ERICSSON

April 6, 2015

Ex Parte

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

RE: Amendment of the Commission's Rules with Regard to Commercial Operations in the 3350-3650 MHz Band, GN Docket No. 12-354;
Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band, ET Docket No. 13-49

Dear Ms. Dortch:

On April 2nd, 2015, Mark Racek, Bruce Gustafson, and Chris Richards of Ericsson, met with Roger Sherman, Brian Regan, Chris Helzer, Kamran Etemad, and Paul Powell, of the Federal Communications Commission's Wireless Telecommunications Bureau, and Julius Knapp, Karen Backley, and Mark Settle of the Commission's Office of Engineering and Technology.

At the meeting, Ericsson discussed general spectrum usage principles and specifically the 3.5 and 5 GHz bands, as outlined in the attached presentation. More specifically, Ericsson addressed the technology, co-existence, and operations of an innovative new technology – License Assisted Access – Long Term Evolution ("LAA-LTE").

Pursuant to the FCC's rules, I have filed a copy of this notice electronically in the above-referenced proceedings. If you required any additional information, please contact me.

Sincerely,

/s/ Mark Racek
Mark Racek

Attachment

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Director, Spectrum Policy
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LICENSED ASSISTED ACCESS -LTE

Christopher Richards
Radio Systems Architect

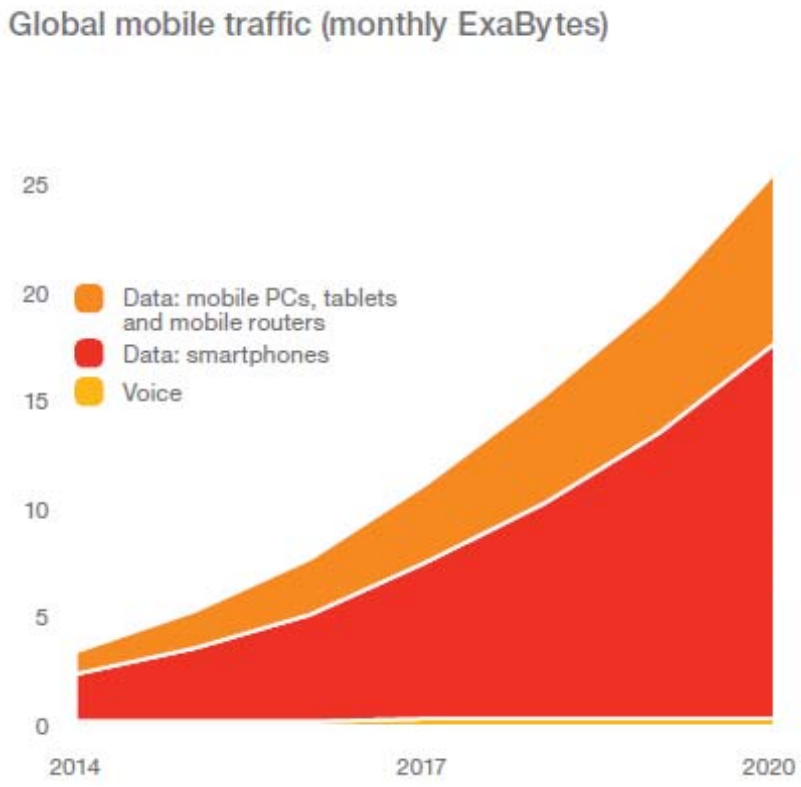
Bruce Gustafson
Mark Racek
Office of Govt and Industry Relations

AGENDA

- Mobile Traffic Growth and Spectrum
  - Mobile Traffic Growth
  - Performance Requirements
  - Spectrum Usage Principles
  - Why LAA-LTE ?
- LAA-LTE Introduction and Benefits
  - LTE-U Forum
- LAA-LTE Technologies
  - Channel Selection
  - Co-Channel Existence
  - Channel Load Measurements

MOBILE TRAFFIC GROWTH

- Total mobile data traffic is expected to rise at a compound annual growth rate of 40%
- Traffic growth expected to outpace the available licensed band spectrum capacity
  - Especially at high-traffic hot spots
- Offloading to unlicensed spectrum already adopted or considered by operators
  - Large amount of unlicensed spectrum for sharing



PERFORMANCE REQUIREMENTS

1000X
Mobile Data Volumes

5X
Lower Latency

10X
Battery Life

10-100X
End-user Data Rates

10-100X
Connected Devices

Critical Communications

<5ms e2e delay

99.999% transmission reliability

500Kmph relative velocity

Extreme availability

Massive Communications

>10yrs battery lifetime

>80% cost reduction

20dB better coverage

Scalability and flexibility

Intelligent Transport Systems

Connected Sensors

Source: METIS

SPECTRUM USAGE PRINCIPLES

Licensed Dedicated

Mainstream approach for MBB

350 MHz now, need 1500-2000 MHz

- Efficient for large area and population coverage
- Predictable quality of service
- Reliable at high load at all times
- Affordable, economies of scale, high valuations

Licensed Shared Access

Complementary for MBB

- Fast unlocking of mobile spectrum
- Either-or usage between incumbent and licensee
- Predictable quality of service
- Protects incumbent, lends investment security

Unlicensed

Medical, industrial, Wi-Fi

>500 MHz today

License Assisted Access - LTE

- Efficient for indoor / controlled environments and short ranges
- Unpredictable quality of service
- Reliable at low load, unreliable at high load

FREQUENCY EVOLUTION

INTRODUCTION

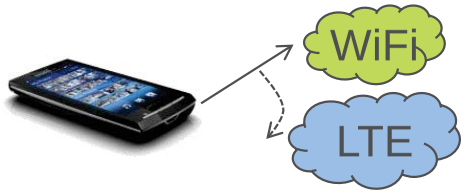
Ericsson is active in the development of unlicensed solutions across multiple technologies and is a member of standards and trade association organizations like WFA, IEEE, ETSI, 3GPP, etc.

Licensed Assisted Access-LTE is a major step on the road to 5G, by aggregating licensed and unlicensed spectrum in the 5 GHz and 3.5 GHz bands.

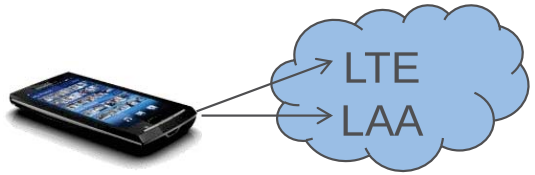
Ericsson's objective is to explain LAA-LTE operation in the 5 GHz band and to show how LAA-LTE can achieve excellent co-existence with other unlicensed uses of the 5 GHz band.

OFFLOAD SOLUTIONS

- Separate Wi-Fi network for unlicensed spectrum offloading
  - Traffic serving is based on hard switch between the two technologies
  - Already deployed by some operators



- LAA-LTE offloading with a single network management framework
  - Single network enabling reduced operations & management overheads
  - Substantially higher off-loading capacity and user experience

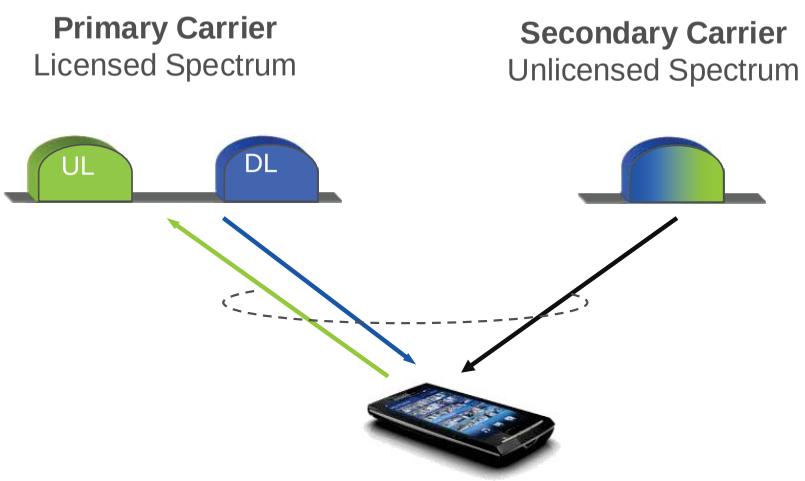


- Ericsson develops both solutions to meet customers needs

LICENSED ASSISTED ACCESS

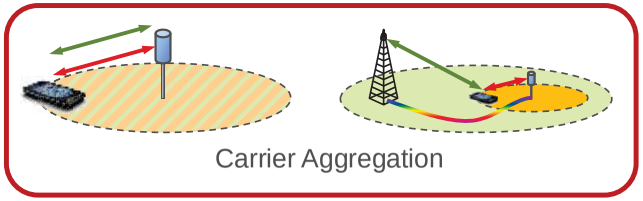
- Unlicensed spectrum as performance booster managed by a licensed carrier

- Carrier aggregation framework
  - Licensed band PCell
    - Reliable control signaling
    - Mobility
    - Robust/real-time user data with LTE QoS
  - Unlicensed band SCell
    - Best effort data
    - DL-only



LAA-LTE SALIENT FEATURES

- Simplified network management
  - Management of one network
- Reliability and Quality
  - Wide-area coverage and mobility support
  - LTE quality of service provisioning
  - Robust control and fallback to licensed band LTE
- Enhanced performance for traffic hot spot
  - LTE designed for large coverage and to operate in interference limited operation environment
  - Substantially higher off-loading capacity and user experience
  - An alternative to current operator Wi-Fi offloading
- Always used in conjunction with licensed carrier via LTE carrier aggregation



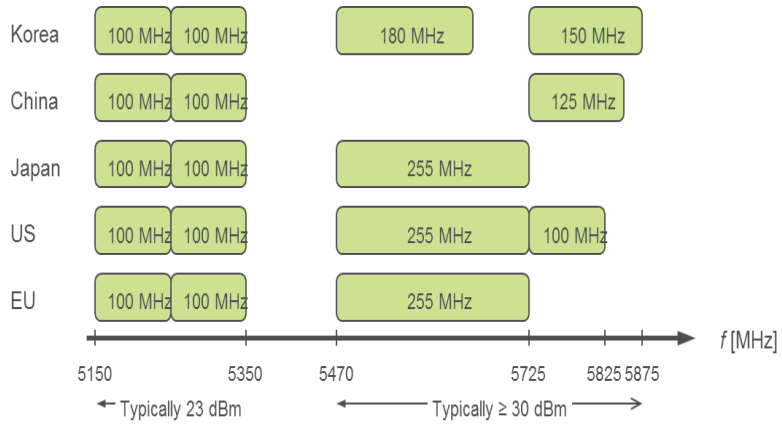
- Operator deployed small cells
  - Not targeting user-deployed stand-alone nodes
- Dynamic channel coexistence
  - With other technologies
  - With other operators

LTE-U FORUM

- LTE-U Forum consisting of major 3GPP and Wi-Fi equipment vendors
  - http://www.lteuforum.org/
- LTE-U Forum work performed independently of 3GPP
  - Expect parts of the technology to be re-used in future 3GPP specifications
  - LTE-U Forum specifications are open for any vendor to implement
- Focused on DL-only LAA-LTE with traffic steering
- Developed an extensive system evaluation study using realistic traffic
  - Agreed channel co-existence parameters showing good coexistence with Wi-Fi
  - Developed equipment specifications and conformance test cases

COEXISTENCE SOLUTIONS

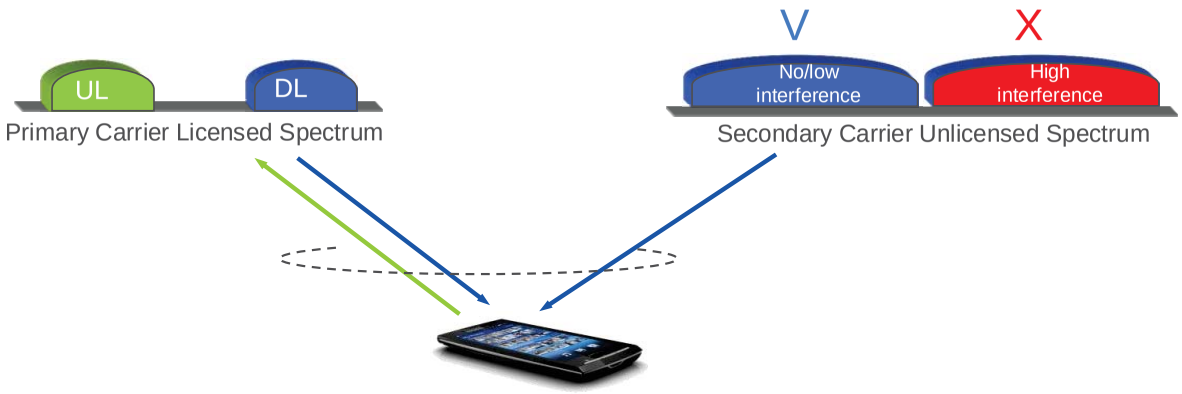
1. **Channel selection at start-up & event-triggered**
   - Select channel with least received interference powers
     - which cause least interference to existing nodes



2. **Co-channel coexistence**
   - Channel monitoring and intelligent traffic steering

CHANNEL SELECTION

- Channel selection is performed at eNB startup, cell configuration and periodically there after
  - Operator configures the set of candidate channels
  - Measure received energy/power on the channels
  - Select the channels with lowest measured received energy/power
  - The selected channels are configured for CONNECTED UEs as DL-only FDD SCells
  - Monitoring is performed continuously and channel re-selection is performed when conditions change



LAA-LTE SCELL CHANNEL RANKING & SELECTION

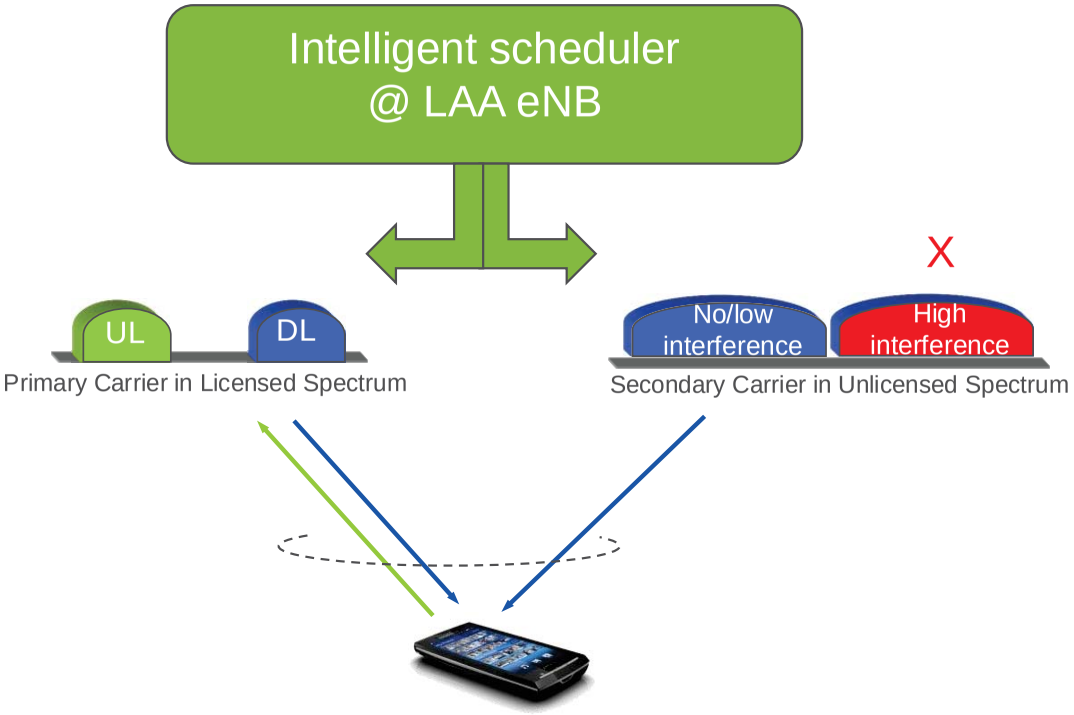
- Channel Ranking
  - Continual process using
    - eNB performance measurements of selected channel(s)
    - Latest channel measurements from UEs
    - Optional Wi-Fi measurements
  - Re-Ranking does not force immediate channel re-selection

- Triggers for Channel Re-Selection
  - Channel Load of selected channel(s)
  - Ability of selected channel(s) to satisfy data demand

- Triggers for Channel Scan
  - System start-up
  - Periodic channel scan timer expired
  - LAA-LTE SCell configuration change

CO-CHANNEL SHARING APPROACH
CHANNEL MONITORING AND TRAFFIC STEERING

- Channel monitoring
  - Measuring channel usage intensity and received power levels
  - Rescanning for better channels if channel conditions change
- Intelligent scheduler dynamically steers data between licensed PCell and unlicensed SCells
  - Traffic steering based on PCell loads and unlicensed SCell channel conditions
    - SCell is used on a “as needed” basis only



GEN1 LAA-LTE ON/OFF OPERATION

- SCell activation/deactivation MAC commands are used to control when UEs monitor the SCell
- A configured SCell has two states
  - In OFF state, no signal (including CRS) is transmitted from the eNB
    - eNB measures channel power/activity level (from WiFi or other LAA-LTE) during OFF
      - The measurement is used in short-term to determine how long to stay OFF
      - The measurement is also saved for long-term periodic channel reselection
  - In ON state, CRS is transmitted and user data can be transmitted
  - The SCell ON/OFF operation is performed even for a clean channel (new interferers can appear any time)

ADAPTIVE ON/OFF PERIODICITY

- eNB adjusts the ON/OFF ratio of each duty cycle based on channel load

- SCell ON duration (e.g., 50 ms)
  - Data transmission periodically (~25ms) suspended during ON period to create transmission opportunities for Wi-Fi
  - The continual ON duration is capped in order to provide channel access to other nodes in order to minimize any impact to delay sensitive transmissions, e.g. VoIP, TCP, Wi-Fi beacons

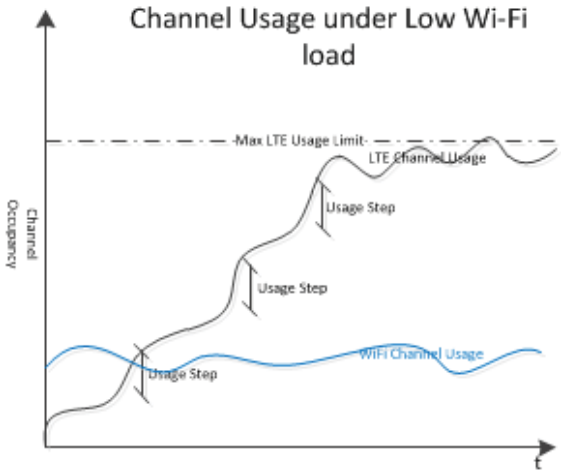
- SCell OFF duration
  - When there is no data to transmit on the Scell, the Scell halts all transmissions and remains OFF state until needed.
  - Channel energy-based listening and measurements provide feedback loop to compute the next ON state duration
    - Determine OFF duration based on measured channel power/activity

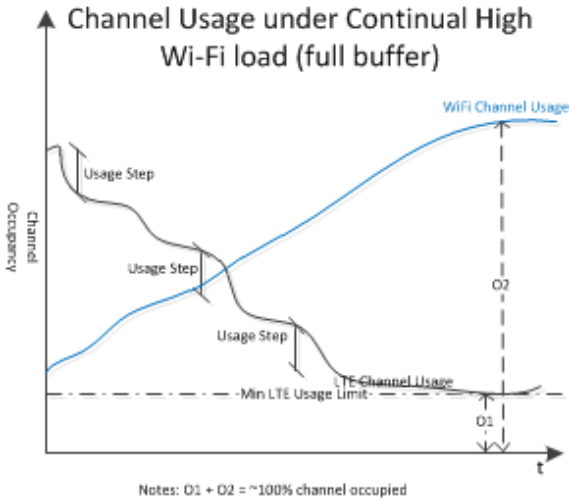
- ON and OFF parameters determine overall channel sharing % at high loads
  - eNB adjusts the ON/OFF ratio of each duty cycle based on channel load

ADAPTIVE ON/OFF ALGORITHM

- Maximize LA-LTE channel usage while bounding the minimum usage:
  - Cap ON time and adjust OFF time
  - LAA-LTE transmissions back-off during high channel load
  - Channel re-selection performed if LAA-LTE Scell is operating at the Minimum level for a period of time

- Algorithm gradually steps up & down allowing more transmission time to LTE when the channel is lightly loaded but reduces to the minimum under continued full buffer usage from other devices on the channel





CHANNEL LOAD COMPUTATION

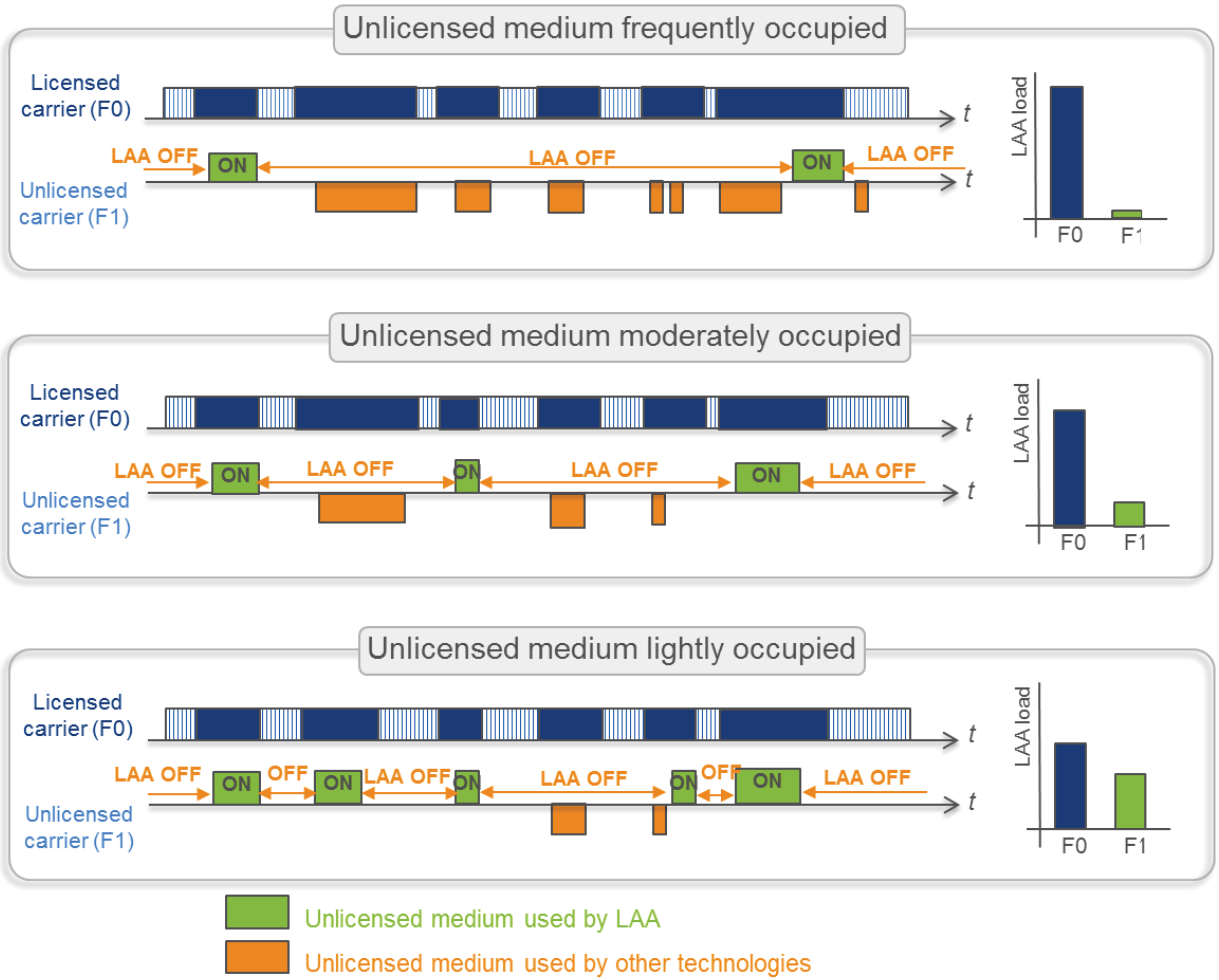
- Energy measurements are used to compute the channel occupancy by other nodes
  - Used for Channel Selection and Channel Usage
- Channel Selection measurements are based on longer term measurements (hundreds of ms)
- Channel Usage performed during SCell OFF period
- Channel occupancy is computed as:
  - Average channel RSSI measured during OFF period
  - Percentage of measurement samples above RSSI threshold during OFF period
- RSSI measurements are technology neutral
  - The channel noise contribution from all users of the shared channel have equal weighting

BENEFITS OF CO-EXISTENCE ALGORITHM

- Technology Neutral
  - Treats all users of the shared channel equally
  - Does not rely on protocol/implementation knowledge of other users of the shared channel
  - Does not depend on counting nodes – not a good indication of channel usage or split
  - Bounds each TX ON duration in order to protect Wi-Fi links
    - Periodically insert short data transmission gaps during TX ON period (at ~25ms intervals)
    - Avoids TCP timeouts (~28ms), Wi-Fi beacon misses (~100ms) - avoiding client disassociations and probe avalanches, disruption to Wi-Fi networks

- Provides predictable channel utilization
  - Avoids sudden peaks in channel usage
  - Enables the eNB scheduler optimize the DL assignments to each UE
  - By providing a minimum usage, the operator is assured that investing in deploying LAA-LTE will be useful for providing capacity

LAA-LTE DYNAMIC CO-EXISTENCE

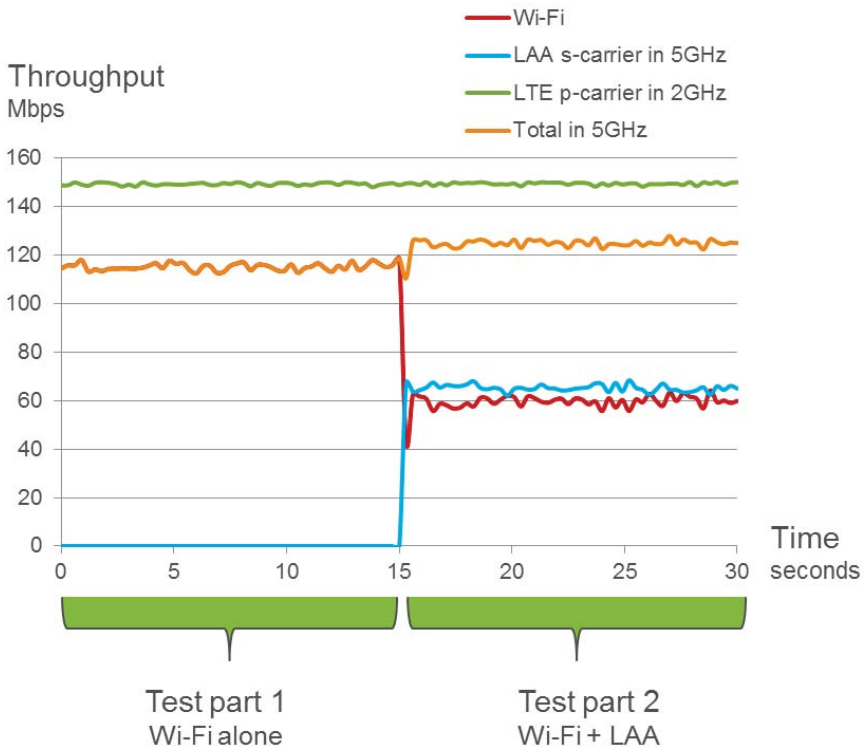


LTE-U FORUM CONFORMANCE TESTS

- Dynamic ON/OFF (co-existence algorithm)
  - ✓Channel sharing with a full buffer Wi-Fi link
  - ✓Channel sharing with two full buffer Wi-Fi links
  - ✓Channel sharing for inter-operator LTE-U and Wi-Fi
  - ✓Channel sharing between intra-operator LTE-U eNBs
  - ✓Opportunistic SCell OFF

- Channel Selection (energy measurements & UE measurements)
  - ✓Clean channel selection with Wi-Fi
  - ✓Channel selection for inter-operator LTE-U

GEN1 LAA-LTE PROTOTYPE DEMO



CONCLUSIONS

- Traffic growth expected to outpace the available licensed band spectrum capacity
- Offloading to unlicensed spectrum considered or adopted by operators
  - Option 1: Wi-Fi network offloading
  - Option 2: LAA-LTE offloading with simplified management and enhanced performance
  - Ericsson offers both types of solutions to customers
- LAA-LTE
  - Will not supplant Wi-Fi
  - Will no more interfere with IEEE 802.11 than IEEE 802.11 interferes with itself
  - Will share spectrum in accordance with the rules of the band
  - Will compete with Wi-Fi and be preferable in certain unlicensed small cell environments
  - Will lay a path to commercial use of shared spectrum including 3.5 GHz PAL/GAA
  - Will evolve for global use
- LAA-LTE is exactly the kind of innovation that unlicensed spectrum and a free market supports

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