LTE System Deployment and Performance in Unlicensed Bands

Standards and Advanced Technology, Mobile and Communications Group

Tech Talk at IEEE ComSoc Event on LTE-U

November 12, 2014

Discussion topics

- LAA in 3GPP LTE Rel-13
- Status in 3GPP RAN1
- Intel's views on LAA coexistence handling
- Challenges to handle divergent solutions
- Simulation results:
  - LTE-WLAN coexistence (two cases)
  - LAA Multi-Operator coexistence
- Summary

LAA in 3GPP LTE Rel-13

- Timeline:
  - RAN1-led SI approved in September 2014 with target of completion in June 2015
  - A Rel-13 WI is expected to follow and be completed by March 2016
- Prioritized operation mode:
  - CA-based DL-only and DL/UL in the unpaired 5 GHz band; higher priority given to DL-only
- Key objective:
  - A single global framework for LAA
  - LAA-WLAN co-existence
    - » Performance impact on WLAN services (data, video and voice services) and in-device coexistence should be studied
    - » Fairness criteria: LAA should not impact WLAN more than another WLAN network
  - Intra-LAA multi-operator co-existence
  - Fulfil regulatory requirements, e.g. DFS, TPC, etc.

Status in 3GPP RAN1

- LAA was discussed in October 2014 for the first time
- High-level agreements:
  - Regulatory requirements in 5 GHz to be captured in the TR
  - LAA supports at least: LBT, limited max Tx duration, DFS, carrier selection and TPC
  - Outdoor and indoor LAA simulation setup based on SCE 2a/3 evaluation methodology
- Detailed simulation scenarios and parameters are very diverse:
  - Representation of WLAN deployment for carrier-WiFi and private WiFi
  - Small cell density and frequency reuse factor, especially if reuse-1 is included in the evaluation;
  - Traffic model, especially how to model VoIP and Video
  - Simulation complexity

Intel's views on LAA co-existence handling

- Views based on our preliminary coexistence studies
- LAA outperforms WLAN in all simulated cases
- LAA degrades WLAN when the shared channel becomes congested; LBT shows potential to improve fairness
- In DL-only operation, LAA DL is vulnerable to near-by WLAN transmissions
- For intra-LTE multi-operator co-existence, the effectiveness of LBT needs to be further evaluated
  - Our preliminary analysis shows that LBT introduces additional protocol overhead and degrades system capacity

Challenges to handle divergent solutions

- LAA attracts operators around the world (North America, EU, China)
- Driven by regional-specific regulatory requirements and time-to-market, multiple solutions are likely to be deployed with different timeframes:
  - Deployments which do not explicitly apply LBT
  - Deployments which apply relatively simple LBT
  - Majority of operators are expected to deploy solutions based on more advanced LBT (LTE Rel-13 specs)
- Intel investigates different solutions from technology and standardization point of view:
  - Analyze the specification and product impact
  - Evaluate the performance via simulation

Challenges to handle divergent solutions (cont.)

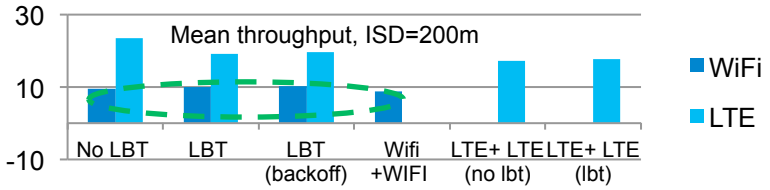
- Potential modifications to UE specs to support LBT in DL-only LAA:

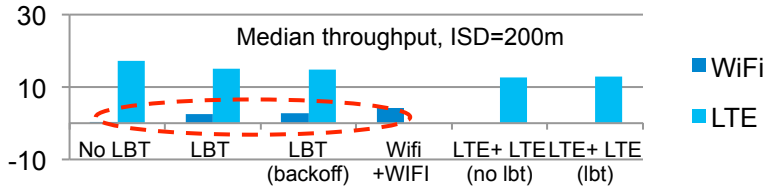
LBT key building blocks	Baseline implementation	Optimizations
Unlicensed carrier dynamic on/off	• Need to specify proper signaling to allow dynamic on/off (e.g., at subframe level) • Need to specify the UE RRM and CQI measurement behavior	
CCA protocol	eNB-based CCA has no UE impact	UE-aided CCA, e.g., RTS/CTS, requires new protocol and signaling
Channel reservation signal	Simple “grab-and-hold” has no UE impact	Reservation signal design optimization may have UE impact
BW occupancy compliance	No UE impact if eNB ensures DL Tx occupancy BW compliance, especially when transmitting PSS/SSS/PBCH	
Cross-carrier scheduling	No UE impact if no more than 5 CCs per UE	• PDCCH overhead optimization may have UE impact, e.g., new DCI format and procedure • Increasing the max number of CCs per UE will have UE impact, e.g., HARQ soft buffer size and HARQ-ACK feedback procedure

LTE-WLAN Coexistence: Case 1

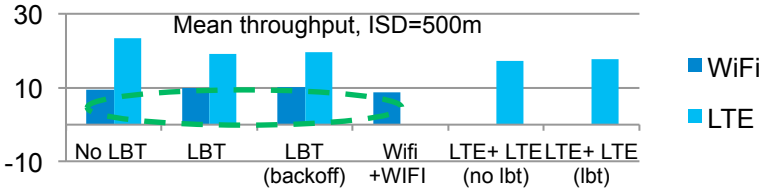
- 23 dBm DL Tx power
- 32 LPNs and 100 UEs /macro / operator
- 12 channels with 20 MHz BW each

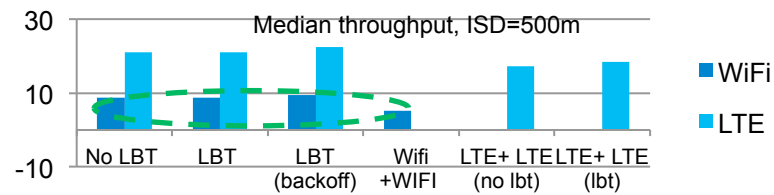
- LTE-WLAN co-existence performance is very sensitive to deployment:
  - In dense deployments, WLAN median performance degrades when coexisting with LAA; applying LBT for LAA improves the fairness between LAA and WLAN



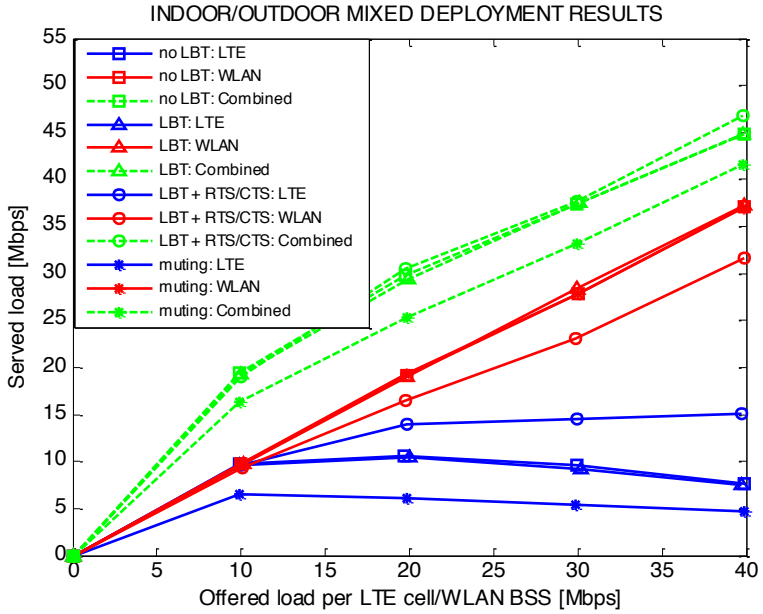


  - In sparse deployments, WLAN performance improves when coexisting with LAA





LTE-WLAN Coexistence: Case 2



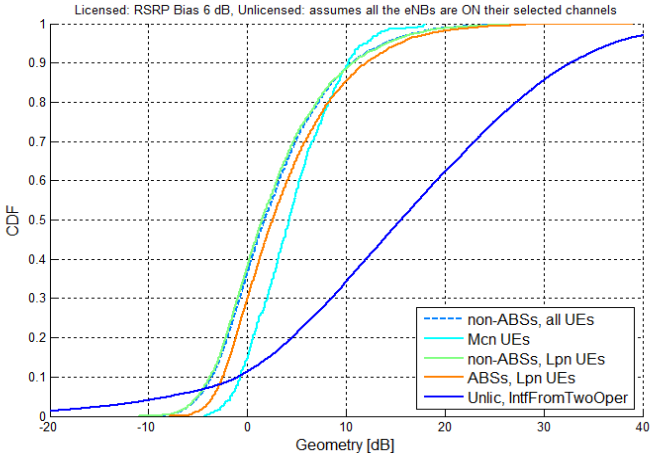
- 30 dBm LAA DL Tx power
- 20 dBm WLAN DL Tx power
- LAA ISD=200m; all outdoor
- WLAN AP dropping up to 35m, all outdoor
- 3 APs per macro cell
- 90 LAA UEs per eNB, all indoor
- 20 STAs per AP, all indoor
- 12 channels with 20 MHz BW each

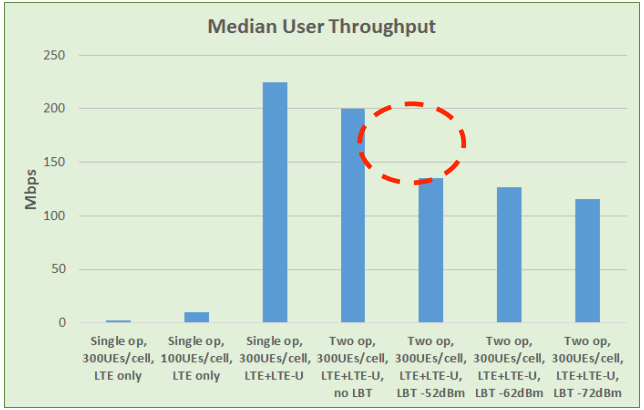
– In indoor deployments, due to the hidden node effect RTS/CTS-like operation is required to achieve a good balance between fairness and spectrum efficiency
– LBT exhibits better balancing than static muting (50% duty cycle) between improving fairness and maximizing overall spectrum efficiency

LAA Multi-Operator Coexistence

- Due to good geometry in the unlicensed layer, 20-200 times gains can be observed when adding 480 MHz in unlicensed bands
- LBT significantly degrades the performance (32%-42%) due to14.3%-25% LBT overhead and loss of spectrum efficiency, i.e., TDM vs simultaneous transmission

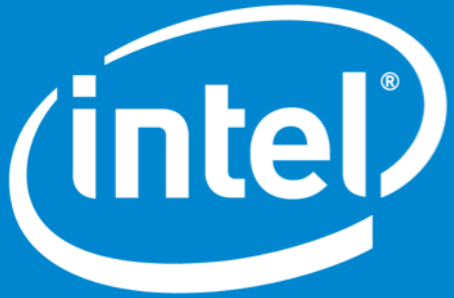
- **30dBm DL Tx pwr**
- **16 LPNs and 300 UEs / macro / operator**
- **ISD=500m**
- **24 channels with 20MHz**





Summary

- Key targets: A single global LAA framework complying with regulatory requirements and addressing coexistence issues – both LAA/WLAN and multi-operator LAA
- LAA deployments with different timeframes (pre-Rel-13 / Rel-13) are expected with focus on CA-based, DL-only operation
- In LAA/WLAN coexistence deployments:
  - LAA degrades WLAN when the shared channel becomes congested; LBT shows potential to improve fairness
  - In DL-only operation, LAA DL is vulnerable to near-by WLAN transmissions
- In multi-operator LAA deployments:
  - The effectiveness of LBT needs to be further evaluated as LBT seems to introduce additional protocol overhead, thus degrading system capacity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