

A Multi-Agent Deep Reinforcement Learning Approach for RAN Resource Allocation in O-RAN

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Abstract—Artificial intelligence (AI) and Machine Learning (ML) are considered as key enablers for realizing the full potential of fifth-generation (5G) and beyond mobile networks, particularly in the context of resource management and orchestration. In this demonstration, we consider a fully-fledged 5G mobile network and develop a multi-agent deep reinforcement learning (DRL) framework for RAN resource allocation. By leveraging local monitoring information generated by a shared gNodeB instance (gNB), each DRL agent aims to optimally allocate radio resources concerning service-specific traffic demands belonging to heterogeneous running services. We perform experiments on the deployed testbed in real-time, showing that DRL-based agents can allocate radio resources fairly while improving the overall efficiency of resource utilization and minimizing the risk of over provisioning.

I. INTRODUCTION

The highly heterogeneous nature of 5G and beyond makes increasingly challenging to meet the performance requirements for emerging use cases. The strict reliability and latency requirements exacerbates the need for intelligent orchestration solutions able to provide resource and cost-efficient services. In this context, network slicing is a key enabler to underpin such challenging scenarios by deploying logically-isolated virtual network instances. Motivated by open architecture and interfaces for intelligent and agile RAN, O-RAN Alliance [1] provides flexibility, interoperable and open interface for virtualization and network innovation. Despite this revolutionary approach, it is still not clear how to efficiently support large network slicing scenarios. Therefore, we address this challenge by proposing a hierarchical architecture for network slice resource orchestration. In particular, given the variable spatio-temporal distribution of mobile traffic demands [2], we envision the dynamic setup of a network of local decision agents (DAs) as virtual software instances co-located within the Near-Real Time RAN Intelligent Controller (Near-RT RIC) premises. These instances are capable of accessing local RAN monitoring information and extracting local knowledge without the need for a centralized entity to make decisions based on the aggregated information.

Our framework, which was initially presented and validated by means of an exhaustive simulation campaign in [3], leverages a distributed learning mechanism and multiple

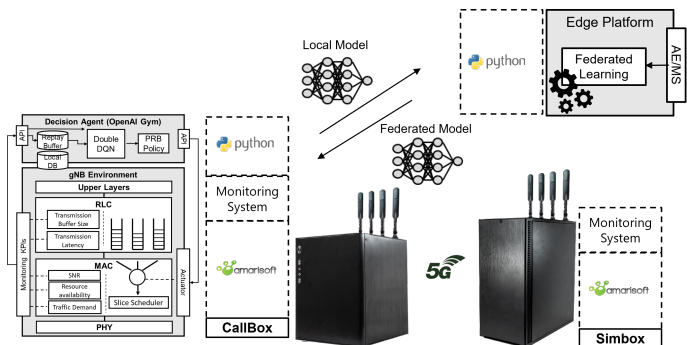


Fig. 1: Federated RAN resource allocation architecture overview.

decision agents that collaboratively specialize their decision policies onto real-time traffic demands, aided by a coordinated exchange of information to avoid the occurrence of conflicting situations. In our approach, we perform resource allocation in a distributed fashion directly at the edge of the network. This brings manifold advantages including *i*) performing radio resource allocation decisions leveraging the most up-to-date information, *ii*) the decision process does not involve a centralized controller, significantly decreasing the need for control information exchange and reducing the overhead towards the core of the network, and *iii*) by allowing information exchange among local DAs, we can establish federated learning schemes to further enrich the capabilities of the DAs. Namely, DAs not only rely on local observations to drive the learning process but can exploit the experience from other (statistically different) RAN nodes to speed up the convergence time and better generalize resource allocation decisions.

II. TESTBED ARCHITECTURE

We propose a distributed architecture for RAN slice resource orchestration based on DRL, consisting of multiple AI-enabled decision agents that independently take local radio allocation decisions without the need for a centralized control entity. We design and implement the overall framework as shown in Fig. 1. The testbed includes:

AMARI UE Simbox: It is capable of simulating tens of

