Avoiding RF Interference Between WiFi and Zigbee

This application note discusses how to avoid RF interference when deploying WiFi and IEEE 802.15.4 / Zigbee radios simultaneously or in close proximity. The testing and deployments conducted for this application note used Crossbow's MICAz Zigbee-ready wireless Smart-Dust sensors and a Crossbow Stargate Gateway running both high-power and low-power WiFi cards. When properly configured, the issue of RF interference and lost data can be avoided. However, without proper care and software configuration serious interference issues can occur.

Disclaimer: Crossbow does not represent this as a complete study, but it is merely practical tips for deployment based on our experience in the field. We also can't confirm whether these test would be relevant for other manufacturers hardware.

WiFi and IEEE802.15.4 / ZigBee Sprectrum

To understand the potential for problems, a review of the RF spectrums and available channels for WiFi (802.11b/g) and Zigbee (802.15.4) is shown below. Since the RF channels in ZigBee and WiFi overlap there is a cause for concern. This concern has also been shown to be an issue in field testing, as discussed later in this application note.

802.11b Channel-to-Frequency Mappings

USA/FCC & Canada regions have 11 total channels allocated. All frequencies are in GHz.

Channel	Lower Frequency	Central Frequency	Upper Frequency
1	2.401	2.412	2.423
2	2.404	2.417	2.428
3	2.411	2.422	2.433
4	2.416	2.427	2.438
5	2.421	2.432	2.443
6	2.426	2.437	2.448
7	2.431	2.442	2.453
8	2.436	2.447	2.458
9	2.441	2.452	2.463
10	2.446	2.457	2.468
11	2.451	2.462	2.473

Table 1: WiFi RF Channels

Figure 1 shows the RF channel spectrum of IEEE801.15.4 / ZigBee against IEEE802.11b / WiFi.

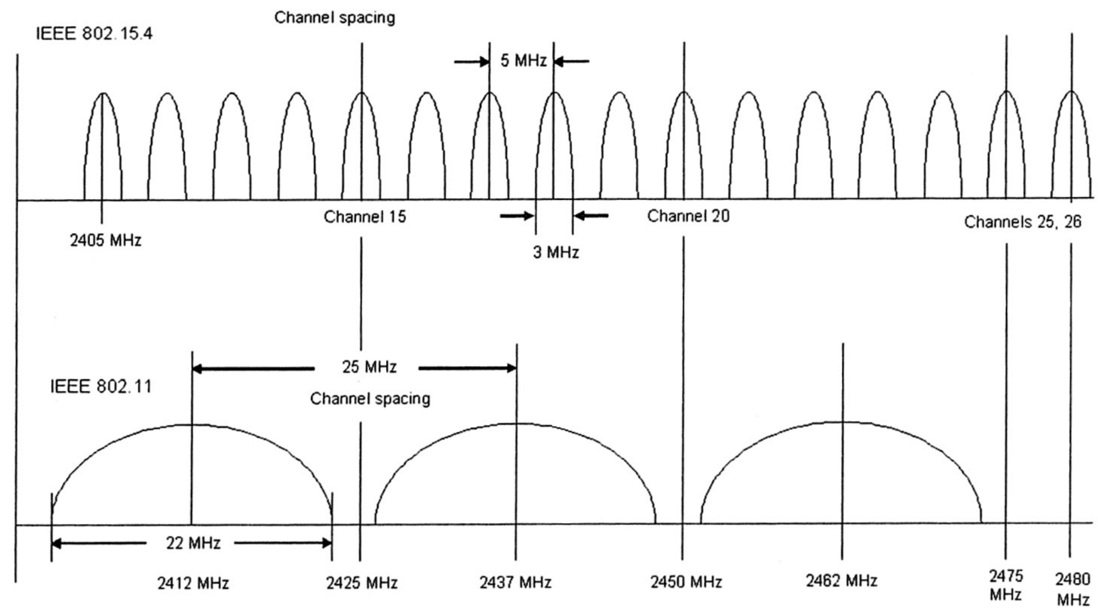

Figure 1: IEEE802.15.4 and IEEE802.11 Channels

What is an RF Spectrum ?
To users who are new to RF and Wireless technologies, an RF spectrum plot as shown in Figure 1 is a graphical way of showing how much energy and at what frequencies a radio operates. The Y-axis is the RF energy or power, and the X-axis is the frequency. Think of the frequency as the "radio station", that the device transmits on. Because both ZigBee and WiFi are "spread spectrum", they do not operate on a single radio channel, they actually occupy bands of frequencies. This results in the hump shape shown above. The radio channel assignment is made by reference to the center frequency of the band (i.e., the center of the hump). As you can see WiFi channels are wider in frequency than ZigBee. This means that WiFi occupies more RF spectrum per channel than ZigBee.

Field Trials with MICAz and Stargate using Low-power and High-power WiFi

A very common field deployment combines a MICAz (ZigBee-ready radio) based sensor network and a WiFi network using Stargate. A number of field trials were conducted to examine the RF interference patterns while running this combination. The results presented here are based on a 6 node MICAz network and Stargate. Each MICAz node was running our Xmesh (surge_reliable configuration) networking layer on base station and remote nodes. In the results, we varied the RF Channel selections and compared the packet delivery success rate and percentage of duplicate packets.

In addition the first test was run with no WiFi card card attached to the Stargate. Another group of tests were run with a standard power 802.11b WiFi card – Netgear MA701. A final group of tests were run with a high power (up to 23 dBM) WiFi card – SMC Networks SMC2532W-B.

During the tests with WiFi enabled, there was continuous traffic on the WiFi channel including a circular retransmission of an 8 MByte file across the WiFi network. The WiFi channel 3 – i.e. 2.422 GHz central frequency was used to connect to the access point. The output power of the MICAz was at maximum RF power.

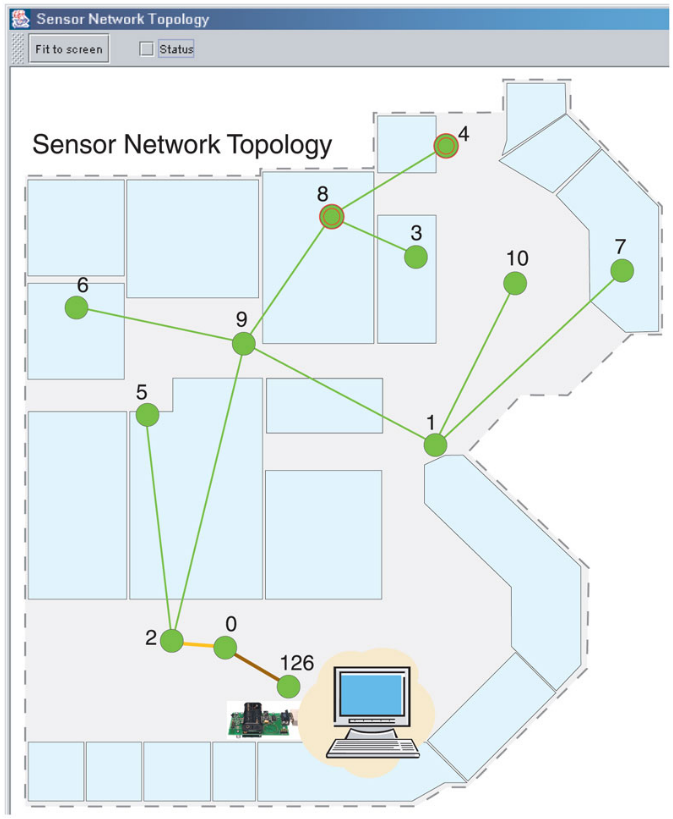

Figure 2: Test Topology

Results:
The packet delivery rates show that when the MICAz's ZigBee and the Stargate's WiFi channel overlap the packet delivery rate is reduced from 100%. When the channels are separated further in frequency, the packet rate is in the normal 99-100% rate. As expected, the degradation is more pronounced when testing is done in the prescence of high-power WiFi card. Interference was also observed on some adjacent channels, due to the interference caused by intermodulation frequencies created by interaction of the WiFi RF signal and the Zigbee RF signal in close proximity.

WiFi at 2.4220 GHz (Channel 3 802.11b band)
Netgear MA701 CF

Percent Packets Received

	Node 1	Node 2	Node 3	Node 4	Node 5
No WiFi	100.00	99.95	100.00	100.00	100.00
Zigbee Channel 11 - 2.405 GHz	100.00	100.00	100.00	100.00	99.95
Zigbee Channel 14 - 2.420 GHz	96.19	98.45	95.05	98.02	94.67
Zigbee Channel 15 - 2.425 GHz	98.93	98.99	98.89	99.05	98.96
Zigbee Channel 20 - 2.450 GHz	99.95	100.00	99.95	99.95	99.95
Zigbee Channel 26 - 2.480 GHz	100.00	100.00	99.95	100.00	99.89

Table 2: Normal (Low) Power WiFi Card and ZigBee radio using MICAz Nodes 1-5

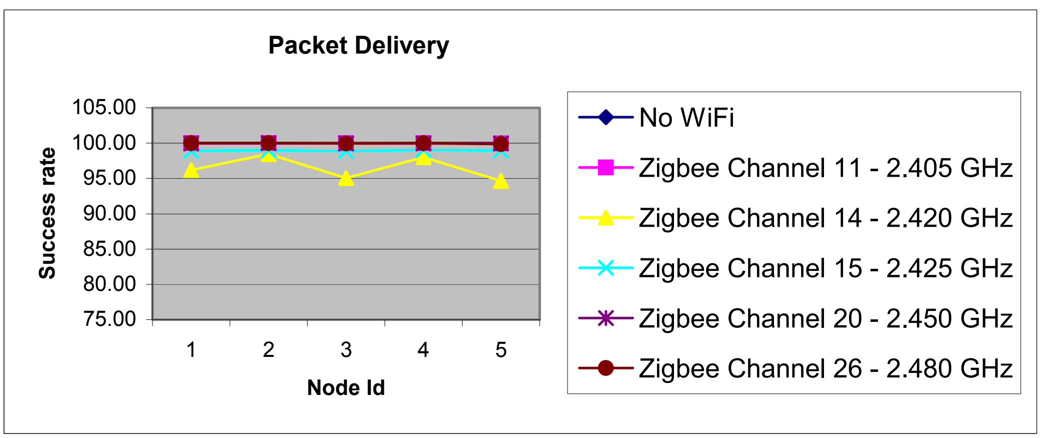

Figure 3: Normal (Low) Power WiFi Card and ZigBee radio using MICAz Nodes 1-5

WiFi at 2.422 GHz (Channel 3 802.11b band)
Hi Power SMC2532-W-B Card

Percent Packets Received

	Node 1	Node 2	Node 3	Node 4	Node 5
No WiFi	100.00	99.95	100.00	100.00	100.00
Zigbee Channel 11 - 2.405 GHz	100.00	100.00	100.00	99.55	100.00
Zigbee Channel 14 - 2.420 GHz	99.30	95.79	96.79	96.06	97.85
Zigbee Channel 15 - 2.425 GHz	98.31	98.75	99.51	98.55	98.30
Zigbee Channel 20 - 2.450 GHz	79.45	86.76	85.86	86.54	86.42
Zigbee Channel 26 - 2.480 GHz	100.00	100.00	100.00	99.96	100.00

Table 3: High-Power WiFi Card and ZigBee radio using MICAz Nodes 1-5

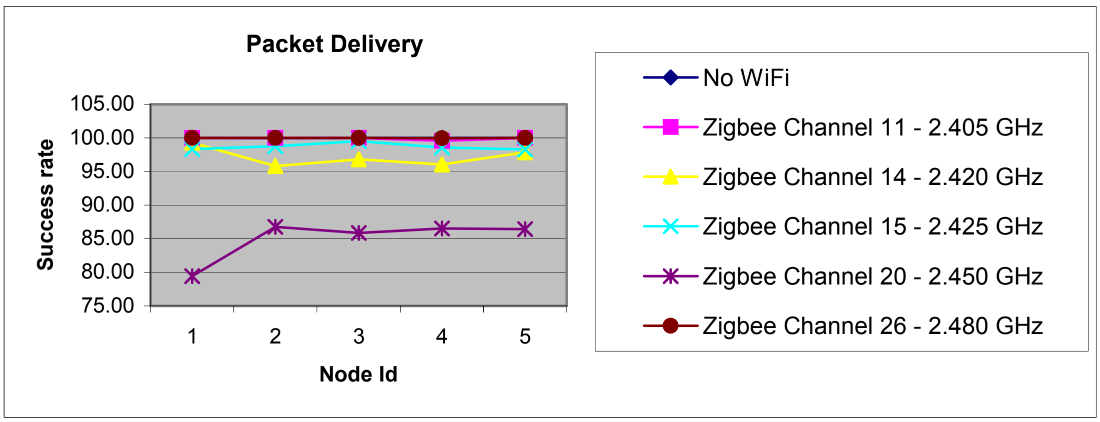

Figure 4: High-Power WiFi Card and ZigBee radio using MICAz Nodes 1-5

Conclusions:

The combination of rapid growth in both wireless sensing and control networks e.g., Crossbow's Smart Dust sensors, and the continuing adoption of WiFi-based computer networks means that developers and installers of these networks must take care to avoid interference and RF congestion. This application note has described why the issue occurs, and how to resolve it thru careful channel selection and assignment.

As Crossbow continues to focus on large-scale and long-term deployments of sensor networking technology, we welcome feedback and shared experiences in this area. Please contact techsupport@xbow.com with questions or comments.