ZigBee Coexistence

By Naveen PS

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Coexistence with WiFi

IEEE 802.11 (WLAN) is widely used in homes, offices, and public places to provide highspeed Internet access. IEEE 802.11b/g networks operate in the 2.4 GHz ISM band and can be the source of the interference with IEEE 802.15.4 networks. An IEEE 802.11b/g node transmitter output power is typically between 12 to 18 dBm ,but IEEE 802.11b/g nodes may have output power as high as 30 dBm. This is significantly higher than the typical 0 dBm output power of a ZigBee wireless node. IEEE 802.11b signals have 22 MHz bandwidth after spreading using DSSS. The maximum data rate of an IEEE 802.11b node is 11Mbps. The IEEE 802.11 g standard supports a data rate of up to 54 Mbps using orthogonal frequency division multiplexing (OFDM), while the frequency bandwidth of the signal is still 22 MHz. IEEE 802.11 g has backward compatibility with IEEE 802.11b. A packet collision is defined as the event where one or more IEEE 802.11b signals corrupt an IEEE 802.15.4 packet transmission such that the retransmission of the IEEE 802.15.4 packet is required. The ZigBee nodes have lower output power, duty cycle, and signal frequency bandwidth compared to IEEE 802.11b/g systems; therefore, a ZigBee system is expected to have very little effect on the operation of an IEEE 802.11b/g system.

Coexistence with Bluetooth

Bluetooth systems operate in the 2.4 GHz ISM band and use the frequency hopping spread spectrum (FHSS) method instead of DSSS to spread their signals. Figure 8.3 shows the Bluetooth basic operation mechanism. The transmitted signal bandwidth is 1 MHz, but the frequency channel is changed using a pseudorandom sequence. The maximum number of hops in Bluetooth is 1600 hops per second in the connection state. There are 79 frequency channels in Bluetooth separated by 1 MHz.

Bluetooth typical output power can be as high as 20 dBm. Bluetooth versions 1.1 and 1.2 were ratified as IEEE 802.15.1. But future versions of Bluetooth will not be ratified as any IEEE standard. The Bluetooth version 2.0 and higher can provide data rates of up to 3 Mbps. The device type in Bluetooth can be either master or slave. A master device can communicate with up to seven devices. The slaves periodically synchronize their clocks with the master. FHSS, similarly to DSSS, provides processing gain, which improves the chance of successful packet delivery when interference is present. An IEEE 802.15.4 signal has 2 MHz bandwidth and may cause interference to three of the Bluetooth channels.

Therefore, if the nearby Bluetooth device is using all 79 channels for frequency hopping, the maximum chance of interference between a single ZigBee node and a Bluetooth node is 3 out of 79 hops, which is approximately 4%. However, a Bluetooth device can reduce the effect of presence of a ZigBee network (or any other network) by using adaptive frequency hopping (AFH). The AFH identifies the channels where interferences are present and marks these channels as “ bad channels. ” Then the sequence of hops is modified such that the frequency channels with high level interference are avoided. The bad channels in the frequency-hopping pattern are replaced with good channels via a lookup table. The Bluetooth master may periodically listen on a bad channel and if the interference has disappeared, the channel is marked as a good channel. Bluetooth slaves can also send a report regarding the channel quality to the master if necessary. The AFH method not only improves the performance of the Bluetooth network, it also reduces the effect of the Bluetooth network on other nearby networks that are not Bluetooth compliant. The Bluetooth devices might not notice the presence of the ZigBee network due to the low duty cycle and low power of typical ZigBee nodes. If the frequency channel used by the ZigBee network is not marked as a bad channel, the Bluetooth network can cause interference to the ZigBee network, depending on the distance between the Bluetooth and ZigBee nodes.

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