UNLICENSED LTE & WIFI COEXISTENCE

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All financials in USD.

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BROADCOM AT A GLANCE

Fortune 300 GLOBAL leader in semiconductors for wired and wireless communications

One of TOP 5 semiconductor companies by revenue*

2014 Revenue: $8.43B

One of the industry’s broadest IP portfolios with >20,000 U.S. and foreign patents and applications

HQ in Irvine, California with DESIGN CENTERS around the world

~10,000 global employees

One of the LARGEST VOLUME fabless semiconductor suppliers

Ships ~7M chips a day


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TECHNOLOGY LEADERSHIP FUELING CUSTOMER EXPANSION

Infrastructure & Networking Group

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99.98% of All Data Traffic Crosses at Least One Broadcom Chip

Source: Broadcom internal estimate
LTE-U / LAA & WIFI COEXISTENCE
LTE-U & LAA are envisioned to complement existing LTE networks with carriers in unlicensed band (5 GHz)

- LTE-U: Pre standard version
- LAA: Version currently being standardized in 3GPP

Initially LTE-U & LAA deployments are expected to be for downlink traffic only on LAA carriers, but later to encompass uplink

Only best effort data to be serviced by the unlicensed band

- QoS sensitive applications such as video and voice continue to use licensed band

Primarily restricted to small-cell usage models
Source: ABI Research: Cumulative Wi-Fi-enabled Product Shipments and Installed Base of Wi-Fi-enabled Products World Market, Forecast: 2000 to 2020.
WI-FI SERVICE PROVIDERS NEED LTE-U/LAA IN HARMONY WITH WI-FI IN 5 GHZ FOR QUALITY VIDEO AND VOICE

- LTE-U/LAA providers have licensed airwaves for voice and video; Other service providers rely solely on Wi-Fi
- Voice and video quality over Wi-Fi must be preserved
- So, are LTE-U/LAA polite enough?
“Old” Wi-Fi configurations are being used in some of the coexistence studies.
Objective: Test VoIP latency when LTE-U and Wi-Fi operate simultaneously

Scenario: Moderately dense indoor deployment
- 4 Wi-Fi AP’s in network A
- 4 LAA nodes (or Wi-Fi nodes) in network B
- 10 data users in each network
- 2 Wi-Fi VoIP users in network A

Results: Average 98 %ile Latency (ms) measured as nominal user requirement
- 44ms when both networks are on Wi-Fi
- 600ms when LAA is active and using only baseline coexistence protocols adhering to EU regulations
- 43ms if robust coexistence is implemented

Wi-Fi VoIP Average 98%ile Latency (ms)
For LAA protocol alternatives

Robust coexistence mechanism needed to guarantee VoIP quality (~50 ms latency) in Wi-Fi deployments
**Objective**: Test if Wi-Fi speeds can exceed video needs of 20 Mbps when LTE-U and Wi-Fi operate simultaneously

**Scenario**: Moderately dense indoor deployment
- 4 Wi-Fi AP’s in network A
- 4 LAA nodes (or Wi-Fi nodes) in network B
- 10 data users in each network
- 2 Wi-Fi VoIP users in network A

**Results**: Average Wi-Fi speeds
- 33 Mbps when both networks are on Wi-Fi
- 19 Mbps when LAA is active and using only baseline coexistence protocols adhering to EU regulations
- 34 Mbps if robust coexistence is implemented

Without Robust coexistence mechanisms, throughput needs for video data (~20 Mbps) will not be met for moderately dense deployments.
Broadcom suggests standardization of at least a three-pronged approach to healthy coexistence among broadband unlicensed technologies:

- Let other data transmissions and handshake mechanisms complete before transmitting; be adaptive to current occupants
  - Solution: LTE-U/LAA should deliberately wait for a nominally acceptable time before transmissions
  - Possible Technical solution: Initial wait for ~43 microseconds prior to arbitration - similar to Wi-Fi

- Back-off transmissions rapidly when significant interference with other users is detected; be adaptive to congestion
  - Solution: LTE-U/LAA should implement technologies similar to those in Wi-Fi such as “Exponential Back-off” which defer transmissions upon detection of interference

- Detect signals that are far below regulatory requirements to maintain thriving unlicensed ecosystem
  - Solution: Match Wi-Fi mechanisms, which detect signals as weak as 1000 times below regulatory requirements
  - Possible Technical solution: LTE-U/LAA should operate at -82 dBm to -92 dBm for preamble or carrier sense detection and at -62 dBm energy detection assuming 20 MHz signal bandwidth
THANK YOU