Unlicensed Spectra Fusion and Interference Coordination for LTE Systems

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Abstract_

Unlicensed spectra fusion knowledge for LTE hold the promise of all evicting the licensed spectra scarcity and enhancing ability. It allows LTE to successfully utilize the unlicensed spectra distributed over high frequency bands with significant different propagation characteristics from its licensed spectra. However, the interference caused by other systems over unlicensed spectra, particularly the public unlicensed spectra, is viewed as the most serious confront. In this paper, aim to guarantee the achievability in existing LTE systems, to design a novel unlicensed spectra fusion scheme based on the popular standard TDDLTE systems. To mitigate the interference, I develop an interference coordination scheme which is carried out in two stages: screen the available unlicensed channels for every UE, and allocate unlicensed spectra based on Hungarian algorithm. I have conducted extensive simulation study and demonstrate that our proposed scheme can handle interference coordination effectively and enhance throughput significantly.

KEYWORDS—Unlicensed spectra fusion, Interference coordination, resource allocation, throughput maximization.

I.INTRODUCTION

Spectrum extension is a straightforward approach for enhancing wireless system capacity. However, radio spectrum is a precious and scarce natural resource and is most often regulated through licensing. Therefore, it is hard for operators to obtain more licensed spectra. Despite spectrum scarcity, various experiments reported that the current fixed spectrum allocation policy has resulted in severely low spectrum utilization in both time and space, even within spectrum-scarce urban areas . To address this issue, US Federal Communication Commission (FCC) published a report prepared by the Spectrum-Policy Task Force, and relaxed the ruling of license usage, stating that "In many bands, spectrum access is a more significant problem than physical scarcity of spectrum, in large part due to legacy commandand-control regulation that limits the ability of potential spectrum users to obtain such access. Thus, in this paper, we focus on the unlicensed spectra fusion mechanism design for LTE systems to enable the use of unlicensed spectra to enhance capacity while guaranteeing communication quality.

The wireless industry is already gearing up for increase in data capacity associated with the requirements of 5G mobile networks planned for 2020 and beyond. The 5G vision is not just limited to matching the increase in mobile data demand, but also includes an improved overall service-oriented user experience with immersive applications such as high definition video streaming, real-time interactive games, wearable mobile devices, ubiquitous health care, mobile cloud, etc. Such

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 03 | Mar -2020 ISSN: 2582-3930

applications not only demand the higher data rates but also require an improved Quality of Experience (QoE) as measured through parameters such as lower latency (round trip time), lower power consumption (longer battery life), better radio coverage (reliable services), cost-effective network, and support for mobility.

These emerging unlicensed band scenarios will lead to co-channel deployment of multiple radio access technologies (RATs) by multiple operators. These different RATs, designed for specific purposes at different frequencies, must now coexist in the same frequency, time, and space. This causes increased interference to each other and potential degradation of the overall system performance due to the lack of inter-RAT compatibility. Two such scenarios where two networks with different access technologies interfere with each other. When a Wi-Fi Access Point (AP) is within the transmission zone of LTE, it senses the medium and postpones transmission due to detection of co-channel LTE Home node's (HeNB) transmission power. Consequently, the Wi-Fi throughput suffers in the presence of LTE transmission. The main reason for this disproportionate drop in the WiFi throughput is due to the fact that LTE does not sense other transmissions before transmitting. In contrast, Wi-Fi is designed to coexist with other networks as it senses the channel before any transmission. However, when LTE works in supplemental downlink-only mode and the UEs do not transmit, there may arise a scenario where a Wi-Fi AP cannot sense LTE HeNB's transmission, thus causing interference to nearby UEs. This problem also arises in multiple Wi-Fi links that overlap in the collision domain, but the network can recover packets quickly as packets are transmitted for a very short duration in WiFi.

It is reasonable to forecast that Wi-Fi and LTE will be among the dominant technologies used for radio access over the next few years. Thus, this paper focuses on coordinated coexistence between these two technologies. When LTE is deployed in an unlicensed band, it is termed as LTE-U. It is suggested in 3GPP that LTE-U will be used for supplemental downlink while the uplink will continue to use licensed spectrum. This makes the deployment even more challenging as the UE's do not transmit in unlicensed spectrum yet experience interference from Wi-Fi transmissions. To alleviate these problems, we extend the interference characterization of cochannel deployment of Wi-Fi and LTE using a simplistic but accurate analytical model We then validate this model through experimental analysis of co-channel deployment in the GHzband using theORBITtestbedavailableatWINLAB.The ORBIT testbed consists of several radio platforms including USRPs.

2.RELATED WORKS

Coordination between multi-RAT networks with LTE and Wi-Fi is challenging due to differences in the medium access control (MAC) layer of the two technologies. Wi-Fi is based on the distributed coordination function (DCF) where each transmitter senses the channel energy for transmission opportunities and collision avoidance. In particular, clear channel assessment (CCA) in Wi-Fi involves two functions to detect any on-going transmissions.

Carrier sense:

Defines the ability of the Wi-Fi node to detect and decode other nodes' preambles, which most likely announces an incoming transmission. In such cases, Wi-Fi nodes are said to be in the CSMA range of each other other. For the basic DCF with no RTS/CTS, the Wi-Fi throughput can be accurately characterized using the Markov chain analysis given in Bianchi's model , assuming a saturated traffic condition (at least 1 packet is waiting to be sent) at each node. **Energy detection:**

Defines the ability of Wi-Fi to detect non-Wi-Fi (in this case, LTE) energy in the operating channel and back off the data transmission. If thebandsignalenergycrossesacertainthreshold, thechannel is detected as busy (no Wi-Fi transmission) until the channel energy is below the threshold. Thus, this function becomes the key parameter for characterizing Wi-Fi throughput in the co-channel deployment with LTE.

3.OVERVIEW

OF TECHNIQUES Interference

description Model:

I propose an analytical model to characterize the interference between Wi-Fi and LTE, while considering the WiFi sensing mechanism (clear channel assessment (CCA)) and scheduled and persistent packet transmission at LTE. To illustrate, we focus on a co-channel deployment involving a single Wi-Fi and a single LTE cell, which involves disseminating the interaction of both technologies in detail and establish a building block to study a complex co-channel deployment of multiple Wi-Fis/LTEs. In a downlink deployment scenario, a single client and a full buffer (saturated traffic condition) is assumed at each AP under no MIMO. Transmit powers are denoted as Pi, i∈ {w, l} where w and l are indices to denote Wi-Fi and LTE links, respectively. We note that the maximum transmission power of an LTE small cell is comparable to that of the WiFi, and thus is consistent with regulations of unlicensed bands. **description of LTE Throughput:**

Due to CSMA/CA, Wi-Fi is active for an average ηS fraction of time . Assuming that LTE can instantaneously update its transmission, rate based on the Wi-Fi interference,

we perform a comparison study to evaluate the effect of LTE interference on w1, observed by experiments and computed by interference characterization model. In this case, LTE signal is lightly loaded on 5 MHz of bandwidth mainly consist of control signals. Thus, the impact of such LTE signal over the Wi-Fi band is equivalent to the low power LTE transmission. Thus, we incorporate these LTE parameters in our analytical model. As shown in Fig. 4, we observe that both experimental and analytical values match the trend very closely, though with some discrepancies. These discrepanciesaremainlyduetothefixedindoorexperimentenvironmentandlackofalargenumberofexp erimentaldatasets. Additionally, we note that even with the LTE control signal (without any scheduled LTE data transmission), performance of Wi-Fi gets impacted drastically.

4.SYSTEM ARCHITECTURE

Feedback information is delivered in air interface. Thus, to protect feedback from the unstable radio environment, we configure feedback channel with licensed bands, which is normally not interfered by other systems. On the other hand, LTE achieves the various features by dynamic unlicensed spectra management, such as channel allocation, power control and so on. In this paper, we only focus on channel allocation by which we further complete the interference coordination and throughput maximization for unlicensed spectra. Considering UE capability, dynamicunlicensedspectramanagementmust be carried out at eNB. For downlink operation, spectrum management can only be executed after eNB receives the feedback information from feedback channel PUCCH (Physical Uplink Control Channel), where feedback information is CCI. On the other hand, in uplink, eNB can immediately fulfill spectrum management following at eNB, and then send the feedback information, namely scheduling signaling of PUUFCH, to UEs, by feedback channel PDCCH (Physical Downlink Control Channel).

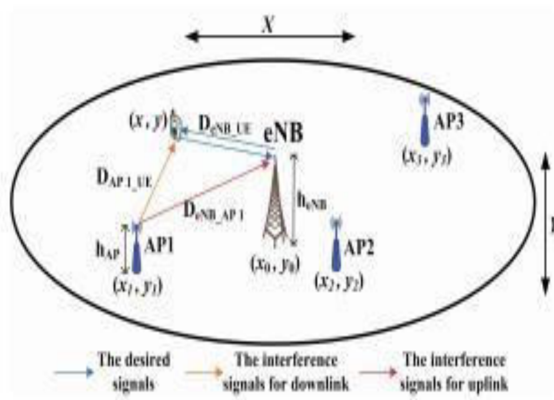

Figure.4.1.system architecture in unlicensed spectrum.

The frame structure of unlicensed spectra, in which the downlink transmission of PDUFCH signaling complies with the channel allocation from and are scheduled by the PDCCH within the same downlink sub-frame. For uplink, UEs send uplink signal on PUUFCHs indicated by the feedback information in PDCCH of the previous downlink sub-frame. It is noteworthy that the issue on whether an unlicensed channel has successful transmission or not is determined by not only the quality of the channel, but also that of licensed channels. For example, the feedback channel outage will terminate the whole fusion procedure, and the outage of the scheduling channel PDCCH in downlink indicatesthat UEs cannot distinguish and demodulate their own transmitted data. Thus, to assess the unlicensed channel transmission performance, the quality of the corresponding licensed channels should be treated as one of the decision factors.

5. CONCLUSION

In this paper, we have developed a novel unlicensed spectra fusion scheme for LTE that can significantly improve the system capacity and effectively perform interference coordination. Because of the particularity of the public unlicensed spectra, the system procedures in our spectra fusion scheme differs from the existing LTE and have not been designed. Thus, one of our main contributions is to design the system procedures of the unlicensed spectra fusion based on the popular standard TDD-LTE. Based on these procedures, the interference coordination scheme is developed in two stages:

1) To ensure that every UE is assigned a channel with link quality satisfying the basic reliability requirement;

2) To maximize the system throughput with guaranteed fairness in the unlicensed channel allocation scheme based on the Hungarian algorithm. we have conducted extensive simulationstudies and show thatour proposed scheme could make every unlicensed channel allocated to the UE that has preferable link quality with higher received signal SINR and lower transmission failure probability. It has been demonstrated that our proposedschemecouldachieveinterferencecoordination on the unlicensed spectra remarkably well.

ACKNOWLEDGEMENT

The work of H. Song and X. Fang was partially supported by the 973 Program of China under Grant 2012CB316100, NSFC under Grant 61471303, and EU FP7 QUICK project under Grant PIRSES-GA-2013612652. The work of Y. Fang was partially supported by US National Science Foundation under grant CNS1343356

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