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On Intelligent Base Station Activation for Next Generation Wireless Networks

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Abstract

The evolution of mobile communications, during the last decades, has led to a rapid increase in the number of users that mobile operators have to serve. To cope with this increase, mobile operators increment the number of base stations they are using resulting in an escalation of the corresponding energy footprint. This is why; the reduction of the total energy that is consumed from base stations has been the epicentre of many researchers. To achieve that, a common approach is to minimize the number of base stations that are used by activating only the necessary base stations without affecting the corresponding quality of service. In this paper, we present a method for predicting crowded areas based on machine learning techniques. The dataset used contains information about the number of users that have been connected to twenty base stations during the time period of 8 days. Prediction results can be used in order to make appropriate suggestions to mobile operators about bases stations that can be activated or deactivated. We propose a Probabilistic Neural Network and confirm its superior performance against two other types of neural networks.

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1. Introduction

Wireless communications have met great popularity during the past decades, passing through numerous phases of evolution like 2G, 3G and recent 4G networks. In parallel, there has been an explosive progression on users' mobile phones (e.g. smartphones); while by 2020 the traffic originating from portable devices is expected to increment exponentially¹. Until recent years, mobile operators (MOs) were increasing the number of Base Stations (BSs) in order to satisfy the escalating number of users. This growth in the number of BSs resulted in an increased energy consumption, which is harmful to both the environment and the MOs maintenance costs². Specifically, BSs' energy consumption is estimated to 60-80%, among various elements of a cellular network, reaching 80-90% even in idle or low traffic state³.

A recent approach that has been addressed from the research community is the dynamic activation and deactivation of BSs in a network, in order to reduce significantly the consumed energy^{4,5}. Specifically, in⁶ the authors formulate a network utility maximization problem aiming to find an optimal activation schedule for each BS and devise a distributed algorithm based on the Lagrangian dual decomposition. Similarly, in⁷ the authors attempt to find an adaptive cell zooming method to reduce the energy consumption of BSs. They formulate an optimization problem taking into consideration varying traffic patterns, interference and service availability.

The authors in⁸ attempt to find the minimum set of BSs to be powered on to satisfy a given traffic demand. To achieve that, they propose two switch-off strategies based either on the cell load or the BS coverage overlap. In⁹ the authors utilize sparse-promoting techniques and propose formulations to select active BSs in order to (a) minimize the total power consumption; or (b) maximize the sum rate performance. An online reinforcement learning algorithm that adapts to the changing network traffic is proposed in¹⁰ in order to dynamically activate and deactivate the resource units.

In this paper, following the above trend, we propose an intelligent BS activation system, in order to locate areas that will be crowded and provide recommendations to MOs about potential BSs to be activated or deactivated. According to¹¹ cellular traffic exhibits periodic fluctuations both in time and space. This behaviour can be attributed to diverse usage examples amid days and nights, weekdays and weekends, and crosswise over residential and business regions. This is why our proposed solution focuses on the use of neural networks. Specifically, we propose a Probabilistic Neural Network (PNN) and compare its performance to two other algorithms that are also based on machine learning.

The rest of this paper is organized as follows. In Section 2, we describe the architecture of the proposed system for processing collected data from BSs using machine learning mechanisms. In Section 3, we present the three different approaches that we use based on machine learning, namely Multilayer Perceptron, Support Vector Machine (SVM) and PNN. The dataset that was employed is presented in Section 4, while in Section 5 we provide the results and discuss on the performance of the three proposed algorithms. Finally, the paper concludes in Section 6.

2. System Architecture

The main idea of the proposed architecture is based on the SDN architecture, which enables the abstraction of low level networking functionality into virtual services, allowing the introduction of new services¹². A representation of the entities involved in the scope of this paper is depicted in Fig. 1. We assume that there is a Centralized Network Controller, based on the SDN architecture, which is responsible for collecting all necessary measurements and reaching the required decisions. In order to enhance the Centralized Network Controller, we introduce the *Intelligent Decision Making* entity.

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