Coexistence of ZigBee and Wifi Using White Space aware HMM Protocol

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Abstract: ***In this information, there are two trends that have reflective impact on our lives: (i) we depend more and more on information technologies, (ii) and our mobility is getting higher and higher. The demand on wireless handheld devices just keeps on increasing. One particular type is gaining wide-spread acceptance—short range wireless technology, due to its low cost. They are WLAN and WPAN. Nowadays, wireless technologies have been incorporated into various communication and networking applications embedded in many military, industrial and civilian products. WPANs focus on the space around a person or object that typically extends up to 10 meter in all directions. The aims of WPANs are low-cost, low power, short range and very small size. The IEEE 802.15 working group was formed to create WPAN standards, which has currently defined three classes of WPANs that are differentiated by data rate, battery drain and quality of service (QoS) capabilities [1]: 1) High data rate WPANs (IEEE 802.15.3) that require very high speed and strong QoS support, and are normally used for multimedia applications; 2) Medium data rate WPANs (IEEE 802.15.1/Bluetooth) that handle a number of various tasks such as cell phones and PDA communications (among themselves or with peripherals, e.g. earphones, printers) and provide QoS suitable for voice communications; 3) Low data rate WPAN (IEEE 802.15.4/LRWPAN) that are intended for a set of industrial, residential and medical applications with requirements of very low power consumption and cost and relaxed needs for data rate and QoS. Wireless Sensor Networks discussed in this paper belong to the third class of WPAN. This paper aims at solving the problem occurring due to the coexistence of Zigbee and Wi-Fi in the same environment. The high power Wi-Fi signals end to override the Zigbee signals and thus deterioting the Zigbee data. This problem has been addressed using white space available in the Wi-Fi spectrum and accommodating the small Zigbee packets in this white space using the hidden Markova model system.***

Keywords: Wi-Fi, Zigbee, coexistence, HMM, white space, cognitive radio

1. Introduction

The low-power, low-rate ZigBee/IEEE 802.15.4 WSN is operating at the 2.4GHz ISM band. However, the 2.4 GHz band is heavily used by several other unlicensed products, most prominent of which are IEEE 802.11b/g/n WLANs. Fig. 1.2 shows the overlapping RF spectrums of ZigBee/IEEE 802.15.4 WSN and IEEE 802.11b/g Wi-Fi. There are already confirmed interference problems between collocated devices of different nature [7]. Therefore, it is important to understand and quantify how the relevant location of interfering devices impacts performance.

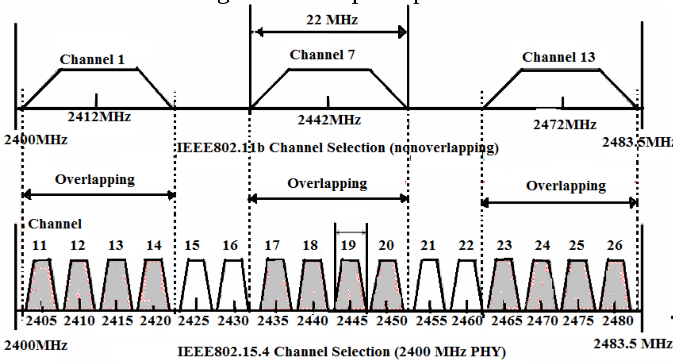

Figure 1: Spectrum allocation for Zigbee and Wi-Fi

After going through the available literature, we became aware of the significant Weaknesses of existing technologies which are designed for alleviating the performance damage on ZigBee system caused by the transmissions of collocated IEEE 802.11 compatible WLAN devices. It is thus of paramount importance to develop cost effective technology that eliminates this threat. We implemented our novel algorithms and developed frame protocols, and Wi-Fi IEEE 802.11g communicating nodes to generate Wi-Fi interference. We can extensive experiments which not only enabled us to assess the performance improvements our proposed technology achieves under interference generated by different Wi-Fi traffic scenarios, but to uncover several specific hardware-protocol interoperability mechanisms which can impact the performance of Zigbee motes under certain operational conditions. This new information led us to the discovery of new, more powerful techniques. That is based on the using of white space frame in the Wi-Fi channel by the use of hidden Markov model and which generate minimal additional cost and can be viewed as an upgrade to existing Zigbee frame to be placed in that white space.Theoretical analysis often makes use of simplified mathematical models and assumptions to reduce complexity and allow analytical tractability. Performance evaluations conducted only through computer simulation have the risk of leaving the impact of hidden factors on the performance unidentifiable. The benefit of this approach can be understood when considering the impact that the mechanisms mentioned above have on the performance. We propose a novel approach that ensures high performance of Zigbee in spite of the presence of strong interference from Wi-Fi, and at the same time keep the Wi-Fi performance almost unaffected.

2. Research Objectives

1) We learn an HMM (Hidden Markov Model) based on the data traces of the network; with such an HMM model we can accurately characterize the dynamic distribution of the durations of white spaces in different times.

2) Based on the HMM model of the white space and the performance estimation we develop a novel Zigbee frame control protocol called HMM-driven Smart White Space-aware Frame Control Protocol which can obtain the optimal trade-offs between link throughput and packet delivery (data traces).

WI-FI

Wi-Fi [3] stands for "wireless fidelity" but since most of our WLANs area unit supported those standards, the term Wi-Fi is employed usually as a word for LAN. Wi-Fi may be a standard technology that permits any device to exchange and transfer information wirelessly over the network giving rise to high speed net connections. Any device that is Wi-Fi enabled (like personal computers, game consoles, Smartphone, tablet etc.) will connect with a network resource just like the net through a wireless network access purpose. Currently such access points additionally referred to as hotspots have a coverage space of regarding twenty meters inside and even a larger space vary outdoors, this is often achieved by victimization multiple overlapping access points (Chan,2005),(Intel house,2003). However with all such options, Wi-Fi additionally suffers from bound shortcomings. Wi-Fi is understood to be less secure than wired affiliations (such as Ethernet) as a result of associate trespasser doesn't want a physical connection. Sites that use SSL area unit secure however unencrypted net access will simply be detected by intruders. As a result of this, Wi-Fi has adopted numerous cryptography technologies. The first cryptography WEP, proved straightforward to interrupt. Higher quality protocols (WPA, WPA2) were supplemental in a while. Associate elective feature supplemental in 2007, known as Wi-Fi Protected Setup (WPS) was deployed; however it additionally had a significant flaw that allowed associate assailant to recover the router's positive identification. The Wi-Fi Alliance has since updated its check set up and certification program to make sure all recently certified devices resist attacks. However security remains a significant concern. There are three 802.11 wireless family customary wide used nowadays.

Overview of IEEE 802.15.4 and ZIGBEE Standard

IEEE 802.15.4 is a protocol designed for LR-WPAN defining the specification of PHY and MAC layers, while ZigBee is a protocol providing NET and APP layer specification and based right on top of the IEEE 802.15.4 specified layers. The IEEE 802.15.4 standard provides the specifications for the two fundamental lower network layers (PHY and MAC layers) for WPANs which focus on low-cost, low-speed ubiquitous communications between devices. The emphasis of this standard is on very low cost communications of nearby simple devices with little infrastructure, limited resource and low energy consumption. The PHY layer provides the physical data transmission service and the interfaces to its management entity. Through these interfaces, the PHY layer can access various layer management functions and stores the essential information. Features of the PHY are energy detection, channel selection and transmission of PHY packets across predefined physical medium. It operates on one of three possible unlicensed frequency bands [11].

- 868.0-868.6 MHz: 1 channel in this band and used in Europe.
- 902-928 MHz: 10 channels in this band and mainly used in North America.
- 2400-2483.5 MHz: 16 channels in this band and used worldwide.

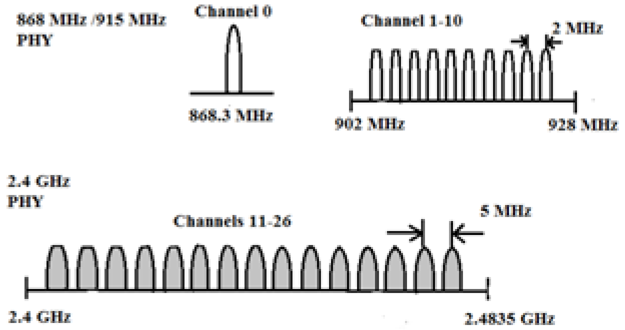

Figure 2: IEEE 802.15.4 Operating Frequency Bands

The standard offers two physical options both based on direct sequence spread spectrum (DSSS) techniques: one working in the 868/915 MHz bands with transferring rates of 20 and 40 Kbit/s, and the other in the 2.4GHz band with a rate of 250 Kbit/s.

Every PHY layer packet, or PHY protocol data unit (PPDU), is constructed with a preamble, a start of packet delimiter, a packet length indicator, and a payload field, or PHY service data unit (PSDU). The IEEE 802.15.4 payload length can expand from 2 to 127 bytes [12].

The IEEE 802.15.4 standard allows the use of a super frame beacon structure, called beacon enable mode, for providing dedicated bandwidth to certain applications in order to minimize the latency and to meet the communication requirements. In beacon-enabled mode, a coordinator broadcasts beacons periodically to synchronize the attached devices for communication. Interference occurring among these devices is prevented. On the contrary, the non-beacon mode uses a simple and traditional channel access mechanism. Under certain circumstances, peer-to-peer network for instance, all the clients remain unknown to each other and can initiate a conversation at will, thus a random and contention based channel access algorithm, i.e. non-beacon mode, is the appropriate choice here. In the non-beacon mode, devices can stay in sleep mode most of the time [13].

WHITE SPACE

White space refers to the unused broadcasting frequencies within the wireless spectrum. TV networks leave gaps between channels for buffering functions, and this house within the wireless spectrum is analogous to what is used for 4G and then it are often accustomed deliver widespread broad-band net. The Federal Communications Commission (FCC) recently united to gauge the legal operation of unaccr-edited devices in "white spaces", i.e., parts of the commissioned TV bands that don't seem to be in active use by incumbent users, like the TV broadcasters[4], [5]. Sub-GHz spectrum has several properties appropriate for electronic communication. Systems should have a sturdy theme for determining the white-spaces, and second, these systems should have a spectrum-aware protocol that utilizes white-spaces of varied bandwidths. The arrival of Wi-Fi frames is very burst and clustered. We tend to observe that frames square measure clustered at the side of short intervals typically but one ms, whereas the idle periods between clusters square measure considerably longer. The short frame intervals square measure attributed to the layer competition mechanism of 802.11, within which senders go into reverse for a brief random time before every transmission. We tend to outline the interval between frame clusters as inter-cluster space whiles the interval between the frames among identical cluster as intra-cluster space. Moreover, white space hereafter refers to inter-cluster space unless otherwise indicated.

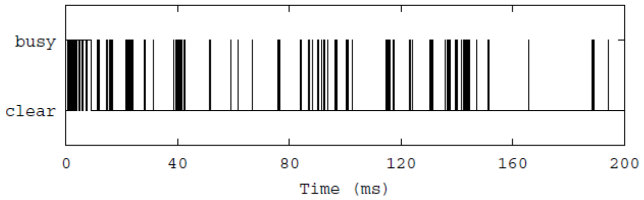

Figure 2: White space shown in between data packets in wi-fi

HMM (Hidden Markov Model)

We will 1st study the Vilfredo Pareto Model of LAN white area projected in [6], and so we'll propose our advanced HMM model of WiMax white space. Earlier projected Vilfredo Pareto Model of Wi-Fi white area supported the actual fact that the arrival method of Wi-Fi frame clusters has the feature of self-similarity and consistent with [6], the self-similarity could be a feature of beginning method with heavy-tailed inter-arrival time. Projected model says that each one white space at intervals window follows Vilfredo Pareto distribution: Hear α and β area unit the size and form of Vilfredo Pareto model and x is the time of the white space. They set α to one time unit. In Vilfredo Pareto model, β is about by λ / (λ-α), wherever λ is that the average inter-onset time of frame cluster. Fig. three shows Associate in nursing example of HMM. In an HMM, there are a unit collection of states say , every state has Associate in Nursing initial state probability that determines that state would be a lot of possible to be the primary state. And every state contains a probabilistic distribution of its observation vectors. We tend to adopt to explain the parameters of the states distributions. The transition chance matrix M wherever Mij = Pr(S(t+1)=Sj | S(t)=Si) determines however a state may transit to a different state. We are going to 1st study the Vilfredo Pareto Model of LAN white space proposed in [6], and so we'll propose our advanced HMM model of Wi-Fi white space. Earlier projected Vilfredo Pareto Model of Wi-Fi white area supported the actual fact that the arrival method of Wi-Fi frame clusters has the feature of self-similarity and according to [6], the self-similarity could be a feature of beginning method with heavy-tailed inter-arrival time. Projected model says that each one white area at intervals window follows Vilfredo Pareto distribution i.e. Hear α and β area unit the size and form of Vilfredo Pareto model and x is that the time of the white area. They set α to one time unit.

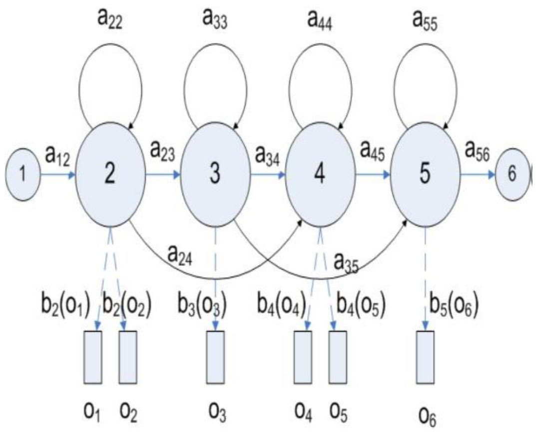

Figure 3: An example of HMM

In Pareto model, β is about by λ / (λ-α), wherever λ is that the average inter-onset time of frame cluster. Fig.3 shows Associate in nursing example of HMM. In an HMM, there area unit a collection of states say , every state has Associate in Nursing initial state probability that determines that state would be a lot of possible to be the primary state. And every state contains a probabilistic distribution of its observation vectors. We tend to adopt to explain the parameters of the states distributions. The transition chance matrix M wherever Mij = Pr(S(t+1)=Sj | S(t)=Si) determines however a state may transit to a different state. The states area unit hidden, rather we are able to infer them from the observations by HMM illation algorithmic program. Let the durations of the white areas (Δt1, Δt2, Δt3,...ΔtN) is the observation sequence (O1,O2,O3,...ON) .Using the Vilfredo Pareto model because the observation distribution for every state. With pre-obtained information traces of the traffic within the current network, we are able to learn all the parameters of this HMM model.

3. Simulation Result

We have chosen communication toolbox of MATLAB, to do the project simulation. Simulation has been done on MATLAB 7.10.0 (R2010a), following results have been obtain in order to show the Data traces of Zigbee and Wi-Fi, White space in Wi-Fi frame during transmission and Coexistence of Zigbee and Wi-Fi frames control using HMM in a randomly selected frames by a user.

A random selection of data frame has been selected in the Matlab GUI by us and with the time to generate the data frames for the transmission that work on current data. The time taken for the frame is for both Zigbee and Wi-Fi frame is marked same so the HMM can be applicable and we can get the white space of Wi-Fi. In this Wi-Fi White Space found is used for the Zigbee low rate frame to be transmitted in the same Wi-Fi frame cluster. Random generation of data traces and there white space frames have been depicted by GUI environment as shown by few steps of procedure to run implementation code in Matlab GUI are:

Step1: Select the current file from the location (Browse for folder).

Step2: Enter "Guide" in command window and Enter.

The GUI code will run and a GUI running window is open to get the randomly selected time frames for the Zigbee and Wi-Fi now just run the window and get the outputs frames according to user.

Figure 4: Matlab window to run GUI graphic.

Thus from the above steps we can generate different frames for Zigbee and Wi-Fi and can get there coexistence of the frames in different time slots. In this thesis we had taken different time for Zigbee and Wi-Fi and had taken there coexistence frame-by-frame. The time will be same for both the frames of Zigbee and Wi-Fi. The time taken by us as 300ms. We get different output frame cluster for Zigbee, WI-FI, and finally the coexistence of both Zigbee and Wi-Fi frame during the same time slot by the use of HMM.

Fig below shows the Zigbee signals generated at random using Matlab.

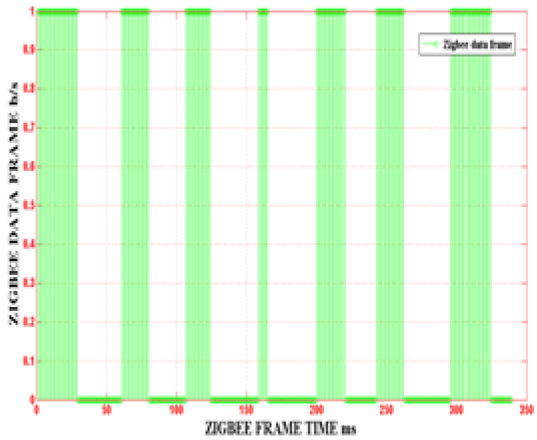

Figure 5: Zigbee Frame Cluster for 300ms

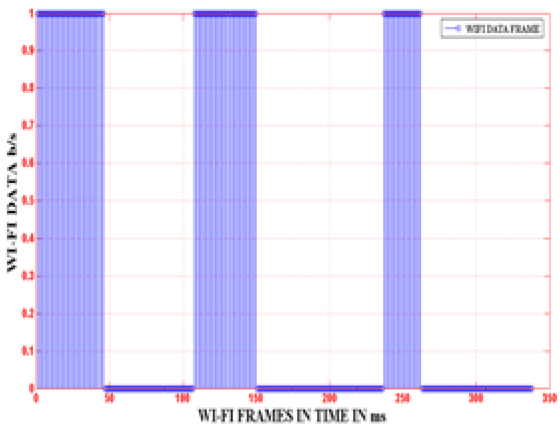

Figure 6: Wi-Fi frame cluster for 300 ms

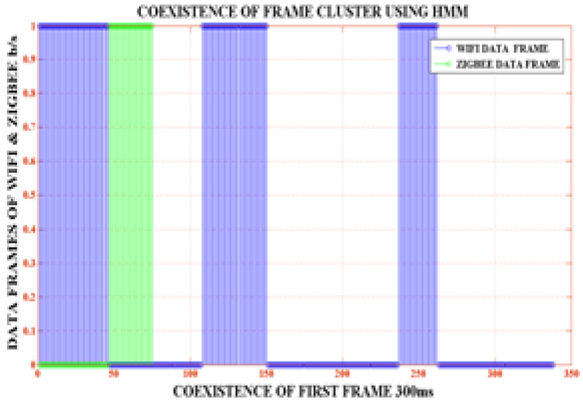

Figure 7(a): Coexistence of Zigbee and Wi-Fi first frame in 300ms

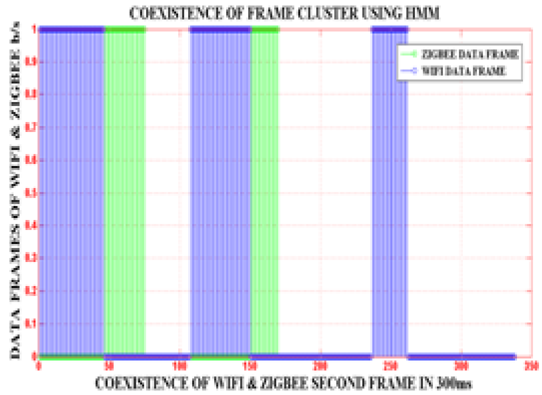

Figure 7(b): Coexistence of Zigbee and Wi-Fi second frame in 300ms

4. Conclusion

The aim of this work presented here is to learn an HMM (Hidden Markov Model) based on the data traces of the network by implementing graphical user interface in Matlab environment which is used for coexistence of Wi-Fi and Zigbee frames. This thesis focuses on the new HMM-driven Smart White Space-aware Frame Control Protocol which can obtain the optimal trade-offs between throughput and data traces.

Finally coexistence simulation results of Wi-Fi and Zigbee frame cluster for same time slot have been shown in figures 6.2, 6.3 for 300ms and in figure 6.5, 6.6 for 700ms and there coexistence for frame control protocol of both the frame is done by HMM by making Zigbee frame-by-frame implementing in the white space of Wi-Fi as shown in figures 6.4 (a), 6.4 (b), 6.4 (c) for 300ms and in 6.7 (a), 6.7 (b), 6.7 (c), 6.7 (d) respectively. The simulation can be proceeding in future by implementing the loop generation of frame for both the channels and also including the wi-max IEEE802.16 protocol in the simulation. From all the above discussion and implementation it has cleared that performance of low rate data signal of Zigbee can coexist with Wi-Fi without making any interference in the Wi-Fi.

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