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Prospects For the Implementation of Cloud Radio Access Network of Cellular Networks

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Abstract: Today, many mobile operators are facing a number of challenges in expanding their Radio Access network infrastructure due to rapid technology upgrades and rising device prices. For operators, it is important that expand of their radio access network in order to meet the needs of users, improve network coverage, and reduce network overloading. Cloud RAN architecture is considering as a priority direction of development of radio access network of next generation cellular networks. This article focused on prospects of implementing Cloud RAN.

Key words: Radio Access Network, Remote Radio Unit/Head, Base Band Unit, virtual Base Band Unit Pool, Medium Access Control, Virtual Machine, Virtual Network Function.

The Radio Access Network (RAN) of traditional cellular networks is commonly consist of stand-alone base stations which process and transmit wireless signal on behalf of mobile phones and forward their data to the core network through backhaul connections. Over the years, the RAN architecture has evolved from the all-in-one base stations to distributed base stations, which separate the radio function unit (a..k.a., Remote Radio Unit/Remote Radio Head or RRU/RRH) from the digital function unit (a.k.a., Base Band Unit or BBU). Baseband wireless signal is carried over fiber links between RRU and BBU which give possibility their physical separation (e.g., by a few kilometers). In distributed base station architecture, BBU performs the antenna array system functionality and the physical and MAC layers and RRU obtains and converts the wireless signal and amplifies the power.

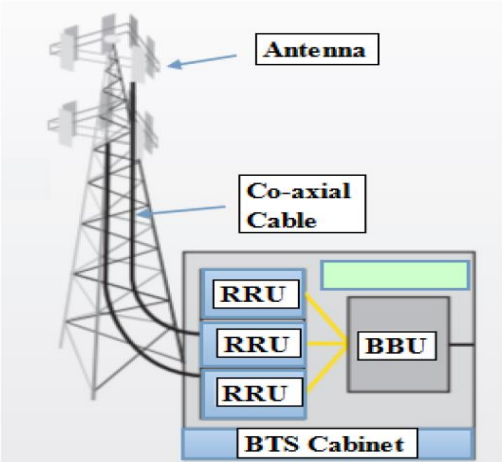

Fig. 1 Distributed base station of cellular networks.

The RAN architecture currently in use exist a number of limitation. They are followings: cellular operators provide their base stations to handle the maximum expected network load, but often not consider traffic fluctuation over time. Therefore, the processing power of base stations is usually not fully utilized. However, it is impossible to share the processing resources among them because base stations are geographically dispersed. Moreover, base stations require their own backhaul transmission equipment, environment surveillance system, cooling system and backup battery, which in turn need large space to host them.

By virtualizing BBUs in data centers as a Cloud RAN can notably reduce the operation, computing, energy and real-estate cost for cellular carriers and enlarge effectivity of RAN. Network virtualization is a significant technique for the C-RAN architecture. The virtualized infrastructure manager deploys a pool of

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virtual BBUs. The cell site simplifies to antennas, Remote Radio Heads (RRHs), and switching functions. The switching functions interconnect the virtual BBUs to the RRHs via high-speed optical links to meet latency requirements. According to traffic demand, the Virtual Network Function (VNF) Manager allocates BBUs to active cell sites and programs an overlay virtual network to switch traffic flows from the cell site's RRH to the Virtual Machines (VMs) hosting the allocated BBU.

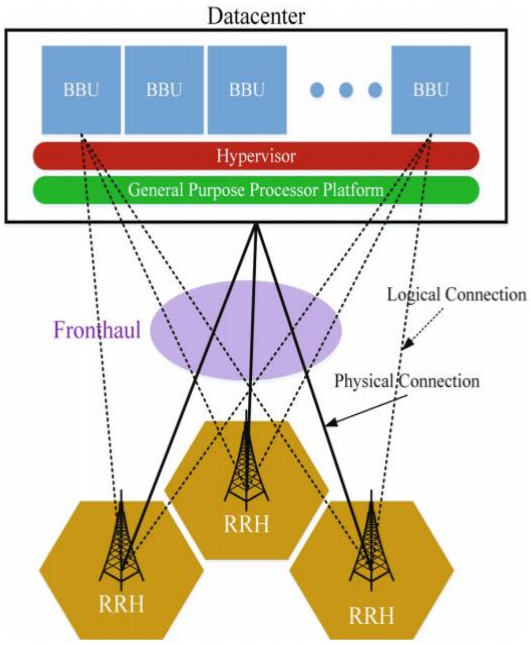

Figure 2. C-RAN architecture

The BBU pool operates over a set of hardware platforms such as a Network Interface Card (NIC), memory and Central Processing Unit (CPU). Moreover, the virtualization technology is implemented in C-RAN by operating systems such as a Linux. The BSs functions are simulated as software, called the vBSs. The requirements of virtualization are customization, efficient resource utilization, and isolation. [1]

There are two main approaches of splitting base station functions between RRH and BBU within C-RAN in order to reduce transport network overhead:

1. **Full Centralization:** In the fully centralized solution, L1, L2 and L3 (physical layer, the Medium Access Control (MAC) and the network layer) functionalities reside in the BBU Pool. In this case, the BBU implements all managing and processing functions of the traditional BS.
2. **Partial Centralization:** In partially centralized solution L1 processing is co-located with the RRH, thus reducing the burden in terms of bandwidth on the optical transport links, as the demodulated signal occupies 20 - 50 times less bandwidth [2] than the modulated one. This solution is however less optimal because resource sharing is considerably reduced.

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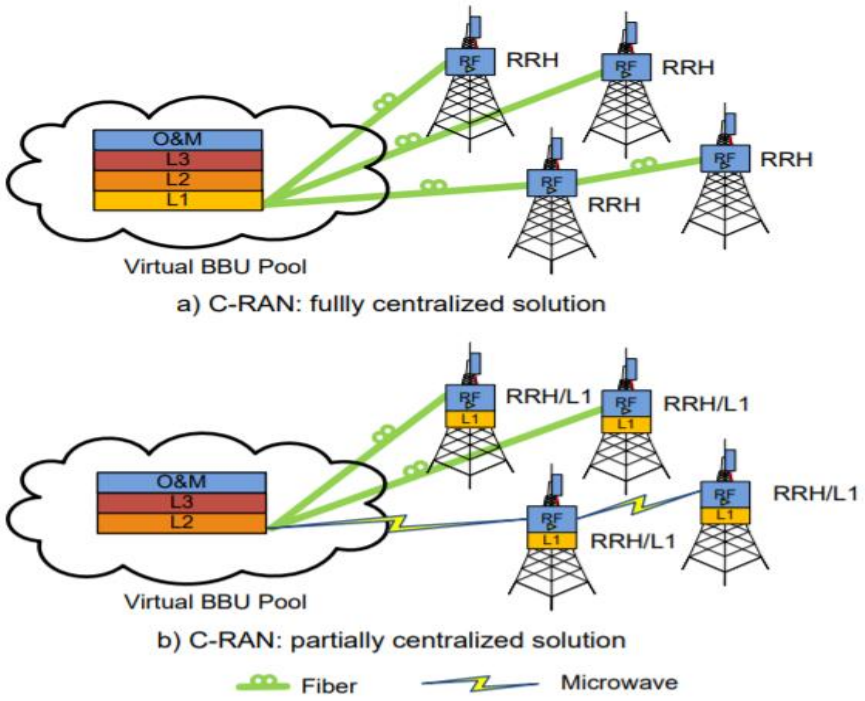

Figure 2. Main solutions of splitting base station functions between RRH and BBU within C-RAN

In C-RAN architecture, the fronthaul link can be wireless or wire, It is expected that future wireless fronthauled by wireless links cannot meet the demands of increasing of data rate. Therefore, High optical fiber fronthaul link is proposed instead of wireless fronthaul to provide the required data rate for the next generation cellular network.[3]

By centralizing and virtualizing the BBUs, Cloud RAN can significantly reduce the operation, computing, energy and real-estate cost for cellular carriers, thanks to easy software/firmware upgrades, fewer site visits and lower site space leasing cost. Capital expenditures (CAPEX) savings stem from the fact that a single virtual BBU can serve traffic from multiple cell sites. Thus, the total number of required BBUs depends on the maximum traffic of the network rather than the maximum traffic of each individual site. Operating expenses (OPEX) savings stem from the fact that the energy consumption of the whole system depends only on the average number of active BBUs, which depends on the average network traffic rather than on the average number of active cell sites. Moreover, a C-RAN system can run multiple independent vBBUs at the same time on one physical server, which has many benefits such as, hardware resources saving, effective server integration and cost reduction. Multiple vBBUs can share the common resources, involving hardware and software systems, which provides effective and flexible utilization. Within the vBBUs, many operators can share programming, network environments and IT platforms.

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