Wireless Broadband Alliance
Driving next generation Wi-Fi experience

Wireless Broadband Alliance (WBA) response to Federal Communications Commission (FCC) Office of Engineering of and Technology and Wireless Telecommunications Bureau public seek of Information on Current Trends in LTE-U and LAA Technology (ET Docket No. 15-105)

Founded in 2003, the aim of the Wireless Broadband Alliance (WBA) is to secure an outstanding user experience through the global deployment of next generation Wi-Fi. In order to make this a reality, the WBA is currently championing various initiatives in the Wi-Fi ecosystem including Next Generation Hotspot (NGH) trials, Wi-Fi Calling, Wi-Fi Roaming and its Interoperability Compliance Program (ICP). Today, membership includes major fixed operators such as BT, Comcast and Time Warner Cable; seven of the top 10 mobile operator groups (by revenue) and leading technology companies such as Cisco, Microsoft, Huawei Technologies, Google and Intel. WBA member operators collectively serve more than 1 billion subscribers and operate more than 10 million hotspots globally. The WBA Board includes AT&T, Boingo Wireless, BT, China Telecom, Cisco Systems, Comcast, iPass, Liberty Global, KT Corporation, NTT DOCOMO, Orange and Ruckus Wireless.

This response is based on the feedback provided by 23 members, 61% of the responses were from Carriers, and 26% from Vendors and 13% from other companies of the Wi-Fi ecosystem.

1. What different variations of LTE in unlicensed spectrum (e.g., LTE-U, LAA) are under active development or on a roadmap for future development? How do they relate to one another in terms of technology, potential use, and timing of availability?

3GPP- LAA (Licensed Assisted Access)

LAA is a global standard being developed by 3GPP in Release 13 that aggregates a licensed LTE carrier as primary cell with one or more unlicensed carriers (or channels) in the 5 GHz bands as secondary cells for downlink and uplink.

More specifically, LAA is being standardized in 3GPP groups RAN1 and RAN2. These groups are discussing whether standardize Carrier Aggregation with uplink or just specify Supplemental Downlink only at this stage. At the upcoming June 2015 RAN plenary when the corresponding Work Item description is approved, this topic will be finalized. LTE-U Forum by contrast has decided to only specify operation in the Supplemental Downlink mode forgoing uplink at this time.

Standalone scenarios are not considered for standardization in 3GPP. Thus, LAA excludes a standalone scenario (i.e., unlicensed access without license spectrum).

LTE-U Forum (LTE-Unlicensed)

LTE-U is a specification developed by the LTE-U Forum members that utilizes the framework of 3GPP LTE Releases 10/11/12 for aggregation of a licensed LTE carrier as a primary cell with one or more unlicensed carriers in the 5 GHz UNII 1 and 3 bands as secondary cells for supplemental downlink. In LTE-U, co-channel coexistence is achieved by adapting the

transmission duty cycle, the duty cycle period and optionally some other parameters on a larger time scale. LTE-U relies on the backoff mechanism of Wi-Fi to co-exist with Wi-Fi. LTE-U cannot be used in countries that require LBT, such as Europe and Japan, while LAA will be a global solution.

On the current path, it appears that non-standard LTE-U will be deployed in the US market using proprietary technology. This version of LTE-U will only serve as license assisted access (no standalone mode envisioned), and will use coexistence mechanisms that are not fully understood and will not provide for fair use of unlicensed spectrum among all technologies.

Additional member´s feedback on the status of implementation and future roadmap development

- The roadmap of LAA deployment is under internal discussion. On the other hand, there is no plan about LTE-U so far since current Japanese regulation does not allow continuous packet transmissions without listen-before-talk on 5 GHz spectrum.
- Only supplemental downlink license assist is being developed currently, both in 3GPP and in the proprietary (non-standard) LTE-U Forum, which is aimed at the US market. Carrier aggregation license assist has been discussed but is unlikely to be deployed within the same timeframe as supplemental downlink.
- Non-standard LTE-U will be in trials phase during the current calendar year, with deployments beginning early 2016 if testing goes as expected.

2. What is the current state of development of the LTE-U and LAA standards and what is the anticipated schedule for completion of the LTE-U and LAA standards?

LTE-U:

LTE-U being developed for the US market is non-standard and proprietary. It may materialize in trial form during this calendar year, with deployment beginning in early 2016.

LTE-U as envisioned by the LTE-U forum does not meet the normal criteria of a standard. Thus, please note that LTE-U is not a standardized technology which is developed in LTE-U forum.

LAA:

LAA is expected to be Work Item of 3GPP Rel.13, and it will be authorized in 3GPP RAN Plenary in June. Development of LAA standards plans to be completed by March 2016. This version will include supplemental downlink, and may include supplemental uplink as well depending on the results for the upcoming meetings.

3. What is the status of coordination between 3GPP and the IEEE 802.11 on LTE-U and LAA, and what is the process for coming to agreement on appropriate sharing characteristics to ensure coexistence with the IEEE 802.11 family of standards?

LTE-U

LTE-U is a proprietary technology being developed for the US market, and its proponents have not coordinated with IEEE 802.11 to ensure adequate coexistence.

LTE-U has nothing to do with 3GPP. LTE-U specifications have already been finalized and published by LTE-U Forum. LTE-U Forum members should consider working with WFA and WBA on enhancing the specifications to address any coexistence concerns.

3GPP (LAA) <> IEEE 802.11

Information have been exchanged between 3GPP and IEEE 802.11 There is a workshop planned for this year.

IEEE 802.11 and 3GPP are exchanging liaison statement (LS) regarding how different systems can co-exist in the same wireless spectrum. For example, latest LS exchange can be found in the following URL: http://www.ieee802.org/Communications.shtml

It is the understanding of the WBA Members that 3GPP member companies will agree on sharing mechanisms and a definition of "fairness" without requiring agreement from stakeholders outside of 3GPP membership. The WBA Members would welcome coordination with 3GPP and IEEE 802.11.

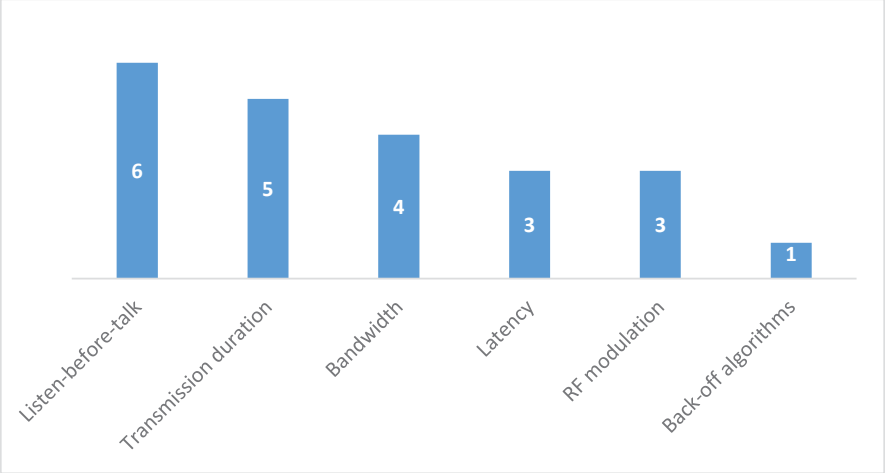
On the other hand, a Member shared that LAA is being developed entirely within 3GPP and there is no active coordination with IEEE 802.11. 802.11 has requested that 3GPP work with it to develop a common coexistence approach, but 3GPP has not responded to that request. 802.11 has also sent 3GPP several liaisons with recommendations for improving its technical work; some of these suggestions have been incorporated, but 3GPP's responses have generally been incomplete and noncommittal.

In summary, communications have been established between the different forums, but stronger collaboration coordination is necessary to ensure a standards process that achieve the coexistence details correctly.

WBA is on the process to start an initiative on LTE coexistence with Wi-Fi, focusing on the business drivers and relevant use cases for carriers to adopt these technologies.

4. What are the anticipated technical characteristics (e.g. bandwidth(s), listen-before-talk, transmission durations, etc.) of LTE-U and LAA?

Members did a voting for most relevant technical characteristics of LTE-U and LAA:



Number of Members that have selected that characteristic.

LTE-U:

Since LTE-U is a proprietary technology, it is difficult to know how it will be implemented. The LTE-U Forum has issued some technical information suggesting that it will use a combination of channel selection and duty cycling. However, the relevant criteria associated with these mechanisms have not been disclosed. We do not know what the duty cycle parameters will be, for instance.

Regarding channel bandwidth, LTE-U is targeting 20 or 40MHz deployments.

LAA:

3GPP has not yet determined the technical characteristics of LTE-LAA. While LAA is likely to incorporate some form of listen before talk, there are several means by which this may be done, some more friendly to other technologies than others, and it is possible that it will be configurable by mobile operators.

The LTE community has suggested avoiding the use of common channels as a primary interference avoidance tactic (i.e. smart LTE channel selection), but when one considers the rapid adoption of 802.11ac with its wider channels (80MHz), the number of available channels in the 5GHz band diminishes rapidly. An adequate spectrum sharing technique is absolutely essential, therefore. Both LTE-U and LAA utilize 20 MHz unlicensed channels. LBT mechanisms that are similar to modern Wi-Fi systems and that go much beyond LBT requirements in Europe are being considered for LAA. LTE-U does not employ LBT. LAA maximum transmission duration is expected to be between 4 and 10 ms, while LTE-U transmission duration can be up to 50 ms.

Members consider the following technical aspects to be critical for fair coexistence of collocated LAA and Wi-Fi networks:

- LBT channel access mechanism with adaptive back off and a contention window that is compatible with 802.11
- Appropriate Clear Channel Assessment level and smart channel selection
- Maximum transmission duration which does not impact voice and video services over Wi-Fi
- Mitigation mechanisms for the hidden node problem

While these technical aspects of LAA have not yet been defined by 3GPP, the WBA is concerned that the LAA specification may mandate use of LBT only where regulations require it, which could be detrimental to existing Wi-Fi deployments. It is the understanding of the Members that pre-standard LTE-U does not employ LBT, though it does limit maximum transmission duration, which raises concerns with respect to Wi-Fi coexistence.

5. What tests or analyses have been performed to understand the impact of LTE-U and LAA on the existing commercial wireless and unlicensed ecosystems?

LTE-U forum related tests/findings:

A number of LTE-U simulation and lab test results from a couple of LTE-U forum members are showing good coexistence with Wi-Fi in some scenarios.

However, there are two specific concerns - LTE-U Forum specifications do not provide ample protection to Wi-Fi in some important scenarios. For example, voice and video services over Wi-Fi are not protected to the degree prevalent in modern Wi-Fi. Thus, Wi-Fi detection thresholds are much higher than those employed by Wi-Fi to avoid collision with other Wi-Fi, and fair coexistence with Wi-Fi uplink transmissions is not guaranteed. Thus, LTE-U – Wi-Fi coexistence is in the hands of the LTE-U chipset maker and may vary greatly from one vendor to another. Another problem is that even for the chipset that is being developed to a higher standard, many of the adaptation parameters, on which coexistence hinges, may be left up to OEM and MNO implementations. Thus, LTE-U – Wi-Fi coexistence may also vary greatly from one implementation to another.

The LTE-U Forum has published analysis results, but because some mechanisms used in pre-standard LTE-U remain proprietary, only the implementing vendors can provide analysis to show the impact of LTE-U and LAA on the existing commercial wireless and unlicensed ecosystems.

3GPP related tests/findings:

There have been numerous 3GPP RAN working group performance simulation contributions/results that can be cited (e.g., Broadcom, Interdigital, and Intel) Reference baseline 3GPP document (study item).

Specifically, 3GPP TR 36.889 captures a summary of the LAA simulations have been performed by the member companies of 3GPP RAN1 during the LAA Study Item. While these simulation results provide interesting and valuable data, it is the opinion of some members of the Wi-Fi vendor and operator community that there are important metrics

not captured in these simulation results, such as jitter, frame re-transmission rate, beacon loss and deferral, and power save signaling loss and deferral.

In conclusion:

In IEEE802, WFA, and 3GPP, computer simulations are performed to clarify performance under environments in which LAA and Wi-Fi coexist. At this stage, we can only see some co-existing simulation result done by manufacturers. The result is only good for reference. Chipset/Device/CPE/Infrastructure vendors should have performed some tests or analyses on that impact. A Member have performed several simulations that demonstrate coexistence impacts on latency and throughput.

In practice insufficient analysis has been performed to understand how LTE-U or LAA-LTE will impact the unlicensed ecosystem. In general, claims of fairness proffered by the proponents of the technologies are based on limited simulations or lab demonstrations, using parameters that are not representative of likely real-world circumstances. Some analysis points to substantial coexistence problems, particularly in dense or high traffic environments, for both LTE-U and LAA-LTE.

6. Precisely how will LAA integrate licensed and unlicensed carriers, particularly with regard to controlling access to spectrum?

The most appropriate response for this question would come from 3GPP RAN1 group as they are developing LAA – however WBA Members provided the following feedback:

- There is an indication that both LAA-LTE and LTE-U will be released for supplemental downlink, with critical elements of control traffic running in the license band and additional downlink capacity being provided through unlicensed bands. Therefore, any operator without licensed spectrum will not be able to utilize either technology. Carrier aggregation license assist may follow supplemental downlink to enable both uplink and downlink traffic to be handled on the unlicensed bands; however, in this form the critical elements of traffic control will remain in the license band. Therefore, in both supplemental downlink and carrier aggregation, the unlicensed component of LTE-U and LAA-LTE is reliant on a licensed mobile network.
- Complimentary, LAA is based on the CA (Carrier Aggregation) technology, and the license spectrum is used for control. LAA make use of LTE-U as the Secondary Component Carrier (SCC) for LTE operators to realize Carrier Aggregation with existing LTE carrier to provide more bandwidth (and also higher speed) via the unlicensed spectrum but without the problem of customer experience degradation when switching from LTE to Wi-Fi Techniques such as Carrier Sensing Adaptive Transmission (CSAT) and Listen Before Talk (LBT) are required for controlling LTE-U access to spectrum for harmonized use of spectrum with other technologies. But application of similar techniques in other unlicensed band should also be considered for the harmonization.
- The unlicensed carriers (SCells) will only carry data traffic and not any control traffic which will all be carried by the licensed carrier, the PCell. Based on the Carrier

aggregation framework, licensed carrier works as a P-Cell and LAA (unlicensed carrier) will work as an S-Cell. LTE eNB can control access to spectrum.

- As long as LTE-U and LAA modes of operation require licensed spectrum (i.e. for the LTE control channels), and as long as coexistence measures remain ill-defined or unproven, there is a reasonable risk that LTE-U and LAA systems could prohibit access to the spectrum for other uses, including Wi-Fi.

7. To what extent is a standalone form of LTE-U being developed, that is, a form that can operate without a licensed primary channel?

The most appropriate response for this question would come from LTE-U Forum and other organizations working on this topic – however WBA Members provided the following feedback:

LTE-U is being developed for regions, such as the U.S., which do not require Listen Before Talk (LBT). More details about the technical characteristics can be found in LTE-U Forum's LTE-U Technical Report and LTE-U Supplemental Downlink (SDL) Coexistence Specifications.

While doing so would be technically feasible, standalone LTE-U or LAA-LTE is not being developed. A recent contribution (http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_80b/Docs/R1-152374.zip) of mobile operators in 3GPP reveals why this is the case. In a presentation entitled "Way Forward on precluding standalone access of LTE on unlicensed carriers", 12 mobile companies including some of the major US carriers justify the preclusion of LTE-U standalone based on concern about "drastically different business models", "possible disintermediation of cellular operators", and sending the "wrong message on the primacy of licensed spectrum".

8. Are existing devices capable of software upgrades to implement LTE-U and LAA?

WBA Members shared that they would not like to make statements, for now, about potential capabilities of devices. Leaving to the device vendors to explain feasible functionalities on devices.

9. What frequency bands are envisioned for deployment of LTE-U and LAA?

The most appropriate response for this question would come from forums working on this topic – however WBA Members provided the following feedback:

Mainly 5GHz U-NII spectrum but potentially also 3.5 GHz spectrum (3550-3700 MHz). More specifically, LTE-U and LAA-LTE are targeting operation in the 5GHz band ranging from 5.150 GHz to 5.925 GHz.

LTE-U limits this further to 2 bands, 5.150 – 5.250 GHz and 5.8 to 5.925 GHz, while LAA-LTE leaves the whole range open. However, it is possible that the technology could be deployed in any unlicensed band.

10. What plans do carriers and manufacturers have for pre-standard deployment of LTE-U and LAA equipment including possible upgrades to 3GPP-based LTE-U or LAA and how would the above questions (particularly with respect to coexistence issues) be addressed relative to pre-standard versions of LTE-U and LAA?

The most appropriate response for this question would come from manufacturers and forums working closely on this topic.

While questions remain about the level of fairness and coexistence in 3GPP-based LAA-LTE, it appears clear that pre-standard or non-standard LTE-U will not contain adequate coexistence mechanisms. The crux of non-standard LTE-U coexistence is duty cycling, which is non-cooperative and does not account for the needs of other systems using the shared unlicensed spectrum.

11. In addition to information in response to these questions, FCC encourages parties to submit whatever additional information they feel is relevant to this matter.

There are millions of Wi-Fi users in the unlicensed spectrum already, and if new users of that spectrum do not employ medium access mechanisms and transmission duration limits which are compatible with 802.11, the impact to the members of the WBA (operators with deployed Wi-Fi) could be severe. LTE-U as it stands today has been developed without the participation of standards bodies, and has protocol elements which are proprietary, leaving WBA members without the ability to assess the impact that it will have on their existing Wi-Fi deployments. LAA is still under development with in 3GPP, and so may still result in a standard that is compatible with 802.11. Communication and coordination with stakeholders in the 802.11 ecosystem would be welcomed and encouraged by the WBA.

Similarly, Wi-Fi and other technologies utilizing license exempt spectrum deliver tremendous benefit to consumers and have been an engine for economic growth. The deployment of LTE-U or LAA in 5GHz without adequate coexistence mechanisms would be disastrous for consumers, businesses, schools, and other user groups. A reasonable assurance of coexistence can be achieved if stakeholders agree on the following principals:

- The appropriate listen before talk (LBT) mechanism for LAA is what 3GPP designated Category 4, i.e. adaptive back off and a variable contention window compatible with 802.11 specifications, which furthermore cannot be modified by the operator beyond the standard parameters.
- LTE-U/LAA devices would utilize an appropriate clear-channel access (CCA) threshold.
- LTE-U/LAA access points and base stations should employ an intelligent channel selection algorithm cognizant of Wi-Fi utilization levels.
- Any notion of airtime fairness should result in channel occupancy by LTE devices which places them on an equal footing with Wi-Fi. And whereas LTE-U/LAA use of the spectrum might be downlink only (i.e. originating from the base station), the channel occupancy result should be fair to both Wi-Fi access points and stations.

- Specific and measurable performance metrics, such as throughput, latency, and jitter, ought to be defined to ensure that the Wi-Fi user-experience in the presence of LTE-U/LAA is not diminished to a greater extent than it would be by having an equivalent number of competing Wi-Fi devices in the vicinity. And that this regime should account for a variety of common applications, including real-time Wi-Fi communications (e.g. VoIP, video, gaming, etc.) where latency and jitter are directly related to channel accessibility.
- LTE-U/LAA systems should incorporate interference detection and remediation mechanisms triggered when certain thresholds of utilization or performance degradation are exceeded.
- Coexistence can be enhanced in devices which house both an LTE radio and a Wi-Fi radio. Such devices should be able to detect Wi-Fi SSIDs that are co-channel with LTE-U transmissions, and they should maintaining the end-user's prerogative to connect to the network of their choosing.
- Specifications and product implementations should address the general challenge of hidden nodes and should specifically consider the impact of LTE-U/LAA on low-power Wi-Fi devices.
- The Wi-Fi and mobile communities should undertake joint specification, testing, and certification of all the above.
- Overcome demonstrated interference by LTE in the lower ISM band
- Mechanisms in order to allow Wi-Fi to operate without latency impairments for voice over WI-FI

Also, there was one Member recommending that LTE-U Forum members should consider enhancing LTE-U specifications with input from WFA and WBA to address coexistence concerns.

Any enquiry to WBA regarding this document should be sent by e-mail to the PMO Office to the care of Tiago Rodrigues (pmo@wballiance.com) or by letter to:

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