DaintreeNetworks

Visual network analysis using the Daintree Networks Sensor Network Analyzer

Application Note AN034

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Sensor Network Analyzer Release 3.0 (2009-03-31)

About network visualization

Traditional network analysis uses passive monitoring to observe communications and interactions within a wireless embedded network, and then presents information about these interactions in lists and tables. You can also view the physical devices within the network, which often have LEDs that flash to let you know when they're communicating.

Network visualization takes analysis to the next level by actually *showing* you what is happening in your network. Visualization provides a graphical rendition of network topology and information flows between devices in a wireless embedded 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.

Not only can visualization help those who are new to wireless embedded networking more easily understand what is going on within the network, it can also help those with many years of experience to quickly identify and locate problems (and potential problems) within the network.

Daintree's Sensor Network Analyzer (SNA) provides an advanced visualization system for network protocols that use 802.15.4 MAC Association. The visualization system includes many options for customizing not only what information is shown, but also the way in which that information is formatted, including the ability to overlay devices on a floor plan. It also provides the ability for "active" analysis, which enables the SNA to poll devices and obtain details not available through passive sniffing alone (such as neighbor LQI and device power/battery levels).

About Daintree's Sensor Network Analyzer (SNA)

The SNA combines a powerful protocol analyzer with network visualization, measurements and diagnostics for wireless embedded networks. It 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.

It also provides a powerful commissioning tool that helps to hide the complexity of the underlying technology, and provides straight-forward configuration, testing and troubleshooting capabilities. Its graphical representations makes if fast and easy for installers to monitor network formation and measure key parameters such as link quality and bindings.

About the 2400E Sensor Network Adapter

Daintree's 2400E Sensor Network Adapter can be used as an active device, which means that under the control of the SNA it is capable of "active analysis."

Active devices are able to join an 802.15.4 or ZigBee network, interact with other devices on it, and actively poll devices to gain information not available through passive "sniffing" alone.

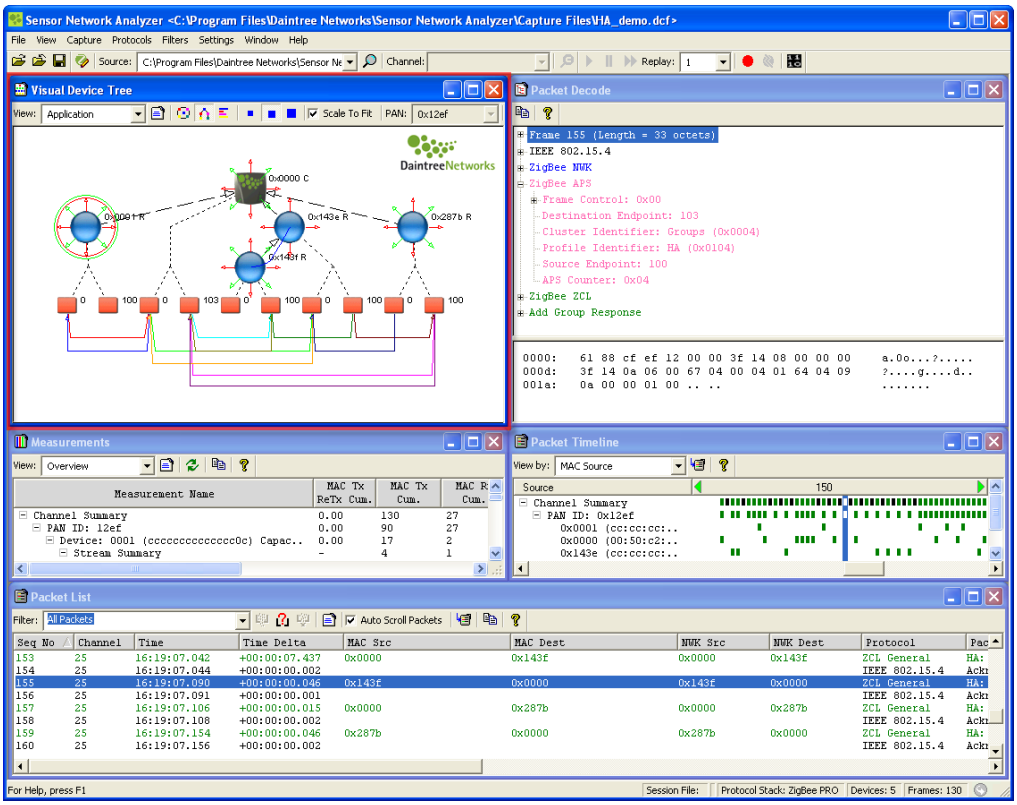
Visit www.daintree.net to find out more about Daintree products.

About the SNA's visual windows

The SNA provides two visual windows: the Visual Device Tree (VDT) and Visual Device Layout (VDL). Note that the VDL is available only in the SNA Professional edition.

Visual Device Tree (VDT)

The VDT is shown in the upper-left corner of the SNA (by default).



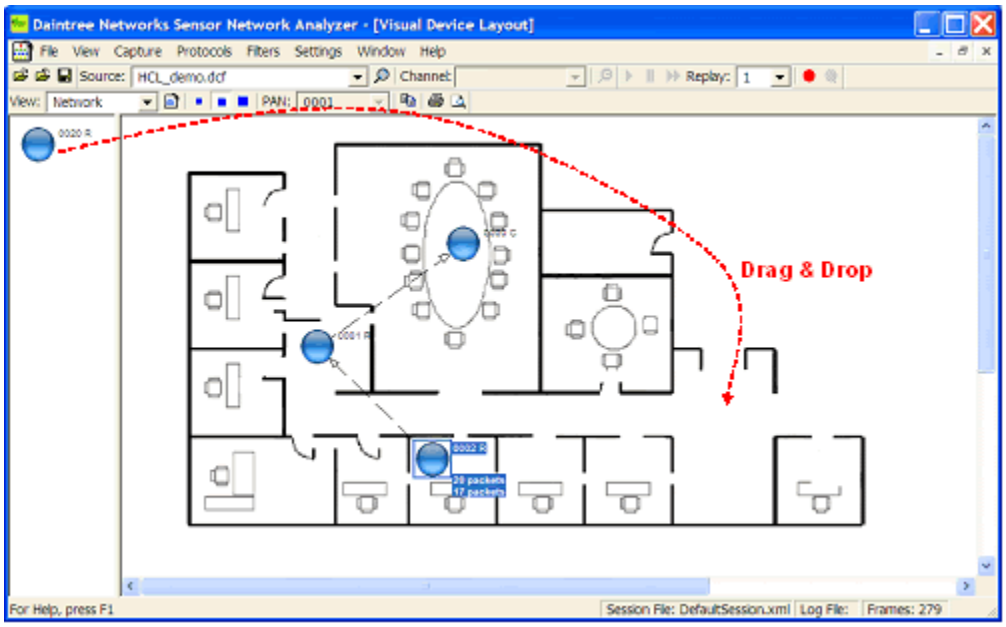
This window shows network topology using a device association tree:

- Devices are added dynamically based on 802.15.4 MAC Association Response messages.
- Lines are shown between parent and child devices to indicate an association.
- Routes can be filtered by selecting (clicking on) a device to display only those routes associated with selected device, or by selecting a route to highlight each of the devices traversed by the selected route.
- APS endpoints are shown along the bottom of the VDT window, with bindings represented by a line linking two endpoints.
- You can select which details to show for devices, routes, endpoints and bindings, for example, long address for devices, measurements for devices and routes, and profile and cluster IDs for endpoints and bindings.
- Additional customization options include the ability to switch between tree, radial and text views; assign images and text labels to individual devices; show device health; and show re-associated/dis-associated devices.

Visual Device Layout (VDL)

The VDL provides an alternative view to the Visual Device Tree. Instead of the SNA automatically drawing devices in a tree, the VDL window allows you to place devices on a background image such as a floor plan. This allows you to create a visual representation that corresponds to the physical layout of the network. Note that the VDL window is hidden by default.

1. From the SNA's **View** menu, select **Visual Device Layout** to open the VDL window.
2. From the SNA's **Settings** menu, select **Visual Options**. Then select the background image to display and click **OK**.
3. Drag and drop images from the left column to place them on to your image. As you place each device, the associations between devices are shown and updated.



Once the VDL is populated, this window offers equivalent functionality to the VDT in terms of visualizing MAC, NWK and APS layer information about the network. You can continue to move the devices around the window as required—devices are not locked in place in any way.

Active vs. passive discovery

The SNA has two different modes in which it discovers network topology: passive and active. The devices it can discover, and therefore display, differ depending on the current mode:

- During a **passive** discovery the SNA starts to discover devices AFTER it begins capturing, Therefore, any devices that joined the network before the capture began will not show up in the window.
- During an **active** discovery the SNA is able to join a network that has already formed, and then poll the network to discover its devices and routes. That means that the SNA can show ALL devices within the network, including those that joined before it began capturing.

Note that active discovery is supported only when using capture hardware capable of active analysis and only for networks using the ZigBee protocol stack. Find out more about the SNA's active analysis from *"Active" analysis and configuration using the Daintree Networks SNA application note*.

Customizing the VDT display

Radial, tree or text layout

You can change the layout in which the information is shown in the VDT, to select the way in which you can best view the size and complexity of your network:

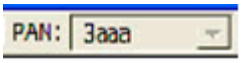
Tree: Draws the VDT as a tree with the coordinator as the root. (This is the default layout)

Radial: Draws the VDT with the coordinator in the middle and shows devices in rings around the coordinator. This is useful for large, complex networks.

Text: Shows a textual description of the device tree. This is the only layout in which you can display details for multiple PANs.

PAN selection

If you are monitoring multiple networks, use the **PAN** option in the VDT's toolbar start to select which one you want to view. (The VDT will show the device tree for a single PAN at a time.)



Views

The Radial and Tree layouts support different views that determine what additional information is shown on the layout. Each view comprises one or more view items. The SNA provides a number of pre-defined views. These can be extended with custom user-defined views.

Select the view you want to use from the **View** Selector drop-down on the Visual Device Tree toolbar.

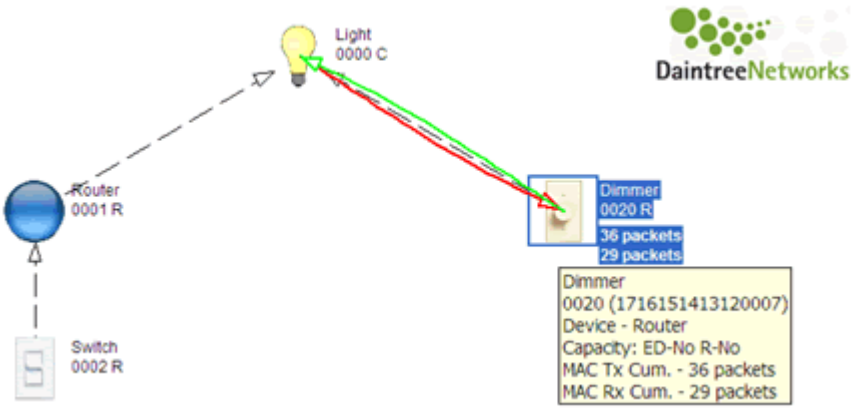
Customizing a view

You can customize visual views to specify which information you do and don't want to show. For example, you can select to either show or hide information including the long address for devices, measurements for routes, and bindings.

1. In the Visual Device Tree window, select the **View** you want to configure.
2. From the **Settings** menu, select **Visual Options** to open the Visual Options dialog box. The tabs shown in this dialog box vary, depending on what item types have been selected for the view. (Refer to the SNA's online help for detailed descriptions of the following options.)
   - **Visual Tree**
     Specify overall options about the way in which the VDT is displayed including whether to show re-associated/dis-associated nodes, and whether to show grid lines in Radial layout.
   - **Devices**
     Specify the way in which device details are displayed including whether to long addresses, device health indicators, measurements and device types.
   - **Associations**
     The VDT shows links between devices corresponding to each MAC layer association. You can select whether to show or hide these, and also the color, width, and style in which to display associations.
   - **Routes**
     Routes show the flow of packets through the network. Select to show route details as either routes or streams (where a stream shows the packet from the source to destination without any information about the intermediate hops traversed by the packets, and a route shows all packet flows traversing a sequence of nodes from source to destination). You can also select whether to show measurements, and whether to show unicast, broadcast and failed/malformed routes.
   - **Endpoints**
     Endpoints are shown along the bottom of the visualization, designed to show the flow of application layer information in the network. Specify options including whether to display ZDO endpoints and bindings, and the format in which to show binding details.
   - **Battery Levels**
     The Power/Battery level information is useful in understanding which devices in the network are running on mains power and which are running on batteries. Select the icon you want to use to specify the different types of power sources available.
   - **Neighbor LQI**
     The LQI values are useful to understand the connectivity of each device to other devices in the network. This measurement can identify devices with poor connectivity that are vulnerable to being disconnected from the rest of the network. LQI values are shown as arrow heads. You can specify the color and thickness of the arrow heads used to indicate a given range of LQI values.

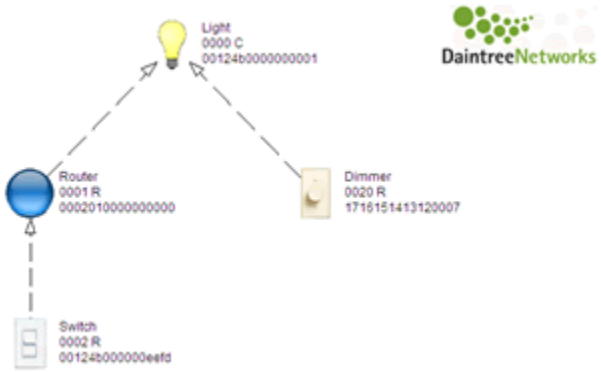
Getting details about network devices

Position the cursor over the top of a device to display information including the its type, address and measurements.



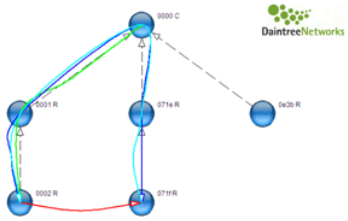
Displaying long address and device type

1. From the **Settings** menu, select **Visual Options**.
2. On the Visual Options dialog box, select the **Devices** tab.
3. Select to **Display Long Address** if you want to show the device's long (IEEE) address underneath its short address. Note that the full IEEE address and can take up a lot of screen real estate, so you can also select to limit the number of significant bytes to display.
4. Select to **Display Device Type** if you want to show the following details:
   - **C** (for Coordinator)
   - **R** (for Router)
   - **ED** (for End Device, which is a device with RxOnWhenIdle set to TRUE)
   - **SED** (for Sleeping End Device, which is a device with RxOnWhenIdle set to FALSE)
5. Click **OK** to save your settings.



Getting details about routes

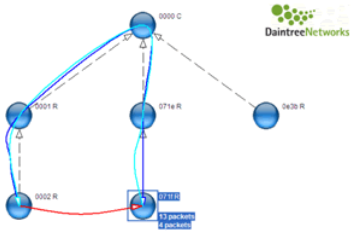
The SNA's Visual Device windows display routes that indicate the flow of packets through the network. Each route is shown as a spline that intersects each device the route traverses. An arrowhead is used to show the direction of the route.



Finding routes for a specific device

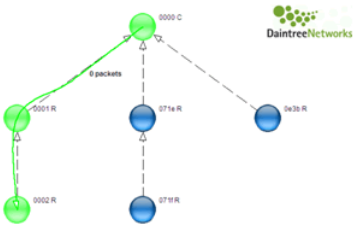
Click a device (to select it) to show only those routes that begin or end with that device. Note that you can select multiple devices by holding down the Ctrl key.

The selected devices are highlighted (as shown). When no devices are selected, all routes are displayed.



Highlighting devices for a specific route

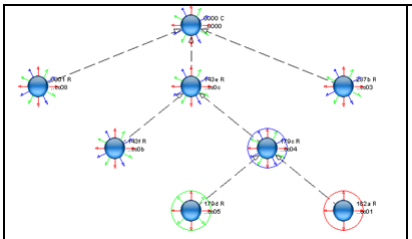
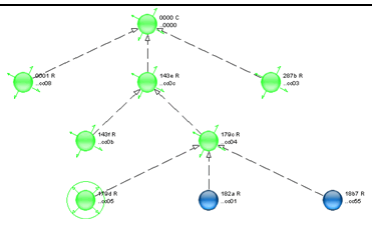
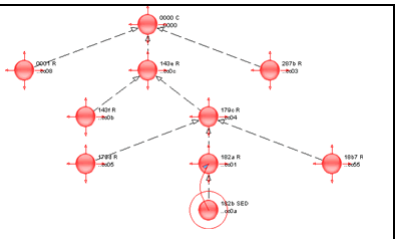
Routes are selected by clicking the spline representing the route. When a route is selected, each of the devices the route traverses is highlighted using the same color as the route spline.



Displaying route history

You can specify the number of observed packet flows or unique routes to display on the VDT:

1. From the **Settings** menu, select **Visual Options**.
2. On the Visual Options dialog box, select the **Routes** tab.
3. Specify the route history and types of routes to display in the VDT. (The available route types are described below.)
4. Click **OK** to save your settings.

		
The SNA uses colored circles and arrows to represent broadcast (or multicast) routes.	Click a circle or arrow to highlight all devices that form the selected broadcast flow.	Unicast routes are drawn as an arrow (curve) through each device that sends the packet.

Displaying broadcast/multicast routes

The SNA uses colored circles and arrows to represent NWK broadcasts:

- Nodes that initiate NWK broadcasts are enclosed in a circle.
- MAC broadcasts are indicated using four arrows.
- The circles and arrows are color-coded to represent the broadcast flow.

Each device can have multiple arrows and circles in different colors to represent that it has initiated or transmitted multiple broadcasts.

Displaying unicast routes

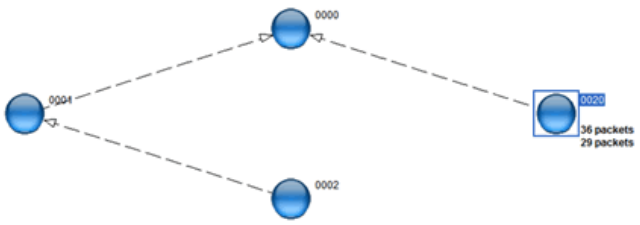
These may be unicast hops as part of a NWK broadcast.

This is common for a NWK broadcast that is initiated by a sleeping end device. The sleeping end device will use MAC unicast to forward the packet to the parent to rebroadcast (as shown above).

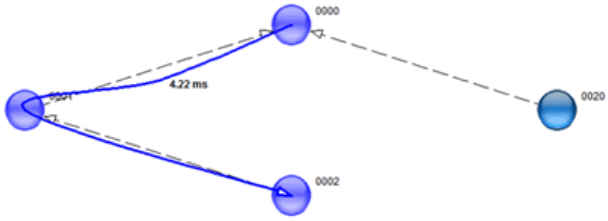
Similarly, a parent device receiving a broadcast will use MAC unicast to forward the packet to each of its sleeping end device children.

Displaying performance measurements

1. From the **Settings** menu, select **Visual Options**.
2. To display device measurements, on the Visual Options dialog box, select the **Devices** tab. Then specify the device measurement options to display:
   - Select to show measurements always or only when a device is selected.
   - Select up to two measurements to display.
   - You can conserve screen real estate by selecting "compressed format" (where the two measurements are shown on a single line separated by a slash), and by suppressing the measurement units



3. To display route measurements, select the **Routes** tab. Then specify the measurement options to display:
   - Select to show measurements never, always, or only when a route is selected.
   - Select which measurement to display.
   - Select to suppress measurement units if you want to conserve screen real estate.

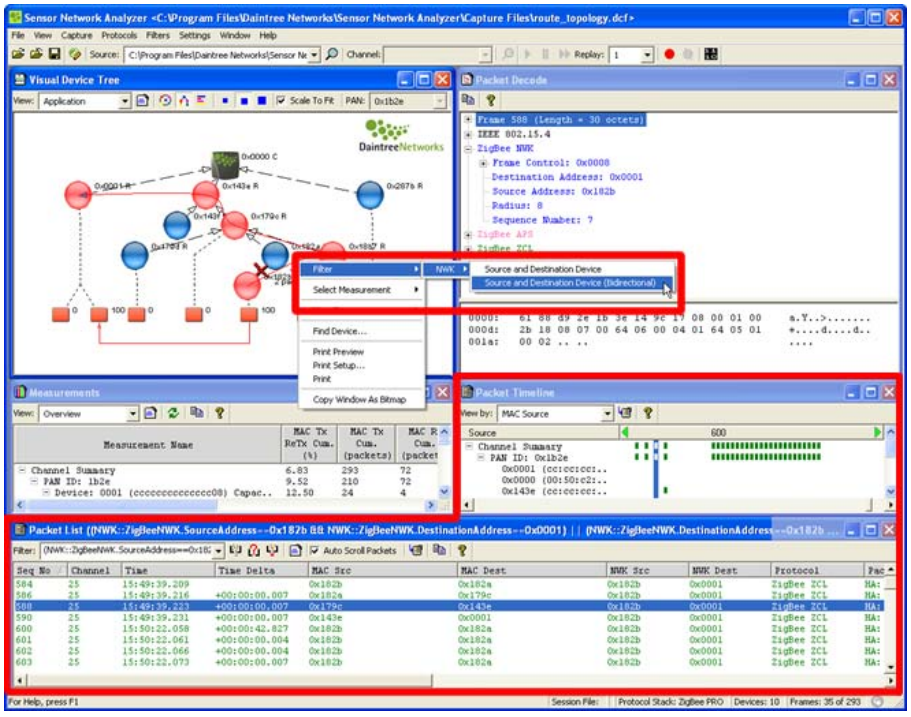


4. Click **OK** to save your settings.

Using the VDT to filter the Packet List

You can use the VDT window to select which packets to show in the SNA's Packet List and Packet Timeline windows:

1. In the VDT, right-click the device, route, endpoint or binding on which you want to filter.
2. For **devices**, select the MAC or NWK layer filter to apply:
   - Match all packets at the MAC or NWK layer where the selected device is the Source, Destination, or either (this matches both the short and long addresses).
   - Match when the selected device participated in the MAC layer association sequence. (This is useful for debugging network formation issues.)
3. For **routes**, select the NWK layer filter to apply:
   - Match all packets at the NWK layer corresponding to the associated stream (between the given source and destination).
4. For **endpoints**, select the APS layer filter to apply:
   - Match all packets at the APS layer where the selected endpoint is the Source, Destination, or either.
5. For **bindings**, select the NWK or APS layer filter to apply:
   - Match all packets at the NWK layer corresponding to the associated stream (between the given source and destination).
   - Match all packets at the APS layer where the selected binding's endpoints are the Source, Destination, or either.
   - Match packets between the associated endpoints on a specific APS Cluster ID.
6. To reset filters, select **All Packets** from the Packet List's Filter drop-down list.



Customizing the visual display

Displaying device health

Device health indicators help you to readily identify unresponsive or unavailable devices:

1. From the **Settings** menu, select **Visual Options**.
2. On the Visual Options dialog box, select the **Devices** tab.
3. Select whether or not to show device health indicators:
   - Specify the number of **RxReTx** (retransmitted) frames that indicates an error.
   - Specify the number of lost packets (or failed routes) that indicate an error.
4. Click **OK** to save your settings.

An **unavailable** device is identified using a red cross. This indicates that packets are being addressed to the device but it is not responding, and that no packets are being transmitted by the device.

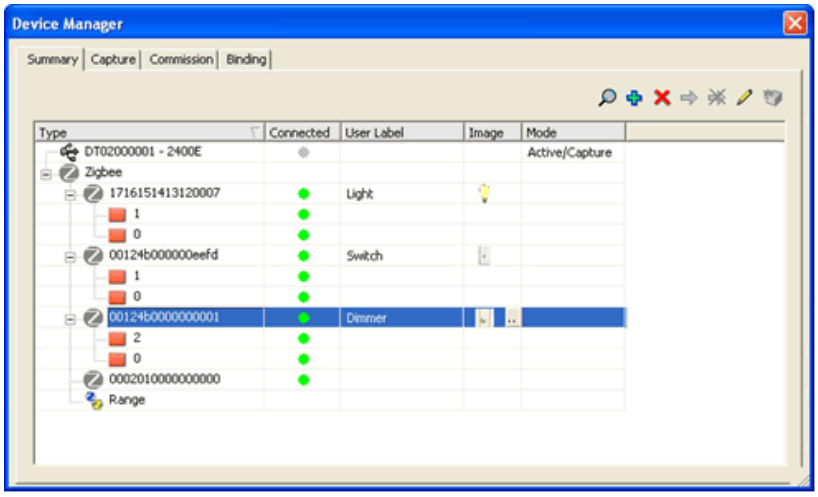
An **unresponsive** device is identified using a red question mark. This indicates that the number of retransmitted frames addressed to the device, or packets lost at the device, exceed the threshold defined above.

Assigning icons and labels to individual devices

You can assign logical names (text labels) and custom icons for individual devices to highlight their purpose within the network.

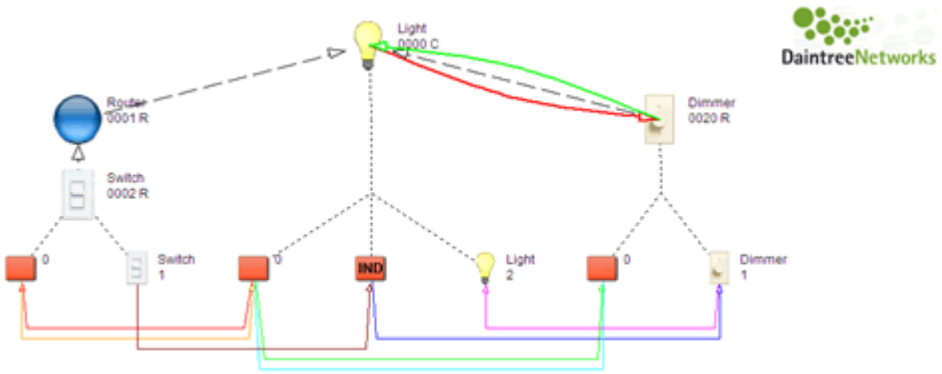
When assigning icons to devices, you can use the icons provided in the **Daintree Networks\Sensor Network Analyzer\Graphics\DeviceIcons** directory, or import your own images to use.

1. From the **Settings** menu, select **Device Manager**.
2. On the Device Manager **Summary** tab, select (click) the device for which you want to specify a name and image.



3. Click the **User Label** field to select it, and then type a name for the device. This name is shown in both the Visual Device and Measurements windows.
4. In the Image field, click ... and select **Browse Image**. Navigate to the **Daintree Networks\Sensor Network Analyzer\Graphics\DeviceIcons** directory to select one of the default icons, or else navigate to the directory in which your custom icons are located.
5. Click an image to select it, and then click **Open**.

If you now look at the Visual Device window, you'll see that the device is displaying the text label and image you specified. These text labels and icons will be saved when you save your current session.



Assigning custom icons based on MAC address

By default, the icon used in the VDT and VDL windows is the one that best matches the MAC address. For example, a device with a MAC of 00:22:81:00:01:71:00:00 will use the 00228100.bmp image file.

To use your own custom icons, save a .bmp or .ico image that is named using an appropriate MAC mask to the **C:\Program Files\Daintree Networks\Sensor Network Analyzer\Graphics** directory.

Note that any icons you assign through Device Manager to specific devices take precedence over these default MAC address icons.

Creating custom icons

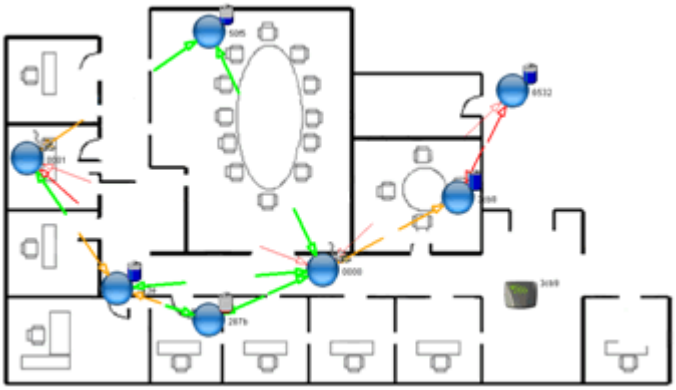
Your custom icons need to be created in the following format:

- 256 colors
- 48x48 pixels (the SNA will automatically resize images as required
- bmp, gif, png or ico format

Viewing device battery levels and neighbor LQI

Note that these options are available only when using a capture device capable of active analysis.

- From the VDT **View** drop-down list, select either **Battery Levels** or **Inter-Device LQI**.
    - **Battery levels** are depicted using an icon drawn in the top right-hand corner of each device. A separate icon is shown for each power source or battery level. This information is useful in understanding which devices in the network are running on mains power and which are running on batteries.
    - **LQI values** are shown as arrow heads. An arrow head that points in towards a particular device represents an LQI detected by that device. The direction where the arrow is coming from represents the neighbor that the LQI value relates to. These values are useful to understand the connectivity of each device to other devices in the network.



Finding devices

If there are many devices showing in the VDT, it can be difficult to pick one out of the many. You can use the Find Devices option to quickly locate any device by its long or short address.

1. Right-click any device or route in the VDT, and then select **Find Device**.
2. In the Find Device dialog box, select to search by either Long or Short Address, and then type the address.
3. Click **Find**. When the device is located, it will be highlighted in the VDT. If required, the SNA will scroll the window to ensure that the selected device is visible.

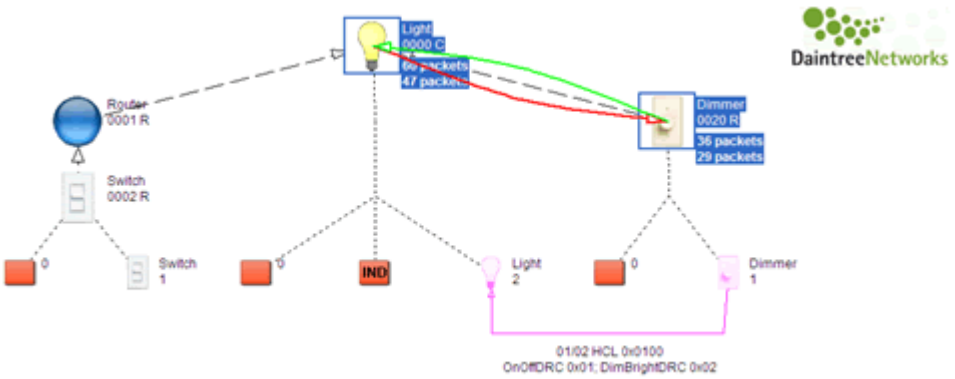
Getting details about APS endpoints and bindings

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

- extended device tree, to show endpoint information on each of the end devices
- display of (implicit) bindings between endpoints on different devices
- display of the flow of packets between endpoints

Selecting endpoints and bindings

You can view additional information about endpoints and bindings by selecting them in the same way as routes and devices.



- Select an **endpoint** (by clicking it) to highlight the source and destination end devices and show routing information. When you select an endpoint for which multiple bindings exist, it acts as a filter to display only those associated bindings.
- Position the cursor over an **endpoint** to display the profile and list of cluster IDs (incoming and outgoing) for which the SNA's measurement system has detected a packet flow.
- Select a binding (by clicking it) to display details including the profile and list of cluster IDs.