

# Demo: Intelligent Radar Detection in CBRS Band in the Colosseum Wireless Network Emulator

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## ABSTRACT

The ever-growing number of wireless communication devices and technologies demands spectrum-sharing techniques. Effective coexistence management is crucial to avoid harmful interference, especially with critical systems like nautical and aerial radars in which incumbent radios operate mission-critical communication links. In this demo, we showcase a framework that leverages Colosseum, the world’s largest wireless network emulator with hardware-in-the-loop, as a playground to study commercial radar waveforms coexisting with a cellular network in CBRS band in complex environments. We create an ad-hoc high-fidelity spectrum-sharing scenario for this purpose. We deploy a cellular network to collect IQ samples with the aim of training an ML agent that runs at the base station. The agent has the goal of detecting incumbent radar transmissions and vacating the cellular bandwidth to avoid interfering with the radar operations. Our experiment results show an average detection accuracy of 88%, with an average detection time of 137 ms.

## 1 INTRODUCTION

The evolution of wireless technology has led to increasingly complex wireless systems design. This requires optimal resource sharing among expanding user sets, prompting researchers to turn to AI as a promising solution for modern system challenges. AI-driven solutions have enhanced network efficiency and optimized spectrum utilization, outperforming traditional model-based methods in various channel conditions and SNR scenarios. These advancements enable multiple wireless systems to coexist harmoniously, but challenges remain regarding potential interference, particularly for applications with critical safety communication links. For instance, 5G RANs could interfere with incumbent radar signals in the 3.55 – 3.7 GHz RF band, necessitating thorough research and mitigation strategies to ensure reliable operation for both systems [2]. AI-driven spectrum-sharing and interference mitigation algorithms, running often as AI/ML

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applications in Radio Access Network (RAN) Intelligent Controllers (RANs) like O-RAN’s xApps and rApps, have shown promise in optimizing spectrum utilization and mitigating interference [3, 5]. However, they often require a reliable testing playground and abundant high-quality data.

To address these challenges, we propose a framework for emulating spectrum-sharing scenarios and twinning waveform signals [8] with both cellular and radar nodes in a high-fidelity digital twin system [7] as depicted in Figure 1.

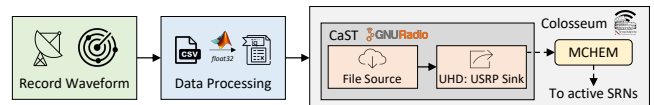


Figure 1: Waveform twinning to integrate signals in Colosseum.

The system, implemented on Colosseum [1], the world’s large wireless network emulator with hardware-in-the-loop, provides reliable data collection, AI network training, and realistic scenario testing. Our framework uses IQ samples of radar and cellular communications to train a Convolutional Neural Network (CNN) to detect radar signals and notify the RAN to halt operations, eliminating interference on incumbent radar communications. Experimental results show an average accuracy of 88% with an average detection time of 137 ms complying with the minimum detection requirements of commercial transmissions in the CBRS band [4].

## 2 SYSTEM DESIGN

We examine the use case of a 4G RAN transmitting in the CBRS bandwidth that needs to vacate said bandwidth due to an incumbent radar transmission. To accomplish this, we design (i) an ad-hoc scenario in Colosseum to collect data and run our experiments, and (ii) a CNN for radar detection.

**Colosseum Waikiki Beach Scenario** The scenario aims at representing the propagation environment of Waikiki Beach, Honolulu, Hawaii, and has been created through the CaST toolchain [6]. As shown in Figure 2, the scenario comprises of: (i) a cellular BS (red circle) located at 3 m from the ground with GPS coordinates taken from the OpenCellid database of real-world cellular deployments; (ii) six static UEs (blue circles) uniformly distributed in the surroundings of the BS at 1 m from the ground level emulating hand-held

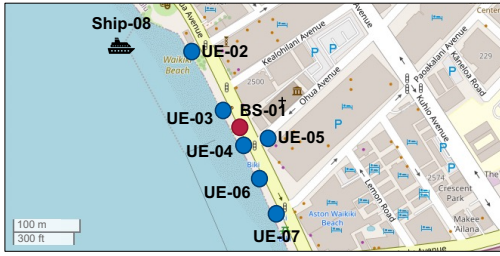


Figure 2: Location of the nodes in the Waikiki Beach scenario.

devices; (iii) one ship (black icon) equipped with a radar, whose antennas are located at a height of 3 m and moving in a North-South linear trajectory alongside Waikiki beach at a constant speed of 20 knots (~10 m/s). We leverage the MATLAB ray-tracer to characterize the environment and derive the channel taps among each pair of nodes of our scenario to finally install it in the Colosseum system.

**CNN Model** The BS uses an ML inference model trained offline, deployable as a dApp [3], to detect radar signals during or before cellular communications. Figure 3 shows the model architecture of the lightweight CNN we leverage which can properly represent our framework’s capabilities.

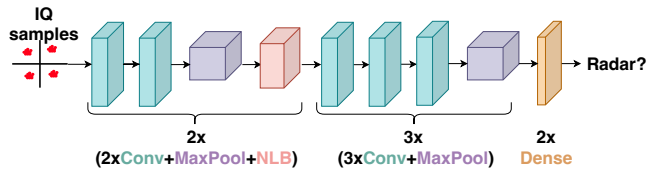


Figure 3: CNN model used to train the radar detector.

It consists of a smaller version of VGG16, commonly used in wireless applications, where to the first two convolutional blocks we also append a Non-local Block (NLB). The model takes as input In-phase and Quadratures (IQs) in the shape of  $(batch\_size, 1024, 2)$  and offers a binary label to each sample: 1 if radar exists, and 0 otherwise. We collect IQs from the Waikiki Beach scenario and we train the ML agent with different combinations and reception gains of radar and cellular signals achieving an average detection accuracy of 88%.

### 3 DEMONSTRATION

This demonstration leverages Colosseum and the newly created scenario to deploy a twinned srsRAN-based protocol stack with 1 BS and 6 UEs and to run a traffic analysis by generating UDP downlink data streams through iPerf. At a certain simulation time, the radar signal is transmitted through a GNU Radio flow graph, designed to support custom radio waveforms. Figure 4 shows the evolution in time of our demonstration experiment with the top portion displaying the downlink cellular spectrogram centered at 980 MHz (i.e., the downlink center frequency that we use for srsRAN in Colosseum), and the bottom one the results of the radar

detection system. From 0 to 50 seconds the BS serves UDP traffic flows to the UEs. At second 50, the radar starts transmitting and the ML agent detects it and shuts down the BS. When no more radar transmissions are detected (second 90), the BS receives the turn-on command and, after the UEs reconnect, it resumes the data streams. The system leverages a voting system of 100 samples to avoid false positives and false negatives, and a batch size of 10 for a good trade-off between computation time and granularity. This demonstration proves the effectiveness of our intelligent detector in identifying radar signals and vacating the cellular bandwidth.

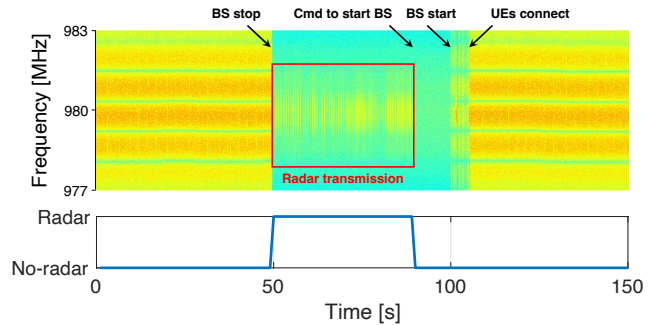


Figure 4: (top) Downlink cellular spectrogram; (bottom) radar detection system result. The BS is shut down when a radar transmission is detected and resumes normal operations after no radar is detected.

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