Upgrading Wi-Fi fingerprinting to 5G. A hybrid simulation case

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Abstract. This research project is an extensive study of the upgrading process of fingerprinting technology from 2.4 GHz to 5G mmWave FR2, with the primary location being a secondary school environment. The work aims to evaluate and identify optimal combinations of existing 2.4 GHz Wi-Fi, 5 GHz Wi-Fi, and emerging 5G mmWave FR2 technologies to enhance indoor localization systems. Leveraging advanced simulation software, the study explores various scenarios to achieve the most effective integration of these technologies. Early results indicate that the adoption of 5G technology faces considerable challenges in overcoming signal loss through walls, a problem less significant in the current Wi-Fi technologies. Nevertheless, it is preliminarily suggested that these barriers can be mitigated by a large-scale deployment of 5G access points (AP's). Further research is ongoing to refine the findings and develop practical recommendations for deployment in similar environments. This study holds significant implications for the design of future indoor localization systems, particularly as the global infrastructure transitions towards more sophisticated 5G networks.

Keywords. Indoor, positioning, 5G FR2

1. Introduction

The rapid growth of digital connectivity in the 21st century has needed a substantial evolution in indoor localization systems. These systems, vital for a plethora of applications ranging from building navigation to security, have traditionally relied on 2.4 GHz and 5 GHz Wi-Fi technology. However, with the advent of 5G technology, and more specifically, 5G millimeter-wave

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Frequency Range 2 (mmWave FR2), the landscape of indoor localization, is undergoing a significant shift.

Our study investigates the possibilities for indoor positioning that the relatively new the relatively new 5G mmWave FR2 and compares the results with the currently prevalent 2.4 GHz and 5 GHz Wi-Fi technology in a secondary school environment. The school's building structure, comprising numerous walls and classrooms with several obstacles, makes it an ideal setting to test the efficacy and challenges of this upgrade process.

For the realization of this work, we use a radio signal simulator (EMSlice, www.emslice.com), which allows simulating 2.4 GHz Wi-Fi, 5 GHz Wi-Fi, and 5G mmWave FR2 signals, as well as their combination. Thus, it is possible to gain insights into the synergies among the technologies, potential challenges, and optimal deployment scenarios, before the true deployment.

To ensure the veracity of our simulation results, we validated them against real-world data collected from similar settings. By correlating our simulated results with the actual performance of these technologies, we evaluated the accuracy of our simulation model and minimized the risk of misleading conclusions. Specifically, a simulation has been carried out with the EMSlice software, using a scale mapping of a secondary school as a reference. Specifically, in this center there are 6 2GHz/5GHz AP's and 38 readings have been taken to corroborate the correct functionality of the simulation software and to adjust different parameters. Figure 1 shows the position of the different AP's, as well as the points where the test signals have been taken. These signals were obtained with a Samsung 22 Ultra mobile phone, stopping at each test point for 5 seconds to stabilize the signal and capturing the RSSI power obtained. All signals were taken in a row.

The main goal of the current research is to find where to add 5G mmWave FR2 in a secondary school building for using this technology for indoor positioning.

2. Results

Following data collection and analysis, our preliminary findings have yielded results of interest in the area of indoor localization through 5G mmWave FR2 technology. In our simulation, we incorporated the use of fingerprinting with the goal of improving location accuracy in the post-compulsory school environment.

Currently, only the KNN algorithm is being used for testing. In the future, we will proceed to test different algorithms to verify their usefulness. The results of applying KNN in different contexts are presented in Table 1.

In terms of accuracy, our results thus far indicate that the use of 5G technology with fingerprinting does not provide a significant improvement over traditional 2.4 GHz and 5 GHz Wi-Fi technologies. Relative performance was determined through a comparison of the results obtained in the simulation and the data collected in the real environment, keeping the same conditions for both scenarios.

However, it is important to highlight that, although accuracy may not have improved significantly, the use of 5G technology with fingerprinting proved to be sufficiently accurate for room-level localization. This implies that, although the location accuracy may not be granular enough to determine the exact location within the room, it is effective enough to determine in which room the device is located.

Analyzing the difficulties encountered, it was found that the structure of the school building, with its numerous walls and partitions, presented challenges in the implementation of 5G mmWave FR2. For this reason, part of the work will also focus on studying the number of AP's required to achieve acceptable results. As initial work, Table 1 shows the accuracy results using the KNN algorithm on different combinations of AP's.

At the end of this study, our goal is to present optimal deployment recommendations for 5G mmWave FR2 in a real environment using simulation software to achieve both a better absolute positioning and a study on the needs of AP's to perform a positioning only at room level. A secondary objective is to produce a map of simulated RSSI signals for future use by other researchers.

	2.4GHz	5GHz	5G FR2	2.4GHz+ 5GHz	2.4GHz+5G FR2	5GHz+5G FR2	2.4GHz+5G Hz+5G FR2
KNN Precision	93.46%	87,58%	69.93%	93.46%	90.85%	86.93%	92.16%

Table 1. KNN algorithms with different wireless technologies

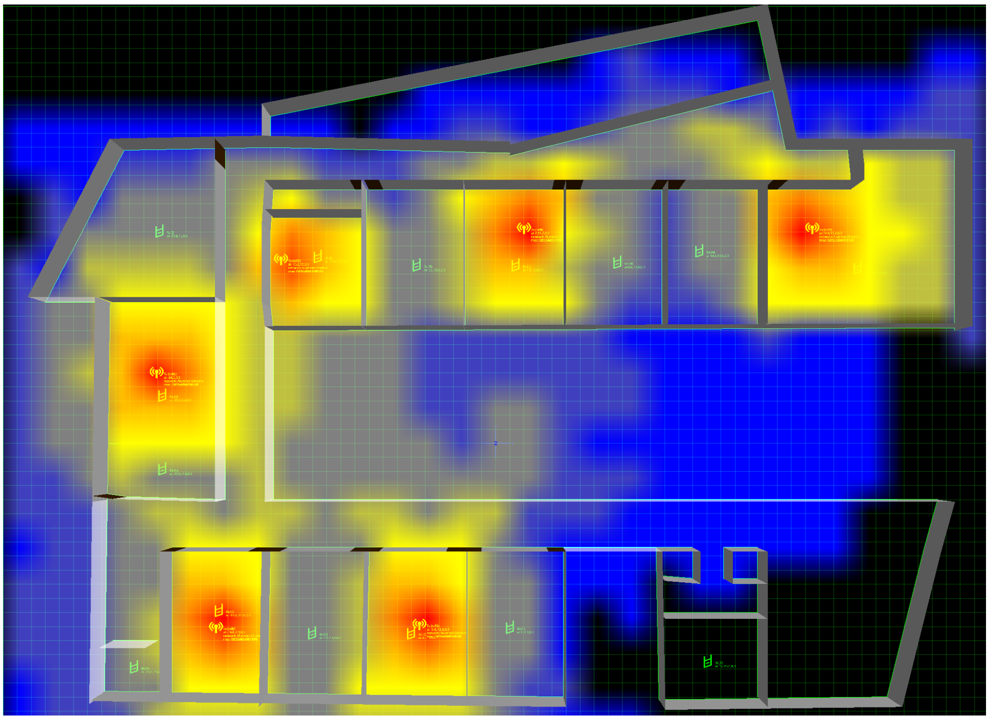

Figure 1. Map of signals in the secondary school

3. Conclusion

Our preliminary findings reveal that signal loss, particularly through walls, is more important for 5G mmWave FR2 than for Wi-Fi technologies, although it is possible to take advantage of this loss for some kind of indoor positioning applications. Another line of research of the current study is focused on whether many 5G AP's are really necessary if we only want room level positioning.

At the end of this study, our goal is to present optimal deployment recommendations for 5G mmWave FR2 in a real environment using simulation software. A secondary objective is to produce a map of simulated RSSI signals with different signal types for future use by other researchers.

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