5G (ENCQOR) Academic Technology Development Program Challenge Statement

Autonomous Multi-RAT Radio Resource Management for 5G

Challenge Launch Date	September 25, 2018
Challenge Deadline	~~October 23, 2018 at 2PM EST~~ Deadline extended to November 13, 2018 at 2PM EST Late submissions will not be accepted
Challenge Statement	Massive amounts of data are anticipated to be pipelined over 5G networks to serve smart cities, connected autonomous cars, and IoT applications. The complexity of radio resource management (RRM) in 5G networks will however be unprecedented due to the highly configurable signalling, and the dense heterogeneous architectures spanning multiple radio bands. The challenge is to develop autonomous RRM techniques that maximize the capabilities of 5G networks, adapt to the continually changing environment, and enable various applications and services. Due to interdependency between the different RRM parameters, and the time varying channel conditions, a new optimization paradigm is required which exploits, but is not limited to, machine learning and artificial intelligence. Of particular interest is applying reinforcement or unsupervised learning for: **1) Multi-RAT dual connectivity management,** including link selection and carrier aggregation management that accounts for user QoS requirements and minimizes latency, and **2) Dynamic joint configuration of LTE-NR physical channels** to control the spectrum sharing for each of the control channels, data channels and reference signals, as well as the amount of spectrum allocated for each of uplink and downlink traffic. Parameters such as periodicity, density and amount of physical resources have to be adapted based on the deployment scenario, numerology, channel conditions, and the configuration of LTE network involved in the dual connectivity.
Project Partner	Ericsson Canada Inc.

Timeline	2 Years
Available funding	Up to 150,000 CAD
Applicant Type	**Ontario based College/University**
Location	Work can completed remotely at the Academic Institution with some face to face workshops and meetings in Ottawa
Project Details	**The main scope includes:** ○ **5G Multi-RAT Dual Connectivity Management**: ▪ Developing Machine Learning (ML) based algorithms that select the LTE/NR links and determine the amount and type of user traffic that is sent on each leg, and for each carrier in multi-carrier setups. ▪ The solution should consider and adapt to various factors such as the user QoS requirements, network load and latencies, radio conditions, and user distribution. ▪ The techniques devised should be able to achieve different network defined objectives such as minimizing the total latency for end users or maximizing network throughput. ○ **Dynamic Joint Configuration of LTE-NR Physical Channels:** ▪ Develop a machine learning (ML) algorithm to calculate the optimal configuration of the NR frame including the resources, periodicity and density of the control channels, data channels and the reference signals used for channel estimation (e.g. CSI-RS). This is in addition to configure the amount of spectrum allocated for uplink and downlink traffic. ▪ The ML algorithm has to take into consideration a predefined level of channel estimation accuracy and a maximum tolerable level of throughput degradation under LTE-NR dual connectivity. ▪ The algorithm extends to consider user-specific optimal configurations which meet a target user QoS level in different deployment scenarios (e.g. FDD and TDD systems). ▪ The algorithm shall be applicable to large scale 5G network experiencing intercell interference, and other network dynamics due to user mobility and traffic variations. ○ The developed ML based optimization models should consider: ▪ computation constraints to provide real time decisions. ▪ erroneous physical layer measurements, time varying user requests, and 3GPP standard constraints. ▪ conflicting network objectives such as the trade-off between accurate channel estimation with long-term spectral efficiency gains on the one hand, and maximizing the instantaneous throughput on the other hand.

	○ Performance evaluation should consider different 5G deployment under state-of-the-art propagation models to mimic real network scenarios. **Deliverables:** • Machine learning based algorithms/techniques that solve the dual connectivity and joint physical channel problem and are able to adapt to the aforementioned varying conditions and network objectives. • The ML models should be integrated with a link level simulator and evaluated under different mobility patterns, traffic scenarios and deployment use cases. • The ML models should be developed using state-of-the-art machine learning suites and libraries (e.g. Scikit-Learn, tensorflow, etc.). • The framework has to be 3GPP Rel 15.2 standard compliant, and if possible compliant with supported features in Ericsson's product by the time of completion. • A detailed report explaining the key findings of the study and the detailes of using the developed machine learning framework. **This challenge strategically important for the development of the industry and the ENCQOR consortium since it:** • Provides autonomous solutions to solve complex 5G multi-RAT management problems – and enables the tuning of channel resources and network architecture to maximize spectral efficiency and user QoS. • Builds a strong 3GPP knowledge and competence in the Canadian academia.
Project Goals/ Outcomes	• A machine learning and inference model that calculates the optimal traffic distribution among LTE and NR, and dynamically configures the spectrum share of control and data channels for both uplink and downlink, and the reference signals parameters to achieve the target latency and throughput. • An integrated simulation framework or testbed which comprises the machine learning framework and 3GPP compliant link simulator (or hardware). • A set of recommended configurations for the frame structure including all the allocation of reference signals, and the resulting data channel allocations under dual connectivity scenario.
Applicant Capabilities	• 3 researchers (Ph.D. level) available to work on the project • Strong background in wireless communications and 5G standards (Physical and MAC layer) • Experienced in machine learning, signal processing, linear/non-linear optimization and artificial intelligence

	• Hands-on experience in using standard compliant event driven simulators (e.g., ns-3).
Additional Information	• N/A