

Energy and Cost Efficient Cloud Radio Access Network for 5G Deployment

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Doctor of Philosophy



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Statement of Originality

This is to certify that to the best of my knowledge and belief, all material presented in this thesis is the original work of the author, unless otherwise stated. The content of this thesis has not been previously submitted as a part of any academic qualification to any other university or institution.

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Abstract

Fifth generation (5G) cellular networks expects huge traffics, hence the demand of using traffics in 5G communication networks is increasing day by day. More base stations (BSs) with a blender of large and small cells are required to fulfill these expanding capacity requests. This will result in a more intricate network management and operation. The existing model, on the other hand, have a large amount of energy consumption in mobile networks, which contributes 60-80% of energy consumption in the whole network. In addition, BSs causes a greater impact to the environment by emitting large volumes of CO₂. Furthermore, BSs are both costly and energy inefficient because of their complex architecture and temporal-spatial nature of traffic demand. Regardless of traffic requirements, the processors in the baseband are continuously on resulting in energy loss and poor resource utilization. Existing models are not widely considered for next generation 5G cellular networks due to the following reason. Firstly, in traditional networks, each base station covers a small area as they are connected with only a fixed number of sector antennas. Secondly, the framework capacity is restricted by interference and it is difficult to improve the system capacity. Lastly, but not least BSs are generally underutilized because of the dynamic behavior of network traffic. To address this, the Cloud Radio Access Network (C-RAN) architecture has been developed as a 5G solution to simplify the management and control of future mobile networks. However, the cost and energy consumption of C-RAN may potentially rise owing to the anticipated dense deployment of Remote Radio Heads (RRHs).

Motivated by the importance of energy-cost efficient wireless network, in this thesis, cost of network, power consumption, throughput, energy efficiency, and the numbers of active Base Band Units (BBUs) were studied considering stochastic nature of network traffic load profile and tempo-spatial behavior of renewable energy generation. This study deals with the energy efficiency (EE) performance of the network by varying system parameters like transmission bandwidth and different solar module capacity. This thesis carried out the study considering inter-cell interference, path loss model and load-dependent BS power consumption model that are responsible for affecting the system performance.

Thus, an initial study was conducted on a baseline power model for the architecture of traditional radio access networks. Because baseband processing power, cooling, and housing are shared in the cloud, the prior basic power consumption models are not applicable to C-RAN. Firstly, a power model for C-RAN is formed, allowing for the dynamic execution of the BBU-RRH mapping. It is suggested that a Cloud Server (CS) in the BBU pool monitor the load conditions of every BBU in the pool. Then, to lower energy usage on the BBU pool of the C-RAN architecture, a load consolidation method based on load conditions is devised. Secondly, a cost model is suggested in an effort to lower the C-RAN's overall cost. Thirdly, to improve the network's energy efficiency (EE), a hybrid powered C-RAN architecture and necessary energy usage algorithms are suggested. Finally, the performance of the proposed C-RAN has been thoroughly compared with some of the existing counterparts for further validations.

Keywords: Cloud radio access network, fifth generation, power consumption, renewable energy, hybrid power supply, energy efficiency, spectral efficiency, load consolidation, bandwidth aware, modified best fit algorithm, millimeter-wave fronthaul, cost analysis, cost-efficient.

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