July 2022

OPTIMIZED USE OF LICENSED CARRIER PRIMARY CELL SPECTRUM WITH NEW RADIO UNLICENSED (NR-U) AND LICENSED-ASSISTED ACCESS (LAA) DEPLOYMENTS

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ABSTRACT

Long-Term Evolution (LTE) and 3rd Generation Partnership Project (3GPP) Fifth Generation (5G) private and public wireless networks are deployed using both licensed spectrum and shared or unlicensed spectrum. Shared or unlicensed spectrum is frequently used in a carrier aggregation (CA) mode where a licensed carrier is aggregated together with an unlicensed carrier. However, CA is commonly enabled only when a user equipment (UE) has a higher volume of download (DL) data that needs to be drained, hence current mechanisms result in the use of a licensed carrier to drain the DL data for the UE with the unlicensed carrier not being used. Furthermore, unlicensed spectrum carriers are often mandated to operate with lower EIRP and hence has limited coverage footprint compared to licensed carrier with higher EIRP, which can better serve the users further away from the cell compared to unlicensed or share spectrum carrier. To address such a challenge, techniques are presented herein that support flexible options for the optimal utilization of both licensed and unlicensed spectrum. Aspects of the presented techniques support the default activation of CA for DL data draining for Licensed-Assisted Access (LAA) or any unlicensed or shared spectrum-capable UEs within a coverage footprint. Further aspects of the presented techniques support an operator configurable threshold for the distribution percentage of the DL data for LAA-capable UEs based on a UEs DL data. The need may be served by different modulation capabilities (such as, for example, 256 quadrature amplitude modulation (QAM)) for a primary cell (PCell) and a secondary cell (SCell) and may be driven by the number of LAA carriers that are configured on an evolved Node B (eNB) and the number of LAA-capable UEs that are under a cell. Further aspects of the presented techniques support the default automated activation of LAA CA for priority users such that any DL data packet, irrespective of burst size and volume, may be drained through an unlicensed carrier when the user device can be served by an LAA carrier.

DETAILED DESCRIPTION

Private network Long-Term Evolution (LTE) and 3rd Generation Partnership Project (3GPP) fifth-generation (5G) deployments initially make use of allocated licensed and shared spectrum (such as the Citizens Broadband Radio Service (CBRS) General Authorized Access (GAA) and Priority Access License (PAL) spectrum (e.g., Band 48 (B48) and N48)) or a licensed carrier that is allocated by respective authorities. In order to improve their overall capacity, a private network or a communications service provider (CSP) operator with a capacity constraint (as a result of, for example, holding a low amount of licensed spectrum or shared spectrum (e.g., CBRS)) may utilize the LTE unlicensed spectrum in a Band 46 (B46) (i.e., 5 gigahertz (GHz) Wi-Fi) carrier to improve their download (DL) capacity using Licensed Assisted Access (LAA) or a New Radio Unlicensed (NR-U) deployment in a 5G environment.

LAA allows an operator to use unlicensed 5GHz Wi-Fi spectrum (3GPP B46 carriers) as a supplemental downlink (SDL)-only channel for carrier aggregation (CA) with a licensed carrier channel. Up to four unlicensed spectrum B46 channels of 20 megahertz (MHz) each may be used as a secondary cell (SCell) component carrier (CC) with a licensed primary cell (PCell) carrier for DL CA.

During operation, user equipment (UE) capability information is used by an evolved Node B (eNB) to configure the UE for DL CA. CA for a configured UE is activated when the licensed cell carrier needs additional bandwidth to drain the downlink traffic to LAA CA-capable UEs. The DL data for LAA-capable UEs is drained by both a licensed carrier and an unlicensed carrier in equal proportion or, alternatively, in a vendor-specific implementation. Such an approach results in less utilization of an unlicensed carrier, and, accordingly, does not provide any significant relief for a licensed cell carrier's capacity. Moreover, an unlicensed cell is used by only LAA-capable UEs requiring CA to drain the DL data. In order for an operator to attain the maximum benefit of an unlicensed Wi-Fi 5GHz spectrum B46 carrier, the best possible utilization of an unlicensed carrier is necessary.

To address such issues, techniques are presented herein that support methods for achieving the maximum utilization of LAA unlicensed carriers (or a 5G NR-U carrier). As a result, the presented techniques provide significant relief in terms of the utilization of a licensed carrier by an LAA-capable UE, thus providing more capacity for a licensed carrier to provide DL data for non-LAA-capable UEs. A licensed carrier with better capacity and coverage can therefore be optimally used for service reliability to provide better throughput while an unlicensed carrier may optimally serve the UEs under its coverage footprint for non-Guaranteed Bit Rate (GBR) traffic.

Figure 1, below, presents elements of an exemplary arrangement according to aspect of the techniques presented herein and reflective of the above discussion.

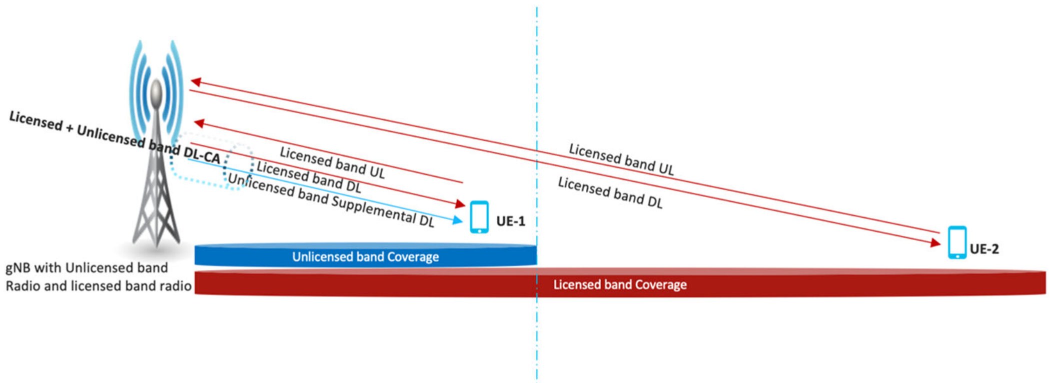

Figure 1: Exemplary Arrangement

Figure 2, below, provides an overview of LAA.

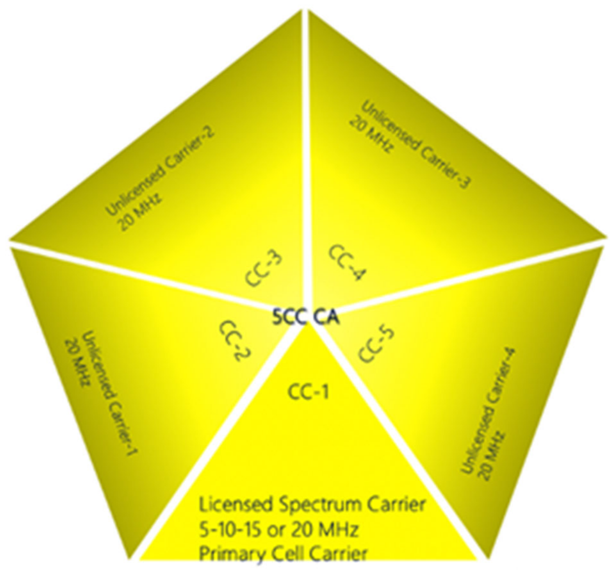

Figure 2: Licensed Assisted Access (LAA)

In a typical network configuration, an LAA base station (BS) with limited functionalities (compared to that of an eNB) schedules uplink and DL transmissions in licensed and unlicensed bands, respectively. However, existing radio access network (RAN) original equipment manufacturers (OEMs) have not implemented optimal techniques for the efficient use of an unlicensed carrier.

As a result, more traffic is drained through a licensed carrier during LAA CA, with an unlicensed carrier in LAA mode being used only when CA is activated, which often is based on the amount of traffic that is to be scheduled for a UE.

LAA-capable UEs are configured for LAA CA based on UE capability information. When a UE is downloading a sizeable quantity of content, upon the arrival of a high volume of non-GBR DL data in a UE's buffer an LAA secondary cell is activated and transmission to the UE is scheduled according to settings in the eNB. LAA employs a maximum of 1 watt (W) of power for the Unlicensed National Information Infrastructure (U-NII) range 1 and 2 sub-bands of B46 and 250 milliwatts (mw) of power for the U-NII 2 range sub-band of B46.

For a UE that is near an LAA cell, when the signal-to-interference-plus-noise ratio (SINR) is better than 23 decibel (dB) an LAA eNB can use 256 quadrature amplitude modulation (QAM). When the UE moves away from the cell, or when a SINR threshold changes, the modulation scheme falls back to 64 QAM, 16 QAM, and so on.

According to the techniques presented herein, subject to the number of LAA SCell carriers that are on an eNB and the number of LAA-capable configured and active users, when a UE is near the cell and has good SINR conditions (such that 256 QAM modulation can be activated) the eNB will send all of the non-GBR DL data through the LAA SCells so that a PCell (which is based on a licensed carrier) is not used. Unlike an LAA SCell, if a PCell has more power, and if the PCell can serve the UE with 256 QAM modulation and with 2x2 multiple input, multiple output (MIMO) or 4x4 MIMO, but the SCell can serve the UE only with 64QAM modulation, the PCell and the SCell may be used in accordance with a new set of operator configurable thresholds (which will be described below) that may be used for the active scheduling of the users.

Aspects of the techniques presented herein support an operator configurable threshold for the distribution percentage of the DL data for LAA-capable UEs based on a UEs DL data. The need may be served by 256 QAM modulation on an SCell, by 256 QAM modulation on a PCell, by 256 QAM modulation on an SCell and a PCell, or by 256 QAM modulation on a PCell and 64 QAM modulation on an SCell. The above may be driven by the number of LAA carriers that are configured on an eNB and the number of LAA-capable UEs that are under the cell. A PCell is able to serve a UE with 4x4 MIMO 256 QAM modulation or 4x4 MIMO 64 QAM modulation, an SCell can serve the UE with 2x2 MIMO 256 QAM modulation, and the loading of the SCell and the PCell may be based on the application of applicable attributes (e.g., thresholds).

Further, aspects of the presented techniques support the default automated activation of LAA CA for priority users such that any DL data packet, irrespective of burst size and volume, may be drained through an unlicensed carrier when the user device can be served by an LAA carrier. Still further, aspects of the presented techniques support a UE scheduling priority on an LAA SCell such that, when LAA is used, a PCell will be used less aggressively and the LAA SCell will be used more aggressively.

Additionally, according to the size of the PCell carrier (e.g., 5 MHz, 10 MHz, 15 MHz, 20 MHz, etc.) and power (EIRP), an operator may, according to aspects of the techniques presented herein, configure a weighted sharing mechanism for the DL of non-

GBR data. Such a mechanism may employ a scheduling weight parameter for LAA carriers where the size of a licensed carrier may determine a corresponding weight.

Figure 3, below, presents elements of an exemplary LAA arrangement according to aspect of the techniques presented herein and reflective of the above discussion.

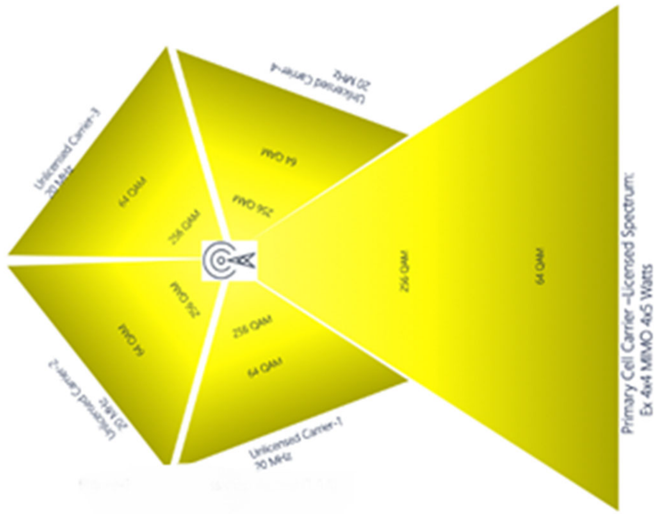

Figure 3: Exemplary LAA Arrangement

Unlike an unlicensed SCell, which has a total output power limitation of 1W or 250mw for all of the transmit (TX) branches combined, a PCell on a licensed spectrum does not have such a limitation. A licensed cell can be a micro- or a macro-overlay supporting 4T4R, 4x4 MIMO, with up to, for example, 4x60W of transmission power per branch. An LAA-capable UE may employ 256 QAM modulation on a licensed carrier that is much further away than an unlicensed carrier (subject to the deployment of LAA at the same node or separately from a macro perspective). Under such a scenario, aspects of the techniques presented herein support the use of the licensed carrier to drain the traffic for a given DL data threshold and the use of the unlicensed carrier subject to a loading of the licensed carrier.

The same scheduling priorities and weights (as described above) may also be applied to a 5G NR-U in allocated unlicensed bands for both private wireless networks as well as CSPs.

While LTE and 5G technologies will be used along with existing Wi-Fi solutions for private wireless network (PWN)/ Non Public Wireless Networks (NPN) deployments by enterprise entities, the deployment of NR-U and LAA offer a robust solution with better performance. A network equipment vendor may work with selected RAN partners to implement the efficient usage innovation, according to the techniques presented herein and as described and illustrated above, or they may incorporate the same in their own solutions to offer a high performing network offering that supports the efficient usage of both licensed and unlicensed spectrum.

It is important to note that aspects of the techniques presented herein may also be applied within a shared spectrum model and can, for example, be used to prioritize a desired spectrum usage.

In summary, techniques have been presented herein that support flexible options for the optimal utilization of both licensed and unlicensed spectrum. Aspects of the presented techniques support the default activation of CA for DL data draining for LAA-capable UEs within a coverage footprint. Further aspects of the presented techniques support an operator configurable threshold for the distribution percentage of the DL data for LAA-capable UEs based on a UEs DL data. The need may be served by different modulation capabilities (such as, for example, 256 QAM) for a PCell and an SCell and may be driven by the number of LAA carriers that are configured on an eNB and the number of LAA-capable UEs that are under a cell. Further aspects of the presented techniques support the default automated activation of LAA CA for priority users such that any DL data packet, irrespective of burst size and volume, may be drained through an unlicensed carrier when the user device can be served by an LAA carrier.