Electricity Minimization Hassle For Usage Of Base Station Snoozing In H-CRAN-Cloud

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Abstract— In this paper, a electricity minimization hassle the usage of base station snoozing is proposed for heterogeneous cloud radio get admission to net- works (H-CRANs) deliberating the computing delay constraints. in the proposed machine, that's modeled the use of M/M/ok queues, the edge device coexists with the small base station (SBS) to offer computing competencies beside the principal cloud. In wellknown, the SBS sleeping is ruled by the provision of resources supplied the macro base station (MBS) that's in fee of accommodating offloaded customers from drowsing SBSs. but, switching off lightly loaded SBSs can impose significant burdens on cloud servers. right here, the proposed dozing scheme lets in SBSs serving extra computing obligations to stay lively to be able to fulfill the project of completion cut-off dates asked via mo- bile customers and to preserve the cloud reaction time within a predefined restriction. In different phrases, the proposed scheme ambitions to save power by mission a centralized choice of active and napping SBSs deliberating the delay constraints of both cloud and cellular devices. First, we con- sider a disjoint cloud-facet system, wherein computing services can be furnished via both the cloud or the threshold tool, and goal to limit the wide variety of energetic SBSs. The problem is formulated as a zero-1 knapsack problem with SBS usage considered as the weight whilst the ratio of computing duties to all incoming duties is considered because the cost of that SBS. on this trouble, that is solved the use of dynamic programming, SBSs processing much less computing obligations are given better values; and as a result, better threat to sleep compared to others. Secondly, a shared computing system is proposed whereby energetic SBSs (side devices) make a contribution to the overall computing functionality. here, an exhaustive search method is used to acquire the most suitable strength saving. We additionally proved that the shared computing device performs higher in phrases of response time compared to the disjoint gadget relying on the variety of lively SBSs.

Index Terms–H-CRAN, cloud-edge computing, energy, response time,M/M/k.

1 Introduction

Future cellular networks are characterized by their capability to satisfy the stringent needs of mobile users in regard with latency and data rate [1]. Due to the vast diversity of radio access technologies (RATs) deployed in heterogeneous networks (HetNets), the management of such networks is becoming more complicated and challenging. To this end, performing data aggregation from all network nodes in the centralized baseband unit (BBU) pool for processing, in the well-known architecture of heterogeneous cloud radio access networks (H-CRANs), can achieve huge success in this direction [2]. The remote radio heads (RRHs) and small base stations (SBSs) in H-CRANs are basically deployed to provide high data rates by exploiting the spatial reuse of frequencies. Meanwhile, macro base stations (MBSs) are in charge of providing cross-tier management such as user association, handover management, traffic flow, and network-wide coverage. In other words, SBSs belong to the data plane whereas MBSs belong to the control plane.

From the computing perspective, having the complex computing tasks such as computer vision and data analytics processed in the central cloud is a big step towards improving the computing performance for users and machines [3]. Nevertheless, the ever increasing number of connected devices in the context of Internet of Things, smart homes, autonomous driving, etc., will eventually overload or even crash cloud servers. Thus, it is essential to filtrate data to reduce the burden on the cloud and network resources, and to improve the quality of experience (QoE) especially in regard with end-to-end delay [4] [5].

Bringing computing services at the vicinity of mobile users in the paradigm of edge (fog) computing can significantly reduce the end-to-end delay experienced by users. This reduced delay helps support the emerging delay-sensitive applications such as E-health, real-time control, and vehicular communications [6] that can tolerate a delay of only few milliseconds [7]. Edge devices are equipped with the necessary hardware to enable small-scale cloud-like functions such as computing and storage. Moreover, edge computing benefits the close proximity with mobile users to offer geo- and context-aware services such as content caching. It is thus obvious why edge computing which complements the cloud is described as ”fog” because fog physically resides closer to the ground (users) compared to the ”cloud” seen in the sky [8]. To take full advantage of edge computing, it is necessary to coordinate edge devices with the central cloud on one hand, and with the H-CRAN on the other hand [9]. With the help of software-defined networking (SDN) technology, efficient coordination of computing and communication nodes can be achieved with less complexity.

One of the main constraints that stands in the way of future networks is the high energy consumption. Not only because energy raises the operational expenditures, but also because it causes detrimental impacts on our planet. Adopting smart SBS operation mechanisms can significantly reduce energy consumption since base stations account for 80% of the overall energy consumption in cellular networks [10]. Controlling the operation of SBSs can be achieved in a distributed or centralized manner. In the former, an

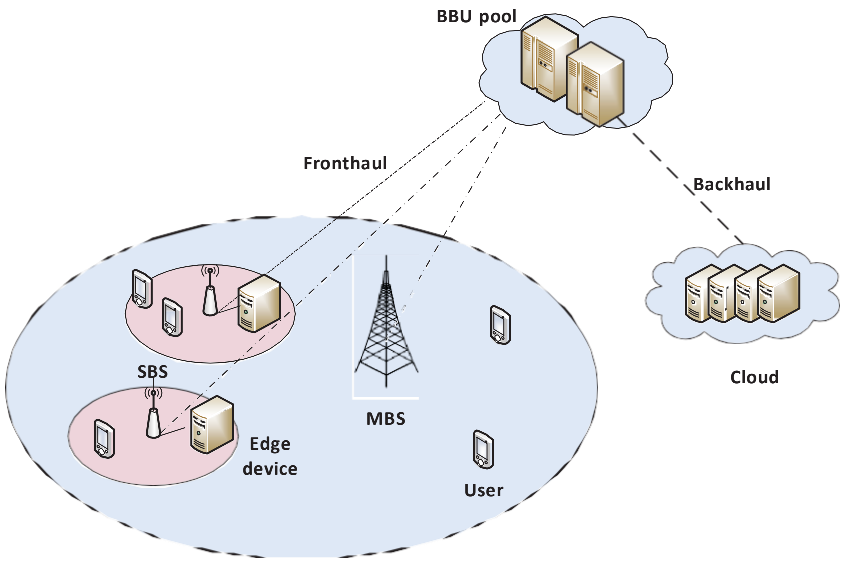

Fig. 1: H-CRAN-CE system layout.

SBS operates as a stand alone entity using intelligent self-organized features. Whereas in the centralized control, data from SBSs, MBSs, and other supporting nodes enter the central BBU pool for an optimal network-aware processing. The overhead of the centralized control is naturally higher compared to the distributed one; however, the informed and ceratin decisions of the centralized control boosts the overall system performance. Therefore, prior to initiating the On/Off and traffic offloading processes, network nodes should be well coordinated to maintain high QoS [11].

Similar to traffic offloading in cellular networks, computing tasks can also be offloaded from edge devices tothe cloud and vice versa depending on the desired QoS requirements such as energy and delay [12]. In other words,computing tasks can be processed either locally by the edge device or remotely by the cloud via the MBS through backhaul links [13]. However, offloading tasks to the central cloud will inherently increase the burden on cloud servers, communication resources, and backhaul links. Moreover, adopting coordinated task offloading in the layered cloud- fog architecture can increase the communication overhead and thus extra delay [14]. Therefore, it is essential to take into account the consequences of task offloading on both thecommunication and computing nodes. From the aforemen- tioned, we propose a coordinated cellular-computing archi- tecture that considers both communication and computing resources towards optimal SBS sleeping operation. Fig. 1 depicts the state-of-the-art H-CRAN-cloud-edge system.

The organization of this paper is as follows. Section 1 provides an overview, related work, and the main contribu-tions of this work. Section 2 describes the power, network, and computing models. The computing-aware SBS sleepingscheme is introduced in Section 3, followed by SBS sleeping in the proposed shared computing model in Section 4. In Section 5, simulation setup and results are demonstrated, and finally, Section 6 provides concluding remarks.

1.1 Related Work

Over the last few years, SBS sleeping gained considerable attention in the context of HetNets. Nevertheless, limited amount of research considered SBS sleeping from both com- munication and computing perspectives. In [15], a sleeping strategy was proposed by which all RATs are activated when resource utilization in the MBS reaches a threshold value. The N-policy scheme in [10] is concerned with the energy- delay tradeoff in SBS sleeping without considering traffic offloaded from sleeping SBSs to the MBS. Furthermore, the SBS activation delay was the goal of [16], wherein authors used iterative approaches to maximize energy efficiency considering wake-up times and coverage probability re- gardless of the MBS traffic load. All aforementioned works were considering performance in a communication environ- ment; that is to say, no computing aspects were involved.

However, the proliferation of computing hungry applications have brought the attention of both academic and industrial communities recently. For instance, a hierarchicaledge-cloud architecture was proposed in [17] to achieve workload balancing among different computing tiers. By dynamically distributing the workload on different servers,over 25% improvement in program execution time was ob- tained. In a similar context, authors in [8] considered work-load scheduling to find the optimal power-delay tradeoff in cloud-fog computing systems. Furthermore, a schedulingalgorithm was proposed in [18] to minimize the queue delayin cloud servers in order to guarantee the ultra-low latency in Internet services.

Since communication nodes play a major role in link- ing computing tasks with computing infrastructure, it is essential to consider both communication and computing nodes in contemporary research work. Here, a joint energyharvesting and SBS sleeping was studied in [19] aiming at minimizing energy consumption and improving the cachingperformance in cache-enabled SBS networks. The work considered the effect of SBS sleeping while maximizing the hitratio of cached contents.

Unlike most related work, we aim to maximize power saving considering the SBS load, MBS load, cloud response time, delay experienced by users, and traffic offloaded from sleeping SBSs to the MBS. The joint operation of both communication and computing nodes can improve the network-wide performance and provide sophisticated sleeping mechanism for future networks.

The contribution of this work is three-fold: A SBS sleeping mechanism is proposed to save energy in integrated H-CRAN-cloud-edge networks under the constraints of cloud response time and task completion deadline. In other words, two types of constraints are considered namely the long-term statistical cloud response time, and the instantaneous task completion time. In this part of the work, the cloud and edge servers are assumed to have disjoint operation; that is, the workload cannot be shared (disjoint queue model). The problem is formulated as a 0-1 knapsack problem wherein the SBS utiliza- tion represents the weight whereas the amount of incoming computing tasks represents the value of that SBS. Here, SBSs serving less amount of comput- ing tasks are given higher values than others. The proposed problem, which is solved using dynamic programming, is a centralized SBS sleeping scheme that aims to select the optimal subset of sleeping SBSs considering cloud and user constraints. A novel shared cloud-edge computing architectureis introduced in coordination with the cellular in frastructure. Here, edge and cloud servers are inte- grated in a unified queue system i.e. one queue and shared servers. Thereby, edge devices contribute to the improvement of the computing response time byincreasing the total number of functioning servers.The optimal subset of sleeping SBSs is then found in the later system using exhaustive search approach. Again, the computing response time and task com- pletion deadline are considered as constraints in thisproblem.

CONLUSION

The problem of SBS sleeping in integrated H-CRAN-cloud- edge networks is studied in this paper. First, a SBS sleep- ing mechanism was proposed to save energy taking into account the constraints of task completion deadline and cloud response time. The problem was formulated as a 0-1 knapsack problem and solved using dynamic programming. Secondly, a joint cloud-edge computing model was intro-duced such that edge devices contribute to the total network computing resources beside the cloud to improve the system computing capability. Finally, finding the optimal power saving in the later system was found using an exhaustive search strategy. Abiding by the fact that traffic associated with sleeping SBSs will be eventually served by the MBS, the MBS utilization was considered as a major practical constraint that defines the observations and results obtained

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