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LTE over Unlicensed Frequencies: Challenges for Coexistence

Background

In recent months, Qualcomm, Ericsson, Huawei, Verizon, China Mobile and others have expressed increasing interest in deployment of LTE using unlicensed spectrum. There are two versions: LTE-Unlicensed (LTE-U) and LAA. LTE-U is the pre-standard proprietary version contemplated by the LTE-U Forum. LAA, short for License Assisted Access, is the version currently being developed by 3GPP. LTE-U and LAA are expected to be deployed initially through small cells for downlink traffic only, but later to encompass the uplink as well. As currently conceived, LTE-U and LAA rely on a combination of licensed and unlicensed spectrum. The LTE control channels operate in a licensed frequency, and a carrier has flexibility to determine whether to send data over the licensed or unlicensed frequency. For example, if the unlicensed frequencies become congested, a control channel may instruct the device to revert to licensed frequencies for data transmission, or vice-versa. This arrangement provides licensed carriers with access to additional spectrum without the associated expense of obtaining a license, while still allowing them to maintain the high quality of service expected by consumers for such licensed services.

Unlicensed frequencies serve as a catalyst for innovation

In the last 20 years, radio technologies in unlicensed spectrum, such as Bluetooth, Wi-Fi, and ZigBee, have been widely adopted. Access to unlicensed bands has enabled innovation and business deployment by entities ranging from the world's largest companies to the smallest of startups. Interest in LTE-U and LAA is additional evidence of the pressure on existing unlicensed allocations and the importance of making additional unlicensed spectrum available for commercial use.

LTE-U and LAA present challenges in coexisting with other unlicensed technologies

LTE-U and LAA present new challenges in ensuring that diverse and varied technologies are able to effectively utilize unlicensed frequencies. Unlike Wi-Fi and some other unlicensed technologies, LTE-U does not appear to be specifically designed with co-existence protocols in mind. Wi-Fi, for example, listens and waits for the band to be clear. This is known as “listen before talk” (LBT). Once the band is clear, Wi-Fi waits for an additional randomly selected, interval, and then, only if the band is still clear does it begin transmission. This is known as “initial wait.” If a collision -- e.g., simultaneous transmissions by Wi-Fi devices -- occurs, then larger random intervals are chosen before the next transmission to decrease the probability of collision. This increase in length of the random intervals is referred to as "exponential backoff."

It is the combination of all three of these politeness protocols, (LBT, initial wait, and exponential backoff) and Wi-Fi's ability to sense extremely weak signals (approx. 1000 times weaker signal strength than the level defined by EU regulatory requirements), that make it such a good neighbor to other technologies.

By contrast, LTE-U looks for the cleanest or least used band before selecting the band and commencing data transmission (channel selection). Once a band is selected, LTE-U then may use proprietary algorithms that monitor other wireless traffic on that channel, and shares the spectrum by using "duty cycle (on/off periods)"-based protocols. These algorithms are still evolving and are unavailable for industry to evaluate their ability to ensure fair coexistence with other unlicensed technologies deployed in the same bands. This process also relies on LTE-U operators to self-regulate the duty cycle period, and therefore, time allocated for Wi-Fi transmission. Real time services, such as voice and video over Wi-Fi will suffer the greatest harm as a result. Unlicensed technologies such as Wi-Fi will be at the mercy of LTE-U operators, whose incentive is to choose a duty cycle that maximizes LTE-U's time on air at the direct expense of Wi-Fi and other unlicensed technologies. Recognizing that the temptation to maximize duty cycles could impede coexistence among users and be harmful to the entire ecosystem, even licensed operators and equipment manufacturers that rely on Wi-Fi as a complement for licensed services have reason to be concerned about LTE-U deployments. It is important that no technology in the unlicensed band has the power to regulate or control the amount of access for itself or other technologies. This power becomes akin to licensed spectrum usage where a provider must pay for this level of control over the medium.

While LAA is still working through the 3GPP standards process, it is important that the standard focus on fairness and include co-existence protocols to ensure that it is a friendly unlicensed technology. These could include protocols such as LBT, "initial wait," and "exponential back-off," but it is not clear today what precise set of coexistence mechanisms may enable effective sharing.

If LAA does not adopt fair co-existence protocols, it will always be more likely to get through when the transmission conflicts with Wi-Fi. The Wi-Fi transmission will be blocked because LAA will begin transmission shortly after the air is clear, potentially interrupting current Wi-Fi transmissions. In contrast, Wi-Fi will wait for longer and longer intervals if collisions occur, and thus allow the competing LAA signal to fill the unlicensed channel. Additional coexistence mechanisms may be necessary to address this imbalance.

Unless co-existence protocols are carefully vetted by industry stakeholders, LTE-U and LAA have a real potential to crowd out other uses of the band, including new and innovative technologies as well as established technologies like Bluetooth, ZigBee, and Wi-Fi.

Holders of spectrum licenses should not have a special claim to unlicensed spectrum

Licensed and unlicensed frequencies are complementary. Exclusive access to licensed spectrum provides the certainty major operators need to make large investments in their wide-

area networks, while broad eligibility for access to unlicensed spectrum fosters widespread contributions to innovation and investment in emerging technologies. To maintain these distinct but complementary opportunities, unlicensed spectrum must be genuinely available to all potential users who operate according to the rules; having a license for other spectrum must not become a legal or practical requirement for using unlicensed spectrum. Indeed, unlicensed bands have been a platform for innovation precisely because they do not require entrepreneurs to seek permission to offer new products or services. LTE-U and LAA should be deployed in a way that does not undermine this co-existence framework.

In particular, if LTE-U and LAA take advantage of exclusive rights to licensed spectrum to operate a control channel and are deployed without appropriate co-existence mechanisms in unlicensed spectrum, then licensed carriers could exploit their unique ability to combine those two aspects to essentially drown out other users in the unlicensed bands. The result could be that those bands become unusable by existing unlicensed technologies as well as new entrants seeking to offer innovative services. LTE-U and LAA devices may be more willing to risk congestion because if the unlicensed channel becomes crowded, the LTE devices can fall back on licensed spectrum. Wi-Fi devices, for example, don't have that option, thus Wi-Fi technology is designed so that Wi-Fi devices must be good neighbors to each other and other technologies.

Coexistence models should ensure that the unlicensed bands remain open to innovation.

As the history of the unlicensed bands shows, conflicts among technologies typically are resolved through cooperation and without regulatory intervention. For example, Wi-Fi, Bluetooth, Zigbee, and cordless phones all coexist in the 2.4 GHz band. Indeed, the standards for Wi-Fi and Bluetooth specifically incorporate mechanisms to ensure that they can fairly coexist with each other. We anticipate the same level of careful attention to these mechanisms for technologies deployed in the 5GHz band, whether Wi-Fi, LTE, or other applications. In particular, LTE-U and LAA would best be developed within a similar cooperative framework. As a part of any coexistence strategy, however, it will be important to ensure that users of unlicensed bands who do not have access to licensed spectrum are able to use the unlicensed frequencies effectively alongside LTE-U and LAA. Without such assurances, the introduction of LTE-U and LAA could compromise wireless investments and future innovation.