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QoS-Aware Tethering in a Heterogeneous Wireless Network using LTE and TV White Spaces

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A B S T R A C T

Wireless networks have resource limitations; in a dense area, cellular spectrum resources are insufficient and affect the system performance. A Long Term Evolution (LTE) network aims to serve heterogeneous users with different QoS requirements. Traditional approaches need new infrastructure and degrade performance of delay sensitive applications, which may result in users with minimum rate requirements being in high blocking probability. To utilize wireless resources efficiently, users want to access the same medium to connect with the same multicast group and be overhauled at the same time. In this paper, a new technique is proposed for operator-controlled called the QoS-Aware Tethering in a Heterogeneous Wireless Network using LTE and TV White Spaces (QTHN) to improve QoS for Constant Bit Rate (CBR) and Best Effort (BE) users. The proposed QTHN converts the whole dense wireless network into hexagonal clusters via two layer network communication. In a cluster, one node is selected as a cluster head and all other nodes act as slaves. Within a cluster, a cluster head acts as an access point known as a Hotspot (*H*), which is further connected to the Base-station (BS). The proposed QTHN aims to improve QoS within heterogeneous wireless network using LTE and unused White Spaces in a wireless dense area. Simulation results show that the proposed QTHN reduced the numbers of blocked users and improved network utility.

1. Introduction

Wireless technology was introduced to replace the cables needed to connect different devices. Traditionally, wireless networks are based on the cellular concept, and have well defined infrastructure support. Since there is frequent use of technology, an on-demand wireless network attracts users by automatically constructing a network [1]. Thus, as of today, many solutions have been proposed for short-range communication but every technology has its own benefits and limitations. It is a reality that many unresolved research issues in wireless need to find a complete and reliable solution. In reality, LTE and TV White Spaces (TVWS) are widely used technologies, and capable of much more beyond just connectivity between a small number of devices. Therefore, the combination of LTE and TVWS can extended network capability to satisfy user need. Research in the area of LTE and

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TVWS is getting more attention from academia and industry. To resolve issues of configuration and communication in a decentralized manner, where topology changes dynamically is a challenging task. Therefore, network formation improvement is required. As of today, many solutions have been proposed, mostly researchers focusing on simplicity and reliability, but none of them completely fulfill the user requirement. Therefore, it motivates improving on network formation considering QoS to meet the user requirement.

Wireless network connections offer organizations and consumers many advantages, such as portability and flexibility [1]. They increase the productivity of output and decrease installation costs. The 4G LTE network has achieved high spectrum efficiency due to Orthogonal Frequency Division Multiple Access (OFDMA). However, network performance and insufficient spectrum resources are still a hot issue for researchers. Spectrum demand in crowded venues, such as conferences, shopping malls, sports stadiums, and concerts is a critical issue where bulky nodes compete for limited spectrum. There are a few solutions to overcome insufficient spectrum and QoS to add new APs and femtocells; however, these techniques are not satisfactory from the user's perspective [13]. At the outset, the rising requirement of cellular data capacity drastically increases the number and density of cell locations in smaller cells. Where, they have to frequently perform handovers and other mobility procedures within less time [21]. Secondly, organizing a large number of cells through a cost-effective way can create some problems. It is possible that many cell locations may not have a direct straight, less delay backhaul network link to the operator's core network where mobility is normally synchronized. This main issue is particularly imperative for femtocells [2]. To minimize the backhaul cost, femtocells may not be linked in a straight line to the operator's core network, and as an alternative connection through a private Internet Service Provider (ISP), it is followed by a link through the public Internet. If femtocells are employed in an open way for wide-area network coverage, handovers among femtocells will become more frequent and the network delays to the core network can affect the handover time. In such scenarios with speedy mobility in small cells and network handover delays, connections can haul from one cell to another and minimize the quality of the connection link.

Using highly developed physical layer technologies can enhance the spectral competence of the limited available spectrum, but it is still not enough. It has been investigated that the performance of the physical layer is reaching its theoretical perimeter [3]. Heterogeneous Network (Het-Net) deployment is considered as a key objective of LTE-Advanced. Het-Net deployment is the combined deployment of macro, pico, relay and other low-power devices by using the same frequency. In this employment, when many relay devices and pico devices are employed across the macro coverage area, the physical coverage overlap can generate two main issues. The first issue is that it increases the co-channel interference with the increase of the number of co-channel cells. The second issue is that when a low power device cell is covered with a macro cell, most User Equipment (UE) is provided by the macro device and the macro cell data traffic is not expertly dispersed to the low-power device cell; thus, it decreases the throughput of UE [4].

To meet the increasing demand of the spectrum, unlicensed spectra, such as vacated television band has gotten much attention from researchers and industry. The TV white-space (TVWS) operates on 50–700 MHz and it has better propagation characteristics compared to WiFi [15,16]. Sharing spectrum resources and improving QoS are the main challenges in a dense wireless network [22]. In the proposed QTHN devices can operate on both TVWS and LTE when necessary. These have been investigated to overcome spectrum and QoS problems. Furthermore, the proposed QTHN uses a two layer approach where mobile nodes in a cluster connect to a Hotspot that is directly connected with the BS and relay the slave data as shown in Fig. 1. The Hotspot uses priority-based scheduling for relaying mobile node data. In the event of a large number of active nodes in a single cluster create bottleneck, by using QTHN, the traffic load is balanced over a number of cells.

The remainder of the paper is organized as follows. Related work is investigated in Section 2. The proposed methodology is proposed in Section 3. The next section, 4, provides the simulation results and discussion. Finally, the paper is concluded in Section 5.

2. Related work

Mobile devices having wireless technologies are emerging so fast that it is directed to a complex spectrum usage along with the incompetent utilization of the radio electromagnetic spectrum. The existing Fixed Spectrum Access (FSA) strategy is not appropriate for it as it uses the spectrum very incompetently because most of the time the channel bandwidth remains unutilized due to less subscriber load on a certain channel. Many research works [6,8,11,23] have proposed for efficient spectrum utilization. One of them is the Dynamic Spectrum Access (DSA). For this purpose, a cognitive radio is also an attractive solution to the spectral congestion problem. It has introduced the usage of the frequency bands that are not heavily

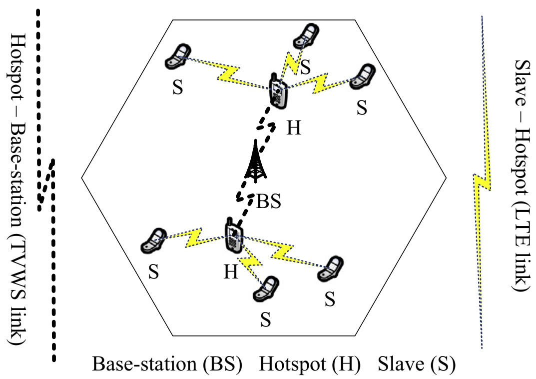

Fig. 1. The proposed QTHN configuration.