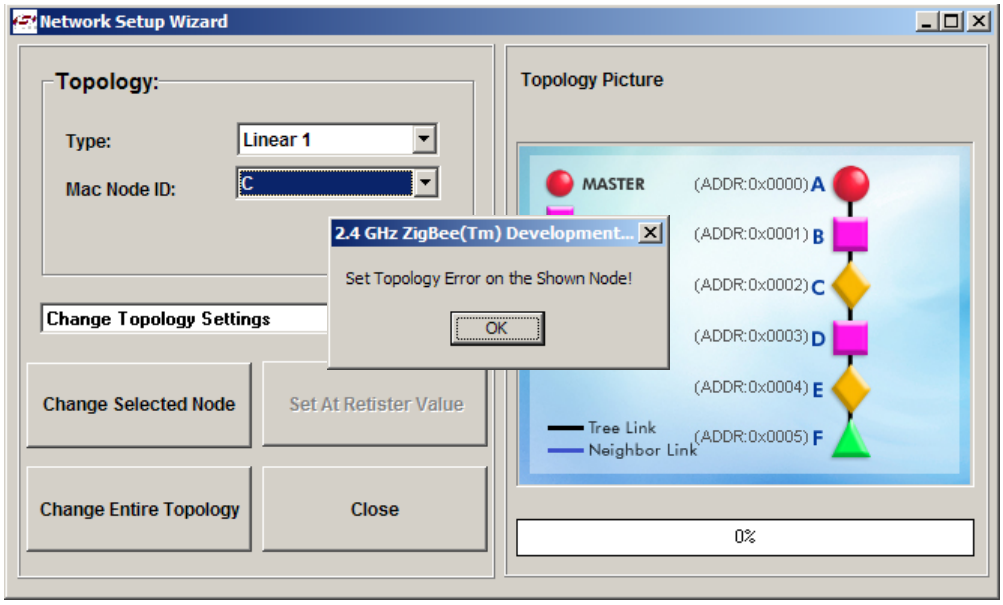

Figure 10. Example Set Topology Error

4. Advanced Operation

This section describes tools available through the GUI that are intended for those more familiar with the ZigBee protocol. Various diagnostic tools facilitate testing of network-level commands and topologies. Table managers provide a convenient way to examine neighbor, blacklist, and address tables.

This section also describes each GUI menu in additional detail.

4.1. Device Menu

4.1.1. Device Configuration Wizard

The Device Configuration Wizard displays attributes of the node connected to the PC through the USB port.

Start the Device Configuration Wizard either by pressing the button from the main screen, or by the *Device* → *Device Configuration Wizard* menu option.

Refer to "Section 2.3. Configure Nodes" on page 3 for additional detail.

4.1.2. Device Setting

The Device Setting tool allows the user to view or modify details of the node setup. This tool communicates to the board connected to the PC via the USB port.

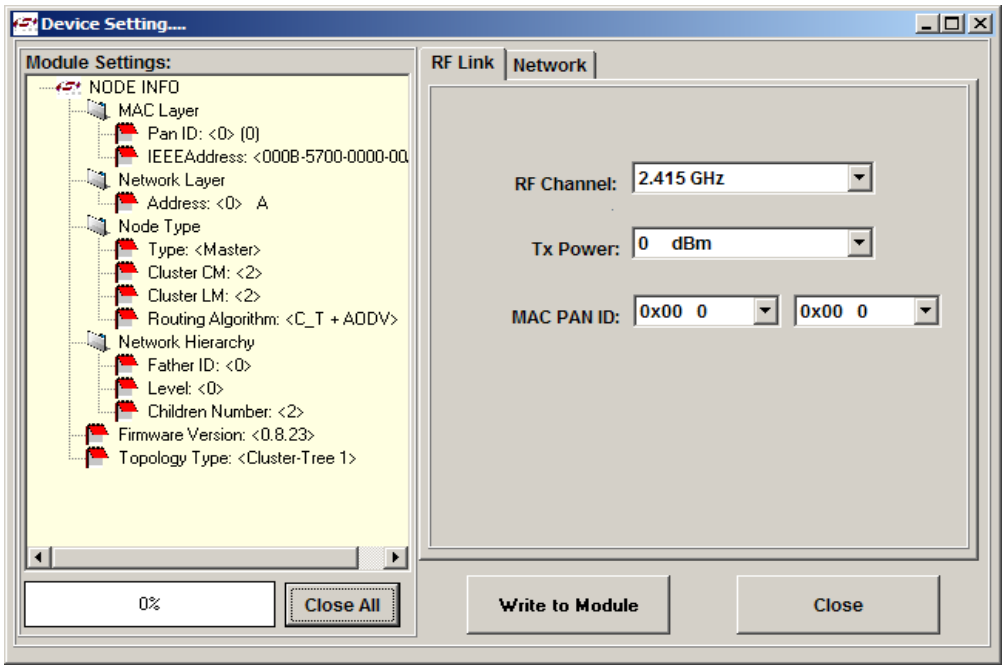

Figure 11. Device Setting Window

Many of the node's attributes may be viewed or modified through the Device Setting window, which is useful for debugging purposes. In contrast, the Device Configuration Wizard should be used for initial configuration, as it is more convenient.

Viewable/Changeable Attributes include the following:

- RF channel
- TX power
- MAC PAN ID
- Node type
- Network options
  - Routing Algorithm (not used in demo)
  - Maximum number of children
  - Maximum number of levels

Other attributes may only be viewed:

- IEEE (EUI) address. This is also labeled on the PCB on the battery holder
- Net address (node shortcut letter next to address for simplicity)
- Firmware version
- Topology type. Use Mouseover feature to see diagram.

4.2. Link Menu

4.2.1. Blacklist Editor

This editor selects nodes to exclude from communication, even though they may be within radio range. This is intended for demonstration purposes to force communication through specific network paths.

For example, Figure 12 contains the blacklist table for node A of the Cluster Tree topology. In this topology, node A can communicate to nodes D, E, and F (blacklisted) only by relaying a message through nodes B or C (neighbors). Adding node B, for example, to the blacklist will block communication from the master to nodes B and D. Communication to node E is still possible, but is now forced through node C.

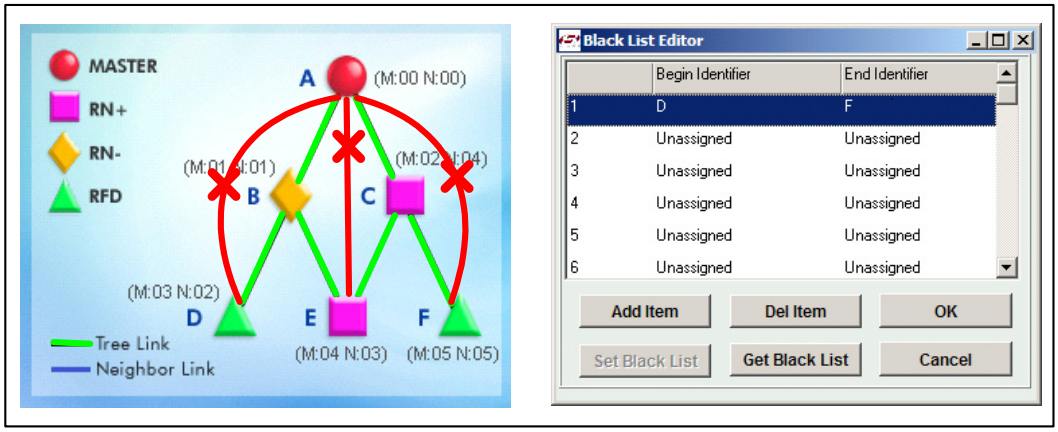

Figure 12. Node A Blacklist Example

4.3. Network Configuration Tools

4.3.1. Network Configuration Wizard

The Network Configuration Wizard sets each node's network properties. The wizard may be used to configure a single node at a time via USB or to reconfigure the entire network over the air.

Start the Network Configuration Wizard shown in Figure 13 either by pressing the button from the main screen, or by the *Network → Network Configuration Wizard* menu option.

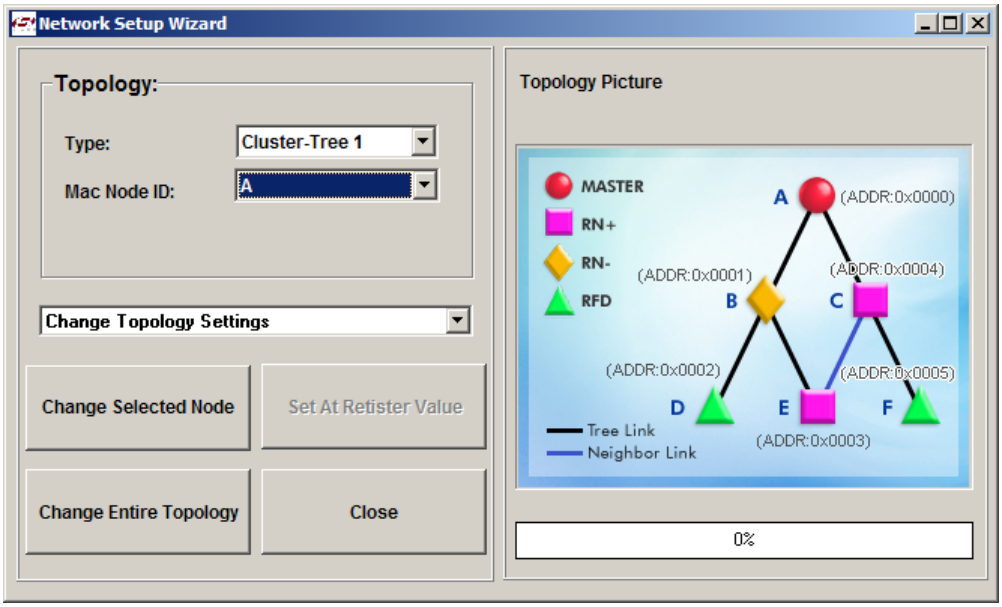

Figure 13. Network Configuration Wizard

The Network Configuration Wizard sets the following for each node:

- Neighbor table
- Children table
- Addresses
- Blacklist table

Note: The Network Configuration Wizard does not configure the frequency or transmit power. It is advisable to use the Device Configuration Wizard to configure the device when in an unknown state.

The primary use of the Network Configuration Wizard is to reconfigure all nodes of a network over the air, as described by the steps in "Section 3.4. Reconfigure Network" on page 9.

Many different preconfigured network topologies are available. Refer to the “Appendix—Network Topologies” for further detail.

4.3.2. Network Commands

The Network Commands window is used to verify the wireless connection to remote nodes by sending a simple query. This is described in additional detail in "Section 3.2. Communicate with Each Node" on page 6.

4.3.3. Table Manager

The Table Manager provides additional insight to the network structure. Open the Table Manager shown in Figure 14 using the *Table Manager* button from the main screen or from the *Network → Table Manager* menu.

The Table Manger shows attributes of a single node. Select the node connected to the PC USB port or a remote node connected over the air using the *Local Table* or *Remote Table* radio buttons, respectively. Click *Refresh* to read the information from the node to the screen as shown in Figure 14. All attributes are read-only from this manager.

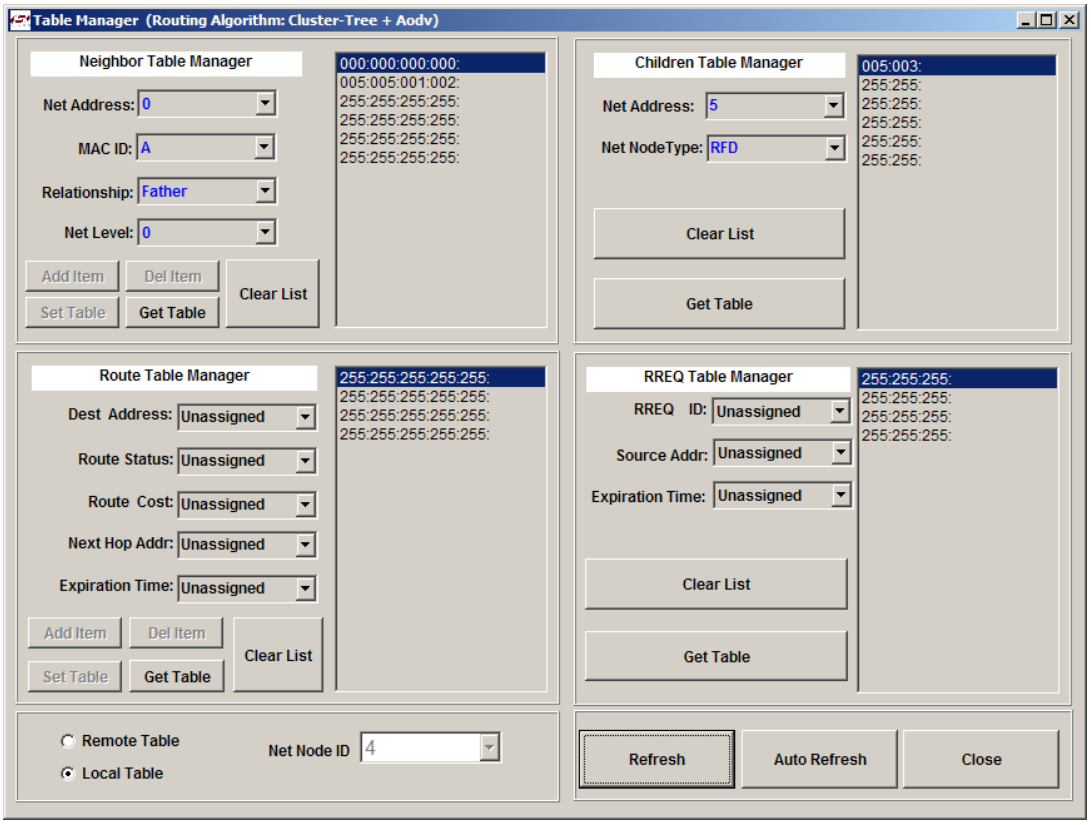

Figure 14. Table Manager

The Neighbor Table Manger lists adjacent nodes. Because this is a preconfigured demonstration, only selected nodes will appear even though additional nodes may be within range. Examine the decoded attributes in the dialog box by clicking on the numerical table entry.

The Children Table Manager lists the nodes one network level below.

The Route Table Manager and RREQ Table Manager data are not used in the context of this demonstration.

APPENDIX—NETWORK TOPOLOGIES

The 2.4 GHz Development Kit GUI contains a variety of preconfigured networks for demonstration purposes. These network configurations allow the user to force a specific topology for evaluation through the Network Setup Wizard, overriding the ad-hoc networking aspect of the ZigBee protocol.

Some of these topologies require additional modules, available separately from Silicon Laboratories.

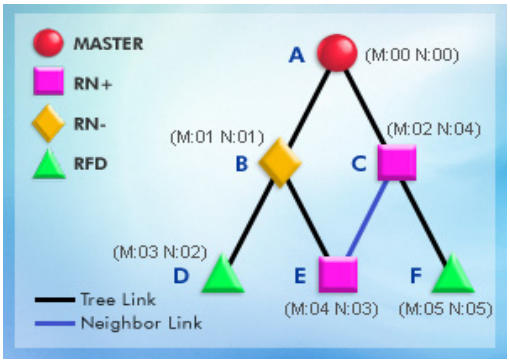

Figure 15. Cluster Tree 1

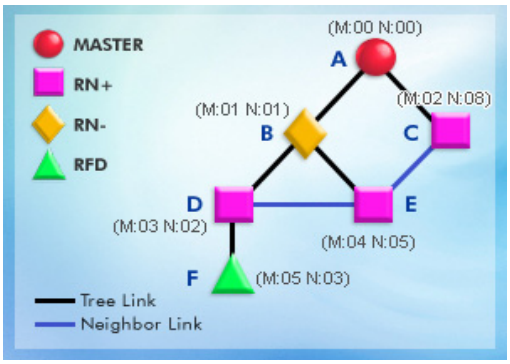

Figure 16. Cluster Tree 2

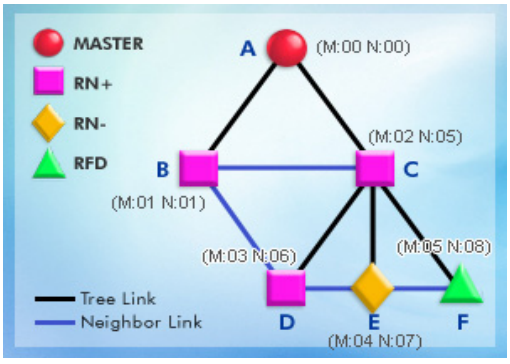

Figure 17. Mesh

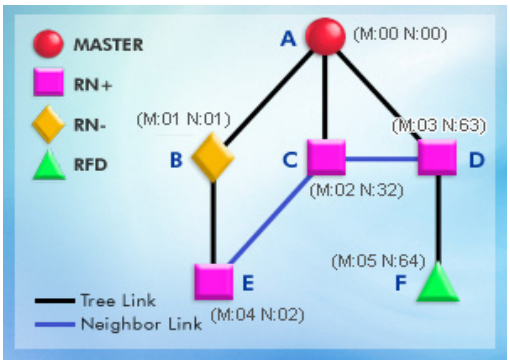

Figure 18. Hybrid 1

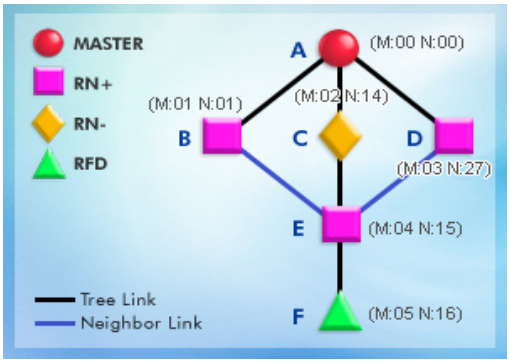

Figure 19. Hybrid 2

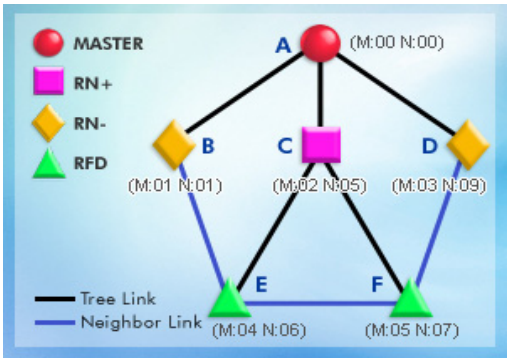

Figure 20. Hybrid 3

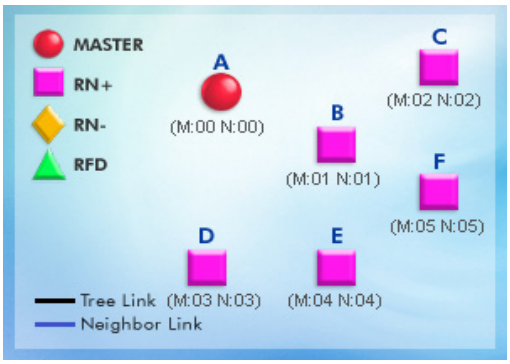

Figure 21. Hybrid 4

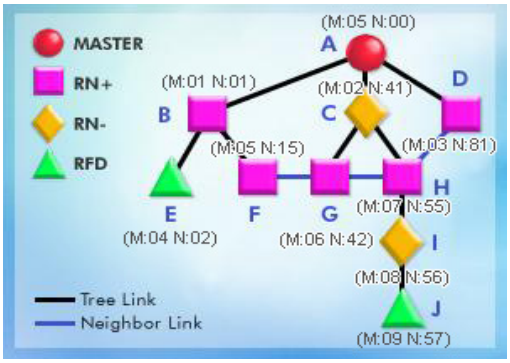

Figure 22. Hybrid 5

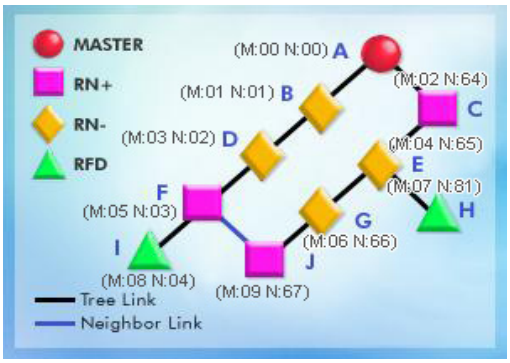

Figure 23. Hybrid 6

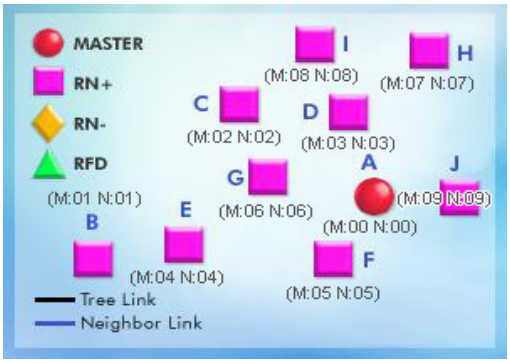

Figure 24. Hybrid 7

Figure 25. Linear 1

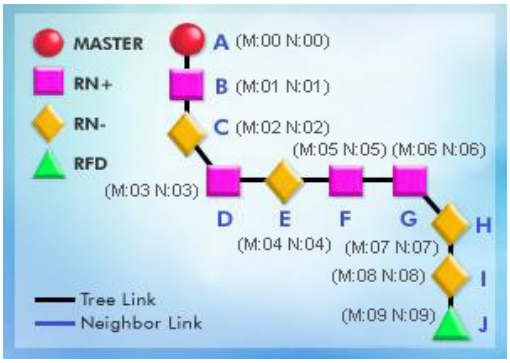

Figure 26. Linear 2

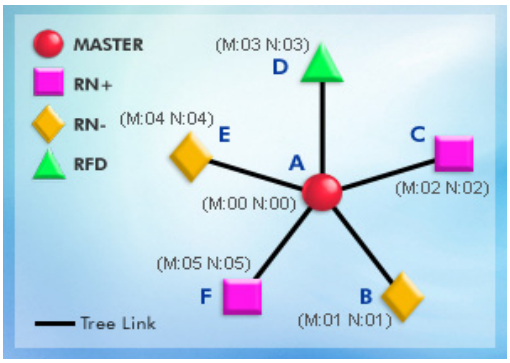

Figure 27. Star

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

- Updated Figure 1 on page 1.

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