Energy Efficient Resource Allocation and Utilization in Future Heterogeneous Cellular Network

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***Abstract*—Future Mobile Heterogeneous Cellular Networks are emerging as promising technology in terms of high speed, low latency and ubiquitous connectivity. Providing energy efficient services in exponentially increasing user size and rigorous utilization of mobile services is a key challenge for mobile operators. The mobile operators deployed dense small cells to enhance the network capacity for providing the network services to maximum users. Instead of fully utilize of the existing deployment, operators leads to enhance the number of small cell base stations to enhance the network coverage. When the number of small cells increases, the energy consumption of the cellular network also increases. Thus a resource efficient, cost effective and energy efficient solution is required to control the deployment of new base station that consequently enhance the energy efficiency. In this paper, an efficient resource allocation and utilization model is proposed using Cognitive Fusion Centre (CFC). Where the CFC has Resource State Information (RSI) of the network resources and manages the free available resources. It helps in generating resource segment to facilitate the incoming users at peak hours. The propose solution can be deployed to any dense environment for maximum resource utilization.**

***Index Terms*—HetNet; Resource Allocation; Cognitive Fusion Centre (CFC); Efficient Resource Utilization.**

I. INTRODUCTION

The aim of Future Mobile Heterogeneous Cellular Networks(FMHCN) is to provide ubiquitous connectivity for any kind of devices and any kind of applications that may benefit from being connected, which may require 1000-fold more capacity, extreme low-latency (under 1 ms), and low energy consumption (90% reduction) for trillions of devices [1]**.** The traffic demand in cellular network is increasing rapidly, forcing mobile operators to provide larger capacity to serve more users. Therefore, the number of base stations (BSs) has increased dramatically. When the number of BSs in Wireless Heterogeneous Cellular Network (WHCN) increases, the energy consumption will also increase. It is proven fact, that increasing number of BSs is directly proportion to the energy consumption of the network, thus effecting energy efficiency of BSs [2], [3]. To realize the vision of essentially unlimited access to information and sharing of data anywhere, any time for any one and anything. In the FMHCN era, with a large number of BSs deployed, the energy consumption will increase tremendously. Therefore, the cost-effective, flexible, and energy efficient solution becomes one of the most urgent and critical challenges in the design of Heterogeneous Cellular Networks (HCNs) [4]. Traditionally, macro cells and small cells usually operate on separate dedicated channels in the ultra-dense environment. This dedicated channel approach leads to resource underutilization because base stations may not be able to fully utilize their radio resource with fixed partitioning when the traffic load in the network is fluctuating [5]. With the tremendous growth in wireless traffic and service, it is inevitable to extend efficient utilization of available free resources to wireless networks [6].

In this paper, an energy efficient resource allocation scheme is proposed using Cognitive Fusion Center (CFC), where CFC generates the segments of available free resources. In this proposed scheme a segment number is assigned to a user for getting resources. A Segment consists of radio resources such as spectrum, frequency, power and related hardware such as SBSs, routers etc. shown in Figure 1. The CFC generates the segments through segment generator of each available resources based on its Quality of Services (QoS) i.e. (energy efficiency). By Efficient Resources Allocation and Utilization (ERAU), large amount of the energy consumption can be saved significantly, and also will help in saving the cost of equipment's and its installation in WHCN. The proposed scheme consists of three layers. 1. Physical Network Resources Layer (PNRL), which includes all Physical Resources (PR). The PR consists of radio resources such as spectrum, frequency, power and related hardware such as SBSs, routers etc. 2. Cognitive Fusin Center Layer (CFCL), where manage and generation of all available free resources through segment generator. 3. Segment Cloud Layer (SCL), which is consists of all generated segments. The segment generation is done by the SG, which is the part of CFC at CFC layer. The simulation results show that a large amount of energy is saved compared to current baseline techniques. According to our information, we are the first to exploit the energy efficient resource allocation and utilization by CFC and segment generation to achieve low energy consumption and high-energy efficiency for WHCN.

Therefore, according to the next generation due to very heavy traffic load, we need the efficient resources allocation and utilization framework for base stations (BSs) and Radio Resources (RSs). Numerous researches done in area of cellular network resources utilization, but does not consider small cell network. Recently, some work has been done using small cell resource allocation and is referred as key component for achieving energy and spectrum efficiency [7] [8]. In [9] presented a scheme for spectrum sensing using cognitive radios that can make the radio sleep when not in use to save energy. It also employs fusion center where local informative decisions are made in terms of on or off. All of the operations uses logical AND and logical OR. But continuous sensing of spectrum requires higher energy making this technique computationally expensive. The author [10] presented a technique for relay and user selection that is energy efficient. It optimized scheduling keeping QoS requirements met. The scheme was based on three steps that are (1) first it did user scheduling then (2) relay scheduling and (3) it merged both scheduling results and achieved optimal scheduling. However, this scheme added computational overhead. [11] Uses an intelligent database for energy saving in small cell network. This network focuses on dense urban environment settings like shopping malls, train stations (both indoor and outdoor). The approach focused on keeping the information of usage and signal strength in database to take decision whether to turn on, off or sleep the BS. These stations are taken on traffic requirement thus making this scheme energy efficient.

The author [12] presented a small cell network topology management scheme for future network. The approach focused on sleeping or turnoff the BS in terms of traffic requirement. It also migrate the users to other BS in order to manage the load as well as keeping energy efficiency in place. This scheme proved theoretically to provide similar experience, but without applying the efficient utilization of free available resources algorithm. Green communication for wireless network is getting much attention where the focus is to minimize the transmission power while achieving QoS [13]. Energy efficiency (EE) is defined as ratio between consumed energy and throughput. EE is taken as most common metric towards achieving the green communication. It includes studies of optimizing MIMO system [14] optimizing the cell and usage of multiple cell for multiple user system [15]-[18] and work on reducing interference [19]. From [14]-[18] the presented techniques makes the basic assumption that channel state information (CSI) should be available at each node. Cloud based network architecture are being adapted as they can help in achieving green computing. In Distributed RAN (DRAN), the two units Digital and Radio exists at same premises. The Digital Unit is designed for peak hours but traffic on the DRAN is variable during whole day. Thus all of the energy is wasted for RAN making it incompatible for use in future communication. Cloud RAN or CRAN can achieve the aim by centralizing all data unit to single location cloud and only leaving radio at cell site. Thus saving tremendous amount of cost and resources in whole communication [20], [21]. In CRAN resources are made available in pools and resource from pool or set of pools can be allocated thus providing flexibility in configuration and allowing dynamic sharing of spectrum [22]. Energy efficient resource allocation is a major issue of cellular network. It is evident from research that major energy consumption happens due to a large number of small Cells and other radio resource.

To our knowledge very limited research has been done in the area of optimum utilization of resources in Wireless Cellular Network (WCN). Thus our research is focused on efficient resources allocation and utilization of SBSs, RBSs, other radio resources and spectrum in WCN. In order to address these challenges, this research presented the Energy efficient Resource Allocation and Utilization scheme that will play an important role in achieving high-energy efficiency.

II. SYSTEM MODEL

Consider an efficient resources model for saving as shown in Figure 1. The model comprises of three layers i.e Physical Network Resource Layer (PNRL), Cognitive Fusion Centre Layer (CFCL) and Segment Cloud Layer (SCL). PNRL includes all physical devices of network infrastructure and communicate CFCL through Physical Network Controller (PNC) and Cognitive Layer Controller (CLC). CFCL includes CFC and SG and communicate above layer with Cognitive Segment Controller (CSC). Consider a user try to request some physical resources (PR_1, PR_3) at peak hours. PNRL first see if the resource is available it will immediately allocate the resource to that particular user. In Case, if resources not available PNRL transfer the request to CFCL.CFCL will check the available resources within CFC. CFC maintains the updated resources segment information within the deployed infrastructure. CFC will send the RSI of free available resources to SG. The SG will generate the segments of available free resources and place. The generated segment in SCL and the number of Segment send to PNC through CLC.

According to author [23] energy consumption by a single BS is given as

$$E_{BS} = P_{BS} \cdot t. \tag{1}$$

where,

$$P_{BS} = P_{DP} + P_{AMPL} + P_{RU} + P_{COV} + \sum_{i}^{m} P_{AC_i} + \sum_{j}^{m} P_{LB_j} \tag{2}$$

where, P_{Dp}, P_{Ampl}, P_{RU}, P_{cov},$AC_i$and P_{LB} respectively, are power of digital signal processing, power of amplifier, power of radio unit, power of AC/DC converter, power of air conditioner i, power of lamp ‘j’ and ‘t’ is the operating time. The Units of Power and time Watt and Second respectively [24].

Instead of deploying another BS for resource allocation, the proposed model can be used to efficiently utilize the current resources. Thus, the proposed model can be beneficial for the network in terms of coast and energy efficiency.

The detail description of the proposed model is illustrated in Algorithm 1.

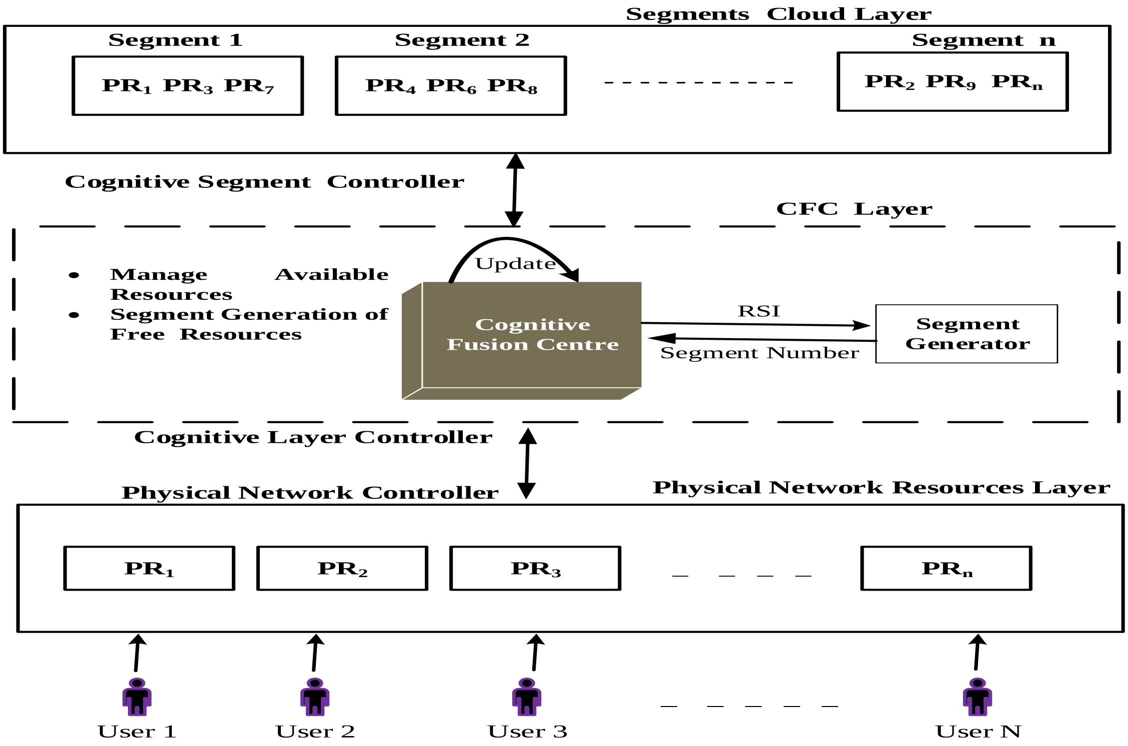

Figure 1: Efficient Resources Utilization Model for Energy Efficiency in HCN

Algorithm 1
Step 1: Request *REQ* from User *U* to *PR*
Step 2: *PR* forward to *PNC*
Step 3: *PNRL* collects *REQ* and send to *CFCL*
Step 4: *CFC* share RSI with *SG*
Step 5: *SG* Generate Segment and send Segment Number to *PNRL*
Step 6: *SG* also sends Segment to *SCL*
Step 7: *PNRL* send segment number to *PR* for *U*.

Initially a request *REQ* is send from user U to Physical Resource PR for allocation of resource. Each physical resource has its own resource state information that helps in efficient resource allocation, thus a bundled request as shown in following and is sent to PNC. While in step 3: PNC receives request from all resource and have to merge each and every request to be sent to SFSL for segment creation and allocation Where 'M' is to total number of resource request from users and 'N' are total no of resource state information received from resources. In Step 4, CFC run the function called as Gen_Seg that takes input of all request and generate the Segments against request. This method will return an array for that will contain all the segment information and user requests. The SG will take the request from CFC and will create the segments and will return segment number against each request. That will then move back to user telling allocation of resources.

III. Results And Discussion

In this Section, we compare the performance of our proposed ERAU model with conventional baseline RAC Method of [7]. We suppose when the number of users are increases 1000 – 10000. The Energy Consumption also increase due to increases of SBS in baseline, but in proposed ERAU not more increases due to efficient utilization of existing available free resources.

A. Energy Consumption Vs Traffic Load

In conventional WHCN, energy consumption is increased with increase in traffic load, as they are directly proportional to each other. Our proposed scheme ERAU efficiently reduces the energy consumption compared to conventional system by doing efficient resource utilization. It is evident from comparison that conventionally resources are mostly underutilized and new resources are added to cater the new demands while ERAU efficiently utilize the resource and does not require addition of new resource. Thus ERAU is energy efficient than traditional scheme.

B. Small Cells Increasing Vs Free Resources

During peak-hours, when the operators increases the number of small cells to enhance the network capacity. This means that using traditional technique there will be more free resources available. Thus, ERAU will outperform the traditional system by efficiently doing the resource utilization and even reducing the number of small cells or handling more users than traditional network. It will also outperform the traditional scheme in QoS as more free resources means larger segment size that means higher data rates.

IV. Conclusion

In this paper, an energy and resources efficient allocation and utilization wireless scheme investigated for HCN. The Simulation results proved that a large amount of energy consumption can be reduced by using ERAU model in wireless cellular network. There is a CFC, which creates segments through Segment generator for the user's accommodation. The work focused on minimizing the energy consumption in the upcoming wireless Heterogeneous Cellular Network. Therefore, by the implementation of efficient resource allocation and utilization, we can get high-energy efficiency. The large amount of energy very easily saved with high Quality of Service (QoS), when the traffic loads very high at peak hours. It helps in easy deployment with higher data rate of multiple-Gbps with significantly reduced cost and as comparatively to the existing scheme/models. Since the future 5G is still at infant stage, it is open up for future research area such as Device-to-Device communication using mm-Wave, Software Design Architecture.

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