Sensor Network Analyzer

User Guide

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May 2005

Version History

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References

[1] IEEE Standard 802.15.4-2003, IEEE Standard for Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Low Rate Wireless Personal Area Networks (LR-WPANS).

[2] ZigBee Network Layer Specification, Version 1.00, ZigBee Alliance.

[3] Application Support Sub-layer Specification, Version 1.00, ZigBee Alliance.

[4] ZigBee Device Objects, Version 1.00, ZigBee Alliance.

[5] Security Services Specification, Version 1.00, ZigBee Alliance.

[6] ZigBee Application Framework, Version 1.00, ZigBee Alliance.

[7] ZigBee Device Profile, Version 1.00, ZigBee Alliance.

Table of Contents

1 System Overview 5
2 Installation & Licensing 6
2.1 Software Installation 6
2.2 Software Activation 7
2.3 Capture Hardware Installation 8
2.4 Connecting the 2400E Sensor Network Adapter 9
2.5 Configure SNA For Capture Hardware 12
2.6 2400E Regulatory Guidelines 13
3 Sensor Network Analyzer Overview 15
3.1 Major Components 15
3.2 Opening the Example Capture Files 15
3.3 Capture from live network 18
4 Operating the Sensor Network Analyzer 19
4.1 Single and Multi-Node Operation 19
4.2 Modes of Operation 19
4.3 SNA Operating Model 20
4.4 Initiating a Capture Session 21
4.5 Capture Options 23
4.6 Multi-Node Capture 24
5 The Protocol Decoder 25
5.1 Packet List Window 26
5.2 The Packet Decode Window 27
5.3 The Packet Data Window 29
5.4 Protocol Decoder Display Filters 29
5.5 Logging 33
6 Device Tree 35
6.1 Device Tree Window 35
6.2 Device Tree Options 36
7 Measurements 38
7.1 Measurements Window 38
7.2 Context Menus 39
7.3 Measurements Options 42
7.4 Available Measurements 43
8 Visual Device Tree 45
8.1 MAC Layer Visualization 45
8.2 Network Layer Visualization 46
8.3 Application (APS) Layer Visualization 50
8.4 Context Menus 52
8.5 Visualization Options 56
8.6 Custom Icons 57
8.7 Device Naming Table 58
9 Security 62
9.1 Security Options 62

9.2 Decoding Encrypted Packets 62
9.3 MAC Layer Security 63
9.4 NWK Layer Security 64
9.5 APS Layer Security 65
Appendix A: Application Navigation 67
Appendix B: Capture File Formats 71
Appendix C: Protocol Decoder Display Filter Fields 74
Appendix D: 2400E Firmware Upgrade 83
Appendix E: Sensor Network Access Point (Model 2400A) Firmware Upgrade 84
Appendix F: IEEE 802.15.4 Channels and Frequencies 85

1 System Overview

Welcome to Version 1.1 of the Daintree Networks Sensor Network Analyzer (SNA). The Sensor Network Analyzer combines a powerful protocol analyzer with network visualization, measurements and diagnostics for IEEE 802.15.4™ and ZigBee™ applications. The analyzer provides automatic display of network formation, topology changes, and router and coordinator state changes allowing rapid detection of incorrect network behavior and identification of device or network failures.

The Sensor Network Analyzer works in conjunction with other products in the Daintree Networks Sensor Network product family, like the 2400E Sensor Network Adapter, to provide analysis for small and large networks. With multi-node capture, analysis of large networks across wide areas (such as multiple rooms within a facility) is possible.

The SNA application also supports several chipset evaluation boards as capture devices, allowing flexibility in making use of existing development hardware.

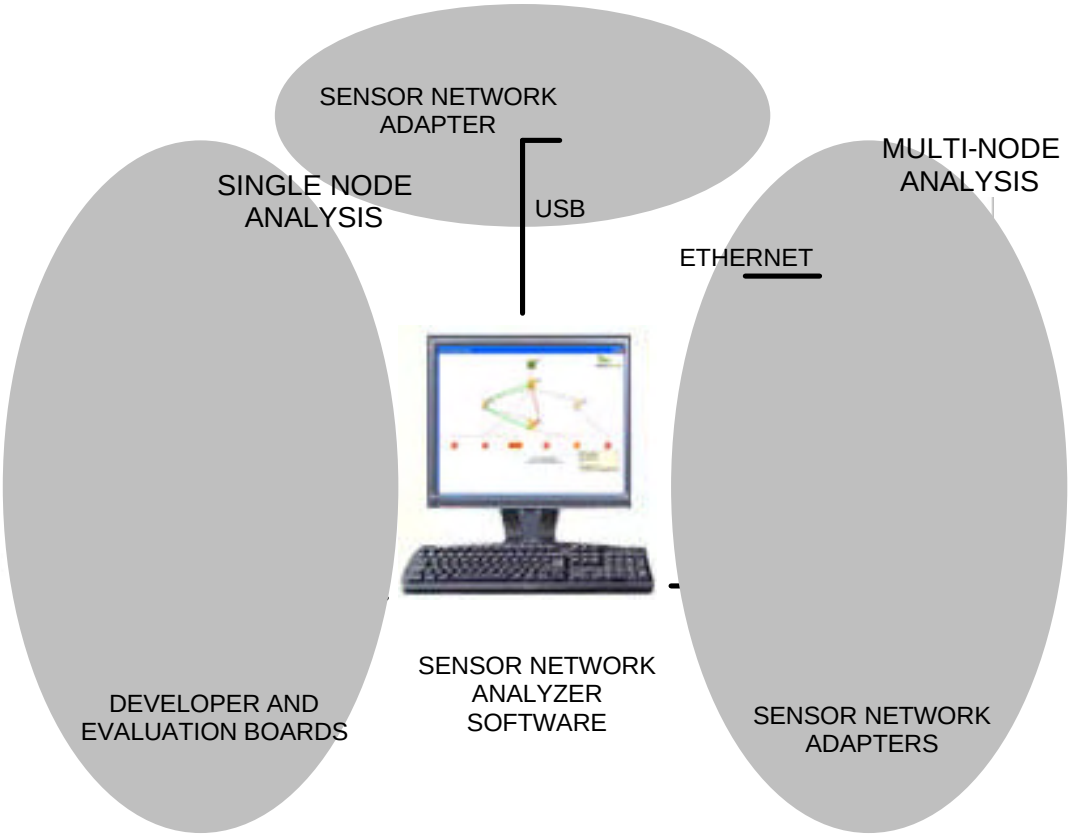


Figure 1 System Overview

2 Installation & Licensing

Installation consists of the following steps:

- Installing SNA software
- Entering activation code to activate license
- Attaching capture hardware (Daintree supplied, and/or third party development kit)
- Configuring SNA software for the specific capture hardware

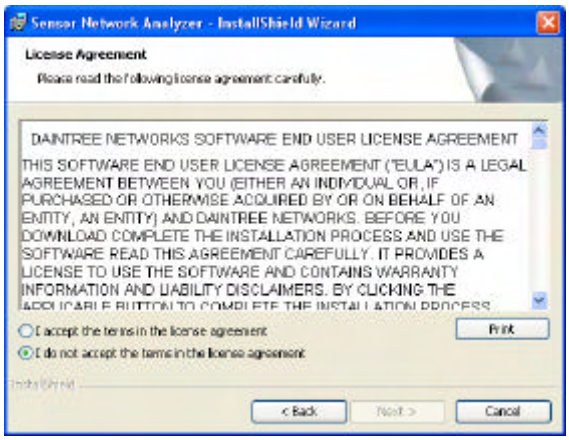
2.1 Software Installation

To install the SNA software, follow these steps:

- Make sure you have at least 100 MB of available disk space for a typical installation,
- Run the SNA install executable
  - CD Version: Insert the Sensor Network Analyzer CD; the installation starts automatically. If the installation does not start automatically, browse to the CD and manually run Setup.exe,
  - Downloaded Version: unzip and run the downloaded executable SNA_Setup_v1.1.exe (or applicable file name),
- Follow the installation instructions:
  - Read and accept (or decline) the License Agreement (as shown below)

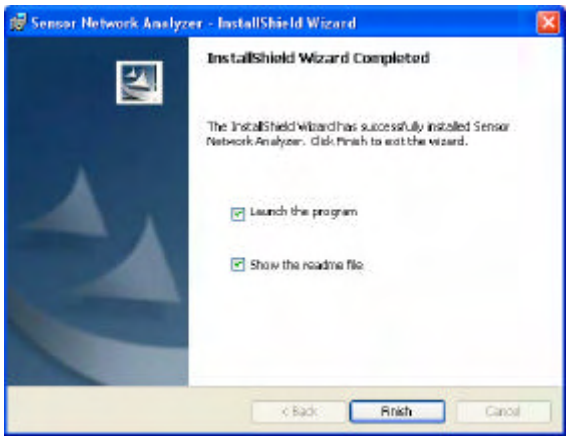
  If you accept the License Agreement:
  - Enter User Information,
  - Accept the default installation location, or choose an alternative location, then proceed through confirmation to begin the install process. ,
  - If you have a previous version of the SNA it will be automatically uninstalled at this time,
  - The Installation will proceed to completion.

As described above, the End User License Agreement is presented at installation time and outlines the full terms and conditions of use. Subsequent to installation, this file can also be viewed in the Daintree Networks\Sensor Network Analyzer installation directory.



Once the installation is complete you will be presented with the following screen. It is suggested that you view the readme file at this time, which contains notes specific to this release. Choose to launch the

program at this time to continue with the activation process. Otherwise run the application at a later time when you are ready to activate.



2.2 Software Activation

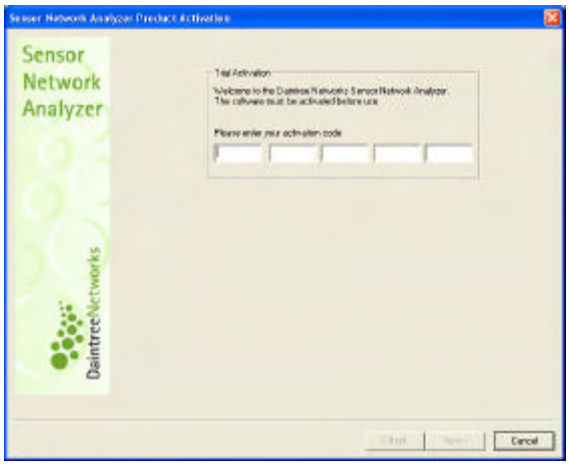
The Daintree Networks Sensor Network Analyzer requires an activation code to enable the software. Activation consists of an on-line validation of the activation code. Note that the computer on which the software is to be activated must be connected to the Internet during the activation process. If you are upgrading from a previous version of the SNA which was activated under a perpetual license the pre-existing activation will be preserved and you will not be prompted for a new activation.

The software provides support for a 30 day evaluation license. The evaluation period begins when the activation code is entered. When a license is purchased, a permanent activation code is provided. This will enable activation for perpetual use of the software. The software may be activated for perpetual use during installation, or an evaluation license upgraded during or following an evaluation period.

At the end of the evaluation period, and in the absence of a perpetual license, the software will default back to a 802.15.4 MAC and ZigBee NWK layer protocol analyzer providing packet sniffing and decode capability. The unique SNA visualization and measurement features and application layer decodes will not be available.

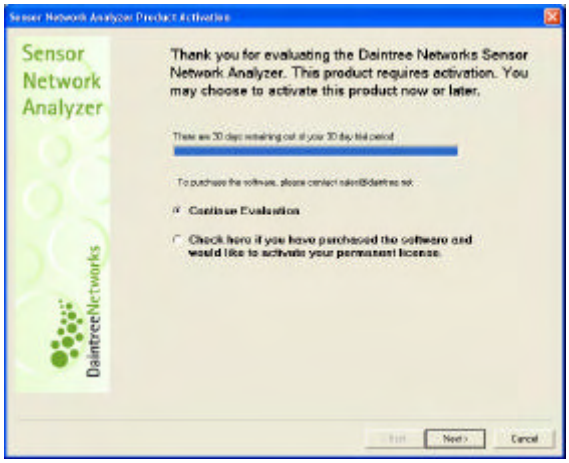
Enquiries related to the evaluation and/or purchase of the Daintree Networks Sensor Network Analyzer software, including access to an activation code, can be made by email to sales@daintree.net, or contact Daintree Networks or a representative directly. For contact details see the Daintree Networks web site at www.daintree.net.

When the application is first run you will be presented with an activation screen. Enter either a trial or perpetual activation code and continue.



Once activated, the software is tied to the PC on which the software was activated. The activation code cannot be used to activate the software on another PC. Questions relating to the use of the licensing mechanisms and activation codes should be sent to support@daintree.net.

If you are using the software under an evaluation version of the license you will be presented with an evaluation status screen following activation, and again each time the application is started during the trial period. You may continue the evaluation during the trial period, or enter a perpetual activation code which is supplied when the product is purchased.



2.3 Capture Hardware Installation

To capture and analyze packets from a live 802.15.4/ZigBee network, the Sensor Network Analyzer (SNA) must be connected to one or more capture devices.

The SNA supports the following capture devices:

- Daintree Networks 2400E Sensor Network Adapter.
- Daintree Networks 2400A Sensor Network Access Point. Note that the 2400A provides equivalent functionality to the 2400E when used as an analyzer capture device.
- Development and evaluation hardware components from a number of third parties, including Chipcon, Ember, Freescale, Atmel and ZMD. Refer to the SNA release notes (readme file viewable within the program file installation directory for a list of supported hardware components).

Multi-node capture is only supported using the 2400E Sensor Network Adapter. Use of multiple 2400E Adapters enables analysis of a physically distributed network, where one or more devices in the network are outside of the range of a single capture device. To purchase the 2400E contact Daintree Networks or a representative. Contact information can be found at www.daintree.net.

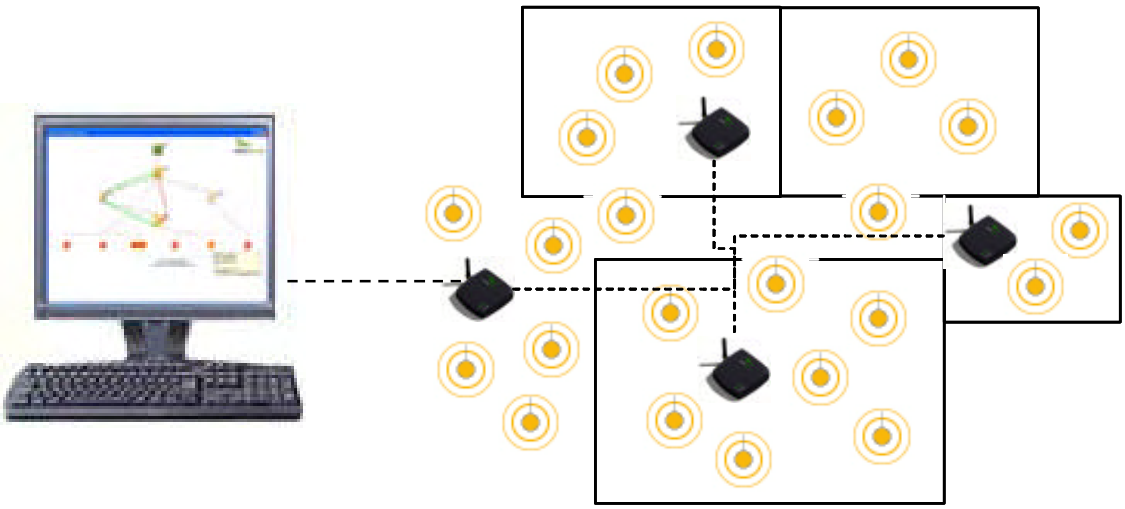


Figure 2 Multi-node Capture

This User Guide describes how to use the SNA with the Daintree Networks 2400E Sensor Network Adapter. To use one of the chipset vendor evaluation boards as a capture device, consult the appropriate or Daintree Networks SNA Getting Started Guide supplied with the evaluation kit, or Daintree Networks Application Note. Application Notes are available on the web at www.daintree.net or by contacting support@daintree.net.

2.4 Connecting the 2400E Sensor Network Adapter

The 2400E Sensor Network Adapter is shown below. The 2400E can be connected to the system using USB or Ethernet. The connections are at the rear of the device, as shown below.

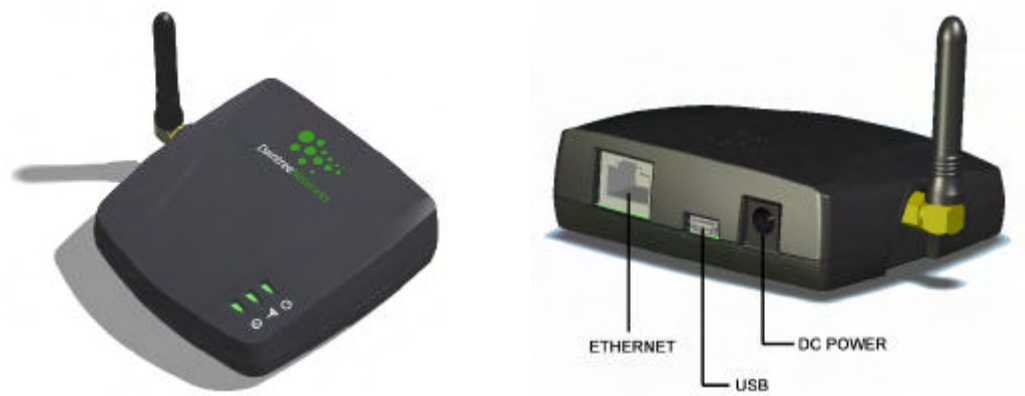


Figure 3 Sensor Network Adapter and Connectors

Adapter Indicators

Various indicators provide status information for the adapter. The indicators at the front are as follows:

- POWER will light when powered by means of USB or the DC jack,
- RADIO ACTIVITY flashes to indicate receipt of packets over the wireless interface on the selected channel,
- STATUS will be on and green when the adapter is ready to be used. This LED will turn orange when the adapter is booting or having its firmware updated. It will be red or will not lit should there be some problem with the hardware device

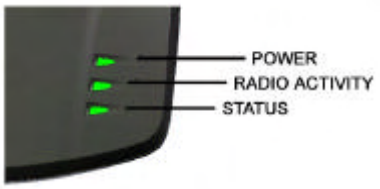


Figure 4 Sensor Network Adapter Indicators - Front

There are two indicators integrated into the Ethernet connector.

- RX / TX indicates activity on the network,
- LINK indicates that an Ethernet connection has been established.

Figure 5 Sensor Network Adapter Ethernet Indicators

Connecting via USB

If you connect the 2400E to the SNA PC using USB, the adapter will draw power from the USB connection. The adapter may also be powered using 9V DC power. When a 9VDC source is applied, the 2400E will draw power from that source and not the USB. A multi-country AC adapter is included with the purchase of the 2400E. If installing for the first time, the Found New Hardware wizard will prompt you to install drivers for the new hardware.

- Select “Install from a list or specific location” and click Next.
- Select “Search for the best driver in these locations”, and “Include this location in the search” and Browse for the Program Files\Daintree Networks\Drivers\2400E (or alternative application installation) directory.
- Select Next and the wizard will automatically find and install the required drivers. Note that during installation you will see a Windows warning message “The software you are installing for this hardware: Daintree Networks – 2400E Sensor Network Adapter has not passed Windows Logo testing to verify its compatibility with windows XP.” Click Continue.

Connecting via Ethernet

To connect the 2400E Sensor Network Adapter to the SNA application via Ethernet the 2400E must first be configured for use on the network using one of two methods:

- By means of the Device Configuration utility. The Device Configuration utility enables the configuration of the Hostname and IP address of the 2400E. By default, 2400E's ship with DHCP enabled and the hostname is set to the unit's serial number. The utility is found under the SNA's Settings menu.
- Manually, by editing the resources.txt file as explained later in this document ('Configure SNA for Capture Hardware').

The Device Configuration utility is available for the capture device currently selected in the capture device Source drop down toolbar list. The given device may be connected via Ethernet or USB for the purpose of configuration. If there is no currently selected capture device, the Device Configuration utility will not be available. It is recommended that the 2400E be connected via USB if the current IP configuration parameters are unknown.

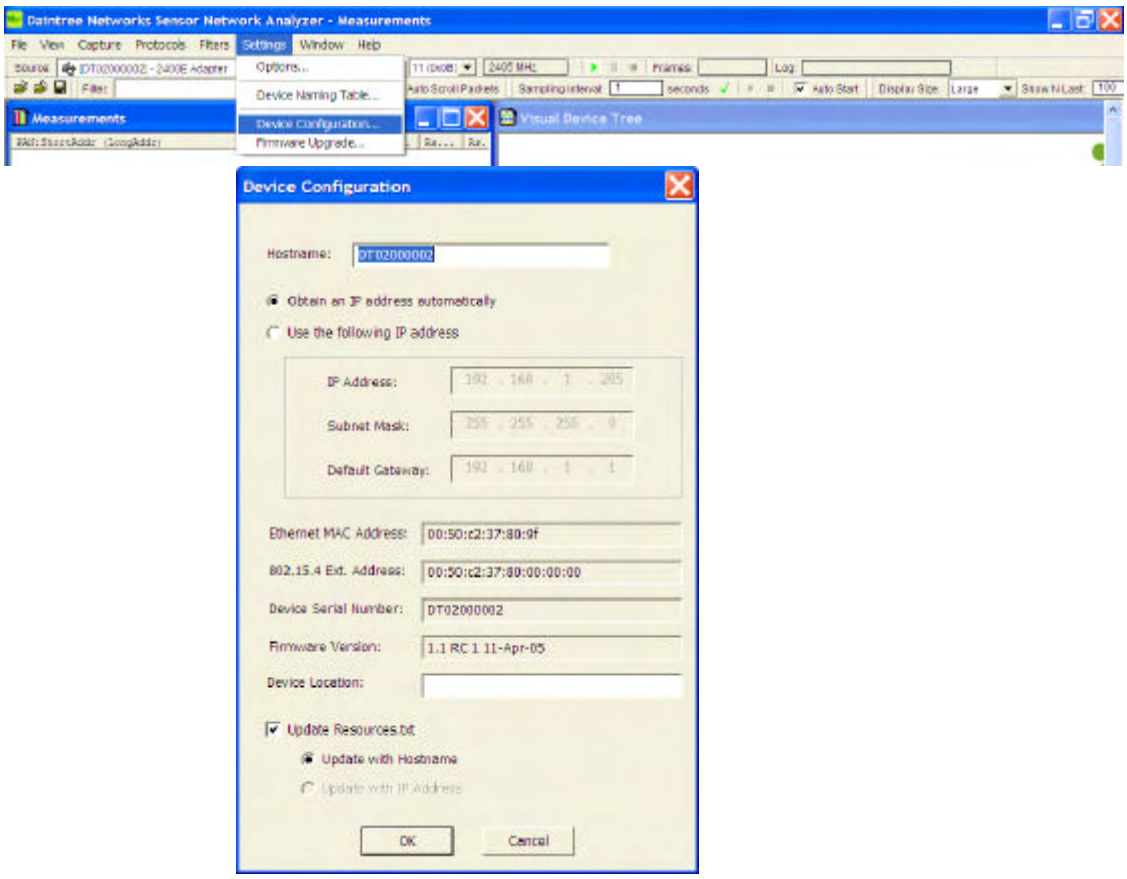


Figure 6 Device Configuration Utility

The Device Configuration Utility provides useful information about the current device configuration and allows the user to configure:

- Hostname (Default value corresponds to Device serial number),
- IP Address
  - Obtain automatically (using DHCP), or

- Define static IP Address,
- User Defined Location String (to help identify the unit)
- Options to update resources.txt (see next section below).

NOTE: When using the Device Configuration utility to change the hostname and/or IP address of a Daintree capture device (2400E or 2400A), it is possible for connectivity to the device is lost. This will occur if the IP address is not valid on the current subnet, or if the IP address for a given hostname is changed and a router/gateway/server device caches the previous hostname binding. If IP connectivity is lost to a given device it can be reconfigured by connecting it to the PC via USB.

2.5 Configure SNA For Capture Hardware

The resources.txt file is currently used to enumerate hardware available to the SNA. Inclusion of entries for capture hardware you wish to use in conjunction with the SNA is a necessary pre-requisite to it being available to the SNA. The only exceptions to this are capture devices connected via USB, once installed, they will be automatically recognized and do not require an entry in resources.txt. When operating over the Ethernet interface an entry is required to specify the IP address or hostname of the device.

The resources.txt file is located in the Daintree Networks\Sensor Network Analyzer directory (or other program installation directory as chosen at installation time). It should also be available through the Start > Program Files menu for the SNA. This file can be edited using your favorite text editor.

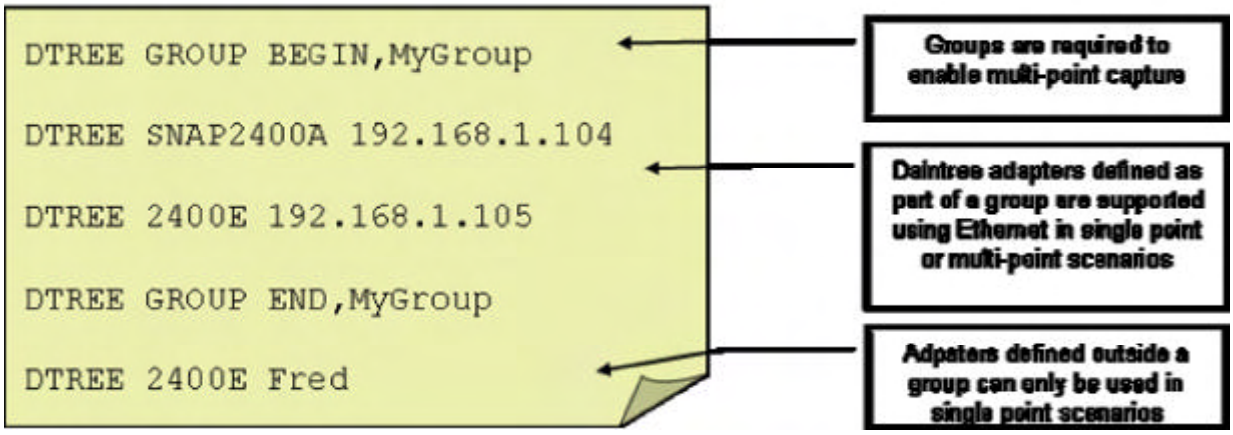


Figure 7 Resources.txt File Entries

File Format

The format of each line in the resources.txt file is as follows:

```
MFR   TYPE   [PARAMS]

Where
    MFR = manufacturer code (DTREE = Daintree Networks)
    TYPE = capture device type
    [PARAMS] = device specific configuration parameters
```

The resources.txt file also supports the concept of device groups for the purpose of multi-point capture. To nominate the specific devices to be used in a multi-point session, enclose the device identifiers between the following statements:

```
DTREE           GROUP BEGIN,[Group Name]
…
DTREE           GROUP END,[Group Name]
```

Where [Group Name] is a user-defined common name for the group of devices, for example “Warehouse”. Note that the commas are required. Multiple groups may be defined in the same file. The same device may be listed multiple times in the same file. To capture using the group, select the group by name from the list of available capture sources.

Supported Devices

```
Daintree Networks Sensor Network Access Point Model 2400A
Config Format:  DTREE  SNAP2400A  [PARAMS]
[PARAMS]:                  IPAddress | Hostname
                           where IPAddress = IP Address of 2400A

Daintree Networks Sensor Network Adapter 2400E
Config Format:  DTREE  2400E  [PARAMS]
[PARAMS]:                  IPAddress | Hostname
                           where IPAddress = IP Address of 2400E
```

Daintree adapters can be referred to by hostname or by IP address. The use of a hostname depends on the ability of the network to respond to address queries for the given hostname based on protocols such as DNS or NetBIOS. If such facilities are not available, the 2400E (or 2400A) can be referred to by its’ IP address.

Other third party development kits are also supported. Specific hardware supported is listed in the release notes for the SNA, viewable at install time or by opening the file SNA Read Me.htm located in the application program file directory. Instructions for configuring third party hardware via the resources.txt file are contained in application notes describing how to use the SNA with that specific hardware component. These may be found at www.daintree.net.

Using the Device Configuration Utility to Update resources.txt

When using the Daintree Networks’ supplied 2400A or 2400E units, the IP address and hostname can be configured using the Device Configuration utility as described in the previous section. When changing the IP address or the hostname, the resources.txt file will be automatically updated with the new device configuration parameters. There is a selection available which allows the user to select whether to update the resources.txt file with the hostname or the IP address. The IP address option is not available if the “Obtain an IP address automatically” option is selected. If the user chooses to define a static IP address the user can choose to write the IP address or the hostname into resources.txt.

2.6 2400E Regulatory Guidelines

The Daintree Networks 2400E Sensor Network Adapter is a Low Power Wireless Communications Device and as such is subject to various international regulations with respect to emissions and associated regulatory standards. The product should be installed with a minimum separation distance from persons of 20 cm.

Changes or modifications not expressly approved by Daintree Networks 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.

The 2400E may only be used with the supplied antenna. Use of the device with any other antenna is a violation of FCC rules and will void the user's authority to operate the equipment.

3 Sensor Network Analyzer Overview

This section provides a brief overview of the Sensor Network Analyzer (SNA) application. Subsequent sections will provide additional detail on each major application area.

The Sensor Network Analyzer is a tool for developers of wireless sensor networking technology and applications. A range of hardware devices enable comprehensive network analysis through passive observation from one or more vantage points. The analyzer provides visualization, measurements and packet decodes for IEEE 802.15.4™ and ZigBee™ wireless communications.

With device tree visualization, the network structure can be analyzed and changes to the network structure can be observed. Overlaid on the same device tree are routes and application endpoint flows. These allow developers and implementers to rapidly determine how packets are flowing through the network, how alternate routes are used and to analyze end-to-end application-layer connectivity. A measurement system also provides detailed measurements such as packet counts and latency. With integrated diagnostic tools that provide detailed packet-by-packet, field-by-field information, switching between summary visual and measurement information, and detailed protocol information will allow rapid diagnosis of root causes of problems.

The Sensor Network Analyzer works in the Daintree Sensor Network family to provide analysis for small and large networks. With multi-node capture, analysis of large networks across wide areas or multiple rooms is possible. The analyzer also supports several chipset evaluation boards to allow flexibility in using available hardware.

3.1 Major Components

To get started with the SNA application, launch the application. From the Start menu, choose All Programs, Daintree Networks, Sensor Network Analyzer. Enter activation code as required.

You will see each of the major components of the SNA application:

- Visual Device Tree window, used to display network topology using a device association tree,
- Measurement window, used to display network wide statistics,
- Packet List window, used to display a scrolling list of packets,
- Packet Decode window, which provides the detailed decode of the selected packet in the Packet List.

Each window can be maximized, minimized, hidden, or resized.

There are two additional windows that are minimized by default:

- Device Tree window, which provides a textual view of the device association tree,
- Packet Data window, used to display raw hex dump of the selected packet in the Packet list.

All application windows can be reached via the menu items listed in the menu bar along the top of the main application window. Toolbars are available for the most commonly used features.

3.2 Opening the Example Capture Files

The best way to learn the key features of the application is to open files from previously captured live networks. This can be done prior to installing capture hardware. Two sample capture files are provided with the standard installation and can be found in the Daintree Networks/Sensor Network/Analyzer/Capture Files directory (or alternative installation directory if chosen):

- “topology_and_route.dcf”, which demonstrates the formation of a small network, and
- “HCL_demo.dcf”, which demonstrates a simple Home Control Lighting application.

First Example: topology_and_routes.dcf

Use the File -> Open menu item or corresponding toolbar item to open the example "topology_and_routes.dcf" file. This can be found in the "Capture Files" directory.

Once the capture playback is complete, you will see the following screen shot:

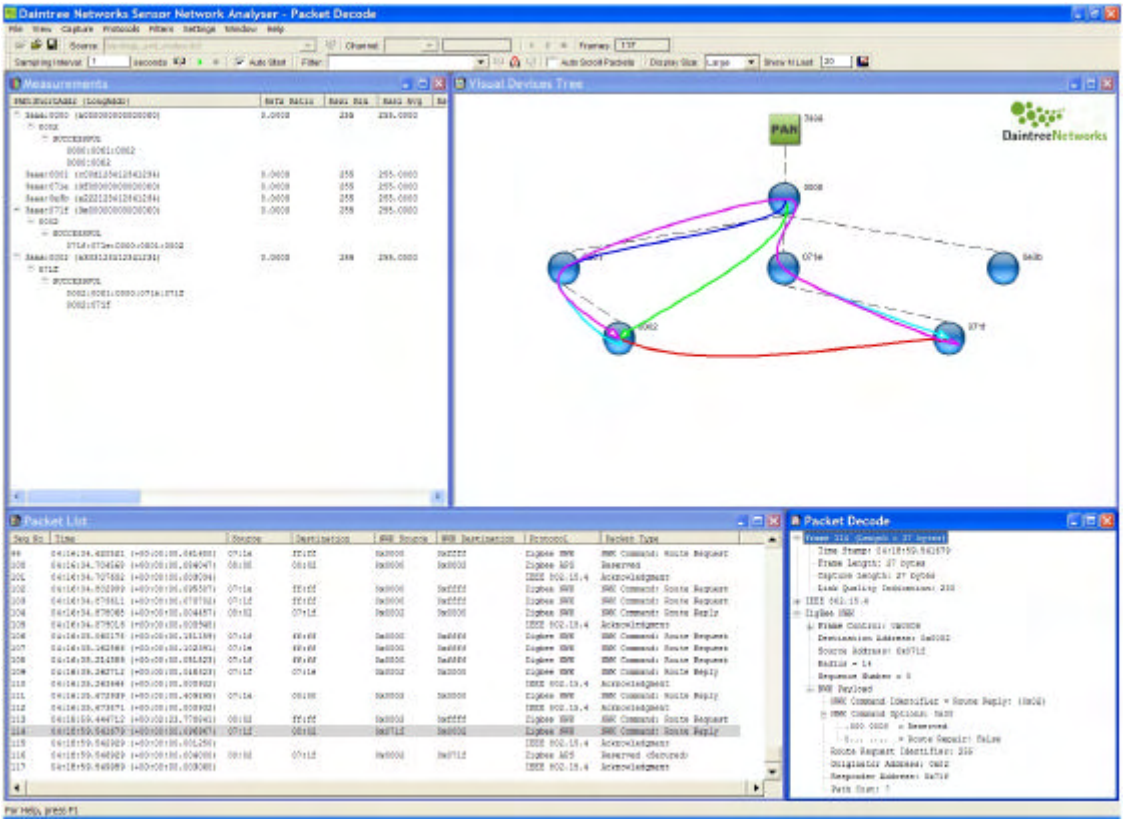


Figure 8 Default screen layout after loading "topology_and_routes" capture file

This highlights each of the major components of the application:

The **Visual Device Tree** window shows network topology by means of a device association tree:

- Devices are added dynamically based on 802.15.4 Association Response messages,
- Routes are displayed on the Visual Device Tree. The number of Routes shown may be varied using the "Show Last N" option available from the Visualization Options or directly from the toolbar,
- Routes can be filtered to show only those routes between two devices by selecting (clicking on) the devices on the Visual Device Tree,
- A given route can be selected by clicking on the route itself; each of the devices traversed by the given route are highlighted.

The **Measurements** window displays network wide statistics:

- Measurements are broken down by Device, Stream (Source/Destination Device Pair), and Route,
- Expand the Measurements view to display the full set of available statistics.

The **Packet List** window shows a scrolling list of packets:

· The selected Packet from the Packet List is shown in the **Packet Decode** window,

· There is an additional Packet Data window (hidden by default) that shows a raw hexadecimal and ASCII dump of the selected packet,

· A Filter can be applied to the Packet List to display only packets matching a given criteria (typically the value of one or more protocols fields),

· Filters can be defined from the Filters menu, Filters Toolbar or by right-clicking on a protocol field in the Packet Decode window.

Second example: HCL_demo.dcf

Open the file "HCL_demo.dcf", which is located in the same Daintree Networks\Sensor Network Analyzer\Capture Files directory. After opening this file, the SNA will look like the following screen shot.

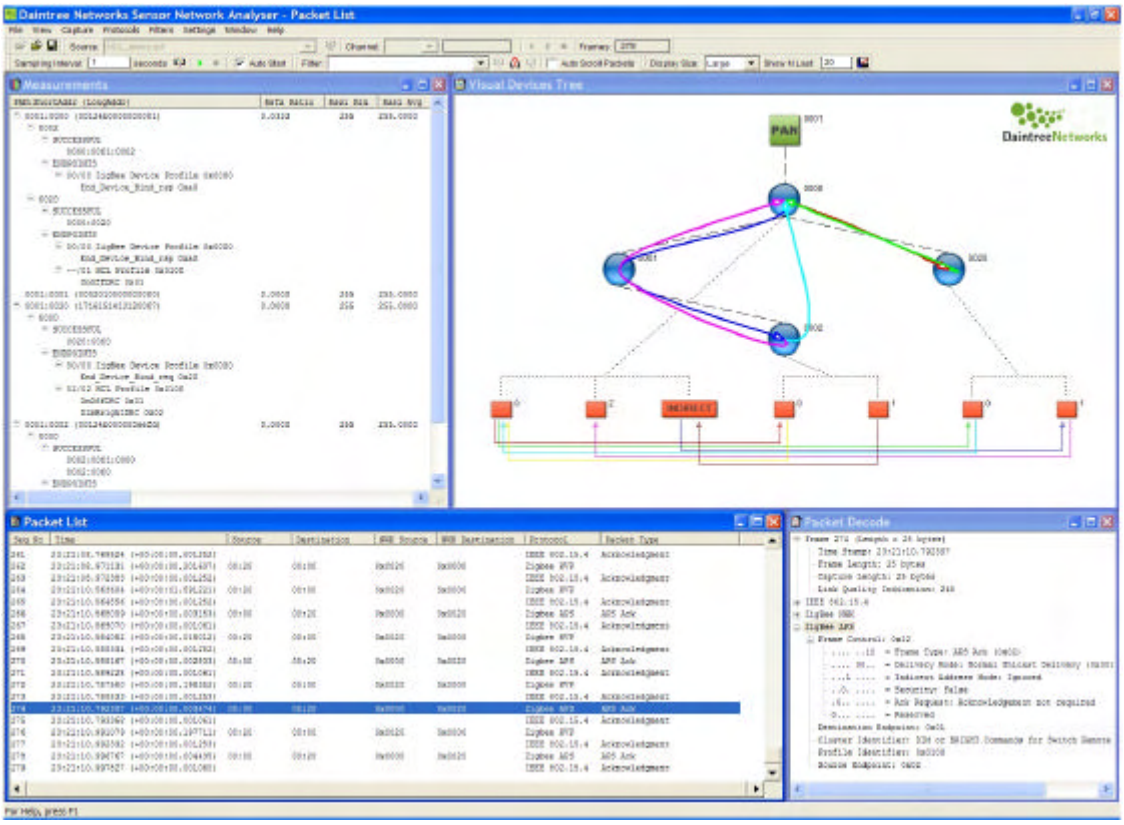


Figure 9 Default screen layout after loading "HCL_demo" capture file

This file contains additional application layer endpoint information. This reveals additional information in the Visual Device Tree and Measurements windows. In particular:

The **Visual Device Tree** window contains an extra layer of information corresponding to APS endpoints:

· The lines linking the endpoints represent the flow of APS messages between endpoints and typically correspond to APS layer bindings,

· Endpoint 0 represents the ZigBee Device Object (ZDO) on each device, and the lines linking them represent ZDO messages between devices. There is an option available to turn off the display of ZDO endpoints and bindings to reduce clutter on the screen,

- A line directly linking a non-zero endpoint corresponds to a direct binding from source to destination,
- The “INDIRECT” endpoint is used to indicate the flow of indirectly addressed packets to and from the ZigBee coordinator. This does not correspond to an actual APS endpoint,
- Lines linking endpoints to and from the logical “INDIRECT” endpoint, show the flow of indirectly addressed APS packets from source endpoint to coordinator and coordinator to destination endpoint,
- Bindings to and from a given endpoint can be filtered by selecting (clicking on) an endpoint,
- A Binding can be selected by clicking on the line linking two endpoints,
- The Application layer profile and clusters corresponding to a given binding are shown when the binding is selected.

The **Measurements** window is extended with the list of endpoints detected on each device.

3.3 Capture from live network

To setup the Sensor Network Analyzer application to capture from a live capture device, follow the following steps:

- Ensure required capture hardware has been installed and configured (refer to the installation section earlier in this document).
- Select Capture Device from list of available capture devices,
- Select Channel,
- Start Capture.

Select the Capture Source from the list of available devices as shown below. If the given device is not shown but it has been added to the resources.txt and connected to the PC, click the antenna like icon to search for capture devices. If the device is correctly connected it will be shown in the list of available devices.

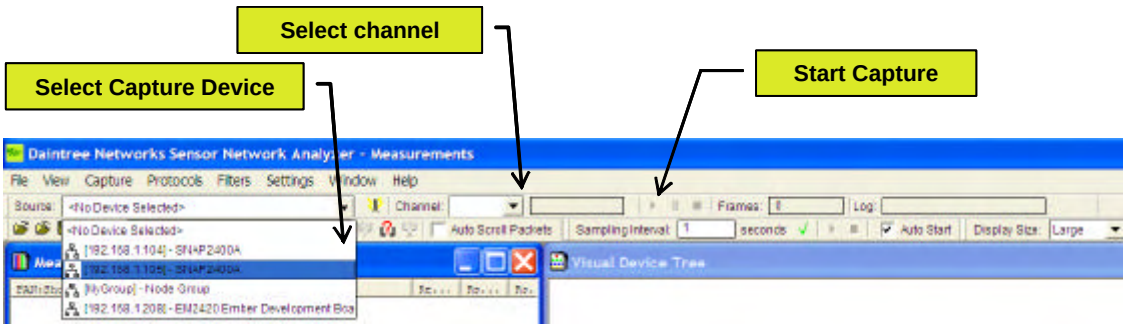


Figure 10 Selecting Capture Source

Select the Channel from the drop down list of available channels. The list of channels will automatically update based on the available frequency range.

Start Capture using the Capture -> Start menu item or using the start button on the main toolbar. If the Auto Start option is selected the Measurements will automatically start when capture starts. Measurements may be started and stopped independently of the capture. Restarting measurements clears all statistics from the measurements window, and clears all routes and endpoint bindings from the Visual Device Tree.

4 Operating the Sensor Network Analyzer

4.1 Single and Multi-Node Operation

One of the key differentiating features of the Sensor Network Analyzer over basic "sniffers" is its multi-node capability. This is important for the following reasons.

The low power nature of 802.15.4-based wireless sensor radios means that there transmission range is relatively limited. With the help of the ZigBee networking protocol, the fact that such devices can link with each other and forward traffic on behalf of one another helps overcome what would otherwise be a major limitation.

Nevertheless, from a passive analysis point of view this provides a significant challenge. It is important that an analyzer operating in as a passive observer of the network to be able to see all communications between devices. The SNA addresses this by enabling multiple capture devices (observational points) to be networked together to provide a complete view of network activity. The analyzer is able to both synchronize traffic streams from Daintree's capture devices, and filter out duplicate packets, and in so doing create a composite and correctly time ordered sequence of packets representing the overall network traffic.

It is very important that for reliable analysis, sufficient capture devices be placed around the network to observe all traffic. Failure to do so may lead to missing transactions resulting to incorrect conclusions being drawn about network activity. For example, a device association not observed during network formation may result in significant inaccuracies in the network topology represented. For more information on capture device placement and conditions which may lead to loss of multi-node synchronization, contact Daintree Networks directly.

4.2 Modes of Operation

The SNA is able to operate in two modes:

- Live network analysis;
- Post-analysis using logs of previously captured live traffic.

4.3 SNA Operating Model

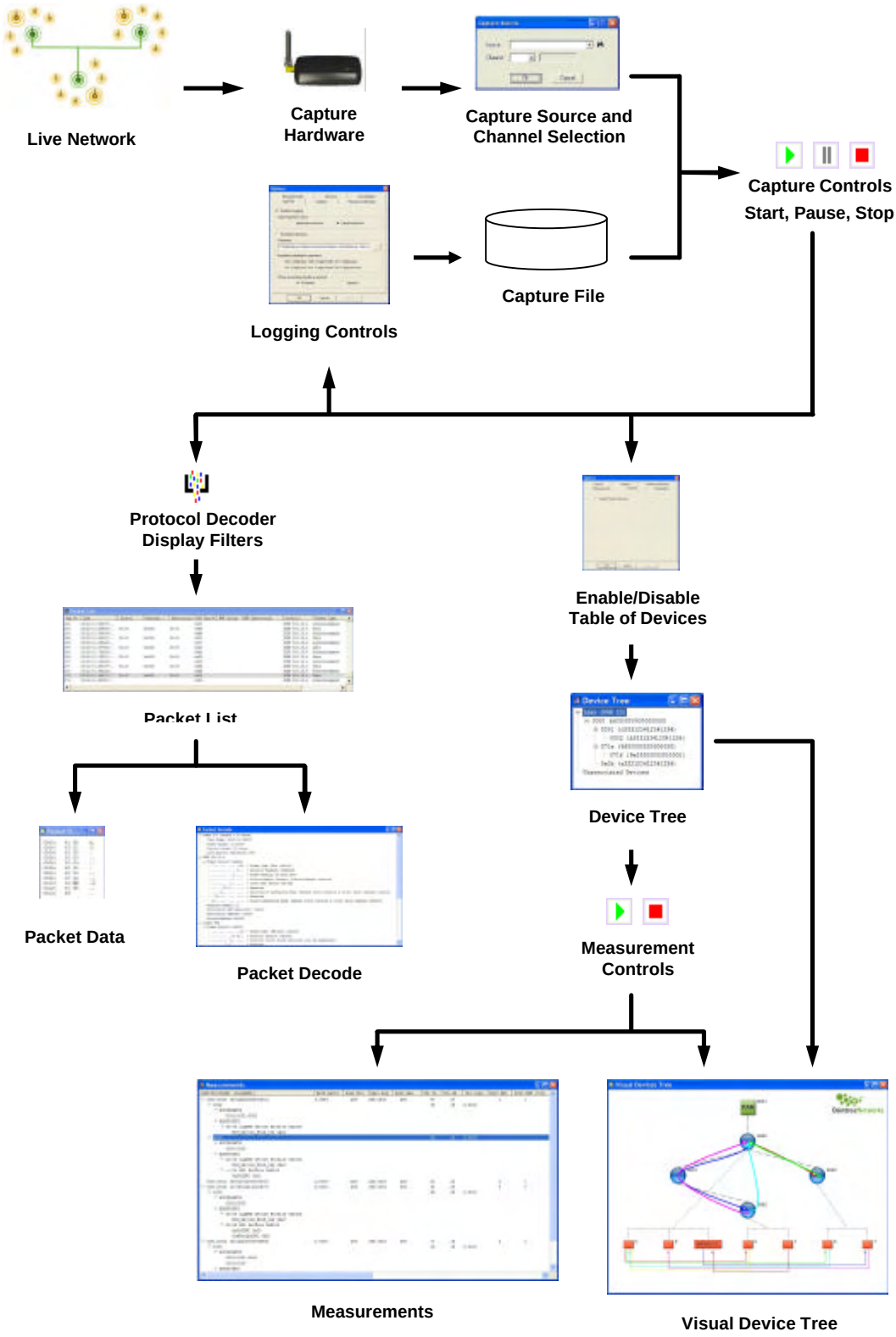


Figure 11 SNA Operating Model

The available controls include:

· Start/Stop Capture: this is the master control whether the analyzer is capturing from a live network or replaying a previously saved capture. When capture is started, ALL data from a previous capture is cleared including the Packet List, the Device Tree and any measurements,

· Enable/Disable Device Tree: this will enable/disable the Device Tree, Measurements and Visualization. However it is independent of the Packet List,

· Start/Stop Measurements: this will stop and stop the collection of measurements and much of the derived information (NWK layer routes, APS layer bindings) that are used to populate the Visual Device Tree. For a given capture session, measurements can be stopped and restarted multiple times.

Subsequent sections of this User Guide will describe each of these components and their corresponding window in more detail.

4.4 Initiating a Capture Session

A capture session is a discrete and continuous period of time during which all air interface activity is captured to memory and displayed (subject to any display filters in effect). A capture session can be initiated and controlled by means of the **Capture Menu** or the **Capture Toolbar**.

All incoming data during a capture session can be logged to disc as it arrives. Alternatively, the capture data can be saved to a log file post-capture. In this way it can be retrieved and analysed at a later time. Note that while the results from a previous capture session are open within the viewer a new capture session cannot be initiated.

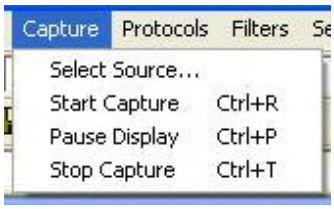


Figure 12 Capture Menu

Each of the Capture Menu items is described below:

Select Source…	Allows selection of a capture source through a dialog box. The dialog box includes the search button, drop down list of sources and channel selection.
Start Capture	Starts capture operations from the selected device.
Pause Display	Toggles the updating of the display of captured data, allowing the user to check through the data whilst the capturing continues.
Stop Capture	Stops capture operation.

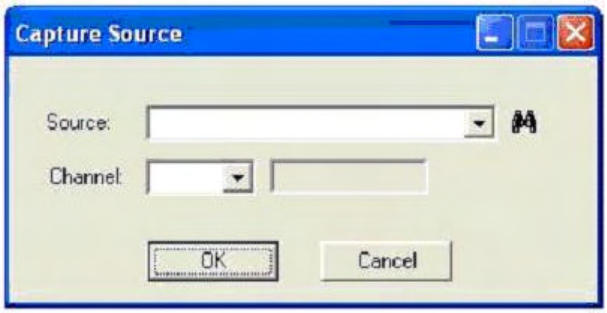
The most common capture controls are also available from the Capture toolbar.

Figure 13 Capture Toolbar

Each of the capture menu and toolbar items is described below.

Select Source

Select Source enables selection of the source for the capture session. If there is a capture operation in progress, this menu item is disabled. Otherwise it results in a dialog box as follows.



The Source drop down list will list all available capture devices.

Otherwise, after selection of a capture device, a specific channel may be selected from the drop down box. The channel will default to the first channel in the band. The dialog box also includes a Search for Capture Devices button (see below).

(Search for Capture Devices) Results in an operation whereby new capture sources are identified. Refer to the sections of this manual detailing hardware configuration for more information.

Channel

Enables selection of the receive channel by means of a drop down list. The channel number is shown in both decimal and hexadecimal. Note that only valid channels for the specific source device are listed. The frequency of the selected channel is displayed adjacent to the channel number. If the Resource Manager has been launched and is active then this button will be disabled.

Start Capture

Begins a new capture session. If there is no capture source selected or if a capture operation is already in progress this menu item is disabled. Whether or not the display is cleared at the start of the capture session is determined by application configuration settings. To erase the existing display contents at the start of a new capture session, enable 'Clear Display on Capture Start' on the Capture tab of the Options panel in the Settings.

Pause Display

This will not pause the capture session itself, but will ensure that incoming packets are not presented via the display. This can be useful for studying existing display contents without the distraction of updates being presented. If there is no capture operation in progress, this menu item is disabled. Clicking the 'Pause Display' toolbar button again will result in the display being updated with all received information since the pause began.

Stop Capture

Clicking on this toolbar button (or selecting the action from the Capture Menu) terminates the capture session. If there is no capture operation in progress this menu item is disabled.

Frames: Displays the total number of frames received since the capture session began. Note that this may be different to the number displayed in the packet list if the user chose not to clear the display when the capture session was initiated, or if filters have been applied.

4.5 Capture Options

The capture options dialog is as shown below.

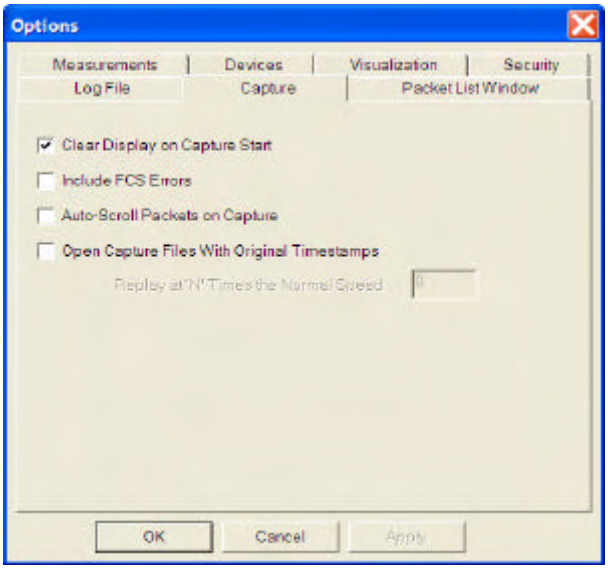


Figure 14 Capture Options

The following options are available:

Clear Display on Capture Start	To erase the existing display contents at the start of a new capture session.
Include FCS Errors	If enabled, packets with FCS errors are forwarded to the Packet List, otherwise they are discarded.
Auto Scroll	If enabled, the Packet List will automatically scroll to show the latest packets as they arrive. This option is also available on the Capture Toolbar.
Open Capture File with Original Timestamps	When a capture file is saved, it is saved together with a marker indicating the time at which each of the packets arrived. This option allows the capture file to be played back at a the same rate as the original capture from the live network. Furthermore there is an additional option to replay at an integer multiple of the normal rate to speed up the playback. If this option is not enabled captured packets are played back at the maximum rate possible.

4.6 Multi-Node Capture

Multi-node capture is available by setting up a node-group in the resources.txt file as shown below.

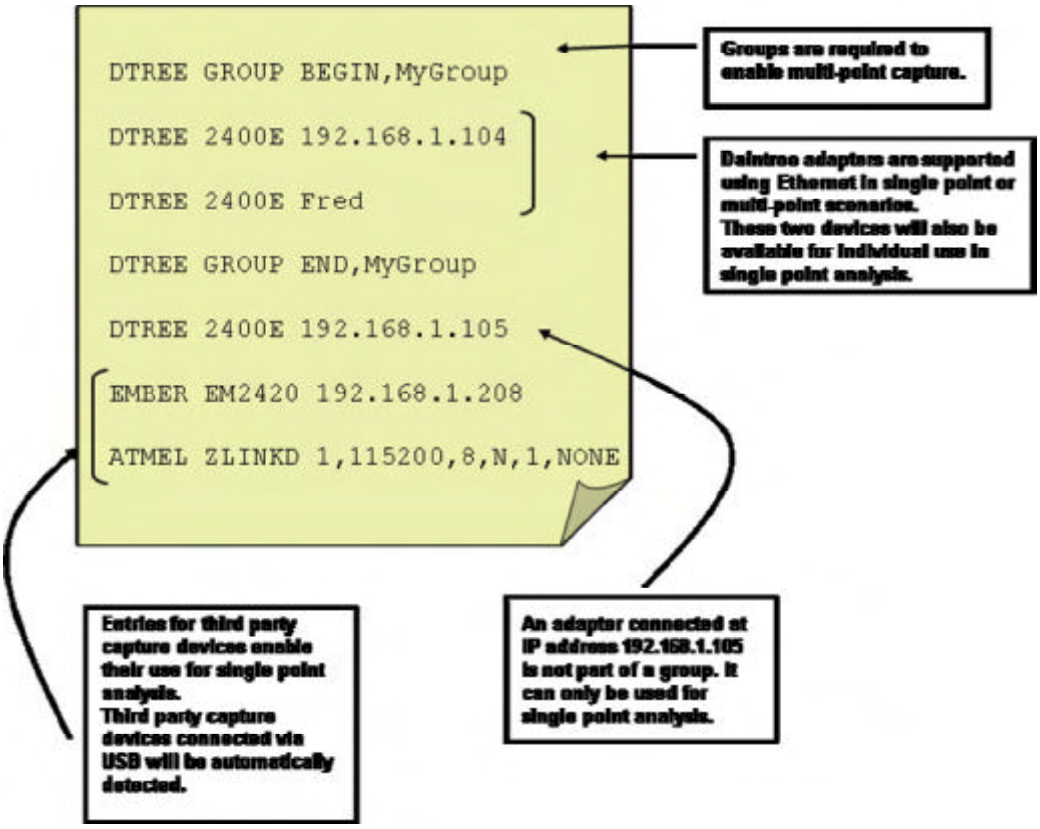


Figure 15 Multi-node Capture Setup

Multiple groups may be defined in the same resources.txt file. Furthermore the same device may be defined multiple times in the same resources.txt, potentially appearing in multiple groups.

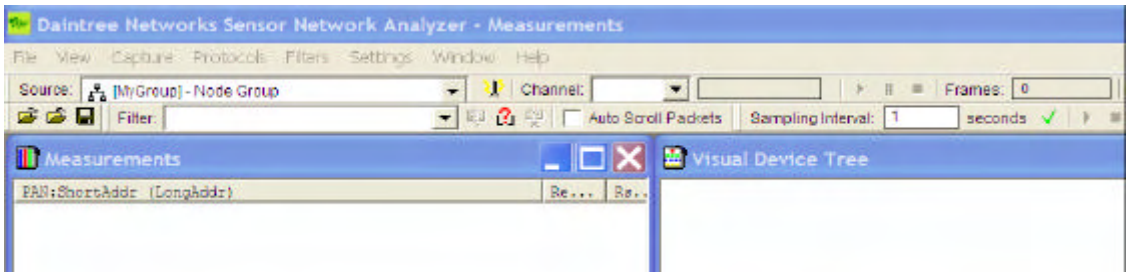
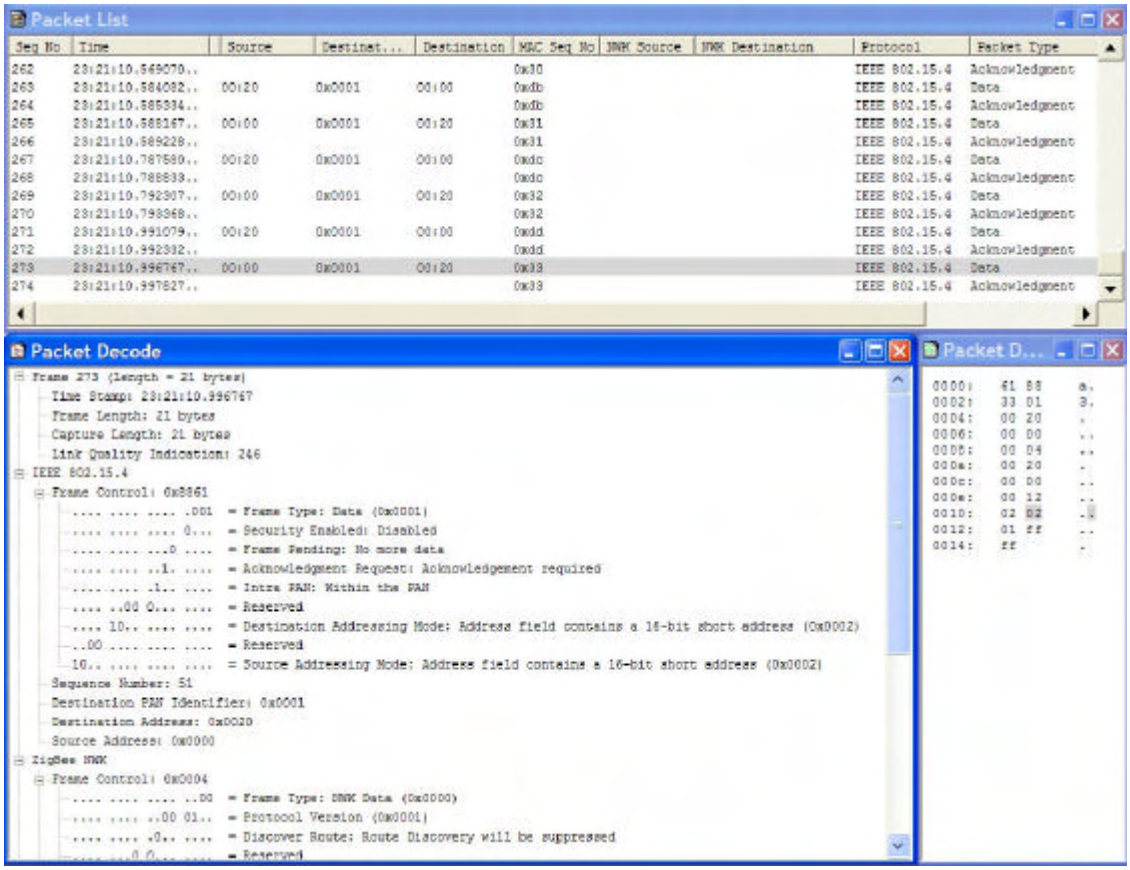


Figure 16 Multi-node Group Selection

A multi-node group may then be selected as the current capture source. Once selected, packets from each of the nodes will be correlated together and presented to the SNA application as a single stream of packets for decode and analysis.

5 The Protocol Decoder

Together the Packet List, Packet Decode and Packet Data windows provide a comprehensive protocol decoder for 802.15.4 and ZigBee networks.



Packet List Window	Lists received packets sequentially with summary information.
Packet Decode Window	Displays the decoded structure of an individual packet.
Packet Data Window	Displays the packet data itself in hexadecimal and ASCII.

5.1 Packet List Window

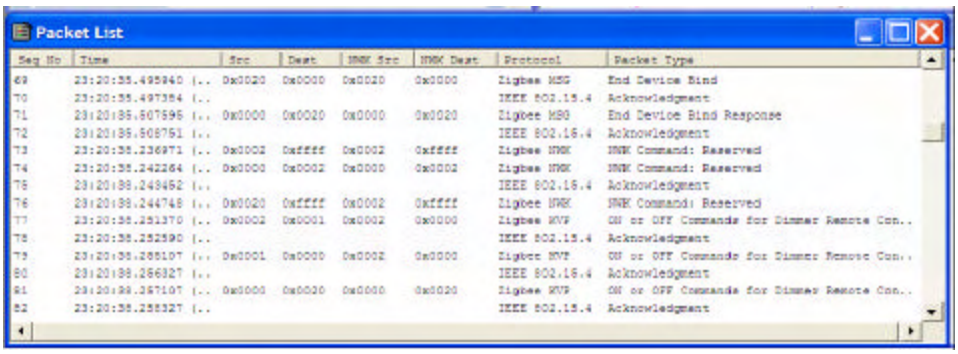


Figure 17 Packet List Window

The Packet List shows packets received sequentially, in the time order they were received. Display filters can be used to define a subset of received information for display. For example, only MAC command frames may be displayed. Each individual packet is listed on a separate line, and includes summary information for that packet.

Selecting a packet in the list (by clicking on it) will result in a decode of that packet appearing in the Packet Decode window if open. The packet list can be scrolled through using the up and down arrow keys.

The available summary fields are as follows. The user can control which fields are shown (fields that are disabled by default are highlighted as such in the table below).

Index	Index (sequence) number of the packet. The index is initialized to 1 at the beginning of a capture session. Note that indices are assigned to all packets received, so an index omitted in this list will be indicative of a filter being applied.
Time	Time at which the packet was received, as provided by the capture device. The format is 'seconds.microseconds' where 'seconds' is the time in seconds since midnight, January 1, 1970, and 'microseconds' is an offset in microseconds from this time.
Src PAN	The MAC Source PAN field (disabled by default)
Src	The MAC source address field.
Dest PAN	The MAC Destination PAN field (disabled by default)
Dest	The MAC destination address field.
MAC Seq No	The MAC Sequence Number (disabled by default)
NWK Src	The NWK source address field.
NWK Dest	The NWK destination address field.
NWK Seq No	The NWK Sequence Number (disabled by default
APS Src EP	The APS Source Endpoint (disabled by default)
APS Dest EP	The APS Destination Endpoint (disabled by default)
APS Profile	The APS Profile ID (disabled by default)
APS Cluster	The APS Cluster ID (disabled by default)
AF Seq No	Application Frame Sequence number (disabled by default)
Protocol	The appropriate protocol layer corresponding to the packet. All packets will be decoded to the maximum extent possible, unless protocol layer

	decoding is disabled through the Protocols Menu.
Packet Type	The actual packet type. For example, ZigBee NWK layer packet types may be 'Command' or 'Data'.

The list of summary fields can be manipulated using the Packet List Options dialog available from the Settings -> Options menu item.

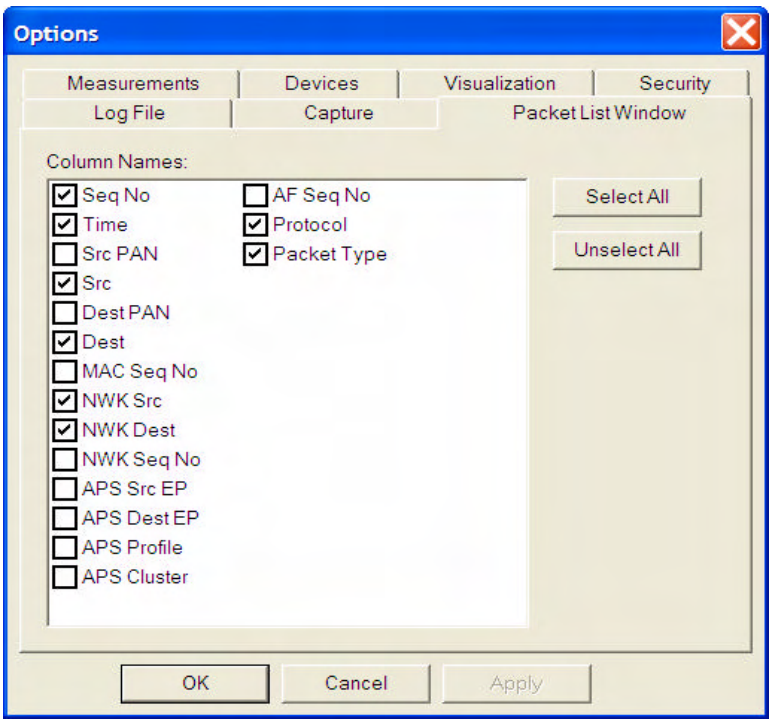


Figure 18 Packet List Options

5.2 The Packet Decode Window

The Packet Decode window shows the decoded structure of the packet currently selected in the Packet List window.

The decode appears as an expandable tree. The state of each node defaults to 'collapsed' when the application starts. Clicking on a node (the **[+]** or **[-]** symbols) will expand or collapse that branch of the tree accordingly. The application will remember which nodes in the decode tree have been expanded. As subsequent packets are selected, the same expanded or contracted state of equivalent nodes will be carried over, provided they are contained within the packet.

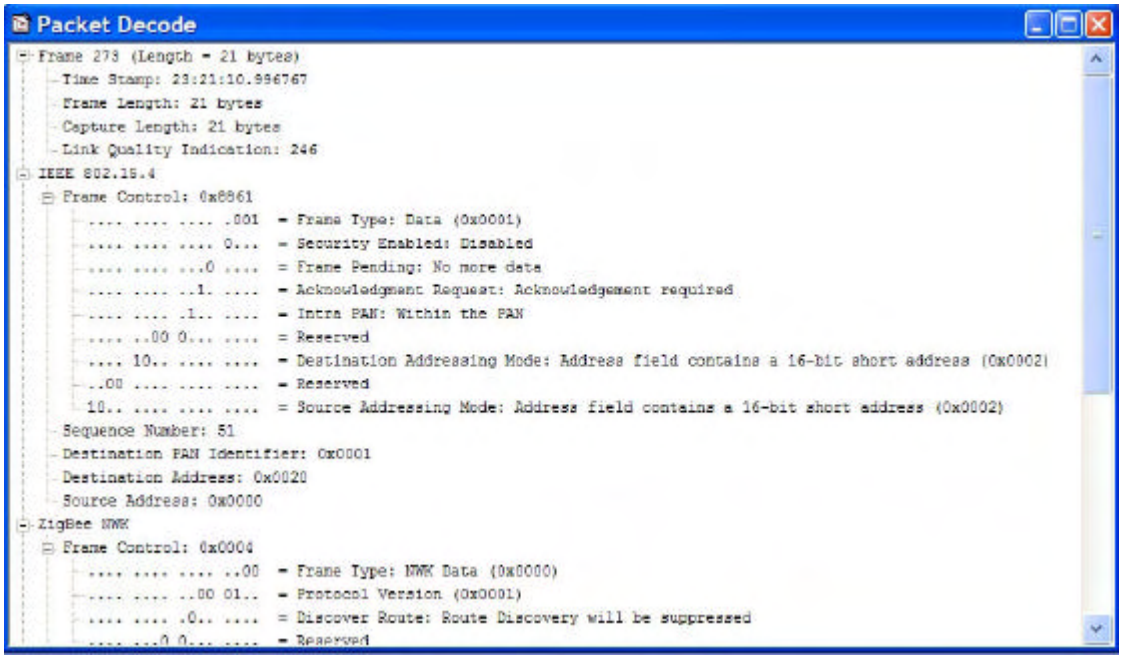


Figure 19 Packet Decode Window

Right-clicking on a node inside the Packet Decode tree brings up the context sensitive menu.

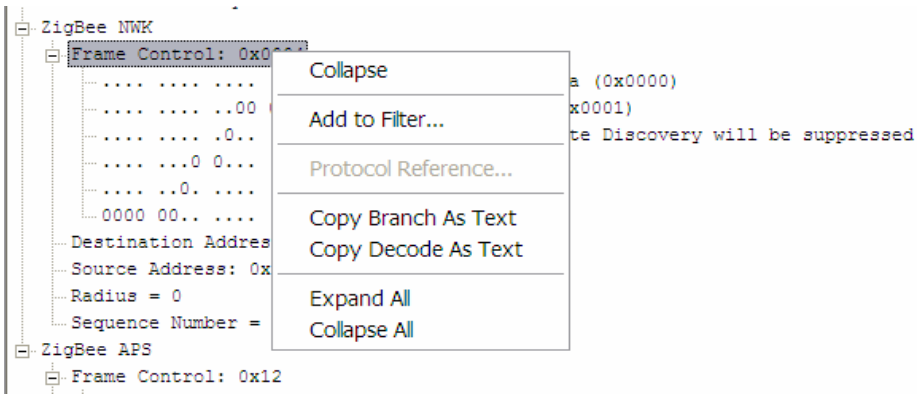


Figure 20 Packet Decode Context Sensitive Menu

Expand/Collapse	Expands or Collapses the current level of the tree
Add to Filter…	Opens the Define Filter… dialog with a pre-defined filter based on the highlighted field and its current value.
Copy As Text	Copy the requested text to the Clipboard for pasting into another application (e.g. text editor)

Expand/Collapse All	Expands of Collapses the entire decode

Selecting particular fields within the Packet Decode window will cause the packet data corresponding to that field to be highlighted in the Packet Data window when that window is displayed.

5.3 The Packet Data Window

The Packet Data window displays all data contained within the packet in its raw hexadecimal and ASCII form, 16 octets per line. The first column is an index of octet numbering. Packet data corresponding to a field which has been selected within the Packet Decode window will be highlighted.

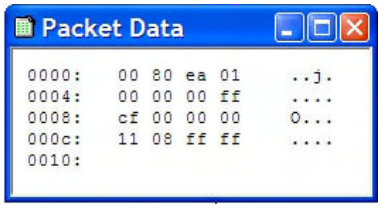


Figure 21 Packet Data

Selecting particular bytes in the Packet Data window will automatically highlight the corresponding fields in the Packet Decode window.

5.4 Protocol Decoder Display Filters

Display filters provide a means of pre-selecting the types of packets displayed within the Packet List (and hence Packet Decode and Packet Data) windows. This can be useful when wishing to observe particular device or network activity, for example, only NWK layer commands initiated by a particular device.

Display filters invoke filtering for display purposes only. In other words they limit what is displayed according to the conditions specified by the filter. Defining and applying a filter will not result in data accumulated within a capture session to be discarded. When a display filter is removed, the Packet List window will revert to containing all received packets during that particular capture session.

Display filters are applied to the protocol decoder windows only. They do not provide filtering for measurements or visualization.

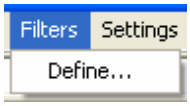
Defining Filters

Several methods are available to define a filter.

- Using the Filter Menu or the Filter Toolbar (if displayed). See below.
- By right clicking on a field within the Packet Decode window. Right clicking on a field within the Packet Decode window will provide an option to define a new filter using that field by means of the 'Define Filter' menu item. Selecting this will launch the Define Filter dialog box with the field in question pre-selected.

Filter Menu and Filter Toolbar

The Filters Menu may be used to define the filter conditions.



Define… This menu item brings up the 'Filters' dialog box. If a capture operation is in progress, this menu item will be disabled.

Filters may also be defined using the Filters Toolbar. In addition, the Filters Toolbar allows Filters to be applied or reset.

Filter: Indicates any display filter currently applied. If no filter is active then the field will be blank. A drop down list can be used to retrieve recently defined filters. An existing filter may be edited or a new filter typed or pasted into this toolbar field.

This drop down list will display the filter as it is being created and will also allow the user to manually update the filter string. The user will also be able to choose from the drop down list any of the last 10 defined filters.

Reset Filter

Disables any currently active filtering, clearing the Filter field in the Filter Toolbar.

Apply Filter

Applies a filter which has just been defined.

Define Filter

Opens the filter definition window, enabling construction of a new filter.

Note that when filters are active the display window titles will be appended with 'Filtered'.

Filter Expressions

Filters may be specified to varying degrees of complexity, as described below.

Simple Filters

A simple filter is a conditional relationship between a single protocol field and some defined value, expressed in the format **(** FIELD *field operator* VALUE **),** where

FIELD is the name of a specific protocol field. Valid field names and their descriptions are listed in an appendix to this document.

field operator is a comparator which can be one of the following

==	Equal to
!=	Not equal to
<	Less than
>	Greater than
<=	Less than or Equal to

>=	Greater than or Equal to

VALUE is a constant

Example: (mac-layer.seqNo == 170)

Note that simple filter expressions are required to be bracketed.

Compound Filters

A compound filter consists of two or more simple filter conditions conjugated in the following manner

((SIMPLE FILTER **)** *append operator* **(** SIMPLE FILTER **))** where

append operator is a comparator which can be one of the following

&&	And
||	Or

Example: ((mac-layer.seqNo == 170) || (mac-layer.seqNo == 87))

As with simple filters, compound filter expressions are required to be bracketed.

Multi-Stage Filters

Typical syntax for multi stage filters:

((SIMPLE FILTER **)** *append operator* **(** SIMPLE FILTER **)** *append operator* **(** SIMPLE FILTER **))**

((SIMPLE FILTER **)** *append operator* **(** COMPOUND FILTER **))**

((COMPOUND FILTER **)** *append operator* **(** SIMPLE FILTER **))**

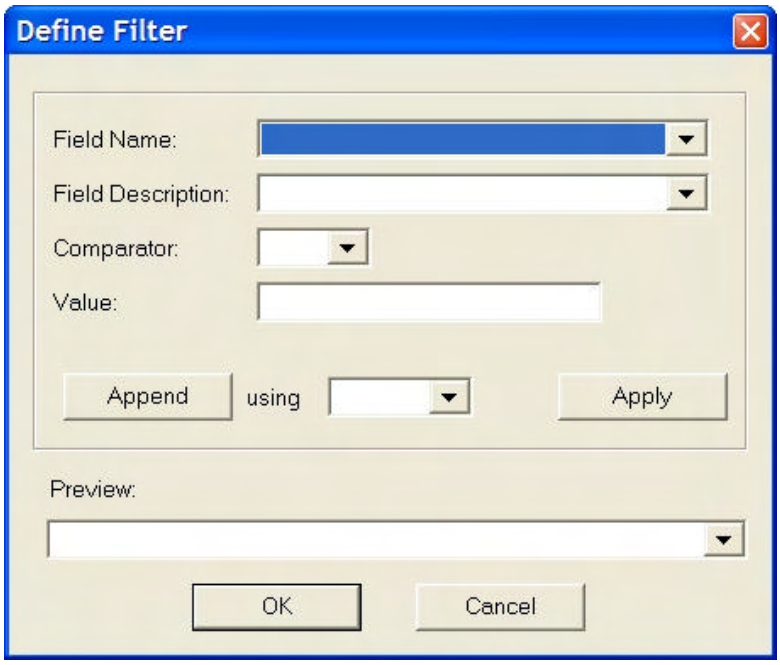
((COMPOUND FILTER **)** *append operator* **(** COMPOUND FILTER **))**

Example: ((mac-layer.seqNo == 170) || (mac-layer.seqNo == 87) && (mac-layer.fcFrmType == 0))

Again, multi-stage filter expressions are required to be bracketed.

The Define Filters Dialog Box

The Define Filters dialog box may be launched from the Filter Menu, Filter Toolbar or from within the Packet Decode window. The appearance and use of the define filters dialog box is described below. Refer to the information above concerning filter expressions for more information on field operators and append operators.



Field Name

The name of a specific protocol field in shorthand notation. Valid names are listed later in this manual.

The protocol field name may be typed or pasted. Alternatively, it may be selected from the drop down list, which contains all possible field names.

When the define filter dialog box is launched from the Packet Decode window using the right click it will be preloaded with the relevant filter name. When launched from the Filter Menu or Filter Toolbar it will default to blank.

Field Description

Is a textual description of the protocol field shown in Field Name above it. This is an informational display only, but does allow a protocol field to be chosen from the drop down list, providing a more meaningful field description. If a protocol field is chosen from this drop down list, it's shorthand notation will be shown in Filed Name above it, replacing any previously selected field name.

Comparator

Is the *field operator* described above in the reference information on filter expressions. A comparator may only be selected from the drop down list.

Value

A constant, being the VALUE described in the reference information on filter expressions above. This text field will allow the user to enter the protocol field value against which the comparison is to take place.

Append using

This button will <u>append</u> the currently defined filter onto the end of the preview string using the selected operator as the *append operator*. This allows the user to build compound filters. Valid operators are && (and) and || (or), chosen from the drop down list.

Apply

This button will <u>replace</u> the contents of the preview string with the defined simple filter.

Preview

This drop down list will display the filter as it is being created and will

	also allow the user to manually update the filter string. The user is also be able to choose from the drop down list any of the last 10 defined filters.
OK	Accept the filter and close the dialog. If the filter has changed this will apply the new filter and make it active.
Cancel	Closes the dialog, causing any changes to be discarded.

5.5 Logging

If enabled, logging saves incoming packets as they are received as a background activity, automatically and transparently to the user. An alternative to logging is to save a capture session to a log file at the end of that session. Logging options are available from the Settings -> Options Menu item as shown below.

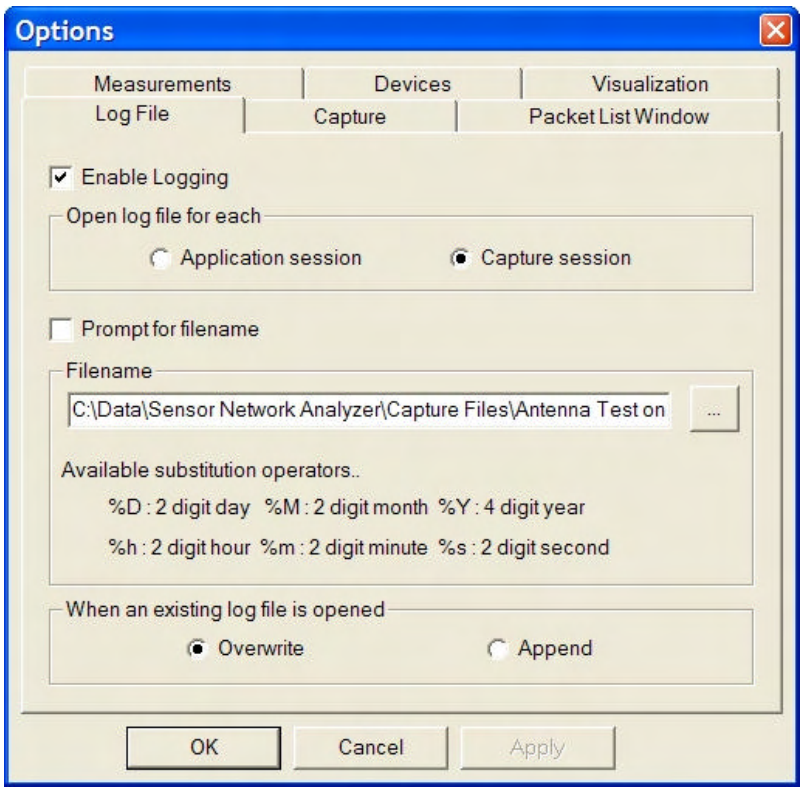


Figure 22 Logging Options

Each of the available options is described below:

Enable Logging	Background logging will not occur unless this box is checked. If logging is disabled, all remaining fields in this tab will be inactive. The application will initially default to logging disabled.
Open log file for each	This radio button selection allows the user to determine whether the log file logic is executed once only at application start up time or each time a capture session is started. If 'Application session' is selected, one log file will be created, consisting of all data including that from multiple capture sessions. If 'Capture session' is selected, a new log file will be created at the start of each capture session. That is, the log file is opened concurrent with a Start Capture operation, and closed when a Stop Capture operation

occurs.

Prompt for filename

If checked, each time the application launches or a capture session is initiated (depending upon the 'Open log file for each' preference) the user will be prompted to manually enter a log file name.

Filename

Specifies the log file name. If 'Prompt for file name' is selected this field will be disabled and its contents ignored.

The file extension defaults to .dcf unless otherwise specified, and assumes default text format. Refer to the description of capture file formats later in this document for more information. The contents of this field will default to the last filename specified even if it is from a previous application session.

To enable automatic unique file name creation facilitating completely automatic background operation, the file name may be constructed from or appended with date and time descriptors. For example, specifying c:\temp\mycapturefile_%M%D%Y_%h%m%s.dcf would result in a log file name of the format c:\temp\mycapturefile_08272004_140312.dcf.

When an existing log file is opened

This radio selection will allow the user to specify what happens to an existing log file of the same name when the log file logic is executed. If 'Overwrite' is selected the log file will be overwritten without warning. If 'Append' is selected the log file is appended with new data.

6 Device Tree

The Device Tree offers a network and device-centric view of an 802.15.4 or ZigBee network. It automatically detects network formation, reports changes to the network structure and notifies of the states of individual devices in the network, especially with regard to formation. The Device Tree is created from the same packet stream, using the same live capture packets or opened capture file as the Protocol Decoder Windows. Note that Protocol Decoder Display Filters have no affect on the Device Tree (or for that matter, measurement or visualization windows).

6.1 Device Tree Window

The Device Tree window displays the network topology by observing 802.15.4 ASSOCIATION-Response messages.

It provides a tree-view of the network topology, as shown below.

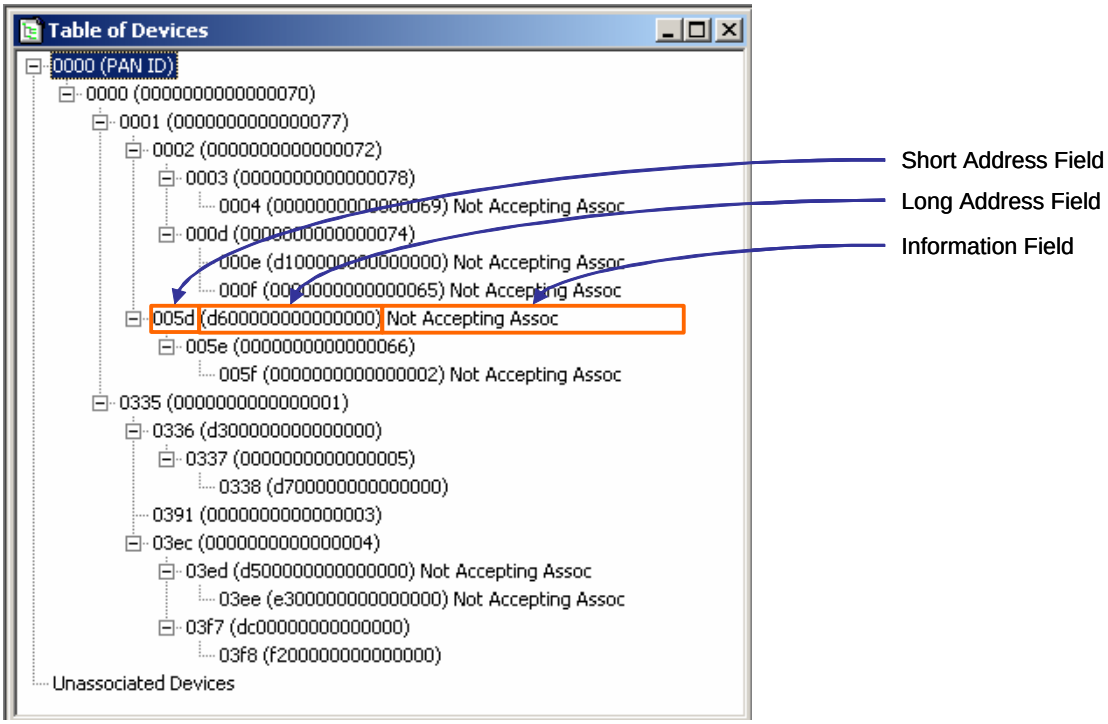


Figure 23 Device Tree Window

The Device Tree provides topology information for multiple PANs, and within each PAN, each device's long and short addresses, and the device hierarchy.

An additional information field is provided which may display:

- If the device is accepting associations
- If the device has reassociated to another location in the device tree.
- Disassociated devices are shown in a separate section.

Each level of the tree may be expanded or collapsed as implied by the tree display format.

The Device Tree window will be updated only when a change occurs to the table, but no more often than once a second.

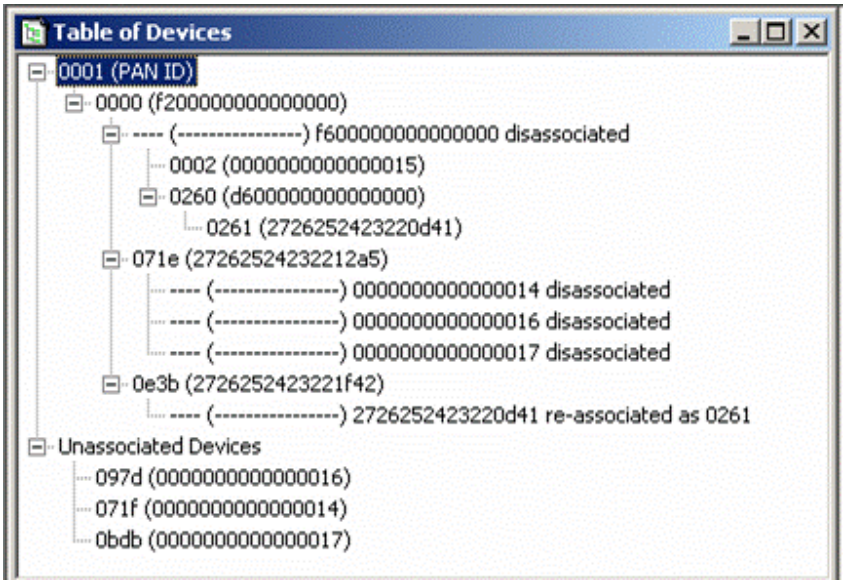


Figure 24 Device Tree - with Dis-associations and Re-associations

NOTE: The Device Tree uses MAC layer Association Response messages to detect new devices joining the network. As such it is important for the capture session to begin when the network is formed such that it detects these association messages. If a capture session is started after the formation of the network, the Visual Device Tree will not be displayed.

6.2 Device Tree Options

The Settings -> Options menu item contains a Devices tab.

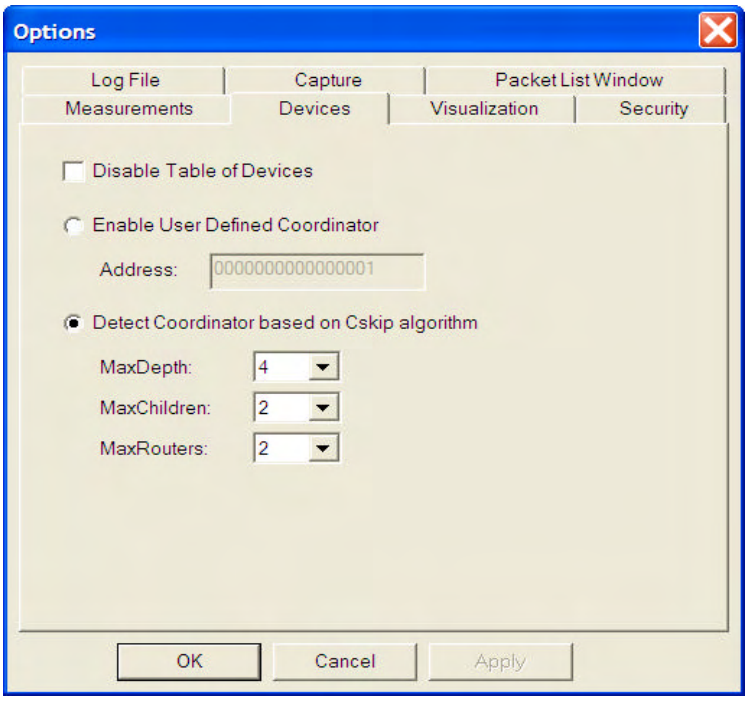


Figure 25 Devices Options

The first option is a checkbox option to disable the Table of Devices. This will default to “Enabled”. If “Disabled”, the Table of Devices will not process any subsequent packets, and this will disable all measurements and visualization features which are dependent on the Table of Devices. Under normal operation, when disabled, the Table of Devices simply slaves off the capture system controls.

The other options associated with the Table of Devices are concerned with coordinator detection. Coordinator detection is complicated by the fact that there is no message defined in 802.15.4/ZigBee networks that carries both the short and long address of the coordinator. The Device Tree component typically requires the first device that associates with the coordinator to be a Router device. It uses detection of the Short Address of 0x0001 to identify such an association. If instead an End-Point device, with short address other than 0x0001, joins the coordinator the default algorithm used to identify the coordinator and device tree may be unreliable. To overcome this issue the user should define a User Defined Coordinator, or set the Cskip parameters in the Device Options (Options menu, Devices Tab).

When using the User Defined Coordinator, the SNA will look for the device with the supplied long address and when detected configure it as the coordinator with address 0x0000.

When using the CSKIP based approach, the SNA will calculate which short addresses the coordinator may assign to its children and if its see one of those addresses being allocated it assumes the parent device is the coordinator with address 0x0000.

7 Measurements

7.1 Measurements Window

The measurement system provides summary information on the state of devices, streams and routes.

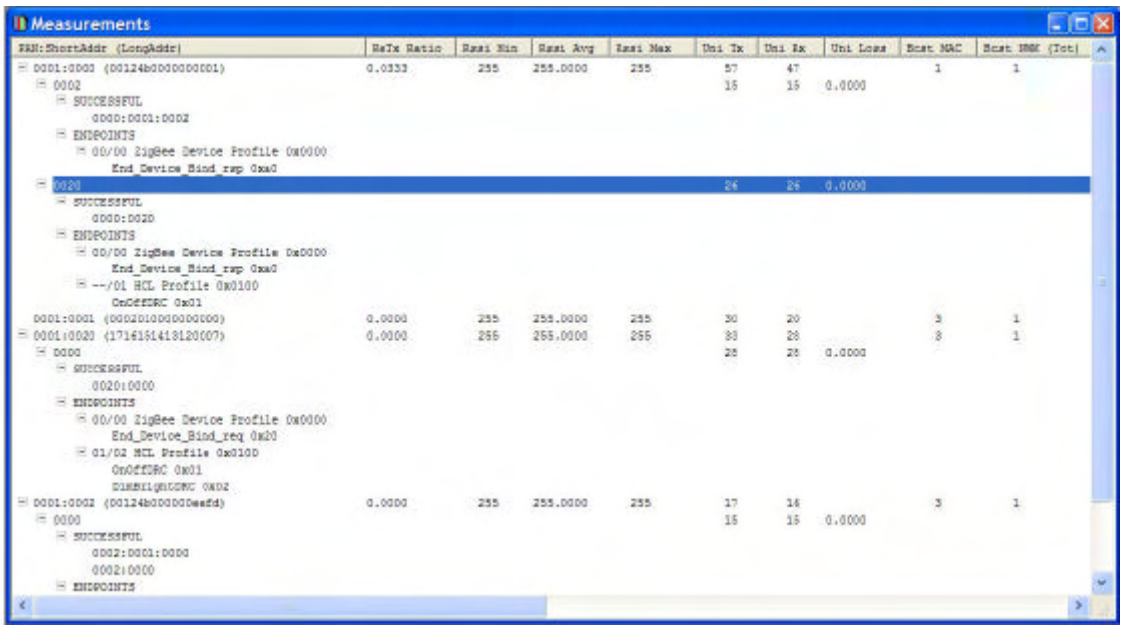


Figure 26 Measurements Window

The Measurements window is a multi-column display with the first column containing an expandable/collapsible tree that will adjust the display (ie., show/hide) for the entire row (across all columns). The hierarchy supported in the tree is PAN, device, stream, route type, and route. All but the route can be expanded and collapsed.

A **Stream** is defined as all packets transmitted at the NWK layer between two devices.

A **Route** is defined as a unique sequence of nodes traversed by a given stream of packets. Hence a stream will be comprised of one or more routes. Packets on a given route are tracked using the Source device and the NWK layer sequence number.

Route Types

A number of route types are supported. These include:

Route Type	Description
SUCCESSFUL	A given packet correctly arrived at its destination and all hops from source to destination device were detected.
MALFORMED	A given packet correctly arrived at its destination but some hops were not detected and the analyzer cannot be 100% sure of the path taken by the packet. For this route type, the first hop was detected.
MALFORMED-S	A variant of the MALFORMED route where the first hop was not detected.

REROUTE	For packets that arrive at the destination but via a re-route.
FAILED	A given network layer packet was detected at one or more hops but the packet was not detected arriving at its intended destination.

Note the comments on multi-node capture earlier in this user guide for appropriate configuration of the system and placement of capture hardware.

Start/Stop Controls

The Measurement System is provided with an additional set of start/stop controls. This enables multiple measurement sessions within a single capture session (the Start/Stop capture controls provide the overriding capture controls for the analyzer). When the measurement system is turned on, any existing measurements will be flushed (set to zero). Measurements will be taken from the time it is turned on. The measurement system cannot be turned on (and its controls must be disabled) if the capture system is off. For more information see the chapter on operating the SNA, earlier in this user guide.

When a logfile is loaded, the measurement system is turned on automatically. There is an option to disable this **Auto-Start** feature in the measurements tab of the Options dialog box.

The Measurement System is subject to a sampling interval that determines how often the measurements are updated. The sampling interval is set to 1 sec by default but can be changed to any integral number of seconds. When Measurements are stopped, the current sampling interval is completed and the measurements updated.

The Measurement Start/Stop controls, sampling interval and Auto-Start selection are available from the Measurement Toolbar.

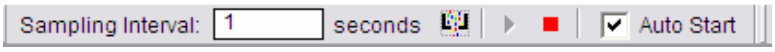


Figure 27 Measurements Toolbar

7.2 Context Menus

Each level of the Measurements hierarchy provides a unique right-click context menu. Context menus enable the selection (and highlighting) of corresponding items in the Visual Device Tree, or provide shortcut packet filter operations to filter the packets shown in the packet list based on the selected item in the Measurements View. Different context menu items are available for different items.

Device Context Menu

The Device Context menu is available by right-clicking on a device in the measurements window.

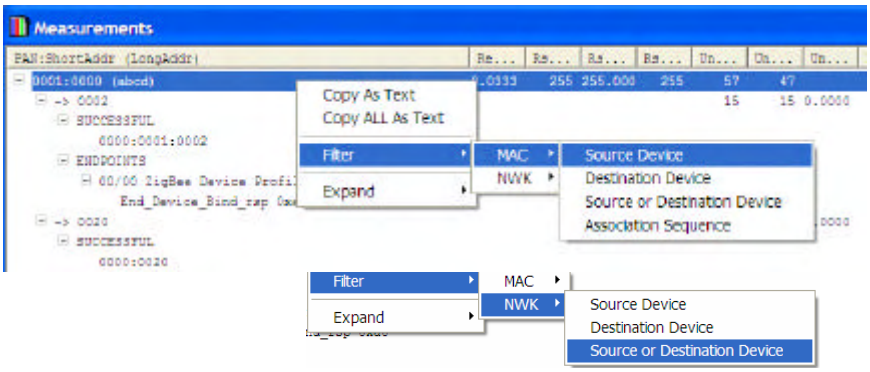


Figure 28 Device Context Menus

The following context menus are available:

- MAC Layer Filters to match all packets where the selected device is the Source, Destination, or either (this will match both short and long addresses),
- Mac Layer Filter to match when this device has participated in the MAC layer association sequence; this is useful to debug network formation issues,
- NWK Layer Filters to match all packets where the selected device is the Source, Destination, or either.

Stream Context Menu

As described earlier, a Stream represents all of the Network layer packets flowing between two devices. At the stream level the following context menus are available.

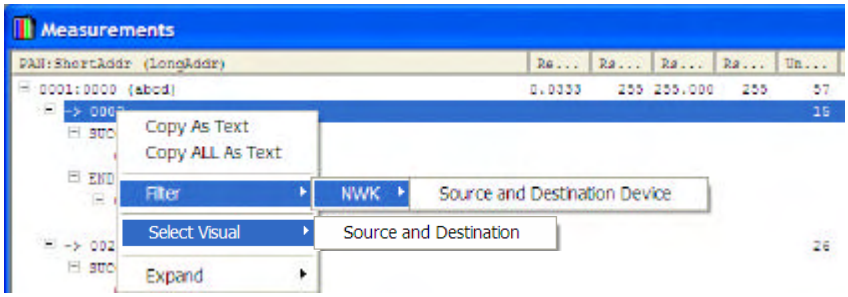


Figure 29 Stream Context Menus

The following context filters are available:

- NWK Layer Filters to match all packets corresponding to this stream i.e. between the given source and destination,
- Select Visual -> Source and Destination option to highlight the given source and destination device in the Visual Device Tree.

Route Context Menu

As described earlier, a Route represents all of the Network layer packets flowing between two devices along a given path (identified by the sequence of nodes traversed by the packets). The Route Context Menu is available by right-clicking on a Route in the Measurement window.

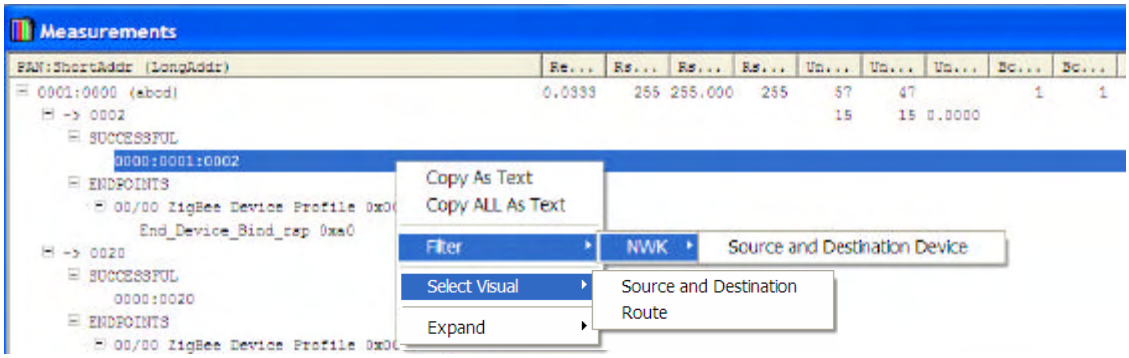


Figure 30 Route Context Menus

The following context menus are available:

- NWK Layer Filters to match all packets corresponding to the associated stream i.e. between the given source and destination,
- Select Visual -> Source and Destination option to highlight the given source and destination device in the Visual Device Tree
- Select Visual -> Route to select and highlight the corresponding route in the Visual Device Tree.

APS Binding Context Menu

An APS Binding represents all of the APS layer packets flowing between two APS end-points on two different devices. The APS Binding context menu is available by right-clicking on an APS binding in the Measurements window.

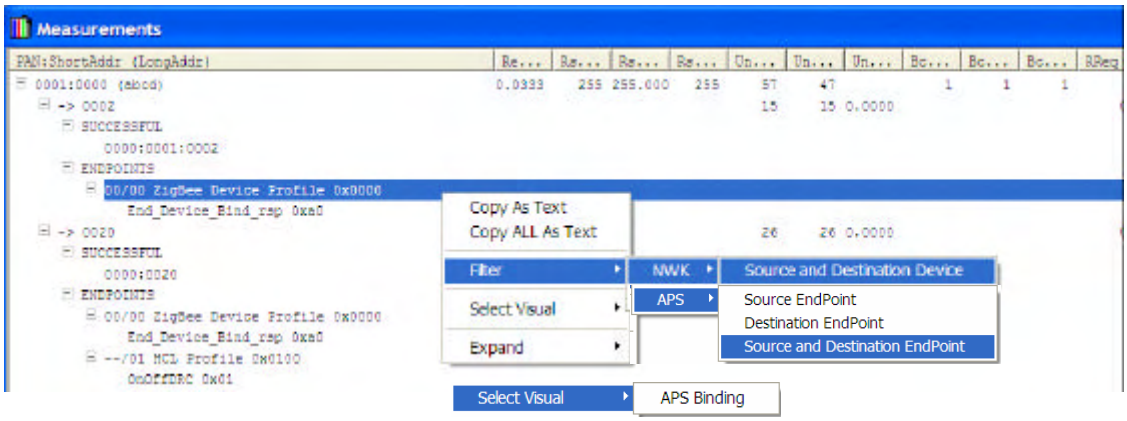


Figure 31 APS Binding Context Menus

The following context menus are available:

- NWK Layer Filters to match all packets corresponding to the associated stream i.e. between the given source and destination,
- APS Layer Filters to match packets flowing from the Source Endpoint and/or to the Destination Endpoint
- Select Visual -> APS Binding to select and highlight the corresponding APS Binding in the Visual Device Tree.

APS Cluster Context Menu

An APS Cluster identifies a specific class of Application layer attributes being exchanged by two APS end-points on two different devices. The APS Cluster Context Menu is available by right-clicking on an APS Cluster in the Measurements window.

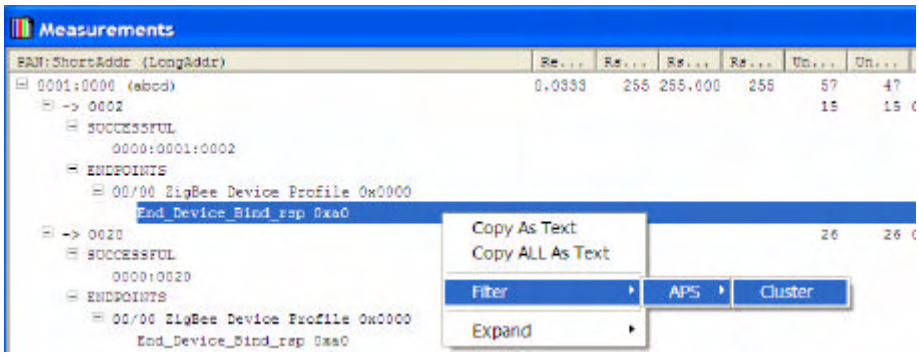


Figure 32 APS Cluster Context Menus

The following context menus are available:

- APS Layer Filters to match all packets on the given cluster between the given source device/endpoint and the given destination device/endpoint.

Expand Context Menu

The Expand right-click context menu is available for the entire Measurements Window and is not specific to different levels of the measurement hierarchy. The Expand menus determine to what level the Measurements hierarchy is expanded and collapsed and hence determines what is shown at any point in time.

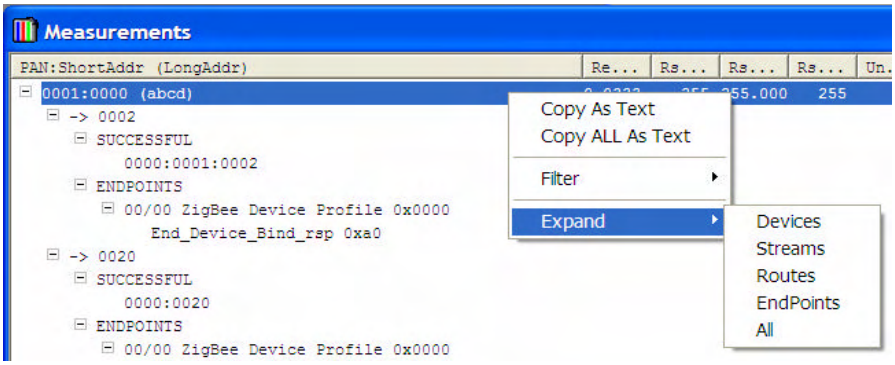


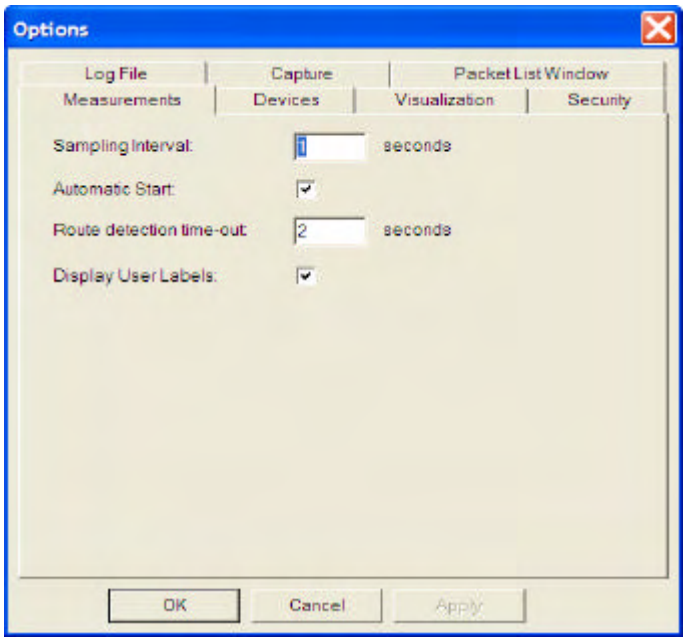
Figure 33 Expand Context Menus

The following context menus are available:

- Expand Devices will show the device level but collapse all others,
- Expand Streams will show Devices and Streams but collapse routes and APS Endpoints,
- Expand Routes will show Devices, Streams and Routes, but not APS Endpoints,
- Expand Endpoints will show Devices, Streams and APS Endpoints but not Routes,
- Expand All will show everything.

7.3 Measurements Options

There is an Options tab in the Options dialog available from the Settings -> Options menu item.



This provides an alternate location for setting the sampling interval and for selecting the Auto-Start feature.

The Options dialog also provides for setting of a “Route Detection Timeout”. This is the amount of time in seconds during which the Analyzer will wait for all hops of a given route to be detected. If at the end of the route detection timeout the final hop has not been detected the given Route will be marked as FAILED. Routes are timed out at the end of each sampling interval if it has been longer than the Route Detection Timeout since the last packet was detected on the route.

The “Display User Labels” option will show user labels for devices shown in the Measurements view based on the label defined in the Device Naming Table (see later section). If selected the user label will be shown instead of the devices long address. This option is disabled by default.

7.4 Available Measurements

Transmission Measurements				
	ReTx Ratio	RSSI Min	RSSI Avg	RSSI Max
Device	Yes	Yes	Yes	Yes
Stream				
Status	Retransmission ratio: the proportion of retransmitted packets detected RSSI values are as reported by the Capture Device for each packet.			

Basic Packet Measurements					
Uni Tx	Uni Rx	Uni Loss	Bcst MAC	Bcst NWK (Tot)	Bcst NWK (Unique)
Yes (MAC)	Yes (MAC)		Yes	Yes	Yes
Yes (NWK)	Yes (NWK)	Yes (NWK)			

All of these are running in Alpha-1 (except for UNI Loss)
These measurements are basic counts that do not do any route tracking. They simply count on the basis of packets transmitted from source (MAC or NWK) and packets received at destination (MAC or NWK)

Route Discovery Measurements			
RReq	RRep	Rrep Cost	Rerr
Yes	Yes	Yes	Yes

Packet Performance Measurements						
	Tx Count	Rx Count	Loss	SeqErr	Duplicate	BitErr
Stream	Yes	Yes	Yes	Yes	Yes	Yes
Simple	Yes	Yes				Yes
Reroute	Yes	Yes				Yes
Malformed	Yes*	Yes				Yes
Failed	Yes	Yes**				
Status	These measurements are all reliant on the use of a unique sequence number, identifying the packet uniquely transiting through the network. The four types of routes are : Simple (normal transmission through the network), Reroute (one or more reroute occurred), Malformed (missing hops or did not see initial transmission) and Lost (packet did not arrive at destination, or did not see last hop)					
Notes	* Tx count may be less than Rx count. ** By definition, Rx count = 0 and Loss = 100%.					

Latency Measurements			
	Delay Min	Delay Avg	Delay Max
Stream	Yes	Yes	Yes
Simple	Yes	Yes	Yes
Reroute	Yes	Yes	Yes
Malformed	Yes*	Yes*	Yes*
Failed			
Status	Latency measurements are only possible for packets that were detected through their final hop.		

8 Visual Device Tree

The Visual Devices Tree Window provides a graphical rendition of network topology and information flows between devices.

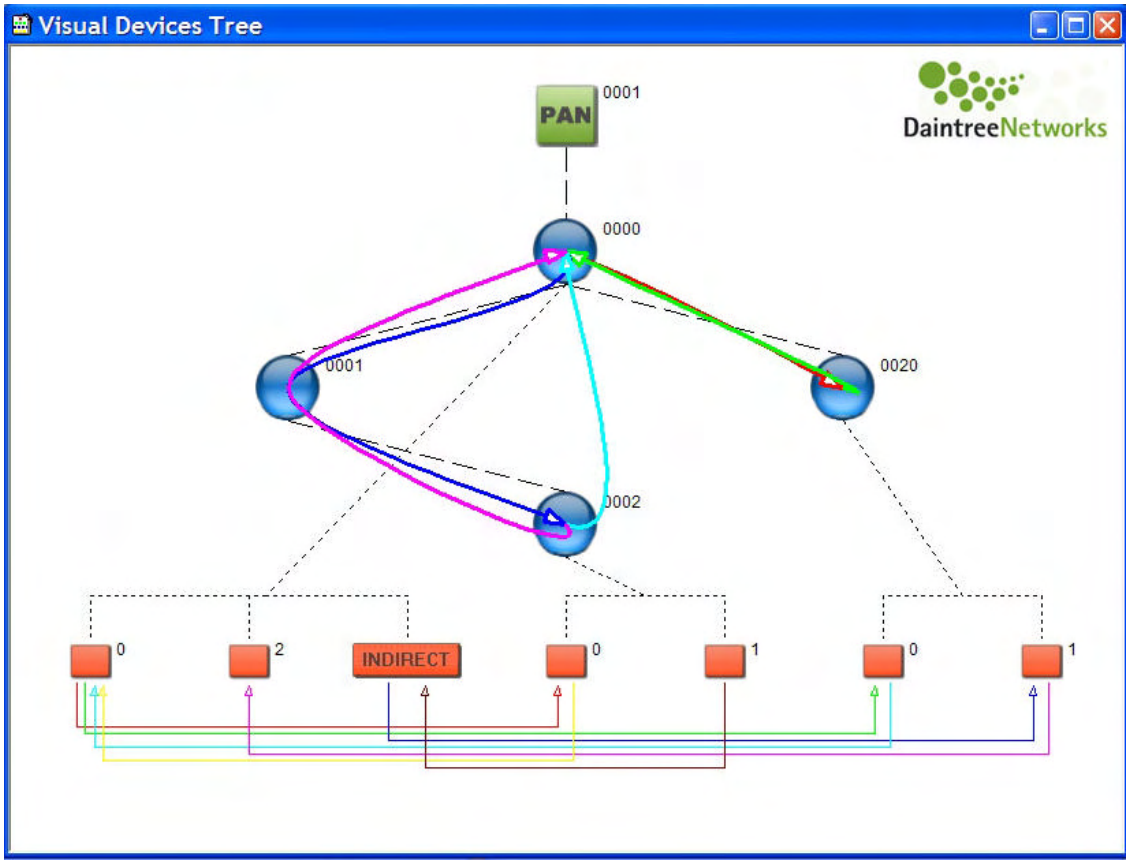


Figure 34 Visual Device Tree

8.1 MAC Layer Visualization

In its most basic form, the Visual Device Tree Window provides a graphical tree diagram that represents the latest device association tree. This corresponds to the Device Tree Window contents.

Devices are shown as circles (or icons as described below) with links between them corresponding to each MAC layer association. Devices are labeled with the Short Address. Fly-over help is available for each device which displays the long IEEE address.

The Visual Device Tree Window displays the device association tree for a single PAN at a time. The current PAN ID will be shown in a rectangle as the root of the tree. Right clicking on the PAN ID will allow the user to select from a list of available PANs.

The window has a resize option which can be useful for optimizing the visibility of various sized networks. The user may choose from large, medium and small devices and fonts. This essentially provides a three level zoom-in and zoom-out capability. This selection is available from the toolbar and by right-clicking anywhere in the Visual Device Tree window. If the network is too large to fit in the current window scroll-bars will appear enabling the user to scroll around the diagram.

NOTE: The Visual Device Tree uses MAC layer Association Response messages to detect new devices joining the network. As such it is important for the capture session to begin when the network is formed such that it detects these association messages. If a capture session is started after the formation of the network, the Visual Device Tree will not be displayed.

Reassociations

In 802.15.4 networks it is not uncommon for a device to lose its association and reassociate with another device in the tree. For these reassociated devices, the previous location in the tree is shown in grey (for the default application icons). There is a grey arrow linking the old location to the new location in the tree with an arrow head indicating the old and new location. A chain of linked re-associated nodes is used to display multiple reassociations of the same device.

A configuration option is available to hide re-associated nodes and an additional option to disable the re-association arrows (which is only available if the user chooses to show the reassociated nodes). Re-associated nodes can only be hidden if they do not have any active children.

The following demonstrates the appearance of a Reassociation, where device previously a child of 0e3b assigned short address 0e3c has reassociated elsewhere as 0196.

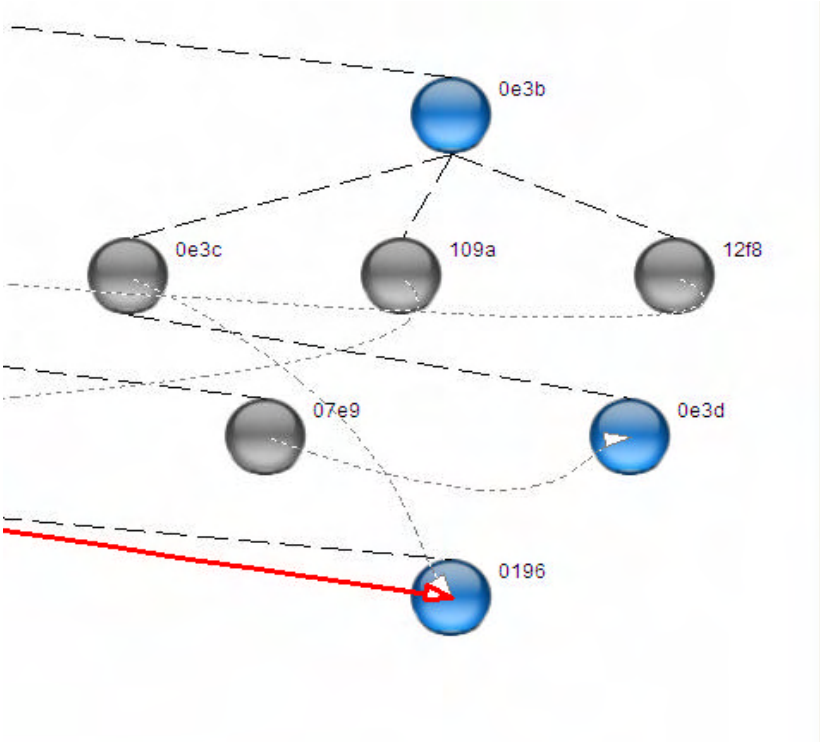


Figure 35 Visual Reassociations

Note that inactive devices, such as a device that has been powered off or removed, will reassociate if re-introduced to the network, but will remain displayed until such a reassociation occurs. As such it is often difficult to identify idle or inactive devices. This is an artifact of there being no requirement in 802.15.4/ZigBee that a device make such an event known, or polling-like events which would reveal it.

8.2 Network Layer Visualization

The network layer visualization adds NWK layer routing information to the visualization. This will show the flow of packets between devices. The display of NWK layer routes can be enabled or disabled explicitly by the user using the Protocol Menu selections.

The Visual Devices Tree Window will display routes that indicate the flow of packets through the network. Each route is shown as a spline that intersects each device the route traverses. An arrow-head is used to show the direction of the route.

Routing information is based on the same route detection algorithm used by the Measurement System. As such routes will only be displayed if the Measurement System is active. Whenever the Measurement System is restarted, all routes are cleared from the measurement system data structures, and all routes will be removed from the visualization. The device association tree will remain intact.

Routes are shown in a variety of colors. The color of an individual route is selected from a color palette of 16 different colors, different from the color used to draw the devices. If more routes are required than number of available colors, colors are reused. Colors are used to differentiate the routes; there is no special meaning associated with any particular color.

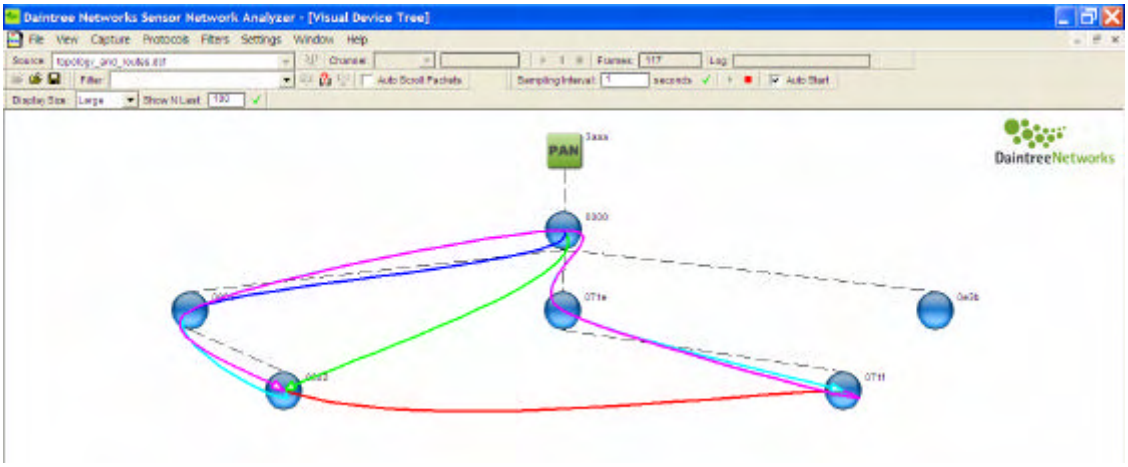


Figure 36 Visual Display of Routes

Device Selection

The user can choose to restrict display of routes to those between a particular source and destination device. Devices are selected by clicking the devices on the diagram, first the source and then the destination. Devices are unselected by clicking in an open area of the display. The selected devices are highlighted. Both source and destination are highlighted using the same highlighting mechanism, but the user can distinguish them based on the arrow-head on the route/s. If there are no devices selected, routes will be shown for the entire PAN.

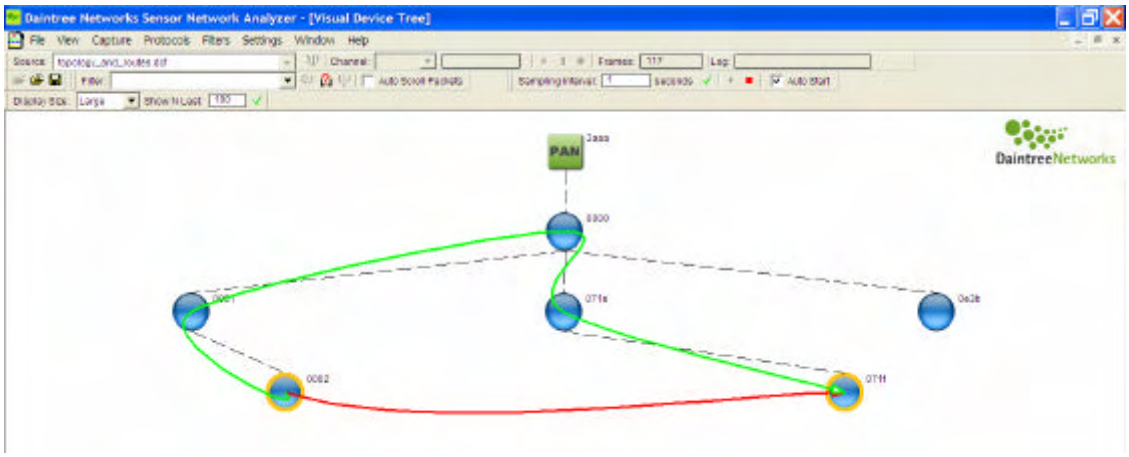


Figure 37 Device Selection

In the example shown above device 0002 has been selected as the source, and device 071f has been selected as the destination. Only the routes between those two devices are shown.

Route Selection

Routes can be selected by clicking on the spline representing the route. When a route is selected, each of the devices the route traverses will be highlighted using the same colour as the route spline. The route can be unselected by clicking on an open area of the display.

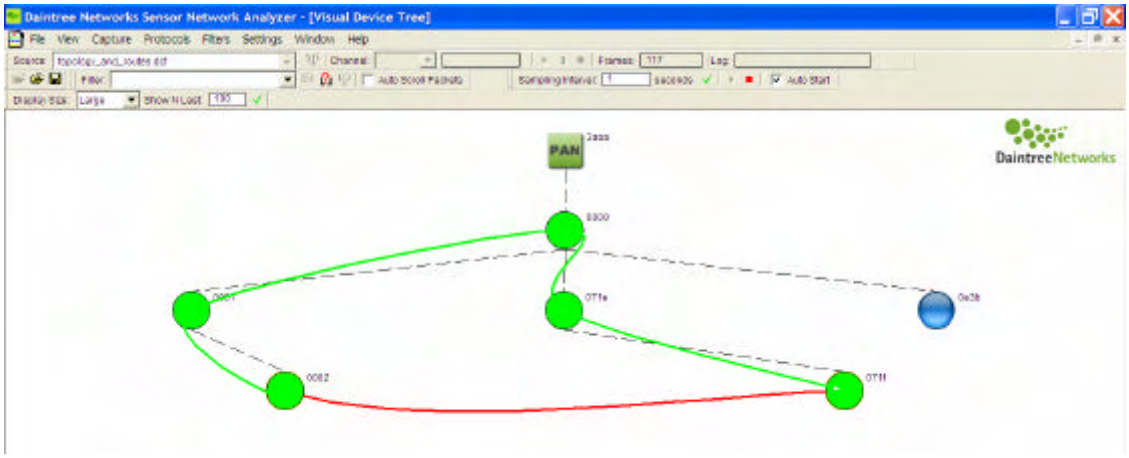


Figure 38 Route Visualization

The system will auto-select the latest route such that when a new route is detected, it is automatically highlighted together with each of the devices it traverses. This applies whether or not there is a selected source and destination device. If there is a currently selected source and destination device only the latest route between those two devices is auto-selected. If the user explicitly selects a route the SNA will maintain the user selection. Auto-selection only occurs when there is no current user selected route.

Displaying different route types

The Visual Device Tree displays SUCCESSFUL, FAILED, MALFORMED and MALFORMED-S routes:

- For FAILED routes the SNA shows only the segment of the route that was detected ,

- FOR MALFORMED-S routes the SNA shows the route from the first node detected up to its destination
- For MALFORMED routes the SNA shows the complete route from source to destination with dashed lines indicating the missed hops.

There is an option to disable the display of FAILED/MALFORMED routes and as such only display SUCCESSFUL routes.

8.3 Application (APS) Layer Visualization

The APS layer visualization adds application endpoint and binding information to the visualization. This includes:

- Extended device tree to show endpoint information on the end devices
- Display of (implicit) bindings between endpoints on different devices,
- Display of the flow of packets (routes) between endpoints.

The APS layer support can be enabled or disabled explicitly by the user using the Protocol Menu selections.

Like the network layer visualization, the application layer visualization will only be displayed if the Measurement System is active. The APS layer analysis is based on the detection of APS data packets. The APS packet header includes the source endpoint, Profile ID, cluster ID, and destination endpoint (although source or destination EP may be absent in when indirect addressing is used).

One of the complexities involved with APS layer analysis is the use of indirect addressing. Indirect addressing is used when a particular end device does not have direct support for binding i.e. it doesn't know the final destination for the APS packets it sends. Instead the end device will forward the APS packets to the co-ordinator, the co-ordinator performs a binding table lookup and then forwards the packets to the associated destination/s. Direct (unicast) and indirect addressing are treated separately as described below.

Direct (Unicast) Addressing

APS Packet Flows between end devices are identified. These packet flows are broken down by end-point pairs and then further broken down by profile ID and cluster ID. When a new packet flow is detected between endpoints, the visualization is updated to show the endpoints on each end device, and a link between the source and destination endpoints to represent the (implicit) binding. We mean implicit in that the link is based on the flow of APS data packets as opposed to the detection of explicit bind requests. The link will be shown as a line linking the endpoints as shown below.

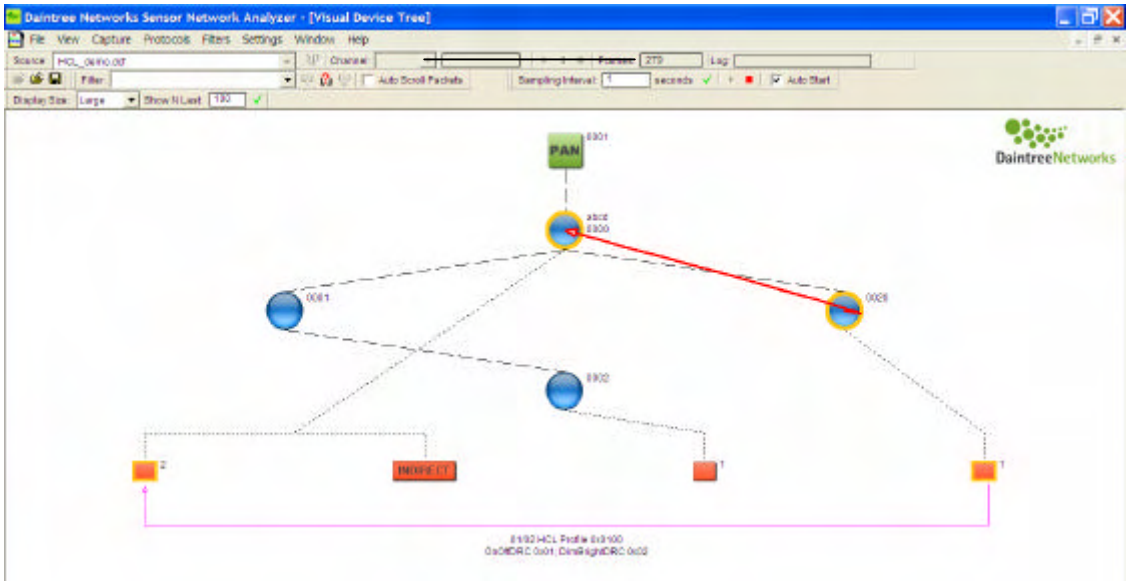


Figure 39 APS Layer Visualization – Direct Addressing

Endpoint Selection

The user is able to select an end-point, and if multiple bindings exist for the given endpoint, the selected endpoint acts as a filter that results in the display of only those bindings associated with this endpoint. If a single binding exists for this end-point, this will select the corresponding source and destination end devices for the purpose of showing routing information. The selected end-points, devices and binding are be highlighted. If an existing binding does not exist, the selection acts as a filter whereby only future bindings that include this endpoint will be shown. Under these circumstances, when a new binding is added, the corresponding source and destination device are automatically selected for the purpose of drawing routes. The selection can be unselected by selecting another device, end-point or clicking on an empty area of the display. While selected, the drawing of new bindings is suppressed.

ZDO and Endpoint 0

ZDO bindings (those between end-point zero) are shown by default on the visual representation just like any other APS binding. However there is an option to disable the display of ZDO bindings (enabled by default). Disabling the display of ZDO bindings can reduce clutter on the screen since there is usually significant ZDO activity on the network.

Endpoint Flyover Help

Flyover help is provided on each endpoint to display the Profile ID and the list of Cluster IDs (incoming and outgoing) active on the end-point. It is important to note that the list of Cluster IDs only include those clusters where the measurement system has detected a packet flow, as opposed to the full list of Cluster IDs supported by the end-point.

Binding Selection

A binding can be selected by selecting the line drawn between two endpoints. Once selected, information about the binding including the Profile ID and the list of cluster IDs is shown directly under the selected binding.

Indirect Addressing

Indirect addressing is handled by considering separately the following packet flows:

- The flow of packets from the source end-point (EP) to the co-ordinator
- The flow of packets from the co-ordinator to destination end-points (EPs).

Each segment is shown independently in the Visual Devices Tree window. These are displayed as follows:

- There is a special INDIRECT endpoint associated with the coordinator. All indirect bindings are shown intersecting with this special endpoint.
- Packet flows from source endpoint to the coordinator are shown as a binding from the source endpoint to the INDIRECT endpoint.
- Packet flows from the co-ordinator to destination endpoints are shown as a binding from the INDIRECT endpoint to the destination endpoints.
- Selecting a source endpoint results in automatic selection of the corresponding end device and route to the coordinator.

Visually this will look something like the following diagram.

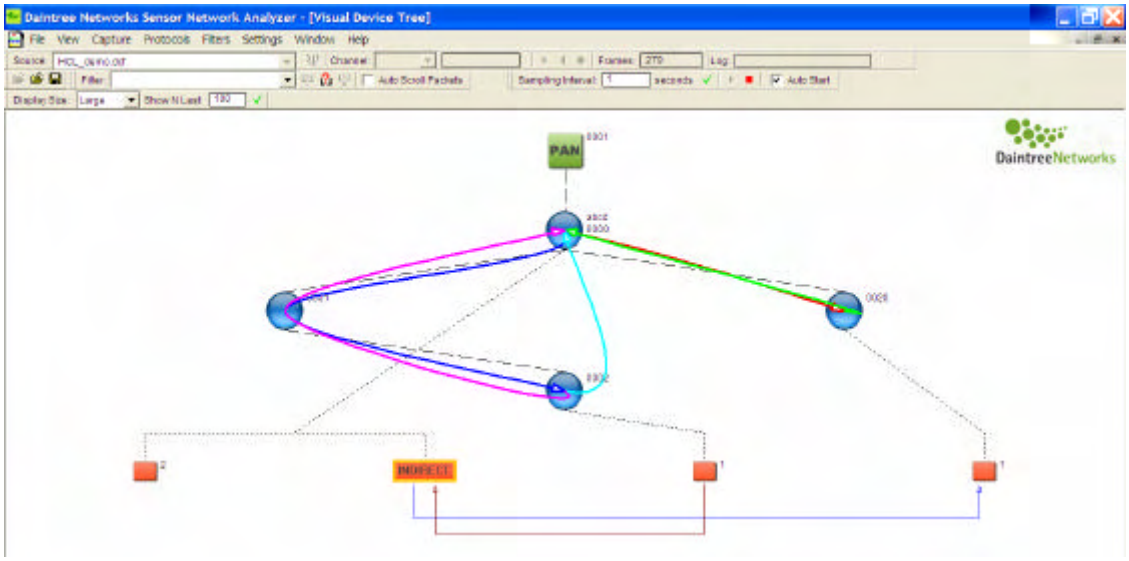


Figure 40 APS Layer Visualization – Indirect Addressing

8.4 Context Menus

The Visual Device Tree provides context menus to quickly access important functions relative to various items in the Visual Device Tree window. The right-click menu item can be selected after moving the mouse above interesting item in the VDT window and selecting the right-click menu button.

Device Context Menu

A right-click menu item is available when clicking on a device in the Visual Device Tree.

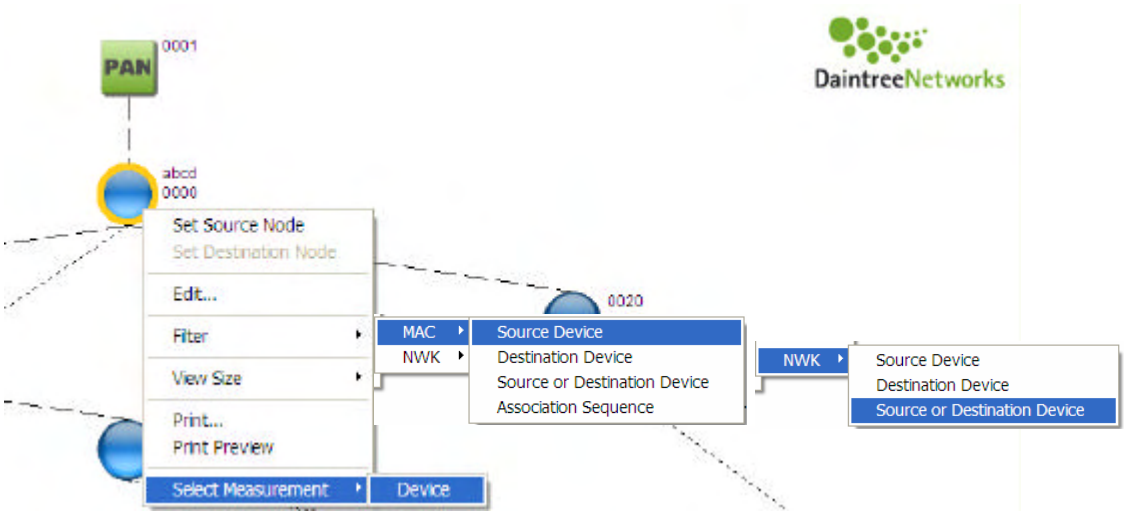


Figure 41 Device Context Menu

The available menu items include:

- Edit… menu item to bring up the Device Naming Table to edit the device properties,
- MAC Layer Filters to match all packets where the selected device is the Source, Destination, or either (this will match both short and long addresses),
- Mac Layer Filter to match when this device has participated in the MAC layer association sequence; this is useful to debug network formation issues,
- NWK Layer Filters to match all packets where the selected device is the Source, Destination, or either.
- A Select Measurement -> Device menu option that will select the corresponding device entry and bring it into focus in the Measurements window.

Route Context Menu

As described earlier, a Route represents all of the Network layer packets flowing between two devices along a given path (identified by the sequence of nodes traversed by the packets). The Route Context menu is available by right-clicking on the route spline on the Visual Device Tree window.

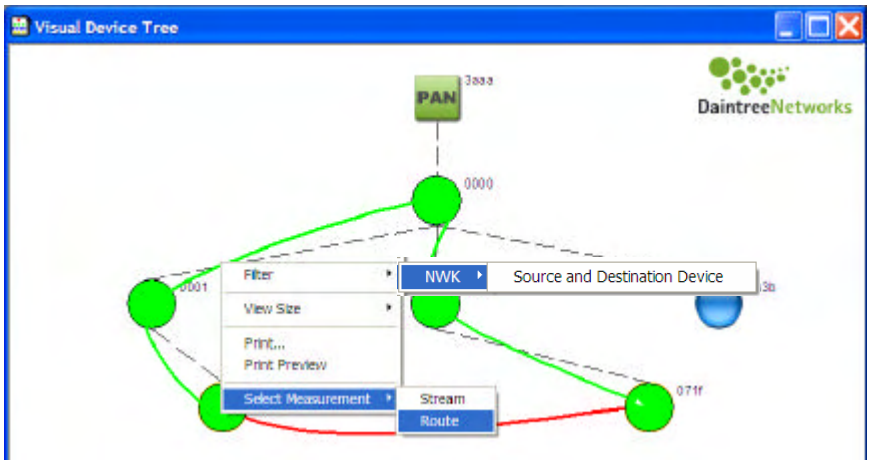


Figure 42 Route Context Menus

The following context menus are available:

- NWK Layer Filters to match all packets corresponding to the associated stream i.e. between the given source and destination,
- Select Measurement -> Stream option to highlight the given source and destination device in the Measurements window
- Select Measurement -> Route to select and highlight the corresponding route in the Measurements window.

APS Endpoint Context Menu

The Route Context menu is available by right-clicking on the APS Endpoint on the Visual Device Tree window.

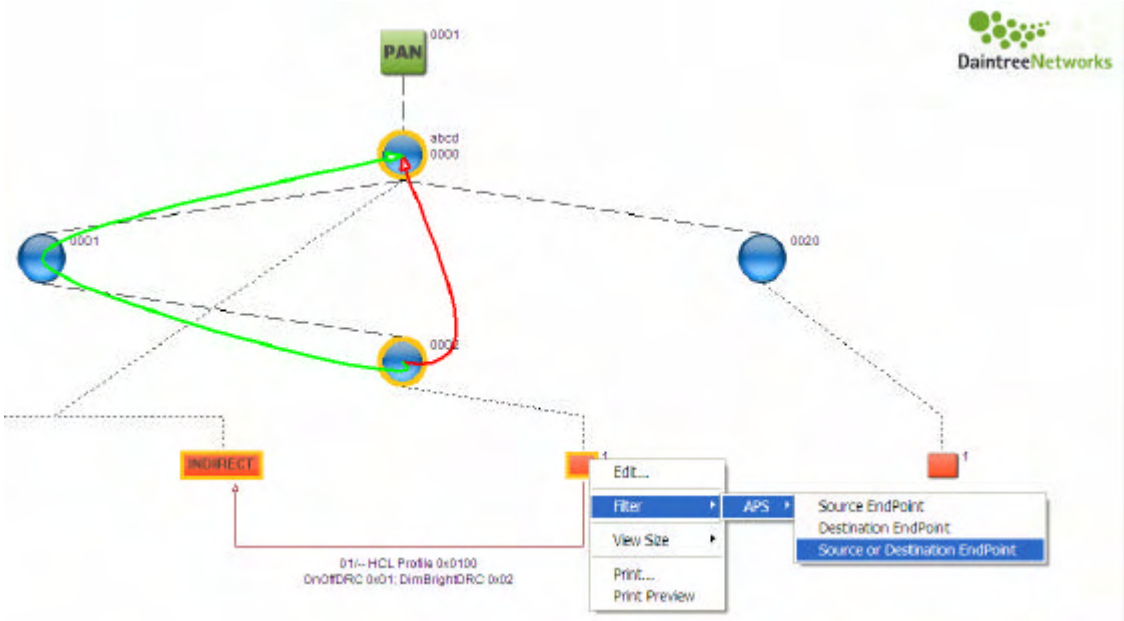


Figure 43 APS Endpoint Context Menus

The following context menus are available:

- APS Layer Filters to match all packets corresponding to the associated endpoint, as a Source, a Destination or either.

APS Binding Context Menu

An APS Binding represents all of the APS layer packets flowing between two APS end-points on two different devices. The Route Context menu is available by right-clicking on the APS Endpoint on the Visual Device Tree window.

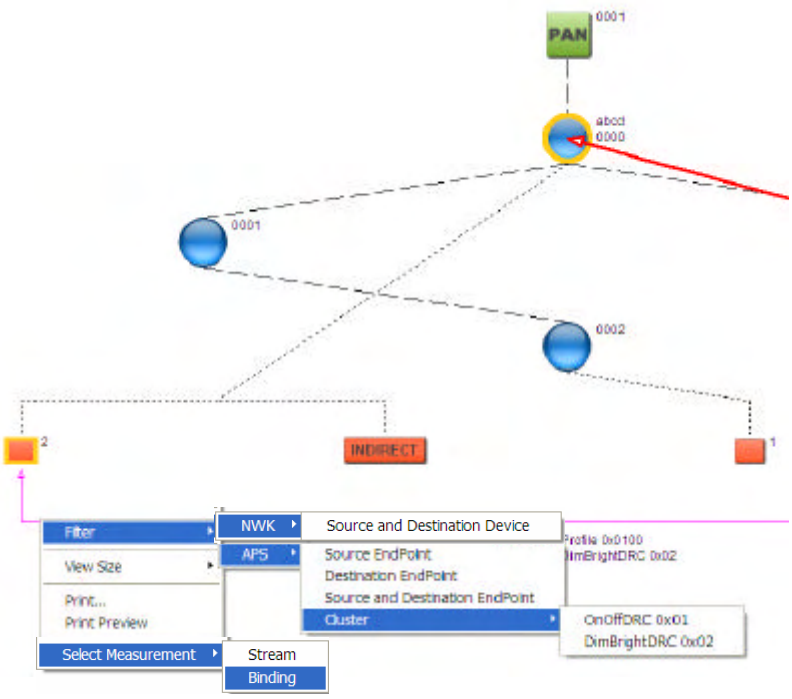


Figure 44 APS Binding Context Menus

The following context filters are available:

- NWK Layer Filters to match all packets corresponding to the associated stream i.e. between the given source and destination,
- APS Layer Filters to match packets flowing from the Source Endpoint and/or to the Destination Endpoint
- APS Layer Filters to match packets between the associated endpoints on a specific APS Cluster ID
- Select Measurement -> Stream option to highlight the given source and destination device in the Measurements window
- Select Measurements -> APS Binding option to select and highlight the corresponding APS Binding in the Measurements window.

Common Context Menus

There are other context menu items available from the Visual Device Tree that do not depend on the currently selected item. These include:

- View menu to select Large, Medium or Small icons,
- Print and Print Preview menu items.

Printing the Visual Device Tree

There is a Print option available from all Visual Device Tree context menus. To preview the Print option, select the Print Preview option.

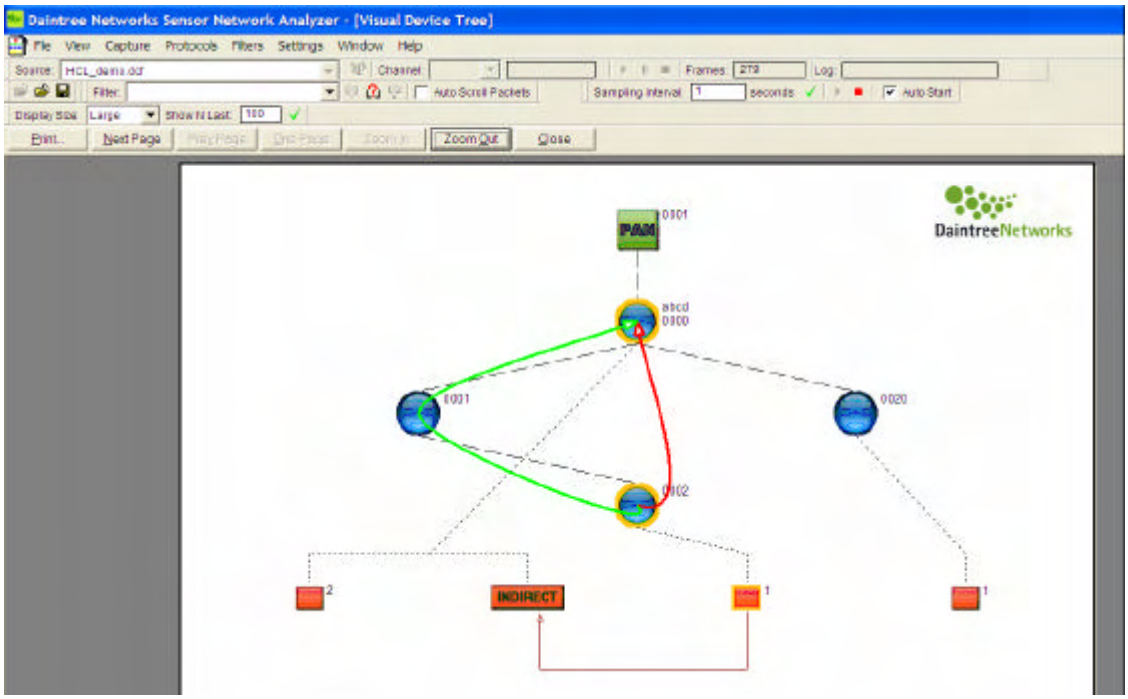


Figure 45 Visual Device Tree Print Preview

The Print Preview window provides a preview of what the Print will look like. The Preview image can be zoomed in and out and if too large to fit on one page the image can be viewed a page at a time.

8.5 Visualization Options

There are visualization options which can be set within the Visualization tab in the Options dialog, available from the Settings -> Options menu item.

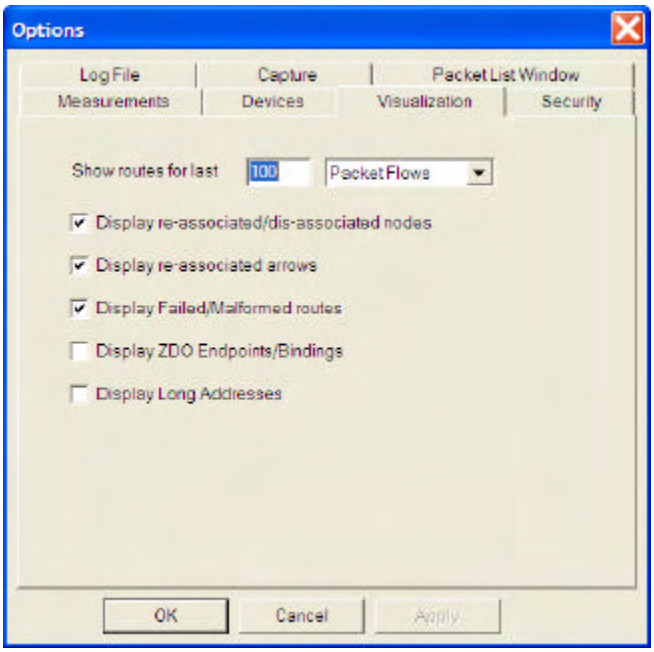


Figure 46 Options Dialog

The user can choose to show routes based on the last N packet flows or the last N distinct routes, where the user nominates the number N. The default value is 10. The same value N applies to routes shown for the entire PAN or for a selected source and destination. The analyzer stores the routes for the last N packet flows (or routes) for the entire PAN and for all streams (source/destination pairs) such that as the user changes the selected nodes, routes will appear for the last N rather than having to wait for the next N for routes to be drawn.

NOTE: There is an option to show the last N routes (regardless of the number of packet flows). This option results in a deterministic number of routes being shown as opposed to the last N flows option which could result in 1 route or N routes.

Reassociations and Reassociation arrows may be hidden. This can help reduce clutter on an otherwise busy visualization.

Failed/Malformed Routes can be hidden such that only SUCCESSFUL routes are shown.

ZDO Bindings/Endpoints may be hidden. This essentially removes control messages and leaves only those endpoints and endpoints carrying application layer data messages.

There is also an option to show long addresses for each of the devices in the Visual Device Tree. By default, only short addresses, and if defined, user labels from the Device Naming Table are shown. While long addresses are typically very informative, they occupy significant real estate.

8.6 Custom Icons

Each device in the visualization is drawn based on the contents of a standard Windows® bitmap (.bmp) file stored externally to the analyzer. Default icons are shipped with the application. Furthermore the default icons are compiled into the application such that they can still be displayed if the external files are not available. The user may override the default icons by replacing the external icon files with an icon of their own creation or choosing.

The default icons are stored in the Daintree Networks\Sensor Network Analyzer\Graphics directory (or an alternative program directory of the user's choosing at install time).

Standard Windows® bitmap files which are used to create node and other icons in the Visual Devices Tree Window. The application uses three sizes of icons, depending upon whether the view scale is *Small*,

Medium or *Large*. The icons are provided as 48x48, 256 color bitmaps and are then resized by the application based on the currently selected scale.

The standard icon files are

- Node.bmp (standard node)
- NodeSel.bmp (a selected node)
- Endpoint.bmp (standard endpoint)
- EndpointSel.bmp (a selected endpoint)
- PAN.bmp (PAN symbol at the top of the tree)

1. Locate the the SNA application graphics subdirectory. The default location is \Program Files\Daintree Networks\Sensor Network Analyzer\Graphics\
2. Save the existing icons for re-installation in future if required, for example for the node icons by renaming as follows:

   Node.bmp to Node_default.bmp

   NodeSel.bmp to NodeSel_default.bmp
3. Place the custom icons into this directory as Node.bmp and NodeSel.bmp. For example

   NodeSpecial.bmp as Node.bmp

   NodeSpecialSel.bmp as NodeSel.bmp

8.7 Device Naming Table

The Device Naming Table stores information about wireless devices under test and impacts how each device is represented by the SNA software. Devices may be associated with a logical name (text label) and/or custom icon to highlight the purpose of the device in the network.

The device naming table is available from the Settings -> Device Naming Table menu item. It is also possible to bring up the Device Naming Table from the Visual Device Tree by right-clicking on a device and selecting the Edit… menu item.

The Device Naming Table is shown in the figure below.

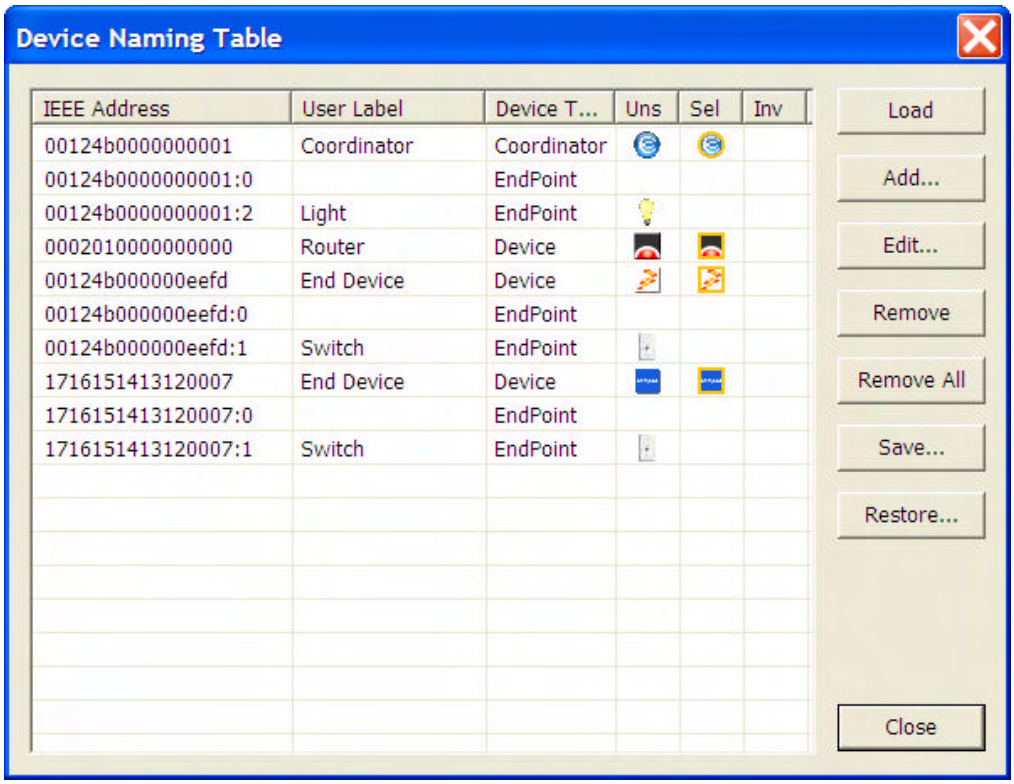


Figure 47 Device Naming Table

The Device Naming Table contains a list of device identified by the IEEE Address, and listing various attributes associated with each device. These attributes include:

- User Label: this label will be shown on the Visualization and optionally on the measurements window.
- Device Type: this differentiates between coordinator, device or the endpoints on each device,
- Icons: Unselected, Selected or Invalid icons can be associated with each device.

The Device Naming Table provides the following operations:

- Load: the contents of the DNT can be loaded based on the devices detected as part of the current capture session,
- Add…: to add a new device,
- Edit…, to edit the currently selected device,
- Remove, the currently selected device,
- Remove All; clear the Device Naming Table,
- Save…; save the contents of the DNT to file,
- Restore…; restore a previously saved DNT file.

When adding or editing a device entry, the following edit… dialog is displayed:

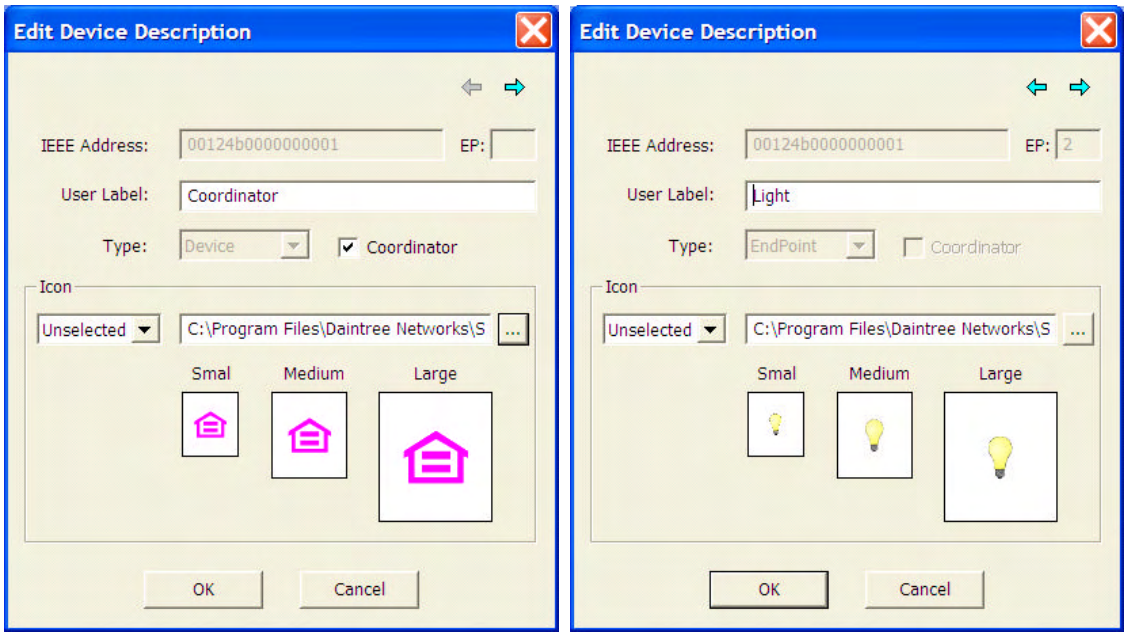


Figure 48 **Device Naming Table – Edit Device Description**

It is possible to edit the details of a device or its endpoints. When editing a device, the endpoint field is blank. Both devices and endpoints can have an associated User Label and/or Custom Icons associated with it. The Icons may indicate the purpose of the device or endpoint, the vendor or any other visual description that can meaningfully be associated with it. Icons are selected by browsing to the location of the icon in the file system. By default icons are stored in the Daintree Networks/Sensor Network Analyzer/Graphics directory.

After assigning user labels and/or custom icons to a device, the representation of the device in the Visual Device tree is modified accordingly, as shown in the image below.

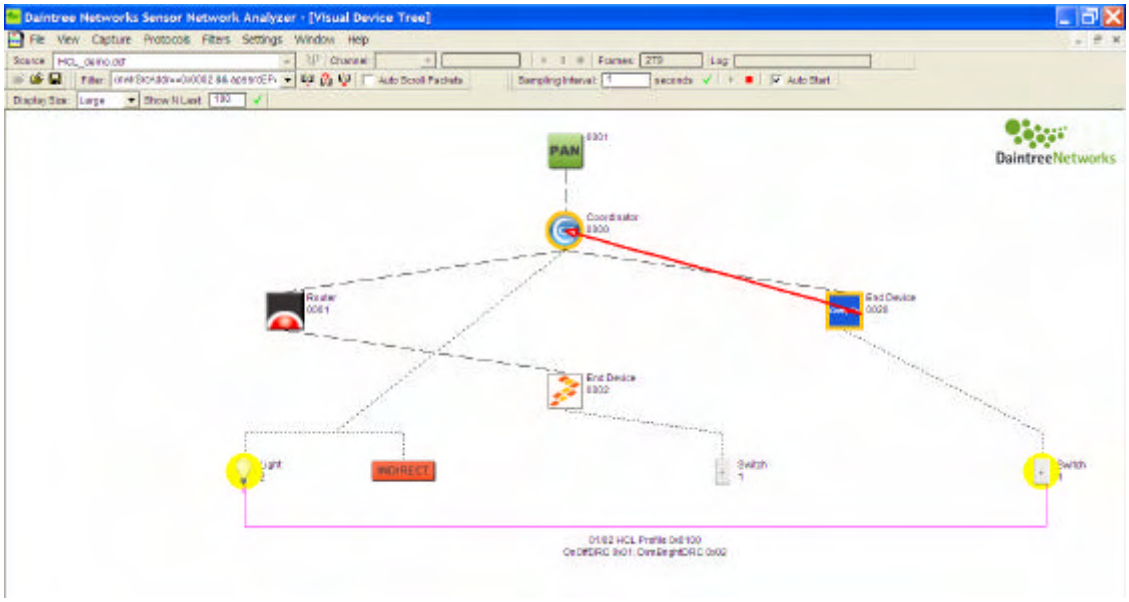


Figure 49 **Visual Device Tree – with User Labels and Custom Icons**

In this example, devices are shown with icons representing different ZigBee platform vendors, while endpoints are shown based on their application layer purpose e.g. light or switch. Example device icons are provided in the Daintree Networks/Sensor Network Analyzer/Graphics directory.

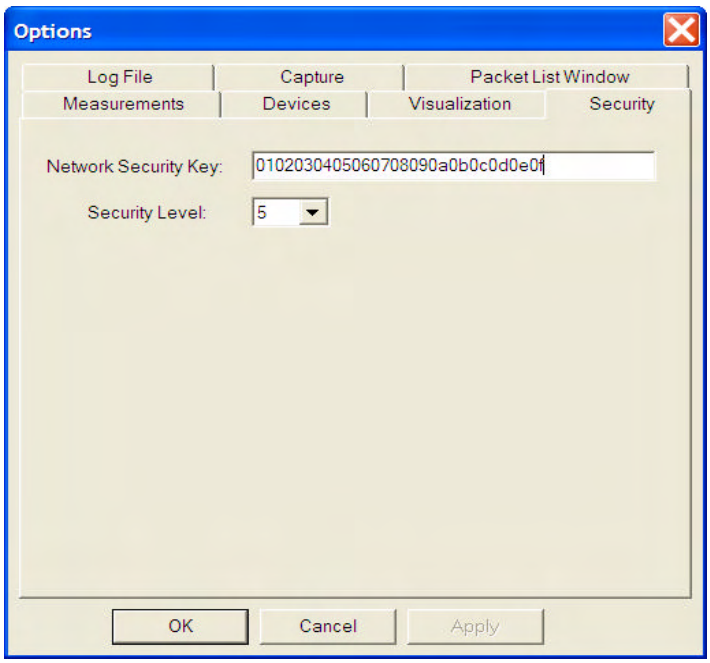
9 Security

The SNA application, and more specifically the protocol decoder and network analysis capability can operate on encrypted traffic streams. The software decrypts these traffic streams and presents the decrypted streams for subsequent decoding and analysis. Decryption requires access to the appropriate key/s as described below.

ZigBee uses the CCM* mode of authentication and encryption. The CCM* mechanisms are described in the Appendices of the ZigBee Security Services specification.

9.1 Security Options

There is a Security tab available from the Options dialog (available from the Settings menu).



There will be a field available to enter the Network Key as a 16 digit hex string. The key is defined in user order (the opposite of Network byte order). The default key is all zeroes.

There will be a field available for the user to enter the current security level. This will default to 0x05 corresponding to the default security level used by the Home Controls (Residential) Stack Profile. In a future release we will consider having the Security Level automatically detected as one of the Settable Parameters associated with the current Stack Profile (as carried in the Beacon Payload).

Each of these options will apply to the MAC, NWK and APS layer security.

9.2 Decoding Encrypted Packets

This section describes how encrypted packets are handled by the Packet List, Packet Decoder and Packet Data windows.

Packet List Window

Packets that are successfully decrypted are shown in the Packet List as if they were never encrpypted. Subsequent fields in the packet are displayed as usual. If packets are encrypted and cannot be decrypted

that Packet Type field in the Packet List will show to what layer the packet was decoded and highlight that the subsequent contents are encrypted using the (Secured) identifier.

Packet Decode Window

The Packet Decode will decode the contents of the decrypted payload (as if the payload was never encrypted)

Additional security headers and trailers added to the encrypted packet like the Auxiliary Header and MIC field will be left in place and decoded.

If decryption fails, the Decode will show the payload as “Encrypted Payload: Decryption Failed” and not attempt to decode the payload any further.

Packet Data

For packets that have security enabled, the packet data window will display the decrypted data (after decryption) such that it corresponds to the data shown in the Packet Decode window.

9.3 MAC Layer Security

MAC Layer security requirements are spread across the 802.15.4 spec and the ZigBee Security Services spec. The Daintree Networks SNA Security support is based on the ZigBee 1.0 specifications.

The SNA will decrypt secure MAC layer packets that were encrypted as follows:

- Encrypted MAC layer packets have the “Security Enabled” flag set in the MAC Frame Control field.
- There is a common Network wide key used to secure all layers of the ZigBee Stack.
- There is a common security level operating across all layers of the ZigBee Stack (as defined by the active Stack profile)
- The Nonce is formed using the 64-bit Source Address, 32-bit Frame Counter and 8-bit Security field (in that order). All fields are stored in Network byte order. The 8-bit Security Field corresponds to the Security Level currently in use (all other bits in the Security field are clear).
- When encryption is applied to MAC layer packets, the encryption will only apply to the payload portion of the MAC payload, i.e. the Beacon payload, the Command payload or the Data payload, depending on the type of the MAC frame type.
- The Secured Payload consists of the Frame Counter, the Key Sequence Number (Security Field?), Encrypted Payload and Encrypted Integrity Code.
- Authentication occurs over the Full MAC Header and MAC payload (including the additional Frame Counter and Key Sequence Number field).

NOTE: This description describes the Daintree interpretation of the ZigBee MAC layer specifications.

Hence an encrypted MAC layer Command frame looks like the following:

<table>
<tr><td>MAC Header</td><td>Command Frame Identifer</td><td>Frame Counter</td><td>Key Sequence Number</td><td>Payload (Encrypted)</td><td>MIC (Encrypted)</td></tr>
<tr><td></td><td></td><td colspan="4">Secured Payload</td></tr>
<tr><td></td><td colspan="5">MAC Payload</td></tr>
</table>

Hence MAC frames are decrypted as follows:

- Use the user supplied Network Key and Security Level. The security level determines whether encryption is used and the length of the message integrity check (MIC) field used to authenticate the packet.
- Create the nonce string using the fields from the Packet in the following order: MAC Source Address (8 octets), Frame Counter (4 octets), Security Control Field (1 octet). Each field is set in the nonce using network byte order.
- If the security level indicates that decryption is required (4 <= Level <= 7) invoke the CCM* decryption routine with the MAC command payload as the encrypted payload (including the additional integrity bytes) and the MAC Header and unencrypted MAC payload fields (including the Frame Counter and Key Sequence Number/Security Control Field) as the additional unencrypted authentication data.
- If authentication succeeds the CCM* decryption routine returns the decrypted payload.
- The decrypted payload can be used to override the previously encrypted NWK payload in the packet for subsequent downstream processing by the decode engine or analysis algorithms.
- If decryption is not required we will not even bother to authenticate the packet, but instead will just decode each of the additional security fields.

9.4 NWK Layer Security

NWK Layer Security features are as defined in the ZigBee 1.0 Security Services specification.

The Daintree SNA can decrypt secure NWK layer packets that were encrypted as follows:

- Encrypted NWK layer packets have the “Security Enabled” flag set in the NWK Frame Control field.
- There is a common Network wide key used to secure all layers of the ZigBee Stack.
- There is a common security level operating across all layers of the ZigBee Stack (as defined by the active Stack profile)
- The AUX Security Header is placed in the NWK layer packet between the NWK Header and Network Payload. The AUX Header consists of the Security Field, Frame Counter, Source Address, and Key Sequence Number.
- The Nonce is formed using the 64-bit Source Address, 32-bit Frame Counter and 8-bit Security field from the AUX Header. All fields are stored in Network byte order.
- The low order three bits of the Security Field correspond to the current Security Level. These bits are masked out (set to zero) in the AUX Header prior to transmission (but after authentication). These bits must be masked back in at the receiver prior to authenticating and decrypting the received packet (in both the AUX Header and the Nonce).
- When encryption is applied to NWK layer packets, the encryption applies to the entire NWK payload.
- Authentication occurs over the Full NWK Header, the AUX Header and the NWK payload.

Hence an encrypted NWK layer frame that looks like the following:

NWK Header	Aux Header	NWK Payload (Encrypted)	MIC (Encrypted)

The SNA will decrypt the frame as follows:

- Use the user supplied Network Key and Security Level. The security level determines whether encryption is used and the length of the message integrity check (MIC) field used to authenticate the packet.
- Create the nonce string using the fields from the AUX Header in the following order: Source Address (8 octets), Frame Counter (4 octets), Security Control Field (1 octet). Each field is set in the nonce using network byte order.
- If the security level indicates that decryption is required (4 <= Level <= 7), invoke the CCM* decryption routine with the NWK payload as the encrypted payload (including the additional integrity bytes) and the NWK Header and AUX Header as the additional unencrypted authentication data.
- If authentication succeeds the CCM* decryption routine returns the decrypted payload.
- The decrypted payload is used to override the previously encrypted NWK payload in the packet for display by the Packet Decode engine or subsequent downstream processing by the Measurements or Visualization analysis algorithms.

9.5 APS Layer Security

APS Layer Security features are as defined in the ZigBee 1.0 Security Services specification.

The Daintree SNA can decrypt secure APS layer packets that were encrypted as follows:

- Encrypted APS layer packets have the “Security Enabled” flag set in the APS Frame Control field.
- There is a common Network wide key used to secure all layers of the ZigBee Stack.
- There is a common security level operating across all layers of the ZigBee Stack (as defined by the active Stack profile). Note however that APS command frames are always secured using a security level of 7.
- The AUX Security Header is placed in the APS layer packet between the APS Header and APS Payload. The AUX Header consists of the Security Field, Frame Counter, and Key Sequence Number.
- The Nonce is formed using the 64-bit Source Address, 32-bit Frame Counter and 8-bit Security field. The Source Address is derived from the Network layer source address by looking up the corresponding IEEE long address in the AID address table (or using a ZDO query). The Frame Counter and Security field are derived from the AUX Header. All fields are stored in Network byte order.
- The low order three bits of the Security Field correspond to the current Security Level. These bits are masked out (set to zero) in the AUX Header prior to transmission (but after authentication). These bits must be masked back in at the receiver prior to authenticating and decrypting the received packet (in both the AUX Header and the Nonce).
- When encryption is applied to APS layer packets, the encryption applies to the entire APS payload.
- Authentication occurs over the Full APS Header, the AUX Header and the APS payload.

Hence an encrypted NWK layer frame that looks like the following:

APS Header	Aux Header	APS Payload (Encrypted)	MIC (Encrypted)

The SNA will decrypt the frame as follows:

- Use the user supplied Network Key and Security Level. The security level determines whether encryption is used and the length of the message integrity check (MIC) field used to authenticate the packet.
- Create the nonce string using the Source Address (derived from NWK source address) and fields from the AUX Header in the following order: Source Address (8 octets), Frame Counter (4 octets), Security Control Field (1 octet). Each field is set in the nonce using network byte order.
- If the security level indicates that decryption is required (4 <= Level <= 7), invoke the CCM* decryption routine with the APS payload as the encrypted payload (including the additional integrity bytes) and the APS Header and AUX Header as the additional unencrypted authentication data.
- If authentication succeeds the CCM* decryption routine returns the decrypted payload.
- The decrypted payload is used to override the previously encrypted APS payload in the packet for display by the Packet Decode engine or subsequent downstream processing by the Measurements or Visualization analysis algorithms.

Appendix A: Application Navigation

The application provides the following menu items:

File Menu

Menu Item	**Function and Action Resulting**
Open…(Ctrl-O)	Opens a previous capture file in the decoder. The dialog box's "`Files of Type`" list box will contain "`Capture Files (*.dcf)`" and "`All Files (*.*)`" with the former being the default. Displays the first PDU's in the list, selects the first and decodes it. If there is any unsaved data the user will be prompted to save it, using the same operation as described for `File|Save`. If a capture is currently in progress, this menu item is disabled.
Close (Ctrl-W)	Closes the capture file and clears the capture windows. If the current capture has not been saved, provides the option to save the capture to a file before closing. Otherwise the capture data is lost (unless it has been saved using the logging functionality). If a capture is currently in progress then this menu item is disabled.
Save…(Ctrl-S)	Allows the user to save a capture to a named file prompting for a filename in all cases. The input field will be preloaded with the previous filename used. The dialog box's "`Save as Type`" list box will contain "`Capture File (*.dcf)`". The user will be able to choose whether the data saved consists of filtered or unfiltered data. If a capture is currently in progress then this menu item is disabled.
Exit	Exits the application, prompting the user to choose a file name for saving of the capture data if they wish, using the same operation as described for `File|Save`.

View Menu

Menu Item	**Function and Action Resulting**
Packet List	Opens/closes the packet list window (check mark against item in list when displayed).
Packet Decode	Opens/closes the packet decode window (check mark against item in list when displayed).
Packet Data	Opens/closes the packet data window (check mark against item in list when displayed).
Device Tree	Open/Close the device tree, a tabular view of all devices detected on the network
Measurements	Open/Close the Measurements View
Visual Device Tree	Open/Close the Visual Device Tree
All	Opens/closes all display windows. Selecting this item will cause all unopened windows to be opened.
Toolbars	This is a submenu.
Capture	Displays/hides the capture toolbar (check mark against item in list when displayed).
Filter	Displays/hides the filter toolbar (check mark against item in list when displayed).
File	Displays/hides the file toolbar (check mark against item in list when displayed).
Measurements	Displays/hides the measurements toolbar (check mark against item in list when displayed).
Visualization	Displays/hides the visualization toolbar (check mark against item in list when displayed).

All	Displays/hides all toolbars.

Capture Menu

NOTE: If the user is viewing a file previously recorded this menu will be disabled.

Menu Item	Function and Action Resulting
Select Source…	Allows selection of a capture source (from those available) through a dialog box. The dialog box includes the search button, drop down list of sources and channel selection. If there is a capture operation in progress, this menu item is disabled.
Start Capture	Starts capture operations from the selected device. If there is no source selected or a capture operation is in progress, this menu item is disabled.
Pause Display	Toggles the updating of the display of captured data, allowing the user to check through the data whilst the capturing continues. If there is no capture operation in progress, this menu item is disabled.
Stop Capture	Stops capture operation. If there is no capture operation is progress, this menu item is disabled.

Protocols Menu

Menu Item	Function and Action Resulting
ZigBee NWK	Toggle ZigBee NWK layer decodes and analysis. Toggles check mark against the item in list. The value of this setting is stored in the registry. Upon application start up this item will be reinitialised to its last setting.
ZigBee APS	Toggle ZigBee APS layer decodes and analysis. Toggles check mark against the item in list. The value of this setting is stored in the registry. Upon application start up this item will be reinitialised to its last setting.

If ZigBee NWK decodes are disabled data remaining after the 802.15.4 header information is decoded will be labelled “MAC Payload.” If ZigBee APS decodes are disabled, data remaining after the NWK header information is decoded will be labelled “NWK Payload.”

In both cases, the length of data will be appended to the name. For example: “MAC Payload (41 octets)”. The data will not be displayed in the “Decode” window, only in the “Data” window.

If ZigBee NWK is disabled then ZigBee APS will be disabled by default. If ZigBee APS in enabled, ZigBee NWK will be enabled by default.

Filters Menu

Menu Item	Function and Action Resulting
Define…	This menu item brings up the “Filters” dialog box. If a capture operation is in progress, this menu item will be disabled.
Reset	Clear any active filter and display all packets

Settings Menu

Menu Item	Function and Action Resulting
Options	Displays a tabbed dialog box which allows the user to alter configurable settings. These settings are persevered in the system registry. The supported tabs are: • LogFile • Capture • Packet List Window • Measurements • Devices • Visualization.
Device Naming Table…	The device naming table allows users to assign custom icons and logical names to devices based on their 802.15.4 IEEE Address.
Device Configuration…	This menu item is used to configure the networking properties of the device and also reports device specific information. If a capture operation is in progress, a capture file is open or a third party capture device is currently selected this menu item will be disabled.
Firmware Upgrade…	This menu item allows the firmware upgrade of 2400E Adapters connected via USB. If a capture operation is in progress, a capture file is open or a third party capture device is currently selected this menu item will be disabled.

Window Menu

Menu Item	Function and Action Resulting
Cascade	Cascades the currently open windows so that they are overlapped in the top left hand corner of the screen.
Tile Horizontally	Tiles the currently open windows horizontally so that they share the screen space evenly.
Tile Vertically	Tiles the currently open windows vertically so that they share the screen space evenly.
Tile Default Layout	Tile all windows according to the default layout with: • Measurements shown in top left corner, 40% width, 60% height of the total screen size, • Visualization shown in the top right corner, 60% width and 60% height, • Packet List shown bottom left, 40% height, 60% width, • Packet Decode shown bottom right, 40% height, 40% width. This provides a quick overview of the full capabilities of the application with the visualization taking up the a sizeable portion of the screen area. The Packet Data and Device Tree windos will be hidden by default.
Arrange Icons	Arranges the minimised window icons in the bottom left hand corner of the screen.
(Window Selection)	A dynamically created list of the open windows. This allows the user to select between the currently open windows.

Help Menu

Menu Item	Function and Action Resulting
Quick Start Guide	Causes this user guide to be displayed. It will open a PDF file using the

	default PDF viewer (if installed).
User's Guide (F1)	Causes this user guide to be displayed. It will open a PDF file using the default PDF viewer (if installed).
About	Displays copyright, identification and version information.

Toolbars

A toolbar exists for each major function of the application to provide easy access to common tasks. The description of each toolbar will be contained in the relevant section of the document.

Appendix B: Capture File Formats

The Sensor Network Analyzer uses a default file extension of .dcf (for *Daintree Capture File*).

Format Descriptor

To convey the format of the information in the capture file, the first line or record of the file may contain be formatted as below:

```
#Format=type
```

where *type* is the format type specification. For example,

```
#Format=1
```

If this line is not present in the file then file format 1 is assumed. Note that including the format descriptor will be ignored if it appears on any line or in any record other than the first.

Format 1

This is the format used by the Sensor Network Protocol Decoder (SNPD) and pre-1.0 release versions of the SNA. It consists of readable text, fields are delimited by a white space (one ASCII space character). Records (packets) are delimited by a new line (CR LF characters).

Field Descriptions

Field Name	Length (chars)	Field Data Type (all fields appear as text)	Description
Sequence Number	1–10	32-bit unsigned decimal integer.	Sequence number for the packet. The Sequence Number is initialised to 1 at the beginning of a capture session.
Timestamp	1–10.1–6	32-bit unsigned decimal integer.32-bit unsigned decimal integer.	Time at which the packet was received, as provided by the capture device. The first integer is the time in seconds since midnight, January 1, 1970. The second integer is an offset in microseconds from this time. The integers are separated by a period ('.').
Length	3	8-bit unsigned decimal integer.	This is the number of octets represented in the *Data* and *Signal* fields combined.
Data	2–250	Concatenated 8-bit hexadecimal.	The actual packet data. This comprises the IEEE 802.15.4 PSDU (PHY Service Data Unit, or payload), in other words, the entire MAC frame. Its length is indicated by the *Length* field, being *Length* - 4.
Signal	4	8-bit signed hexadecimal integer. 8-bit unsigned hexadecimal integer	This contains information concerning signal strength and packet checksum. It's format is capture device dependent.

Signal Field Details

Capture Device	First Octet	Second Octet
Daintree Networks Sensor Network Access Point	RSSI (Received Signal Strength Indicator).	Most significant bit indicates received packet Frame Check Sequence (FCS) status. 1 = FCS OK

0 = FCS in error.

The least significant 7 bits is an unsigned integer being a measure of the average signal strength correlation between the first 8 symbols of the received PHY protocol data unit. It can be considered a measure of the "chip error rate" of the received signal. A value of ~110 indicates a maximum quality frame, a typical value of ~50 is indicative of lowest quality frame reception.

Example

A log file example is shown below.

```
#Format=1
1 1087369893.0 13 0080d8addebeba44cf000002eb
2 1087369893.139287 21 23c8dfaddebebaffff0989952248000000018e02eb
3 1087369893.140347 5 0200df01eb
4 1087369893.245415 21 0080d9addebeba44cf0010098995224800000001ec
5 1087369893.251246 18 63c8e0addebeba0989952248000000402e9
```

Format 2

This is the default format used since SNA Version 1.0. Fields are delimited by a white space (one ASCII space character). Records (packets) are delimited by a new line (CR LF characters).

Field Descriptions

Field Name	Length (chars)	Field Data Type (all fields appear as text)	Description
Sequence Number	1–10	32-bit unsigned decimal integer.	Sequence number for the packet. The Sequence Number is initialised to 1 at the beginning of a capture session.
Timestamp	1–10.1–6	32-bit unsigned decimal integer.32-bit unsigned decimal integer.	Time at which the packet was received, as provided by the capture device. The first integer is the time in seconds since midnight, January 1, 1970. The second integer is an offset in microseconds from this time. The integers are separated by a period ('.').
Length	3	8-bit unsigned decimal integer.	This is the number of octets represented in the *Data* and *Signal* fields combined.
Data	2–250	Concatenated 8-bit hexadecimal.	The actual packet data. This comprises the IEEE 802.15.4 PSDU (PHY Service Data Unit, or payload), in other words, the entire MAC frame. Its length is indicated by the *Length* field, being *Length* - 4.
LQI	5	16-bit unsigned decimal integer.	This is the LQI of the packet.
FCS	1	0 or 1	This is the FCS correctness of the packet. If 1 the FCS was correct. If 0 it was incorrect.

Example

An example of the log file is shown below:

```
#Format=2
1 1087369893.0 13 0080d8addebeba44cf0000ffff 22 1
2 1087369893.139287 21 23c8dfaddebebafffff0989952248000000018effff 23 1
3 1087369893.140347 5 0200dfffff 25 1
4 1087369893.245415 21 0080d9addebeba44cf00100989952248000000ffff 19 1
5 1087369893.251246 18 63c8e0addebeba0989952248000000004ffff 21 1
6 1087369893.252211 5 1200e0ffff 23 1
```

Appendix C: Protocol Decoder Display Filter Fields

The following tables list the valid protocol decoder display filter arguments and their descriptions.

CAPTURED FRAME

hdr-frame.frmLength	Frame Length
hdr-frame.capLength	Capture Length
hdr-frame.malformedData	Malformed Packet

MAC

Mac	IEEE 802.15.4
mac.fc	MAC Frame Control
mac.fcFrmType	MAC Frame Control Frame Type
mac.fcSec	MAC Frame Control Security Enabled
mac.fcFrmPend	MAC Frame Control Frame Pending
mac.fcAckReq	MAC Frame Control Acknowledgment Request
mac.fcIntraPAN	MAC Frame Control Intra PAN
mac.fcResBits789	MAC Frame Control Reserved Bits 7-9
mac.fcDestAddrMode	MAC Frame Control Destination Addressing Mode
mac.fcResBits1213	MAC Frame Control Reserved Bits 12-13
mac.fcSrcAddrMode	MAC Frame Control Source Addressing Mode
mac.seqNo	MAC Sequence Number
mac.destPANId	MAC Destination PAN Identifier
mac.destAddr	MAC Destination Address
mac.srcPANId	MAC Source PAN Identifier
mac.srcAddr	MAC Source Address
mac.Pay	MAC Payload
mac.PaySupFrm	MAC Beacon Superframe Specification
mac.PaySupFrmBcnOrd	MAC Beacon Superframe Specification Beacon Order
mac.PaySupFrmSupOrd	MAC Beacon Superframe Specification Superframe Order
mac.PaySupFrmFinalCAP	MAC Beacon Superframe Specification Final CAP Slot
mac.PaySupFrmBatExtn	MAC Beacon Superframe Specification Battery Life Extension
mac.PaySupFrmResBit13	MAC Beacon Superframe Specification Reserved Bit 13
mac.PaySupFrmPANCord	MAC Beacon Superframe Specification PAN Coordinator
mac.PaySupFrmAssPermit	MAC Beacon Superframe Specification Association Permit
mac.PayGTSSpec	MAC Beacon GTS Information GTS Specification

mac.PayGTSSpecDescCount	MAC Beacon GTS Information GTS Descriptor Count
mac.PayGTSSpecResBits36	MAC Beacon GTS Information Specification Reserved Bits 3-6
mac.PayGTSSpecPermit	MAC Beacon GTS Information GTS Permit
mac.PayGTSDir	MAC Beacon GTS Directions
mac.PayGTSDirMask	MAC Beacon GTS Information GTS Directions Mask
mac.PayGTSDirResBit7	MAC Beacon GTS Information Directions Reserved Bit 7
mac.PayGTSListDesc	MAC Beacon GTS Information GTS List
mac.PayGTSListDescDevAddr	MAC Beacon GTS Information GTS List Device Short Address
mac.PayGTSListDescStartSlot	MAC Beacon GTS Information GTS List GTS Starting Slot
mac.PayGTSListDescLength	MAC Beacon GTS Information GTS List GTS Length
mac.PayPendAddrSpec	MAC Beacon Pending Address Specification
mac.PayPendAddrSpecAddrPend	MAC Beacon Pending Address Specification Number of Short Addresses Pending
mac.PayPendAddSpecResBit3	MAC Beacon Pending Address Specification Reserved Bit 3
mac.PayPendAddrSpecExtAddrPend	MAC Number of Extended Addresses Pending
mac.PayPendAddSpecResBit7	MAC Beacon Pending Address Specification Reserved Bit 7
mac.PayPendAddrSpecShortAddr	MAC Beacon Pending Address Pending Short Address
mac.PayPendAddrSpecExtendAddr	MAC Beacon Pending Address Pending Extended Address
mac.PayCmdFrmId	MAC Command Frame Identifier
mac.PayCmdFrmArqCapInfo	MAC Command Association Request Capability Information
mac.PayCmdFrmArqCapInfoAltPAN	MAC Command Association Request Capability Info Alternate PAN Coordinator
mac.PayCmdFrmArqCapInfoDev	MAC Command Association Request Capability Info Device Type
mac.PayCmdFrmArqCapInfoPowerSrc	MAC Command Association Request Capability Info Power Source
mac.PayCmdFrmArqCapInfoReceiver	MAC Command Association Request Capability Info Receiver On When Idle
mac.PayCmdFrmArqCapInfoResBits45	MAC Command Association Request Capability Info Reserved Bits 4-5
mac.PayCmdFrmArqCapInfoSecCAP	MAC Command Association Request Capability Info Security Capability
mac.PayCmdFrmArqCapInfoAllocAddr	MAC Command Association Request Capability Info Allocate Address
mac.PayCmdFrmArsShortAddr	MAC Command Association Response Short Address
mac.PayCmdFrmArsAssStat	MAC Command Association Response Association Status
mac.PayCmdFrmDntDisReas	MAC Command Disassociation Notification Disassociation Reason
mac.PayCmdFrmCrlPANID	MAC Command Coordinator Realignment PAN Identifier
mac.PayCmdFrmCrlCordAddr	MAC Command Coordinator Realignment Coordinator Short Address

mac.PayCmdFrmCrlLogChan	MAC Command Coordinator Realignment Logical Channel
mac.PayCmdFrmCrlShortAddr	MAC Command Coordinator Realignment Short Address
mac.PayCmdFrmGTSChar	MAC Command GTS Request GTS Characteristics
mac.PayCmdFrmGTSCharLength	MAC Command GTS Request GTS Characteristics GTS Length
mac.PayCmdFrmGTSCharDir	MAC Command GTS Request GTS Characteristics GTS Direction
mac.PayCmdFrmGTSCharType	MAC Command GTS Request GTS Characteristics Characteristics Type
mac.PayCmdFrmGTSReqResBits67	MAC Command GTS Request GTS Characteristics Reserved Bits 6-7
mac.BcnPay	MAC Beacon Payload
mac.BcnPayProt	MAC Protocol ID
mac.FCS	MAC Frame Check Sequence

NWK

nwk	ZigBee NWK
nwk.fc	NWK Frame Control
nwk.fcFrmType	NWK Frame Control Frame Type
nwk.fcProtoVer	NWK Frame Control Protocol Version
nwk.fcDiscRoute	NWK Frame Control Discover Route
nwk.fcResBits78	NWK Frame Control Reserved Bits 7-8
nwk.fcSec	NWK Frame Control Security
nwk.fcResBits1015	NWK Frame Control Reserved Bits 10-15
nwk.destAddr	NWK Destination Address
nwk.srcAddr	NWK Source Address
nwk.bcstRadius	NWK Broadcast Radius
nwk.bcstSeqNo	NWK Broadcast Sequence Number
nwk.Pay	NWK Payload
nwk.PayCmdFrmID	NWK Network Command Identifier
nwk.PayCmdFrmCmdOpt	NWK Network Command Options
nwk.PayCmdFrmResBits06	NWK Network Command Reserved Bits 0-6
nwk.PayCmdFrmCmdOptRouteRepair	NWK Command Options Route Repair
nwk.PayCmdFrmRouteRequestID	NWK Command Route Request Identifier
nwk.PayCmdFrmRouteRequestDestAddr	NWK Command Route Request Destination Address
nwk.PayCmdFrmRouteReplyOrgAddr	NWK Command Route Reply Originator Address
nwk.PayCmdFrmRouteReplyRespAddr	NWK Command Route Reply Responder Address
nwk.PayCmdFrmRoutePathCost	NWK Command Route Path Cost
nwk.PayCmdFrmRouteErrorCode	NWK Command Route Error Code
nwk.PayCmdFrmRouteErrorDestAddr	NWK Command Route Error Destination Address

nwk.Information	NWK Network Layer Information
nwk.InfoProf	NWK Stack Profile
nwk.InfoVer	NWK Network Protocol Version
nwk.InfoSec	NWK Network Security Level
nwk.InfoRteCap	NWK Device Router Capacity
nwk.InfoDepth	NWK Device Depth
nwk.InfoCap	NWK Device Capacity
nwk.InfoTxOff	NWK Tx Offset

APS

aps	ZigBee APS
aps.fc	APS Frame Control
aps.fcFrmType	APS Frame Control Frame Type
aps.fcDeliveryMode	APS Frame Control Delivery Mode
aps.fcSrcEPPresent	APS Frame Control Source Endpoint Present
aps.fcSec	APS Frame Control Security
aps.fcAckReq	APS Frame Control Ack Request
aps.fcResBit7	APS Frame Control Reserved Bit 7
aps.destEP	APS Destination Endpoint
aps.HCLClustID	APS Cluster Identifier
aps.ZDOClustID	APS Cluster Identifier
aps.profileID	APS Profile Identifier
aps.srcEP	APS Source Endpoint
aps.SecFrmHeader	APS Auxiliary Frame Header
aps.SecCtrl	APS Auxiliary Frame Header Security Control
aps.SecCtrlSecLevel	APS Auxiliary Frame Header Security Control Security Level
aps.SecCtrlKeyID	APS Auxiliary Frame Header Security Control Key Identifier
aps.SecCtrlExtndNonce	APS Auxiliary Frame Header Security Control Extended Nonce
aps.SecCtrlReserved	APS Auxiliary Frame Header Security Control Reserved Bits 6-7
aps.FrmCounter	APS Auxiliary Frame Header Frame Counter
aps.SrcAddr	APS Auxiliary Frame Header Source Address
aps.KeySeqNo	APS Auxiliary Frame Header Key Sequence Number
aps.SecAPSPay	APS Encrypted APS Payload
aps.Pay	APS Payload
aps.PayCmdFrmID	APS Command Frame Command Identifier
aps.PayCmdSKKEInitAddr	APS Security SKKE Command Initiator Address
aps.PayCmdSKKERespAddr	APS Security SKKE Command Responder Address

aps.PayCmdSKKEData	APS Security SKKE Command Data
aps.PayCmdTKeyKeyType	APS Security Transport-key Command Key Type
aps.PayCmdTKeyKeyDesc	APS Security Transport-key Command Key Descriptor
aps.PayCmdTKeyKeyDescKey	APS Security Transport-key Command Key Descriptor Field Key
aps.PayCmdTKeyKeyDescDestAddr	APS Security Transport-key Command Key Descriptor Destination Address
aps.PayCmdTKeyKeyDescSrcAddr	APS Security Transport-key Command Key Descriptor Source Address
aps.PayCmdTKeyKeyDescSeqNo	APS Security Transport-key Command Key Descriptor Sequence Number
aps.PayCmdTKeyKeyDescPartnerAddr	APS Security Transport-key Command Key Descriptor Partner Address
aps.PayCmdTKeyKeyDescInitFlag	APS Security Transport-key Command Key Descriptor Initiator Flag
aps.PayCmdUpdDevDevAddr	APS Security Update-Device Command Device Address
aps.PayCmdUpdDevStat	APS Security Update-Device Command Status
aps.PayCmdRemoveDevChildAddr	APS Security Remove Device Command Child Address
aps.PayCmdReqKeyKeyType	APS Security Request Key Command Key Type
aps.PayCmdReqKeyPartnerAddr	APS Security Request Key Command Partner Address
aps.PayCmdSwitchKeySeqNo	APS Security Switch Key Command Sequence Number

ZIGBEE DEVICE OBJECTS

zdo	ZigBee ZDO
zdo.IEEEAddr	ZDO Discovery IEEE Address
zdo.ReqType	ZDO Discovery Request Type
zdo.StartIndex	ZDO Discovery Start Index
zdo.NWKAddrOfInterest	ZDO NWK Address Of Interest
zdo.InterfaceEndpoint	ZDO Endpoint/interface
zdo.Interface	ZDO Interface
zdo.Endpoint	ZDO Endpoint
zdo.ProfileId	ZDO Profile Id
zdo.NumInClust	ZDO Number of Input Clusters
zdo.InClustList	ZDO Input Cluster List
zdo.NumOutClust	ZDO Number of Output Clusters
zdo.OutClustList	ZDO Output Cluster List
zdo.NWKAddr	ZDO Network Address
zdo.LocalCoord	ZDO Local Coordinator
zdo.SrcAddr	ZDO Surce Address
zdo.SrcEndPint	ZDO Source End Point

zdo.ClustId	ZDO Cluster Id
zdo.DstAddr	ZDO Destination Address
zdo.DstEndPint	ZDO Destination End Point
zdo.ScanChannels	ZDO Scan Channel
zdo.ScanChanVal	ZDO Channel Frequency
zdo.ScanChanReserved	ZDO Reserved
zdo.DevAddr	ZDO Device Address
zdo.Stat	ZDO Status
zdo.IEEEAddrRemDev	ZDO IEEE Address of Remote Device
zdo.NWKAddrRemDev	ZDO Nework Address of Remote Device
zdo.NumAssocDev	ZDO Number of Associated Device
zdo.AssocDevList	ZDO Associated Device List
zdo.NWKAddrAssocDev	ZDO Network Address of Associate Device
zdo.StatDisRegRsp	ZDO Discovery Register Response Status
zdo.StatEndDevAnnceRsp	ZDO Discovery End Device Announce Response Status
zdo.StatEndDevBindRsp	ZDO End Device Bind Response Status
zdo.StatBindRsp	ZDO Bind Response Status
zdo.StatUnbindRsp	ZDO Unbind Response Status
zdo.StatActiveEPIFRsp	ZDO Active End Point/InterfaceStatus
zdo.ActiveEPIFCount	ZDO Active End Point/Interface Count
zdo.ActiveEPIFList	ZDO Active End Point/Interface List
zdo.MatchLength	ZDO Match Length
zdo.StatActiveMatchList	ZDO Match List
zdo.ActiveNetworkCount	ZDO Active Network Count
zdo.ActiveNetworkListCount	ZDO Active Network List Count
zdo.ActiveNetworkListCount	ZDO Active Network List
zdo.Length	ZDO Length
zdo.NodeDesc	ZDO Node Descriptor
zdo.NodeDescLogReserved	ZDO Logical Type and Reserved
zdo.NodeDescLogType	ZDO Logical Type
zdo.NodeDescLogReserved	ZDO Reserved
zdo.APSFlagFreq	ZDO APS Flags and Frequency
zdo.APSFlags	ZDO APS Flags
zdo.Freq	ZDO Frequency band
zdo.MACCapFlags	ZDO MAC capability flags
zdo.MACCapFlagsAltPANCoord	ZDO Alternate PAN coordinator
zdo.MACCapFlagsDevType	ZDO Device Type

zdo.MACCapFlagsPowerSrc	ZDO Power source
zdo.MACCapFlagsReceiver	ZDO Receiver on when idle
zdo.MACCapFlagsReserved1	ZDO Reserved
zdo.MACCapFlagsSecCap	ZDO Security capability
zdo.MACCapFlagsReserved2	ZDO Reserved
zdo.MFGCode	ZDO Manufacturer code
zdo.MaxBufSize	ZDO Maximum buffer size
zdo.MaxTransferSize	ZDO Maximum transfer size
zdo.PowerDesc	ZDO Node Power Descriptor
zdo.PowerDescCurrentMode	ZDO Current power Mode
zdo.PowerDescAvailNode	ZDO Avaliable power sources
zdo.PowerDescCurrentSrc	ZDO Current power source
zdo.PowerDescCurrentSrcLevel	ZDO Current Power source level
zdo.SimpleDescRspStat	ZDO Status
zdo.SimpleDescRspLength	ZDO Length
zdo.SimpleDesc	ZDO Simple Descriptor
zdo.SimpleDescEPIface	ZDO End Point/Interface
zdo.SimpleDescEndPoint	ZDO End Point
zdo.SimpleDescIface	ZDO Interface
zdo.SimpleDescAppProfileId	ZDO Application Profile Identifier
zdo.SimpleDescAppDevId	ZDO Application Device Identifier
zdo.SimpleDescAppDevVerFlags	ZDO Application Device Version/Flags
zdo.SimpleDescAppDevVer	ZDO Application Device Version
zdo.SimpleDescAppFlags	ZDO Application Flags
zdo.SimpleDescAppInpClustCount	ZDO Application Input Cluster Count
zdo.SimpleDescAppInpClustList	ZDO Application Input Cluster List
zdo.SimpleDescAppInpClustVal	ZDO Cluster
zdo.SimpleDescAppOutClustCount	ZDO Application Output Cluster Count
zdo.SimpleDescAppOutClustList	ZDO Application Output Cluster List
zdo.SimpleDescAppOutClustVal	ZDO Cluster
zdo.ComplexDesc	ZDO Complex Descriptor
zdo.ComplexDescFieldCount	ZDO Field Count
zdo.ComplexDescField	ZDO Field
zdo.ComplexDescFieldXMLTag	ZDO Compressed XML Tag
zdo.ComplexDescFieldData	ZDO Field Data
zdo.ComplexDescLanguageCode	ZDO ISO 639-1 language code
zdo.ComplexDescCharSetId	ZDO Character set identifier

zdo.UserDesc	ZDO User Description
zdo.NWKCount	ZDO Network Count
zdo.NWKListCount	ZDO Network List Count
zdo.NWKList	ZDO Network List
zdo.NWKDesc	ZDO Network Descriptor
zdo.NWKDescPANId	ZDO PAN ID
zdo.NWKDescFlags	ZDO Network Descriptor Flags
zdo.NWKOpMode	ZDO Operational Mode
zdo.NWKLogChan	ZDO Logical Channel
zdo.NWKBcnOrder	ZDO Beacon Order
zdo.NWKPermitJoining	ZDO Permit Joining
zdo.NbrTableEntries	ZDO Neighbor Table Entries
zdo.NbrListCount	ZDO Neighbor Table List Count
zdo.NbrList	ZDO Neighbor Table List
zdo.NbrEntries	ZDO Neighbor Entry
zdo.NbrPANID	ZDO PAN ID
zdo.NbrExtAddr	ZDO Extended Address
zdo.NbrNWKAddr	ZDO Network Address
zdo.NbrDevType	ZDO Device Type
zdo.NbrRelationship	ZDO Relationship
zdo.NbrDepth	ZDO Depth
zdo.NbrRNCapacity	ZDO RN Capacity
zdo.NbrBcnOrder	ZDO Beacon Order
zdo.NbrRNCapacity	ZDO Permit Joining
zdo.NbrTransFail	ZDO Transmit Failure
zdo.NbrPotentialParent	ZDO Potential Parent
zdo.NbrLQI	ZDO LQI
zdo.NbrLogChan	ZDO Logical Channel
zdo.RtgTableEntries	ZDO Routing Table Entries
zdo.RtgListCount	ZDO Routing Table List Count
zdo.RtgList	ZDO Routing Table List
zdo.RtgEntries	ZDO Routing Entry
zdo.RtgDestAddr	ZDO Destination Address
zdo.RtgStat	ZDO Status
zdo.RtgNextHopAddr	ZDO Next-Hop Address
zdo.BdgTableEntries	ZDO Binding Table Entries
zdo.BdgListCount	ZDO Binding Table List Count

zdo.BdgList	ZDO Binding Table List
zdo.BdgEntries	ZDO Binding Entry
zdo.BdgSrcAddr	ZDO Source Address
zdo.BdgDstAddr	ZDO Destination Address

MSG

msg	ZigBee MSG
msg.transSeqNo	MSG Transaction Sequence Number
msg.transLength	MSG Transaction Length
msg.transData	MSG Transaction Data

KVP

kvp	ZigBee KVP
kvp.transSeqNo	KVP Transaction Sequence Number
kvp.transAttrType	KVP Transaction/Attribute Data Type
kvp.transType	KVP Transaction Type
kvp.attribDataType	KVP Attribute Data Type
kvp.attribId	KVP Attribute Identifier
kvp.errorCode	KVP Error Code
kvp.attribData	KVP Attribute Data
kvp.attribDataCharCount	KVP Character Count
kvp.attribDataCharData	KVP Character Data
kvp.attribDataOctetCount	KVP Octet Count
kvp.attribDataOctetData	KVP Octet Data

Appendix D: 2400E Firmware Upgrade

There is a firmware upgrade utility available for the 2400E. Under normal circumstances the firmware loaded on to the module prior to shipment is suitable for use with the Sensor Network Analyzer software. If the SNA software detects the need for an upgrade it will display detailed instructions to the user.

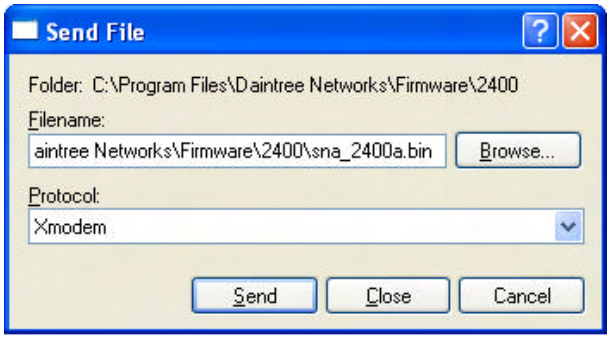
Under all other circumstances the user should not run the Firmware Upgrade utility to upgrade the firmware of the 2400E unless requested to do so and given detailed instructions by a Daintree support representative.

Appendix E: Sensor Network Access Point (Model 2400A) Firmware Upgrade

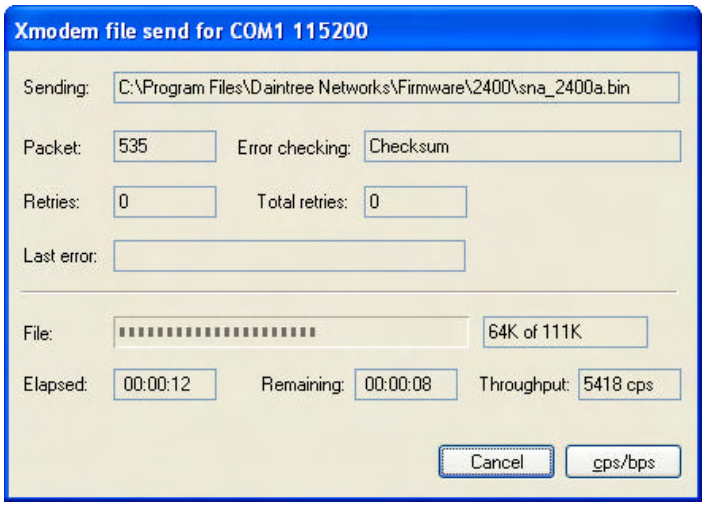
The firmware used on Daintree Networks 2400A Sensor Network Access Point capture devices needs to be upgraded for these devices to function as capture devices with the SNA Version 1.1 software. This firmware upgrade is achieved on the 2400A by connecting to the 2400A's serial port and using a terminal emulation program, such as HyperTerminal, which supports the XMODEM protocol.

Procedure

- Start HyperTerminal (or other terminal program) and connect to the 2400A's serial port. The connection settings are 115200, 8N1:
- Choose "Transfer|Send File…" option from the menu.
- Ensure that "Xmodem" is selected and enter the name of the .bin file to download to the 2400A. The firmware file to download can be found at Program Files\Daintree Networks\Firmware\2400\sna_2400a.bin (or alternative application installation directory):



- Power cycle the 2400A's power connection.
- Press the send button in HyperTerminal within 5 seconds of turning the 2400A's power on.
- A dialog box will appear, showing the progress of the transfer:



- When the transfer has completed the firmware will have been successfully upgraded and be ready for use.

Appendix F: IEEE 802.15.4 Channels and Frequencies

868MHz BAND			
CHANNEL LOGICAL SEQ NUM	CHANNEL NUMBER (DECIMAL)	CHANNEL NUMBER (HEX)	FREQ. MHz
1	0	0	868.3

915MHz BAND			
CHANNEL LOGICAL SEQ NUM	CHANNEL NUMBER (DECIMAL)	CHANNEL NUMBER (HEX)	FREQ. MHz
1	1	01	906
2	2	02	908
3	3	03	910
4	4	04	912
5	5	05	914
6	6	06	916
7	7	07	918
8	8	08	920
9	9	09	922
10	10	0A	924

2.4GHz BAND			
CHANNEL LOGICAL SEQ NUM	CHANNEL NUMBER (DECIMAL)	CHANNEL NUMBER (HEX)	FREQ. MHz
1	11	0B	2405
2	12	0C	2410
3	13	0D	2415
4	14	0E	2420
5	15	0F	2425
6	16	10	2430
7	17	11	2435
8	18	12	2440
9	19	13	2445
10	20	14	2450
11	21	15	2455
12	22	16	2460
13	23	17	2465
14	24	18	2470
15	25	19	2475
16	26	1A	2480

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