Graduate Research

Enabling a "Use-or-Share" Framework for PAL–GAA sharing in CBRS Networks via Reinforcement Learning

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RICE ece redefining limits

CBRS Overview

- Citizens Broadband Radio Service
- 3.55 – 3.7 GHz managed by central database
- Thee-tier spectrum sharing
- FCC encourages "Use-or-Share" to avoid spectrum warehousing

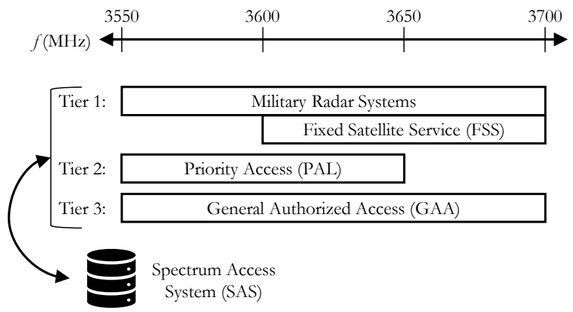

Figure: CBRS band has three priority tiers that are managed by a database.

Challenges:

- Currently no way to facilitate PAL–GAA spectrum sharing.
- LTE is susceptible to hidden and exposed terminal problems

Solutions:

- Introduce Listen-Before-Talk (LBT) Schemes for PAL–GAA coexistence.
- Use Q-Learning to learn an adaptive energy-detection threshold (EDT) to combat problematic topologies.

LBT Schemes

- GAA nodes measure the energy in the spectrum during the Clear Channel Assessment (CCA).
- If the measured energy is less than the threshold, the node transmits in the next subframe.

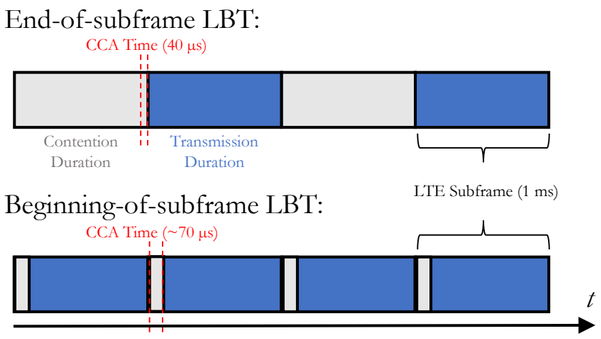

Figure: LBT schemes that are evaluated in the paper.

Shared-Spectrum Testbed

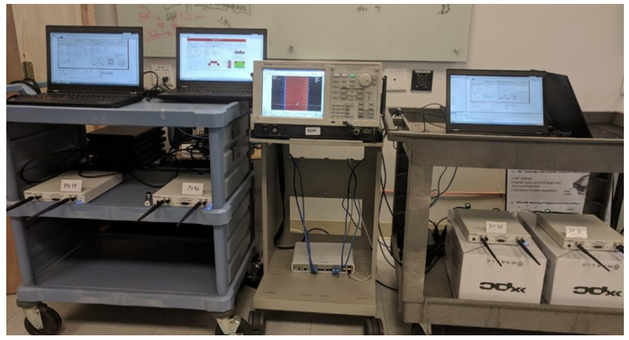

Figure: Photograph of the shared-spectrum testbed. Four USRPs connected to host PCs running LabVIEW Communications with a real-time signal analyzer.

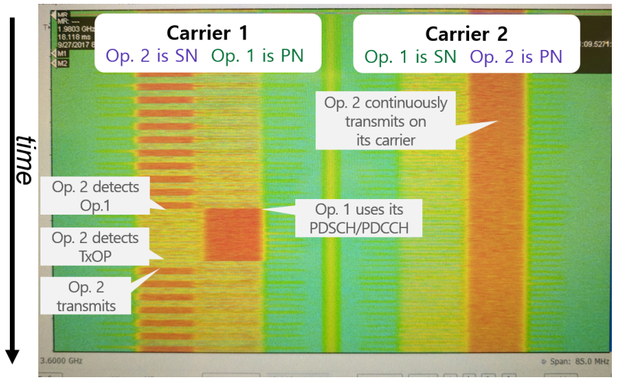

Figure: Real-time signal analyzer spectrogram for end-of-subframe LBT,

- Each operator is restricted to half of the full carrier to allow for visual distinction
- Op. 2 transmits on the outer resource blocks
- Op. 1 transmits on the inner resource blocks.
- Op. 2 has heavy traffic
- Op. 2 performs LBT on Op. 1's spectrum

Simulation Results

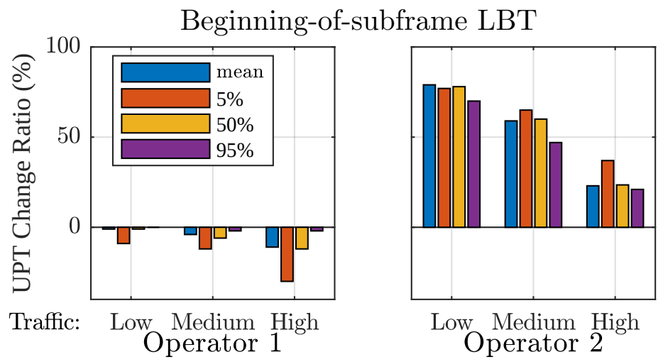

Figure: User-perceived throughput (UPT) change when the GAA operator uses beginning-of-subframe LBT

Q-Learning Algorithm

- Learn EDT to reduce PAL interference and improve GAA UPT
- Share the PAL buffer occupancy and queue length with Coexistence Manager through CBRS Alliance backhauls.
- States: PAL has a high or low buffer occupancy item Actions: GAA increase or decreases its EDT

Reward	Conditions
Positive	■ PAL queue length is low, and the last action was to choose a high EDT value (-62 dBm). ■ The average PAL queue length goes from high to low.
Negative	■ PAL queue length is low, but the last action was to choose a low EDT value (-77 dBm). ■ The average PAL queue length goes from low to high following the last epoch, and the buffer occupancy is large.

Exposed-Node Simulation

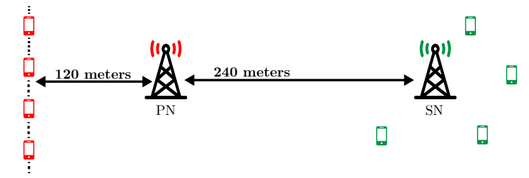

Figure: Exposed node test topology where the PN UEs are at the cell edge opposite of the SN. Here, the PN users experience a low SINR but are not susceptible to collisions from the SN. The SN needs to adjust its EDT to be less sensitive to PN transmissions.

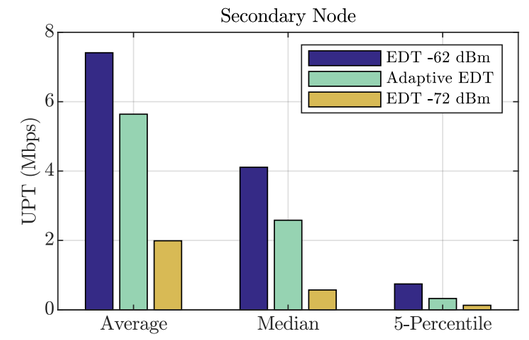

Figure: An adaptive EDT via Q-Learning helps the GAA Node learn a better EDT over the case where it uses a static, low EDT.

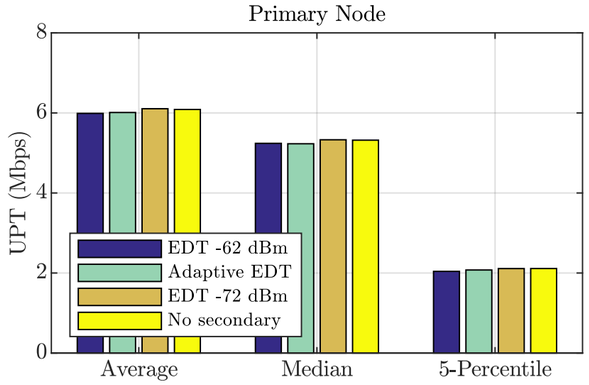

Figure: The PAL is hardly affected by the SN.