Fronthaul Design in Cloud Radio Access Networks: A Survey

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Abstract—Cloud Radio Access Networks (C-RAN) was proposed as a solution to overcome the challenges faced by the current Radio Access Networks (RAN). C-RAN was introduced as a change in the architecture of the Base station (BS). Fronthaul is a communication link between the BS entities of the proposed architecture. The change in BSs' architecture places some technical challenges to utilize the benefits offered by C-RAN. Fronthaul capacity limitation and delay are the major bottlenecks of the C-RAN practical implementation. To prevail over these limitations, various C-RAN models in terms of functional splits are proposed. But none of the architectures is finalized among the industry and academia. In this paper, exhaustive literature is presented on the advantages offered by C-RAN architecture. To make full utilization of those advantages, different C-RAN architectures and fronthaul architectures were proposed. Fronthaul compression is crucial for bringing sustainability to C-RAN architecture. As part of the study, different compression techniques are discussed in this literature. Besides the theoretical study, various practical implementation of C-RAN testbeds is examined.

Index Terms—C-RAN, Fronthaul Compression, Resource Allocation, CoMP, Precoding.

I. INTRODUCTION

Data explosion in the era of smart-phones is skyrocketing. According to the Cisco report, the global mobile data traffic for 2016 became 7.2 exabytes per month, and it will increase 7-fold approximately by 2021 [1]. To support users' growing appetite for higher data rates, traditional Radio Access Network (RAN) has to improve its network throughput. The most prominent way to achieve high throughput is by deploying more Base Stations (BSs) for the densification of cell coverage [2]. But, each new BS deployment will increase the Total Cost of Ownership (TCO), which has to be bear by the Telecom Network Operator (TNO). The Average Revenue Per User (ARPU) for the TNOs is not increasing at the expected rate. There is a chance network cost may surpass the revenue if no remedial actions are taken. Traditional RAN has other drawbacks, such as resource sharing is not possible; resources are not effectively utilized as the BS is working all the time irrespective of load conditions, and the tidal effect problem [3]. To address the above challenges faced by traditional RAN, a change in architecture for BSs is proposed, which is popularly known as Cloud Radio Access Network (C-RAN) [4].

Under C-RAN, the traditional BS (eNodeB) is decoupled into two main components: 1) Remote Radio Heads (RRHs), 2) Base-Band Processing Units (BBUs) [5]. The RRHs include light-weighted Radio Frequency (RF) units and antennas to provide a wireless interface for User Equipment (UE).

Whereas the BBUs include all signal processing units and all functional blocks of L2 and L3 protocol stack, located centrally like data centers. The function split between RRH and BBU follows a fully centralized structure [6]. Fig. 1 depicts the architectural difference between traditional RAN and C-RAN [7]. Centralization of BBUs at the BBU pool has many advantages like feasibility of resource sharing, on-demand resource allocation, the possibility of implementing advanced technologies like joint processing and Coordinated Multi-Point (CoMP), etc. [8].
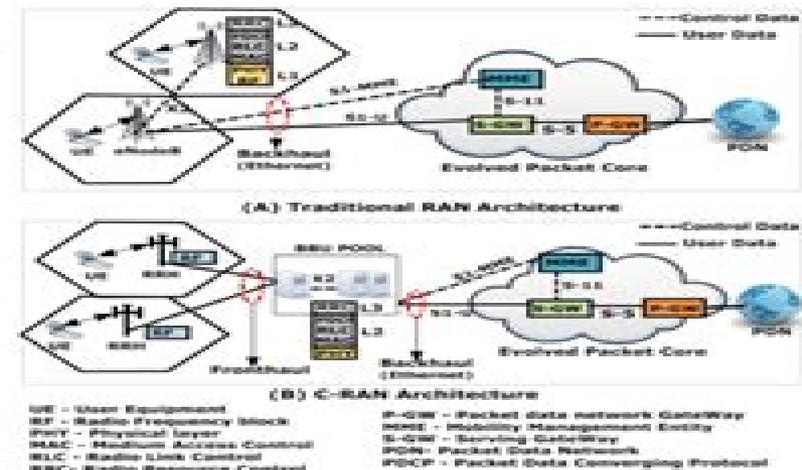

Figure 1. Architectural difference between traditional RAN and C-RAN. (A) traditional RAN architecture. (B) C-RAN architecture.

Due to the full centralized structure of C-RAN, there is a vast communication overhead between RRH and BBU. Being only RF section at RRH, I/Q samples are sent over the fronthaul to the BBU for further processing. The required fronthaul data rate is directly proportional to the number of antennas used at RRH, due to which the use of C-RAN in 5G with massive MIMO seems to be hypothetical [9]. There are two possible directions to address the above problem, which are fronthaul compression and baseband functional

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