Emerging Trends in Mobile Communications

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1 Centralized-RAN

Technology offers us a unique opportunity, though rarely welcome, to practice patience.

(Lokos, *Patience: The Art of Peaceful Living*)

1.1 Introduction

Global mobile data traffic is increasing at a substantial rate. It is estimated by cisco, (*Global Mobile Data Traffic Forecast Update, 2017-2022*) that it will grow seven fold from 2017 to 2022, with cell network advances and cut off in data price. To satisfy the consumer demands the network capacity is to be increased. It can be done by adding cell sites or by implementing the techniques like Multiple Input Multiple Output(MIMO). But increasing cell sites requires high capital investment and also results in increase in interference.

1.2 Architecture

1.2.1 Traditional Macro Base

In the traditional architecture(Figure 2a), radio and baseband processing is done inside a base station. The antenna module is generally located near the radio module, coaxial cables are used to connect them, signal loss associated with them is high. This architecture was popular during 1G and 2G mobile networks.

1.2.2 Base station with RRH

In the Remote Radio Head (RRH) architecture(Figure 2b), the base station has two components namely, a radio unit and a signal processing unit. The radio unit is called a RRH or Remote Radio Unit (RRU). The signal processing part is called a BBU or Data Unit (DU). This architecture was introduced during 3G networks and right now the majority of base stations use it.

The distance between a RRH and a BBU can be extended up to 40 km, where the limitation is coming from processing and propagation delay. In this architecture, the BBU equipment can be placed in a more convenient place, enabling cost savings on site rental and maintenance compared to the traditional RAN architecture. RRHs can be placed up on poles, leveraging efficient cooling and saving on airconditioning in BBU housing. One BBU can serve many RRHs. RRHs can be connected to each other in a daisy chained architecture. Common Public Radio Interface (CPRI) is the radio interface protocol widely used for IQ data transmission between RRHs and BBUs.(Figure 1)

1.2.3 Centralized base station architecture, C-RAN

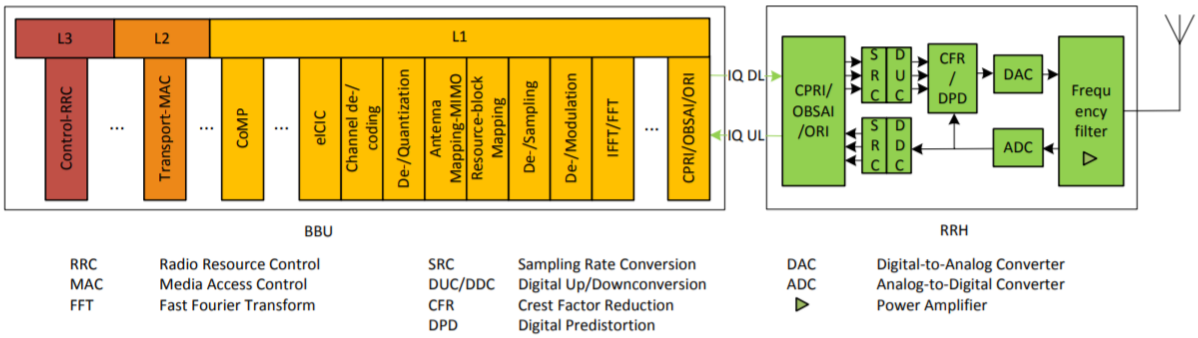

Figure 1: Sub modules of BBU and RRH. Source: (Checko et al., *Cloud RAN for Mobile Networks - a Technology Overview*)

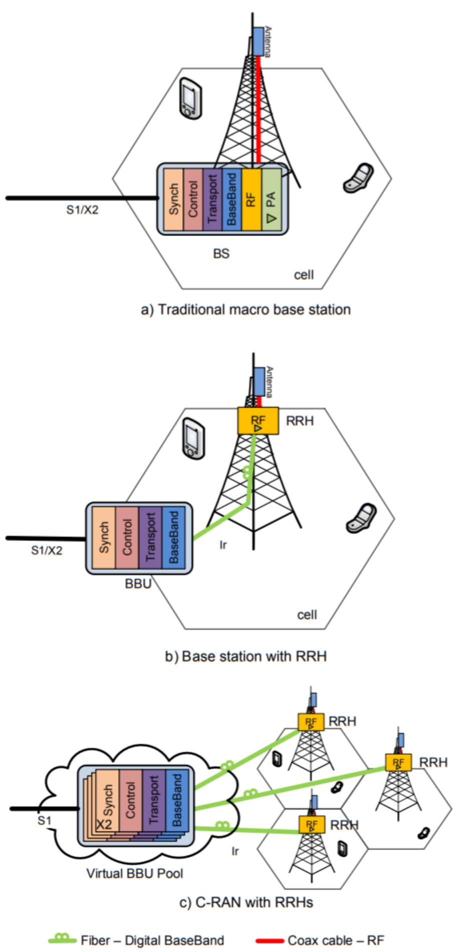

Figure 2: Base station architecture evolution. Source: (Checko et al., *Cloud RAN for Mobile Networks - a Technology Overview*)

In C-RAN(Figure 2c), in order to optimize BBU utilization between heavily and lightly loaded base stations, the BBUs are centralized into one entity that is called a BBU Pool. A BBU Pool acts as a virtualized cluster to perform baseband processing. The concept of C-RAN was first introduced by IBM under the name Wireless Network Cloud (WNC) and builds on the concept of Distributed Wireless Communication System. Since then various companies exploited the architecture and proposed improvements.

Figure 3 shows an example of a C-RAN mobile LTE network. The fronthaul part of the network spans from the RRHs sites to the BBU Pool. The backhaul connects the BBU Pool with the mobile core network. At a remote site, RRHs are co-located with the antennas. RRHs are connected to the high performance processors in the BBU Pool through low latency, high bandwidth optical transport links. Digital baseband, i.e., IQ samples, are sent between a RRH and a BBU.

1.3 Advantages

Energy Efficient and Cost-saving With centralized processing, the number of BS sites can be reduced. Thus the air conditioning and other site support equipment's power consumption can be largely reduced.
As the BBU pool is a shared resource among a large number of virtual BS, it means a much higher utilization rate of processing resources and lower power consumption can be achieved.

Capacity Improvement In C-RAN, virtual BS's can work together in a large physical BBU pool and they can easily share the signaling, traffic data and channel state information (CSI).

Adaptability to Non-uniform Traffic C-RAN is also suitable for non-uniformly distributed traffic due to the load-balancing capability in the distributed BBU pool.

1.4 Challenges

Bandwidth, Latency and Jitter C-RAN brings a huge overhead on optical links between RRH and BBU pool as shown in figure 1. The transport network not only needs to support high bandwidth and be cost efficient, but also needs to support strict latency and jitter requirements.

BBU cooperation, interconnection and clustering There is a need to improve the performance between BBUs. Cells should be optimally clustered to be assigned to one BBU Pool, in order to achieve statistical multiplexing gain, facilitate CoMP, but also to prevent the BBU Pool and the transport network from overloading.

Virtualization technique A virtualization technique needs to be proposed to distribute or group processing between virtual base station entities and sharing of resources among multiple operators. Any processing algorithm should be expected to work real time - dynamic processing capacity allocation is necessary to deal with a dynamically changing cell load.

1.5 C-RANs towards 5G

It is envisioned that 5G will bring a 1000x increase in terms of area capacity compared with 4G, achieve a peak rate in the range of tens of Gbps, support a roundtrip latency of about 1 ms as well as connections for a trillion of devices, and guarantee ultra reliability.

The field trials conducted by China Mobile have verified the throughput gain brought by C-RANs based on an uplink LTE model, reaching up to near 300%. Through dense RRHs in C-RANs, massive connections are efficiently supported, and it is not hard to provide good service for trillion of devices if the density of RRHs is sufficiently high. Although a big gap is still observed compared to 5G requirements, the result has shown the potential advantages of C-RANs. Meanwhile, different advanced techniques can be involved in C-RANs to further improve the spectrum efficiency.

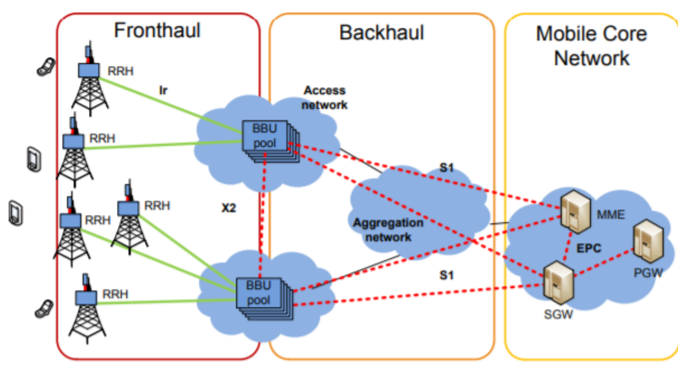

Figure 3: C-RAN LTE mobile network. Source: (Checko et al., *Cloud RAN for Mobile Networks - a Technology Overview*)

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