



## CHAPTER 3

# Cisco Spectrum Expert Overview

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## Analysis and Cisco Spectrum Expert

This chapter provides an overview of the Cisco Spectrum Intelligence technology and how Cisco Spectrum Expert implements that technology.

### Cisco Spectrum Intelligence

Cisco Spectrum Intelligence addresses several current shortcomings in radio frequency (RF) network technology. These shortcomings exist in numerous RF domains such as the WLAN technology used by 802.11 computer networks. These shortcomings fall into several inter-related categories.

#### RF Visibility and Unlicensed Bands

Currently, RF network system administrators lack sufficient awareness of the RF environment in which their access points and stations (for WLANs) operate. Issues arise because many RF network technologies operate in unlicensed bands, which means that multiple technologies—technologies which are not meant to interoperate and which represent different aspects of the RF infrastructure—compete for use of the same bandwidth.

##### Discovery

Current network technologies, such as those used to monitor 802.11 WLANs, are only aware of other network elements. They are unable to discover other nearby sources (competing technologies) emitting radio frequency signals in the unlicensed bands.

##### Wi-Fi Performance

WLANs operate in the unregulated 2.4 GHz and 5 GHz bands and are subject to interference from other devices operating in this same frequency spectrum such as microwave ovens, cordless phones and cordless headsets, wireless surveillance cameras, garage door openers, Bluetooth technology, and other devices. There can also be co-channel interference (CCI) due to neighboring WLANs. These competing devices can degrade 802.11 network performance resulting in slow data rates and excess packet retransmissions. There is a CCI category in the Interference Power chart for displaying the CCI impact on your network.

## Wi-Fi Troubleshooting

Current WLAN technologies are aware of network devices so they can determine if there is an excess load on the network from network stations. Current technologies cannot see the whole RF spectrum in the unlicensed band and cannot identify sources of RF activity which can cause dropped network connections and other problems.

### Summary

Current 802.11 (Wi-Fi) technologies offer protocol-level awareness, but not physical layer (RF) awareness. Lacking full RF spectrum awareness, existing WLANs cannot apply appropriate, adaptive responses to improve performance in the face of interferers and competing networks.

## Cisco Spectrum Expert: Mitigation and Performance Enhancement

Cisco Spectrum Expert includes sophisticated technology to detect and classify sources of RF activity. Using this data, network engineers can use a variety of methods to enhance Wi-Fi WLAN performance and reliability. Some of these methods are listed below.

### Clean Channels

If a certain part of the frequency spectrum is in constant use by other devices, the network engineer can program the network to not transmit over those channels. By deliberately searching for “clean” channels, the network devices can be set to broadcast over those channels.

### Identifying, Locating, and Removing Interferers

Cisco Spectrum Expert can identify the types of devices which are producing RF interference. An interferer is any non-network RF device which broadcasts in the same frequency bands as network devices and can cause disruption to your network. For example, in the 802.11 domain, typical interferers include microwave ovens, cordless headphones and headsets, 802.11 FH devices, and Bluetooth devices. The network engineer is alerted to the presence of these devices and can take steps to address the problem (including relocating or shutting off the devices).

With Cisco Spectrum Expert Software, the network engineer can also use Cisco Spectrum Expert Software’s **Device Finder** mode to make the Cisco Spectrum Expert-enabled computer into a lightweight homing device to track down the precise location of the signal source. (See “[Device Finder Mode](#)” for more information.)

**Tip**

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The optional directional antenna, available from Cisco, can help with determining the location of Wi-Fi devices.

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### Device Specific Solutions

By knowing the ID of specific interfering devices, custom solutions can also be tailored to specific technologies and specific brands of these technologies.

## Cisco Spectrum Expert Solution

Cisco Spectrum Expert is a combined hardware and software technology which implements Cisco Spectrum Intelligence technology. Cisco Spectrum Expert makes the 802.11 WLAN system “spectrum savvy”, ensuring greatly increased reliability and performance. Cisco Spectrum Expert consists of two primary components:

- **Cisco Spectrum Expert Software**—The Cisco Spectrum Expert Software analyzes data from the Sensor card and provides a GUI-based view of network and RF activity.
- **CleanAir-enabled Cisco products and Cisco Spectrum Expert Sensor Wi-Fi (Sensor Card)**—Spectrum sensors provide the hardware foundations for Cisco Spectrum Intelligence. Each Sensor card incorporates the SAgE ASIC, which is a spectrum analyzer on a chip. SAgE provides visibility for the RF spectrum in the unlicensed bands on which Wi-Fi WLANs operate.

The SAgE ASIC is in its second generation. Cisco Spectrum Expert Software support for the two versions of the Sensor Card requires specific versions of the application:

- SAgE 2 support as of Spectrum Expert 4.0.68 and later releases
- SAgE 1 support as of Spectrum Expert 3.3.52 and earlier releases

Cisco CleanAir-enabled Access Points

- Cisco Aironet 3500 Series Access Points—This access point was introduced in the Cisco Wireless LAN Controller release 7.0.98.0. The 7.0.98.0 release required CleanAir-enabled access points to be in SE Connect mode to work with Cisco Spectrum Expert application. This support was enhanced to include support for Local and Monitor modes in Cisco Wireless LAN Controller 7.0.116.0 release.
- Cisco Aironet 3600 Series Access Points—This access point was introduced with Cisco Wireless LAN Controller software release 7.1.91.0 and supported Cisco Spectrum Expert with the access point SE Connect, Local, and Monitor modes.

See the [Cisco Wireless Solutions Software Compatibility Matrix](#) for more information on supported controller software release for the access points.



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**Note** The Cisco 3600 Access Point was introduced in Cisco Wireless LAN Controller 7.1.91.0 release. If your network deployment uses Cisco 3600 Access Points with release 7.1.91.0, we highly recommend that you upgrade to the Cisco Wireless LAN Controller 7.2.103.0 release.

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With Cisco Spectrum Expert, the Sensor card and application are integrated into one convenient platform. A network engineer uses the application’s device finder mode to observe how the signal strength from an interferer varies as he moves about the enterprise, which makes it possible to quickly pinpoint the location of the interfering device.

## Spectrum Sensor Card

As a first step in the spectrum analysis process, the ambient RF environment must be scanned and analyzed to determine the sources of RF activity in the neighborhood of the network, especially causes of interference or other problems.

The essential internal components of a Sensor card include:

- **Radio**—The radio transceiver detects the RF spectrum and feeds this data to SAgE.

- **SAGE**—The Spectrum Analysis Engine (SAGE), performs a Fast Fourier Transform (FFT) of the RF spectrum and provides the feed of low-level data concerning the behavior of the RF spectrum. Low-level data includes basic information on the power vs. frequency in the spectrum at a given instant and information on individual pulses in the RF spectrum.

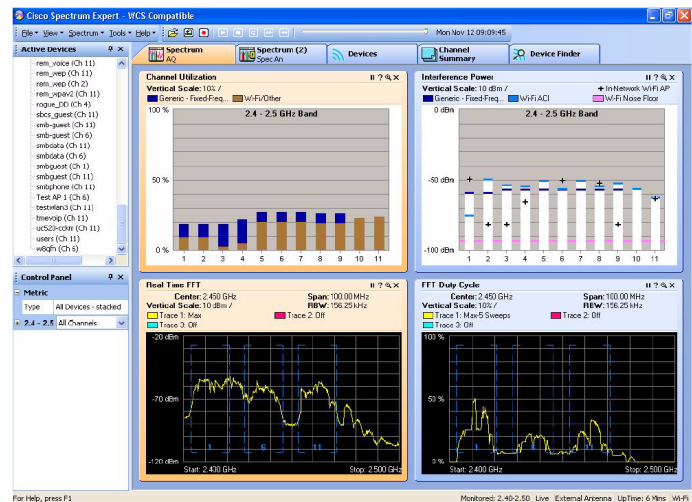
SAGE also performs on-board statistical analysis of the spectrum and statistical analysis of RF pulses (which relieves external MCUs or CPUs of this processor-intensive task).

- **CPU**—To be fully useful, data from the Sensor card requires further software analysis from a microprocessor. The Sensor card borrows some of the processing power from the laptop's microprocessor (CPU) to perform these calculations. The CPU provides low-level analysis of the data stream. The analysis engines include:
  - **Measurement Engine**—Aggregates SAGE data and normalizes it into meaningful units.
  - **Classification Engine**—Identifies specific types of interferers (Bluetooth devices, microwave ovens, cordless phones and headsets, radar, and so on).

## Cisco Spectrum Expert Software

The Cisco Spectrum Expert Software runs under Windows XP (Service Pack 2 or later) or Windows Vista operating systems. The application provides the interface (GUI) which connects the network engineer with the resources available from the Sensor card:

- **Spectrum Views**—Provides plots and charts that offer a direct view into the RF spectrum, including measurements of RF power and network device activity. See the “[Spectrum Menu](#)” section for more information.
- **Active Devices**—Displays all currently active devices in the network neighborhood including both network devices and interferers. See the “[Active Devices](#)” section for more information.
- **Devices**—Provides detailed information on both current and historical device activity. See the “[Current Devices vs. Historical Devices](#)” section for more information.
- **Channel Summary**—Provides a statistical overview of RF activity (such as power levels and number of interferers present) on a per-channel basis. This view gives you an instant picture of which channels are subject to excess interference, and which channels have the best potential for trouble-free network activity. See the “[Working with the Channel Summary](#)” section for more information.
- **Device Finder**—In **Device Finder** mode, Cisco Spectrum Expert Software is a convenient, user-friendly RF “sniffer” optimized for displaying RF power data in a way that quickly enables the network engineer to track down interfering devices. See the “[Device Finder Mode](#)” section for more information.



- **Tools**—Supports configuration of Cisco Spectrum Expert Software. See the “[Tools Menu](#)” section for more information.

## Cisco Spectrum Expert Online Help

Detailed reference information is found in the Cisco Spectrum Expert Online Help system, which can be accessed by selecting **Help > Help Topics**.

## Cisco Spectrum Expert Operating Scenarios

Cisco Spectrum Expert can be used in several different modes which are described below.



### Note

For detailed instructions on using Cisco Spectrum Expert in real-world applications, see the “[Cisco Spectrum Expert and Real World Applications](#)” section.

## Firefighting Mode

Critical Tasks:

- Identify, diagnose, and resolve problems in the RF environment as quickly as possible.

Centerpiece Applications:

- Spectrum Charts
- Devices View
- Device Finder
- Channel Summary

Typically, the IT Administrator will have the Cisco Spectrum Expert Software running with the **Channel Summary** or one or more **Spectrum Plots** and **Spectrum Charts** in view. **Spectrum Charts**, in particular, are an important resource for detecting problems that may stress the network.

- The **Channel Utilization** chart—Indicates when one or more channels are becoming overloaded with devices.
- The **Channel Utilization** chart—Indicates when one or more channels have an overall excess of RF activity which may be due either to device overload, or interferers, or both.

Once a problem occurs and before it progresses too far, the Administrator can determine and isolate the cause of the problem through a combination of the **Devices View**, **Channel Summary**, and the **Device Finder**.

## RF Expert

An RF expert is an individual with an advanced knowledge of radio frequency technology and its associated physics and electronics. This individual is familiar with the use of spectrum analyzers as well as the inner workings of wireless network systems. An RF expert is most likely to be involved with installations where the wireless system is considered mission critical.

The RF Expert uses Cisco Spectrum Expert as a 24 hour-per-day, 7-day-per-week spectrum analysis tool.

Critical Tasks:

- Investigate reported spectrum events at the raw RF level.
- Review raw RF data for cases that are unclassified by Cisco Spectrum Expert Software.
- Confirm that recommended solutions have alleviated the problem.

#### Centerpiece Application: **Spectrum Analyzer Plots**

The RF Expert primarily uses the detailed **Spectrum Analyzer** plotting capabilities of Cisco Spectrum Expert Software's **Spectrum Plots**. When he is called in on a problem, he uses the **Spectrum Plots** to confirm and/or supplement the intelligence capabilities built into Cisco Spectrum Expert Software.

For example, if Cisco Spectrum Expert Software reports that a video interference signal is occurring, the RF expert may wish to view the **Power Vs. Frequency** and **Real Time FFT** plots to confirm that it is not some other type of device. In addition, there will always be cases where Cisco Spectrum Expert Software does not recognize the type of interference at work. In that case, the human intelligence of the RF expert helps fill in the missing gaps.

Another critical use of the **Spectrum Analyzer** capabilities is to confirm when a problem has been fixed by corrective action. When a fix has been attempted, the IT department can't afford to wait until the next day to see that no problems resurface. The RF expert can use the **Spectrum Analyzer** functions to perform before-and-after comparisons that confirm that a fix (for example, shielding was placed around an interference device) has indeed fixed the problem. These comparisons are enabled by Cisco Spectrum Expert Software's record/playback capabilities.

See the "[Spectrum Instant Replay](#)" section for more information.

## Site Survey—Network Install and Initial Configuration

Cisco Spectrum Expert Software is an invaluable tool for supporting pre-installation Wi-Fi site surveys, and also for the initial installation and configuration of a WLAN system.

Critical Tasks:

- Set channel usage for Wi-Fi access points
- Pre-emptive interference mitigation

Centerpiece Applications:

- Spectrum Plots and Charts
- Device Finder
- Channel Summary
- Devices View

Cisco Spectrum Expert Software can be used prior to deployment of a Wi-Fi WLAN network, to obtain information which is essential for planning an optimum deployment.

- **Band and Channel Allocations**—Cisco Spectrum Expert Software can determine which bands or channels have the most RF activity. Wi-Fi access points can then be programmed to use other channels, resulting in higher speed transmissions, and reduced packet retransmissions.
- **Pre-emptive Interference Mitigation**—Any interferers which are discovered to be contributing significant RF activity can be moved, de-activated, or shielded, before putting the WLAN system into operation.
- **Access Point Placement**—As a lightweight, mobile RF probe, Cisco Spectrum Expert Software can determine which general areas have the highest level of RF activity—as determined by the **Devices View**, the **Device Finder**, and the **Spectrum Plots and Charts**—and therefore require the most access points for adequate network coverage.

## Technical Concepts

Cisco Spectrum Expert Software is designed to make the RF spectrum accessible even to non-experts by performing a tremendous amount of high-level analysis on behalf of the user. For example, Cisco Spectrum Expert Software can classify interfering devices, sparing the user the necessity of interpreting a spectrum graph to determine which kinds of interfering devices are present.

Cisco Spectrum Expert Software provides a great deal of technical information, so some familiarity with RF concepts is helpful. Neither this manual nor the online Help system attempts to present a detailed discussion of radio frequency theory, but a few concepts are worth some clarification.

### Duty Cycle

Among the various measures of RF power, Cisco Spectrum Expert Software includes the ability to measure and report on the RF duty cycle. *Duty cycle* is a general term which relates to how much RF energy is present in the spectrum, as measured not by raw RF power (not in watts or dBm), but rather in terms which indicate how much RF power is present in some operational or functional sense. The goal is to have a measure of RF power which suggests how much impact the RF power will have on network performance. Cisco Spectrum Expert Software uses two different measures of duty cycle:

- The percentage of time that the RF signal is 20 dB above the noise floor.
- The percentage of time a transmission from a known device is present in the channel or band.

This guide indicates which measure of RF power is used by various Cisco Spectrum Expert Software display modes. The Online Help also includes a topic (**Duty Cycle** in the **Background Information** folder) which compares the usage of duty cycle in various contexts in the Cisco Spectrum Expert Software.

## Device Classifiers

You, as the user, make the vital distinction between network devices (Wi-Fi) and interferers. In addition, the Cisco Spectrum Expert Software supports this distinction, in terms of how data is structured and classified on the display. However, the underlying technology used to detect and classify both network devices and interferers is the same. Cisco has developed advanced classifier algorithms, which run on the processor on your laptop. These classifier algorithms use the spectrum data from SAgE (discussed above) to categorize devices which are part of your network, or which can interfere with your network.

The classifiers supported in Cisco Spectrum Expert Software 4.1 include:

- Wi-Fi ACOI
- Wi-Fi Stations (Standard, Inverted and Invalid Channels)
- A wide variety of Bluetooth devices (SCO and ACL)
- DECT like Phones
- Generic Continuous transmitters (For example, FM Phones, NTSC, and so on.)
- 802.15-4 devices
- Super AG
- Video Camera
- Canopy
- Radar
- Xbox
- WiMax devices (Mobile and Fixed)



## Generic Device Classifiers

Cisco Spectrum Expert supports the ability to classify “generic” devices. Generic devices cannot be linked to a specific device type, manufacturer, or transmission protocol. They are identified by their physical layer transmission characteristics. An example of such a device is a cordless phone that uses an unrecognized transmission protocol to exchange data with its base station (i.e., a phone that does not use Bluetooth, 802.11FH, TDD or DECT).

The following list of generic signals recognized by Cisco Spectrum Expert 4.1 is subject to revision without notice:

Pulse Type	Analog or Digital	Modulation Type	Output Parameters
Continuous	Digital	FSK	RMS power, bandwidth, coarse and fine CF <sup>1</sup>
Continuous	Digital	OFDM	RMS power, bandwidth
Continuous	Analog	FM	RMS power, bandwidth, coarse and fine CF
Continuous	Analog	CW	RMS power, coarse and fine CF
Burst	Digital	FSK	RMS power, bandwidth, symbol rate, coarse and fine CF, burst period
Burst	Digital	OFDM	RMS power, bandwidth, burst duration

1. CF = center frequency, PAP = peak-to-average power

In the **Active Devices List**, these devices will be identified via a hierarchical listing which will indicate the pulse type, modulation type, and possibly the frequency. For example:

### Generic Devices [5]

#### Burst, Fixed Frequency [3]

##### Channel Group @ 2431.3 MHz [2]

Device 1 (FSK)

Device 2 (FSK)

##### Channel Group @ 2434.3 MHz [1]

Device 1 (FSK)

#### Continuous [2]

Device 4 (CW) @ 2430.1 MHz

Device 7 (FSK) @ 2440.1 MHz

The bracketed numbers indicate the number of devices.

A similar naming scheme is used in the **Devices View**.

## Interferers: Classified (Named), Generic, and Unclassified

As indicated, Cisco Spectrum Expert classifies many different interferers – that is, devices which are not network devices, but which produce RF power in frequency bands that affect your network. For purposes of Cisco Spectrum Expert operations, there are three broad categories of interfering devices:

### Classified Named Interferers

For many interfering devices, Cisco Spectrum Expert can detect and classify the type of device, in some cases to the extent that it can name the specific model of a device in question. So, for example, Cisco Spectrum Expert will not only identify an interferer as being a Bluetooth device, it will also indicate a

brand name and model. However, for our purposes, a “named” device is one for which Cisco Spectrum Expert can indicate the category of operation (Bluetooth, microwave oven, cordless phone, and so on.). The user interface displays a picture of a typical device that matches the RF signature when a user double-clicks on a device in the Active Devices pane or Devices View.

### Classified Generic Interferers

These are devices for which Cisco Spectrum Expert has a great deal of technical information about the *signal* from the device, such that the general nature of the RF emitter can be identified. However, the Cisco Spectrum Expert system does not present a name (such as **DECT2**, or **Bluetooth**); and Cisco Spectrum Expert does not present a list of devices (product names) that can be in this category.

For the generic devices, Cisco Spectrum Expert provides the kind of signal details indicated in the table, Generic Device Classifiers. In fact, what Cisco Spectrum Expert essentially provides are detailed parameters about the RF signal from the device, rather than about the device per se.

**Example:** In the case of “Continuous Transmitter FSK”, “Continuous” means the device transmits continually rather than in bursts; “FSK” refers to the signal modulation. (“FSK” stands for Frequency Shift Keying.) Specific devices, such as DECT2 devices, are also “continuous FSK” transmitters; but if Cisco Spectrum Expert does not identify the interferer as, say, DECT2, it’s because other expected transmission properties of DECT2 devices were not detected. Hence, Cisco Spectrum Expert only provides the broader, generic classification based on the type of signal.

### Unclassified Interferers

An “unclassified interferer” is literally one that Cisco Spectrum Expert does *not* classify. That means it is not identified, as a device, anywhere on the screen (such as in the **Devices View** or the **Active Devices** list). It also means the device is not included in counts of devices. On the **Channel Summary** display, the **Interferer Duty Cycle** field does not include measurements of unclassified interferers. However, Cisco Spectrum Expert still does see RF energy from unclassified interferers. See the following note.



#### Note

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The plots and charts which show RF power (**Real Time FFT, Power vs. Frequency**, and the **Swept Spectrogram**) or duty cycle (**FFT Duty Cycle, Channel Utilization, Channel Utilization vs. Time**, and **Swept Spectrogram**) *do* show *all* RF power / duty cycle detected by the Sensor card, regardless of the source. So, power/duty cycle from unclassified interferers is also included.

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Naturally, Cisco tries to minimize the number of interferers that Cisco Spectrum Expert cannot classify at all.



#### Note

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The **Interferer Duty Cycle** on the **Channel Summary** is an estimate of the percentage of the time that a transmission is present in the channel or band. To be included in this estimate, the transmission must be associated with a known, identified device. So, transmissions from unclassified interferers are automatically excluded. In addition, it is possible that there may be some transmissions from generic interferers which Cisco Spectrum Expert cannot actually identify as belonging to those devices. Those transmissions are also not included in the **Interferer Duty Cycle** shown on the **Channel Summary**.

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