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Research paper

Network Efficiency Amendment Utilizing Cloud Radio Access Network In Mobile Communications

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Abstract

Mobile data traffic is finding exponential growth currently in telecommunications industry. It has become important to concentrate on both spectral and energy efficiencies in utilizing cellular networks under green communication standpoint. Thus, for 5G the utmost priority is that to increase data traffic and reduce the total network energy ingesting by half. The proposed work is to design the Cloud Radio Access Network (C-RAN) with energy efficient, flexible and capacity-enhanced features by effectively bundling and establishing relation between BBU and RRU utilizing Catechistic technique. Mathematical results with realistic parameters prove that the projected optimization design clearly improve the energy efficiency of C-RAN's compared to standard schemes.

Keywords: *Bundling up, Catechistic algorithm, Data sharing, Energy efficient, Mapping RRH and BBU*

1. Introduction

It is predictable that the supplies for high speed mobile networking including high quality video streams, social networking and machine to machine communication will increase in hundreds times by 2020. This can be due to the increase of mobile users besides the high expectation to get higher quality of services. In addition, such growth will come in parallel with the promising 5G cellular networks to handle all network traffic and provide high quality services. In order to reflect such growth, operators such as AT&T and Telecoms will need to modify their infrastructure to handle such increase in the number of users and services expected. This can cost operators a lot in terms of capital and operating expenses which are expected to grow exponentially in such cases. On the other hand, the revenue of such operators is decreasing as they are mostly experiencing low growth in their incomes.

The division of the cellular networks that requires being adapted to handle such growth is called Radio Access Networks (RAN). RAN included base stations and users associations wirelessly to the system in addition to handling user signaling and managements. This is noticeably taking the maximum costs in such systems as base stations operation and organization get actually difficult and charge huge. Additionally, to answer user's growth and necessity, additional base stations will need to be operated in the same area so that a base station does not get congested. Though, having additional base station will bring in the difficulty of base stations synchronization so that they will not influence each other. The system will become progressively difficult in requisites of physical operation and synchronization. Furthermore, the charge of such system will be much more such that no operator will be able to handle such cost and hence a better cost efficient resolution required to be planned.

And so forth, Cloud Radio Area Networks (C-RAN) [1] was first introduced by China Mobile in 2009 to house such expansion in mobile communications. It is a new mobile structural design that has the prospective to manage as many base stations as the network. In C-RAN, the baseband and channel processing is visualized and shared among operators in a centralized baseband puddle. Such systematization and sharing allows for more lively traffic handling and improved consumption of resources including base stations stationing. Such structural design would have the potential to reduce the operating cost as base stations are visualized instead of actually stationing in all areas. Adding up, it reduces the energy and power consumption compared to conventional networks due to the reality that base stations will be deployed on the same physical device.

The main thought behind C-RAN is to split down the traditional base station into a digital utility unit, known as the Baseband Unit (BBU), and an economical radio utility unit, known as the Remote Radio Head (RRH). While RRHs are disseminated across many sites, BBUs are shared in a cloud data center. Further, RRHs are associated to BBUs through high-performance optical front haul links. RRHs only have fundamental broadcast and reception functionalities, but BBUs handle figuratively intensive baseband processing. Traditionally, each BBU is assigned to one RRH. In this setting, radio and computing resources, dimensioned for the peak-load conditions, are exclusively dedicated to one RRH. This leads to unproductive resource consumption, predominantly at low-load environment [2]. On the other hand it is promising to accomplish numerical gain by clustering RRHs adequately. Naturally as a utility of network load environment, a one-to-many logical bundling may be realized, such that RRHs pool the resources of one single BBU, increasing network energy efficiency

2. Related Work

Generally, the Energy efficiency can be calculated by means of power utilization standard (watts/unit area) [3]. But commonly accepted standard is the percentage of the network throughput and the total power consumption (bits/Joule) [4], [5], [6]. To perk up the network efficiency, there are several options of increasing the data rate, or decreasing the RRH transmit power, or turning off the RRHs, bundling the RRH and BBU effectively or reducing the front haul rate for power cutback, and also by implementing any combination henceforth.

Amongst the roundabout approaches, [4] sets the user rates and convert the energy efficiency gain difficulty into a power minimization crisis. Even if data-sharing and compression methodologies are considered, the partial front haul capability constraint is not considered. The effort of [7] captures a diverse power minimization idea for downlink C-RANs under the data-sharing methodology, where in users are split into several groups. Applying the arbitrary matrix assumption, [6] ideates heuristic user association (UA) methods that maximize the corresponding energy efficiency under data sharing. Conversely, the proposal of [8] openly increases the energy efficiency using the compression-based strategy. Nevertheless, in [8] the data-sharing condition and the power consumption at the front haul links are not addressed. It is significantly clear that the abovementioned proposals focus on single-hop transmission networks only, while a realistic BBU is normally connected to RRHs via a number of routers over a multi-hop front haul network [9], [10]. Recent works in [9] try to increase the network throughput of a downlink multi-hop C-RAN, where network programming is considered important to utilize the front haul associations in the multi-hop transmission. Conversely, the maximization of energy efficiency has not yet been achieved.

Furthermore, RRH grouping has been projected, in the journalism, for many reasons. In [11], the authors propose a lively clustering to introduce inter-cell cooperation. RRHs that are mapped to one BBU concurrently broadcast the similar signal. This makes the most of the system effectiveness. The authors in [12], bring in clustering to capitalize on user fulfillment. Signaling consignment is bargained, without negotiation on user quality of service. They also improve network energy utility, uttered through the number of dynamic BBUs. In [13], the proposal is on a active channel allotment. They actively transform the BBU-RRH relation, when non-interfering channels are allotted to adjacent RRHs. The projected resolution has a straight impact on network's energy efficiency. But, we consider that efficiency could be even more improvised using other optimal algorithms and the network utilities better used.

This paper concentrates on the C-RAN downlink with an ability of multi-hop and capacity-limited front haul transmission. The intention is to directly maximize the network energy efficiency by BBU-RRH bundling using Catechistic technique, in order to enhance radio resource utilization and power consumption. We not only depend over the number of dynamic BBUs, but also assume a power minimization replica to closely examine the impact of bundling up the RRH on network efficiency.

The rest of the paper is structured as follows: Section 3 describes the system model under consideration. Section 4 introduces our Catechistic algorithm, while section 5 put together and explain the optimization solution for the data-sharing strategy. Performance evaluation is presented in section 6. Section 7 concludes the paper.

3. System Model

We consider a Cloud Radio Access Network topology which comprised of Primary Users (PU), Secondary Users (SU), Radio Resource Head (RRH) and Primary Base Station (PBS) /central base band unit (BBU). Fig. 1 and Fig 2 demonstrate the downlink of a common C-RAN representation with multi-hop and single-hop links, where the baseband unit (BBU) in the hub network connects to a set of m RRHs $rr\square_1, \ldots, rr\square_m$, via a front haul network of R routers and N noiseless front haul links [4], [9], [14], The objects are the RRHs with different average demands $\delta_1, \ldots. \delta_m$ and the BBUs are the containers with a highest Capacity limit, ε. Focus to the BBU maximum capacity and to the environmental adjacency conditions, the BBU-RRH relation must be established in such a way to decrease the number of lively BBUs, while affording the equal level of Quality of Service as that of a one-to-one relationship. There exists a neighboring relation, given by $m_{ij} = 1$, between m_i and m_j when they are geographically nearby. While they have no sharing border, $m_{ij} = 0$.

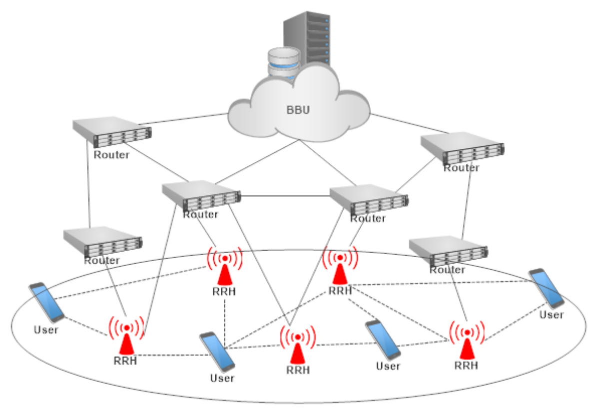

Fig. 1: A general C-RAN structure with multi-hop links

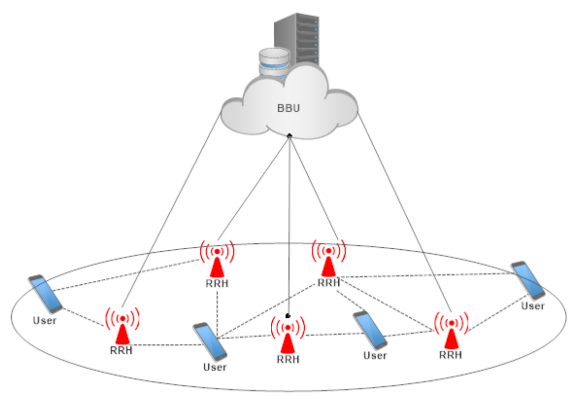

Fig. 2: A general C-RAN structure with single-hop links

4. Catechistic Algorithm

Inspired by the Agglomerative Hierarchical Clustering (HAC) algorithm, we propose an algorithm that attempts to fill up all vacant, such that channel bandwidth is utilized to the fullest. The individuality of our algorithm, in comparison with the HAC strategy, is that it takes into concern the physical adjacency restriction. Algorithm 1 describes our catechistic method. We indicate by m set of RRHs, δ their load/demand, ϒ set of resource blocks in RRH and ω be the cluster set.

Algorithm follows the below steps

1. Get the demands δ of all RRHs
2. Select the RRH with largest demand δ(max).
3. Collect the neighbors of high demand RRH based on the distance ε and their corresponding loads δ.
4. Among the neighbors, find the RRH with least demand δ(least)
5. Check whether the sum of high demand and least demand not exceeds capacity of BBH,
6. Repeat the bundling till the above condition is over ridden.

Algorithm 1: Catechistic algorithm

1 Assign δ_m to ΄ϒ
2 Initialize ω to m
3 Continue
a. Arrange δ_m
b. Select RRH $rr□_{max}$with largest demand δ(max)
c. Assign δ □with δ_{max} and $rr□_{max}$with M'
d. Choose all RRH satisfying ε_{ij}=1
e. Select δ_{min} and assign to δ_l,
f. Now check if ε >= δ□ + δ_l then,
g. club $rr□_{min}$ with M'
4 Else
5 $\delta_{min} - \delta_l$
6 Select next lowest δ and perform from e
7 Until ΄ϒ is not void

5. Optimization Solution for the Data-Sharing Strategy

With the data-sharing methodology, users' anticipated signals are transmitted by the BBU to a selected set of RRHs which then considerately execute pre-coding and transmit the coded signals to the users [4], [9], [14]. Below are the mentioned phases of the established communication.

- **Data broadcast with Network programming at BBU**

For data transmission, every router will copy and transmit onward its received data to the adjacent routers, or use a type of coding to create encoding and decoding messages for the information transmission [15]. As given in [16], the copy-and-forward method is not the best while the coding operation at routers achieves highest capacity. In [9], the proposal utilize a network coding strategy that consists of a routing plan and a code transfer to decide the rate and substance of each flow of data being transmitted across the network. The proposal of [17] shows that interference coding only offer minimal output gain over self-determining coding. Hence, this paper presumes that multicast transmission is routed and coding is done independently.

- **Signal programming and broadcast by RRHs**

In receipt of the message from all sessions via the multi-hop downlink network, an RRH generates a baseband signal. The RRH is subjected to the average transmit power. Flat-fading channel from RRH remains unaffected during the transmission and are accessible at the BBU and RRHs [9] [18].

- **User relationship and RRH stimulation at Radio Access links**

An RRH is always dedicated to serve a user if and only if the corresponding coder of the message symbol is not a zero matrix and assures that no user is allotted to a dormant RRH.

We try to increase the network energy efficiency which is given as the ratio of the achievable sum rate/ network throughput and the total power utilization. The optimization solution for the multi-hop C-RAN with the data-sharing method is planned as follows.

$$P_{optimal} \triangleq \frac{R_{sum}}{P_{total}}$$

6. Performance Evaluation

From design perspective, we utilize a network topology made of 10 primary users, 25 secondary users and 1 primary base band unit. Every RRH is imitated with 2 antennas and each user with 1 antenna for communication. The snooze mode and the lively mode of each RRH utilize 56W and 84W of power, respectively. NS3 Simulations are performed for various load/demand conditions, like low, medium, and high load environment. The LTE parameters and the adopted parameters used in our numerical examples are listed in table I. 16-QAM modulation scheme is assumed to be utilized. Performance results are averaged and shown with 95% target.

Table I:

PARAMETERS	VALUES
Coverage Distance between RRHs	5km
Total Bandwidth	20MHz
Max RRH transmit power	24dBm
Data Rate	100Mbps
Inter packet interval	100ms
Resource block duration	0.5ms

The operational or network efficiency of radio resources are defined as a function of average RRH load/demands. It is proposed as the ratio of the entire number of used resource blocks in all RRHs to the number of operating BBUs.

From graphical results Fig. 3 and Fig 4, we infer that at low demand criteria, the operational efficiency of resources is achieved to be almost 80% with bundling RRH.

And at intermediate demand, the operational performance has similar numerical as for low demand conditions with bundling RRH. It illustrates that the projected algorithm performs much better than the standard methods in terms of the energy efficiency. To conclude, the bundling of RRH and establishing proper data sharing strategy has a huge impact on the number of operating BBUs, henceforth reducing network power consumption without compromising user Quality of Service (QoS).

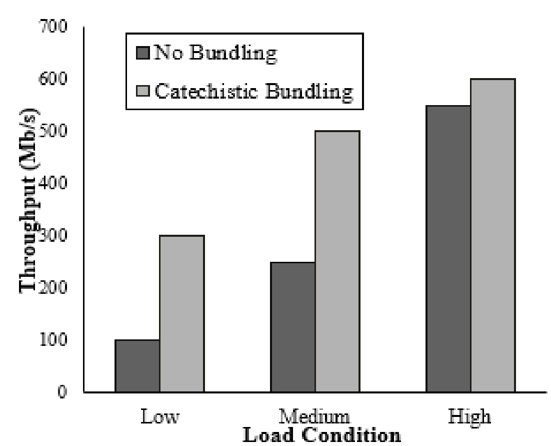

Fig. 3: Various Load Conditions Throughput for non bundling and Catechistic Approach

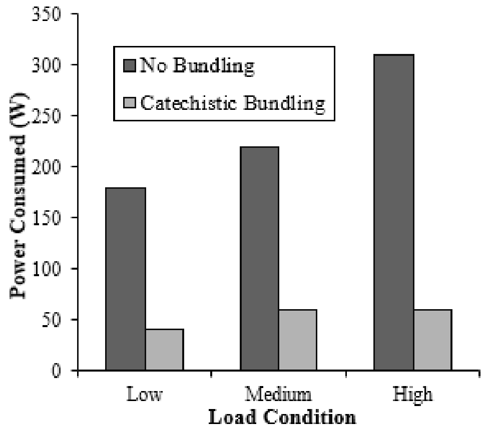

Fig. 4: Various Load Conditions Power Consumed for non bundling and Catechistic Approach

7. Conclusion

In this paper, we have addressed the RRH bundling using catechistic strategy in Cloud Radio Access Network and presented optimal solutions. Our effort initiated important advancement on energy efficiency and operational efficiency, at low and intermediate demand conditions, without concession on user quality. The planned proposal offers optimal performance optimal solution, at low and medium load conditions, with reduced computational difficulty. As future work, we propose to incorporate the inter-cell interferences and handover issues and study their impact on the RRH bundling.

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