Calibration of a 2.45 GHz Indoor Direction of Arrival System Based on Unknown Antenna Gain

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***Abstract*— In this paper we discuss the calibration procedure and effectiveness for an indoor Direction of Arrival (DOA) positioning system based on a switched six-beams antenna operating at 2.45 GHz. The introduced calibration procedure consists in optimizing the radiation pattern parameters of the antenna to minimize DOA estimations error, over a limited set of known positions. The estimations are obtained by the multiple signal classification (MUSIC [1]). We demonstrate that in a realistic indoor environment the mean errors for the DOA estimations are less than 4.9 deg for both the DOA coordinate angles θ and θ, with a peak error of 8 deg, while a DoA estimation accuracy less than 3 deg was observed.**

I. Introduction

Wireless positioning is becoming a fundamental attribute of many distributed systems and an enabling technology for context-aware applications. While the fundamental principles have been thoroughly investigated in the literature, successful implementation of wireless localization is still challenged by many practical issues. Multipath propagation and interferences impair the signals used for RF-based positioning, especially when the system needs to operate indoors or in industrial spaces.

We address the challenges of wireless positioning in complex radio environments by proposing a system that uses a switched-beam antenna for *Direction Of Arrival* (DOA) estimation. The systems implements single-anchor positioning as discussed in our previous work [2], [3]. This paper further extends the applicability of the solution by assuming that neither the radio environment nor the radiation patterns of the antenna are supposed to be completely known.

We observe that accurate measurements of the 3D radiation patterns is a complex procedure that requires sophisticate equipment. Additionally, the physical environment surrounding the antenna has a significant impact on its radiation characteristics, and this contribution is generally unpredictable at the design stage. Therefore, we propose a positioning system that uses multiple directional antennas with *uncalibrated* 3D patterns described by parametric functions. The parameters are thus fixed using a calibration procedure performed at deployment time.

In this paper Section I describes the switched beam antenna used in the proposed positioning systems, while Section II discusses the implementation of the algorithm used for DOA estimation In section III the proposed calibration algorithm is discussed. Finally in section IV, the experiments show that satisfactory positioning results are possible using the proposed calibration scheme.

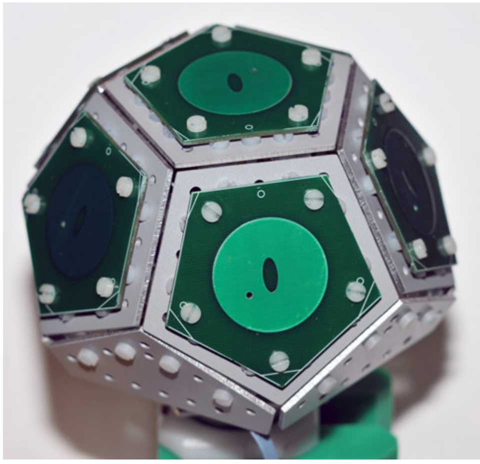

Fig. 1. The prototype of the 2.45 GHz switched six-beams antenna arranged on a dodecahedron geometry.

II. Smart Antenna for Wireless Positioning System Base Station

A. Smart Antenna Architecture

Figure 1 shows the switched beam antenna used in our positioning system. The antenna design, its operation principle, and its performance were discussed in detail in [3]. The operative frequency is 2.45 GHz, but, unlike the version described in our previous work, this prototype does not implement the circular polarization (CP) diversity; in fact, it features a single feed probe that excites the right hand CP. To ensure accurate DOA estimation, each antenna element has to be in its maximum receiving condition when the other are in a null zone in order to have angularly uncorrelated signals at the input of the various elements.

An entire domain coverage of 2π steradiant is guaranteed if the cumulative radiation pattern is almost isotropic. This constrain leads to the selection of the particular regular platonic solid geometry of the dodecahedron, which have the property to have identical pentagonal faces and identical dihedral angles of 116 degree. The prototype in Fig. 1 permits also the test of different antenna element design which respond to different gain and directivity specifications.