Ruckus
Simply Better Wireless.

white paper

Making Sense of Convergence:
LTE-U, LAA-LTE, and LWA

Q2 2015

Wi-Fi and cellular are two very successful technologies that have complemented each other over the years. Wi-Fi's great strength is that it runs in unlicensed spectrum so it can be deployed by anyone, and it is supported on all data centric devices. Its sweet spot is high capacity density applications with low mobility. Cellular technology has swept across the globe over the last few decades and is now a trillion dollar industry. Its great strength is ubiquity, mobility, and real-time applications. As we look to the future, there is no doubt that these two technologies are going to continue to converge with a goal of giving the user an always-best-connected experience. In fact it is generally agreed that 5G will not so much be a new modulation technology as it will be a tighter coupling of Wi-Fi and cellular. There are many different approaches to convergence that have been developed over the years, and as with everything else in this world, the market will decide.

LTE in Unlicensed Bands (LTE-U and LAA-LTE)

LTE-U is one option that has gotten a lot of attention over the last 18 months. It is a concept that is being promoted by Qualcomm, and the RAN industry, to run LTE directly over the unlicensed bands. It isn't so much convergence as it is way to obtain additional spectrum for mobile services. This concept is now under development by 3GPP (3rd Generation Partnership Project) for standardization in Release 13 as LAA-LTE (license assisted access). LAA-LTE continues to run all control channels in the licensed band and uses the unlicensed bands for additional data plane capacity. LAA-LTE uses the carrier aggregation capability in LTE-Advanced to combine the unlicensed and licensed bands to enable a seamless service offering. The great challenge with this approach involves getting LTE to peacefully coexist with Wi-Fi in the unlicensed bands, but the sharing of spectrum is not in the LTE DNA.

Making Sense of Convergence:
LTE-U, LAA-LTE, and LWA

Figure 1: LTE-U uses the Carrier Aggregation feature in LTE Advanced to Create a Service that uses both Licensed and Unlicensed Spectrum

LTE assumes that it has full control over the frequency bands in which it operates and is not designed to contend for access. This creates a problem in the unlicensed bands, which are all about contention. To this end, the Wi-Fi industry employs listen-before-talk (LBT) technology. With LBT, any device wishing to use the band must listen to see if it is occupied, and if it isn't, the device can seize the band and start transmitting. The band can only be held for a maximum of 10 msec after which it must be released and the LBT process repeated. This assures fair access to the medium and has proven to be a very effective way of sharing unlicensed spectrum. The challenge for using LTE in unlicensed bands is how best to implement LBT, as it will require changes to the LTE MAC.

The importance of a strong LBT implementation can't be emphasized enough. Failure to correctly implement listen-before-talk, will limit the viability of LTE-U technology, as public venue owners and other businesses will be reluctant to deploy anything that might negatively impact the unlicensed bands. For most public venues, a high quality Wi-Fi service is mission critical. In many cases it plays a major role in bringing customers into their building and keeping them there. This causes public venues to put a premium on protecting the unlicensed bands. This makes it essential that any LAA-LTE standard coming out of 3GPP support LBT per IEEE specifications.

Public venues include airports, stadiums, convention centers, hotels, train stations, shopping malls, etc. These are highly desirable locations with heavy data demands, and their wishes and desires matter greatly when deploying any radio technology on their premises, be it licensed or unlicensed.

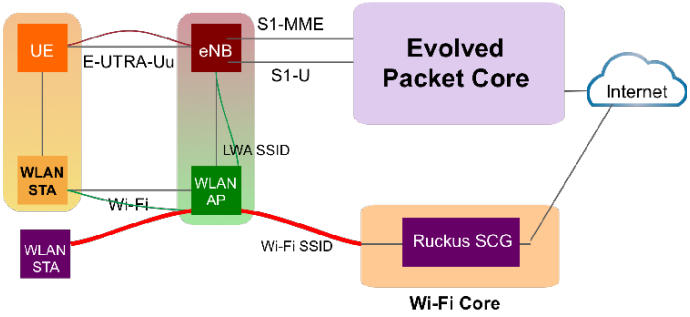
LTE + Wi-Fi Link Aggregation

There is, however, an alternative to using LTE in unlicensed spectrum that should be much more palatable to the broader industry, and that is LTE + Wi-Fi Link Aggregation (LWA). This approach is also being promoted by Qualcomm to achieve a very similar result to LTE-U and LAA-LTE. With LWA, Wi-Fi runs in the unlicensed bands and LTE runs in the licensed bands, and the two radio technologies are combined to offer a compelling user experience. Both technologies are allowed to do what they do best, and LTE no longer needs to perform any unnatural acts. Unlike the deployment of LTE in unlicensed spectrum, which requires all new network hardware and all new smartphones, LWA could be enabled with a straightforward software upgrade. A smartphone with updated software can power-up both radios and split the data plane traffic so that some LTE traffic is tunneled over Wi-Fi and the rest runs natively over LTE. The traffic that flows over Wi-Fi is collected at the Wi-Fi access point and then tunneled back to the LTE small cell, which anchors the session. This does require a dedicated SSID (service set identifier) in the Wi-Fi access point. The flows are combined at the LTE small cell and then sent on to the evolved packet core (EPC) and from there to the Internet. The advantage of this approach is that all Wi-Fi traffic can benefit from the services provided by the mobile operator's EPC without needing to use 3GPP S2a, S2b, or S2c interfaces. These services include billing, deep packet inspection, lawful intercept, policy, authentication and the list goes on. If the LTE signal is lost, this service will drop and the user can reinitiate an Internet connection over Wi-Fi. This approach is somewhat similar to multi-link TCP, except that the traffic is combined in the cellular RAN rather than back in the Internet.

LTE + Wi-Fi Link Aggregation (LWA) does require that LTE small cells be deployed in the venue, and that any Wi-Fi APs in the venue get a software upgrade to support LWA. The Wi-Fi APs can also continue to support non-LWA traffic on a separate SSID as well, so it is the best of both worlds. LWA is a solution that doesn't impact the unlicensed band, does leverage existing Wi-Fi access points, and can improve indoor cellular performance.

Making Sense of Convergence:
LTE-U, LAA-LTE, and LWA

Figure 2: LTE + Wi-Fi Link Aggregation allows a Wi-Fi access point to support both standard Wi-Fi SSIDs and an LWA SSID



LTE Small Cells and LWA

We expect LWA to proceed rapidly through the standards process and emerge in 3GPP Release 13 in the summer of 2016. It provides more upside than using LTE in unlicensed bands with none of the downside. This now brings us to LTE small cells, which are a key part of any LTE-U, LAA-LTE or LWA solution. This technology is starting to emerge, and it will get even better with the addition of LWA. For LTE small cells to be broadly deployed, we need to look beyond the technical issues, which have mostly been resolved, and instead focus on the business model for broad-based deployment in high-density locations. Much can be learned about the business model by looking at the Wi-Fi phenomenon. The secret of Wi-Fi's enormous success in high-density public venues can be distilled down to the following:

- The venue pays for the deployment
- It can be easily installed by a VAR (value added reseller) with modest radio skills
- The equipment is inexpensive and easy to operate.

For LTE small cells to be truly successful, they must emulate this model. Let's look a bit more closely at what is required:

The Venue Pays:

Once you get past high-density locations like airports and convention centers, for which the mobile operator will gladly pay for the deployment, the burden has to shift to the venue. In order for public venues to be willing to pay for an LTE small cell deployment, they will usually require a neutral host solution. These venues want any person who enters their building to be able to connect to the wireless network. The traditional neutral host cellular solution for large public venues is DAS (distributed antenna systems). This is a topic that is starting to attract a lot of careful thought in the LTE small cell community, and the 3.5 GHz band is seen as part of the solution. The "venue pays model" also puts a premium on making sure that any small cell deployment does not encumber the unlicensed bands. LWA does a much better job of this than does LTE-U, and should pass muster with public venues.

Must be installed by VARs:

Public venue LTE small cell deployments must be deployable by the same network of VARs that support Wi-Fi deployments. If radio engineers are required, it will push the cost of these deployments far beyond what makes financial sense (especially as we move beyond high-density venues). A key capability here is support for self-organizing network (SON) capability in LTE small cells. To a large extent, Wi-Fi network are already self-optimizing which greatly simplifies the install.

Cost effective equipment:

This may be one of the biggest challenges with an LTE small cell deployment. Today indoor 802.11ac access points can be purchased for under $1,000, with 802.11n access points being a lot less expensive than that. LTE small cells will need to hit these same price points to successfully penetrate lower density venues. Adding an additional 5 GHz radio to these units to support LTE-U or LAA-LTE will certainly push up the costs of these devices; a cost that the venue may not wish to bear. With LWA, the existing Wi-Fi APs in the venue can support LWA with a software upgrade.

Conclusions

The convergence of Wi-Fi and LTE small cell technology will play out over the remainder of the decade. The end result will be to enable an always best-connected experience for the user. LTE-U, LTE-LAA, LWA, and multi-link TCP are all options for converging these two great radio technologies, and there are others as well. The future looks bright for carrier grade Wi-Fi technology and LTE small cells.

Copyright © 2015, Ruckus Wireless, Inc. All rights reserved. Ruckus Wireless and Ruckus Wireless design are registered in the U.S. Patent and Trademark Office. Ruckus Wireless, the Ruckus Wireless logo, BeamFlex, ZoneFlex, MediaFlex, FlexMaster, ZoneDirector, SpeedFlex, SmartCast, SmartCell, ChannelFly and Dynamic PSK are trademarks of Ruckus Wireless, Inc. in the United States and other countries. All other trademarks mentioned in this document or website are the property of their respective owners. April 2015

Ruckus Wireless, Inc.
350 West Java Drive
Sunnyvale, CA 94089 USA
(650) 265-4200 Ph \ (408) 738-2065 Fx

Ruckus®
Simply Better Wireless.

www.ruckuswireless.com