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An 802.11 Channel Assignment Algorithm Inspired by the Minimum-Spanning-Tree

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Abstract— Since so many 2.4 GHz devices are in use, the 802.11 standard's channel assignment in the 2.4 GHz band remains a hot topic. Because there are only three channels on this band that are not overlapping, users may experience significant levels of interference in congested areas. Using the Prim's method, a greedy technique for locating undirected graph's minimal spanning trees (MSTs) is investigated for channel assignment in this sort of network. Operational range is often restricted to a few tens of meters, which is normal for this kind of technology. Researchers are primarily concerned in finding out how accurate and helpful common RF modules may be when used at normal ISM frequencies.

INTRODUCTION

The 2.4 GHz band of the 802.11 standard is still plagued by the problem of interference. It is vital to ensure a dependable transmission in this band due to the usage of several versions of 802.11 (b, g, n, and ac). A large density of access points need more than the three non-overlapping channels that are currently available. Our ISPs may recommend three channels (1, 6, and 11) although clients may select others according to their own preferences because channel assignments are frequently random. Figure 1[24] depicts the typical channel distribution in a seven-room home. Xirrus Wi-Fi Inspector software [6] was used to count the number of APs in each space.

As many as 11 to 28 Access Points (APs) have been found in each room, with anything from zero to seventeen APs transmitting on the same channel. Number one, number six, and number eleven are the busiest channels in that order.Using tools that a regular user may utilize in earlier research, we looked at two real networks and optimized channel selection in each one

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[7]. According to the findings, channel coordination in private networks is lacking, and further effort is needed to address this issue. Methods and software solutions are available to enhance channel allocation. In this section, we'll examine The Global Positioning System and the Glonass satellite constellation (with Galileo and Beidou in future). There is enough precision in the free/civilian versions of these systems for the majority of uses. Small, light, and less power-hungry gadgets have become more accessible thanks to constant advancements in electronics. Even though indoor alternatives exist, they are nonetheless lacking in efficacy. Some physical phenomena (such as video, ultrasound, MEMS dynamics, and UWB pulses) have been proposed as possible localization techniques; however, none of them have gained traction [1-10].

Received Signal Strength Indication (RSSI) measurements are used to calculate distances between the user and beacons in this system. A better indication of received signal power is Received Signal Strength Indicator (RSPI) rather than RSSI, and it is vital to know this. In terms of consumer electronics, such systems are too costly and impracticable.

Assumed that the RSSI is a time-invariant function specified (with some precision) by the manufacturer of the RSPI that is being utilized in the system. The receiving route further alters it. Assumption: No matter which instrument is used to measure RSSI, it will have the same and consistent relationship to any received signal.

RELATED WORKS

many options. For the average user, these strategies might be confusing and have short-lived impacts due to optimization being done from only one network perspective.

802.11 networks come in a variety of forms. They include tiny, privately owned networks, as well as those that are administered by a company. First ones are planned, second ones are unplanned. Administrator networks make use of comprehensive management approaches. Such solutions are based on a distribution of throughput that ensures a level of fairness [8]. The next approach makes use of dynamic power level regulation The best network capacity, the lowest degree of interference, the most possible throughput, and fairness may all be achieved using the channel assignment approach. There are two common goals for well-designed networks: maximum network capacity and low interference power. In order to help administrators make choices, the map coloring approach is used to show the results of the measurements.

Choi et al. 2002 took a different tack on this problem [2] [3]. Analyzing two factors, the number of APs and their data distribution, is done by using Integer Linear Programming (ILP). Many details about the network, as well as a great deal of computation, are required for an algorithm. Wertz et al. 2004 [3] came up with the solution of creating a priority map. The process is extensive and requires a number of phases in order to get the best possible network. It's possible that the AP's number and location will be changed. The fairness problem is a part of the patching algorithm ([4]). CFAssign - RaC [5] shows how APs and end users both see the 802.11 environment. Aspects like channel assignment and throughput balancing are also considered as part of this process.

Since channel selection is difficult in small private networks, they typically suffer [7]. Small home networks can be set up using either of three approaches. Figure 6 shows how many people utilize each channel, whereas Pick Rand[7] determines the coefficients of channels that are superimposed. To identify the optimal solution at any given time, Dynamic interference calculations and channel switching are used in SAW[4].

There are several Wi-Fi notions in literature that don't work well in a chaotic home network. As a result, The authors chose to look for a static solution that could be used to both current and future 2.4 GHz Wi-Fi networks.

First, a modulo 3 mechanism-based technique [2] has been devised. Although just three non-overlapping channels need to be assigned since network boundaries are believed to conform to each other, it may be prudent to do comparable analyses for additional channels. The RAA algorithm's reference array is initially constructed using the first approach described below. The RAA method can be used if the APs are distributed across a small area of space. It is possible to assign an individual number to each AP, as well as to know the AP's X and Y coordinates, using any of these two approaches. A reference array can only be built using the suggested Modulo 3 technique in simple circumstances when AP coverage regions are congruent. Networks having random access points (RAPs) can employ RAA to assign channels. The boundary and three-dimensional arrangements that we have in apartment buildings are not resolved by RAA. The RAA mechanism guarantees that there will be no more than d/2 distance between channels, which is the coverage area of a single AP. A minimum level of interference between APs is not guaranteed by the RAA method, although it is better than no channel assignment. As an added drawback, it's restricted to two-dimensional scenarios

only.

802.11 NETWORKS: INTER CHANNEL INTERRUPTION Because of their partial overlap, spectral filters can only reduce the intensity of the 802.11 standard signal in each individual channel [3]. Using the Correlation Ratio Coefficient, one may express the correlation between the signal power in distinct channels (CRC). The only variation in signal strength between two stations broadcasting on the same channel but belonging to different networks is the CRC. It is possible to compute the CRC in a number of methods. Such being the overlap of mask curves or frequency ranges, for example Using a signal power density per Hz approach, we may determine the frequency range overlap across distinct channels. Because of the importance of bandwidths, the outcomes vary widely [7].

WAVE PROPAGATION ENVIRONMENT

The propagation space's geometry is a 15 x 4.8 m long rectangular chamber. Five beacons have been installed at various sites. n = 5 (tab. I). All RSSI measurements were performed with the receiver P in a fixed location (tab. I). There are a total of 1.3 meters above sea level in all of the beacons, including Point P. Throughout the inside of the building, there are three brick walls, a fully-glazed fourth wall, and concrete ceilings (fig. 2). Nothing stands in the way of a plane taking off or landing on the broad expanse of a grass airport. There is no difference in location between beacons and point P in the indoor situation

TABLE I.

BEACONS AND P-POINT COORDINATES

	B1	**B2**	**B3**	**B4**	**B5**	**P**
***X* [m]**	0.60	14.55	8.40	14.55	0.65	7.00
***Y* [m]**	0.35	0.35	0.40	3.60	3.60	2.50

I. MEASUREMENTS MADE BOTH INSIDE AND OUTSIDE

Each beacon has logged at least 500 RSSI readouts. Every 700 ms, the whole measurement set is taken again, consisting of 5 RSSI reads from each of the 5 beacons.

An indoor positioning error statistic is shown in Fig. 4 as a function of the RSSI frequency.

II. PROPOSED ALGORITHM DESCRIPTION

A. *Initial presumptions*

Following assumptions are established prior to algorithm development:

a) There are three or four channels in the 2.4 GHz spectrum that may be used, depending on how many channels you want to employ.
b) Each Access Point (AP) has a unique serial number,
c) The amount of APs does not fluctuate, therefore the environment remains stable.
d) For each AP in the considered

area, provide the following information

Because each AP has a unique MAC address, the b) assumption can be verified with ease.. Hexadecimal code is used to encode the unique MAC address of a device. It is possible to put these addresses into ascending order and assign a value to each one, beginning with 1 (the first access point) and ending with N (the last access point) (the total number of access points). D is a reasonable assumption, although it can also be satisfied in theory. To begin, we require the position of our own AP, then the manner by which this data will be disseminated, and ultimately, we must get information on the locations of other APs. Previously, the authors had examined this option [12]. There are a few ways worth mentioning like GPS and digital maps or tools incorporated in the 802.11 V and K changes. It is necessary to provide each accessible channel a unique identifier when there are just three or four: channels 1, 6, and 11.

B. *Algorithm description*

1) *Graphing a collection of APs*

Let's start with the five APs shown in Fig. 3 as a starting point. Both physical and channel space distance affect the level of interference between each pair of APs. In instance, when the physical distance between two APs grows, the power of their connection diminishes.

I. REDUCING NUMBER OF BEACONS

It's impossible to tell which measurement has the greatest degree of uncertainty in advance. The use of some beacons (or their combination) may actually lead to a worsening of location accuracy. The average indoor positioning error for all three- and four-beacon configurations may be seen in Tab. VI. The findings are compared to the average positioning errors when all five beacons are utilized.

TABLE VI.

AVERAGE INDOOR POSITIONING ERROR [M] VS NUMBER OF BEACONS (B)

***f* [MHz]**	**433**	**868**	**2400**
1-2-3-4-5 (all beacons)	*2.85*	*2.79*	*6.49*
1-2-3-4 (without B5)	7.44	7.29	**5.58**
1-2-3-5 (without B4)	**1.84**	**1.81**	**5.35**
1-2-4-5 (without B3)	3.75	3.68	7.26
1-3-4-5 (without B2)	3.67	3.56	6.94
2-3-4-5 (without B1)	**2.10**	**2.08**	7.41
1-2-3	6.57	6.48	**4.45**
1-2-4	9.30	9.09	**6.24**
1-2-5	**2.67**	**2.63**	**5.78**

1-3-4	7.51	7.36	**5.31**
1-3-5	**2.21**	**2.13**	**5.54**
1-4-5	6.86	6.59	8.76
2-3-4	5.39	5.35	6.61
2-3-5	**1.05**	**1.06**	**6.34**
2-4-5	**2.21**	**2.20**	9.06
3-4-5	3.03	2.97	7.47

Tab. VII replicates the external environment's measurements.

Beacons employed in certain numbers and combinations show improvement. Beacons 1 and 4 are deleted from the indoor 433 MHz and 868 MHz bands, resulting in a significant decrease in average location error. Beacons 4 and 5 are eliminated for the best 2.4 GHz performance. To get the best accuracy in the 433/868 MHz range, only use beacons 4 and 5 – no beacons 1 or 5 for 2.4 GHz. Notice that these results only relate to the place P.

CONCLUSIONS

An algorithm for Wi-Fi AP channel assignment inspired by the greedy MST has been devised and described. Multiple APs were used to test the method, including two-dimensional and three-dimensional models with three and four channels, respectively. When compared to the exhaustive approach, which ensures that the best solution is found, there is a very minor loss in results (usually less than 10%) and a large gain in execution time. Exhaustive procedures become impractical when there are more than 10 APs and/or more than three channels accessible on a low-end processor (even days). As a result, the suggested algorithm is a viable option. Both methods benefit from using four channels instead of three, although the gain is generally less for the greedy approach.

It is imperative that future research incorporates three-level AP distributions and a more realistic model of inter-AP interactions.

When using the ISM bands at 433 MHz and 868 MHz, positioning is most effective when RSSI readings are used. If you utilize RF modules, you will see this outcome. However, the 433 and 868 MHz bands still outperformed the 2.4 GHz band and were shown to be highly dependent on the quantity and mix of beacons used in the experiment as well

In all cases, the location uncertainty was primarily caused by high transmitter (RSSI0) and propagation (n) parameter uncertainties. With less barriers and interference, the propagation model is closer to free space, therefore outside location is a no-brainer.

This low overall location accuracy can be attributed to the lack of any data filtering or processing. This was done on purpose to explore the accuracy of "raw" positioning. Techniques like RSSI fingerprinting, Kalman filtering, and Markov chains have been developed by other authors that can greatly minimize the location error - down to few centimeters. It's also feasible to use many bands at the same time. As a result, an acceptable and practical indoor positioning system is possible, especially when employing the ISM bands at 433 and/or 868 MHz.

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