Crossbow

MoteView Users Manual

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www.xbow.com

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About This Document

The following annotations have been used to provide additional information.

NOTE

Note provides additional information about the topic.

☑ EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

WARNING

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

The following paragraph heading formatting is used in this manual:

1 Heading 1

1.1 Heading 2

1.1.1 Heading 3

This document also uses different body text fonts (listed in Table 0-1) to help you distinguish between names of files, commands to be typed, and output coming from the computer.

Table 0-1. Font types used in this document.

Font Type	Usage
`Courier New Normal`	Sample code and screen output
`Courier New Bold`	Commands to be typed by the user
Times New Roman Italic	TinyOS files names, directory names
Franklin Medium Condensed	Text labels in GUIs

1 Introduction

1.1 Wireless Mesh Networking Overview

Wireless sensor networks have attracted a wide interest from industry due to their diversity of applications. A key to realizing their potential is multi-hop mesh networking which enables scalability and reliability.

A mesh network is a generic name for a class of networked embedded systems that share several characteristics including:

- **Multi-Hop**—the capability of sending messages peer-to-peer to a base station, thereby enabling scalable range extension;
- **Self-Configuring**—capable of network formation without human intervention;
- **Self-Healing**—capable of adding and removing network nodes automatically without having to reset the network; and
- **Dynamic Routing**—capable of adaptively determining the route based on dynamic network conditions (e.g., link quality, hop-count, gradient, or other metric).

When combined with battery power management, these characteristics allow sensor networks to be long-lived, easily deployed, and resilient to the unpredictable wireless channel. With mesh networking, the vision of pervasive and fine-grained sensing becomes reality.

A wireless network deployment is composed of the three distinct software tiers:

- The **Client Tier** provides the user visualization software and graphical interface for managing the network. Crossbow provides free client software called *MoteView* that bundles software from all three tiers to provide an end-to-end solution.
- The **Server Tier** is an always-on facility that handles translation and buffering of data from the wireless network and provides the bridge between the wireless motes and the internet clients. *XServe* and *XOtap* are server tier applications that can run on a PC or Stargate.
- The **Mote Tier**, where *XMesh* resides, is the software the runs on the cloud of sensor nodes forming a mesh network. The *XMesh* software provides the networking algorithms required to form a reliable communication backbone connecting all nodes within the mesh cloud to the server.

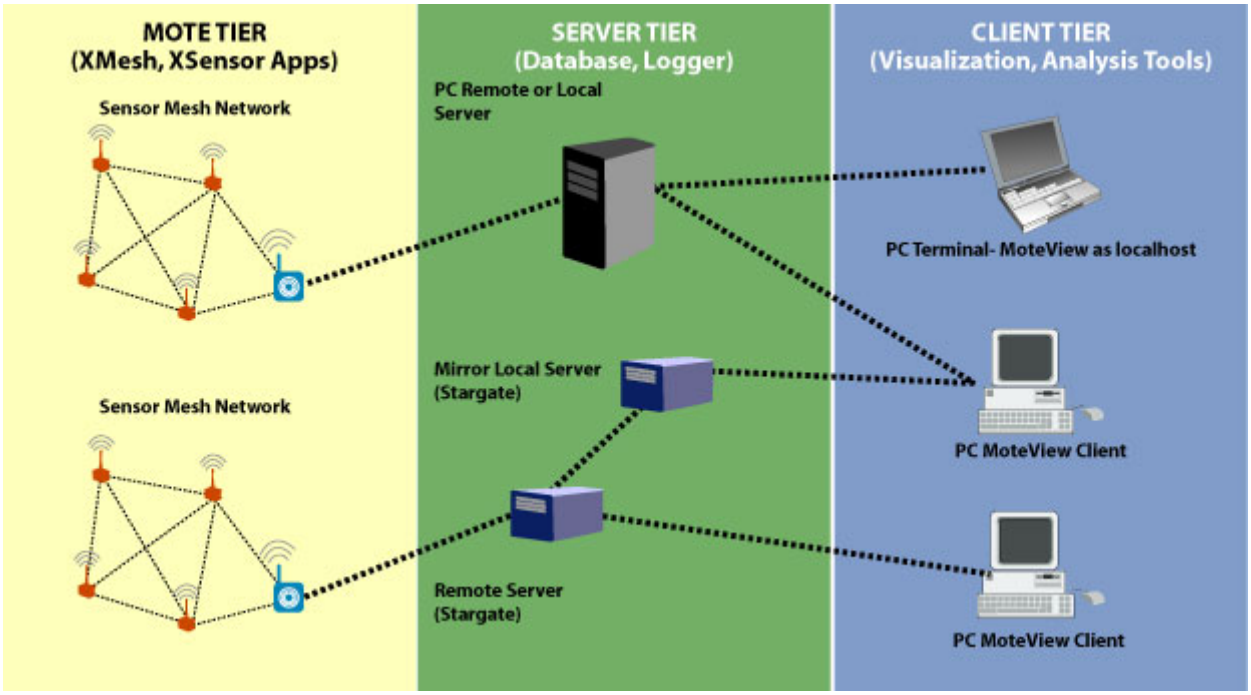


Figure 1-1. Software framework for a wireless sensor network

1.2 MoteView Overview

MoteView is designed to be an interface ("client tier") between a user and a deployed network of wireless sensors. *MoteView* provides the tools to simplify deployment and monitoring. It also makes it easy to connect to a database, to analyze, and to graph sensor readings.

Figure 1-1 depicts a three-part framework for deploying a sensor network system. The first part is the Mote layer or sensor mesh network. The Motes are programmed with *XMesh*/TinyOS firmware ("application") to do a specific task: e.g., microclimate monitoring, asset tracking, intrusion detection, etc. The second layer or Server tier provides data logging and database services. At this layer sensor readings arrive at the base station (e.g., MIB510, MIB520, MIB600, or Stargate) and are stored on a server or Stargate. The third part is the client tier in which software tools provide visualization, monitoring, and analysis tools to display and interpret sensor data. The purpose of this document is to explain the features of *MoteView* and to provide information on the supported Mote layer applications, Mote platforms, and sensor boards.

1.3 Supported Sensor Boards and Mote Platforms

MoteView supports all of Crossbow's sensor and data acquisition boards (Table 1-1) as well as the MICA2, MICA2DOT, and MICAz processor/radio platforms (Table 1-2). In addition, *MoteView* can be used to deploy and monitor sensor integrated platforms such as the MSP Mote security/intrusion detection system and the MEP Mote environmental monitoring system (Table 1-3).

Table 1-1. Sensor (MTS series) and data acquisition boards supported by MoteView and their plug-and-play compatible Mote platforms

Sensor and Data Acquisition Boards	Mote Platforms		
	MICAz	MICA2	MICA2DOT
MTS101	✓	✓	
MTS300/310	✓	✓	
MTS410	✓		
MTS400/MTS420	✓	✓	
MTS450	✓	✓	
MTS510			✓
MDA100	✓	✓	
XBW-DA100	✓		
MDA300	✓	✓	
MDA320	✓	✓	
XBW-DA325	✓		
MDA500			✓
MTP400		✓	

Table 1-2. Mote processor/radio (MPR) platforms supported by MoteView

Mote Platforms	Model Number(s)	RF Frequency Band(s)
MICAz	MPR2400	2400 MHz to 2483.5 MHz
	MPR2600	2400 MHz to 2483.5 MHz
MICA2	MPR400	868 MHz to 870 MHz; 903 MHz to 928 MHz
	MPR410	433.05 to 434.8 MHz
	MPR420	315 MHz (for Japan only)
	MPR600	868 MHz to 870 MHz; 903 MHz to 928 MHz
MICA2DOT	MPR510	868 MHz to 870 MHz; 903 MHz to 928 MHz
	MPR510	433.05 to 434.8 MHz
	MPR520	315 MHz (for Japan only)

Table 1-3. Sensor integrated (MEP, MSP) platforms supported by MoteView

Sensor Integrated Mote Platforms	Description of Usage
MEP410	Microclimate and ambient light monitoring
MEP510	Temperature and humidity monitoring
MSP410	Physical security and intrusion detection

1.4 Supported Mote Software Applications

XMesh is Crossbow's multi-hop mesh networking protocol that has various options including low-power listening, time synchronization, sleep modes, any-to-base and base-to-any routing. All of our sensor and data acquisition boards are supported with *XMesh* enabled applications. Refer to the *MoteConfig User's Manual* for details.

2 Installation

2.1 Supported PC Platforms and Operating Systems

MoteView is supported on the following platforms:

- *Windows XP Home*
- *Window XP Professional*
- *Windows 2000 with SP4*

NOTE: The filing system on the hard disk must be NTFS.

For information on converting from FAT to NTFS, please click on the following link:
http://www.microsoft.com/technet/prodtechnol/winxppro/maintain/convertfat.mspx

2.1.1 PC Interface Port Requirements

The gateway platform used in the base station determines the PC interface port required by *MoteView*:

1. For a **MIB510** serial gateway: an RS-232 serial port.
2. For a **MIB520** USB gateway: a USB port.
3. For a **MIB600** Ethernet gateway: A wired Ethernet or 802.11 wireless card only if the MIB600 is on a LAN with wireless access.
4. For a **Stargate** or other server: A wired Ethernet, an 802.11 wireless card only if the Stargate has a wireless modem or is on a LAN with wireless access, or a cellular modem for wireless Internet access.

2.2 Additional Software Requirements

For the application to run the following additional components are required:

- PostgreSQL 8.0 *database service*
- PostgreSQL *ODBC driver*
- Microsoft .NET 1.1 *framework*

The installation files for these components are included on the *MoteView* installation CD.

2.2.1 PostgreSQL

All the visualization tools in *MoteView* require being connected to a database. This database can reside on your PC ("localhost"), a remote server, or a Stargate. The size of this database is bound by the storage available on the system.

IMPORTANT: The *PostgreSQL 8.0* installation requires administrative privileges on the system, including the ability to create a new user called *postgres* (for *PostgreSQL*).

IMPORTANT: Running the *PostgreSQL* database service is required if your PC is hosting both the server and client layer functions.

2.3 Installation Steps

Shut down all the programs running on your computer.

1. Insert the *MoteView Support* CD into the computer's CD drive.
2. Double-click on ***MoteViewSetup.exe*** from *MoteView* folder.
3. At the **Welcome to the MoteView Setup Wizard** window, click **Next>**.
4. Select the desired installation directory, then click **Next>** (see Figure 2-1).

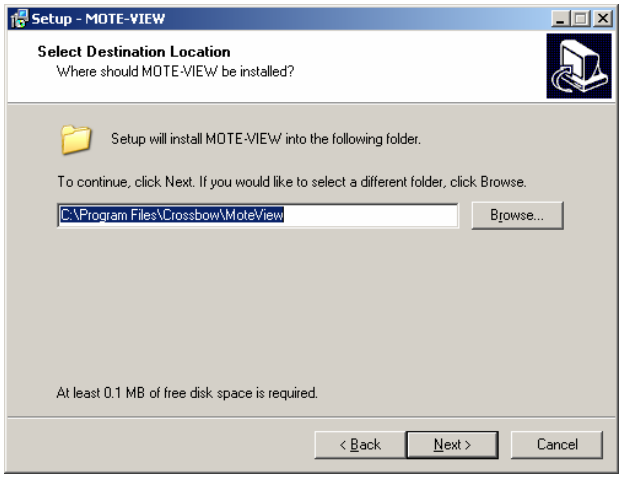


Figure 2-1. Step 4: Destination folder select and confirm screen

5. Select the desired Start Menu folder name and click **Next>**.

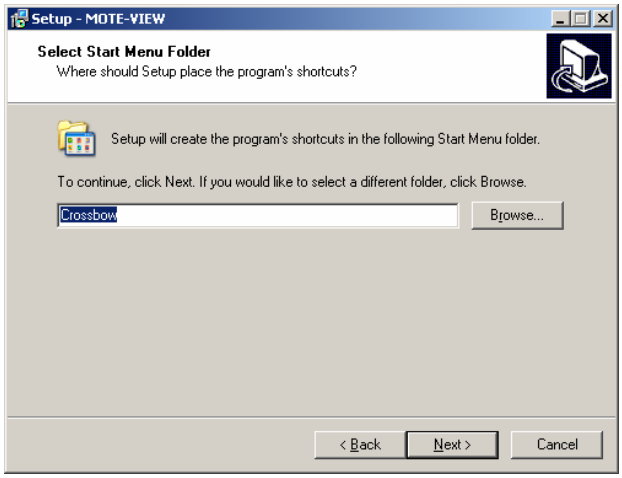


Figure 2-2. Step 5: Screenshot for selecting the Start Menu folder for MoteView

6. Select all available installation tasks and click **Next>** (see Figure 2-3).

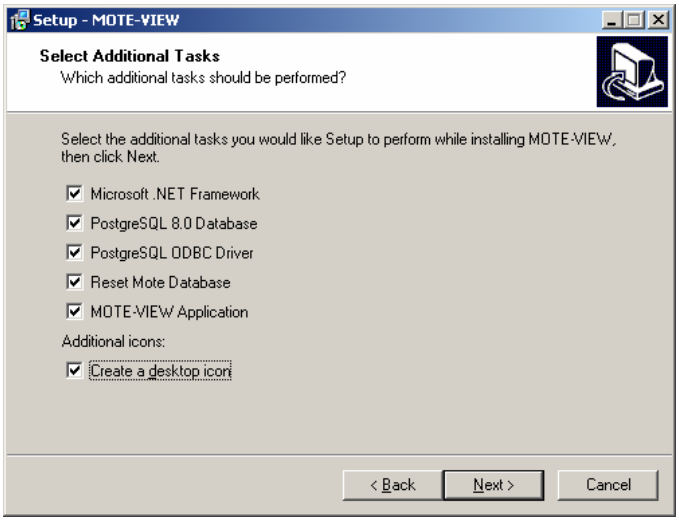


Figure 2-3. Step 6: Select all options if installing MoteView for the first time

7. Confirm your selections and click **Install.**

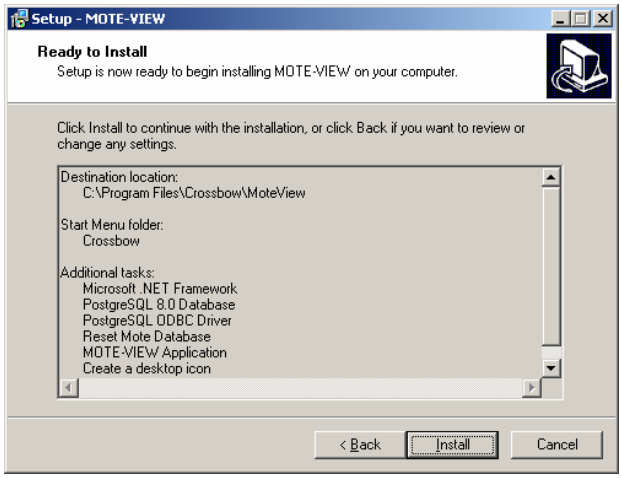


Figure 2-4. Step 7: Confirm you selections with this screen

Execute the .NET framework and *PostgreSQL* OBDC installation prompts if applicable and follow the instructions.

: NOTE: If you have a version of MoteView prior to v1.0 you may get a **PostgreSQL 8.0.0-rc1** window (Figure 2-5) when installing the database. Record the exact error message in *C:\Program Files\PostgreSQL\8.0.0-rc1\tmp\initdb.log*. In most cases you can simply click the **OK** button and proceed. However, in other cases you may have to do the following:

a. Uninstall *PostgreSQL 8.0* from **Start>Control Panel>Add or Remove Programs**

b. Remove the *C:\Program Files\PostgreSQL* directory manually through the Windows Explorer utility (**Start>**Right Click**>Explore**).

c. Reinstall *MoteView* with all checked **except** the .NET Framework.

Figure 2-5. Error window that may occur during the *PostgreSQL* Installation

8. Please note that if you receive an MDAC warning such as the one pictured below, you may ignore this warning and continue on with the installation. The warning is simply notification that your operating system contains an MDAC version that is newer than what *MoteView* is installing.

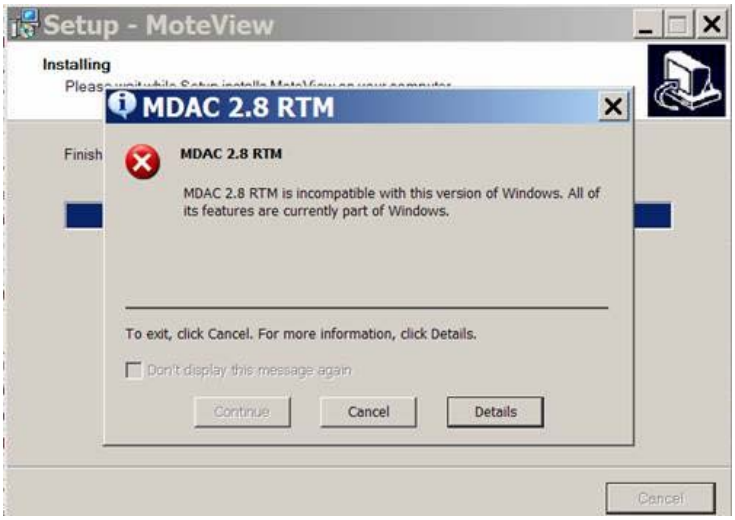


Figure 2-6. MDAC 2.8 RTM incompatibility message that may appear during .NET installation. This warning can be ignored by clicking on Cancel

9. When the Setup Wizard has finished it will ask if you want to start *MoteView*. You may start *MoteView* now, but in some cases it may ask you to restart your computer first.

10. If you have restarted or at any time after you can start *MoteView* by double- clicking on the *MoteView* icon or by going to the installation folder (the default install folder is ***C:\Program Files\Crossbow\MoteView***) and clicking on ***MoteView.exe***.

3 Application Quick Start

Once a sensor network is running and *MoteView* is installed on a PC, minimal configuration is necessary to start collecting data from the sensor network.

3.1 Verify PostgreSQL Installation

During the installation of *MoteView* a static database was included to make it possible to demonstrate *MoteView's* features without having to be connected to an active sensor network or a remote server/database. The steps described here also apply to viewing data collected from an active sensor network.

1. Click on the green connect icon  , in the upper left hand corner or select **File > Connect to Remote Database/Stargate** from the menubar. The **Database Server Configuration** will appear (see Figure 3-1).

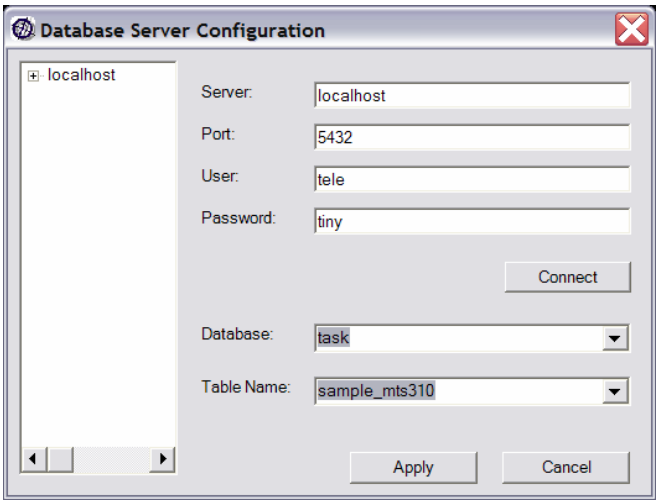


Figure 3-1. Database Server Configuration window which provides access to remote or local servers and databases

2. Click on `localhost` and select `task`. Press **Connect.**
3. Check that the pull down item next to **Database = task** and that **Table Name = sample_mts310.**
4. Click on **Apply.** *MoteView* will then access the `sample_mts310` table in the database `task`.

NOTE: If the task database is not available, or if the table names are empty, the PostgreSQL install was not successful. Verify that the *psqlODBC* drivers have been installed using the **Control Panels>Add or Remove Programs** wizard. Verify that the postgres database service has started using the *Task Manager*. If not, use the **Control Panels>Administrative Tools>Services** to start the postgres service.

A good source of debugging information is
http://pginstaller.projects.postgresql.org/faq/FAQ_windows.html

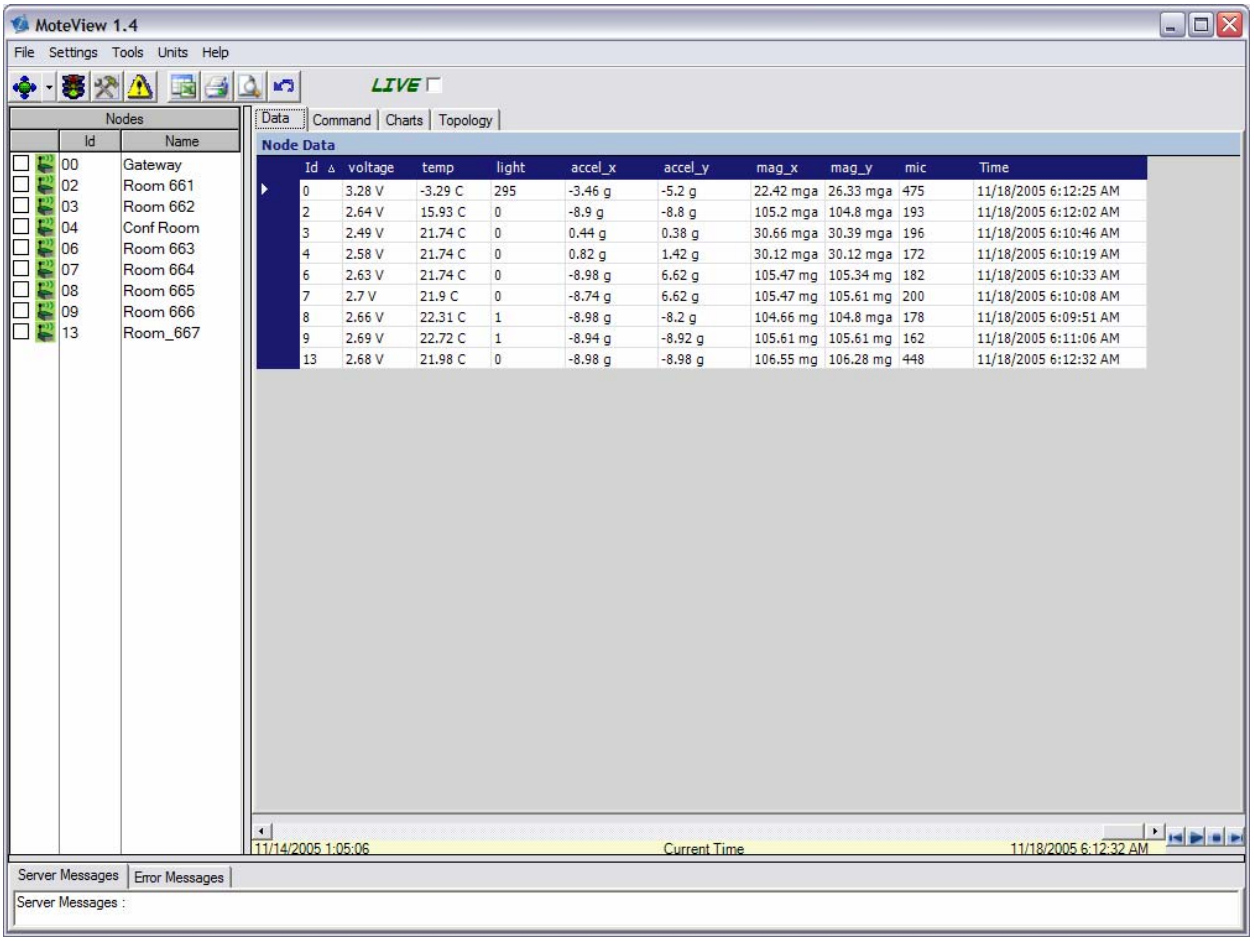


Figure 3-2. *MoteView* connected to the *sample_mts310* table in the *task* database

IMPORTANT: There are two ways to repair a corrupt database installation:

1. Select **Tools > Reset Database** from the MoteView menu
2. Open a File Manager, navigate to C:\Program Files\Crossbow\MoteView, and execute "resetdb.cmd".

A *sample_mts300* table and a *sample_nodehealth* table are also included in the default *task* database created by the *MoteView* installer.

3.2 Connecting to an Active Sensor Network on your local PC

Use the following steps to access data from an active sensor network connected to your local PC via the MIB510, MIB520 or MIB600 gateway.

1. Select **File > Connect to MIB510/MIB520/MIB600/Stargate** from the menu.
2. If using a MIB510/MIB520, make sure that the **MIB510/520 COM** is set to the correct port number and that the **baud** rate is **57600**. For MIB520's, enter the higher of the 2 COM ports installed by the MIB520 driver.

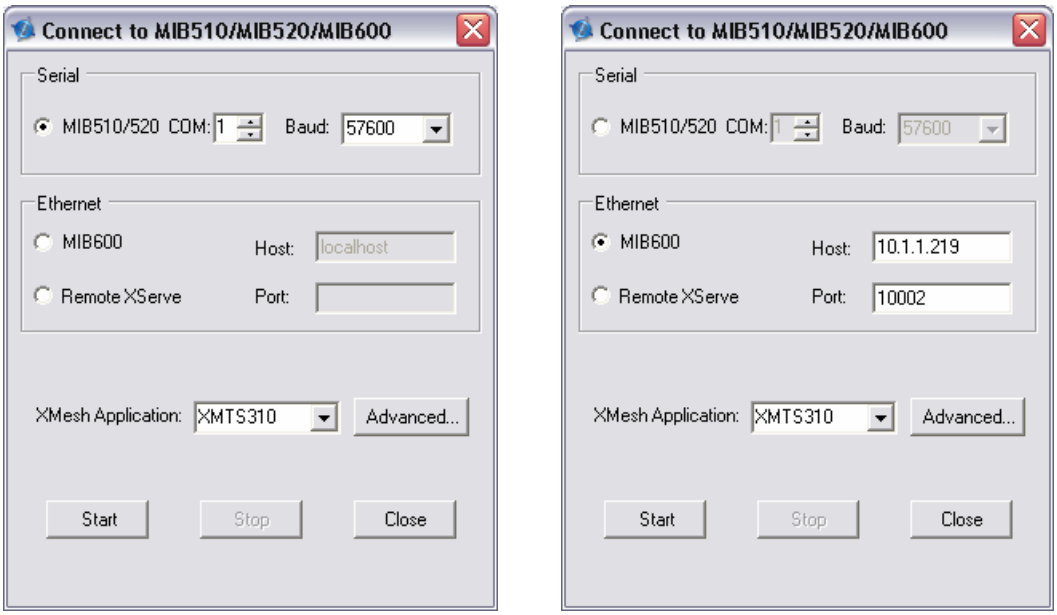
NOTE: The **MIB520** requires the installation of the *FTDI FT2232C* drivers. Once these drivers are installed, the **Device Manager** (**Start > Control Panel > System > Hardware**) will display the **MIB520** as two new virtual com ports. Refer to the *MPR-MIB Series User's Manual* for details.

3. If using a **MIB600**, select **MIB600** in the **Ethernet** group-box and enter the IP address of the MIB600 in the **Host** text-box. The **Port** should default to **10002**.

NOTE: The IP address of the **MIB600** can be identified by using the *Lantronix DeviceInstaller* application. Refer to the *MPR-MIB Series User's Manual* for details.

☑ EXAMPLE 3-1:

Screenshots of the **Connect to MIB510/MIB520/MIB600** popup window are shown below. On the left is an example of connecting to an MIB510 on COM1. The baud rate is set to **57600**. On the right is an example of connecting to an MIB600 assigned with IP address 10.1.1.219, which is connected to the LAN.



4. Choose the **XMesh Application** that matches the firmware programmed on the Mote.

If you have an *XMesh* Application…	Then choose one of the following pull down choices
Default. Use when you don't see the *XMesh* application	**(none)**
XMTS101_<freq>_<mode>	**XMTS101**
XMTS300_<freq>_<mode>	**XMTS300**
XMTS310_<freq>_<mode>	**XMTS310**
XMTS400_<freq>_<mode>	**XMTS400**
XMTS410_<freq>_<mode>	**XMTS410**

If you have an *XMesh* Application…	Then choose one of the following pull down choices
XMTS420_<freq>_<mode>	XMTS420
XMTS450_<freq>_<mode>	XMTS450
XMTS510_<freq>_<mode>	XMTS510
XMDA100_<freq>_<mode>	XMDA100
XBW-DA100_<freq>_<mode>	XBW-DA100
XMDA300_<freq>_<mode>	XMDA300
XMDA300p_<freq>_<mode>	XMDA300P
XMDA320_<freq>_<mode>	XMDA320
XBW-DA325_<freq>_<mode>	XBW-DA325
XMDA500_<freq>_<mode>	XMDA500
XMEP410_<freq>_<mode>	XMEP-SYS
XMEP510_<freq>_<mode>	XMEP-SYS
XMSP410_<freq>_hp.exe	XMSP410

5. If you are not able to receive data, you may also need to select the **Live** check box on the main *MoteView* screen if it has not been previously selected. Use the **Server Messages** pane at the bottom of your *MoteView* display to verify that node data is being received by your PC.

3.3 Connecting to an Active Sensor Network on a Remote PC or Stargate

To connect to an active sensor network on a remote PC requires changes to the database server and gateway settings

1. Click on the green connect icon  , in the upper left hand corner or select **File > Connect to Remote Database/Stargate.** The **Database Server Configuration** will appear (see Figure 3-1).
2. Enter the **server** name, **port**, **user** and **password**. Press **Connect.**

NOTE: The **Port**, **Username**, and **Password** fields are preset to reasonable defaults and should **not** have to be changed.

3. The **Database** and **Table Name** fields should be filled with the details of the remote database server. Select a table corresponding to the sensor board you wish to view and press **Apply.**

NOTE: If you are unable to view the tables on a remote database, verify that the remote PC's firewall accepts connections from your client PC. Also, check that the `pg_hba.conf` file has valid authentication information, and that the `postgresql.conf` file has the following line `listen_addresses = '*'`

4. Select **File > Connect to MIB510/MIB520/MIB600/Stargate** from the menu bar.
5. Click the **Remote Xserve** radio button and enter the **host** IP address. The **Port** should default to **9001.**
6. Choose the **XMesh Application** that matches the firmware programmed on the Mote. Click **Start.**

4 User Interface Functional Description

4.1 *MoteView* at a Glance

MoteView has four main user interface sections:

1. Toolbar / Menus: Allows the user to specify actions and initiate command dialogs.
2. Node List: Shows all known nodes in a deployment and health status summary.
3. Visualization Tabs: Enables the user to view the sensor data in various ways.
4. Server / Error Messages: Displays a log of server events and incoming messages.

4.2 Node List

The Node List displays all the known nodes in a deployment.

Table 4-1. Features and icon properties of the node list

Node List Feature	Description
Checkbox next to node id	Select nodes to be plotted in the Charts view
Change node properties	Double click on a node in the list or right click and choose **Properties**.
Sort data	Click on the column header. Static display only when not in "live" mode.
Add nodes	Right click on any node or use the auto-detect feature as results arrive.
 Gray Mote icon	No results received
 Green Mote icon	Fresh results within the last 20 minutes
 Moss (light green) Mote icon	Results stale by >20 minutes
 Yellow Mote icon	Results stale by >40 minutes
 Orange Mote icon	Results stale by >60 minutes
 Red Mote icon	Results stale by more than a day

The time intervals for the node color changes can be edited from the dialog box that appears when you right-click on the node and select **Set TimeRange.**

4.3 Visualization Tabs

Four visualization tabs (**Data**, **Command**, **Charts**, **Topology**) provide alternate methods of viewing your sensor data.

4.3.1 Data

The **Data** tab displays the latest sensor readings received for each node in the network (see Figure 4-1 for an example from the demo database). The columns include node ID, server timestamp and sensor values from the sensor board firmware packet. The sensor data is automatically converted into standard engineering units.

Left-clicking the column header allows you to sort by node ID, parent, temperature, voltage, last result time, or any other sensor reading. Right-clicking the column header displays a pop-up menu with unit conversions relevant to the sensor.

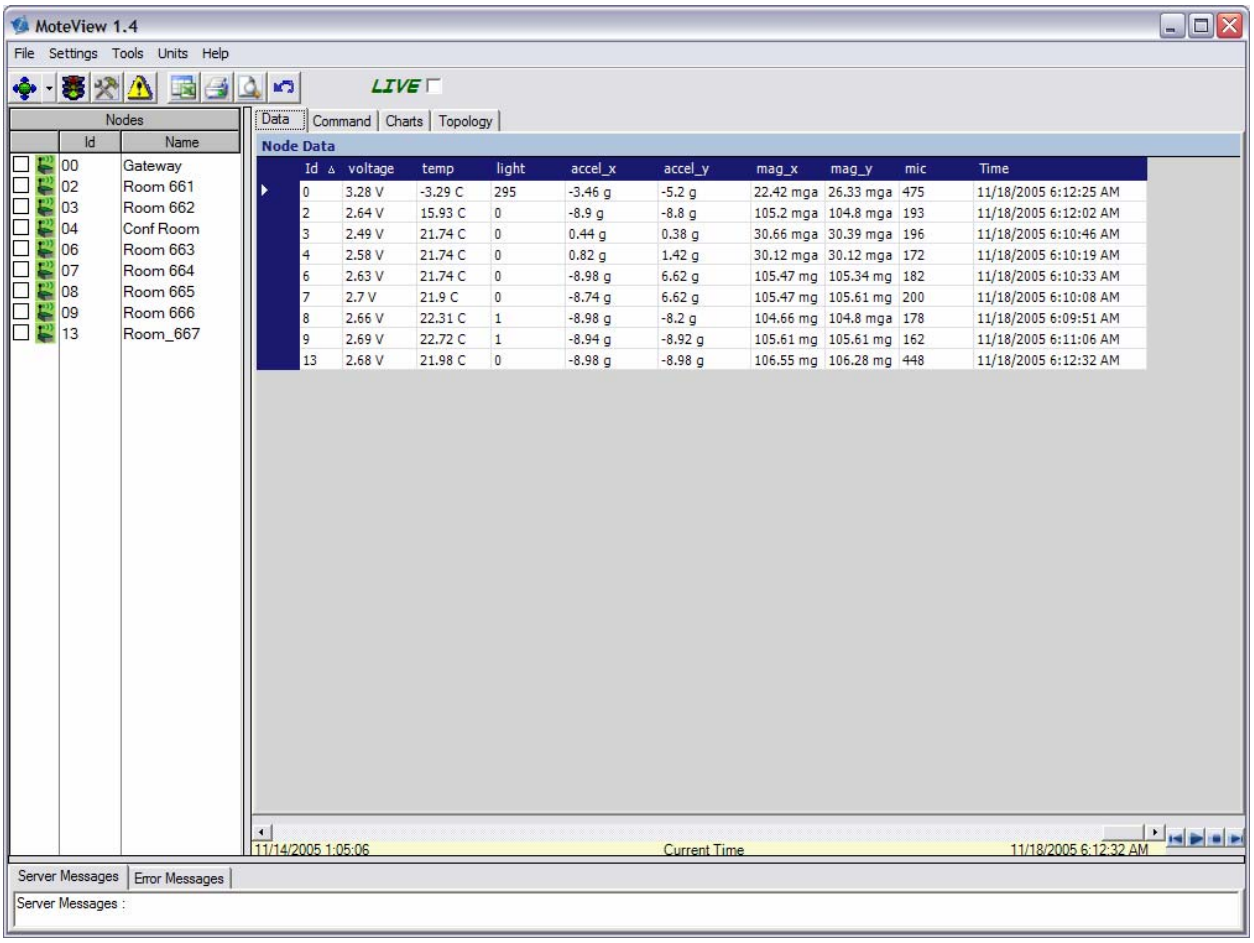


Figure 4-1. Screenshot of a demo database displayed in the *Data* tab

4.3.2 Command

The **Command** tab provides the user with an ability to change different node parameters wirelessly.

> **NOTE:** These commands do not get stored in the EEPROM and hence are volatile.

To modify the data sample and transmission rate, do the following:

1. Click on the **System** tab on the left side of the **Command** tab.
2. Select the **Node ID**. Check "**All Nodes**" to modify the data rate for all nodes in your network
3. Enter a data rate and press **Set**. The minimum data rate supported is 300 ms for high-power nodes. The default data rate for most high-power applications is 2 seconds. The default rate for low-power application is 3 minutes

To obtain the 64-bit unique ID of a Mote, do the following:

4. Click on the **System** tab on the left side of the **Command** tab.
5. Select the **Node ID**. Press **Get**

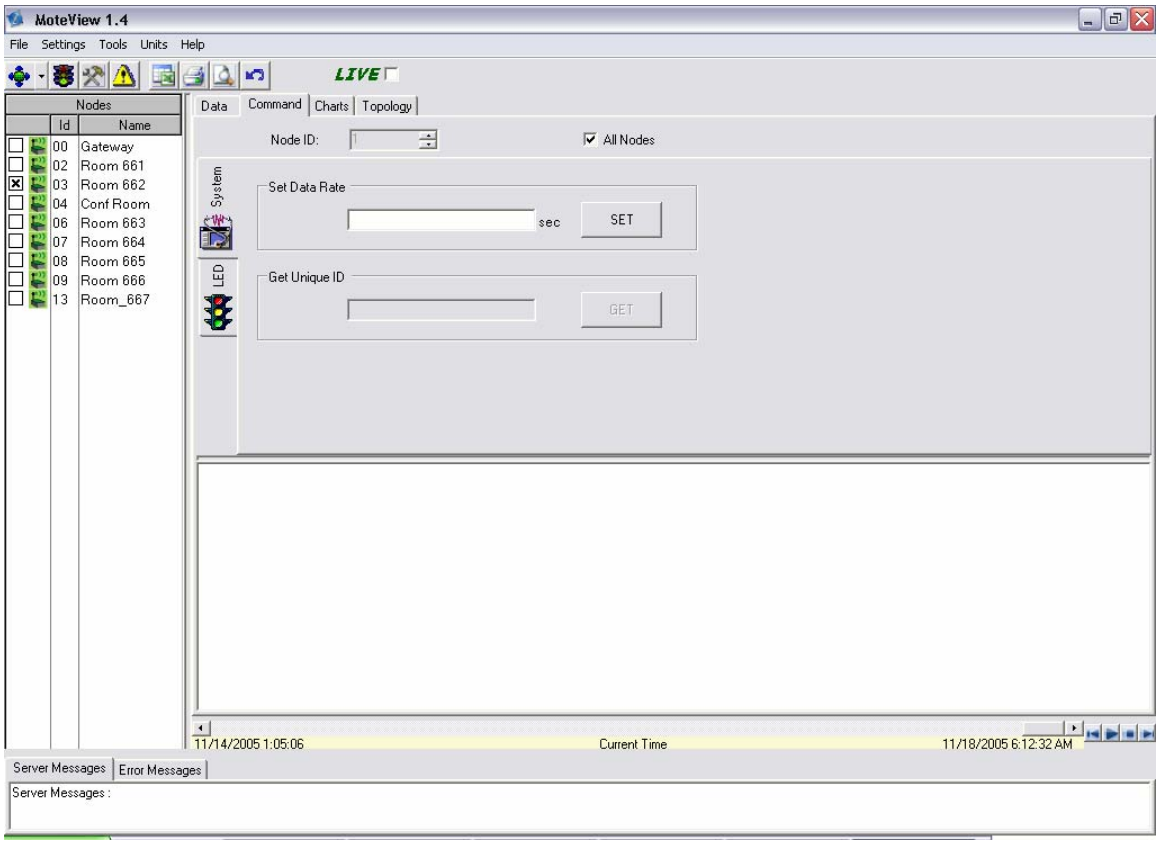


Figure 4-2. Screenshot of the System Configuration in the *Command Tab*.

To change the LED status, do the following.

1. Click the **LED** tab on the left side of the **Command** tab.
2. Select the **Node ID** of your network. If changing the system parameters for all nodes, check the **All Nodes** checkbox.
3. Select the Red, Yellow or Green LED(s) and check

   ON – To turns the LED On.

   OFF – To turns the LED Off

   TOGGLE – To toggle the state of the LED
4. Press **SET** to send the specified commands to node (s) in your network.
5. Press **SET ALL** to activate all LEDs simultaneously.

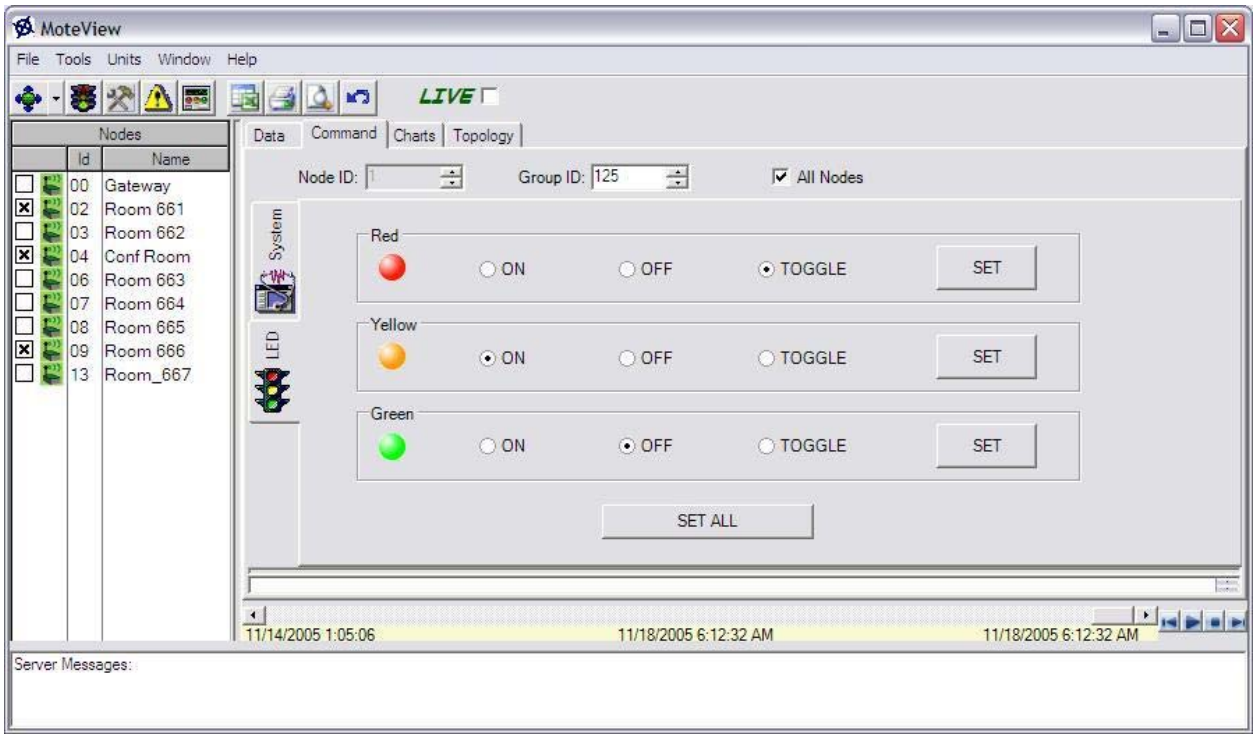


Figure 4-3. Screenshot of the LED actuation in the *Command Tab*

4.3.3 Chart

The **Chart** tab provides the ability to generate graphs of a sensor reading against time for a set of nodes. The following features and constraints apply to the graphs plotted in this view.

- Up to 3 sensor types can be selected for plotting, i.e., 3 different graphs.
- Up to 24 different Nodes can be selected for plotting. A different plot color will be used for each node; a legend is displayed on the right side of the window.
- The x-axis on the graph shows the date and time.
- The y-axis on the graph shows data in engineering units for the sensor readings.

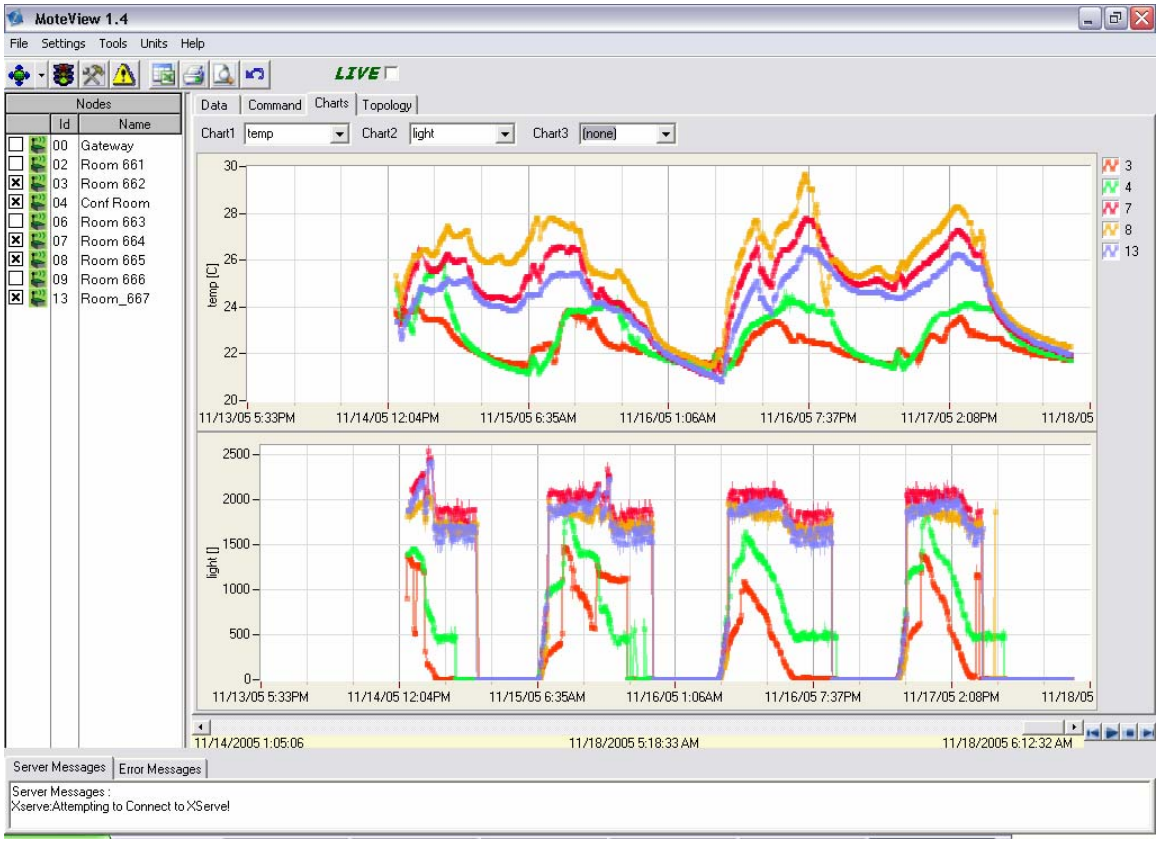


Figure 4-4. Screenshot of the demo database in the *Chart* tab

- The user can zoom into and pan through data, as instructed in Table 4-2, within each of the graphs independently of each other.

Table 4-2. How to zoom, pan, and reset in the Chart View.

Desired Action	Instructions
To zoom in	Hold down the "Shift" key. Left click and drag a region to zoom into. Release the mouse to complete the region selection. Release the "Shift" key.
To pan through data	Hold the "Ctrl" key Left click and drag a point within the chart to the new location. Release the mouse button.
To zoom out fully	Go to the Tools menu and select "Refresh View."
To undo a zoom	Hold down the "Shift" key Right click once for each level of undo
To undo a pan	Hold down the "Ctrl" key Right click once for each level of undo

- Right-clicking allows the user to select a fixed x-axis range (last hour, last day, last week, last month, last quarter, all data).

4.3.4 Topology

The **Topology** tab shows a Mote network map with placement and parenting information. This allows the user to define and view a topology of their Mote deployment.

- New nodes will show up in the upper left hand corner.
- The user can drag nodes and place them at a new location on the map with a left click of the mouse. Node locations are stored in the database and are shared by all users of that database.

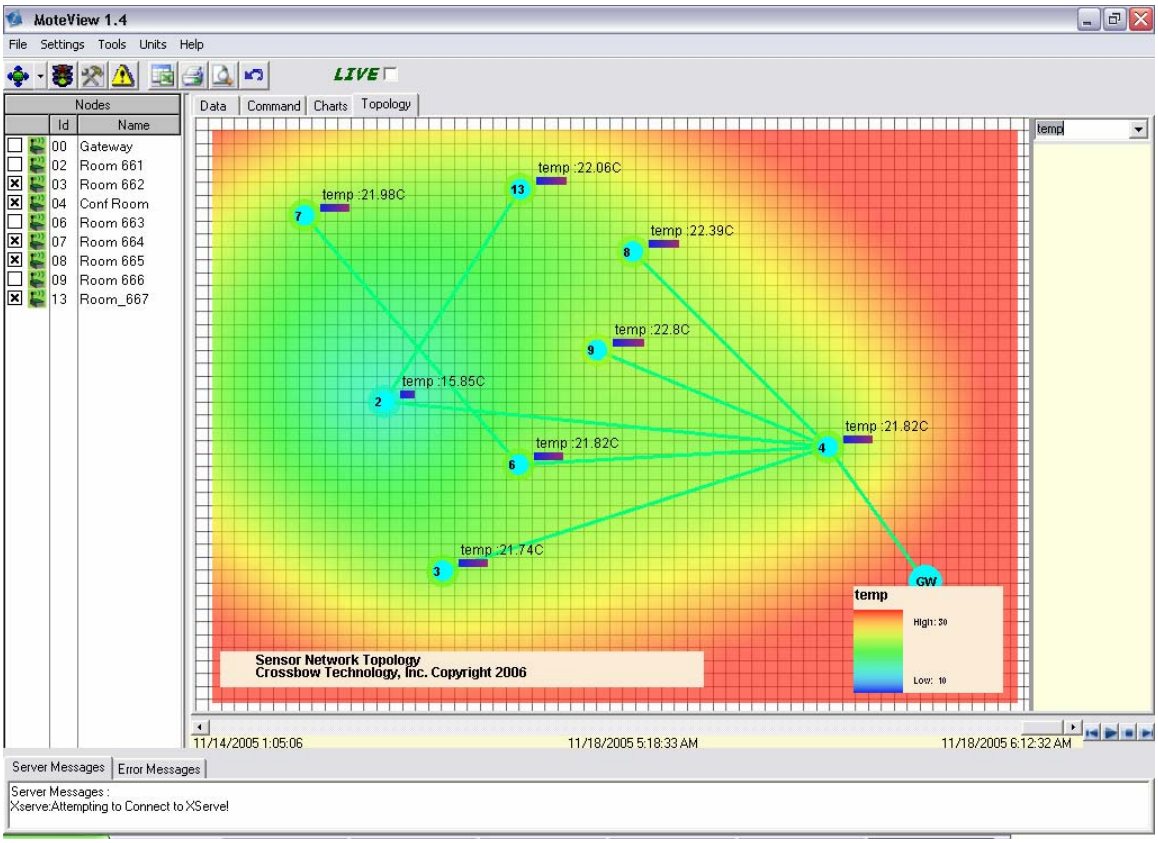


Figure 4-5. Screenshot of the demo database in Topology view

- A visualization pop-up menu will appear when the user right clicks the background bitmap.

Table 4-3. Items from the visualization pop-up menu that appears when right-clicking in the map area of the Topology view

Visualization Menu	Description
Add Node	Creates a new node at the current mouse location. A Mote properties dialog will appear to allow selection of node name and id number.
Arrange Nodes > Grid	Will automatically arrange all the nodes into a grid layout. This is useful when there are a large number of unplaced nodes.

Visualization Properties	Allows the user to visualize temperature gradients or other Mote properties using a specific color pattern.
MSP Properties	Sets the orientation of quadrant 1 relative to image in the topology view and the draw radius of a PIR event (Applicable for *MSP410* users)
Load Bitmap	Allows users to select a bitmap from their file system to be the background of the map. Supported background image formats include: .bmp, .gif, .ico, and .jpg. The image will be automatically scaled to fit the available screen space.
Use Default Bitmap	Use the standard grid as the background of the topology view.

The Visualization Properties lets users customize the following:

Sensor Color Gradient – Allows users to specify the minimum and maximum sensor values and associate specific color with it.

1. Right-click on the Topology bitmap and select Visualization Properties.
2. Click on the Sensor tab of the Visualization Properties
3. Select a Sensor type from the drop-down list
4. Specify desired Maximum and Minimum sensor values
5. Click on the square colored box next to Maximum Color or Minimum Color
6. This will bring up another dialog box
7. Move the square marker on to choose the desired color and click OK.

The Sensor info also lets users display the sensor readings next to the node on the topology map and specify the font for the text.

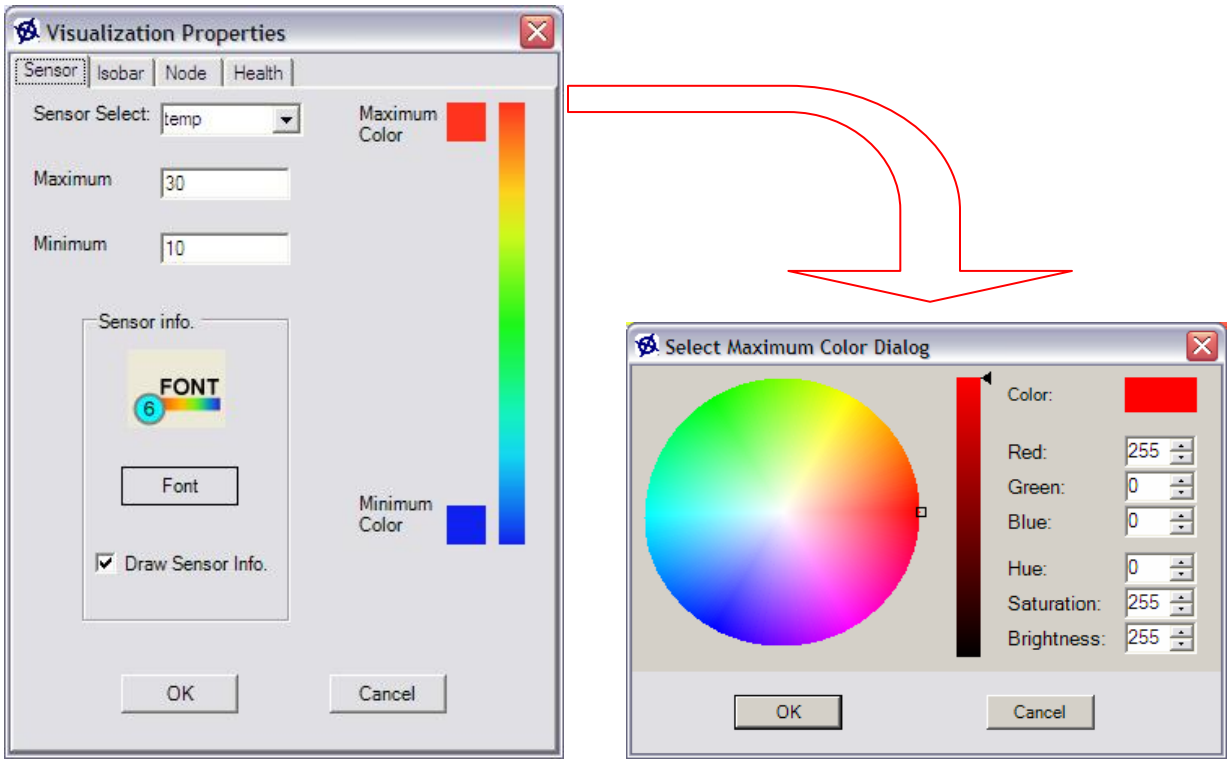


Figure 4-6. Screenshot for Sensor Gradient Visualization Dialog

Mote Visualization – Users can choose from 3 different display styles for nodes.

None – No nodes are displayed

BlackDot – A black dot is displayed to represent the node

MoteGlow – A colored circle is displayed along with the node ID. The circle's color is based on the current sensor value and the minimum and maximum sensor values specified in the visualization properties.

Users can also check options for Draw Links between nodes and specifying whether Gateway has a sensor on it for gradient visualization.

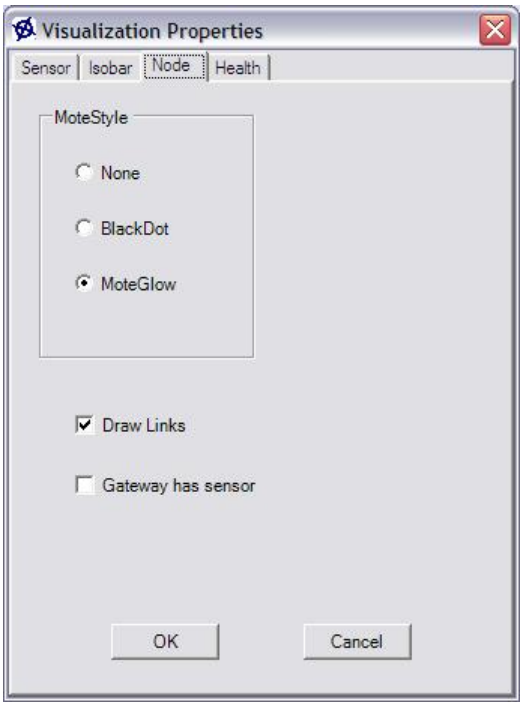


Figure 4-7. Screenshot for Mote Visualization Dialog

To view a color gradient superimposed on the topology view, select the **Draw Gradient** radio button in the **Isobar Visualization** box.

Users can also specify the **Mote Radius** (as a percentage of bitmap image size; 0=0%, 10=100%) for spread of gradient around the node; check options for displaying the ScaleBar Legend and drawing the Logo.

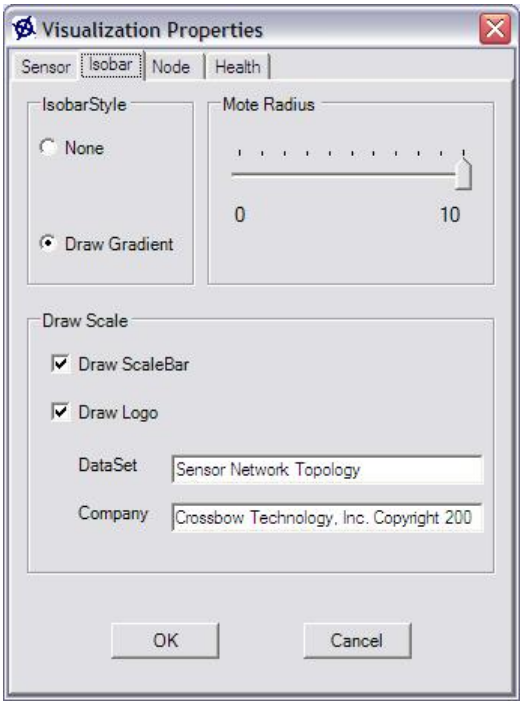


Figure 4-8. Screenshot for Isobar Visualization Dialog

Health Visualization - Users can specify the time duration after which the link between the nodes goes grey. If a packet is not received from any after the specified minutes, the link would turn grey.

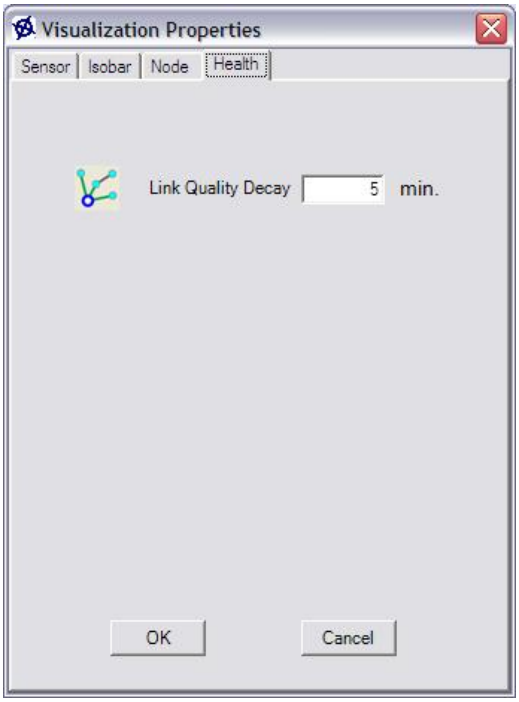


Figure 4-9. Screenshot for Link Quality Visualization Dialog

4.3.5 Live/Historical/Playback Mode

In order to have *MoteView* display data from an active sensor network, the users must check on the **Live** checkbox. In Live mode, *MoteView* refreshes the node list, charts, and topology views as packets are received at the base station.

If **Live** is unchecked, the **time-bar** at the bottom of the visualization tabs will be enabled. This allows users to scroll back and forth and view data collected at different times. The **time-bar** interface is supported on the **data** and **topology** tabs.

On the right-hand side of the **time-bar** are a collection of **playback** controls. Scroll the time-bar to a specific time and press the play button to view an animation of the data collected over time. Right-clicking on these controls will open a settings dialog that allows the user to set the playback interval.

5 Menus

The *MoteView* menu area contains the **File**, **Settings**, **Tools**, **Units**, **Help** menus and a toolbar providing quick access to some of the more common features of the *MoteView* application. From left to right, the toolbar provides buttons for database connection, data logging with *XServe*, *MoteConfig*, Alerts Manager, export to spreadsheet file, print, print preview, refresh view, and displaying live (vs. historical) sensor network data. This chapter will describe the features in each of these menu items.

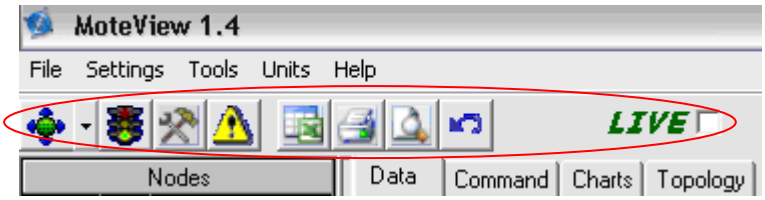


Figure 5-1. Screenshot showing a portion of the MoteView window to highlight the icon toolbar menu

5.1 File

5.1.1 Connect to MIB510/MIB520/MIB600

This will bring up the Connect to MIB510/MIB520/MIB600 dialog which enables a user to start and stop logging Mote data on the user's PC ("**localhost**") using the *XServe* software tool.

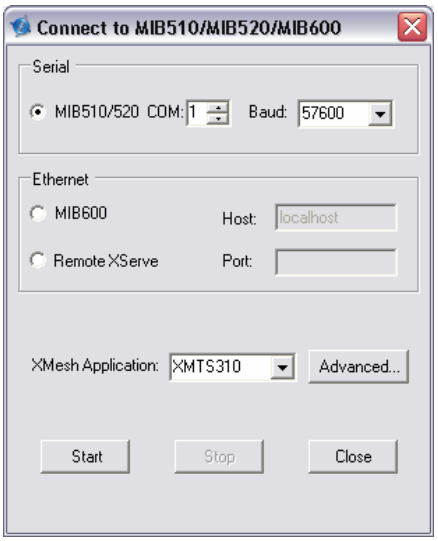


Figure 5-2. Connect to MIB510/MIB520/MIB600

Pressing the **Advanced** button opens the Advanced Logging Dialog.

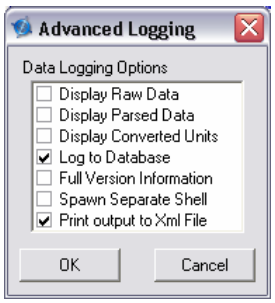


Figure 5-3. Advanced Logging Dialog Window

Table 5-1. Description of advanced logging options and the equivalent *XServe* flag

Advanced Logging Option	Description	*XServe* flag
Display Raw Data	The raw packet bytes coming into the PC.	`-r`
Display Parsed Data	The raw ADC values displayed as parsed fields.	`-p`
Display Converted Data	The incoming data converted to engineering units.	`-c`
Log to Database	Will store raw ADC values to *PostgreSQL* database.	`-l`
Full Version Information	Display exact version for all board modules	`-v`
Spawn Separate Shell	Launches *XServe* in command line shell	n/a

The **Start** button will be enabled if *XServe* is not already running. Clicking on **Start** will initiate *XServe* as a separate process with the given options. The output of *XServe* will be streamed to the **Server Messages** pane. If **Spawn Separate Shell** has been selected, the *Xserve* output will be displayed in the *Command* window, as shown above in Figure 5-4.

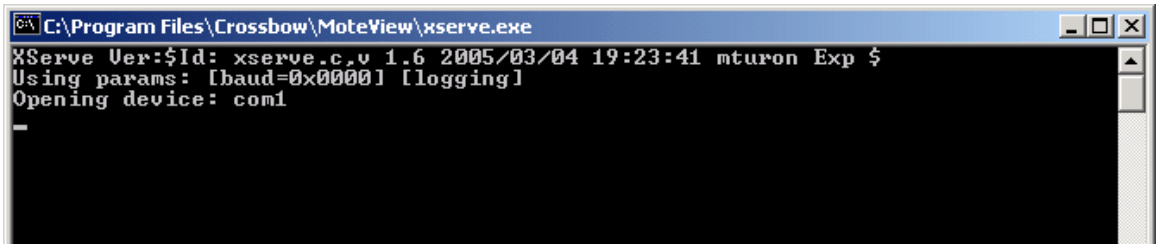


Figure 5-4. Portion of a *Command Prompt* window that appears once the data logging has started

If **Log to Database** is selected, Xserve will output the SQL statements used to insert the contents of each data packet as they arrive. Following is an example of the MTS400 and MDA300 SQL statements.

XMTS400 / XMTS420 Logging Output

```
INSERT into mts420_results
(result_time,nodeid,parent,voltage,humid,humtemp,inte

rsemacal1,intersemacal2,intersemacal3,intersemacal4,prtemp,press) values
(now(),

0,126,377,1391,6517,45446,46808,38941,45989,26835,18130)
```

XMDA300 Logging Output

```
INSERT into mda300_results
(result_time,nodeid,parent,voltage,humid,humtemp,adc0
,adc1,adc2,digi0,digi1,digi2) values
(now(),0,126,377,960,6678,2500,2243,2505,0,0,0)
```

5.1.2 Connect to Database

The **Database Server Configuration** dialog can also be opened by clicking the Connection  icon on the toolbar.

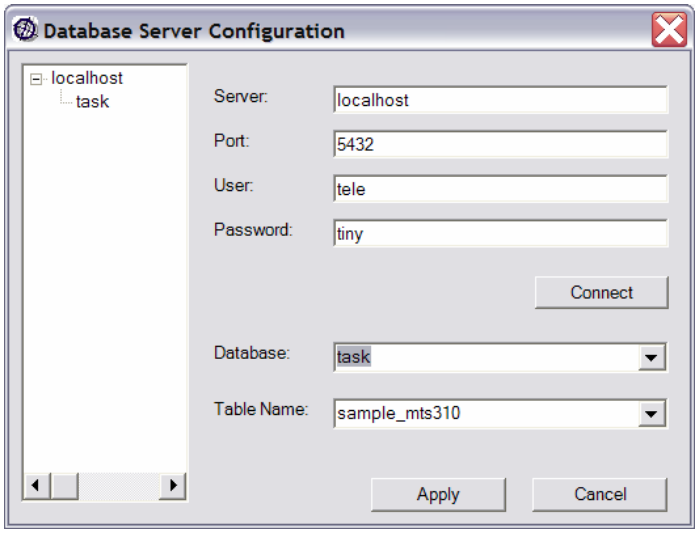


Figure 5-5. The Database Server Configuration dialog box

Specify the following fields:

- **Server**: Can be a hostname or IP address. To specify your workstation as a local server enter **`localhost`**.
- **Port**: TCP/IP port of *PostgreSQL* database server. Defaults to **`5432`** which is the standard *PostgreSQL* port.
- **User:** username for database server - **`tele`** is the default.
- **Password**: password for database server - **`tiny`** is the default.

After typing in the four fields above, click the **Connect** button to attempt to connect to the specified database and update the pull down lists for what is available on that server.

To complete server selection, the pull down lists should then be used to specify which result set on the server is to be viewed:

- **Database**: All available *PostgreSQL* databases on the server will be displayed

- **Table Name**: The table files containing results to be viewed. This is populated with available tables.

After selecting a database, table, and client, the user may click **Apply** to have *MoteView* display the results data for the selections. **Cancel** will close the dialog window.

Saved configurations are stored in the tree view to the left in a nested fashion. The server names are listed with the database names enclosed within. Clicking a server name opens the list of saved databases on that server. Clicking on a database name loads those settings into the fields on the right. To connect to a saved configuration, click on the database name and click **Apply**. When a database has multiple result tables, the last saved table will be used.

5.1.3 Import

MoteView can import data from a previously exported SQL data file. This will modify the contents of your database

5.1.4 Export

You can export data into 5 different formats

- *Export Database to SQL* – exports the entire task database to an SQL file
- *Export Table to SQL* – exports the contents of the current table in the task database to an SQL file
- *Export Table to Spreadsheet* – exports the contents of the current table in the task database to a spreadsheet file (delimited text file). The delimiter (comma, tab, space) can be specified in the Settings menu.
- *Export Table to XML* – exports the contents of the current table in the task database to an XML file.
- *Export Active Tab to JPEG* – exports an image of the current tab view to a JPEG file

5.1.5 Print Preview

The Print Preview screen will display the expected output for the Print command for the active visualization tab. The magnifying glass icon allows you to zoom in on the preview. The printer icon will immediately print out the page to the default printer.

5.1.6 Print

This menu items prints the active visualization tab.

5.1.7 Exit

This menu option will exit the application and close *MoteView*. *MoteView* always attempts to save the current configuration when closed and restore that configuration the next time the application is started.

5.2 Settings

5.2.1 General

- *Server Heartbeat* – The user can select how many heartbeat messages are displayed in the Server Messages window. These messages are sent by the xmeshbase firmware at 5 second intervals

- *Playback settings* – The user can set the speed at which historical data is displayed when using the playback controls on the right-hand side of the time-bar.

5.2.2 Node

- *Health Status* – Opens the node health settings window described in Section 4.

- *Properties* – Opens a node properties window for a selected node

  It allows the user to assign a **Name** and **Group** of the Mote.

  The **Color** tab allows the user to select the charting color for the Mote.

NOTE: The **Sensorboard** tab of this dialog is only used to display calibration coefficients for boards that are equipped with an Intersema pressure temperature sensor such as the MTS400, MTS420, and MEP410.

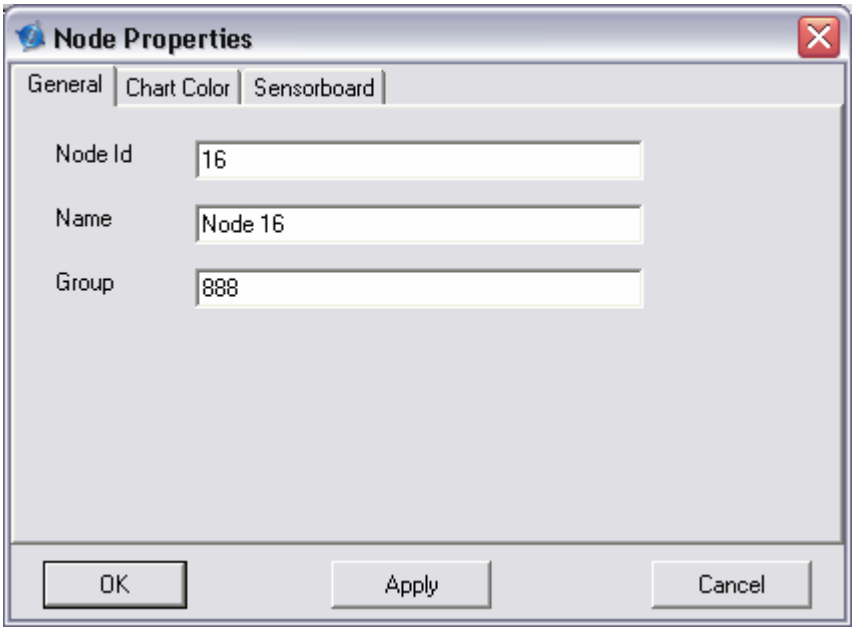


Figure 5-6. Screenshot of the Mote Properties dialog window

5.2.3 Spreadsheet Delimiter

This feature specified how the spreadsheet file (delimited text file) separates its data values. 3 delimiters are available (commas, tabs or spaces).

5.3 Tools

5.3.1 Refresh View

This will force a visual refresh of all visualization windows in *MoteView*. After clicking on this menu the **Nodes list**, the **Chart**, and **Topology** views will all update to display the latest information from the sensor network.

5.3.2 Add Node

This will bring up the Mote Properties dialog which allows the creation of a new node with a user-specified Node ID and name.

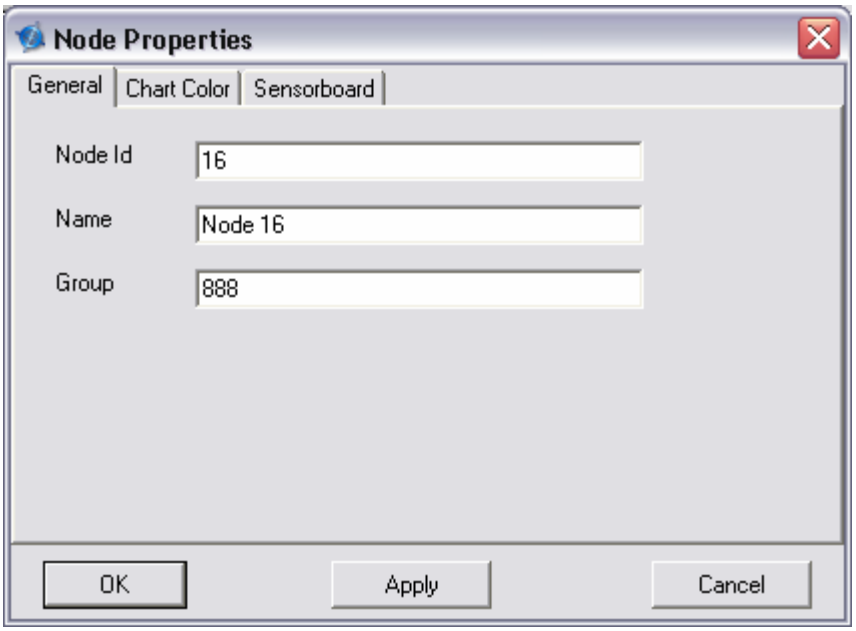


Figure 5-7. Screenshot of the Mote Properties Dialog Window

5.3.3 Program Mote

This opens a separate application called *MoteConfig* which allows users to download firmware to a Mote over a gateway and over the air. Details are available in the *MoteConfig User's Manual*.

5.3.4 Alerts

The *MoteView* alert manager allows users to define alert conditions based on any sensor data of any sensor node. An alert is a user programmable event that gets triggered when sensor data exceeds pre-defined threshold. An alert is composed of several pieces:

1. **Alert ID** – A sequential number to identify the alert
2. **Node Name** – the node whose conditions can trigger an alert
3. **Sensor Name** – the sensor whose readings can trigger an alert
4. **Alert Condition** – the comparison operation to decide when an alert should be triggered
   - Equals
   - Exceeds

- Below
- Exceeds or Equals
- Below or Equals

5. **Alert Threshold** – the value to compare the alert condition against
6. **Unit** – the unit for the alert threshold
7. **Alert Action** – the operation to perform in response to a triggered alert
   - Display a message dialog and console message
   - Send an email (allows text paging a mobile phone)
8. **Alert Interval** – specify the interval for the action to be taken.
9. **Alert Duration** – specify the time interval of the alert condition before the alert should be triggered.

To set an Alert, follow these steps below:

1. Chose from **Tools > Alerts > Alert Manager...** and click the button "**Add New Alert Item**". This operation will add a blank alert item to the list with Alert ID 1 as shown in Figure 5-8.

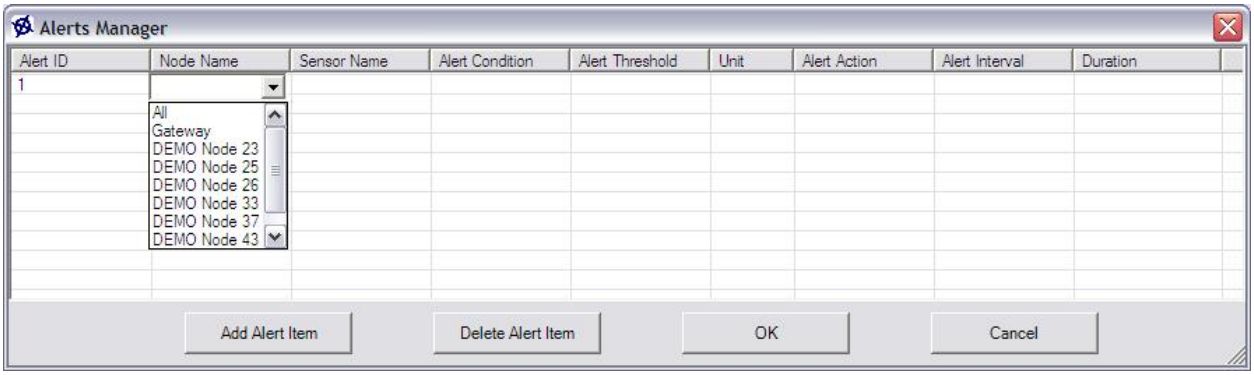


Figure 5-8. Screenshot of the Alert Manager

2. From the **Node Name** drop-down list, select a node that is currently a part of your deployment.
3. From the **Sensor Name** drop-down list, select a sensor that you want to use to trigger the Alert. This automatically updates the Unit column associated with that particular sensor type.
4. From **Alert Condition** drop-down list, specify an appropriate condition to trigger the Alert, viz. "**<**", "**>**", "**<=**", "**>=**", "**=**".
5. For **Alert Threshold** field, input numerical value in the text box.
6. From **Alert Action** drop-down list, chose an action, "**Send Alert Email**" or "**Pop-up Alert Form**".
7. From the **Alert Interval** drop-down list, specify the interval for the Alert to be sent.
8. From **Duration** drop-down list, specify the time duration for which the Alert Condition needs to be met before the Alert Action can be triggered.

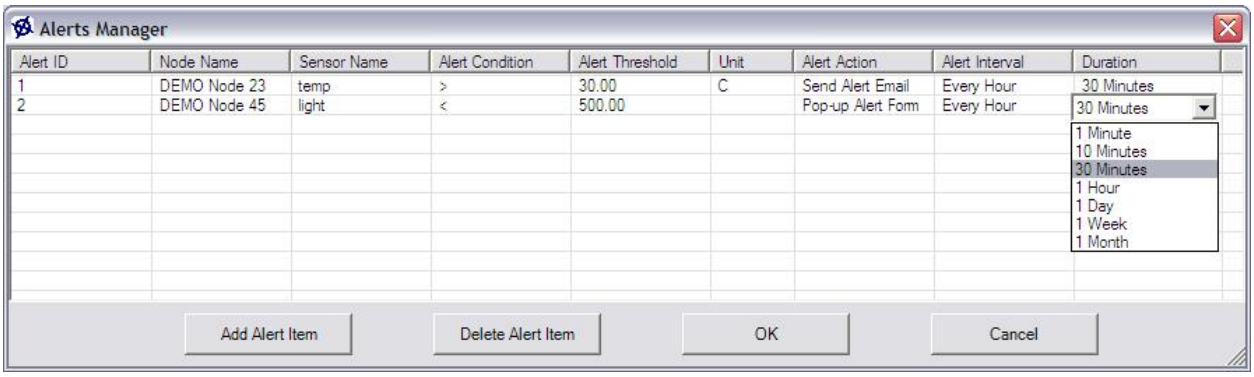


Figure 5-9. Screenshot of the Alert Manager after adding two Alerts

To delete an alert, select and highlight the item that you wish to delete then click the "**Delete Alert Item**" button, the selected alert item will be deleted.

For the Alert manager to send Email, the users should first configure the mail settings. This can be accomplished as follows:

1. Click from **Tools > Alerts > Alert Mail Configure...** and that will bring up the dialog box shown in Figure 5-10
2. Enter the **SMTP Server** name of your mail server
3. Specify the **User Name** and **Password** of your mail account
4. In **Send To** field, specify the Email address where the alert needs to be sent
5. Enter any optional **Message** to be sent in the body of the Email
6. Click on **OK**.

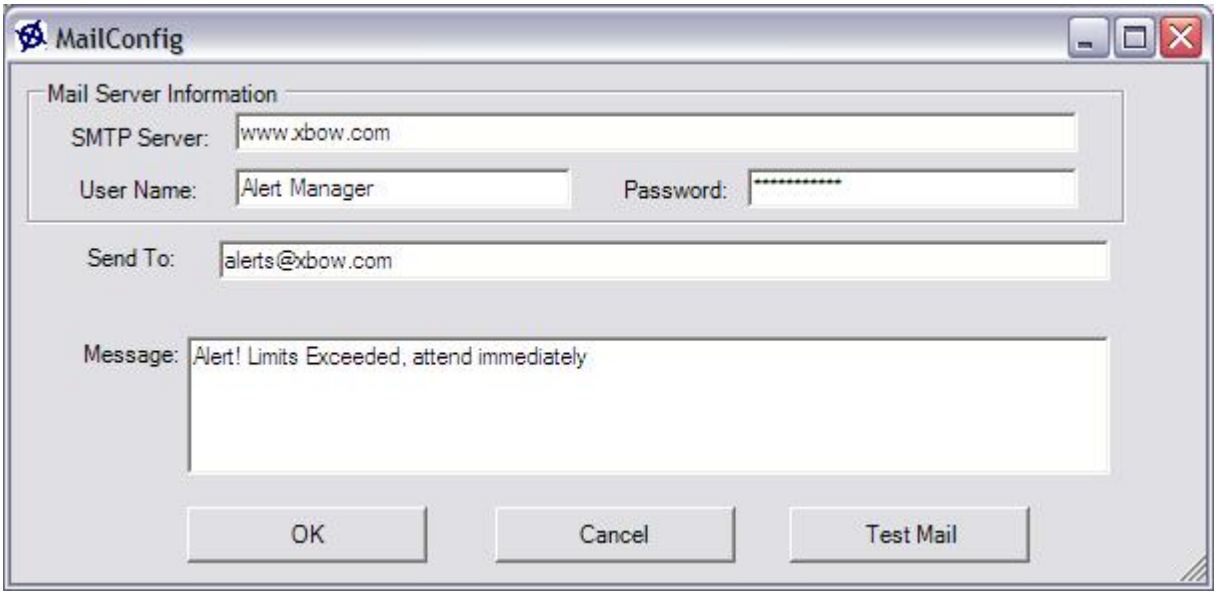


Figure 5-10. Screenshot of the Alert Mail Configuration

5.3.5 MDA Support

MoteView allows users to define their own calibration parameters to convert from raw voltage into engineering units for external sensors when connected via MDA series data acquisition boards. Users can specify the calibration coefficients for each of the available channels.

MDA Support interface allows the users to define custom external sensors, conversions, and associate them with channels on a data acquisition board. It is composed of several pieces:

- MDA Board Type – MDA100, MDA300, MDA320 or MDA325, MDA500
- Sensor Type – Configuration name associated with an ADC channel
- Configuration Name – assigned to a particular sensor
- Units – Engineering units associated with a particular configuration/conversion
- Conversion type – Third order polynomial, look up table or thermistor

To create a new external sensor configuration, follow these steps:

1. MDA Configuration dialog window can be started by clicking on **Tools > MDA Support**. This will bring up a window shown in Figure 5-11**.**

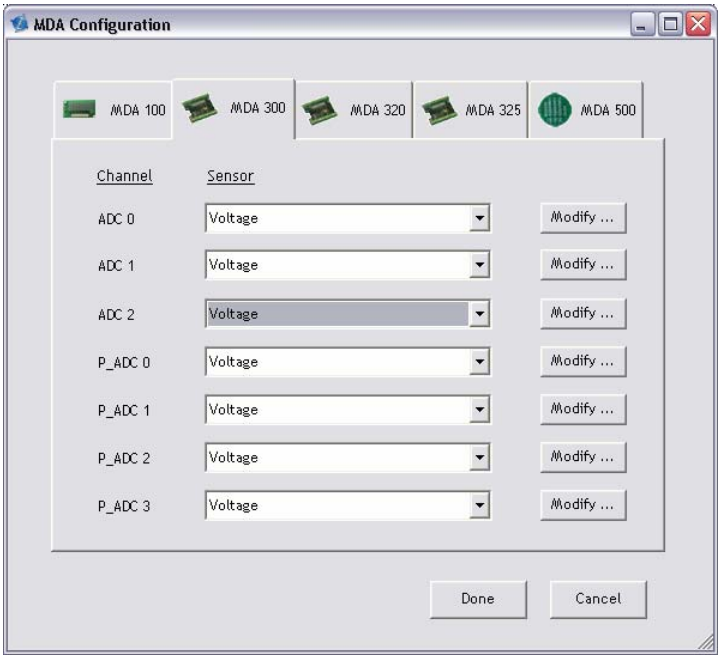


Figure 5-11. Screenshot of the MDA Configuration Support

2. Select the specific MDA board type that you are currently using to connect external sensors.
3. Next to the Channel of interest, from the **Sensor** dropdown box see if any of the choices is relevant to you. If not, click on **Modify...** This will bring up a dialog window for Sensor Configuration as shown in Figure 5-12.

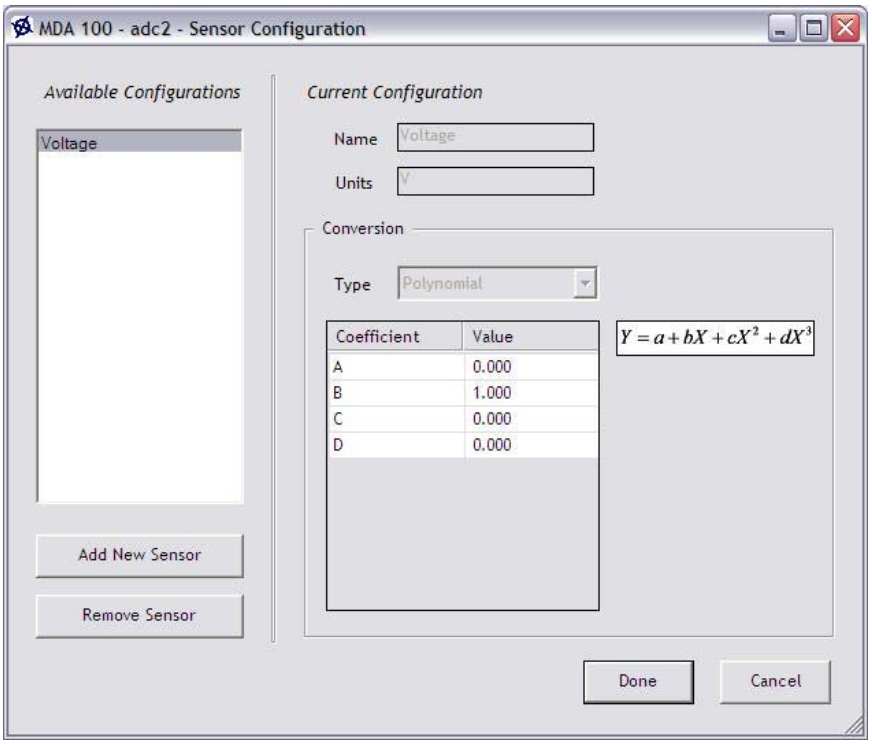


Figure 5-12. MDA Sensor Configuration

4. Click on **Add New Sensor**.
5. Edit the **Name** and **Units** under Current Configuration group box.
6. Under Conversion group box from the **Type** dropdown, select the calibration type (i.e. **Polynomial**, **Look Up Table** or **Thermistor**).
    a. If you used **Polynomial** as the conversion type, then specify the Coefficient values (a, b, c and d) to convert from raw voltage (X) into engineering units (Y) as shown in Figure 5-13.

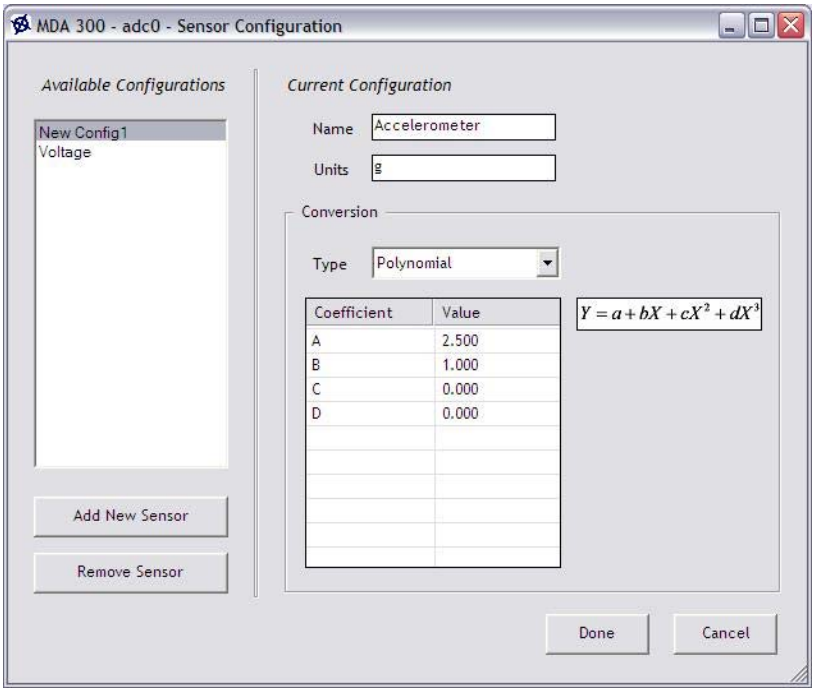


Figure 5-13. MDA300 Sensor Configuration using the Polynomial Conversion

b. If you used **Look Up Table** as the conversion type, then input the **Voltage** readings and corresponding engineering values in the table as shown in Figure 5-14. Users can add or delete a row using the **Add Row** or **Delete Row** buttons.

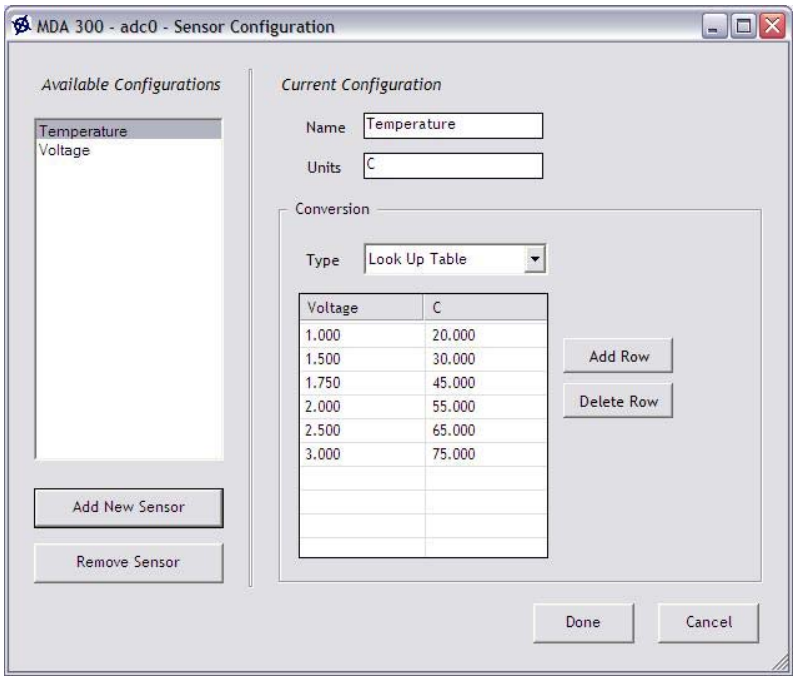


Figure 5-14. MDA300 Sensor Configuration using the Look Up Table Conversion

a. If you used **Thermistor** as the conversion type, input the excitation voltage, external fixed resistance and the Steinhart-Hart coefficients as shown in Figure 5-15. Note that the converted temperature is only available in degrees C.

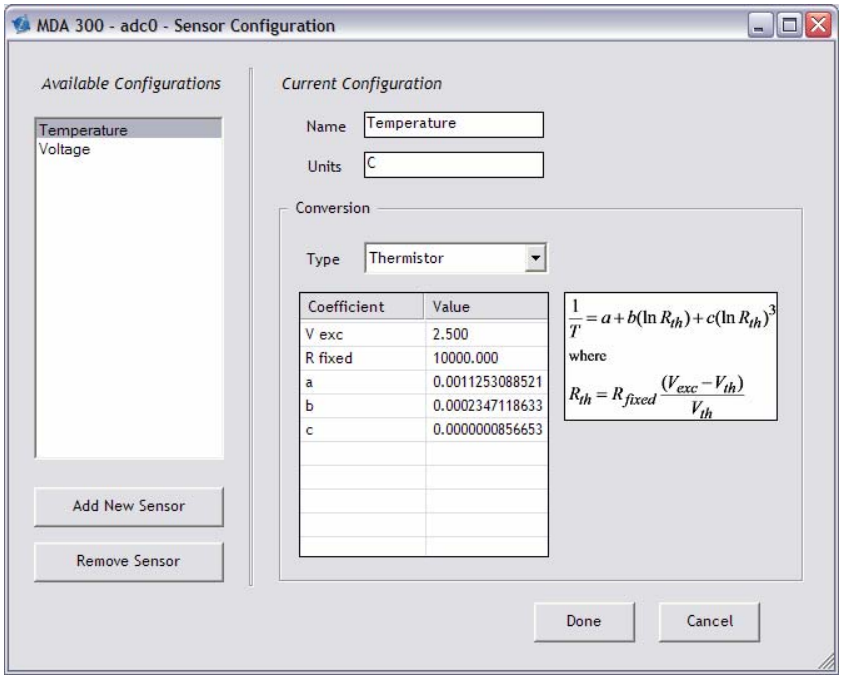


Figure 5-15. MDA300 Sensor Configuration using the Thermistor Conversion

7. Click on **Done** for the new Sensor Configuration to take effect.
8. This saved Sensor Configuration will now be available in **Sensor** dropdown box of Figure 5-11 and can then also be used for other ADC channels.
9. Users can remove a particular sensor configuration by highlighting it and then clicking on **Remove Sensor**.

5.3.6 Reset Database

This executes a script that will delete all data from and reinitialize the task database. This feature is not supported for remote databases.

5.4 Units

The units menu allows the user to select their preferred engineering units for a given class of sensor. All sensors of that class will convert to the units specified by the user. A user may select to view raw data as direct ADC readings instead of a particular unit. The units for a specific sensor can be changed by right-clicking on the **column header** in the **data** tab.

5.5 Help

5.5.1 MoteView User's Manual

This menu item opens the *MoteView User's Manual*.

5.5.2 Support

This menu item opens a browser window to the Crossbow support webpage if your PC is connected to the internet.

5.5.3 About

This displays a splash screen containing *MoteView* version information.

5.6 Server Messages

The S**erver Messages** pane is the bottom section of the *MoteView* window and displays server side messages, database errors, and general status messages as *MoteView* is running.

6 Server Administration

XServe is a powerful packet parsing and data logging server preinstalled by *MoteView*. A user may run *XServe* from a *Cygwin* shell (included in the MoteWorks CD).

NOTE: To use the command line interface for *XServe* you **must** have the *Cygwin* shell installed on your PC. Instructions for installing *Cygwin* from *MoteWorks* InstallShield Wizard are detailed in the *MoteWorks Getting Started Guide*.

For proper operation, the `cygwin1.dll` library in the *MoteView* installation directory must exactly match the `cygwin1.dll` library in the user's *cygwin/bin/* directory.

MoteView starts Xserve when a logging session is started as described in sections 3.2 and 5.1.1. To understand how Xserve can be used from a *Cygwin* shell, type **`xserve -?`** to display the command line options.

```
Usage: xserve <-?|r|a|p|c|xr|xp|xc|dbxmlr|xmlp|xmlc|v|alert|m>
              <-l=tablename>
              <-dbserver=servername> <-dbport=portnum>
              <-dbname=database name> <-dbuser=username> <-dbpasswd=password>
              <-h=path,hostname,portnum,config_file>
              <-m=com,baud,protocol,slaveaddress,defaultregistervaluesas>
              <-xmlfile=filename> <-xmlport=portnum>
              [<-sf=hostname:port> | <-fsf=hostname:port> | <-device=dev>]
              <-port=num> <-baud=num> <-platform=plt>
              <-debug=level>
              <-configfiles=filename:filename:>
              <-loadparsers=filename:filename:...>
              <-loaddatasinks=filename:filename:...>
              <-heartbeat=<num missed>

   -?         = display help [help]
   -r         = raw display of tos packets [raw]
   -a         = ascii display of tos packets [ascii]
   -p         = parsed display of tos packets [parsed]
   -c         = converted display of tos packets [conveted]
   -xr        = raw tos packets xported to file [export raw]
   -xp        = parsed tos packets exported to file [export parsed]
   -xc        = converted tos packets exported to file [export converted]
   -db        = parsed tos packets exported to db [database parsed]
   -dbserver  = database server name (default=localhost)
   -dbport    = database server port number (default=5432)
   -dbname    = database name (default=MoteView db)
   -dbuser    = database user (default=MoteView user)
   -dbpasswd  = database user password (default=MoteView user password)
   -l         = parsed tos packets exported to db
                (deprecated) [database parsed]
   -xmlr      = raw tos packets exported to xml [xml raw]
   -xmlp      = parsed tos packets exported to xml [xml parsed]
   -xmlc      = converted tos packets exported to xml [xml converted]
   -xmlfile   = file name to store exported xml (default=screen)
   -xmlport   = port number to start the xml server
   -v         = show version of all modules
```

```
   -h         = display data through web server
   -m         = export data using modbus
   -port      = set server port <default = 9001>
   -sf        = connect to unframed serial forwarder
   -fsf       = connect to framed serial forwarder
   -device    = connect to serial device <default = /dev/ttyS0>
   -baud      = set serial baud rate <default = 57600>
   -platform  = set platform. <default = mica2>
                values=mica2dot|mica2|mica|telos|micaz
   -debug     = set debug level. <default = DBG_WARNING>
   -alert     = alert when data values are above/below specified ranges
   -daemon    = run in daemon mode
   -nomonitor = run without a system monitor
   -configfiles      = load xml configuration files.
   -loadparsers      = load only the listed parsers files from the
                       shared_lib. (default=all files are loaded)
   -loaddatasinks    = load only the listed datasinks files from the
                       shared_lib. (default=all files are loaded)
   -heartbeat        = turn on the heartbeat monitor and reset after <num
                       missed>
   -convZto2         = convert incoming network packets from micaZ headers to
                       mica2 headers and vice versa
   -conv2toZ         = convert incoming network packets from mica2 headers
                       to micaZ headers and vice versa
   -joinfile         = node mapping file for unique ids joining the nextwork
   -noorganic        = disable organic growth for joining nodes
```

Refer to the Xserve User's Manual for more details.

7 Database Administration

7.1 PostgreSQL

PostgreSQL is an advanced relational database system included in the MoteView installer. The database tables that *MoteView* accesses can be manipulated directly by advanced users. To access the *PostgreSQL* database, from a *Cygwin* shell type

```
psql –h localhost –U tele task
```

Below is an example of what you should get as a response to that command:

```
$ psql -h localhost -U tele task
Welcome to psql 7.4.5, the PostgreSQL interactive terminal.


Type:  \copyright for distribution terms
       \h for help with SQL commands
       \? for help on internal slash commands
       \g or terminate with semicolon to execute query
       \q to quit


task=#
```

You can also use the psql command line interface in the *Windows Command* window from the C:\Program Files\PostgreSQL\8.0.0-rc1\bin folder.

7.2 SQL

SQL is the generic command language used to manipulate databases such as *PostgreSQL*. SQL commands can be typed in directly from the *PostgreSQL* command shell. A list of useful commands follows:

7.2.1 Display all readings

Type

```
select * from <tablename>;
```

The **select** statement will display results out **from** the given **<*tablename*>**. The ***** character is a wildcard meaning that all columns should be displayed.

```
task=# select * from surge_results;
        result_time         | epoch | nodeid | parent | light | temp | voltage |
mag_x | mag_y | accel_x | accel_y
----------------------------+-------+--------+--------+-------+------+---------
+-------+-------+---------+---------
 2004-07-12 12:47:54.29425  |   757 |      4 |      0 |   182 |  135 |     229 |
255 |   255 |     200 |     200
 2004-07-12 12:48:02.26325  |   758 |      4 |      0 |   181 |  135 |     229 |
252 |   252 |     200 |     200
```

7.2.2 Display subset of readings

Type

`select field1, field2,... from <tablename> where fieldn condition value;`

The **`select`** statement will display results **`from`** the given **`<tablename>`**. The **`*`** character is a wildcard meaning that all columns should be displayed.

```
task=# select result_time,temp,light from surge_results where nodeid=1;
        result_time         | temp | light
----------------------------+------+-------
 2004-07-12 12:48:07.31025  |  136 |   234
 2004-07-12 12:48:15.29325  |  136 |   232
```

7.2.3 Rename a table

Type

`ALTER TABLE <tablename> RENAME TO <newname>;`

7.2.4 Delete all readings from table

Type

`DELETE FROM <tablename>;`

7.2.5 Deleting specific readings from table

To delete all results before the specified date, type

`DELETE FROM <tablename> WHERE result_time < '2004-11-20';`

To delete all results with ADC voltage reading greater than 400, type

`DELETE FROM <tablename> WHERE voltage > 400;`

To delete all results from node number 3, type

`DELETE FROM <tablename> WHERE nodeid = 3;`

7.2.6 Delete table entirely

Type

```
DROP TABLE <tablename>;
```

7.3 Database Tools

PostgreSQL includes tools for offline manipulation of data besides the psql shell. The more useful of these are described here. These windows command prompt version of these tools are installed to *C:\Program Files\PostgreSQL\8.0.0-rc1\bin* by default. The *psql* tool is available from the *Cygwin* command prompt as well.

7.3.1 PostgreSQL Export

To output the entire task database to a file, e.g., `my_database.out`.

```
pg_dump –h localhost –U tele –f my_database.out task
```

To save the contents of `mts400_results` table to a file of SQL commands named `mts400data.out`:

```
pg_dump –h localhost –U tele –t mts400_results –f mts400data.out task
```

NOTE: Exporting a database table or the entire database can also be performed by selecting the following from the MoteView menu-bar:

File>Export>Export Database to SQL

File>Export>Export Table to SQL

NOTE: A database table can be exported to an spreadsheet file (tab, comma or space delimited), or XML file by selecting the following from the MoteView menu-bar:

File>Export>Export Table to Spreadsheet

File>Export>Export Table to XML

7.3.2 PostgreSQL Import

To load files from a PostgreSQL exported table, use the following command:

```
psql task < surge.out
```

NOTE: Importing previously exported SQL files can also be performed by selecting the following from the MoteView menu-bar:

File>Import>Import from SQL

8 Health Packets

The pre-compiled *XMesh* applications included with *MoteView* generate health packets at regular intervals. These health packets encapsulate the state of the wireless mesh over time.

MoteView has the ability to display the node health data. To view this data in live mode, select the **Node Health** *XMesh* application from the **Connect to MIB ...** dialog window. To view historical data, select the **node_health** table in the **Database Server Configuration** dialog window.

In addition to the node health packet, each Mote also transmits a neighbor health packet. The latter is logged to the *postgreSQL* database but is not currently displayed by *MoteView*.

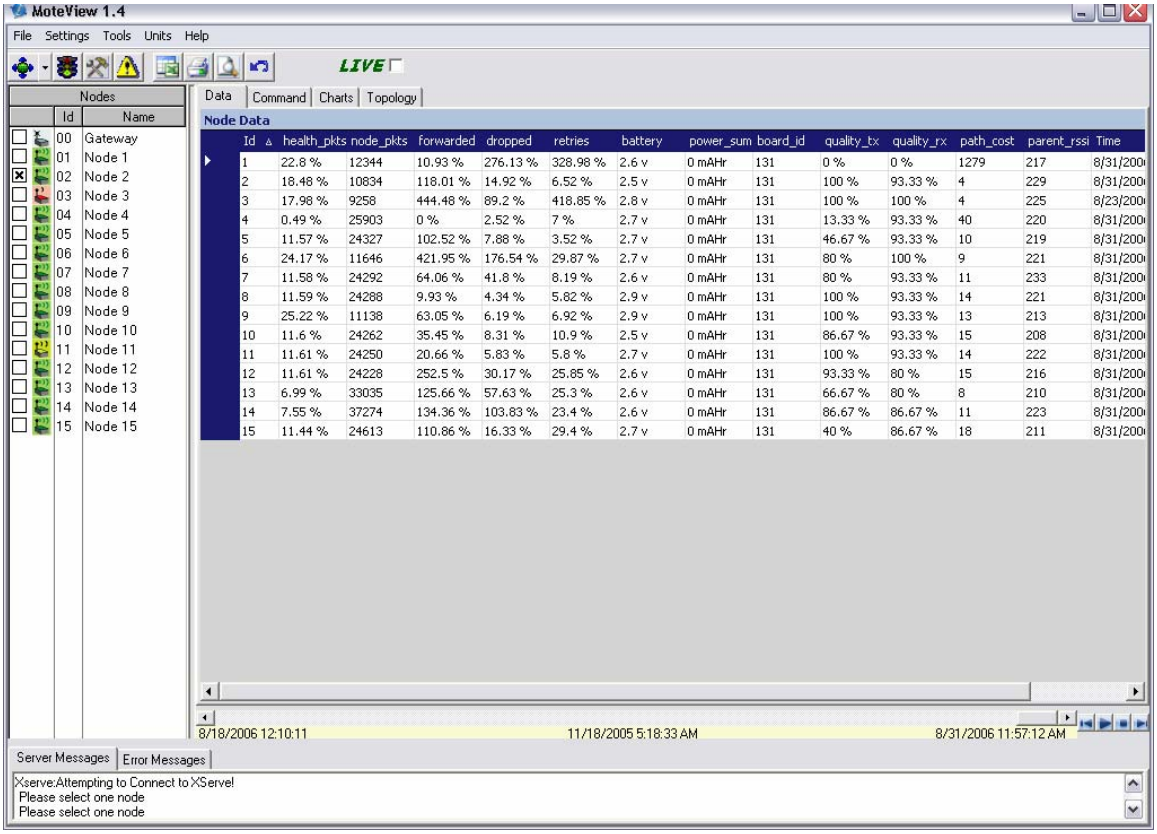


Figure 8-1. Sample Node Health Table

8.1 Node Health Packet Definitions

The node_health table contains the node ID, server timestamp and the following fields:

8.1.1 Node Packets

*Node_pkt*s is the total number of packets that have originated at the node since the last reboot. This number includes all data, node health, neighbor health and route update packets.

8.1.2 Health Packets

Health_pkts is the total number of node health and neighbor health packets that have originated at the node after the last reboot. This number is displayed in *raw units* (number of packets) and *% Packet* (ratio of health packets to node packets).

8.1.3 Forwarded Packets

Forwarded is the total number of packets that the node has forwarded from other nodes. This number is displayed in *raw units* (number of packets) and *% Packet* (ratio of forwarded packets to node packets). A large number would indicate network congestion at this node.

8.1.4 Retry Packets

Retries is the total number of retransmissions that the node had to make due to the fact that the node did receive a link-level acknowledgement.

8.1.5 Dropped Packets

Dropped is the total number of packets that the node has dropped. Packets are considered to have been dropped when 1 packets has been retransmitted 8 times without receiving the link-level acknowledgement. This number is displayed in *raw units* (number of packets) and *% Packet* (ratio of health packets to node packets).

8.1.6 Quality

Quality_tx and quality_rx are estimates of the link-level quality that takes packet collisions into account.

Quality = 1 / Number of transmissions

In *raw units* this is expressed as a number from 0-15 which corresponds to a quality of 0 – 100%.

Quality_tx is the link-level quality from the node to its parent.

Quality_rx is the link-level quality from the parent to a node.

8.1.7 Path Cost

Path Cost is an estimate of the number of transmissions required to send a packet from a node to its base. It takes into account the number of hops and the number of retransmissions per hop that is necessary for a node to send its packet to the base station.

Path Cost = 4 * Estimated Transmission Number (ETX)

Path Cost = 2^{10} / (*quality_tx* * *quality_rx*)

The lowest possible cost is 4; this mean the node requires one transmission to send its packet to the base station.

This number is displayed as a *parent_path_cost* (path cost between a node's parent and the base station) and as a *node_path_cost* (path cost between a node and the base station).

8.1.8 Parent_RSSI

Parent_RSSI is the Received Signal Strength Indicator level of a parent's radio. MoteView displays the raw counts as signed 2's complement integers. To convert these counts to dBm use the following model

- *MICAz Platform*

Convert the unsigned raw counts (x) to a signed integer (y).

If x < 127; y = x

If x > 127; y = x - 256

Convert the signed counts (y) to RSSI in dBm, subtract -45 dBm

RSSI = y – 45 dBm

Example:

Raw Counts = 217

Convert to signed integer → 217 – 256 = -39

Calculate RSSI (dBm) → -39 – 45 = -84 dBm

- *MICA2 Platform*

Calculate VRSSI = raw counts * battery voltage / 1024

P = -51.3 VRSSI – 49.2 [dBm] at 433 MHz

P = -50.0 VRSSI – 45.5 [dBm] at 868 MHz

8.1.9 Battery Voltage

Battery is a measure of the battery voltage available to the Mote.

8.1.10 Board ID

Board_id indicates which sensor board is attached to the Mote.

8.1.11 Power Sum

This measurement is not currently supported by the *XMesh* firmware. This value will always be 0.

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