Radio Resource Management in Coexistence Scenario of LTE and Wi-Fi Over the Unlicensed Spectrums

Joydev Ghosh * • Uttam Kr. Nandi

ETCE Dept., The New Horizons Institute of Technology, Durgapur-08

joydev.ghosh.ece@gmail

Abstract: The development of wireless broadband access network (WBAN) leads to enhance the insufficiency of unoccupied radio resources. This is quite expected in coming times, wireless cellular technologies and wireless local area networks (WLANs) will work together in coexistence scenario within the alike unlicensed spectrums (USs). Although, two most emerging wireless networks, i.e., Long Term Evaluation (LTE) and Wi-Fi, are available to operate in separate bands, but not to operate in the coexisting scenario, particularly in unlicensed spectrum. Here, we review the challenges that occur as a result of the simultaneous functioning of LTE and Wi-Fi within the alike USs from the angle of radio resource management (RRM). We demonstrate that Wi-Fi can strongly affect by LTE transmissions; thus, the integrated LTE and Wi-Fi requires to be cautiously examined. We introduce few feasible coexistence operations and scopes in coming time which may result in the fruitful allied deployment of LTE and Wi-Fi within the alike USs.

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1. Introduction:

To overcome from the mobile traffic offloading (MTO) issue, small cell networks (SCNs) and advancement of dynamic spectrum access (DSA) mechanism has come into light. The idea of small cells (SCs) (Ghosh & Roy, 2016b; Ghosh & Roy, 2015), as proposed for heterogeneous networks (HetNets), is developed from the point of view of the data plane. One of the objectives is to deploy a large number of SCs with smaller coverage radius but will have the ability to serve large traffic loads. The other objective is to implement ideas like self-organization and self-adaptation. These demands cause to go with 3rd Generation Partnership Project (3GPP) to standardize LTE small cells to perform within the licensed spectrum (LS) in Release 12. 3GPP also anticipates the adoption of expanded IEEE 802.11 WLANs in unlicensed bands as a corresponding way out. Dynamic spectrum access (DSA) mechanism has come into view as another method to deal with the growing need of extra capacity in wireless networks and spectrum insufficiency (Akyildiz et al., 2006).

DSA mechanism enablers like cognitive radio (CR) ideas stimulated regulatory service providers to permit license-exempt (LE) action in LS. For example, the United States (Federal Communications Commission, 2010) and Europe (ECC, 2013) published laws at a recent time on functioning of secondary users (SUs) in frequencies made available for unlicensed use at locations where the spectrum is not being used by licensed services, such as television broadcasting. This spectrum is located in the VHF and UHF bands. The alternative initiative is authorized shared access (ASA) (Matinmikko et al., 2013), where existing spectrum holders share their spectrum with SUs in underused locations while keeping defensible interference levels. In spite of SCs and DSA mechanism, spectrum requirement is so high that collaborative operation of LTE and Wi-Fi within the same LE spectrum may be anticipated (Rahman et al., 2011).

Nevertheless, present resource allocation does not incorporate any overlapped frequency band between both techniques. Latest discussions on 3GPP regarding the need for practicality studies about the deployment of LTE in USs is an intense issue (Ericsson, 2013). The goal of this review is to evaluate which expansions would be required from the point of view of LTE to satisfy regulatory demands to use those spectrums, for instance, 5.8 GHz radio band, known as ISM band, is reserved internationally for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than telecommunications.

Certain technical challenges and performance degradation issue are arising from the concurrent operation of LTE and Wi-Fi within the same USs.

This short paper demonstrates the coexistence of LTE and Wi-Fi networks within the same USs from the RRM perspective. We articulate the channel access mechanisms (CAM) for LTE and Wi-Fi, and latest results illustrating the performance of the network when both of them have been incorporated within the same USs. Thereafter we highlight coexistence mechanisms and the different challenging issue regarding the coexistence mechanism considering the adaptation of properties in both LTE and Wi-Fi and transmit power control. Ultimately, Section 6 concludes this short paper.

2. Constraints for Coexistence of LTE and Wi-Fi in Unlicensed Spectrums:

This is essential to consider few issues into the account for enabling different incompatible networks to perform in the same band. One of the vital aspects is coexistence, which involves the definition of bounding limit for using the radio resources from the point of view of time and spectrum. The shortfall of cross-technology coordination and mutual interference mitigation technique are some of the prime issues for the efficient coexistence of different incompatible technologies. Most of the broad-band access networks have interference management schemes, but all of them are launched to perform properly for the technologies of same types. All these in-built features become less effective in multi-layer network protocols, which invoke asynchronous time frames, different channel access techniques (CAT).

Nevertheless, two most useful WBAN networks, incompatible while operate within the same band and also dissimilar too, are LTE and Wi-Fi. Wi-Fi applies orthogonal frequency division multiplexing (OFDM) technique to encode a sequence of digital bits over the many carrier frequencies and also, they are grouped within subcarriers where OFDM symbols are normally transmitted. In Wi-Fi, operating mode, an access point (AP) correlates a fundamental subscriber set (FSS) of wireless stations (WSs) to a wired Ethernet network (WEN). WSs and APs use a Wi-Fi default CAT for sharing information, control, and resource management. CAT uses clear channel based assessment (CCA) named as carrier sense multiple accesses with collision avoidance (CSMA/CA).

In CCA mechanism, nodes follow the channel before data transmission. A node in CCA can collect transmit data arriving from other nodes. If a channel which has experienced a collision, due to the provision of collecting data from other nodes, waits for an amount of time before attempting to retransmit and put in the transmission to a random back off time. A random back off minimizes the probability that the same nodes will collide again, even if they are using the same back off algorithm. CCA and back off reduce the possibility of transmission collisions in Wi-Fi at the price of less channel usage. On the other side, LTE applies orthogonal frequency-division multiple access (OFDMA), which is a more than single user based OFDM. Many accesses are obtained in LTE by allotting subsets of subcarriers to each user equipment's (UEs) for a certain number of physical resource blocks, hence permitting concurrent transmissions from multiple UEs.

In contrast with Wi-Fi applying CCA, LTE has, even more, liability from the point of view of resource allocation in time domain and frequency domain. Besides, LTE does not need carrier sensing before transmission. One of the challenging issues is the LTE deployment for US bands. The initial constraint is that regulatory agencies stop the effective isotropic radiated power (EIRP) in US bands to much lower levels than normally considered in LTE macrocells. In addition, LTE should be capable of evaluating whether Wi-Fi is collaboratively operating within the same band as well as establishing a coexistence mechanism with it. Hence LTE femtocells come into view as a normal deployment model for LTE mechanism in the US.

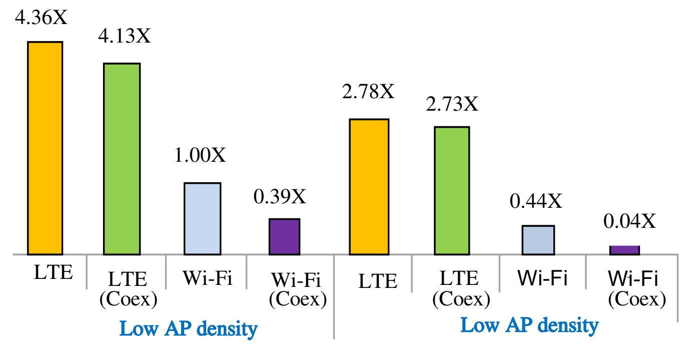

Figure 1(a)

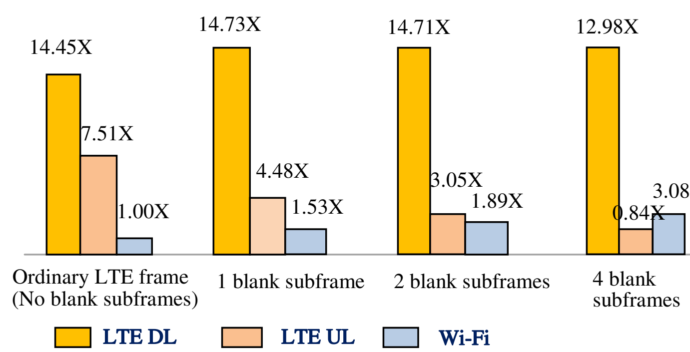

Figure 1(b)

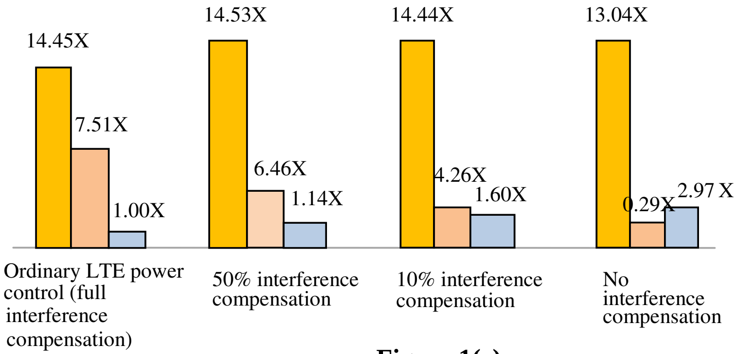

Figure 1(c)

Figure 1. LTE and Wi-Fi average user throughput relative to Wi-Fi low AP density for the indoor scenario. Deployments: low AP density (4 APs per technology) and high AP density (10 APs per technology) with an average STA density of 2.5 per AP for both cases. LTE and Wi-Fi evaluations: isolated (LTE, Wi-Fi) and in coexistence (LTE (Coex) and Wi-Fi (Coex)) (Fig 1a); blank sub frames allocation (Fig 1b); LTE UL power control with an interference-aware operating point (Fig 1c).

3. Channel Selection (CS):

Two main dissimilarities between Wi-Fi and LTE are CS and network deployment. Initially, Wi-Fi was launched to be worked in USs with uncoordinated deployments, whereas LTE was developed to be worked in LSs with coordinated deployments. When both LTE and Wi-Fi operate within the same spectrums, massive degradation due to LTE transmission can be noticed in Wi-Fi performance, as explained earlier. Hence, CS supposes to be a substantial enabler for LTE and Wi-Fi integrated networks. The unplanned deployments of Wi-Fi and the constraints of non-overlapping channels in the ISM bands have encouraged many studies on CS for Wi-Fi networks, which might be exploited with LTE.

In the least, congested channel search (LCCS), the access point (AP) scans those channels that are its own and also search for arriving packets from other APs and chooses the minimum crowded one. The flexibility in subcarrier channel assignment supplied by OFDM and OFDMA technologies may be employed in coexistence scenarios. In spite of static bandwidth channels (SBC), adaptive bandwidth channels (ABC) could be stated and chosen in coexistence scenarios. The best interest of Wi-Fi is to choose a minimum crowded channel to perform the operation due to the fact that Wi-Fi can be obstructed by LTE in a coexistence scenario. In such situation, minimum coordination between APs and LTE eNode Bs for CS could make the task of CS easier. It is one of the challenges as information sharing among the nodes experiencing interference that relies on a common inter technology communication framework, which is presently not available for LTE and Wi-Fi.

4. Transmit Power Control (TPC):

LTE uplink TPC is an option to the LTE blank sub frames time-sharing approach for integrated LTE/Wi-Fi network. A controlled lowering of LTE users transmits power devalues the interference, hence making Wi-Fi transmission opportunities as Wi-Fi nodes identify the existence of the channel as unoccupied. Traditional LTE uplink power control recompenses only a tiny part of the path loss (PL).

This brings down LTE cross-tier interference, especially for the users who located at the cell edges (Ghosh & Roy, 2016a), in such a manner as to achieve desired results. Although, LTE TPC based on PL is not much useful for Wi-Fi coexistence. Wi-Fi coexistence needs scaling down of the transmit power for UEs resulting in large interference to Wi-Fi nodes. An LTE UL TPC with an interference-conscious power functioning point is introduced in (Chaves et al., 2013) for authorizing to exist together with Wi-Fi.

UEs determining large interference is greater chance to cause large interference, so UL transmits power is decreased based on a small amount compensation of the determined interference. LTE power control in UL transmission stipulates UE transmit powers, result in path loss and interference are compensated, and a target signal to interference plus noise ratio (SINR) is obtained maintaining signal quality at the receiver. This tiny amount of compensation of the computed interference corresponds to reduce the target SINR when large interference is noticed. Therefore, LTE UE throughput is reduced correspondingly. As noticed in Fig.1, the reduction of key LTE UEs' transmits power permits co-existing Wi-Fi transmissions at the price of less LTE throughput.

Simulated throughput depicts in Fig. 1 exactly demonstrates that LTE blank sub frames and UL TPC states of different possible trade-off features for coexistence scenario of LTE and Wi-Fi. In Fig. 1b, the concurrent Wi-Fi throughput grow and LTE throughput lessen the number of blank sub frames assigned, whereas in Fig. 1c the decrease in the fraction of interference compensated by LTE UL TPC also reduces LTE throughput to increase Wi-Fi throughput.

5. Standardization

Research unveils that quite a few issues require being dealt with for the operation of LTE and Wi-Fi within the same USs. Regulating bodies (i.e., 3GPP and IEEE) are undertaking few of these challenges. From the point of view of LTE, 3GPP has presently begun discussion on operation in USs. A review model was formed for stating changes require to LTE radio for deployment in USs (Ericsson, 2013). On the other side, with Wi-Fi normally working in USs, IEEE has operated on standardized mechanisms for permitting well organized coexistence among heterogeneous WBAN within TV White Spaces spectrums. One prime instance of IEEE drives to work in TV White Spaces spectrums is the IEEE 802.19 Task Group (TG) (Baykas et al., 2010), where a working group known as 802.19 TG1 pointed out coexistence for IEEE 802 architectures and devices. These reviews can also be helpful for non-IEEE 802 architectures TV White Spaces spectrums. Another drive is the IEEE 802.11af standard, also referred to as White-Fi and Super Wi-Fi (Lekomtcev & Maršálek, 2012) is a wireless computer networking standard in the 802.11 family, that allows wireless local area network (WLAN) operation in TV white space spectrum in the VHF and UHF bands between 54 and 790 MHz (Feng et al., 2013). The standard was approved in February 2014 (Flores et al., 2013). Cognitive radio technology is used to transmit on unused TV channels, with the standard taking measures to limit interference for primary users, such as analog TV, digital TV, and wireless microphones.

Conclusion

The wireless communications community has been probing by means of analyses to get the way out for the purpose to deal with the growing demand of WBAN. In this context of spectrum scarcity, it has been a present context of a discussion about the subject matter of spectrum scarcity to permit emerging technologies like LTE and Wi-Fi to operate within the same USs. In this short communications, we illustrate that Wi-Fi is very badly affected by the simultaneous operation of LTE in the coexistence environment.

This demands a genuine requirement of coexistence operations for improving the performance of both technologies. The usefulness of coexistence enabling features for the integrated LTE and Wi-Fi are explored, and research motivations for further progress of inter-technology coexistence are presented. We also introduce entangled mechanisms by reutilizing the blank sub-frame application and the UL-TPC applied in LTE and present that it can remarkably revamp Wi-Fi performance for the co-existence of LTE and Wi-Fi within the same USs.

Corresponding Author:
Joydev Ghosh, Ph.D.
ETCE Dept., The New Horizons Institute of Technology, Durgapur-08.
E-mail: joydev.ghosh.ece@gmail

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