NETWORKED CONTROLS
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Worry-Free Wireless Networks

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Are concerns about network interference blocking you from considering a wireless building automation solution? Testing reveals mitigation strategies that will help you deploy wireless devices worry-free.

Wireless-network technologies increasingly are becoming commonplace. Commercial and industrial application surely will increase as time goes on. Wireless technology-based building automation and control network devices are poised for an industry debut. Although wireless devices can offer tremendous upside potential, widespread application will occur only after most real or perceived technical risks are voided.

One such risk troubling building-automation-system (BAS) designers is the very real possibility of radio-frequency interference with other wireless devices and systems in a building.

An increasing number of BAS wireless devices utilize networks and devices based on the Institute of Electrical and Electronics Engineers' (IEEE's) 802.15.4 standard. The vast majority of wireless local area computer networks (also referred to as Wi-Fi), the numbers of which have exploded in recent years, conform to the IEEE 802.11b standard. Because both of these wireless networks occupy the unlicensed industrial, scientific, and medical 2.4-GHz band, interference among them can occur when they are in close proximity and/or when their deployment is ungoverned by a channel utilization plan.

CLEAR CHANNELS AVAILABLE

For interference-free deployment of both types of wireless networks, two primary and two secondary clear channels are available for 802.15.4 networks. As shown

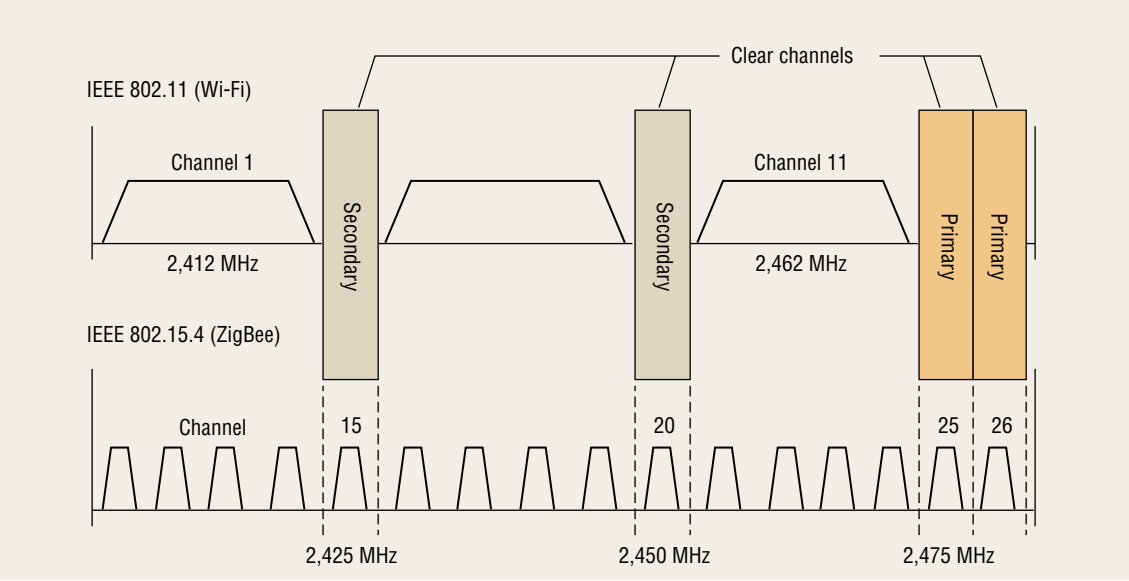

FIGURE 1. Primary and secondary clear channels available for 802.15.4 network use on the 802.11b spectrum.

Distance between 802.15.4 and 802.11b nodes						
	0.5 m	1 m	2 m	4 m	8 m	16 m
Channel 3	19.26	7.48	16.49	5.24	34.22	73.99
Channel 4	16.68	12.74	19.24	32.04	56.08	53.71
Channel 5	80.87	79.62	79.40	86.19	84.91	85.27
Channel 16	85.04	82.96	81.81	84.09	83.48	84.76

TABLE 1. The effect that distance between 802.15.4 and 802.11b nodes has on 802.15.4 delivery rates (shown as percentages).

in Figure 1, two clear 250-kbps channels (25 and 26) exist outside the 802.11b spectrum and should be used as the primary 802.15.4 channels. Also, when the information technology "best practice" of using non-overlapping Wi-Fi channels (1, 6, 11) is employed, two additional clear 250-kbps channels (15, 20) are available for use within the 802.11b spectrum.

UNDERSTANDING PROTOCOLS

The IEEE 802.15.4 and 802.11b protocols are based on the carrier-sense multiple-access/collision avoidance channel-access method. Using this method, each node listens for another node's carrier before transmitting a request-to-send message to assert itself as the transmitting node. All nodes of that protocol type within receiving distance refrain from transmitting for a random time period (as defined by the applicable IEEE standard), thus allowing the transmitting node to occupy the channel.

Because 802.11b request-to-send messages are protocol specific, they are not understood by 802.15.4 nodes and vice versa. This is why interference between the two networks can occur—usually, it is the 802.11b nodes that are the interferers. This is because 802.11b nodes transmit at much higher power levels than 802.15.4 nodes. Typically, 802.15.4 nodes transmit between 1 and 10 mw, while 802.11b nodes transmit at up to 1 w with an antenna of less than 6-dB gain and up to 4 w when using directional high-gain antennas.

In cases of extremely close node proximity, 802.15.4 nodes can cause interference with 802.11b nodes if they are on overlapping channels.

VERIFICATION TESTING

Data taken during testing to quantify how distance between nodes and channel selection affect the performance of 802.15.4 networks in the presence of 802.11b networks are shown in tables 1 and 2. Two series of tests were conducted.

The first test series measured packet delivery of 802.15.4 nodes in the presence of maximum 802.11b traffic on Channel 1 (Table 1). The second test series measured packet delivery of 802.15.4 nodes at various 802.11b data rates at a distance of 2 m (Table 2).

Testing showed that two factors affect the performance of 802.15.4 networks in the presence of Wi-Fi: proximity to the Wi-Fi nodes and traffic volume on the Wi-Fi network. Channels 25 and 26 are optimum performers because these channels are above the 802.11b channel used for testing.

When planning the installation of a wireless BAS, consideration must be given to the possibility of interference with other wireless devices and systems in the building. Because these devices share the radio-frequency spectrum, there is a possibility of interference between systems. This article describes the interference potential between 802.11b wireless local-area-network devices and 802.15.4-based building automation devices and suggests the appropriate strategy to avoid interference.

ABOUT THE AUTHOR

Terry Hubler, a principal engineer for wireless solutions at Siemens Building Technologies Inc., focuses on developing wireless devices used with building automation systems.

FURTHER READING

For more information on this subject, see the article titled "Packet Error Rate Analysis of IEEE 802.15.4 under IEEE 802.11b Interference" by Soo Young Shin, Hong Seong Park, Sunghyun Choi, and Wook Hyun Kwon at *http://mwnl.snu.ac.kr/~schoi/publication/Conferences/05-WWIC.pdf.*

Data rates (kilobytes per second)								
	120	180	240	300	360	420	480	600
Channel 3	86.89	69.56	45.58	37.24	25.91	27.01	16.06	25.16
Channel 4	88.17	84.58	78.22	30.25	43.38	36.21	34.24	27.69
Channel 5	*	84.11	*	77.71	*	83.69	79.13	81.61
Channel 16	*	84.62	*	69.25	*	83.79	84.06	81.44

TABLE 2. The effects that varying amounts of data on an 802.11b network have on 802.15.4 delivery rates (shown as percentages) at a distance of 2 m.