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# Telecom Big Data Based User Offloading Self-Optimisation in Heterogeneous Relay Cellular Systems

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## ABSTRACT

This paper proposes a telecom big data based user offloading self-optimisation (TBDUOS) scheme. Its aim is to assist telecom operators to effectively balancing the load distribution with achieving good service performance and customer management in heterogeneous relay cellular systems. To achieve these objectives, in the cell-level offloaded traffic analysis stage, the optimal offloaded traffic is calculated to minimise the total blocking probability. In the user-level offloading stage, the user portrait is drawn and the K-MEANS algorithm is employed to manage the users clustering in the heavily loaded cell, and finally shifting users to assistant cells. Simulation results show the TBDUOS scheme can effectively reduce the handover failure and call dropping of specific users, especially voice/stream users, high consumption users, high level users. The TBDUOS scheme can also reduce the blocking probability.

## KEYWORDS

Relay, Telecom Big Data, Traffic Offloading, User Portrait, Users Clustering

## INTRODUCTION

In order to meet the explosive demands on cellular systems coverage by emerging smart terminals and mobile phones, the relay technique is employed (3GPP, 2010). The relay station (RS) can be deployed in wireless-hungry areas to extend the wireless coverage, whilst the base station (BS) focuses on the large coverage in LTE-Advanced heterogeneous relay cellular systems (Zheng, 2011). Due to the service diversity and the user mobility, cellular systems also face the challenge of uneven traffic

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distribution (Cao, 2015). Load balancing is widely used to deal with the uneven load distribution (SOCRATES, 2010; Cao, 2011).

Generally, load balancing can be implemented via two methods. The first method is based on channel borrowing. Under the non-full frequency reuse cellular systems (e.g., GSM), a heavily loaded cell borrows idle spectrum resources from neighbouring cells. Typical channel borrowing schemes includes simple borrowing scheme (Engel, 1973), hybrid assignment scheme (Zhang, 1989), channel borrowing without locking scheme (Jiang, 1994). However, the limitation is that these channel borrowing schemes only suit for cellular systems without employing full frequency reuse. Therefore, this method does not suit the LTE/LTE-Advanced cellular systems (Zheng, 2011; Han, 2012). The second method is via offloading traffic from the heavily loaded cell to less-loaded neighbouring cells.

Many traffic offloading schemes are designed from both academics and industry. In (Nasri, 2007), a heavily loaded cell chooses neighbouring cells, which have lower load, as assistant cells. Then, the heavily loaded cell adjusts handover offset ($HO_{off}$) to trigger handover between two cells. This work becomes the milestone of mobility load balancing (MLB). In (Zhang, 2010), cell state is categorized into 'light load', 'high load' and 'normal load'. Then the traffic offloading is between the 'high load' and 'light load' cells, according to their load differences. Kwan (2010) studies the precise $HO_{off}$ based MLB mechanism, in which a heavily loaded cell selects all less-loaded neighbouring cells as assistant cells, and then this heavily loaded cell gradually regulates $HO_{off}$ with a fixed step-size to offload serving users. In (Yang, 2012; Yang, 2014), the authors design the cell load based utility function to adjust $HO_{off}$, in order to offload edge users efficiently. In (Wang, 2010), the neighbouring cell with the lowest load is chosen as the assistant cell in sequence, then the heavily loaded cell shifts users to RSs in assistant cells, thus balancing the traffic distribution evenly. In (Fan, 2011), the load balancing objective is to avoid a cell serving too many users via broadcasting and considering the number of users served by each cell's RS. In (Wu, 2005), the integrated cellular and Ad-hoc relay (iCAR) scheme is designed, in which the mobile ad-hoc relay station (ARS) is employed to relay the traffic from a heavily loaded cell to less-loaded neighbouring cells.

In above mentioned works, cell load is the key factor to decide the traffic offloading direction and to analyse the offloaded user's sequence. Above mentioned load balancing schemes can effectively reduce the load of the heavily loaded cell. However, for telecom operators, traffic offloading should consider comprehensive factors, especially different services' performance degradation under the offloading scenario as well as telecom customers' management requirements.

This paper proposes a telecom big data based user offloading self-optimisation (TBDUOS) scheme in heterogeneous relay cellular systems. Its aim is to balance the load distribution, as well as achieve good service performance and benefit customer management. The TBDUOS scheme consists of two stages. Firstly, the heavily loaded cell considers both the cell load and call blocking to analyse the optimal cell-level offloaded traffic. Secondly, we utilize telecom big data to analyse the user portrait (Wang, 2016) and further manage the users clustering (Rekik, 2006), thus deciding the offloaded users.

This paper is organised as follows: Section II introduces telecom big data and presents the system model. Section III describes the cell-level offloaded traffic analysis stage. Section IV presents the user-level offloading stage. Simulation results and conclusions are given in Section V and VI, respectively.

## TELECOM BIG DATA AND HETEROGENEOUS RELAY CELLULAR SYSTEMS

In cellular systems, the massive transmitted data contains a huge amount of useful information. Generally, telecom big data includes system related information, for example, system key performance indicator, measurement report, network operating status etc. Telecom big data also includes the user related information, for example, user personal information, user's terminal information, user's location information, user's consumption information, upper-layer service information etc. This information will be discussed in detail in Section IV. Therefore, telecom big data has '4-V' features,

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