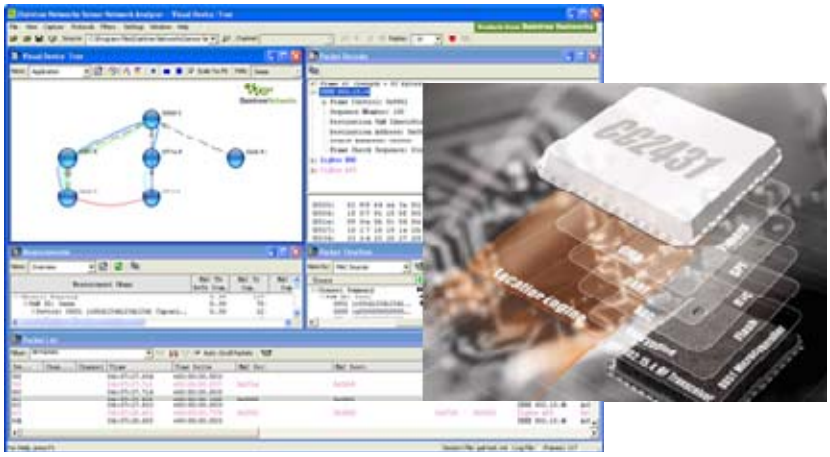
DaintreeNetworks

Locating ZigBee nodes using TI's C2431 location engine and the Daintree Networks Sensor Network Analyzer

Application Note AN016



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Sensor Network Analyzer Release 2.3 (2008-06-27)

About locationing

One of the benefits of wireless sensor networks is the lack of physical connectivity (wiring) between sensor nodes and the network. This helps to reduce installation costs and to simplify things like installing nodes in hard-to-reach locations.

However, this lack of physical wiring is not without its drawbacks. For example, a lack of wires makes it more difficult to locate a node, especially if its location is subject to change (such as a mobile piece of equipment).

Locationing allows you to find the position of nodes whose where-abouts is unknown or subject to change—in particular, those in an ad-hoc wireless network. For example, an expensive piece of medical equipment may be shared within a hospital. Locationing can tell you the room in which that piece of equipment is currently located. Or when first installing and commissioning a network, you may install a number of identical devices (such as lights in a conference room). Locationing can tell you which device is which.

Applications for which locationing is useful include asset and equipment tracking, inventory control, patient monitoring, remote controls, security and commissioning networks.

This application note provides instructions of how to use Daintree's Sensor Network Analyzer application together with the Texas Instruments CC2431 location engine to quickly and easily locate devices within a ZigBee network.

About Daintree's Sensor Network Analyzer (SNA)

The SNA combines a powerful protocol analyzer with network visualization, measurements and diagnostics for IEEE 802.15.4™ and ZigBee® applications. 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.

Visit www.daintree.net to find out more about Daintree's SNA and to view an online demonstration showing how the SNA and TI's CC2431 location engine work together to quickly locate network nodes.

About TI's CC2431 location engine

The CC2431 location engine is part of the Texas Instruments CC2431 System-on-Chip (Soc) solution for ZigBee/IEEE 802.15.4 wireless sensor networks.

The job of the location engine is to calculate the location of a node in a network.

Visit the Texas Instruments web site at www.ti.com/zigbee for details about the SoC solution, and to find out in detail how the location engine works (see *Application Note AN042*).

How does locationing work?

The following provides an overview of how locationing works using the Professional Edition of Daintree's Sensor Network Analyzer.

- If you require additional instructions to use the SNA software, refer to the *SNA User Guide*.
- If you require additional instructions to install the location engine on a node, refer to the documentation that came with the TI CC2431 SoC Solution.

Location nodes

Locationing requires three types of nodes:

- **Reference node:** A stationary device with a well-known and stable location (X/Y position), that can tell other nodes where it is on request. You need between 3 and 16 reference nodes to calculate the location of a Blind node (the more nodes you use, the greater the accuracy).
- **Blind node:** A device that, when requested, will calculate its location. These nodes must contain the TI CC2431 location engine. Using the location engine to perform the location calculations at each Blind node (in a decentralized manner) reduces the amount of data transferred in the network, because only the calculated position is transferred (not the data used to perform the calculation).
- **Location dongle:** A device, such as Daintree's 2400E Sensor Network Adapter, that communicates with the Blind and Reference nodes and collects location details which it then passes on to the SNA application. The SNA can also use this dongle to configure the Blind and Reference nodes.

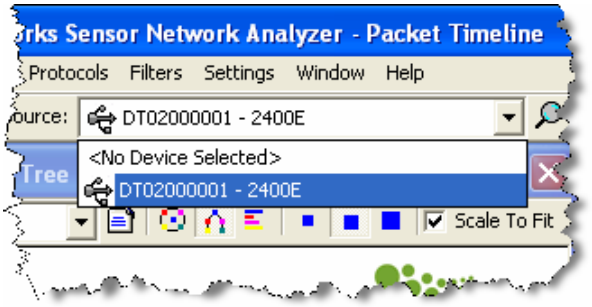
Locationing overview

In summary, locationing is performed through the following steps:

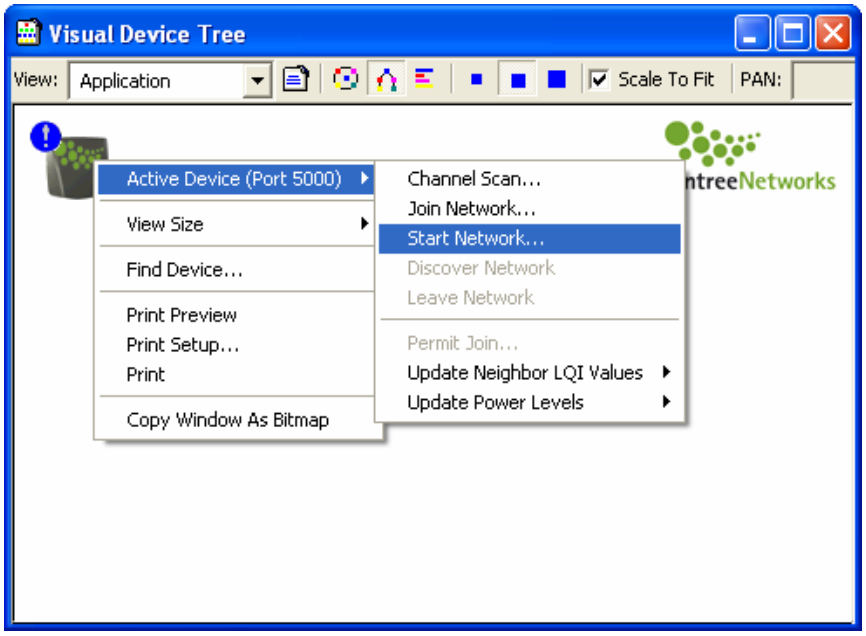
1. A Blind node broadcasts a request to all Reference nodes in radio range. (Reference nodes should be placed to bound the extremities of the area where the Blind nodes are located.)
2. Reference nodes respond to the Blind node with their X/Y location and the Received Signal Strength Indicator (RSSI) of the Blind node request.
3. The Blind node uses its location engine to calculate its position based on the locations and RSSI values from the Reference nodes, and then passes the result on to the Location dongle.
4. The Location dongle passes this information to its controlling software application (in this case the SNA), which is then able to provide the location of the Blind node in a form that makes it easy to identify.

Simple locationing example

1. Start the SNA application and connect the 2400E Sensor Network Adapter to your computer via USB.
2. Select the 2400E from the **Source** list.



3. Right-click the 2400E in the Visual Device Tree window, and then select **Active Device** > **Start Network**.

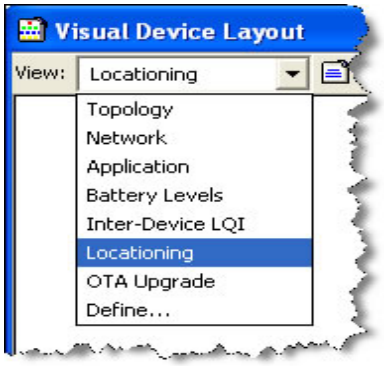


Enter the settings required for your network (see the *SNA User Guide* if you require more instructions).

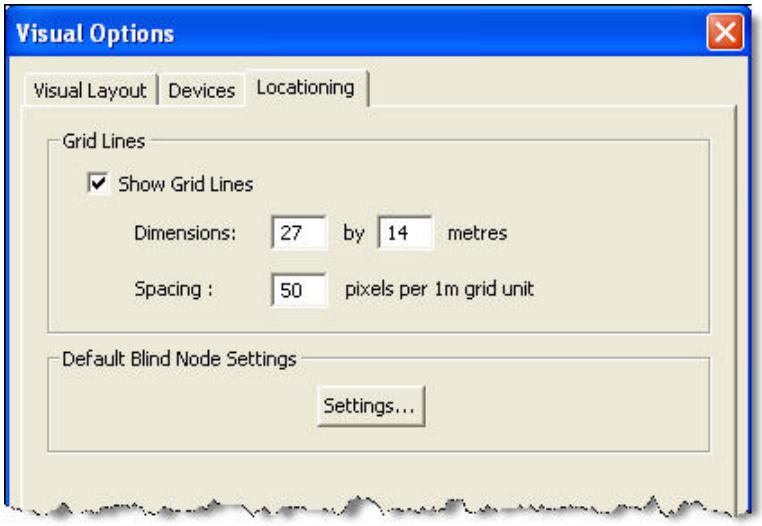
4. From the main SNA **View** menu, select **Visual Device Layout**.

   The Visual Device Layout (VDL) window contains some locationing functionality that is not available through the Visual Device Tree window.

5. From the VDL **View** list, select **Locationing**.



6. Click the icon (next to the View list) to open the Visual Options dialog box.
7. On the **Visual Layout** tab, select the background image (floor plan) to load in the VDL window. This will help you to better visually locate your Blind nodes.
   - Select **Include in Display Size**. This will cause the background image to scale together with the small/medium/large device size selection to ensure each device maintains its relevant position on the background image.
8. On the **Locationing** tab, select whether to use grid lines in the VDL window. Again, these can help you to better visually locate your Blind nodes.



   - **Dimensions:** Specify the width and length of the area represented by your floor plan.
   - **Spacing:** Select the scale of the grid to use.
9. Physically place your Reference nodes around the perimeter of the area in which your Blind nodes are located, and then power them on.

   As the SNA detects each node, it will add it to the left column of the VDL window. Reference nodes are identified visually using an anchor.

10. Drag and drop the nodes onto their correct locations on the floor plan in the right column of the VDL window. You can also right-click a node and enter X and Y coordinates for more exact placement.

11. Turn on your Blind nodes. These are shown on the floor plan in red, which indicates their positions are unknown or being calculated. Blind nodes are identified visually using arrows (to depict movement).

    While their location is being calculated, it is typical for the nodes to move around a few times. Once the location is determined, the node is shown in blue in its correct location on the floor plan.

Note: If nodes are not identified using the Reference and Blind node identifiers, you can get the SNA to refresh the VDL display and correctly identify each node type.

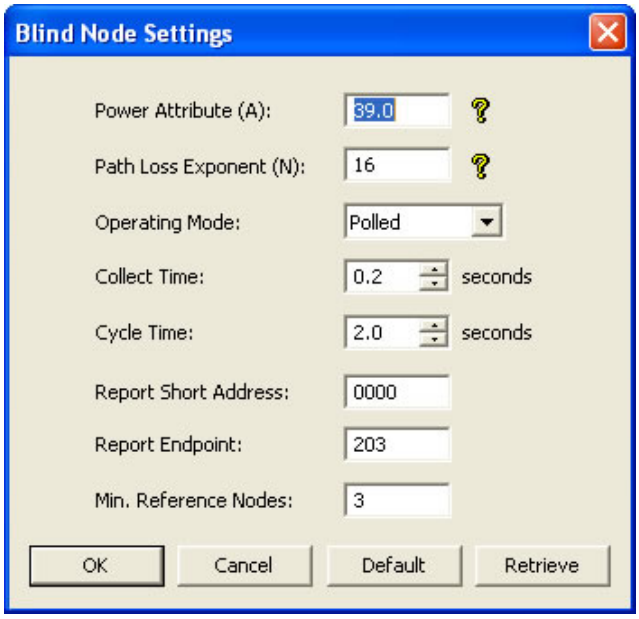
1. Right-click the 2400E icon, and then select **Locationing** > **Discover Blind nodes** to show all Blind nodes with the arrow identifier.
2. Right-click the 2400E icon, and then select **Locationing** > **Discover Reference nodes** to show all Reference nodes with the anchor identifier. You can also right-click an unmarked node and select **Locationing** > **Set as Reference** to set that individual node as a reference node.

Advanced locationing options

Configuring Blind nodes

You can either specify the same settings for all Blind nodes, or configure them one at a time.

- To configure all nodes, click the  icon (next to the View list) to open the Visual Options dialog box. Then on the **Locationing** tab, click the **Settings** button.
- To configure an individual node, right-click the node in the VDL window, and then select **Locationing** > **Configure**.



Polled and Active operating modes

Some of the configuration options you can select depend on the mode in which the Blind node(s) are operating: Polled or Auto.

- In **Polled** mode, any node within the ZigBee network can request the position of the Blind node on demand. After receiving the request, the Blind node acquires data from Reference nodes, calculates its location, and then sends that location back to the original requester.
- When using the SNA for locationing, the 2400E Sensor Network Adapter is the device used to request the Blind node's position and receive its response.
- In **Auto** mode, the Blind node starts collecting Reference node data automatically in a periodic fashion (typically by timer or user event) without having to be manually asked by the host system. By default it sends its calculated location to the network coordinator. When using the SNA, you can specify a Cycle Time to determine how often the Blind node should start location calculations. If the 2400E is not your network coordinator, you also need to specify a Report Short Address to ensure that the Blind node sends its response messages to the 2400E, and not the coordinator.

Configuration options

- **Power Loss (A):** Specify the absolute value of the average power in dBm received at a close-in reference distance of 1 meter from the transmitter, assuming an omni-directional radiation pattern.
- **Path Loss Exponent (N):** Specify the path loss index that describes the rate at which the signal power decays with increasing distance from the transmitter.
- **Operating Mode:** Select the mode in which the Blind nodes should operate:
- **Polled:** Waits for Blind node requests before responding.
- **Auto:** The node automatically calculates its location and sends out response messages.
- **Collect Time:** The number of seconds to wait for Reference node responses after sending the request.
- **Cycle Time:** The number of seconds to wait before starting the calculation cycle. Valid only in Auto Operating Mode.
- **Report Short Address:** The destination address for Blind node response messages to be sent to in Auto mode. The default is the coordinator (00). Note that in Polled mode, responses are returned to the requester's address.
- **Report Endpoint:** Destination endpoint for Blind node response messages in Auto mode.
- **Min Reference Nodes:** The minimum number of reference nodes to use to calculate a location.
- **Default:** Click this button to use the factory defaults specified for Blind nodes.
- **Retrieve:** Click this button to retrieve the configuration settings from the currently selected device.

Locating nodes on a live network

In addition to creating a new network using the 2400E as coordinator, you can also use the 2400E to **Join** an existing network. See the *SNA User Guide* for instructions on how to join a network.

In networks where the 2400E is NOT the network coordinator, you need to be aware of the following configuration setting:

- If the **Operating Mode** is Auto, you must specify the 2400E's address as the **Report Short Address**.

Manually locating nodes

For Blind nodes that are operating in Polled mode, you need to manually issue a request before the nodes calculate their location.

- To find the location of ALL Blind nodes, right-click the 2400E icon (in the left column of the VDL window), and then select **Locationing** > **Locate Blind Nodes**.
- To find the location of an individual Blind node, right-click that node in the VDT window, and then select **Locationing** > **Get Location**.

SNA firmware

The SNA includes a number of firmware files specifically for use with TI's CC2430 and CC2431 modules:

- Locationing node firmware used for OAD from the SNA:
  - TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.bin (Reference node)
  - TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.bin (Reference node)
  - TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r5.bin (Blind node)
  - TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r6.bin (Blind node)
- Locationing node firmware used for flashing from TI's Flash Programmer:
  - TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.hex (Reference node)
  - TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.hex (Reference node)
  - TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r5.hex (Blind node)
  - TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r6.hex (Blind node)

Notes:

- OTA Upgrades required the TI CC2430/CC2431 SoC (System on a Chip) with the following: Rev D or later (that is, those with a date group of 0642 or later) and OAD (Over the Air Download) Flash Board 1.0.
- For more information about the functionality of ***Over the Air Download (OAD)*** firmware, refer to the Daintree Networks application note AN017, *Updating firmware over-the-air using TI's SoC and Daintree's SNA*.
- For more information about the functionality of ***Locationing*** node firmware, refer to the Daintree Networks application note AN016, *Locating ZigBee nodes using TI's CC2431 location engine and Daintree's SNA*.
- For more information about (and to download) ***TI's Flash Programmer***, visit zigbee.ti.com and select **Downloads** > **CC2430** or **CC2431** (depending on which you are using) > **Tools and Software** > **Chipcon Flash Programmer**.

Locationing node firmware used for OAD from the SNA

Firmware for Locationing Nodes used for OAD (Over the Air Downloads) from the Sensor Network Analyzer (SNA):

- Locationing Reference Node firmware for OAD from the SNA
- Locationing Blind Node firmware for OAD from the SNA

See "Notes" on page 10 to find out more about Locationing and OAD.

Locationing Reference Node firmware for OAD from the SNA

There are two firmware files provided:

- TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.bin
- TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.bin

The table below shows the features and settings for these files, most of which are common. Any variations are highlighted in red for easy identification.

Locationing Reference Node	• Security = None • Hardware = TI Battery boards with CC2430 or CC2431
Over the Air Download(OAD)	• Daintree Image version = o 0x0005 for TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.bin o 0x0006 for TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.bin • Daintree Manufacturer id = 0x103A • Daintree Product id = 0x00AD
Commissioning	• Extended PAN id = 0x0050c27710000000 • Channels = 0x07FFF800 // all channel # Preferred Channels = 11, 14, 15, 19, 20, 24, 25 • In Clusters # Commissioning # Basic • Out Cluster # Basic • Functionality: During network join the LED D1 is flashed until it is joined to a network or is flashing slower if join failed. Reset to default settings is done by pressing (or holding down) button S1 during joining and the LED is on for 3 sec if reset has been done. When forming a new network, or scanning to join a network, the devices scans the channels using the Preferred Channels before scanning the rest of the channels in order to avoid the most commonly used WiFi channels and to improve the user experience during installation.
ZDO Optional features	• Mgmt_Lqi_rsp • Mgmt_Leave_rsp • Mgmt_Permit_Joining_rsp

Locationing Blind Node firmware for OAD from the SNA

There are two firmware files provided:

- TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r5.bin
- TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r6.bin

The table below shows the features and settings for these files, most of which are common. Any variations are highlighted in red for easy identification.

Locationing Blind Node	• Security = None • Hardware = TI Battery boards with CC2431
Over the Air Download(OAD)	• Daintree Image version = o 0x0005 for TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r5.bin o 0x0006 for TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r6.bin • Daintree Manufacturer id = 0x103A • Daintree Product id = 0x10AD
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Locationing node firmware used for flashing from TI's Flash Programmer

Firmware for Locationing Nodes used for flashing from TI's Flash Programmer:

- Locationing Reference Node firmware for flashing from TI's Flash Programmer
- Locationing Blind Node firmware for flashing from TI's Flash Programmer

See "Notes" on page 10 to find out more about Locationing and OAD.

Locationing Reference Node firmware for flashing from TI's Flash Programmer

There are two firmware files provided:

- TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.hex
- TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.hex

The table below shows the features and settings for these files, most of which are common. Any variations are highlighted in red for easy identification.

Locationing Reference Node	• Security = None • Hardware = TI Battery boards with CC2430 or CC2431
Over the Air Download(OAD)	• Daintree Image version = o 0x0005 for TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r5.hex o 0x0006 for TI-2430-ZBv2sp1-R-LocRef-OAD_20080612r6.hex • Daintree Manufacturer id = 0x103A • Daintree Product id = 0x00AD
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ZDO Optional features	• Mgmt_Lqi_rsp • Mgmt_Leave_rsp • Mgmt_Permit_Joining_rsp

Locationing Blind Node firmware for flashing from TI's Flash Programmer

There are two firmware files provided:

- TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r5.hex
- TI-2431-ZBv2sp1-R-LocBlind-OAD_20080612r6.hex

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