LTE Operation in Unlicensed Spectrum–Good for Whom?

Written for MIMO World
May 23, 2014

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The clear line separating Wi-Fi in unlicensed spectrum and cellular technologies in licensed spectrum has been breached, and the consequences could reshape the mobile broadband industry. In late 2013, Qualcomm and Ericsson presented to 3GPP how LTE could be designed to operate in unlicensed spectrum by use of a supplemental channel that is aggregated with a channel in licensed spectrum using LTE-Advanced mechanisms. Unlicensed bands would be at 5 GHz.

The potential advantage to a cellular operator is that the same base station, especially in a small-cell environment, could exploit considerably more spectrum, increasing the capacity of the cell, providing LTE users higher average throughputs, and obviating the complicated mechanisms for handover between Wi-Fi and cellular.

Another advantage is that the LTE network can use spectrum more efficiently than a Wi-Fi network, especially under heavy load, since it is a managed network. For example, LTE employs sophisticated scheduling algorithms that determine when to send data to what mobile users. By favoring devices that have a better instantaneous radio signal, physical layer protocols can employ less error correction and higher-order modulation, resulting in higher average spectral efficiency

The benefits seem almost too good to be true.

Disagreements at a number of recent 3GPP meetings examining this technology have shown that indeed the proposed technology is not so simple and that multiple issues must be addressed. First, a licensed spectrum network taking capacity from unlicensed spectrum means less capacity for users in that unlicensed band. Handoff to Wi-Fi from cellular, however, also consumes this capacity.

Second, and more serious, Wi-Fi technologies have been designed from the ground up to co-exist with each other. Two Wi-Fi networks operating using the same radio channel in hearing distance of each other share the spectrum by using medium-access protocols that require a station to wait until the medium is clear before transmitting, and then only doing so after waiting a random back-off period that prevents multiple stations from pouncing onto a channel all at the same time.

In contrast, an LTE network, at least by the unlicensed spectrum rules in some countries, could preempt Wi-Fi users from the channels it uses, which is the source of one disagreement among 3GPP participants, since some operators have invested heavily in public Wi-Fi infrastructure. Such aggressive spectrum occupation would also likely unleash a public outcry, and so engineers are considering what changes should be made to LTE for it to co-exist as a good neighbor with other Wi-Fi networks.

Assuming fairness issues are resolved, operators still have to consider fundamental architectural questions related to what is the best way to deploy millions of small cells to unleash the next wave of mobile broadband capacity. Consider a hotel. Is it more effective to deploy multiple LTE small cells across the property or multiple Wi-Fi access points? Today, Wi-Fi has the advantage because access points are less expensive and because it is the better neutral-host solution.

Neutral host refers to the same piece of equipment supporting multiple operators. Through its Subscriber Set ID (SSID) mechanisms, a Wi-Fi access point can advertise itself and operate as multiple different networks. Thus, any of multiple entities can deploy the Wi-Fi infrastructure, and the end network can look like an operator network, a hotel network, or any other network that has a contractual relationship. Combined with Hotspot 2.0, users can automatically connect with existing subscriptions.

In contrast, cellular equipment currently is tied to a single operator, so in the hotel scenario, every operator with small cells, including those using LTE in unlicensed spectrum, would have to deploy its own infrastructure, a less efficient approach.

One solution to the multi-operator deployment issue is multi-tenant neutral-host LTE small cells. Vendors are working on such equipment, but whether operators will be willing to have their network operate on the same hardware as their competitors remains to be seen. The same neutral-host small cell also supporting both Wi-Fi and LTE operation in unlicensed spectrum seems would be an obvious extension in functionality.

Thus the desirability of LTE operation in unlicensed will depend on how small cell deployments occur in general and how extensive Wi-Fi infrastructure will be, two industry areas evolving both quickly and somewhat unpredictably.

Developers of LTE in unlicensed will also have to consider that Wi-Fi operation varies depending on the country. In the U.S., for example, 5 GHz bands require a capability called Dynamic Frequency Selection (DFS), requiring that if an AP detects particular government radar operation, it has to move to a different channel.

For the multiple reasons discussed, LTE operation in unlicensed bands will take some time to develop. The technology is being considered for 3GPP Release 13, a version of specifications not likely to be completed until 2016, with earliest equipment availability in 2017 and more likely 2018.

At this early stage, how many operators will adopt the technology is unclear, but the reasons for using it are too compelling for the technology to be ignored. The only real question is whether it will play a niche or dominant role.

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