UDC 621.391

PROBLEMS AND OPPORTUNITIES OF LTE IN THE UNLICENSED SPECTRUM BANDS

Pravylo V.V., Chernyavsky A.A.
Institute of Telecommunication Systems,
Igor Sikorsky Kyiv Polytechnic Institute, Ukraine
E-mail: ruskc2beat@gmail.com

Проблемы и возможности LTE в нелицензированном спектре частот

В работе рассматриваются возможности реализации LTE в нелицензированном спектре частот и преимущества данного выполнения. Также были описаны проблемы внедрения LTE систем в нелицензированный спектр частот и технологии, которые позволяют решить эти проблемы.

In this paper the possibilities of implementing LTE in the unlicensed spectrum bands and the advantages of this implementation are presented. Also, the problems of integrating LTE systems in the unlicensed spectrum bands and technologies that solve these problems are described.

Nowadays the amount of wireless mobile subscribers is rapidly growing and the data traffic is exponentially increasing, but the spectrum resources are limited and costly. The licensed spectrum for Long Term Evolution (LTE) is mostly from 700 MHz to 2.6 GHz. So, there are two problems with mobile data traffic: existing spectral resources are not enough to provide efficiently mobile communication and network capacity must be improved through existing wireless technologies and infrastructures. So LTE in the unlicensed spectrum bands at 5 GHz can help to improve the LTE service experience.

Thanks to the support of medium access technology in LTE, the unlicensed spectrum can be very effectively utilized. Moreover, the available unlicensed spectrum at 5 GHz is fairly broad. As a result, LTE-U has a lot of advantages: it will increase the network capacity and the amount of wireless users, improve system coverage, it can be easily integrated into the existing network without any additional network services. Also, using licensed and unlicensed spectrum, LTE-U can ensure a better user experience with the help of the carrier aggregation technique. Carrier aggregation can take over the licensed spectrum quickly to provide service quality when the unlicensed spectrum becomes inefficient.

But there are also some problems with implementing LTE-U. Many other radio access technologies also use the unlicensed spectrum. How to guarantee coexistence between LTE systems and other RATs operating at the same unlicensed spectrum becomes an important issue. Listen-before-talk (LBT) is used to support this coexistence, but there are still many unresolved problems.

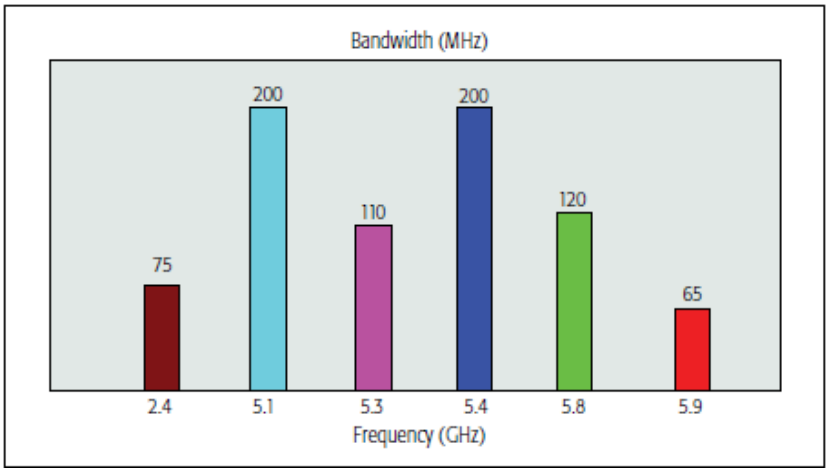

Fig. 1 Available unlicensed spectrum for shared bands

As illustrated in Fig. 1, most unlicensed spectrum bands for sharing 3GPP are around 5 GHz. The industrial, scientific and medical (ISM) radio band is currently hosting Wi-Fi, Bluetooth, UWB, ZigBee and U-NII within 2.4 GHz and 5 GHz bands. There is a task to choose such a band, which will allow LTE to be hosted in the unlicensed band and to cooperate properly with each system in the shared band. Also, the transmission power of the unlicensed spectrum varies because of the environments. The low transmission power, 200 mW or less, is usually used for indoor environments and the high transmission power, 1 W or more, is used in other ones.

To effectively utilize the unlicensed spectrum LTE-U should integrate with licensed spectrum techniques. LTE-U usually works in the areas where there is a coverage by the licensed LTE operation, but the additional capacity is needed, such as for public indoor or outdoor hotspots. Macro cells, small cells and Wi-Fi may access the shared unlicensed band, as shown in Fig. 2. Thus, LTE-U should cooperate with other systems to provide high capacity and efficiency. Also, it is important to work together with the existing LTE system for good coverage and reliable control transmission.

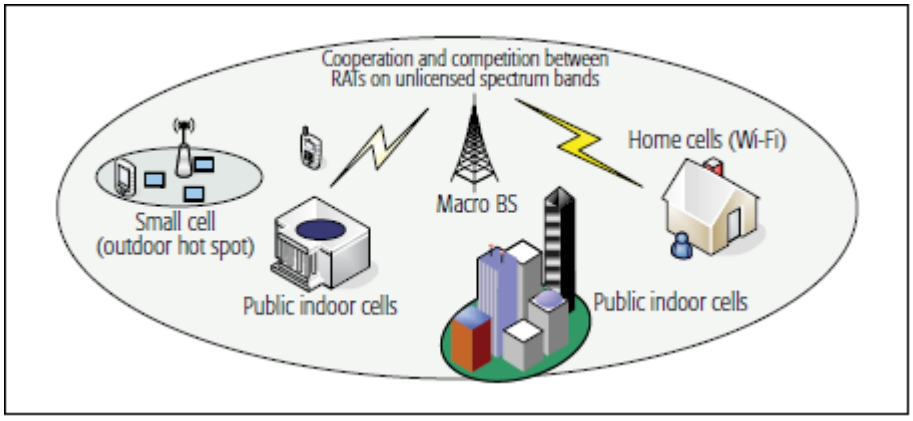

Fig. 2 RATs on unlicensed spectrum bands

The LTE-U medium access process include:

- Carrier Sensing Adaptive Transmission (CSAT). It sets a duty cycle when a small cell sends a part of the cycle and releases channel during the rest of the cycle. During the duty cycle for LTE-U, the channel is occupied by LTE and Wi-Fi needs to keep silent. During the rest of the cycle, Wi-Fi is working in that

channel and the system will determine Wi-Fi medium utilization. Fig. 3 shows an example of usage CSAT.

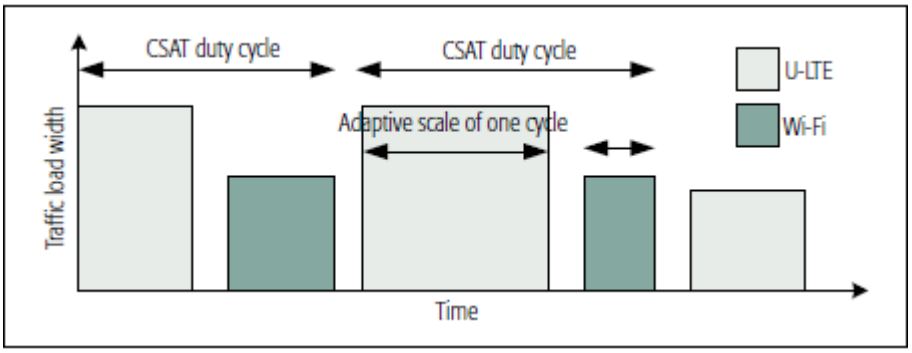

Fig. 3 CSAT duty cycles

- Listen Before Talk (LBT). It is a medium access mechanism through application of clear channel assessment (CCA) time for channel observation. CCA consists of carrier sense (CS) and energy detection (ED). CS means the ability of the receiver to detect and decode a Wi-Fi preamble and ED means the ability to operate channel and cancel data transmission according to energy level.
- Almost Blank Subframe (ABS). To coexist with Wi-Fi transmissions LTE systems can mute their own operations in certain subframes which are called almost blank subframes. They are called “almost blank” because LTE can still transmit some broadcast signals, control signals and synchronization signals over these subframes.

Different channel sensing mechanisms have been adopted in different RAT systems during transmission and reception of packets in the unlicensed band. Since licensed LTE focuses on increasing spectral efficiency and improving the user experience, LTE-U should be designed with less impact on existing Wi-Fi or other RATs. So, such parameters like bandwidth, latency jitter and others should be considered to ensure fair medium access and effective coexistence of all kinds of RATs.

As a result, different RATs will coexist with each other, providing mobile users fast wireless connection. Without implementing any additional network services and infrastructure, LTE-U can use the existing LTE infrastructure to guarantee authentication, security, mobility and quality of service.

References

1. LTE-U: unlicensed spectrum utilization of LTE, Huawei White Paper, 2014.
2. A. Bhorkar, C. Ibars, and P. Zong, “Performance Analysis of LTE and WiFi in Unlicensed Band Using Stochastic Geometry,” Proc. IEEE PIMRC 2014, Sept. 2014, pp. 1310–14.
3. E. Almedia et al., “Enabling LTE/WiFi Coexistence by LTE Blank Subframe Allocation,” IEEE Commun. Mag., vol. 52, no. 11, 2014, pp. 54–61.
4. F. Liu et al., “Small Cell Traffic Balancing over Licensed and Unlicensed Bands,” IEEE Trans. Veh. Technol., vol. 99, no. 99, 2015, pp. 1–16.