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RP-150704

Document for: Discussion
Agenda Item: 13.1.1

Motivation for new work item proposal on Licensed-Assisted Access to Unlicensed Spectrum

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Goal of the presentation

- This document presents an overview of the conclusions and recommendations of the study on Licensed Assisted Access to unlicensed spectrum (LAA), as a motivation for approving the work item on LAA proposed in RP-150625.

Overview of the LAA Study

- The 3GPP study item on LAA was approved at RAN#65 in September 2014.
- Version 1.0.0 of the LAA Technical Report 36.889 was endorsed in May 2015. The results and findings of the study are documented in the Technical Report 36.889 v.1.0.1 submitted to RAN68.
- More than 40 companies participated in extensive technical discussions as part of the 3GPP study. Over 1500 technical contributions were submitted to 3GPP meetings during the study.
- It has been identified that the use of LTE in unlicensed spectrum can serve as a useful additional tool by operators to maximize the value they can provide to users, while the core of the activity of the operators remains anchored to the licensed spectrum.

Design Targets

- A single global solution framework allowing compliance with any regional regulatory requirements
 - A single global solution framework for LAA should be defined to ensure that LAA can be operated according to any regional regulatory requirements. Furthermore, LAA design should provide sufficient configurability to enable efficient operation in different geographical regions.
- Effective and fair coexistence with Wi-Fi.
 - The LAA design should target fair coexistence with existing Wi-Fi networks to not impact Wi-Fi services more than an additional Wi-Fi network on the same carrier, with respect to throughput and latency.
- Effective and fair coexistence among LAA networks deployed by different operators
 - The LAA design should target fair coexistence among LAA networks deployed by different operators so that the LAA networks can achieve comparable performance, with respect to throughput and latency.

Functionalities required for LAA

- Based on the design targets, at least the following functionalities are required for an LAA system
 - *Listen-before-talk* (Clear channel assessment)
 - Discontinuous transmission on a carrier with limited maximum transmission duration
 - *Dynamic frequency selection* for radar avoidance in certain bands/regions
 - Carrier selection
 - Transmit Power Control
 - RRM measurements including cell identification
 - AGC setting
 - Coarse synchronization
 - Fine frequency/time estimation at least for demodulation
 - Channel-State Information (CSI) measurement, including channel and interference

The PHY layer options considered for LAA have at least the following characteristics:

- Support for at least 20MHz system BW option in the 5GHz band
- System bandwidths < 5 MHz are not considered for PHY layer options in LAA

Background on the Coexistence Evaluation Methodology

- The evaluation of the solution framework followed the guideline in the SID, which suggests that LAA should not impact Wi-Fi services more than an additional Wi-Fi network on the same carrier. The coexistence evaluation is based on a two-step approach:
- Step 1: Performance metrics for two Wi-Fi networks coexisting in a given evaluation scenario are evaluated and recorded.
 - Network load can be varied by increasing the file arrival rate or increasing the number of active devices in the network. The Technical Report includes coexistence evaluation reports with 10, 20 and 50 devices per network per 20 MHz carrier.
 - Networks in indoor and outdoor deployments are both considered.
 - Networks sharing one 20 MHz unlicensed channels as well as four 20 MHz unlicensed channels are considered.
- Step 2: Wi-Fi is replaced with LAA for the group of eNBs and UEs served by one of the Wi-Fi operators. Performance metrics of the Wi-Fi network coexisting with the LAA network are evaluated and recorded.
 - Considering 5th, 50th, 95th percentile and mean throughput and delay metrics in addition to VoIP outage metrics at low, medium and high loads for both DL and UL, each evaluation report can contain up to more than 200 metrics with 50 metrics used for comparison to evaluate coexistence.

Studied Channel Access Schemes

- **Category 1: No LBT**
 - No LBT procedure is performed by the transmitting entity.
- **Category 2: LBT without random back-off**
 - The duration of time that the channel is sensed to be idle before the transmitting entity transmits is deterministic.
- **Category 3: LBT with random back-off with a contention window of fixed size**
 - The LBT procedure has the following procedure as one of its components. The transmitting entity draws a random number N within a contention window. The size of the contention window is specified by the minimum and maximum value of N . The size of the contention window is fixed. The random number N is used in the LBT procedure to determine the duration of time that the channel is sensed to be idle before the transmitting entity transmits on the channel.
- **Category 4: LBT with random back-off with a contention window of variable size**
 - The LBT procedure has the following as one of its components. The transmitting entity draws a random number N within a contention window. The size of contention window is specified by the minimum and maximum value of N . The transmitting entity can vary the size of the contention window when drawing the random number N . The random number N is used in the LBT procedure to determine the duration of time that the channel is sensed to be idle before the transmitting entity transmits on the channel.
 - This is what Wi-Fi does

Observations for LAA with DL only

- A majority of sources showed at least one LBT scheme for LAA that does not impact Wi-Fi more than another Wi-Fi network (offering the same traffic to the same users). Within each LBT category, the LBT schemes and/or parameters shown by different sources to not impact Wi-Fi more than another Wi-Fi network may be different.
- All sources that submitted results with a category 1 DL LBT scheme, i.e., no coexistence mechanism implemented by the transmitting node, showed that it cannot operate without impacting Wi-Fi in at least some of the measured performance metrics.
- An LAA network operating a category 2 DL LBT scheme based on the ETSI FBE procedure [4] can operate without impacting Wi-Fi more than an equivalent Wi-Fi network. Further discussion may also be needed on the coexistence performance between two LAA networks, especially for the case where the LBT sensing periods of the two operators' networks are synchronized.
- A majority of sources that evaluated an LAA network operating a category 3 DL LBT scheme based on ETSI Option B [4] with modifications including at least a defer period showed that it can operate without impacting Wi-Fi more than another Wi-Fi network.
- A majority of sources that evaluated an LAA network operating a category 4 DL LBT scheme based on ETSI Option B with modifications including at least defer periods and variable (exponential) contention windows showed that it can operate without impacting Wi-Fi more than an equivalent Wi-Fi network.

Observations for LAA with DL+UL

- **Observation:** A majority of sources showed combinations of LAA DL and UL LBT schemes that do not impact Wi-Fi more than another Wi-Fi network (offering the same traffic to the same users) in any of the measured performance metrics. Category 3 and 4 were tested for the DL and Categories 1 through 4 were tested for the UL. Within each LBT category, the LBT schemes and/or parameters shown by different sources to not impact Wi-Fi more than another Wi-Fi network may be different

Conclusions of the study (1/2)

- It is concluded in the Technical Report that
 - **When an appropriate channel access scheme is used, it is feasible for LAA to achieve fair coexistence with Wi-Fi, and for LAA to coexist with itself based on the evaluated scenarios.**
 - A study of the major aspects of LTE radio interface architecture, protocol termination, radio interface protocols between UEs and RAN and RRM strategies to support Licensed Assisted Access to unlicensed spectrum was conducted and it was determined that it is feasible to support these aspects for LAA downlink and uplink operations.
- Based on the evaluations and findings, **the TR recommends that:**
 - **The channel access framework defined in section 7.2.1.6 [1] be adopted for LAA.** The channel access framework includes a category 4 LBT scheme including random backoff and variable contention windows at least for the downlink data transmissions.
 - The key parameters of the LBT scheme such as contention windows and defer periods should be configurable within limits to enable fair coexistence with other technologies operating in unlicensed spectrum.
 - **LAA supports uplink LBT at the UE.** In LAA systems, where the UE's uplink transmissions are controlled by the eNB, the uplink channel access scheme can be different from the downlink channel access scheme for an LAA SCell.

Conclusions of the study (2/2)

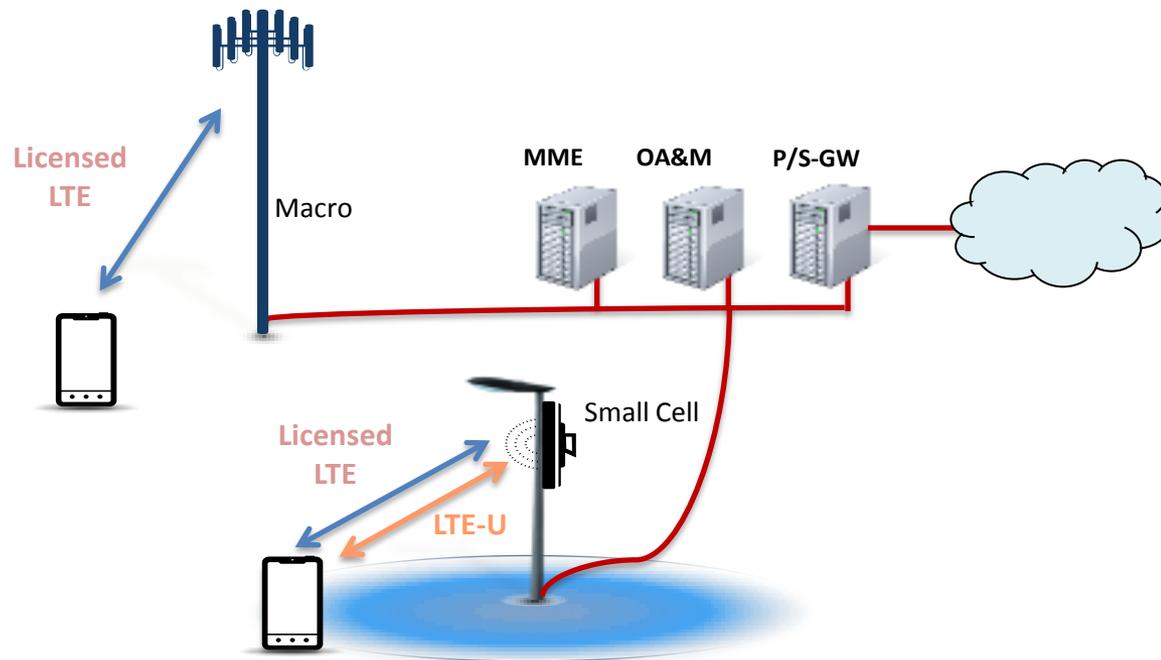
- The study concluded that UE reporting of RSSI measurements to the eNB is considered useful for the purpose of detecting hidden node in the channel selection.
- Based on the studies documented in 8.4, it can be concluded that LAA and Wi-Fi can coexist in adjacent channels. The study shows that LAA causes less adjacent channel interference to a Wi-Fi system compared to another Wi-Fi system.
- The study concluded that existing IDC (In-Device Coexistence) solutions can be used to support WLAN background scanning (e.g. by means of IDC TDM; Autonomous Denial) during LAA operation and that the eNB should enable IDC indications and honour the IDC requests.
- A large set of design targets, physical design options and LTE RAN protocol modifications have been studied and the conclusions and recommendations are captured in section 7.1 and 7.2.
- The impact of DFS (Dynamic Frequency Selection) on operating LTE in unlicensed spectrum has been assessed and it has been concluded that DFS support does not need new specification.
- It is feasible for UEs and BSs to operate in the 5GHz unlicensed spectrum. Suitable RF requirements should be specified taking into account issues including implementation complexity and performance.
- Based on the studies documented in Section 8.3.2.2, 5 GHz unlicensed LAA band(s) will be defined within frequency limits 5150 – 5925 MHz. It is recommended that radio requirements should be specified such that a single filter implementation for UE across the entire frequency range from 5150 to 5925 MHz is possible.

Proposed Work Item Scope

- We propose that the Rel-13 work focuses on the highest priority use cases & scenarios for Licensed Assisted Access in Rel-13, consistent with the coexistence evaluations of the study
- The LAA design should allow fair coexistence between Wi-Fi and LAA and fair coexistence between different LAA systems. This shall be ensured by following the recommendations and conclusions from the TR on LAA for the specification work.
 - The intent would be that the features necessary to ensure coexistence would be made mandatory.
- Usage of unlicensed spectrum for the Secondary Carrier, i.e., always assisted by a Primary Carrier in licensed spectrum
 - DL-only in unlicensed spectrum (first priority)
 - Possible DL & UL in unlicensed spectrum (second priority)

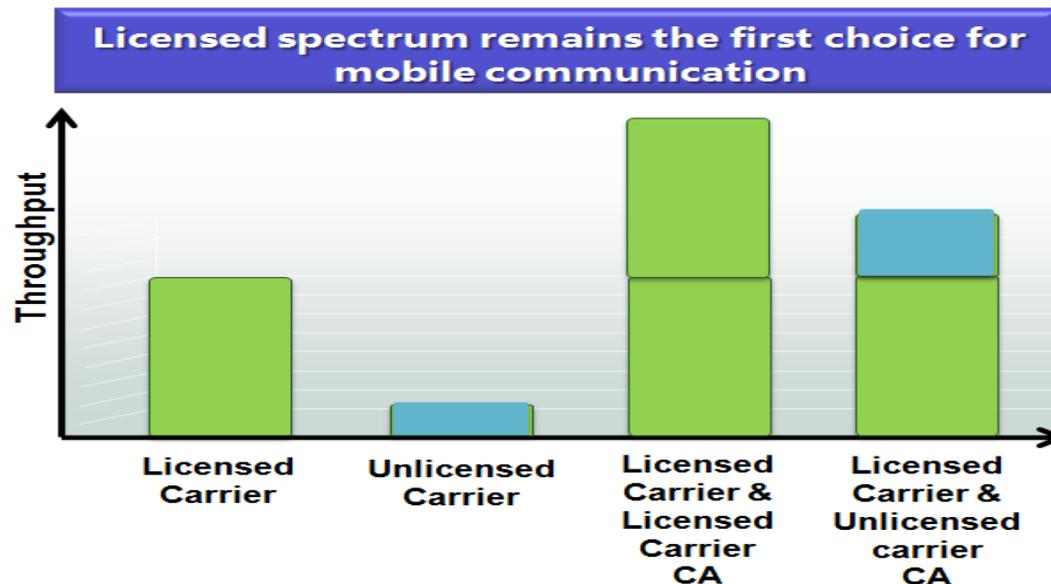
Use Case of highest priority

- The scenarios of interest are **operator-deployed small-cell** scenarios where licensed and unlicensed spectrum is accessed from the same eNodeB building upon the existing carrier-aggregation framework.



Spectrum Allocation Impact

- Using licensed spectrum compared to unlicensed spectrum is always superior in terms of reliability, quality, etc.



- Using LTE for a Licensed-Assisted Access to unlicensed spectrum can only be a complement in some areas where spectrum resources might be limited
 - Some operators use WiFi offloading for capacity boosting
 - LTE-based access can provide benefits, with licensed-assisted access

Proposal

- **Proposed WID in RP-150625**
- **Proposed standard schedule:**
 - Start Work Item at RAN#68
 - Complete global solution for LAA with DL only in Rel-13
 - Best effort to complete LAA with DL+UL in Rel-13

