Mesh Network Evaluation Kit

User's Guide

Version 0.2

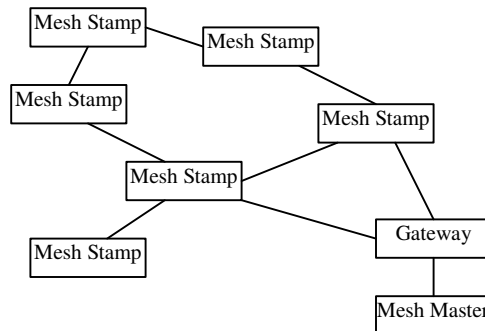Axiometric, LLC
Copyright 2008

1   Introduction

Welcome to the Axiometric Evaluation Kit. This kit provides a fully functional, small MeshPlus® mesh network for demonstration and evaluation of its technical features.

This document is your guide to the kit contents, setting up the mesh network, and testing its features. The configurations and exercises provided in this document are intended to illustrate the mesh features, but are not an exhaustive treatment of all the possible points of interest.

Each application for MeshPlus® will have its own unique requirements and considerations. Evaluators considering the mesh for an application may need to adapt some of the exercises for their environment or create new ones. The MeshStamps® which are provided with the kit are powerful, generic components which demonstrate many features of the mesh. It is anticipated that for specific applications the feature set may need be extended or the MeshStamp® form factor adjusted. This kit is intended to permit interested customers to evaluate the mesh and its capabilities in their own lab and environment with real equipment. It is not necessarily expected that this specific MeshStamp® would be deployed in production by the customer without some adaptation.

2   MeshPlus®

Overview

The MeshPlus® is a network of MeshStamps® where a MeshStamp® is typically a network data collection point associated with some external equipment which is monitored or controlled. In addition to local data collection, each MeshStamp® has the capability to receive and relay information from its neighbor MeshStamps® as well as transmit its own information.

To participate in the mesh network, a new MeshStamp® listens to find its neighbors. Once a neighbor is discovered, the new MeshStamp® receives the current mesh communications parameters such as timing and it can then join the mesh as a full participant. Each mesh may be assigned a unique mesh key so that a new Mesh Stamp may only join its intended mesh.

The data collected by the MeshStamps must typically be retrieved and made available to a Network Management System. Special network access nodes called Gateways are provided to bridge the network data to the Network Management System. In addition to the radio based MeshPlus® Network communications, a Gateway provides connectivity to the Network Management System via Ethernet.

The placement of one or more gateways in the network establishes the direction for the flow of data. The network sends data from its origination point to the gateway. When a MeshStamp® can communicate directly with the gateway, the gateway will typically accept its traffic directly. Mesh Stamps, which cannot communicate directly with the gateway, rely on their neighbors and the mesh structure to relay the traffic all the way to the gateway.

If multiple paths are available to carry data to the gateway, the data will traverse these paths simultaneously so that that if one path becomes unavailable or undesirable, the data will still be successfully delivered. This provides the MeshPlus® network with its self-healing and robustness.

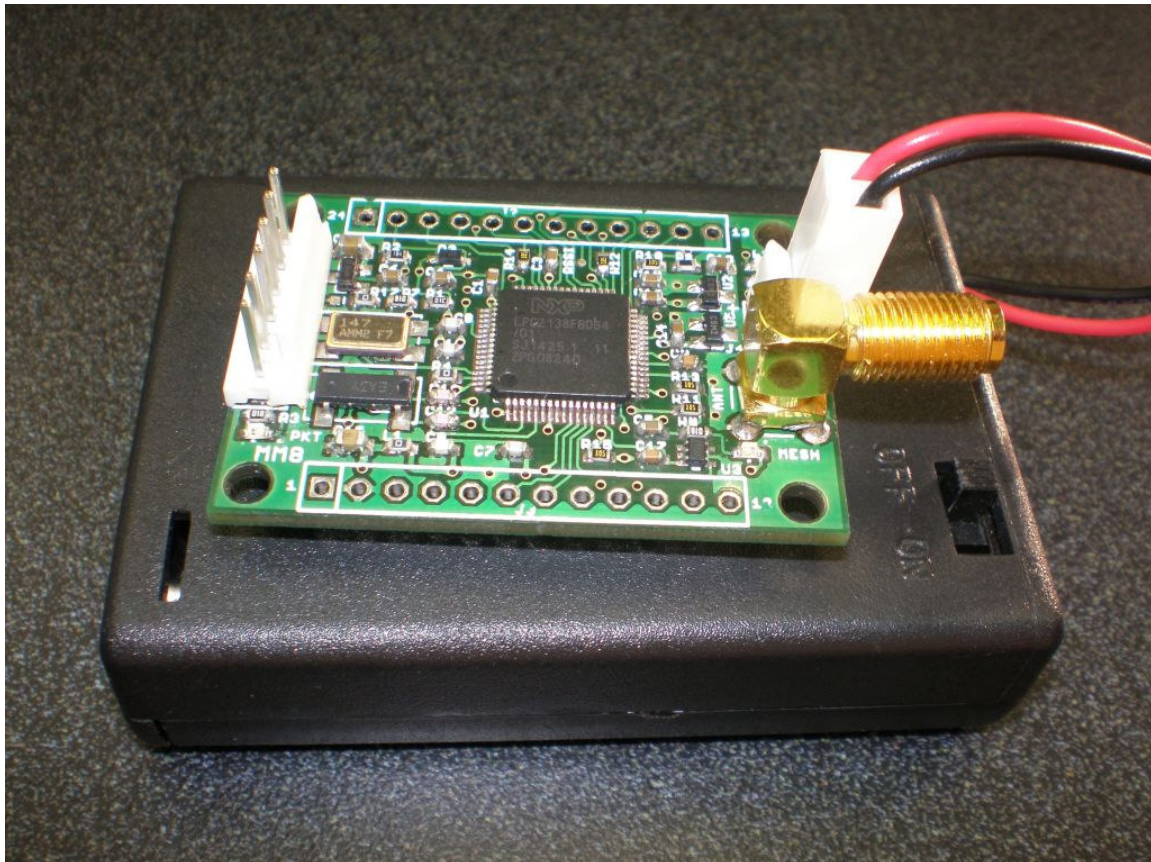Mesh Master — Collector — Ethernet Network — Ethernet Gateway — Axiometric Mesh

Mesh Master is an Axiometric developed JAVA based Network Manager application for MeshPlus® networks. It has two components, the first is the Mesh Master graphical user interface. The second is the Collector.

The Mesh Master GUI provides tools to check the status of the network, configure various network parameters and view the historical data. The Mesh Master GUI accesses the MeshPlus® through the Collector. The Collector is responsible for maintaining communication with the Gateways, synchronizing historical data and configuration with a Gateway when communications is established and receiving current data and status.

These components as an integrated network solution, monitor remote equipment, collect data from the remote equipment, migrate the data to the gateways, deliver the data to Mesh Master for storage, and provide user access to the network data and status.

MeshStamp®

FCC ID: VE4-MM8

The MeshStamp® contains a radio frequency transceiver. Operation of the MeshStamp® in the United States is governed by the rules and regulations of the Federal Communications Commission (FCC). The MeshStamp® has been tested and found to comply with FCC rules and regulations; a label is affixed to the MeshStamp® indicating the FCC Identification Number; this label should not be removed.

NOTE: Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment
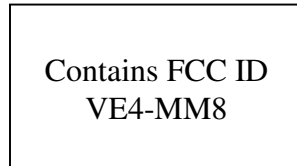
NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate 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.

To comply with FCC RF exposure requirements, the device and the antenna for this device must be installed to ensure a minimum separation distance of 20 cm or more from a person's body. Other operating configurations should be avoided.

Any product containing the MeshStamp® must have a label clearly visible on the outside of the product with the wording "Contains FCC ID: VE4-MM8"

Example of the label:

Contains FCC ID
VE4-MM8

Gateway

An Ethernet Gateway is powered through its Ethernet connector. A Power over Ethernet (PoE) adapter and its AC power cord is provided to power the Gateway.

Please refer to the kit's separate contents sheet to see the gateway id and its configured IP address.

Mesh Master

Mesh Master is provided installed either on a laptop or on a small form factor computer. Monitor, keyboard and mouse are not included and must be provided in order to access the Mesh Master features on the small form factor computer.

A separate User's Guide for Mesh Master is provide in the kit. This material will not be included in this Eval Kit guide, but it will be referenced as appropriate.

3   Setting Up

What is included

3.1.1   Ethernet gateway/small form factor computer

In the Mesh Network Eval Kit you should find the following items:
1.   This Mesh Network Eval Kit Manual
2.   Mesh Master User's Guide
3.   One Ethernet Gateway with associated mounting hardware
4.   One Gateway Antenna
5.   One Power over Ethernet (PoE) adapter and power supply.
6.   One Ethernet cable

7. One Crossover Ethernet cable (orange)
8. Five MeshStamps
9. Five MeshStamp Antennas
10. Five Mesh Stamp battery cases
11. AA Batteries
12. One Mesh Master host computer
13. One Mesh Network Eval Kit Contents Sheet

Ethernet Gateway

The Ethernet Gateway comes assembled in its enclosure. To set up the Ethernet Gateway follow these steps:

1. Remove the Gateway from its box.
2. Remove the bolts, which fasten the top of the enclosure.
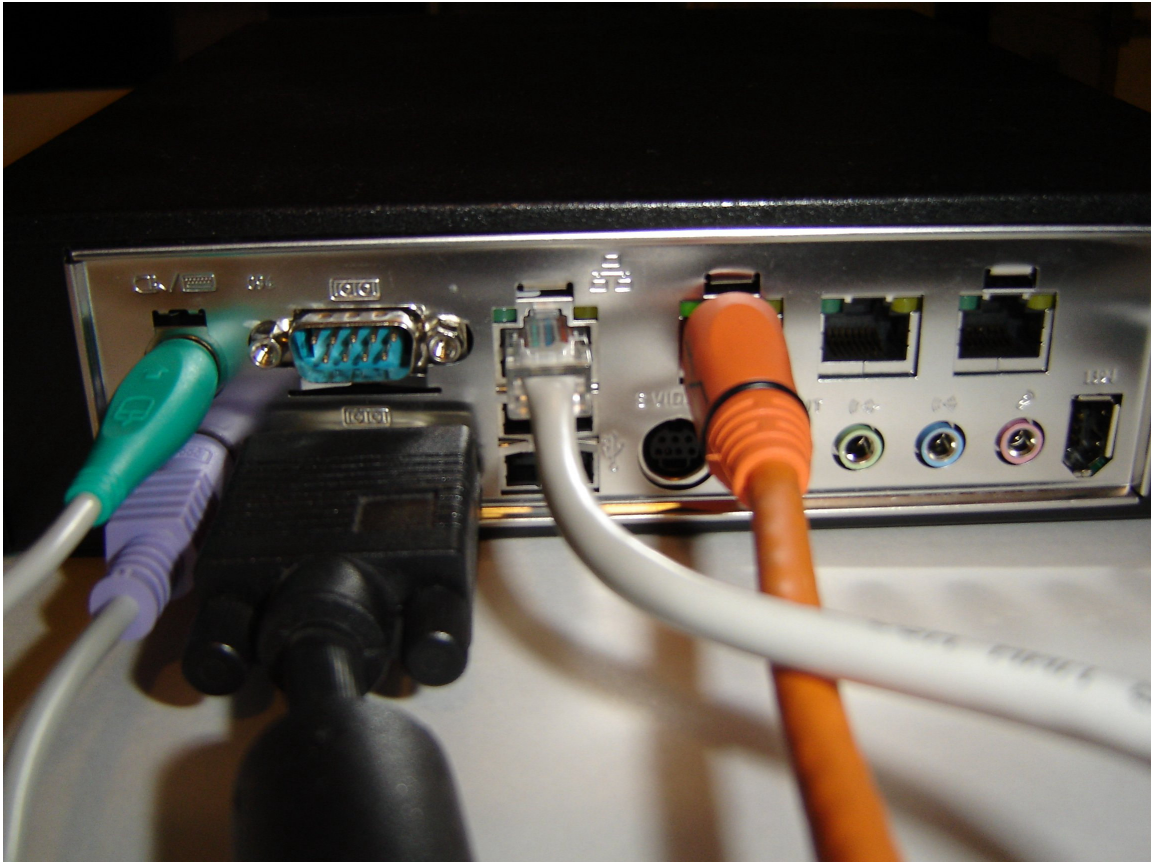3. Remove the top of the enclosure.

4. Plug the Ethernet cable into the Power over Ethernet Adapter (in the PoE port).
5. Plug the Ethernet cable into the Ethernet connector on the side of the gateway enclosure.
6. Connect the PoE adapter to the PoE power supply (DC port).
7. Plug in the PoE power supply.
8. Observe that the Power LED illuminates.
9. Observe that the Gateway module becomes active. (Rcv LED is on, Mesh Status LED is blinking)
10. Observer that the Ethernet Power LED Illuminates.

11. Plug in the keyed battery connector to the main circuit board.
12. Replace the top of the gateway enclosure with its gasket and reattach it with the bolts.
13. Attach the Gateway Antenna to the Gateway.

There may be times when access to the inside of the Gateway is desired to disconnect the battery, observe the LEDs, or access debug functions. At these times, remove the top of the enclosure and its bolts. Replace the gateway enclosure top when done.

Once set up, the Gateway should attempt to establish a mesh. It will continue to broadcast and look for new nodes indefinitely.

Mesh Master – Small form factor computer

To assemble the Mesh Master server collect a keyboard (not included), a mouse (not included), a monitor (not included), an Ethernet cross over cable, the Mesh Master host computer, and the Mesh Master computer power adapter. Then follow these steps:
1. Connect the keyboard, mouse and monitor to the Mesh Master computer.
2. Connect the power adapter to the Mesh Master computer.
3. Connect the Ethernet cross over cable to the Mesh Master computer and the PoE adapter (LAN port).
4. Plug in the Mesh Master computer power adapter.
5. Press the 'power' button on the front of the Mesh Master computer.
6. Observe that the system boots.
7. To place the Mesh Master server on a local network, connect an Ethernet cable to the first Ethernet port (white Ethernet cable in the picture).
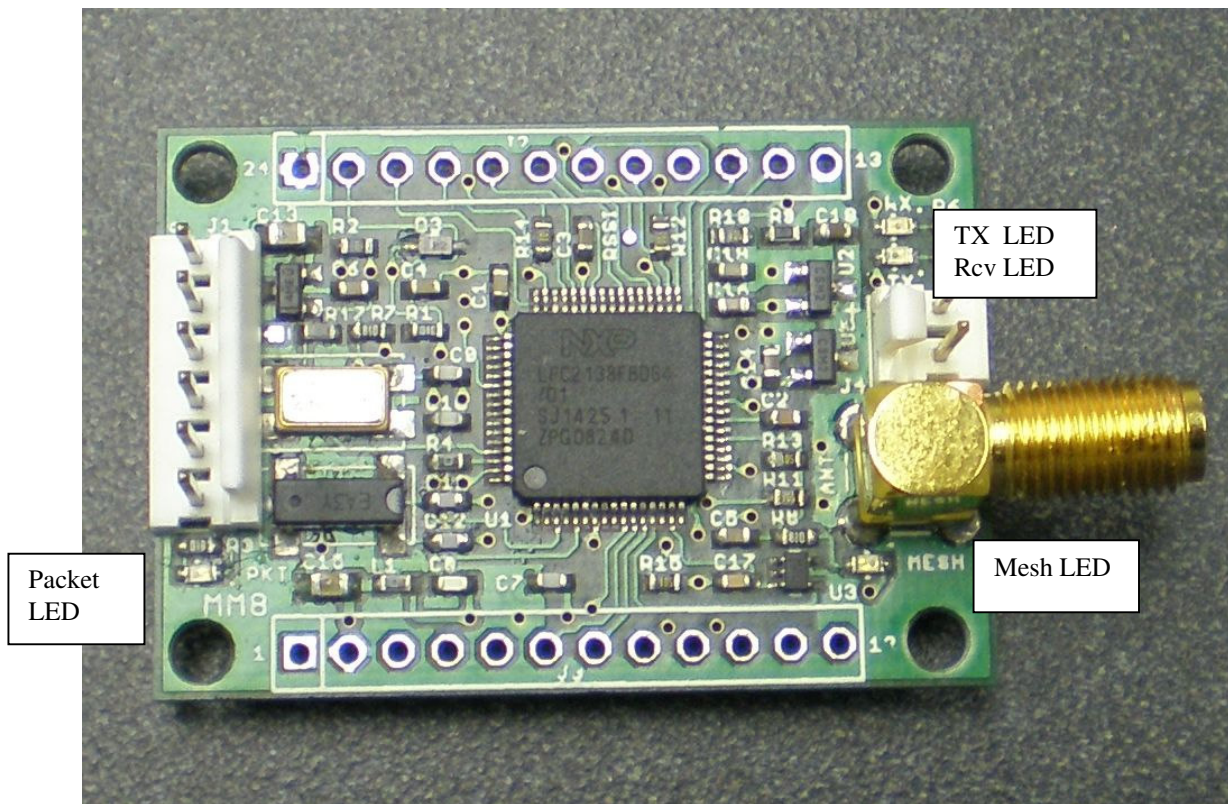
The database used by Mesh Master is installed as a service on the machine so it will start automatically. There are two additional pieces of Mesh Master which are started manually.

First is the collector, which manages communications to the Gateway, captures any data collections from the network and stores them in the database. The collector is started by double clicking its shortcut on the desktop.

Second is the Mesh Master GUI interface. The GUI interface is started by double clicking on its shortcut on the desktop.

If this Evaluation Kit being installed has been powered up before, the Mesh Master database may have retained some old data. To start fresh, follow the procedure in 0 Clearing old Alarms, Data Samples to clear this data.

MeshStamps®

To assemble a MeshStamp® collect 3 alkaline AA batteries, one battery pack, one MeshStamp® antenna and one MeshStamp®. Then follow these steps for each of the MeshStamps®:

1. Insert the 3 batteries into the battery pack. Be sure to follow the instruction on battery direction.
2. Connect the antenna to the Mesh Stamp.

Note: the supplied antenna is the only antenna authorized for use with the MeshStamp®.

3. Insert the keyed connector from the battery pack onto the Mesh Stamp.
4. Observe that the indicator LEDs become active.

Upon receiving power, the Rcv LED will illuminate indicating the Mesh Stamp is listening. The Mesh Status LED will blink indicating that the Mesh Stamp is searching for the mesh. When the Mesh Stamp receives a packet, it will get the mesh timing. Upon receiving the mesh timing, the Mesh Status LED will stop blinking and just illuminate. This could take a few minutes as the Mesh Stamps searches in the time and frequency domains.

Once the Mesh Stamp has synchronized its time with the mesh, it begins honoring the Mesh Duty Cycle. The duty cycle indicates how frequently battery powered Mesh Stamps become active to transmit their data. The Evaluation Kit is pre-configured with a Mesh Duty Cycle of one minute.

When all five Mesh Stamps are set up and connected to the mesh, they should sleep for the Mesh Duty Cycle. Then they should all become active for a few seconds to transmit and receive. After which they sleep again. This is the normal duty cycle of the Mesh Stamps and should continue indefinitely.

If desired, the Mesh Stamp circuit boards may be affixed to their battery case with double stick tape.
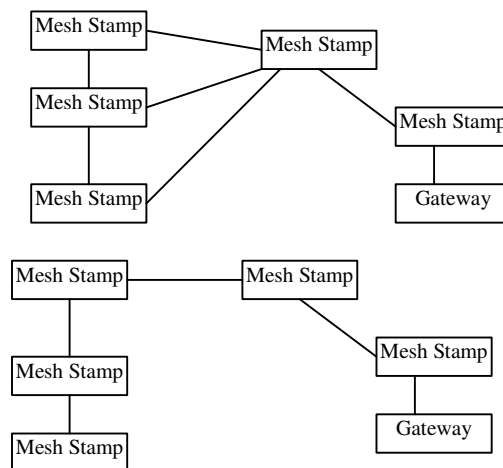
4   Exercising the Mesh

Self-configuring test

One characteristic of the MeshPlus(R) network is that Mesh Stamps may be added to the network without explicit configuration. A properly configured Mesh Stamp will join its network when it finds it. The Mesh will honor the new Mesh Stamp, receive its data and share any new configuration.

The self-configuring nature of the Mesh may be tested by bringing up a new Mesh Stamp and observing as it automatically connects to the Mesh. This feature was actually tested during the set up of this evaluation kit. As the Mesh Stamps were assembled and activated, they should automatically connect to the Mesh.

The Mesh test

When a Mesh is all within radio range of the Gateway, it generally performs as a Star network with each Mesh Stamp's data being picked up by the Gateway directly. To see the nature of the
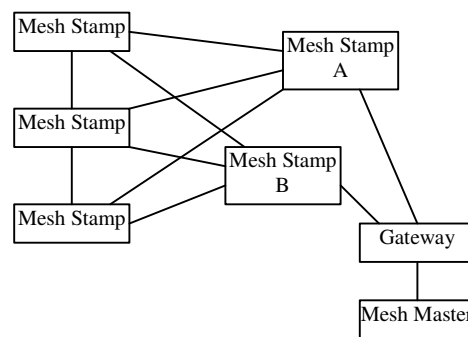
mesh, the Mesh Stamps must be separated so that they are not all communicating directly with the Gateway.

There are various configurations which can be constructed by the Gateway and the five Mesh Stamps. Just a couple are pictured here. To form one of these configurations, distribute the nodes so the desired links are within communications range and the ones you don't want to communicate are out of range. Then bring up the Mesh Status GUI in Mesh Master and observe that the data from all Mesh Stamps continues to be received.

Mesh Master topology tools may also be used to investigate the topology of the network.

The robustness test

The robustness test shows that traffic from the Mesh Stamps continues to be delivered even with some disruption of the mesh.

```
Mesh Stamp                Mesh Stamp
                             A
Mesh Stamp
              Mesh Stamp
                 B
Mesh Stamp               Gateway

                        Mesh Master
```

Build a mesh configuration where the traffic from three nodes traverses two others. Verify that data is being received from all five Mesh Stamps. Then turn the power off on Mesh Stamp A. Verify that data is being received from the remaining four Mesh Stamps.

Restore power to Mesh Stamp A and let it rejoin the Mesh. Then turn the power off on Mesh Stamp B. Verify that data is being received from the four powered Mesh Stamps.

All traffic should have continued to be delivered. With each disruption, the traffic passed through the remaining intermediate node. This demonstrates how the Mesh uses multiple paths for data delivery.

5   Network Activities

Changing Firmware in the network

A challenging maintenance function for a distributed network is to upgrade the firmware of the remote nodes. The MeshPlus® Network provides for firmware upgrades over the network.

The steps to upgrade the firmware are to load the firmware onto the Mesh Master machine, then load the firmware onto the Gateway and finally configure the Mesh Stamps to use and download the firmware.

The duty cycle of a battery-powered mesh will impact the time it takes to download the firmware. The larger the sleep time, the longer it will take to download.

5.1.1 Making the new Firmware available

Move a copy of the binary firmware file onto the Mesh Master machine either over the LAN or via a USB flash drive. Using the Firmware tool under the Configuration menu in Mesh Master, load the firmware file into Mesh Master.

5.1.2 Loading the software on the Gateway

The Mesh Stamps get their firmware image from the Gateway so the next step is to load the image into the Gateway. Use the Configuration tab, of the Gateways tool under the Configuration menu in Mesh Master. Select your Gateway in the left panel. Configure a Mesh Stamp image to be in the swap image space. Then press Apply.

5.1.3 Changing Configuration

Once the Gateway is loaded with the Firmware, the Mesh Stamps must be configured to use it.

Use the Mesh Stamps tool under the Configuration menu in Mesh Master. Configure the secondary image to have the new firmware. Then press Apply. This will cause the Mesh Stamps to load the new firmware in their secondary image space while they continue to run on the firmware in their primary image space.

Once the firmware has been loaded in the secondary image, change the configuration again such that the old primary image is in the secondary image slot and the new firmware image is in the primary image slot. Then press Apply. This will cause the Mesh Stamps to swap the images and start using the new firmware. It also retains the old firmware file as a precautionary measure in case you want to revert back.

Once the new firmware is running and you comfortable that you will not want to revert back to the older firmware, use the Mesh Stamps tool to set the secondary image to the firmware file. Then press Apply. The Mesh Stamps will now copy the new firmware into the secondary image as well. This way if the Mesh Stamp loses confidence in the primary image for any reason and performs a swap, the Mesh Stamp will continue to run on the new firmware after the swap.

Changing Mesh Stamp Configuration

The Mesh Stamps have interval and threshold configuration. The intervals control how often data is sampled and reported. For production systems, these values are typically set based on the billing or control cycles required for the equipment. For lab purposes, they are often accelerated so changes can be seen more quickly. The Logging interval is how frequently the Mesh Stamp records the data measurements locally. The Reporting interval is how frequently the Mesh Stamp reports its local measurements up to the Gateway and Mesh Master. The Topology interval is how frequently the Mesh Stamps report their topology information to the Gateway and Mesh Master.

The threshold configuration determines when certain alarms will be raised. The temperature alarm will be raised when the measured temperature is below the Low Temp threshold or above the High Temp threshold. The Low Battery alarm will be raised when the measured battery voltage is below the Low Battery threshold. The alarm is cleared when the measurement returns to the normal range.

The configuration is changed by altering the fields in the display and pressing the Apply button. The new configuration will be written to the database, retrieved by the collector and sent to the network. Depending on the network size and topology, it may take some time for the configuration to propagate out to all the Mesh Stamps.

Clearing old Alarms, Data Samples and Topology

Some special tools are provided in the lab environment to facilitate testing. The Lab Tools menu choice under the Configuration menu provides access to a feature to delete historical data from Mesh Master. This is intended to permit Operators to clear the Mesh Master logs before performing a test.

Using the DB Tools tab, either press the first Apply button to delete all the historical entries or set the time range to be cleared and press the second Apply button.

6   Contacting Axiometric:

Axometric, LLC
8950 Route 108
Suite 223
Columbia, MD 21044

Telephone: 443-472-4154