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# Utility-function-based radio-access-technology selection for heterogeneous wireless networks☆,☆☆

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ABSTRACT

Radio-access-technology (RAT) selection plays an important role in providing users with Quality-of-Service (QoS) guarantees and improving the utilization efficiency of radio resources over heterogeneous wireless networks, which is one of effective ways to implement Internet of Things (IoT) in future. In heterogeneous environments containing multiple networks with different RATs, diverse factors characterizing users' preferences and QoS features need to be considered for RAT selection. To address this issue, this paper proposes a network selection scheme based on a utility function. The proposed scheme and the utility function jointly take users' QoS demands, preferences, channel state information (CSI), costs as well as network loads into account, such that the radio resource can be efficiently used in supporting diverse services. Simulations results are provided to evaluate the performances of our proposed scheme compared with the existing baseline scheme.



## 1. Introduction

Different radio access technologies (RAT) have been emerging in recent years to support diverse mobile services and wireless connections. The coexistence of diverse RATs often forms the heterogenous networking environments. Consequently, RAT selection is critically important to fulfil users' Quality-of-Service (QoS) requirements as well as to make full use of precious radio resources [1–9]. More importantly, design of efficient RAT selection is crucial for implementation of Internet of Things (IoT) targeting at ubiquitous information access and exchange.

To achieve the above goals, it is clear that we need to comprehensively take multiple factors into account in RAT selection over heterogeneous networks. Specifically, the following issues are critical for design of RAT selection schemes. Firstly, different RATs have their respective advantages and disadvantages. For instance, the LTE network assures the wide coverage, but the deployment cost is usually high and the transmission rate is often limited. In contrast, wireless local area networks (WLAN) support high bandwidth and have low cost in terms of deployment, but only cover a small area. Then, how to develop a unified approach considering diverse features of different RATs would be challenging and has become one of major research dedications for heterogeneous networks in the research community. Secondly, with thriving of diverse multimedia applications, different QoS requirements impose the demand on fine-grained differentiated services [10,11]. The provisioning

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of differentiated services over heterogeneous networks will not only benefit users with better QoS satisfaction, but be able to tailor the wireless resource for efficient utilization. Thirdly, different users have their own preferences and thus the RAT selection strategy also needs to be regulated accordingly. For instance, some users care more about the performances such as transmission rates and delay, some users might concentrate more on low cost, and some users hope to compromise between the performances and cost. Finally, how to best utilize the scarce radio resource is always one of the major targets in RAT selection over heterogenous networks.

Recently, RAT selection approaches have drawn the wide attention from the research community. In [1], the authors proposed a utility function integrating users' QoS demands and the operator benefits for RAT selection. Specifically, the utility function considers the network parameters including the lowest and highest data capacity and the monetary cost. However, consider only these factors are insufficient as the channel state information (CSI) was not well integrated for joint design. In [2], the authors proposed a handoff policy considering cell load condition. In [3], the authors developed a vertical handoff scheme based on QoS guarantee requirements. Wang and Kong [5] proposed a vertical handoff scheme in the heterogeneous network containing WLAN and cellular networks, which also considered the information of cellular network load and moving speed of users. The reference [12] proposed an access control scheme in LTE which aimed at maximizing the resource utilization efficiency under the users' QoS requirements. The authors of [13] proposed an uplink scheduler in LTE as functions of both the QoS requirements and instant CSI. The authors of [14] discussed the resource management and access control issues in cellular/WLAN heterogeneous networks. Reference [15] developed a rate allocation and access control policy. The policy was to maximize operator's benefits based on meeting users' QoS demands. In [16], the authors proposed a resource allocation policy based on a utility function towards distributed control. The authors of [6] designed a network selection policy which can simultaneously assign the original users and new users according to the latest network status. Also, there have been other recently proposed radio access control schemes such as [8,9,7,17,18]. While the aforementioned work addressed various aspects RATs, it is still highly desired to develop a unified criterion integrating as many factors as possible in RAT.

To address the aforementioned problems, in this paper we propose a network selection scheme based on utility function optimization for heterogeneous wireless networks. The utility function comprehensively considers users' QoS demands, users' preferences, differentiated services, users' channel state information, users' cost and network traffic loads. In this paper, we mainly focus on voice service and regular streaming services, or streaming services in short. As is known to all, the voice service has stricter delay requirement and thus typically higher priority to access networks as compared to streaming services. After building the utility function integrating all factors mentioned above, we develop the detailed RAT selection scheme, which can regulate the selection from both users' and networks' perspectives. Simulation evaluations are also presented to compare our proposed scheme with the existing baseline approach.

The remainder of this paper is organized as follows. Section 2 presents the system model. The design and detailed procedures of our proposed scheme are given in Section 3. We conduct further discussions on throughput for voice and streaming services and analyze the complexity in Section 4. Section 5 presents the simulation results for our proposed scheme comparing with the baseline scheme. Finally, the paper concludes with Section 6.

## 2. System model

We consider the heterogeneous network consisting of WLAN and LTE networks. The network topology is illustrated by Fig. 1 . In Fig. 1, there are $N_L$ users in LTE networks, $N_W$ users in WLANs, and $N_n$ newly incoming users, who will select a network to get connected. The coverage radius of the LTE network is denoted by $R_{LTE}$ and the radius of the WLAN network is represented by $R_{WLAN}$. The existing users belonging to the LTE network or WLAN are geographically distributed uniformly. The $N_n$ new users, who are waiting to access the candidate networks, are located in the area covered by both the WLAN and the LTE network, as depicted in Fig. 1. These new authors are also uniformly distributed within the overlapped areas,

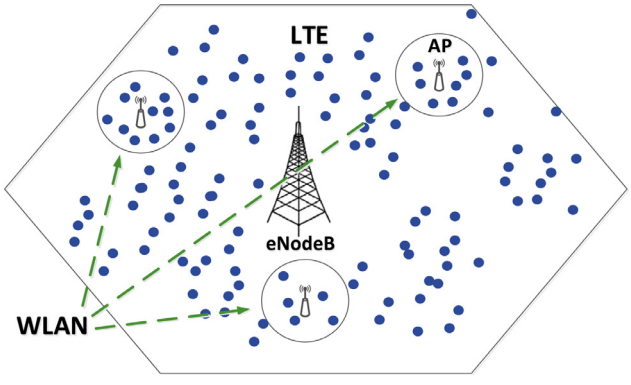


**Fig. 1.** The network topology and system model.