Implementing Cloud Radio Access on a Multi-Core System

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Implementing Cloud Radio Access on a Multi-Core System

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Abstract—In this article, we propose the implementation of a Cloud Radio Access Network (C-RAN) on a multicore unified device that facilitates the processing of multiple distributed antennas in the base band. In order to decrease their runtime, we present a parallel processing model based on both functional and data decomposition of virtualized Base Band Unit (BBU) functions. We are investigating two parallel running BBU work scheduling techniques, where computational resources can be distributed by user equipment (UE) or by code blocks (CB). We implement a batch queuing model by using data obtained while running an open source RAN code to determine the necessary processing power in a data center while following tight latency criteria in the downlink and uplink directions. When processing a hundred LTE-cells in a multicore device, the proposed model is validated by simulation. The findings provide useful advice on the sizing and implementation of Cloud-RAN applications such as cryptography [9].

Index Terms—Cloud Radio Access Network, LTE, multicore device.

1 Introduction

The goal of Cloud Radio Access Network (C-RAN) is to centralize the processing of the baseband of the radio signal coming from various antennas in CO or from cloud storage [11]. In other words, C-RAN dissociates antennas (Radio Remote Heads (RRHs)) and signal processing units (BBU) [2], [3], [6], [7]. The C-RAN can be thought of as a BBU pool that processes tens or even hundreds of cells (eNBs). The site usually consists of three sectors, each equipped with an RRH. The RRH has two downlink RF paths and uplink radio signals that are transmitted over the BBU pool [14]. From a simulation point of view, each antenna (RRH) represents a source of jobs in the upstream direction, while for the downlink direction, jobs come from the base network, which provides connection to external networks (for example, the Internet or other service platforms, such as Wireless Sensor Networks [22]). Then there are two queues of jobs for each cellular sector, one in each direction. Since the time budget for processing downlink subframes is half that of uplink subframes, they can be performed separately on dedicated processors.

In this article, we take a probabilistic modeling approach. We count the number of BBUs allocated in a multicore system. We simulate how various BBU processing tasks are invoked, and we use the data observed when running the Open Air Interface (OAI) open source RAN to tune the parameters of our proposed model.

2 Methodology

The results show that the uplink direction is the dominant processing load and requires splitting and / or acceleration.

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Figure 1. C-RAN infrastructure with multi-mode support.

The encoding and decoding function is the most time consuming with high variability. Also found that containerized approaches provide better performance than hypervisor based approaches. However, the only way to improve C-RAN performance in terms of latency is to avoid decomposing heavy, long tasks into smaller, concurrent tasks. The C-RAN model is illustrated in Figure 1. Modeling principle is as follows:

1) Simulation of data processing. From a simulation point of view, each antenna (RRH) represents a source of jobs in the upstream direction, while for the downlink direction, jobs come from the core network, which provides connectivity to external networks (for example, the Internet or other service platforms). Then there are two queues of jobs for each cellular sector, one in each direction. Since the time budget for processing downlink subframes is half that of uplink subframes, they can be performed separately

on dedicated processors [15], [16].

2) Parallelism from the UEs. In LTE, multiple UEs can be served in a 1 millisecond subframe [1], [5]. The maximum and minimum number of UEs scheduled per subframe are determined by the bandwidth of the eNB. LTE supports 1:25, 2: 5, 5, 10, and 20 MHz scalable bandwidth [4]. In a subframe, each scheduled UE receives a TB (namely, a radio resource group in the form of an RB) for either transmission or reception. For example, when considering a 20 MHz eNB, there are 100 RBs available [21]. According to LTE, the minimum number of RBs allocated to a UE is 6. Therefore, the maximum number of connected UEs per subframe is defined as $b = \lfloor 100/6 \rfloor$. TBs are determined by the radio scheduler of the individual radio bearer function of the UE as well as the amount of traffic in the cell [17].

3) Parallelism CBs. In LTE. When the TV is too large, it is broken down into smaller data units called CBs. Assuming the CB time processing is exponential with the mean, we again get the $M[X] / M / C$ model, where batch size is the number of CBs in TB. If this number is geometrically distributed, the service time TB is exponential, as assumed above. The key difference now is that the individual CBs are processed in parallel by the C cores. The scheduler can allocate the core of each CB due to more granular decomposition and TB [18].

4) There is no parallelism. If TB or CB processing is not parallel, scheduling is based on subframes. A multi-core system where subframes arrive according to a Poisson process, we are forced to consider $M/G/C$ in the system queue [12], [13]. Making exponential assumptions about service times of CB and TB, and assuming the geometric number CB in TB, we get the $M/M/C$ queue [19].

3 Conclusion

We examined the performance of virtualized baseband functions when using parallel processing. We have specifically estimated the processing time for LTE subframes in the C-RAN system. To reduce latency, we investigated the functionality and decomposition of these BBU functions, which results in a batch arrival of parallel running jobs with non-deterministic execution times.

To estimate the required computing power to support the C-RAN system [8], [10], we introduced a mass arrivals queue model, namely the $M[X] / M / C$ queueing system, where the lot size follows the Geometric distribution. The variability of edge delay and job execution time is determined by the distribution of arrivals and services, respectively. Since the execution time of the LTE subframe becomes the residence time of the batch, we obtained the Laplace transform of this last quantity, as well as the probability of exceeding a certain threshold to meet the LTE timeline.

In future work, we will explore the applicability of the proposed model for future 5G smart phones [20].

4 Conflict of Interest

The authors declare no conflict of interest.

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Figures

Figure 1

C-RAN infrastructure with multi-mode support.