A New Model For Indoor WLAN Positioning System

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1 Introduction

In this paper we attempt to answer the following question : how to deploy a WLAN in order to guarantee the requested Quality of Service (QoS) while reducing the location error ? Such a problem includes two aspects : WLAN planning and positioning error reduction. To provide users a optimal wireless access to their local network, WLAN planning not only consists in selecting a location for each transmitter and setting the parameters of all sites, but also acts on allocating one of the available frequencies to each Access Point (AP) configuration [1]. And toward the indoor positioning system, once the Received Signal Strengths (RSSs) from all visible APs are measured and inputted, the location is estimated and outputted using the RSS distribution and machine learning technique [2]. We propose a new approach where WLAN planning and positioning error reduction are modeled as an optimization problem and tackled together during WLAN planning process.

2 Modeling the Problem

AP model : Since different types of APs have different parameter values, we predefine a list of AP types provided for user choice. When one AP is selected, we define its set of parameters such as, azimuth, emitted power and frequency. Furthermore, we predefine a finite set of candidate sites where an AP may be assigned.

Received Signal Strength model : RSS is the principle parameter used in bit rate calculation and positioning estimation. We define three kinds of RSS thresholds. The interference threshold is the minimum RSS a client can receive as interference. The positioning threshold is the minimum RSS a client must received for positioning estimation. The reception threshold is the minimum RSS a client must received to allow it to communicate.

Traffic model : The traffic model of the network defines how to represent the demand for network load it also provides a framework for expressing the QoS desired. In this model, we define service zone, which are represented by polygons covering parts of the building. Several characters of service zone are defined : number of users inside the service zone, bit rate in kbps desired by user for the service zone. In Our model the calculation area is decomposed into a grid. Each grid node is called Marking Position (MP). Thus these service zones are represented by the MPs inside these service zones which are called Test Points (TPs). In the same way as for the service zones, we defined forbidden zone, which must not be covered.

Positioning model : As the service zone defined in the traffic model, in the positioning model we define positioning zone where the positioning error reduction is considered. And these positioning zones are also represented by the MPs which are called Reference Points (RPs). For each RP, we find a set of MPs called Aliasing set in which all the MPs have the same RSS vector as RP.

Throughput model : For the network demand estimation, the QoS is evaluated by an indicator called Signal to Interference plus Noise Ratio (SINR) [1]. The definition is local for each user, given by :

$$\boldsymbol{SINR} = \frac{P_{Best\ RSS}}{\sum P_{Other\ RSS} \times \gamma(\Delta f) + N}$$

Where : $P_{Best\ RSS}$ is the highest Received Signal Strength (RSS). $P_{Other\ RSS}$ are the RSSs of interference channels. $\gamma(.)$ is the protection factor corresponding to the attenuation coefficient between channels. For the positioning error estimation, the accuracy of positioning is estimated by an indicator called Refined Specific Error Ratio (RSER) [2]. The expression of RSER at a MP is as follows :

$$\boldsymbol{RSER} = \frac{1}{(n(n-1))} \sum_{i} \sum_{j \neq i} dist(i,j)$$

Where : i, j : The sequence number of the MPs in the set Aliasing. n : The number of MPs in the set Aliasing. $dist(i,j)$: The Euclidean distance between the MPi and the MPj.

3 Optimizing the problem

Our optimization problem is to determine the decision variables (sites, the transmission powers, azimuths, frequencies) in order to minimize the financial cost under some constraints on QoS and maximal cost installation threshold. The financial cost we consider as objective includes the cost of the network deployment and the cost of penalty for unsatisfied demands [1]. Mathematically, the objective function is formulated by :

$$\sum_{Site} C^{Site}_{network} + \sum_{TP} \beta(p_{tp}) \times \Delta_{tp} + \sum_{RP} \gamma(p_{rp}) \times E_{rp}$$

Where, $C^{Site}_{network}$ is the network installation cost of a site. $\beta(p_{tp})$ is the penalty coefficient according to the priority assigned to the TP. Δ_{tp} is the deviation between the require bit rate and the real bit rate. $\gamma(p_{rp})$ is the penalty coefficient according to the priority assigned to the RP. E_{rp} is the magnitude of positioning error. In this function, the first term is the network installation cost, the second term is the cost of unsatisfied demands on QoS and the third term is the cost of unsatisfied demands on positioning. To solve this optimization problem, a Meta-Heuristics algorithm is being implemented.

Références

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