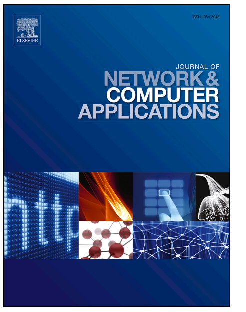

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Deep Mobile Traffic Forecast and Complementary Base Station Clustering for C-RAN Optimization

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Abstract

The increasingly growing data traffic has posed great challenges for mobile operators to increase their data processing capacity, which incurs a significant energy consumption and deployment cost. With the emergence of the Cloud Radio Access Network (C-RAN) architecture, the data processing units can now be centralized in data centers and shared among base stations. By mapping a cluster of base stations with complementary traffic patterns to a data processing unit, the processing unit can be fully utilized in different periods of time, and the required capacity to be deployed is expected to be smaller than the sum of capacities of single base stations. However, since the traffic patterns of base stations are highly dynamic in different time and locations, it is challenging to foresee and characterize the traffic patterns in advance to make optimal clustering schemes. In this paper, we address these issues by proposing a deep-learning-based C-RAN optimization framework. First, we exploit a Multivariate Long Short-Term Memory (MuLSTM) model to learn the temporal dependency and spatial correlation among base station traffic patterns, and make accurate traffic forecast for a future period of time. Afterwards, we build a weighted graph to model the complementarity of base stations according to their traffic patterns, and propose a Distance-Constrained Complementarity-Aware (DCCA) algorithm to find optimal base station clustering schemes with the objectives of optimizing capacity utility and deployment cost. We evaluate the performance of our framework using data in two months from real-world mobile networks in Milan and Trentino, Italy. Results show that our method effectively increases the average capacity utility to 83.4% and 76.7%, and reduces the overall deployment cost to 48.4% and 51.7% of the traditional RAN architecture in the two datasets, respectively, which consistently outperforms the state-of-the-art baseline methods.

Keywords: deep learning, mobile network, big data analytics, C-RAN

1. Introduction

Today, mobile network data traffic is growing explosively as Internet-enabled smartphones and tablets become increasingly popular [1]. According to Cisco [2], global mobile network data traffic has grown 18-fold over the past five years, and the next-generation cellular systems (e.g., 5G) are expected to experience tremendous data traffic growth [3]. In order to accommodate the fast growing data traffic demand, mobile network operators need to increase their *data processing capacity*, such as deploying more base stations, and adding more data processing units to base stations. Consequently, the *capital expenditures* of deploying these network infrastructures are becoming increasingly high, and may harm operator's revenue as network scale grows [4]. Moreover, the *operating expenses* of mobile network infrastructures, such as energy consumption and maintenance spending, are substantially increasing [5]. Therefore, optimizing the capital expenditures and operating expenses has become a necessity for mobile network operators [6, 7].

Even though the overall data traffic demand of the mobile network is growing, the demand in different areas and during different periods of time is not evenly distributed [8]. For example, as shown in Figure 1a, the traffic in a business district (denoted as a blue solid line) observes peaks during working hours, while the traffic in a residential area (denoted as a red dashed line) is relatively higher during evening hours than in working hours. Such a *spatial-temporal non-uniform property* of traffic demand poses great challenges for operators to optimize the capital expenditures and operating expenses of their network infrastructures. On one hand, the data processing capacity of each base station needs to cover its peak traffic volume, leading to high *deployment cost*. On the other hand, the capacity in individual base station is wasted during off-peak hours, resulting in low *capacity utility*.