IEEE 802.15.2

Wireless Communications
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ABSTRACT

This report discusses details about the IEEE 802.15.2 standard including its purpose and various specifications. The report begins with a brief background and introduction of the standard, followed by its impact in the world of wireless communications. It gives a relevant description of the interference problems that arise when multiple technologies operate in the same area while elaborating on the adverse effect of such interference on wireless systems. It highlights the need for this standard and describes the categories of solutions suggested by IEEE 802.15.2 Task group to deal with prevalent technical issues. The report also explains, with suitable examples, how the variety of mechanisms and techniques recommended by 802.15.2 can provide ways to potentially benefit collocated wireless systems by eliminating or minimizing practical problems faced during communication so that the performance of such systems can be significantly improved.

BACKGROUND

Many Groups have emerged of the IEEE 802 standards dealing with a single type of networking standard including the IEEE 802.15 working group who develop and suggest standards and practices for PAN's (personal area networks). When the IEEE 802.15.1 started their work, the concern of 802.15.1 and 802.11b working groups began because of their apprehension with regards to the capability of the networks to coexist while functioning closely. Therefore, it was decided that a new Task Group namely, 802.15.2 shall be created whose job would be to recommend practices that can help in expanding the ability of the multiple wireless networks to co-exist. Its specifications provide suggestions and recommendations instead of solid requirements or necessities for supporting the interoperability of wireless networks. These recommendations can be adopted to enhance products, as these are considered better practices.

INTRODUCTION TO IEEE 802.15.2

Nowadays the simultaneous development of devices, for instance of IEEE-802.1 standard along with various other wireless devices and equipment, which essentially operate in the same unlicensed frequency bands are becoming common However, one big problem in such scenarios is that, when multiple wireless devices are operating together within the same area, they might interfere with each other because they all will use the same ISM band. For example, Zigbee and Bluetooth or a Wireless Local Area Network (WLAN) and Wireless Personal Area Network (WPAN) operating in the same area, using the same ISM band, might interfere with each other.

This mutual interference between the systems can lead to severe performance degradations, which can discourage consumers from using more wireless devices. Some devices that transmit with higher power transmission capability or ones having interference-resistant mechanisms or protocols are still able to transmit their data properly but others that do not have such advantages often suffer at the hands of such interferences.

How this interference can be dealt with, such that these multiple technologies can be used simultaneously without any performance issues, is precisely what comes under the purview of IEEE-802.15.2 standard. In other words, the core purpose of the IEEE 802.15.2 standard is to help in the coexistence of various technologies or wireless systems that operate in the same unlicensed bands of frequency. Due to these reasons, IEEE 802.15.2 is considered a "coexistence" scheme/protocol. Coexistence can be accurately defined as the ability of a system to operate in a shared environment. Such environments require good coexistence policies which do not increase interference to other systems using the same wireless channel. For instance, IEEE 802.15.2 specifies many methods for the coexistence of systems such as ones containing a slow-hopping or static-frequency WLAN with a WPAN. Some of these proposed coexistence methods can also be exploited along with various diverse WLAN and WPAN standards/protocols for better results. Amongst the major targeted users of IEEE 802.15.2 standard are the developers of wireless local area networks (IEEE 802.11 WLAN) and also the customers of the upcoming wireless products or systems which are being designed to work in unlicensed bands of frequency.

INTERFERENCE PROBLEMS

Interference occurs when there is the interaction between two wireless systems that might result in severe deterioration of communication performance. For instance, standards like both IEEE 802.11b and IEEE 802.15.1 define operation in the same 2.4-GHz unlicensed band of the frequency band, which often leads to performance degradation. Many factors affect the extent of interference amongst systems including but not limited to the distance between the two systems' equipment, the power levels of various devices deployed, the quantity of data traffic generation of each wireless network in consideration, and their respective data rates. Moreover, the different kinds of information or data being sent over such networks have wide-ranging levels of sensitivity to the level of interference observed. One such example is that a voice link is often more sensitive to radio interference than to the actual data link that is being used to transmit the file. The task group working for this standard has specified mechanisms and coexistence solutions to recognize as well as handle many such likely interference issues.

Example Elucidating Interference

When operated at the same time within the same frequency band, Bluetooth and IEEE 802.11b will collide and interfere with each other by creating an in-band coloured noise for one another, specifically because these systems transmit on overlapping frequencies. This effect is especially significant in certain scenarios like when one of the two signals is close to or within at least 22-MHz wide passband of the other system's receiver. For instance, when a Bluetooth receiver senses the 802.11b signal at the same time instant when it is receiving a Bluetooth signal, interference can be observed, which is most amplified when the 802.11b signal is within proximity

of Bluetooth receiver passband. Such interference needs an explicit mechanism to combat as Bluetooth and Wi-Fi were not designed with any specific schemes to prevent these kinds of interferences, except for a very limited interference immunity due to the inherent nature of spread spectrum technology itself. This points to the importance of the recommendations and specifications of IEEE 802.15.2 and even functioning of these interacting systems.

IEEE 802.15.2 SPECIFICATIONS

To minimize the aforementioned problems of interference, IEEE 802.15.2 defines several mechanisms that can be deployed to provide conditions amenable to the coexistence of present and well as emerging wireless systems such as the collocated system of Wireless PAN and Wireless LAN. These mechanisms are categorized into two major classes:

1. Collaborative Coexistence mechanism

These can be used when there is information exchange between the WLAN and WPAN network which require a communication link between them. The best-case scenario for such methods is preferably when both network types or devices are embedded or placed into the same pieces of device equipment or in other words, implemented on the same device using the same transmitter. For example, the case when the card of IEEE 802.11b and module of IEEE 802.15.1 are embedded in the same computer. Another example could be that higher priority is given to Bluetooth while voice transmission whereas WLAN is preferred during data transmission. These methods are usually based on a MAC time-domain solution that substitutes the transmission of Bluetooth and WLAN packets. The 802.15.2 standard describes the following collaborative solutions (used when the transmitters are collocated):

- **AWMA or Alternating Wireless Medium Access** is an approach that makes part technologies, obtained by splitting the beacon interval, use TDMA for minimizing or avoiding interference. It is a MAC Layer Solution.
- **Deterministic Interference Suppression** is the mechanism used as a solution for the physical and electrical characteristics of a network. A simple example could be the use of a “Notch” filter (programmable) in the receiver of IEEE 802.11b which helps in eliminating the narrowband interference of 802.15.1.
- **Packet Traffic Arbitration** is a Media Access Control Layer solution involving synchronized packet transmission scheduling between two networks. In this scheme, different PTA blocks are responsible for authorizing the transmissions from the different interfaces. This PTA block coordinates medium sharing in accordance with traffic load and priority.
- **Frequency skipping scheme** is a mechanism that can be employed to handle interference by decreasing the probability of getting the same channel at the same instant of time. In this approach, the radios coexisting in an environment operate by avoiding common frequencies in the network, so they can minimize interference.

2. Non-Collaborative Coexistence mechanism

As obvious from the name, unlike collaboration mechanisms, the non-collaborative schemes do not communicate with each other and therefore do not require any communication links between the wireless systems and must employ mechanisms or unique ways of sensing other networks' interference (if any). They utilize varying techniques for sensing or detecting the presence of other devices in the band involving methods like measuring the bit or frame error rate, the ratio of signal and interference ratio and many others for scheduling of packets and controlling traffic. Some non-collaborative solutions recommended by the standard are-

- **Adaptive Interference Suppression**: Based on the PHY Layer alone, this approach effectively utilizes adaptive filtering at the receiver (E.g., WLAN) to remove narrowband interference.
- **Adaptive Frequency−hopping**: Frequency hopping devices can maintain a bit error rate measurement per frequency used, allowing them to find which of the frequencies have been adopted by other networks so that they can immediately alter their own hopping pattern to prevent any overlap. This technique of detecting interfering channels makes it possible to adapt to a new safe hop sequence that can help them in evading such channels with interference. The key concept of this scheme is to adjust the transmission as per the current conditions of the channel for efficient adaptation.
- **Overlap Avoidance:** This is another MAC Layer solution in which different Bluetooth packet lengths are used to avoid frequency overlap between Bluetooth and 802.11. Bluetooth schedulers can intelligently avoid or skip conflicting frequencies by using packets lengths of proper duration.
- **Adaptive Packet Selection and Scheduling**: This scheme is for the MAC and involves the adaptive selection of packet properties like payload length, ARQ, FEC codes, and traffic scheduling and more in low-interference regions. Since the MAC layer implementation is provider-specific, the prevailing systems can easily adapt to this solution, thereby, not requiring any modification like that of Bluetooth Chipset. The 802.15.1 systems that create different packet types by changing configurations like packet length or error protection degree. Better data throughput and network performance can be obtained if the system can choose the most optimum packet type depending on channel conditions of the forthcoming frequency hop. The cautious scheduling of packet transmission so that IEEE 802.15.1 devices can send during outer WLAN-frequency hops and abstain from in-band transmitting, can serve to minimize WLAN system interference while at the same time helping in increasing the throughput.

Most of the non-collaborative coexistence methods require channel information using which devices like Bluetooth can easily differentiate between the channels that are bad and the ones are supposedly good. The reason for the effectiveness of the above-mentioned schemes is because they can accurately and timely analyze current channel conditions. Furthermore, channel estimation can be performed in different ways like using received signal strength indication, header error check, decoding profile, bit error rate, PER profile or a smart amalgamation of many such techniques.

Comparison of Collaborative and Non-Collaborative mechanisms

The strategy of decreasing the potential for interference by orthogonalizing channel access undertaken by collaborative schemes work significantly well in comparison to the non−collaborative ones. At the same time, collaborative mechanisms often require a relatively tight combination of the respective coexisting wireless technologies and might also involve greater frequency of handshake signals.

CONCLUSION

As elucidated above, 802.15.2 standard suggests many mechanisms for the efficient coexistence of wireless communication systems, especially in systems which include 802.11b and Bluetooth, coexistence and simultaneous operation is very desirable as rapid growth is expected for both these technologies over the coming years. Similarly, many critical usage models require collocation and simultaneous operation of different standards in the same device. Approaches at the system-level that address such coexistence by using PHY and MAC techniques have the potential to at least considerably reduce if not eliminate the interference between the systems. Such robust wireless system design technology is becoming increasingly important in unlicensed bands like Bluetooth, Wi-Fi, and even in unlicensed wireless technologies. Proposals given by IEEE 802.15.2 will therefore provide effective schemes and solutions to address the issues of coexistence highlighted in this report. Such solutions with further research and analysis can be deployed in the industry to meet the ever-increasing needs for the efficient operation of devices like Wi-Fi and Bluetooth, especially when operated in the same areas or in proximity to each other. Instead of clearly defining the implementation, IEEE 802.15.2 suggests that the classification can be based on RSSI, PER, carrier sensing, etc. Currently, the Coexistence Method Development task group is in hibernation under further notice. But several sellers are developing hardware and software coexistence solutions based on this standard as it is a promising precedent for further development and research.