Planning Site Surveys for 6LoWPAN deployments

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With the increased market adoption and deployments of 6LoWPAN Wireless Sensor Networks, (WSN) network managers increasingly need to take into consideration the importance of site surveys. A site survey is a process used to detect the presence of interference coming from other radio sources in a defined deployment area. Site survey should be done before and after the installation to ensure the most appropriate frequency channel is selected for a given WSN. In addition, site surveys may be used to determine the best location and number for 6LoWPAN nodes in a WSN.

Performance degradation or intermittent broken network connections may result from interference and high bit error rate (BER). This is particularly true in the unregulated Industrial/Scientific/Medical (ISM) 2.4GHz band where IEEE 802.15.4/6LoWPAN and 802.11b/g/n (WiFi) devices operate. Additionally, it should be understood that other electronic gear – such as a security camera, cordless phone, microwave oven, amateur radio, wireless USB mouse, video transmitter, RFID reader and others – running in the same band, may add to the interference. The following pictures show the 2.4GHz RF signatures as supported by Metageek Chanalyzer 3.1 release (http://www.metageek.net/docs/chanalyzer3-user-guide/signatures). The RF signature of a 6LoWPAN node has the same signature as the ZigBee node as they use similar physical layer chipsets.
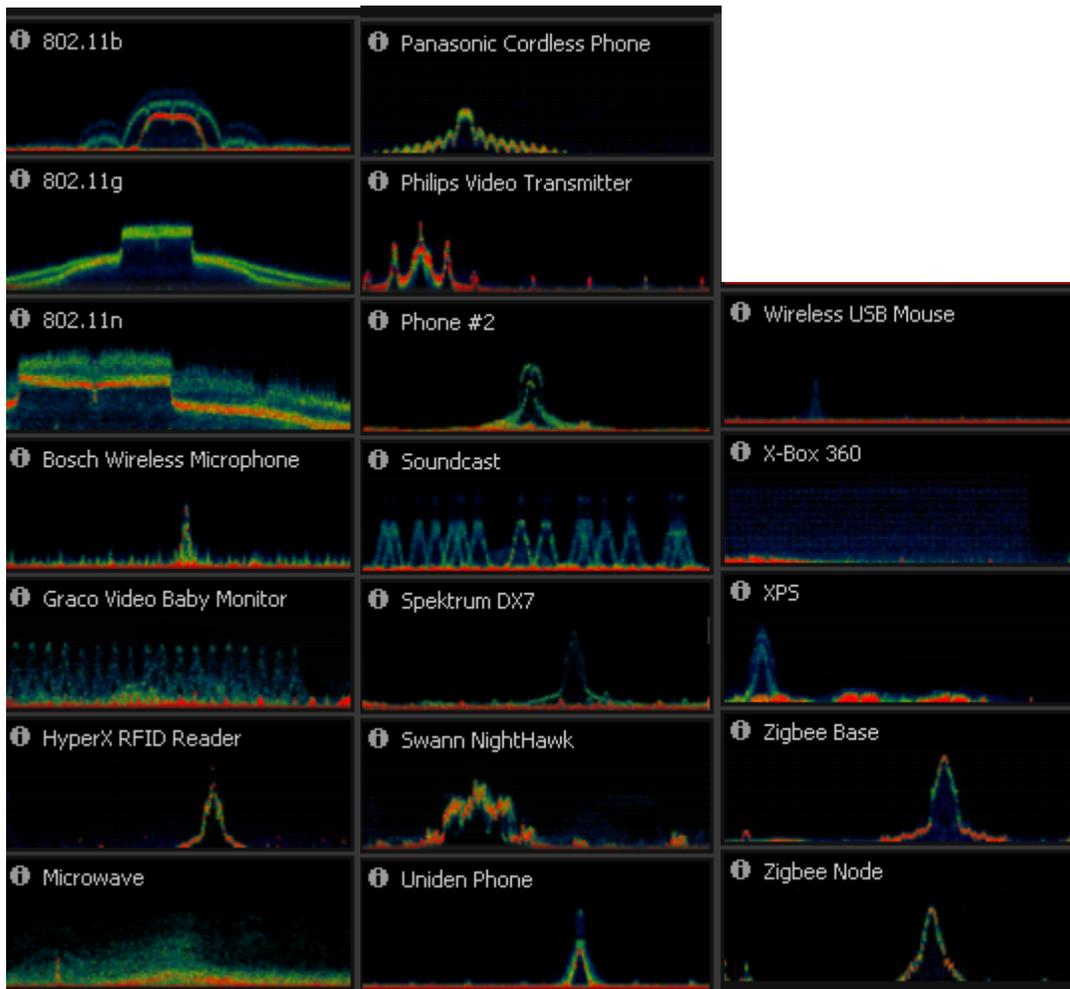
Figure 1 RF Signatures

Technology Overview

The 2.4GHz ISM band is divided into a number of channels, similar to the way TV channels are allocated. However, due to spectrum assignments, operational limitations and regulations for given standards, the exact bands of operation are sometimes different between countries.

In case of IEEE 802.15.4, 16 channels (11-26) are defined in the 2.4GHz band as worldwide, differences between regions only existing in the 780 (China), 868 (Europe), 915 (U.S.), 950 (Japan) MHz bands.
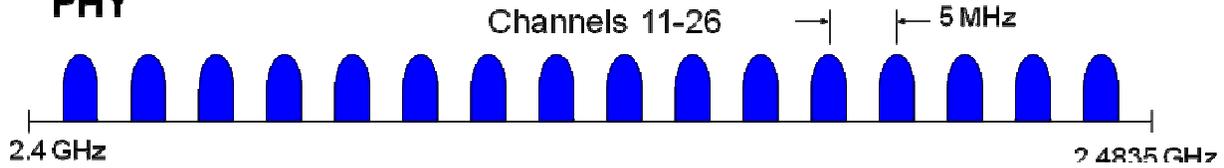
Figure 2 IEEE 802.15.4 2.4 GHz Channels

In the case of IEEE 802.11, channels for the 2.4GHz band in U.S. and Canada are known as WiFi channels 1-11, most European countries allow 2 additional channels (1-13) and Japan adding one more (1-14). To make it more complex for network managers, some WiFi channel numbers overlap with each other, Channel 1 using the lowest frequency band and each subsequent channel increases the frequency slightly. The result is that only 3-4 non-overlapped channels are available depending on the worldwide region. Those are channels 1, 6 and 11 in the U.S., 1, 5, 9 and 13 in Europe.
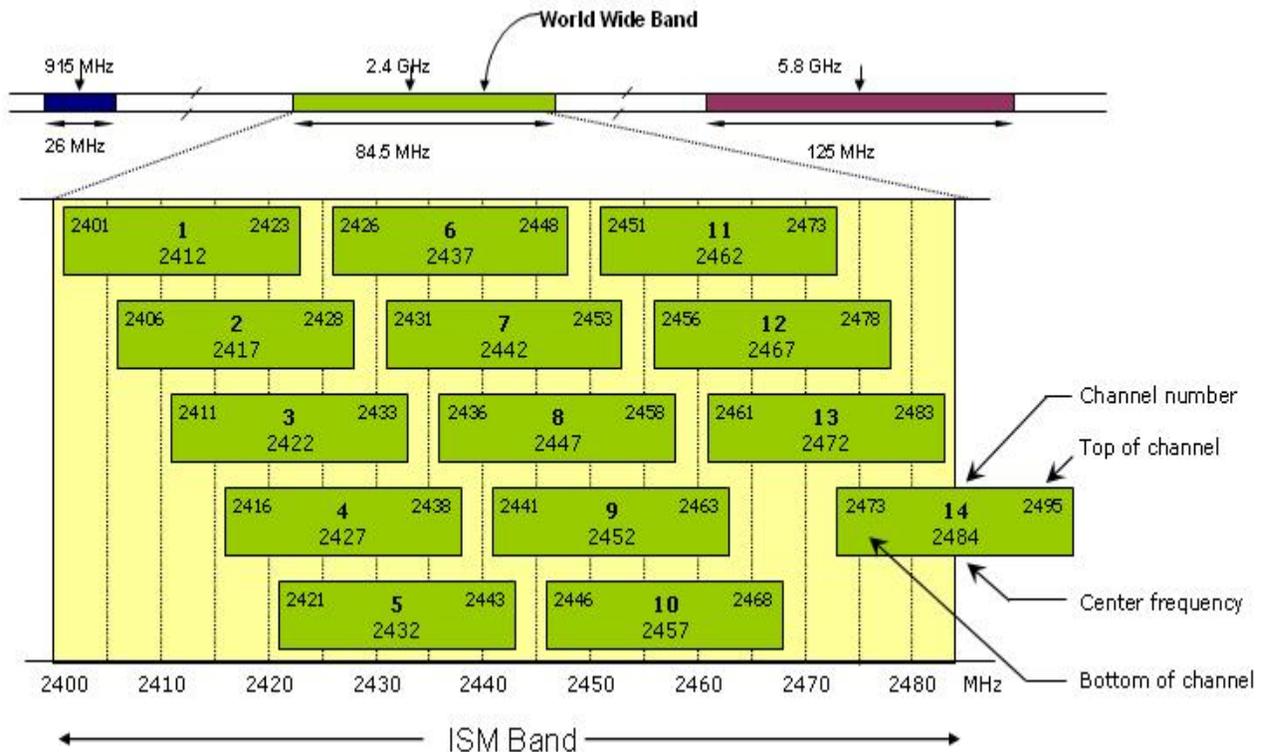

Figure 3 IEEE 802.15.4 Channel Details

Since 6LoWPAN and WiFi networks share the same frequency bands, overlap of channels and transmission power may generate interference which could increase the BER for each networking technology as a result of both technologies being forced to share the physical layer.
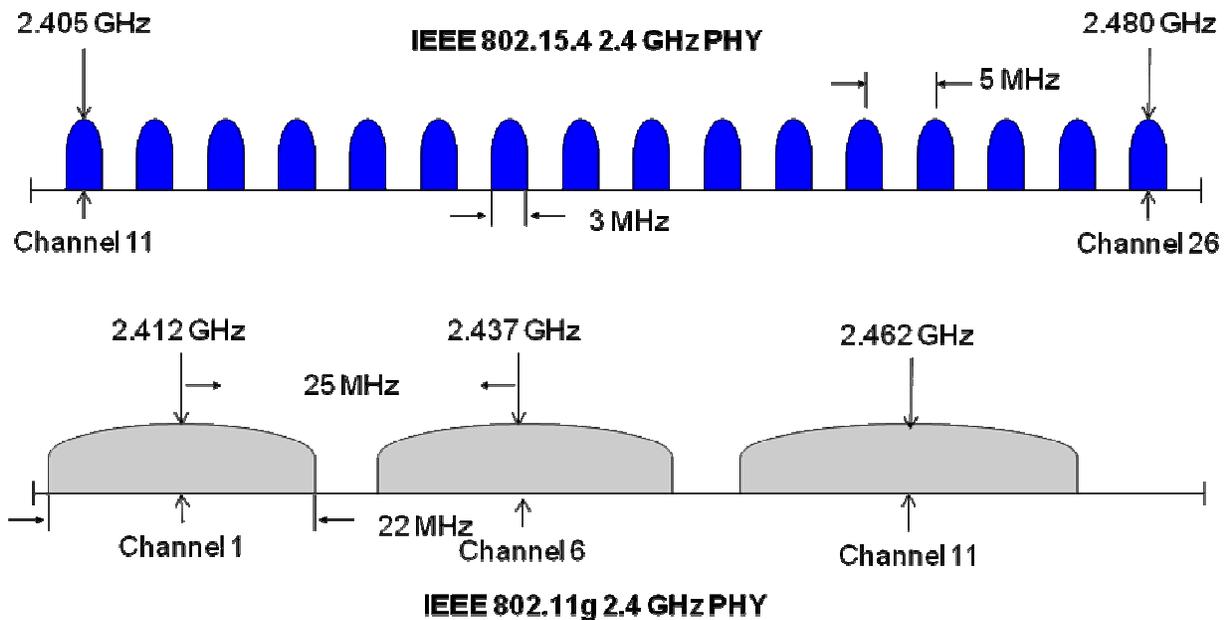

Figure 4 Overlap between IEEE 802.15.4 and 802.11g 2.4 GHz Channels

As shown above in Figure 4, there is no overlap between 802.15.4/6LoWPAN channel 26 and any of the WiFi channels. The Arch Rock PhyNet router is configured with channel 25 as default value on its 6LoWPAN interface, but it can be changed as shown below.

ARCH ROCK PhyNet Router

System | LowPAN | WAN | LAN | Management Server | Support

Info | Settings | Log | Upgrade | Reboot

System

Name:	Boz-PNR1
Model:	Arch Rock PhyNet Router
Version:	3.1.alpha3-20309-20309M
System time:	Tue May 3 13:33:03 CEST 2005
Uptime:	13:33:02 up 2 days, 11:33, load average: 0.00, 0.00, 0.00

LowPAN

PAN MAC:	00-17-3B-00-11-E5-76-20
PAN ID:	15096
Channel:	26
Wireless Security:	enc
IPv4 Subnet:	10.10.0.0/16
IPv6 Subnet:	fd36:441e:6be4:6a3f::/64
Interface ID:	0

Recommendations

As a result of the site survey, network managers must review the default channel set-up of their 6LoWPAN and WiFi equipment to select the most appropriate channel(s), limiting potential sources of wireless interference and BER. The lower the degree of overlap between any technology and channel, the more stable the networks will be. Note that all devices on a given wireless network must be set-up with the same channel value.

- Arch Rock PhyNet Router (PNR) is configured with channel 25 as default. Unless multiple 6LoWPAN networks are deployed on a site, it is recommended that Network Managers keep this default value. Channel value may be changed from the PhyNet router 6LoWPAN interface.

- Arch Rock Phynet network management provides monitoring capabilities for link signal integrity and BER. Network managers should regularly check the quality and stability or their 6LoWPAN networks through the PhyNet Server management interface using the "Connectivity" and "Reliability" tabs.

- On a PhyNet Server, "Survey All Nodes" functionality under the "Connectivity" tab allows a user to take an RF snapshot of a space as well as survey per node neighborhood to zoom into certain areas.

A connectivity survey matrix gets displayed at the end of the tests indicating
- o Ping Success Rate (%)
- o Minimum Signal Strength (dBm)
- o Mean Signal Strength (dBm)
- o Maximum Signal Strength (dBm)
- o Minimum LQI
- o Mean LQI
- o Maximum LQI

Connectivity Survey Report - Matrix

Beginning September 24, 2008 - 10:16:41 am CEST @1222244201
Ending September 24, 2008 - 10:18:07 am CEST @1222244287

Success Rate (%)	Destination Node						
Source Node	1	2	3	4	5	6	7
1.Boz-PNR1 (00173b0011e57620)							
2.Cellar (1bb5) (00173b0010d01bb5)			100		100	98	100
3.Children Bathroom (01c1) (00173b0010d001c1)		100		100	100	100	
4.Desk Window (1177) (00173b0010d01177)		26	100		98		100
5.Main Room (fdbb) (00173b0010cffdbb)		100	100	100		100	100
6.Mikael Bedroom (4772) (00173b0010d04772)		100	100		100		100
7.Relay Top (c39f) (00173b0010cfc39f)		100		100	98	100	

Minimum Signal Strength (dBm)	Destination Node						
Source Node	1	2	3	4	5	6	7
1.Boz-PNR1 (00173b0011e57620)							
2.Cellar (1bb5) (00173b0010d01bb5)			-85		-83	-88	-79
3.Children Bathroom (01c1) (00173b0010d001c1)		-88		-84	-72	-81	
4.Desk Window (1177) (00173b0010d01177)		-92	-81		-82		-70
5.Main Room (fdbb) (00173b0010cffdbb)		-84	-70	-84		-65	-60
6.Mikael Bedroom (4772) (00173b0010d04772)		-89	-80		-64		-74
7.Relay Top (c39f) (00173b0010cfc39f)		-78		-71	-59	-72	

- On a PhyNet Server, under the "Connectivity" tab, network managers can visualize the information related to RSSI and LQI, see details in the "Help Page" as displayed below. When done with the node installation, the site survey should include a check of RSSI values.
  Note: At least three parents with an RSSI >= -80dBm is considered a "good" network. RSSI values can go down further, but it will cut into the safety margin.

Number of hops away from bridge node (gateway server)

Percentage of successful packets sent from node to parent

Time that statistics were last collected for this sensor node

Parent node (with which this sensor tries first to communicate)

Radio signal strength

Current data view

List View Map View Chart View

Refresh Data

Name	Last Stats	Depth	Parent	Link Success	Signal		
ComputerRoom	8:18:32 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	Conf 3				
Alternate 2		2 hops	Shipping Receiving				
Conf 1	8:18:32 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	Shipping Receiving				
Alternate 2		2 hops	Conf 3				
Conf 2	8:17:38 pm	2 hops	Lobby			Ping	Survey
Alternate 1		2 hops	Shipping Receiving				
Conf 3	8:18:40 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	ComputerRoom				
Alternate 2		2 hops	Shipping Receiving				
Lobby	8:18:38 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	Mfg				
Alternate 2		2 hops	Conf 3				
Mfg	8:18:32 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	ComputerRoom				
Alternate 2		2 hops	Lobby				
Shipping Receiving	8:18:32 pm	1 hop	SensorNetServer			Ping	Survey
Alternate 1		2 hops	Conf 1				

Name of sensor node

Alternate nodes with which to communicate

The Tree View shows the structure of the routing tree rooted at the server. Each level of indentation indicates that the nodes ro

The view also shows the signal strength to the parent node, the measured link success rate to that parent, and the duty cycle averages over the last two hours.

The **Ping** link sends a ping to the node, and shows **OK** when the node responds.

The following table describes how to interpret the radio signal strength indicators:

..▪▪▪	Greater than or equal to -40 dBm
.▪▪.	-60 dBm to -40 dBm
.▪..	-70 dBm to -60 dBm
▪...	-80 dBm to -70 dBm
▪▪▪▪▪	Less than -80 dBm

- Arch Rock PhyNet Router configured with WiFi acts as a client, WiFi channel selection depends on the selected Access Point to which the PNR connects. This can be viewed on the PNR management interface "WiFi Scan" which shows all available SSID. It is recommended that the selected WiFi channel does not overlap with the 6LoWPAN channel. "WiFi Scan" display can also be used when performing the site survey to understand the existing WiFi installations in the deployment area. On a new site where WiFi and 6LoWPAN get deployed at the same time, we recommend keeping the WiFi and 6LoWPAN channels separated as much as possible.

| System | LowPAN | **WAN** | LAN | Management Server | Support |

| Settings | Ethernet | WiFi | **WiFi Scan** | OSPF |

SSID	MAC	Channel	Rate	RSSI	S:N	CAPS
FreeBozo	26:4e:9e:61:a9:44	1	54M	-62	33:0	EP
cannibal	00:14:f1:73:1e:b0	11	54M	-53	42:0	EPSs

- Interference generated by other wireless devices such as cordless phones operating in the 2.4 GHz band may not be avoided by channel change, either because the devices also run over a very broad spectrum or they perform permanent frequency hopping. If such a case is identified during the site survey, try switching off the device(s) and check if your wireless signal quality improves. If yes, then consider moving or replacing the device(s) to another location.

- Check your WiFi access points and client configurations for "Transmit Power" and decrease the value when necessary and possible. Similar to a 6LoWPAN deployment, a site survey for a WiFi deployment should determine the maximum signal coverage area and transmit power required to maintain WiFi client connectivity within the boundaries of the operating area.
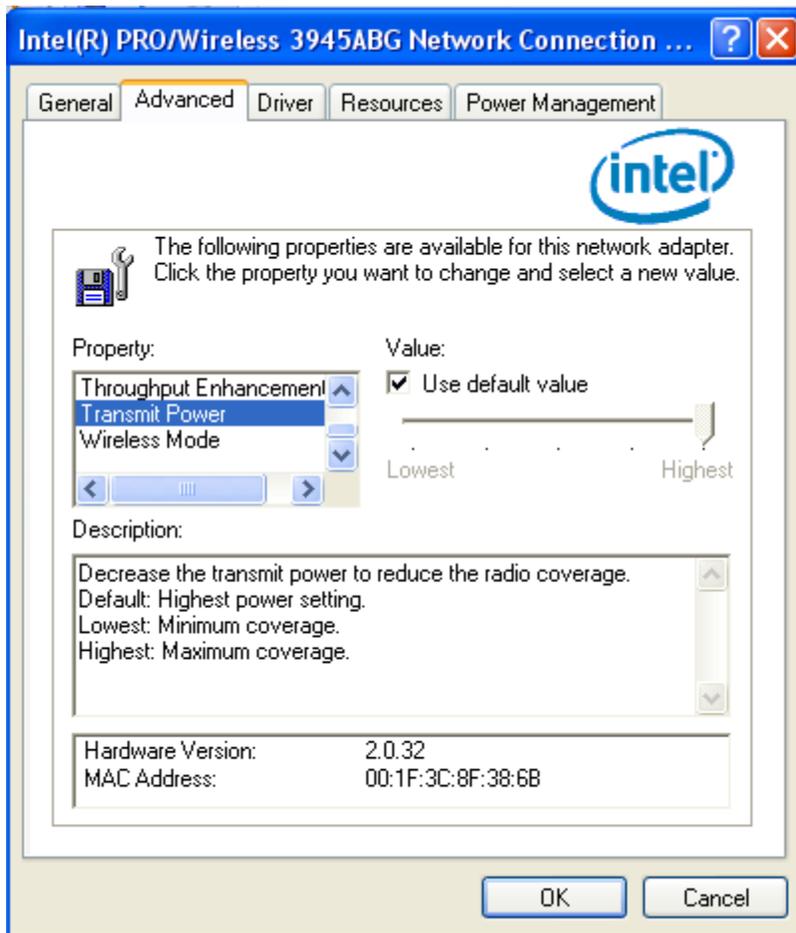
Site survey

A site survey can be performed using various tools – software and hardware – available in the market. Simple test can be done by using the Arch Rock PhyNet Router interface to visualize WiFi and 6LoWPAN channels and link quality as shown in the pictures above. A more complete survey requires a 2.4GHz RF spectrum analyzer to scan and display network activity. This kind of hardware combined with a graphical application will help to identify interference and analyze the signal integrity.

As an example, Metageek Wi-Spy 2.4x hardware combined with Chanalyzer 3.1 software was used to survey a site. It has several operational WiFi networks as well as an Arch Rock 6LoWPAN network. From the below display, channels used by each network are easily identified as

- WiFi – Channel 1
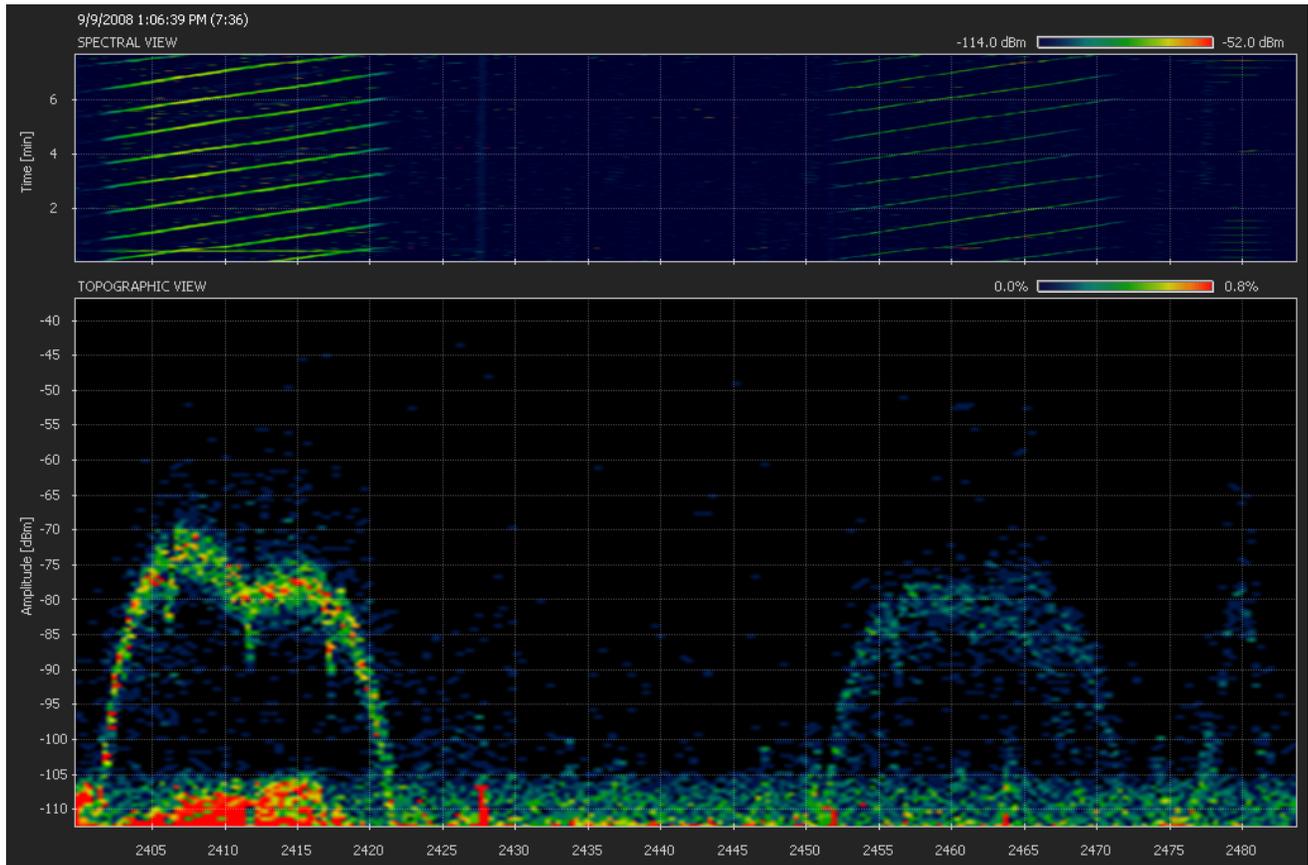- WiFi – Channel 11
- 6LoWPAN – Channel 26

Figure 5 Sample Spectrum Scan

To conclude, a site survey is the best insurance policy when operating in the 2.4GHz spectrum. By doing so, users can avoid potential network disruptions or performance degradations caused by signal interference. In addition, physical installation of 6LoWPAN nodes should follow the recommendations from the PhyNet Physical Network Installation Guide.

Glossary

6LoWPAN – IPv6 over Low power Wireless Personal Area Networks
BER – Bit Error Rate
IEEE – Institute of Electrical & Electronics Engineers
ISM – Industrial/Scientific/Medical
LQI – Link Quality Indicator
PNR – ArchRock PhyNet Router
RF – Radio Frequency
RFID – Radio Frequency Identification
RSSI – Received Signal Strength Indication
USB - Universal Serial Bus
WiFi - Wireless Fidelity (IEEE 802.11b wireless networking)
WSN - Wireless Sensor Networks

References

ArchRock – www.archrock.com
IEEE 802.11 - http://grouper.ieee.org/groups/802/11/
IEEE 802.15.4 - http://www.ieee802.org/15/pub/TG4.html
Metageek – www.metageek.net