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Implementation of Wireless Hart Protocol Using Starter Kit DC9007

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Abstract: *The wireless HART standard is the first open standard wireless communication standard for control and measurement in process industries. It uses secure time synchronized mesh networking with frequency hopping between the field devices. It provides reliable, secure, redundant digital communications which fulfills the requirements of industrial applications viz. monitoring, diagnostic, alarm and event detection. This paper provides the approach for establishing the wireless HART network using SmartMesh wireless HART network hardware viz. DC-90007 starter kit.*

Keywords: *reliable, redundant, secure, SmartMesh wireless HART.*

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I. Introduction

There are already some papers in the literature that have worked in the implementation and simulation of wireless HART protocol. We will discuss some of those that are relevant to the present paper. The paper describe in [11] concentrates on the challenges that one can face using the wirelessHART. It presents the performance evaluation using a new network simulator 3 model for wirelessHART physical layer including error model (Gilbert/ Elliot), station positioning, signal attenuation and energy consumption. It also permits configuring each link with different fault probabilities. The paper describe in [12] gives the co- simulation framework based on the interaction of TrueTime, together with a cross layer wireless network simulator based on OMNET++ platform. The paper describe in [1] represents the routing algorithm based on certain requirements such as redundancy, minimum hop, reliability etc. This article mainly concentrates on parameter testing of minimum hop load balancing algorithm. With the help of this work we first implement the wirelessHART protocol using SmartMesh WirelessHART mesh network. WirelessHART is a secure, networking topology operating in the 2.4GHz ISM radio band. As currently envisioned, wirelessHART utilizes IEEE 802.15.4 compatible DSSS radios with channel hopping on a packet by packet basis. WirelessHART network slot may be dedicated to communication between a network pair or a slot may support Slotted-Aloha shared communication access. HART is a master- slave protocol and is loosely organized around the ISO/OSI 7-layer model for communication [3] [4].

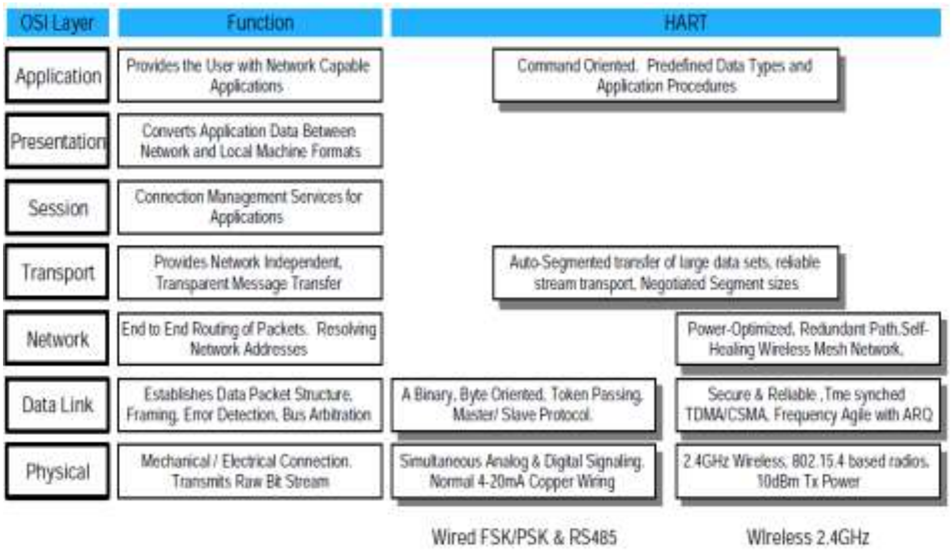

Figure: OSI model structure

1.1 Each WirelessHART should include following components.

1. Field Device –These devices are mounted in the process and must be capable of routing the packets on behalf of other devices.
2. Adapters – connects to the existing HART compatible field devices and enables communication to them via wirelesHART network.
3. Gateways – This enables the communication between the field device and the host applications connected to existing plant communication network.
4. Handhelds – these are the maintenance tools use to configure, maintain or control plant assets.
5. Network Manager – This device is responsible for configuring the network, scheduling the communication between the devices, managing the routes, and monitoring network health. Network manager can be integrated into the gateway, host application, or in process automation controllers.

II. Wireless Hart Frame Format

All data transferred between entities involved in the protocol is transferred in the form of frame. A frame is an encapsulation of user data in control and addressing information. The HART PDU (Protocol Data Unit) consists of 7 fields: Delimiter, Address, Expansion Bytes, Command, and Byte count and check byte. The expansion bytes and data field are optional and may not be present in some messages. Synchronization (Preamble) information is added to this PDU by physical layer. The HART PDU is delimited by combination of unique "start of frame" character (Delimiter) which identifies the frame's beginning and indicates the position of byte count, and by a byte count field which determines where the frame ends. The source and destination of frame is determined by address field along with the frame type. Expansion bytes are optional and their definition controlled by the Hart Communication Foundation (HCF). If a slave device cannot interpret the contents of the expansion bytes then the slave device must not answer the message. The command field identifies the message to the application layer and defines the content of the data field. The data field format is defined later and contains the information transferred between the host application and field device [6].

Figure 1.0: Wireless HART frame format

All portions of the frame including the delimiter shall be protected by a combination off odd parity on each byte transmitted and the trailing check byte field. When all bytes in the frame starting with the delimiter and including the check byte are exclusively or'd (XOR) together the result must be exactly zero (0x00). All fields in a frame must be transmitted in a single contiguous steam (i.e. there should be no more than single idle bit time gap between consecutive characters)[6].

III. Framing

Frame synchronization or "framing" is the process of identifying and receiving a message. For the HART protocol, framing begins at the end of the preamble with the reception of the delimiter. Four key events occurs that allow the successful framing of HART message.[6]

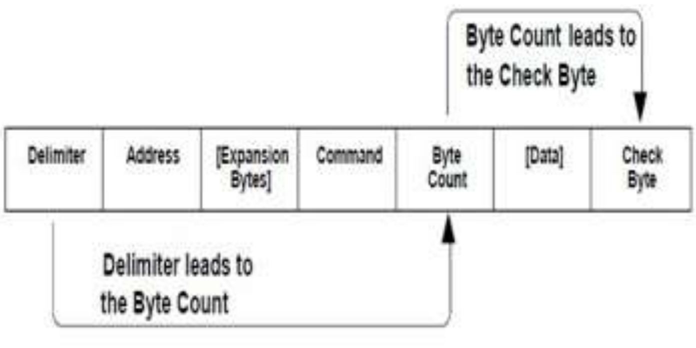

Figure 2.0: Wireless HART framing

3.1 Assertion of Carrier. Once carrier is detected the channel is considered active and non-transmitting devices must stay silent until the end of the (until the reception of the check byte). Communication theory shows that when a valid carrier is present it is impossible for another device to successful transmit a message.
3.2Reception of Delimiter. This allows the capture of the message header (Address, Expansion Bytes, Commands and Byte Count). The delimiter indicates a message.
Reception of Byte Count. The byte count is contained in the frame header and allows the data portion of the message to be framed properly.
3.3 Reception of Check Byte. This indicates the end of the message and is a key element in the error checking scheme.

All HART devices must frame all messages. All HART timing and MAC requirements begin with the reception of the check byte. While several errors are possible during message reception, only three are fatal viz. gap error, loss of carrier, communication error receiving the delimiter, address or byte count. A gap error indicates that the transmitting device malfunctioned mid-message. Loss of carrier indicates that there is insufficient signal strength to allow reliable communication. A communication error while receiving the address means that the slave does not know if the message was for him and the slave should not answer. A error in the delimiter or byte count prevents successful framing of the message. All of these error conditions are fatal, aborts the message reception and discards any portion of the message received [6].

3.4 Smart mesh Wireless HART-DC9007 Starter Kit

smartMesh wireless HART products are designed for the harshest industrial environments, where low power, reliability, resiliency and scalability are key. They are well suited for general industrial applications as well as wirelessHART specific design. SmartMesh wirelessHART compiles with the wirelesHART (IEC-62591) standard, offers the lowest power consumption in its class, and is the most wildly used wirelessHART product available for applications that are not HART specific, no knowledge of the wirelessHART specification is needed to integrate with SmartMesh wirelessHART. Simply proceed without the optional HART applicaton layer.The DC9007 SmartMesh wirelessHART starter kit provides all the tools for evaluating SmartMesh network performance with respect to the application needs, including high reliability, ultralow power, scalability and ease of installation. This accelerates device integration and application development. The DC9007 starter kit includes five motes or nodes (DC9007A/C), to enable users to quickly deploy a multi hop mesh network in the radio frequency (RF) environment specific to the application. The software graphical user interface (GUI) allows to quickly see the mesh network form, as a key performance statistics as data reliability and latency.

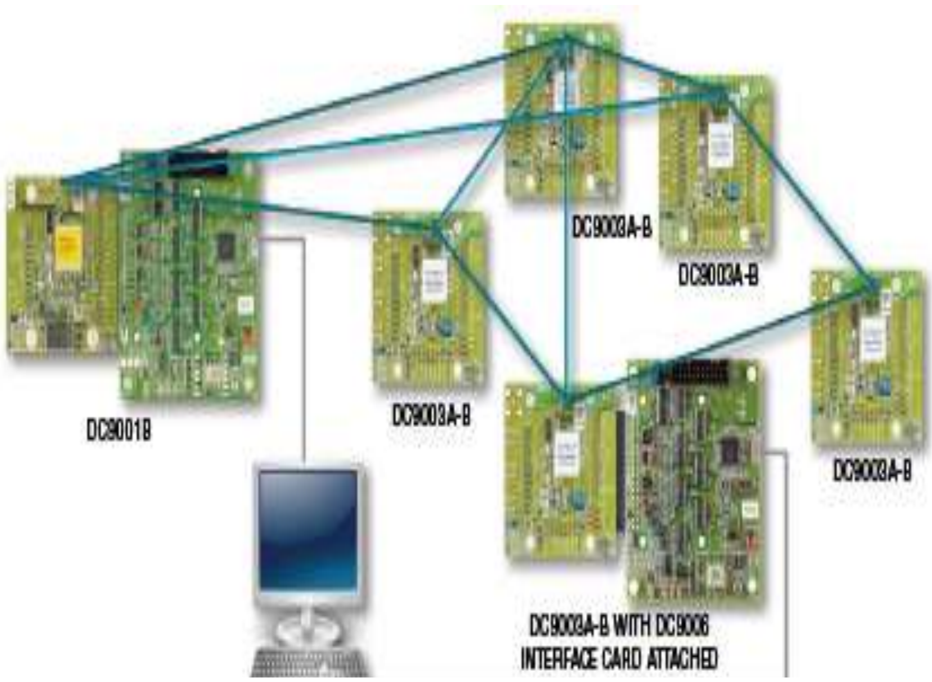

Figure 3.1.1: DC9007 Starter kit

The DC9003A/C evaluation /development mote module features easy-to-probe signal pins. In addition, the starter kit provides access to both manager and mote software application programming interfaces (APIs) to enable application software development. The DC9007 starter kit operates in the 2.4000GHz to 2.4835 GHz international license free frequency band [7], [8].

Serial no.	Component	Description	Cost
1	DC9007 Starter kit	5 motes [DC9003A/C]; 1 network manager [LTP5903cen-whm]; 1 Eterna interface card [DC9006]; CR032 batteries and cables.	1000$
2	MSP430F2 619	16 bit RISC architecture, SPI,I2C, ADC,DAC support	-----

Table 3.1.1: Costing summary of DC9007 starter kit

3.5 Connecting Manager To Computer

The SmartMesh wirelessHART manager is preconfigured with the static IP address for connection directly to a computer. You can temporarily set the computer IP address to a static address that enables the computer to communicate with the manager. The steps are for windows 7 or lower version of windows 7 and windows XP. The steps will vary if using other OS [8].

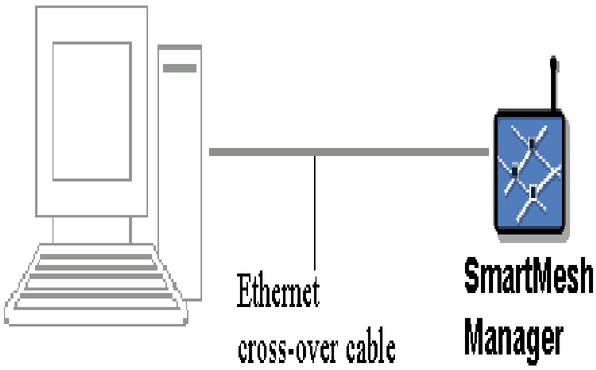

Figure 4.1: connection of manger to computer

1. On Start Menu Click On Control Panel.
2. Double Click Network Connection.
3. Right Click Local Area Connection, And Then Click Properties

4. Click On Use Following Ip Address
5. Ip Address 192.168.99.101 And Subnet Mask 255.255.255.0
6. Click Ok To Close Dialog Boxes
7. Once You Are Finished Using Manager You Can Switch Your Computer Ip Address To Your Network.

3.6 Admin Tool Set

Manager provides the web site based administrative tool, called admin toolset which can be used to view network statistics and mote information, configure serial and Ethernet port settings, set the clock or enable the Network Time Protocol (NTP) server, set the network security mode, and execute selective commands. The admin toolset provides a graphical view of the wireless network (Topology Viewer) and interface for configuring the manager. One can also sue the admin toolset to upgrade the manager software as well as to performs remote software updates on the motes in the network. Admin toolset is supported for windows Internet Explorer 7+, Safari 5.0+ and Firefox 10.0+ to run the topology viewer, admin toolset requires that your computer have the JAVA RUNTIME ENVIRONMENT (JRE) version 6 (or later) installed. Following steps are used to access the admin toolset [8].

1. Connect your computer to manager as above or by using a network.

2. Open the web browser.
3. Enter the manager IP address field eg. https:// 192.168.100.

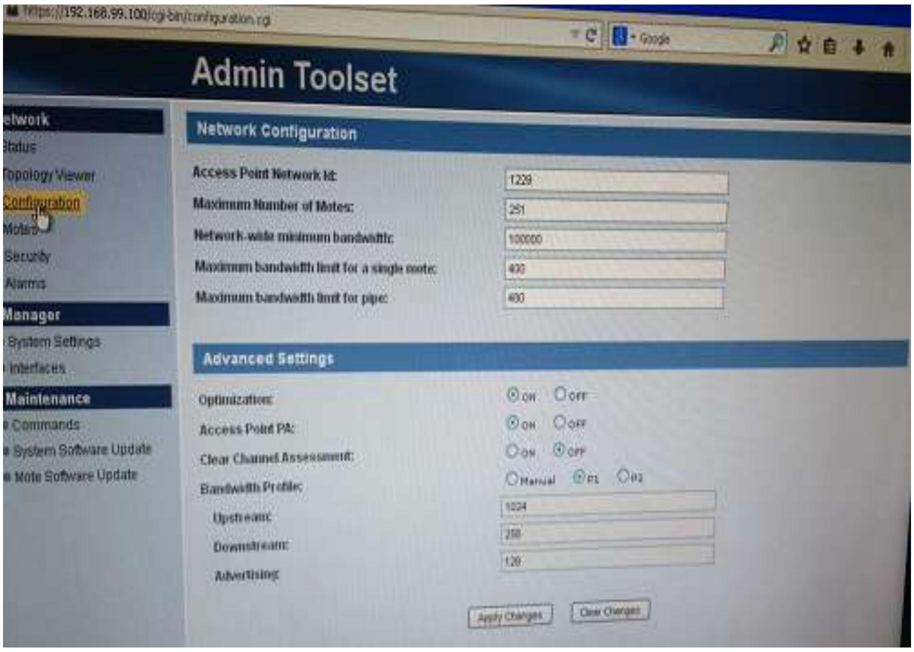

Figure 5.1: view of admin toolset

4. Admin toolset uses secure protocol.
5. Logon by using username and password.
6. Default username is **system** and password is **system**.

3.7 Connecting Manager on LAN

To connect to the manager on the LAN, you will need to change the IP address, as the default IP address is not suitable for most of the network.

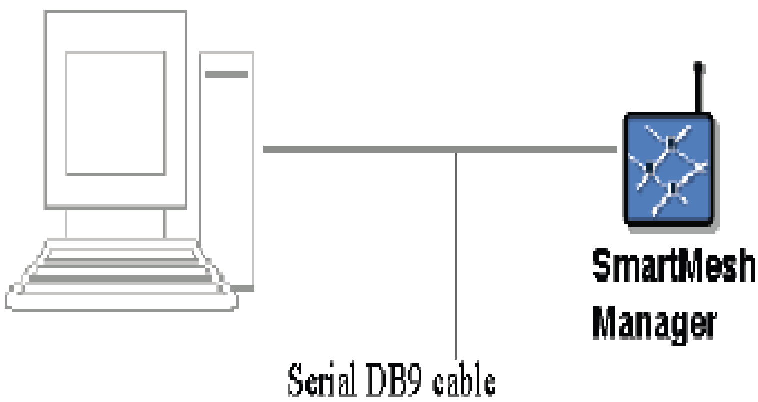

Figure 6.1: Connection of manager to LAN

You can either configure the manager to use DHCP to obtain a LAN assigned IP address, or assigned a static LAN IP address to the manager. If you want to use a static LAN IP address, you will need to obtain it from network administrator. To configure the manager need to have some configuration changes which are given below [8], [7].

1. Established the console connection to the manager using the HyperTerminal for windows XP systems or install TeraTerm or Putty as terminal client on windows 7 systems.
2. Set baud rate: 115200; data bits: 8; parity: NO; stop bit: 1; flow control: NO.
3. At manager login, enter the user name (default: dust)
4. At manager password, enter password (default: dust)

5. Add new console in the manager login using command new console
6. enter username: admin
7. enter password: admin

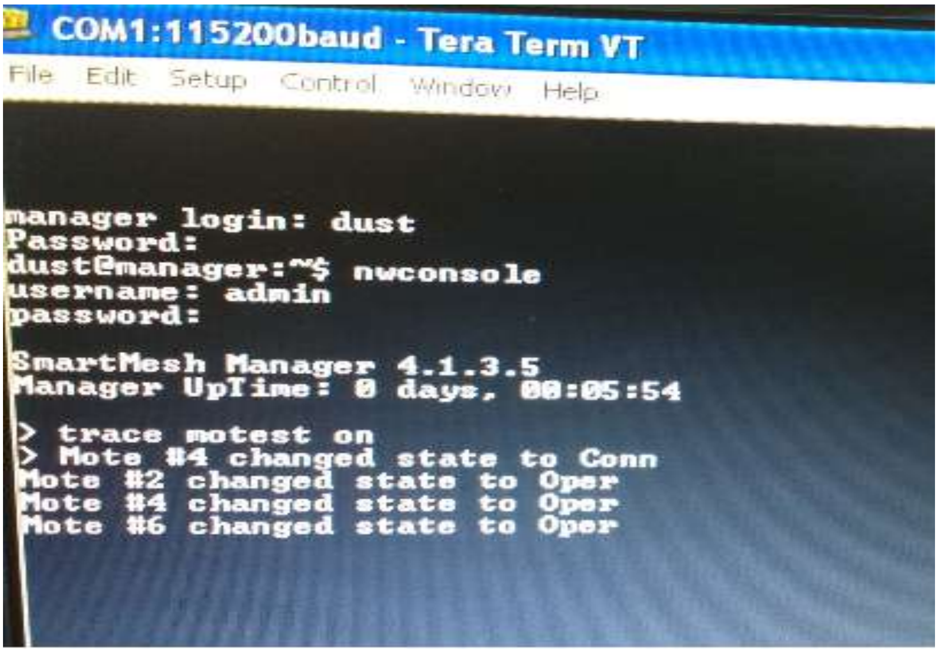

Figure 6.1: Manager connection using TeraTerm.

Once you are connected with manager in using the network, make the motes ON using the hardware key on the mote board. Note that do not make all motes on in a single attempt. Make the first mote ON and execute the command trace motest on in the manager login in TeraTerm, this commands allows the motes and manager to form the wireless mesh network. You can see the motes changing there state from idle to operational with several states in between.

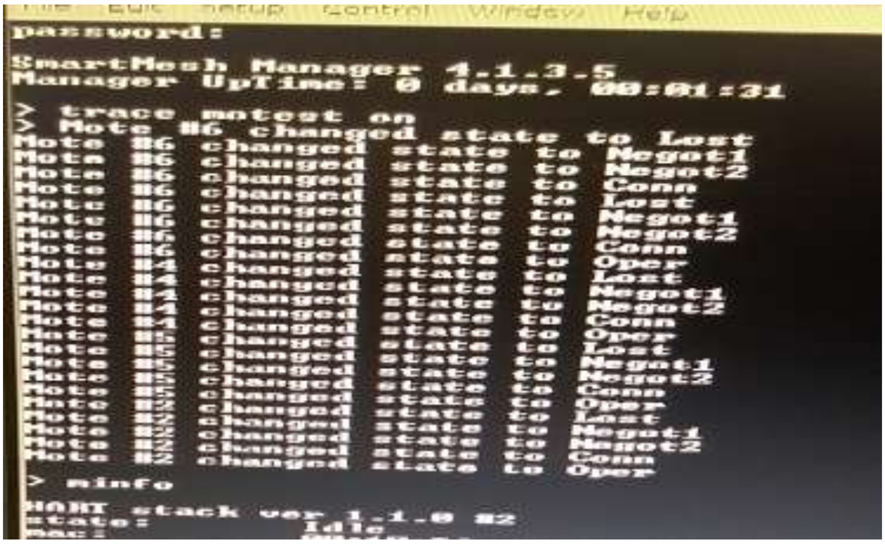

Figure 6.2: connections of mote in wireless network.

3.8 Connecting Mote To Eterna – CLI Interface

Eternal evaluation board (DC9006) is use for the simulation purpose of the wireless HART mesh network. The eternal evaluation board behaves as the sensor controller to communicate with the mote. The eternal board is directly connected to port 1 of the mote while the eternal board is directly connected to the host computer using the micro USB cable [8], [10].

Figure 7.1: Connection of mote and eterna board.

To communicate the eterna with the mote it requires some configuration on the host side. Following are the steps use to configure the host side for successful communication between the mote and eterna evaluation board.

1. Download and install the FTDI driver (http://www.ftdichip.com/drivers/VCP.htm) software and then connect the micro USB cable to the host machine.
2. Once you installed the driver use the same USB port each time for accessing the device.
3. When the installation and mapping of USB port is complete, open the device manager and find out the comp port assigned to the virtual serial ports.
4. Make a note of that comp port.
5. Configure the port as below.

Device	Serial port no.	Usage	Baudrate	Data bits	Parity	Stop bits
Smartmeh Wireless HART Mote	3rd	CLI	9600	8	N	N
	4th	API	115200	8	N	N

Table 7.1: Configuration of comp ports

6. Install the newest version of SmartMesh SDK.
7. After completing the installation of all the software connect the device to the computer and open the CLI port of that device using serial terminal, switch to your device.

3.9 Connecting Mote To Eterna – API Interface

To communicate with the device using API interface we require some API application to be installed on the host machine. API Explorer is a graphical user interface that allows interacting with the application programing interface (API) of all SmartMesh devices. It can connect with IP manager, WirelessHART manager, IP mote running in slave mode, WirelessHART mote running in slave mode [8], [9].

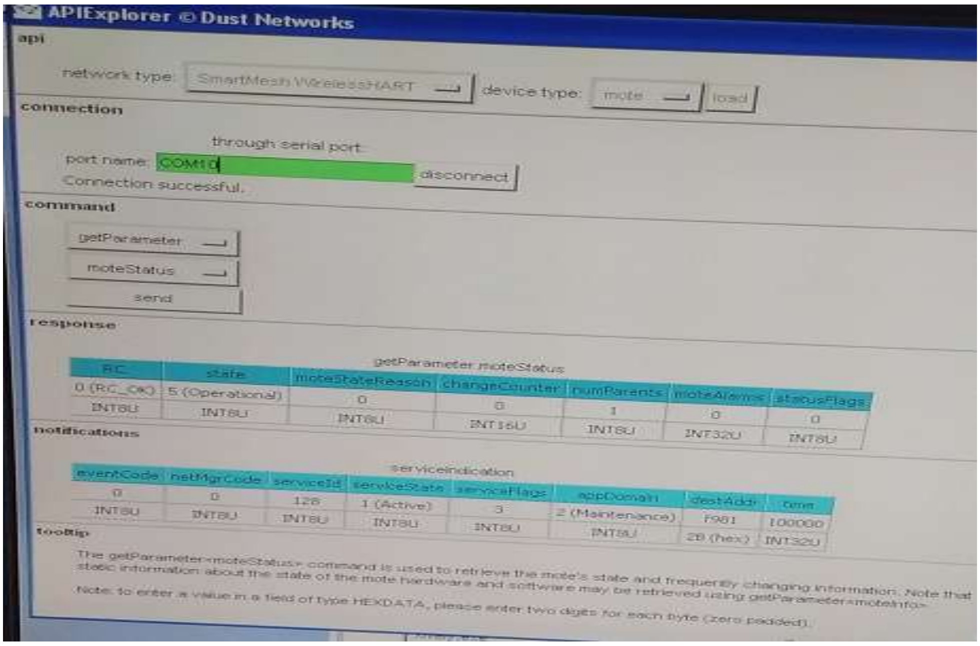

Figure 8.1: API Explorer window

API Explorer is responsible for interacting with the manager and mote. All API commands can be sent from this API Explorer to obtain the response from mote and manager. Above figure shows the example of the command get parameter which is sent to mote and the response is obtained in the response field. PKGen connects to either a SmartMesh IP manager or SmaratMesh WirelessHART manager, allowing you to send commands to the packet generation application to corresponding motes running in master mode. Below figure shows the configuration of mote that sends 300 packets one every 200 mili seconds, each carrying 35 bytes of packet payload [8].

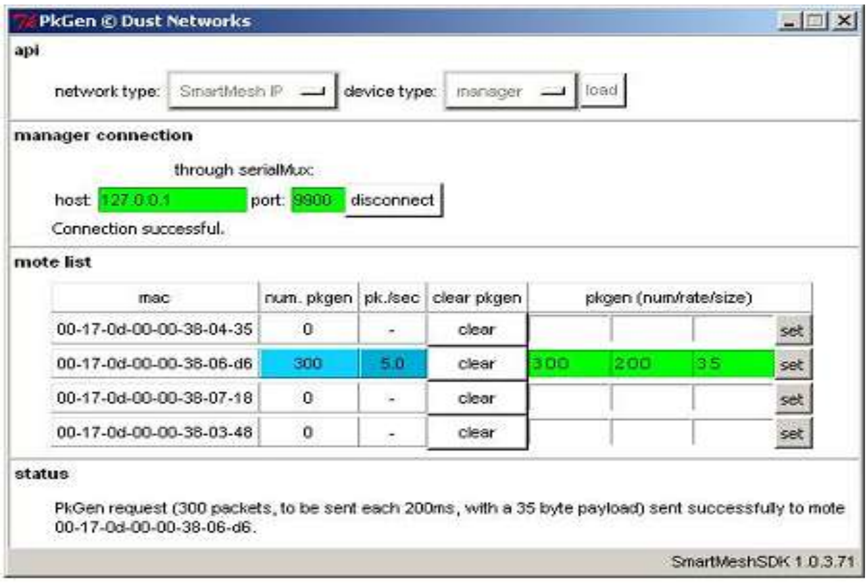

Figure 8.2: PKGen window

3.10 TempMonitor connects to either SmartMesh IP manager or WirelessHART manager, allowing you to send commands to the temperature sampling application on the corresponding motes running in master modes. It interacts with the mote which is in master mode. Below figure shows the example of Temperature Monitor window. TempMonitor is used to monitor the number of packets recived from each mote, monitor the health reports recived from each mote. It retrives temperature and seet the temperature publish rate on any mote.

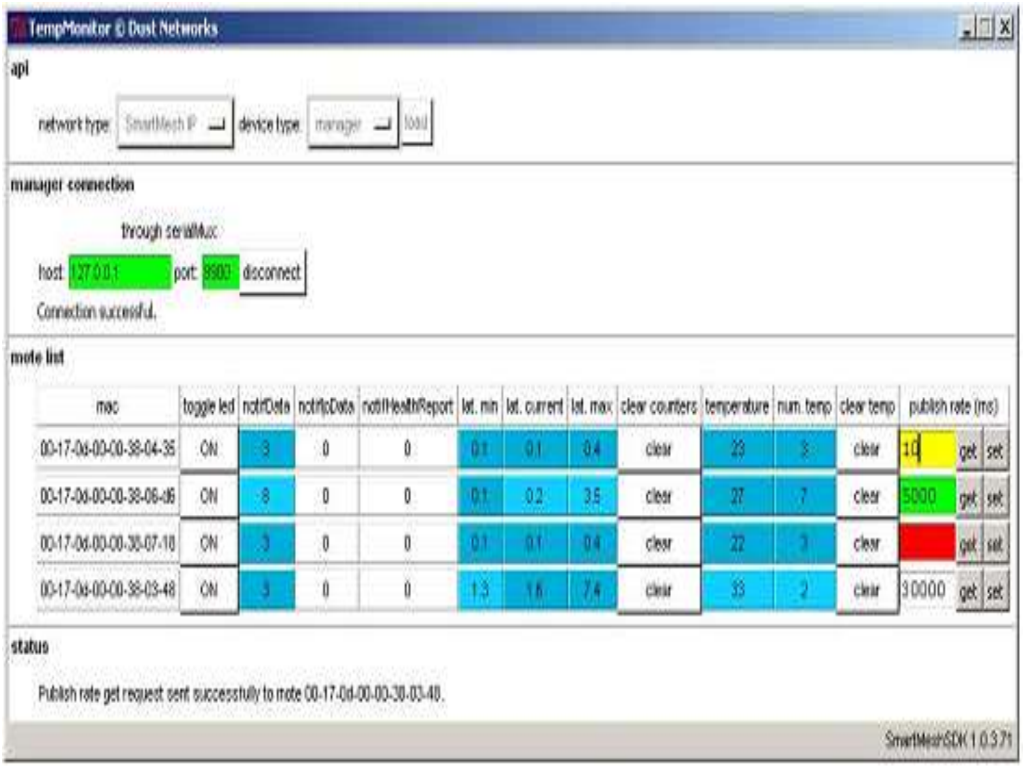

Figure 8.3: TempMonitor window

IV. Results And Conclusion

This paper focus mainly on the interfacing, testing and implementation of the wirelessHART protocol using the SmartMesh WirelessHART mesh network. The mote and manager communication is established and tested using the terminal clients (HyperTerminal, Putty, TeraTerm) on different operating systems. All API commands of mote and manager are sent using the API Explorer and the response of each one is observed in the response field. The mote and the eterna evaluation board are set default in temperature mode. Above figure shown in the section above gives the complete overview about the packets received towards manager of the temperature values. In the future scope one can implement the complete protocol using the actual OEM microcontroller (Sensor/ Field Device) as per the application requirement. After implementation of the protocol in the real time environment we can compare the power consumption, reliability, efficiency of the protocol with some other communication protocol. One can also compare different network scenarios and different node distribution in different environments.

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