Cooperative Proactive resource management for 5G in the unlicensed spectrum

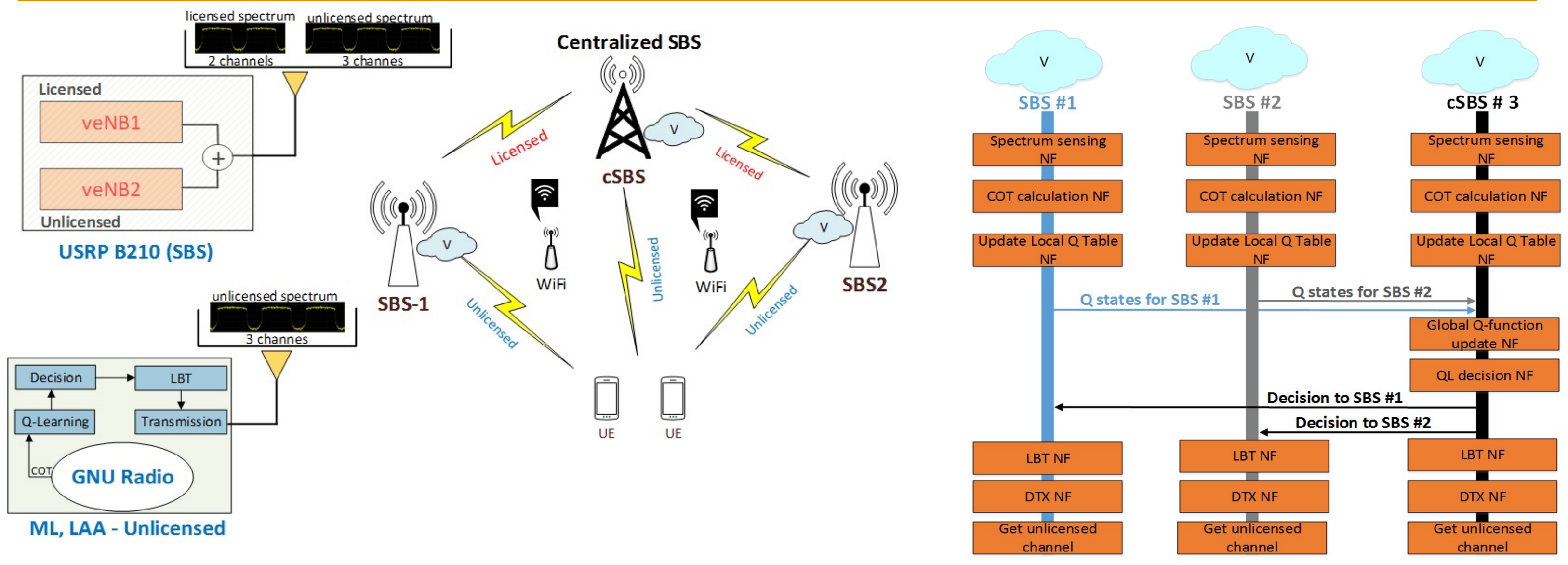
GOALS

- To develop double q-learning machine learning algorithm for small base stations to learn the utility of unlicensed spectrum proactively.
- To allocate the resources of the unlicensed spectrum into the LTE-A system using the LAA concept.
- To deploy a cooperative machine (Q) learning algorithm in order to decide about the spectrum allocation collaboratively.
- To employ in-band communications to collaborate among the SBSs in the licensed bands for efficient implementation.
- To develop and deploy additional QL schemes, in order to compare the performance of each algorithm and to acquire knowledge on which QL configuration achieves the better results.

CHALLENGES

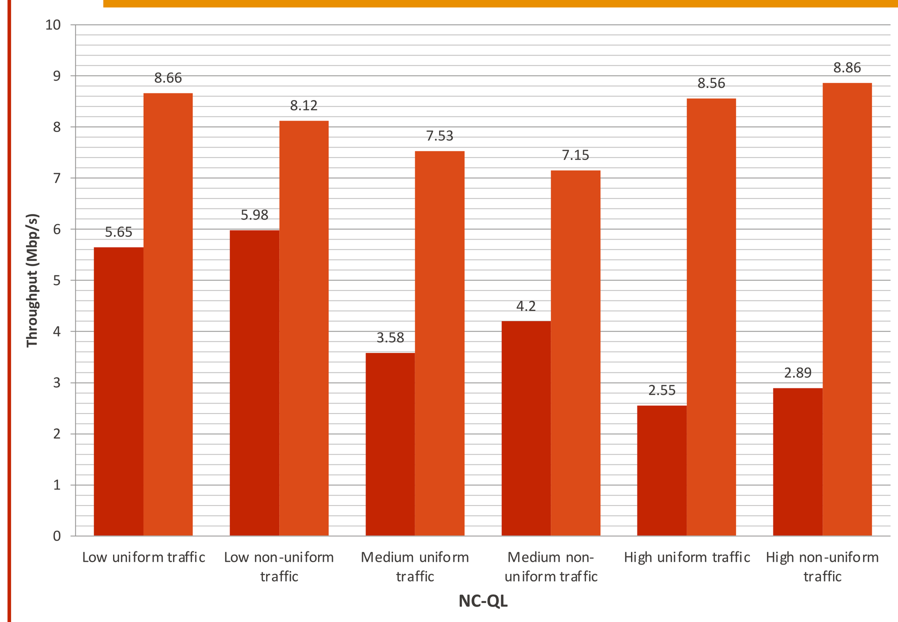
- Learn the availability of the unlicensed spectrum in an efficient way.
- Employ ML for channel estimation instead of conventional methods.
- Deploy small base stations and utilize both licensed and unlicensed channels.
- Use the LAA concept to achieve efficient coexistence in the unlicensed spectrum.

DEMO SETUP



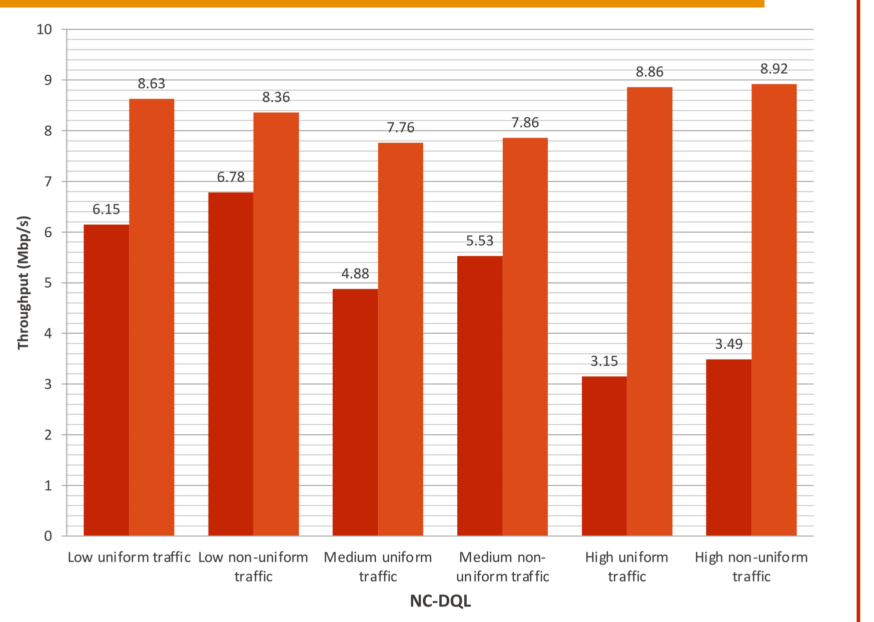
- Three SBS for LTE frame transmission.
- Each SBS transmitts to the unlicensed channel (veNB1) and utilizes the licesed channel for in-band comunication (veNB2).
- One centralized SBS where the cooperative resource management is carried out
- Each veNB1 performs spectrum sensing, LBT and DTX according to the LAA concept.
- One SBS for traffic generation in the unlicesed channel.
- Four different Q-Learning configurations used for proactive resource allocation

RESULTS



Non-cooperative QL (NC-QL)

The QL algorithm runs individually on each SBS. In this setup the SBSs compete for the available network resources.



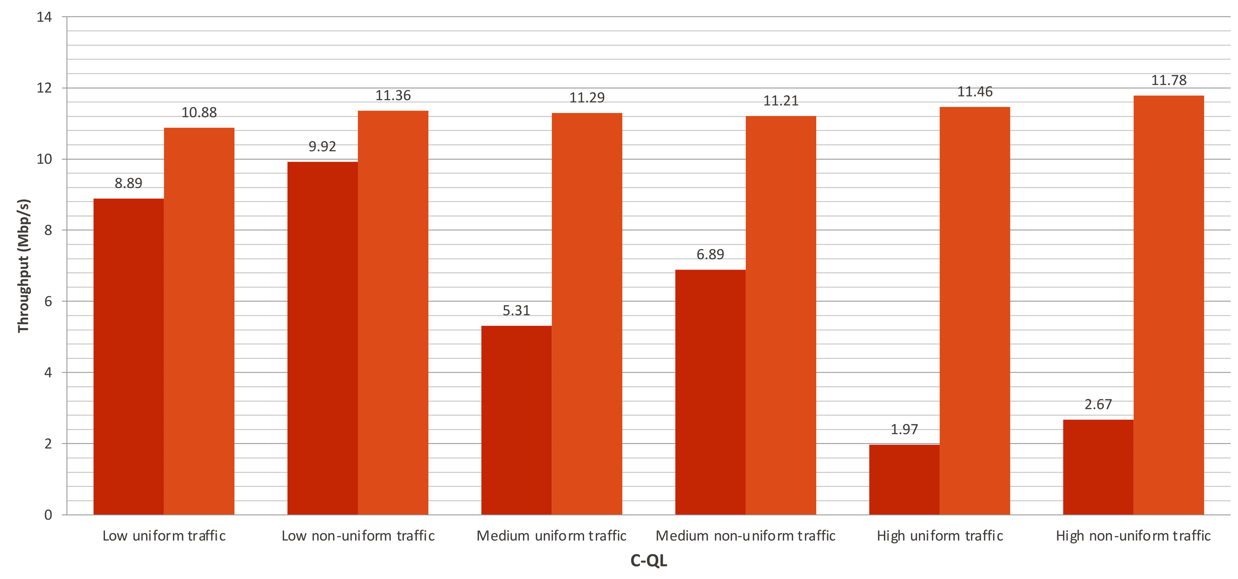
Non-cooperative double QL(NC-QL)

The QL runs individually on each SBS, also taking decisions for transmit power control under the double Q-Learning paradigm

Measurements

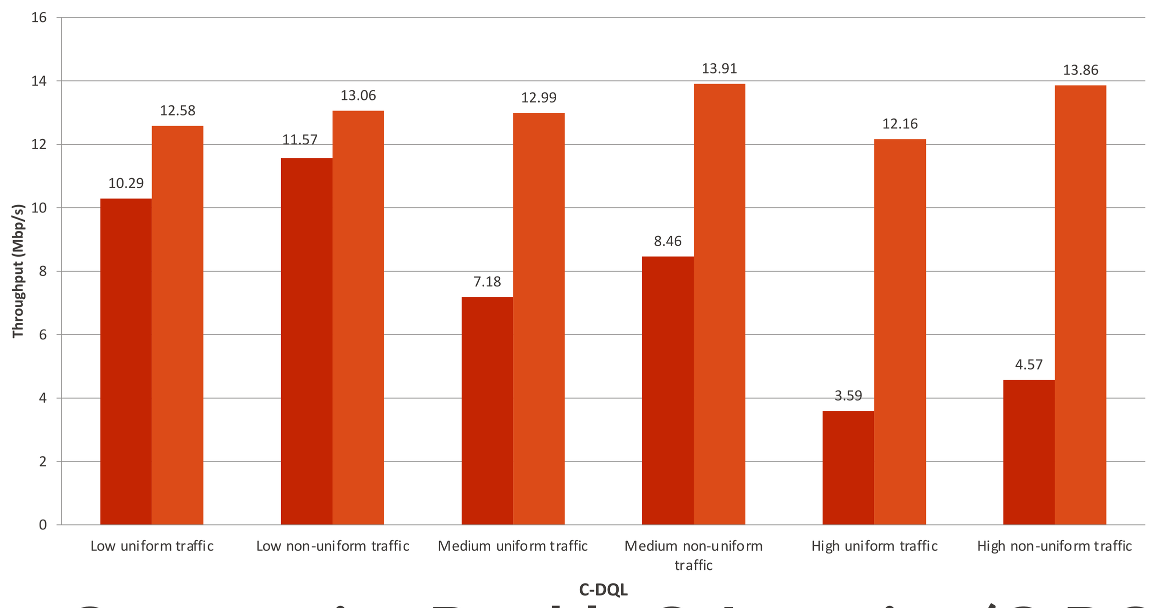
- SBS throughput (red) measures the throughput achieved by the three SBSs collectively.
- Network throughput (orange)measures the throughput achieved by the network as a whole, i.e. the Wi-Fi and SBS throughput combined.

MORE RESULTS



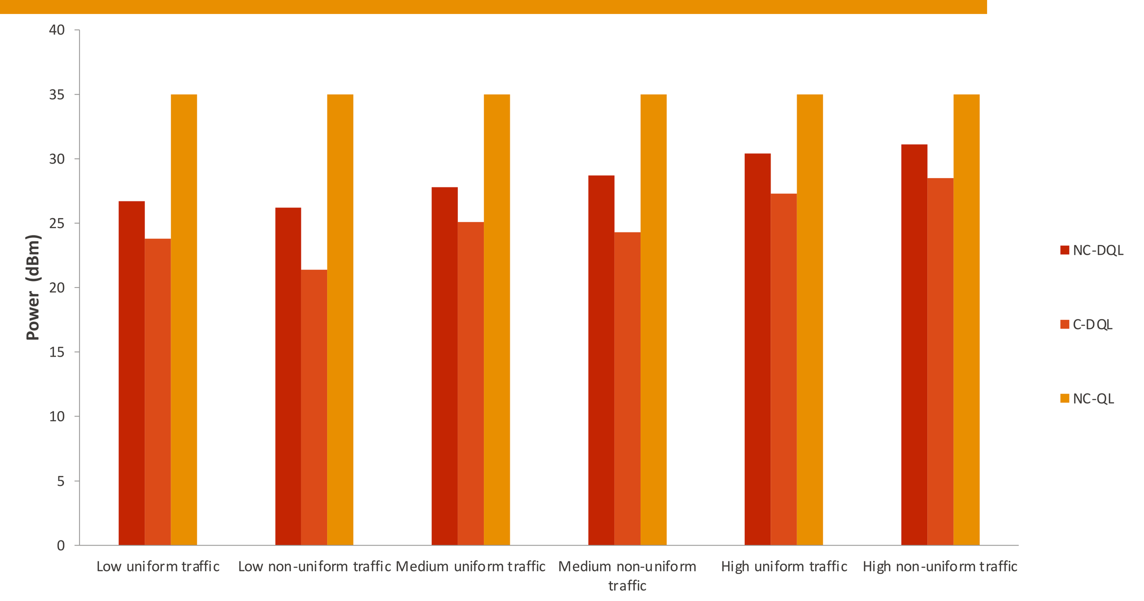
Cooperative Q-Learning (C-QL).

The QL runs in a distributed way on each SBS with the cSBS acting as the centralized controller which is responsible for cooperation between SBSs.



Cooperative Double Q-Learning (C-DQL).

The QL runs on each SBS in a distributed way as in C-QL, while also taking decisions for transmit power control by employing the double Q-Learning algorithm.



Transmit power control

Measuring the power consumption on the transmitter side on each SBS under three different QL configurations.

CONCLUSIONS

- The C-DQL achieves the best SBS and network throughput. Distributed learning takes into account the inputs from every SBS and thus, it fosters cooperation instead of letting the SBSs compete with each other.
- The non-cooperative versions of QL display lower throughput levels. We deduce that a cooperative QL scheme significantly boosts the achievable network throughput when compared with a non-cooperative algorithm.
- The C-DQL performs better in terms of power saving when compared to NC-DQL or algorithm

POST MORTEM

- We plan on further enhancing our solution with better ML techniques to maintain a competitive edge on the emerging market of ML assisted transmission.
- We plan on designing complex experiements with more participating devices so that to emulate high traffic conditions.
- We will utilize the aquired knowledge on the product devolopement cycle and we wil integrate the ML algorithms to enhance its performance.
- We will disseminate the results at the IEEE PIMRC conference in September in London.