MULTI-RADIO FREQUENCY INTERFERENCE IN UNLICENSED BANDS

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Abstract— The increasing density and data rate of unlicensed band wireless devices has led to significant inter- and intra-radio interference problems Multiple competing standards such as the IEEE 802.11b/g, Bluetooth and ZigBee, all of which operate in the 2.4 GHz ISM band, can interfere with each other when used in typical indoor environments, potentially causing significant performance degradation. This thesis aims to characterize different types of heterogeneous interference in the 2.4 GHz unlicensed band and develop techniques to diagnose interference related problems. We have discussed in this report the different type of topology and spectrum band used in unlaced radio frequency. We have described the planning method of 2.4 GB wifi network to avoidance of the interference and collision of the traffic. We have used the latest toll of insider to scan the different radio frequency coming from the other device and strength of the signal of the device. We have created the various set up channel interference and measured the through put by the Netper sec software. Validation experiments show that broad auto-classification of multi-radio interference in terms of congestion, slow links, inter AP interference and Bluetooth interference.

***Key words*: Zigbee, Cordless Phones, Radio Frequency**

I. OVERVIEW OF 2.4GHZ UNLICENSED RADIO FREQUENCY

The main performance challenge for wireless devices is interference from other radio communication devices. Cypress's Wireless USB 2.4-GHz radio system on a chip solution shares the 2.4-GHz unlicensed industrial, scientific, and medical (ISM) band with several other technologies. These technologies include 802.11b/g, Bluetooth, 2.4-GHz cordless phones, microwave ovens, and other proprietary 2.4-GHz devices. The Wireless USB must coexist with these technologies, tolerating these interferences without causing them excessive degradation. This application note discusses how Wireless USB LP/LPstar achieves these goals through interference avoidance. There are specific examples of the WirelessUSB LP/LPstar keyboard mouse reference design interaction with Wi-Fi, Bluetooth, cordless phones, and microwave oven. WirelessUSB LP/LPstar adds to the existing WirelessUSB portfolio, a low-cost wireless solution that uses the unlicensed 2.4-GHz ISM band.

The 2.4-GHz ISM band is attractive to many technologies because it is available worldwide for low-power wireless communications. This application note assumes that the reader is familiar with WirelessUSB devices' operation. How can designers get the best performance out of their 2.4- GHz solution under these hostile conditions? Often, the product works in a controlled lab environment but suffers performance degradation because of interferences from other 2.4-GHz solutions in the field. You cannot do more than what the architects of the Wi-Fi, Bluetooth, and ZigBee standards provide. But when the designer controls the protocol, there are procedures that help minimize the interference from other sources. This application note examines the various interference management techniques provided by 2.4-GHz wireless systems and describes how low level tools are used to create frequency stability in a 2.4-GHz design.

II. WI-FI (802.11B)

The two methods for radio frequency modulation in the unlicensed 2.4-GHz ISM band are frequency hopping spread spectrum (FHSS) and direct sequence spread spectrum (DSSS). Bluetooth uses FHSS while WirelessUSB, 802.11b/g/a (commonly known as Wi-Fi), and 802.15.4 (known as ZigBee when combined with the upper networking layers) use DSSS. All of these technologies operate in the ISM frequency band (2.400–2.483 GHz) available worldwide.

III. BLUETOOTH

Bluetooth is used for ad hoc interoperability between cell phones, headsets, and PDAs. Most Bluetooth devices require regular recharging. Bluetooth uses FHSS and splits the 2.4-GHz ISM band into 79 1-MHz channels. Bluetooth devices hop among these 79 channels 1600 times per second in a pseudo-random pattern. Connected Bluetooth devices are grouped into networks called piconets, each piconet contains one master and up to seven active slaves. The channel hopping sequence of each piconet derives from the piconet master clock. All slave devices must remain synchronized with this clock. Forward error correction (FEC) is used on all packet headers, by transmitting each bit in the header three times. A hamming code is also used to forward error correction of the data payload of some packet types. The hamming code adds an overhead of 50% on each data packet, but corrects all single errors and detects all double errors in each 15-bit code word (each 15-bit code word contains 10 bits of information).

IV. WIRELESSUSB

WirelessUSB is primarily designed as a wireless option for computer input devices such as mouse and keyboards. It is also targeting the wireless sensor networks. WirelessUSB devices operate for months on alkaline batteries and require regular recharging. WirelessUSB uses the DSSS frequency modulation instead of FHSS. Each WirelessUSB channel is 1 MHz wide, allowing WirelessUSB to split the 2.4-GHz ISM band into 79 1-MHz channels, similar to the Bluetooth. Unlike Bluetooth, WirelessUSB devices are frequency agile, that is, they use a fixed channel, but dynamically change channels if the link quality of the channel becomes suboptimal. WirelessUSB uses pseudo-noise (PN) codes to encode each information bit. Most WirelessUSB systems use two 32 chip PN codes, allowing two information bits encoding in each 32 chip symbol. This scheme can correct up to three chip errors per symbol and can detect up to 10 chip errors per symbol. Although the use of 32 chip (and sometimes 64 chip) PN codes limits the data rate of WirelessUSB to 62.5 kbits(for LP only), data integrity is much higher than Bluetooth, especially in noisy environments.

V. ZIGBEE

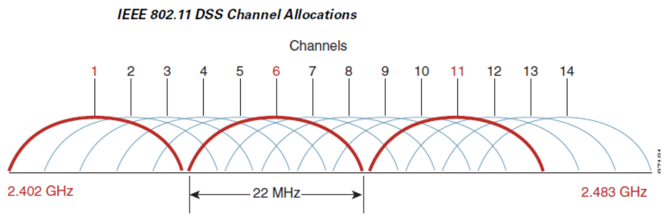
ZigBee is designed as a standardized solution for sensor and control networks. Most ZigBee devices are extremely powersensitive (thermostats, security sensors, and so on) and their battery life is measured in years. ZigBee uses DSSS frequency modulation in the 868 MHz band in Europe, 915 MHz band in North America, and the 2.4-GHz ISM band for the rest of the world. In the 2.4-GHz ISM band, sixteen channels are defined, each channel occupies 3 MHz and channels are centered 5 MHz from each other, with a 2-MHz gap between pairs of channels. ZigBee uses an 11-chip PN code, with four information bits encoded into each symbol giving it a maximum data rate of 128 Kbps. The physical and MAC layers are defined by the IEEE 802.15.4 Working Group and share many of the same design characteristics as the IEEE 802.11b standard.

VI. 2.4-GHZ CORDLESS PHONES

2.4-GHz cordless phones are popular in North America. Most of these phones use DSSS while some of them use FHSS. They do not use a standard networking technology. The phones using DSSS and other fixed channel algorithms typically have a channel button on the phone, allowing users to manually change the channel. FHSS phones do not have a channel button because they constantly change channels. Most 2.4-GHz cordless phones use a channel width of 5 to 10 MHz.

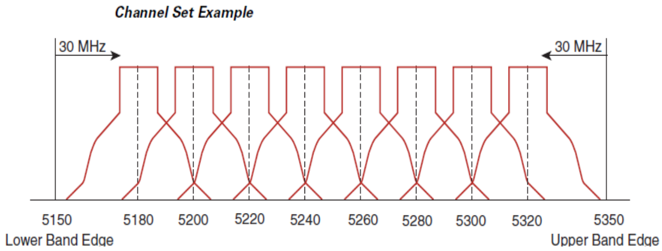
VII. IEEE 802.11B DIRECT SEQUENCE CHANNELS

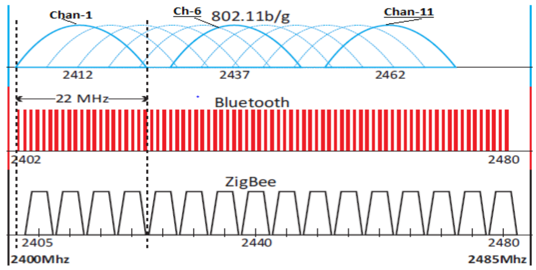
14 channels are defined in the IEEE 802.11b direct sequence (DS) channel set. Each DS channel transmitted is 22 MHz wide, but the channel separation is only 5 MHz. This leads to channel overlap such that signals from neighboring channels can interfere with each other. In a 14-channel DS system (11 usable channels in the US), only three nonoverlapping (and thus, non-interfering) channels 25 MHz apart are possible (channels 1, 6, and 11). This channel spacing governs the use and allocation of channels in a multi-AP environment, such as an office or campus. APs are usually deployed in a cellular fashion within an enterprise, where adjacent APs are allocated nonoverlapping channels. Alternatively, APs can be co-located using channels 1, 6, and 11 to deliver 33 Mbps bandwidth to a single area (but only 11 Mbps to a single client), if 802.11g was used in the same manner the aggregate bandwidth would be 162Mbps with a maximum data rate of 54Mbps).



VIII. IEEE 802.11A CHANNELS

The 802.11a channel shows the center frequency of the channels. The frequency of the channel is 10 MHz on either side of the dotted line. There is 5 MHz of separation between channels, as shown inFor the US-based 802.11a standard, the 5 GHz unlicensed band covers 300 MHz of spectrum and supports 12 channels. As a result, the 5 GHz band is actually a conglomerate of three bands in the USA: 5.150-to-5.250 GHz (UNII 1), 5.250-to-5.350 GHz (UNII 2), and 5.725-to-5.875 GHz (UNII 3).



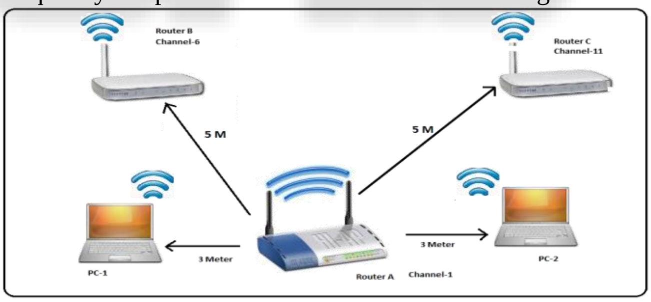


802.11, Bluetooth and ZigBee Channels in the 2.4 GHz ISM Band

A. The test environment of Interference of radio frequency:

1) Test Sceniorio: Three AP Router connected 5 meter distance & PC1 test O/P

We have established test in the multiple unlicensed band frequency in open real environment as shown in figure.

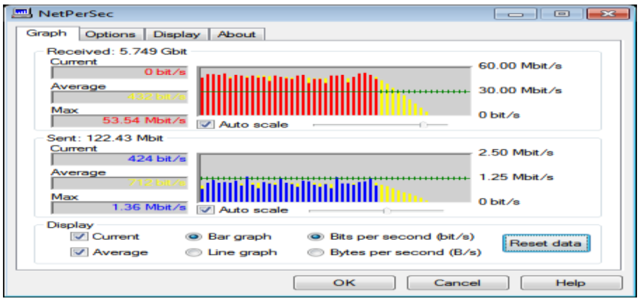


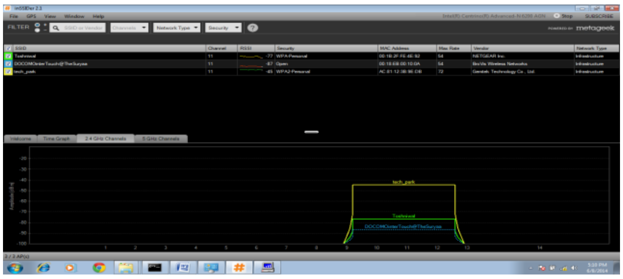
Scinerio:- We have assign the channel-1 router A and channel-6 of router B and channel-11 router and connect the PC1 step by step each router. We observed no through put impact in the data rate transfer.

When we have configured the all router on same channel (like channel 1,6,11) then observed the low data transfer rate due to interference of the similar channel.

When we have switched off the entire router and connected PC1 to PC2 and transfer the file, we get the maximum data transfer rate.

We have connected PC-1 to PC-2 in sharing the file transfer mode and we have transferred 345 MB the file from PC-2 to PC1 and found the through put maximum speed 53.54 Mb.

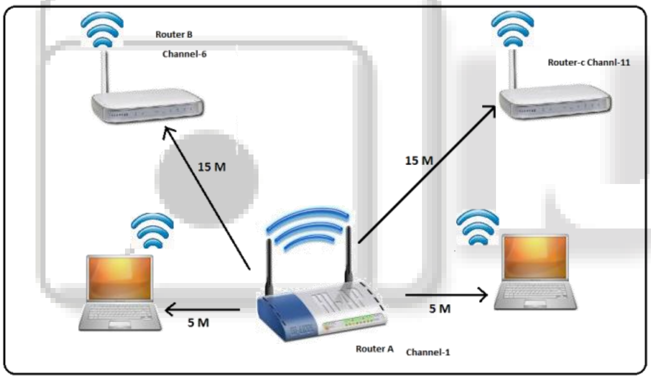




Similarly different test scenario has created to configure the co channel of router and PC's.

We have observed the variation of the data transferred rate due to unlicensed band frequency interference.

B. Test Scenioria: Three AP Router connected 15 meter distance & PC1 test O/P.



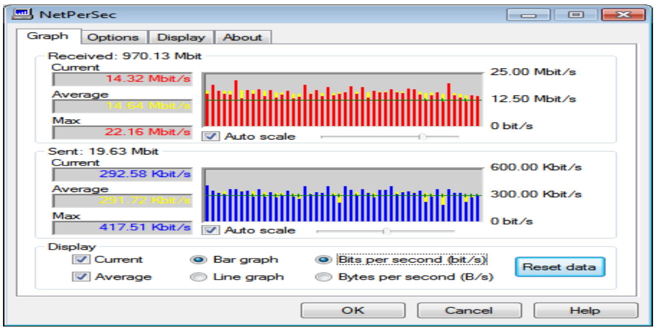
When we have increased the distance from 5 meter to 15 meter of each wireless router and increased the distance between PC1 and PC2 to 3 meter to 5 meter.

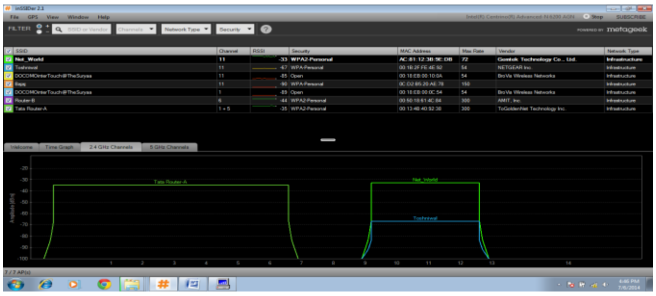
Scenario**:-** We have assign the channel-1 router A and channel-6 of router B and channel-11 router and connect the PC1 step by step each router. We observed little bit improvement in data rate transfer file.

When we have configured the all router on same channel (like channel 1,6,11) then observed the low data transfer rate due to interference of the similar channel as scenario 1.

When we have switched off the entire router and connected PC1 to PC2 and transfer the file, we get the maximum data transfer rate.

We have connected PC-1 to PC-2 in sharing the file transfer mode and we have transferred 20 GB the file from PC-2 to PC1 and found the through put maximum speed 22.16 Mb.





IX. CONCLUSIONS AND ANALYSIS

The analysis of presented results leads to the conclusion that All standard 2.4-GHz networking technologies have made design tradeoffs to mitigate the effects of or avoid interference. Designers can create systems that are frequency agile either by using the procedures provided by the standard being implemented or by building their own protocol using the methods mentioned here in conjunction with radio features such as RSSI when available. While it is not possible to completely eliminate interference from outside 2.4-GHz systems, designers can create systems that are frequency agile thereby giving their product the best chance to survive in today's competitive 2.4-GHz ISM band environment. However it is possible to point out particular pairs of partially overlapped channels with relatively low interference as well as pairs of frequencies that should be avoid for devices working in the same area due to the extremely high level of interference.

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