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Alleviating Airport WiFi Congestion: A Comparison of 2.4 GHz and 5 GHz WiFi Usage and Capabilities

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***Abstract*—A study of airport WiFi band usage and wireless device capabilities reveals that the 5 GHz WiFi bands are significantly underused, compared to the 2.4 GHz band. After uncovering this data trend in studies of airport channel usage, a search of newly manufactured wireless devices showed that many new devices do not possess the capability to operate in the 5 GHz bands. Furthermore, the UNII bands allocated for dynamic frequency selection in the 5 GHz WiFi band are barely used, and a vast majority of recently granted devices do not possess the capability to operate in this band. The data suggests that transition of technology to utilize the 5 GHz bands is likely to reduce the present congestion in the 2.4 GHz industrial, scientific, and medical band, in turn improving notable metrics of wireless communication, such as download time and packet loss in transmission.**

I. Introduction

In a study of airport wireless coexistence issues focused on the WiFi band, it has become apparent that most of the WiFi traffic operates in a small portion of the frequencies allocated for WiFi. While multiple channels in both the 2.4 GHz and 5.8 GHz bands have been allocated, an analysis of data shows that the usage tends to "clump" in the three non-overlapping channels in the 2.4 GHz band, leaving multiple channels either sparsely used or not used at all in the 5.8 GHz band. Given the apparent spectrum crowding issues in airport environments, the authors performed a survey of wireless devices available in the market and analyzed the capabilities of these devices.

The paper analyzes data the authors have taken at airports and other venues across the United States, and attempts to gain insight into why the 2.4 GHz band is crowded, as well as the possible ramifications of spreading out the frequency usage. The goal of this work is to understand the spectral environment created by crowded, bring-your-own-device (BYOD) venues and what barriers exist to optimal efficiency and performance. The benefit will extend beyond airport environments into other BYOD environments, such as hospitals, universities, libraries, and convention centers.

Studies of wireless interference issues related to local area networks at airports have been documented in the literature. Gheorghisor *et al.* describe a study of the feasibility of the simultaneous use of the 5091-5150 MHz band for an Airport Network and Location Equipment (ANLE) network and non-geostationary, mobile satellite uplinks [1]. This paper provides suggestions that ANLE receivers be designed with higher sensitivity (to allow reduced transmitter power) and that multiple subnetworks be installed in each airport [1]. A follow-on paper shows the results of a 2011 analysis on how ANLE transmitters affect the satellite receivers [2]. Claussen describes how a self-deploying network can handle the challenge of moving high density locations of network access in the airport environment [3]. A study of public wireless networks was performed by Balachandran *et al.*, presenting user behavior and performance of the wireless network at a large conference with a significant number of attendees [4]. Calcagnini *et al.* demonstrate the results of electromagnetic interference testing on medical equipment based on hospital WiFi networks [5]. The present paper builds on these analyses to initially investigate the relative use of multiple WiFi bands in a typical public wireless environment: the airport. De Vries *et al.* have investigated metrics for studying spectrum congestion and admit that it is a difficult phenomenon to quantify [6]. This is also the experience of the authors; however, we have attempted to measure and analyze data using different approaches, including spectrum occupancy and retransmission rate. Due to space limitations, only a small portion of this data is presented and considered in this conference paper. The purpose of this paper is to acquaint the reader with spectral congestion issues in airports and to assist the reader in assimilating a path toward quantification, analysis, and solution of these issues.

II. Overview of the Airport Study

This work is part of a study funded by the Transportation Research Board (TRB) to analyze wireless coexistence issues in airport environments. The goal of the study is to pinpoint possible issues of wireless interference, especially caused by passenger/client wireless network usage. Certainly the idea of wireless coexistence spans a large range, but the focus of our work to this point has been to analyze the WiFi bands most commonly used by passengers and airport visitors. The initial study presented in this work presents preliminary results aimed at assessing the ability of passengers to access wireless services. Future work is expected to focus on pinpointing possible issues of interference with mission-

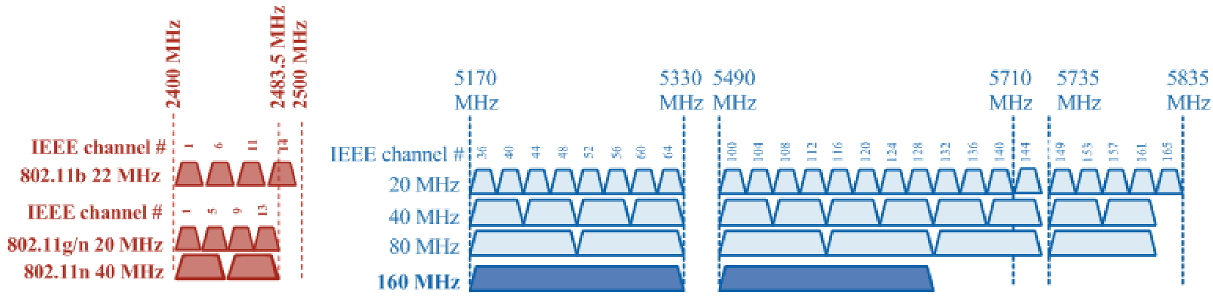

Fig. 1. WiFi channels available for use at 2.4 and 5 GHz (2483.5 to 2500 MHz is not available in the United States).

critical operations at the airport, including airline services, plane-to-controller communications, and radar.

Airports are interested in the outcomes of this study, as they are attempting to provide passengers with the convenience of wireless amenities to conduct business. This is important for major hub airports, as they serve major airlines, and the ability of business travelers to conduct business and communicate while being laid over in their airport will increase business to the airlines. Thus, having a good wireless infrastructure, in turn, increases the business of the airport.

The research team has taken a significant amount of data in several airports, and has noticed the lack of use of the 5 GHz bands. This has prompted (1) a survey of new devices for dual-band versus 2.4 GHz only capabilities, (2) a study of airport access points and channel usage over both bands, and (3) examination of recent grants for wireless equipment and examination of band usage. The results of these parts of the study are detailed in the following sections.

III. A Survey of Available WiFi Bands

Figure 1 provides a summary of the WiFi channels available in the United States at 2.4 GHz and 5 GHz. Table I gives details of these bands, and also shows the relevant rule numbers standardized by the Federal Communications Commission. At 2.4 GHz, there is an industrial/scientific/medical (ISM) band. The 5 GHz range consists of multiple bands. In addition to a 5.8 GHz industrial/scientific/medical (ISM) band, four UNII bands can also be used for WiFi operation. In total, 705 MHz of total bandwidth is available near 5 GHz, compared to 83.5 MHz at 2.4 GHz. Two of the 5 GHz UNII bands are also allocated for dynamic frequency selection (DFS). Approximately 91.6 percent of the available bandwidth for WiFi transmission is in the 5 GHz bands.

Despite the significantly larger amount of available bandwidth near 5 GHz, measurements show that the majority of devices operate in the more crowded 2.4 GHz band. Although the 5 GHz bands are available and offer more bandwidth and higher data rates, most products coming on the market today are, surprisingly, only capable of operating in the 2.4 GHz band. Table II shows the percentage of all certified WiFi devices that are dual band, based on data from the WiFi Alliance database of WiFi certified devices [6].

Table I: Available Bandwidth and Channels for WiFi

Band	Frequency Range	Total Bandwidth	WiFi Channels		FCC Rules
	MHz	MHz	Chan. #	Non-Overlapping	
2.4 GHz ISM	2400-2483.5	83.5	1-13[1]	3 or 4[2]	15C
Lower UNII, Indoor	5150-5250	200	36-48	4	15E
Lower UNII, DFS/TPC[3]	5250-5350	200	48-64	4	15E
Middle UNII, DFS/TPC	5470-5725	255	100-140	11	15E
Upper UNII, SRD[4]	5725-5825	100	149-161	4	15E
5.8 GHz ISM	5725-5875	150	149-165	5	15C

There are pros and cons to operating in both bands. Operating at 5 GHz requires higher-frequency device capabilities and circuitry in the microwave circuit design. Furthermore, the DFS bands require additional certification procedures to provide the FCC blessing of the device using these frequencies, adding cost and time. However, operating only in the 2.4 GHz band has potential downfalls in that the band tends to be the most crowded, whereas higher data rates may be available in the 5 GHz band where bandwidth is more plentiful.

The data is based on the idea that devices qualified for 802.11b are assumed to support only the 2.4 GHz band, while devices qualified for both 802.11a and 802.11b support both the 2.4 GHz and 5.8 GHz bands. The following is the FCC conglomerate data for all presently certified WiFi devices:

[1] In the US WiFi channels 12 & 13 must operate at reduced power. Channel 14 is available in Japan but only for 802.11b operation.
[2] In the 2.4 GHz ISM band there can be 3 non-overlapping 802.11b 22 MHz DSSS channels or 4 non-overlapping IEEE 802.11b/n 20 MHz OFDM channels.
[3] FCC CFR 15.407(h) requires that Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) be used in some portions of the UNII band.
[4] The upper UNII band is restricted to Short Range Devices (SRD), which are limited to 25 mW of radiated power.

Total Certified WiFi Device Grants: 15,748
Total Granted Devices with 802.11a Capability: 5471
Percent of All Device Grants with 802.11a Capability: 35%

It should be noted that many devices may be capable of operation in certain bands, but do not have the FCC grants to operate in those bands. After they receive a grant for operation, they usually send out a firmware update to the devices that permit access to the new bands.

TABLE II: SINGLE VERSUS DUAL BAND WIFI DEVICES IN ALL CERTIFIED DEVICES

Year	Dual Band Devices	Single Band Devices	% Dual Band
2013	1405	2826	50%
2012	1425	3445	41%
2011	1016	2885	35%
2010	582	1975	29%
2009	388	1197	32%

TABLE III: SINGLE VERSUS DUAL BAND WIFI DEVICES IN LAPTOP COMPUTERS[5]

Year	Dual Band Devices	Single Band Devices	% Dual Band
2013	4	7	57%
2012	10	56	18%
2011	42	231	18%
2010	29	139	21%
2009	25	38	66%
2008	44	69	64%
2007	28	57	49%
2006	1	2	50%

[5] The data for laptops certified in 2013 was not charted due to the small number of units. This may be because laptops are increasingly using certified modules and therefore do not require a certification of their own.

Table III shows data for certified laptops by year. Interestingly, this data shows that the percentage of granted devices certified for dual-band use is relatively low. Only 18 percent of new laptop grants in 2012 provide for dual-band use. The following is the overall data for laptops:

Total Certified WiFi Laptop Grants: 626
Total Granted Laptops with 802.11a Capability: 180
Percent of All Device Grants with 802.11a Capability: 29%

This data raises a significant question: why are many devices primarily being equipped to operate only in the more crowded 2.4 GHz band? Not surprisingly from this data, measurements taken by the authors at airports show that the 2.4 GHz band is much more crowded.

Smartphone data is shown in Table 4. It shows a similar trend. The overall data is shown as follows:

Total Certified WiFi Smartphones: 2489
Total Devices with 802.11a Capability: 713
Percent of All Devices with 802.11a Capability: 32%

TABLE IV: SINGLE VERSUS DUAL BAND WIFI DEVICES IN SMARTPHONES

Year	Dual Band Devices	Single Band Devices	% Dual Band
2013	365	764	48%
2012	312	867	36%
2011	123	556	22%
2010	11	259	4%
2009	2	133	2%

IV. AIRPORT USER BAND DISTRIBUTION

Measurements of WiFi usage were performed at 65 airport gates at 16 airports. Figure 2 shows the percentage distribution of band usage measured at these gates. It can be seen that Channels 1 through 14, which represent the 2.4 GHz bands, showed significantly heavier use than the other channel ranges. In all cases of measurement, Channels 100 through 140 were completely unused. This prompts the question of why these bands seem to be underutilized. It seems reasonable that most devices may not be equipped for the dynamic frequency selection protocol required by this UNII DFS band, or that airport access points may not be set to handle 5 GHz traffic. As can be clearly seen, approximately 83 percent of the usage is crowded into the 2.4 GHz band.

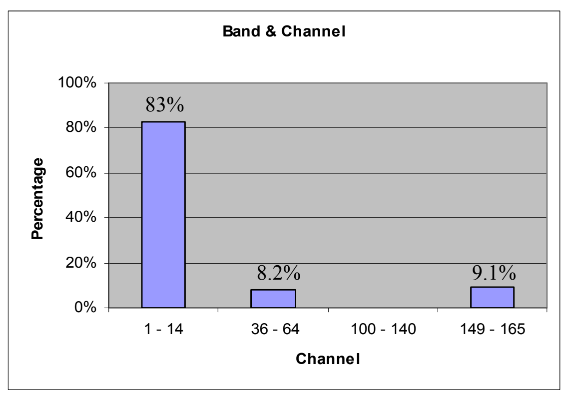

Fig. 2. Distribution of band usage at 65 airport gates

The data on new device capabilities suggests that the unbalanced congregation of devices in the 2.4 GHz band may continue and even get worse in the near future. While airports represent one place where many users are likely to congregate, congestion may also occur in hospitals, libraries, universities, and large meetings and conferences.

This is a problem that must be addressed at the manufacturer level, and wireless device manufacturers must be provided with economic benefit by operating dual-band devices. Such benefit may be based upon faster data rates obtained by the user in crowded environments. Presently, however, the inertia of the 2.4 GHz use and the seeming satisfaction of users has slowed the expansion to dual-band capability of new devices.

V. Manufacturer Case Study: New Devices

We surveyed publically available data on approved FCC grants, and found that companies are less likely to be granted the ability to operate in the UNII bands in the 5 GHz region. For example, one company ("Company A") has received 10 FCC grants since 2008 for wireless routers and access points. All 10 of the devices are designed to operate in the 2.4 GHz ISM band. 9 of these are designed to operate in UNII 5150 – 5250 MHz (not dynamic frequency selection). However, only 2 of the devices are capable of operation in the UNII 5250 – 5350 MHz (roughly Channels 50 – 74) and 5470 – 5725 MHz (Channels 100 – 144) bands, the dynamic frequency selection (DFS) UNII bands. A special demonstration of DFS capability must be presented to the FCC to be granted operating privileges in these bands. These results, astonishingly, show that many devices are not even equipped with capability to operate in Channels 50 through 144. The other interesting notable about this part of the study is that the operating power in the 5 GHz UNII bands is significantly lower than in the 2.4 GHz and 5.8 GHz ISM bands. UNII band use in these devices would be limited to short-range communications.

A second company ("Company B") was surveyed. Out of 10 granted devices, all 10 are certified for operation in the 2.4 GHz ISM band, and 9 of these are certified for operation in the 5.8 GHz ISM band. Only 6 are certified for UNII band operation, and all are specifically assigned to the 5150 – 5250 MHz band, as in the case of Company A. However, no devices are certified for operation in the Channels 100 – 144 (the DFS channels).

Review of 255 grants of a third large company that manufactures routers and access points ("Company C") revealed that only 8 of these devices serviced the low DFS UNII band (5250-5350 MHz) and none of these grants showed capability in the upper DFS UNII band (5470-5725 MHz). This data shows that many companies are not manufacturing devices for operation in these bands.

This data shows two things: (1) The UNII DFS bands are underused and (2) the reason for this underuse is that device manufacturers are not creating devices capable of using these bands. The reason for this may be the extra certification procedures necessary to be licensed for a DFS band, or perhaps the additional cost incurred at building a large amount of frequency variability into a microwave device if it presently does not have capability in any of the 5 GHz bands. Most importantly, a market-induced push will be necessary to encourage use of the 5 GHz bands when the 2.4 GHz bands become intolerably overcrowded. This push does not seem to have happened yet, but with increasing user numbers and larger-bandwidth applications, this impetus may come. In any case, solving the problem of these underused frequencies may address potential congestion issues for WiFi devices.

VI. Conclusions

An initial study of airport wireless band usage has revealed that the 5 GHz WiFi channels are much less used than the 2.4 GHz WiFi channels. A survey of newly manufactured wireless devices, including laptop computers and smartphones, shows that surprisingly low percentages of new devices are capable of dual-band operation. Finally, an examination of relatively new wireless access point and router grants shows that only a small number of devices are being produced that can operate in the 5 GHz dynamic frequency selection UNII bands. This seems to be an indication that the problems of congestion in the 2.4 GHz band, in airports and otherwise, are a result of the industry's lack of configuring devices for 5 GHz WiFi operation. This work suggests need for increased encouragement to manufacturers to use 5 GHz. It is possible that the approval process for the dynamic frequency selection bands is a deterrent to new devices using these bands.

For example, if users were aware that much more bandwidth is available in the 5 GHz bands, they would be likely to buy devices that are configured to use these bands, prompting manufacturers to begin designing their new devices for dual-band operation. Informing users of the issues and higher bandwidths (and hence data rates) at higher frequencies may be useful in pushing this forward.

Acknowledgments

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