

# Spectrum Collaboration Challenge (SC2)



[www.SpectrumCollaborationChallenge.com](http://www.SpectrumCollaborationChallenge.com)

## Phase 3 Open Track Entrance Hurdle Problem Description

11/2/2018



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**Document Change Summary**

<b>Section</b>	<b>Description</b>	<b>Date</b>
	Initial Revision	11/2/18

## 1 Introduction

The DARPA Spectrum Collaboration Challenge (SC2) is the first-of-its-kind collaborative machine-learning competition to overcome scarcity in the radio frequency (RF) spectrum. Today, spectrum is managed by dividing it into rigid, exclusively licensed bands. This human-driven process is not adaptive to the dynamics of supply and demand, and thus cannot exploit the full potential capacity of the spectrum. In SC2, competitors will reimagine a new, more efficient wireless paradigm in which radio networks autonomously collaborate to dynamically determine how the spectrum should be used moment to moment.

The team whose radio design most reliably achieves successful communication in the presence of other competing radios could win as much as \$3,500,000.

This document defines the Entrance Hurdle for new Open Track teams entering Phase 3 of the competition which begins January 1<sup>st</sup> 2019. While participation in SC2 is open to most all interested parties, access to the Colosseum testbed requires DARPA to set limits on the number of teams that can participate in the program in any phase. DARPA also needs to ensure that participating teams have the necessary skillset to field competitive Collaborative Intelligent Radio Networks (CIRNs) that perform properly on the testbed and meet the objectives of SC2. Entrance Hurdles are DARPA's mechanism to ensure both these criteria are met.

Per the SC2 Rules, this document details the Phase 3 Entrance Hurdle that **new** competitor teams must successfully pass in order to compete in the second Phase of competition. Note that Phase 2 teams that successfully qualified and participated in Preliminary Event 2 (PE2) are automatically admitted to Phase 3, and are not required to complete the Phase 3 Entrance Hurdle.

Teams entering the competition in Phase 3 will gain access to the Colosseum Infrastructure upon successful completion of the Phase 3 Hurdle. A new competitor team will be able to integrate against the Colosseum infrastructure and practice against itself for the duration of Phase 2. The new competitor teams will not be able to practice against any other teams until the start of Phase 3.

This document will acquaint new prospective teams with the Phase 3 Entrance Hurdle process and familiarize them with the associated infrastructure and logistics.

For the official competition rules see [SpectrumCollaborationChallenge.com](http://SpectrumCollaborationChallenge.com)

## 2 Phase 3 Entrance Hurdle Description

The Phase 3 Entrance Hurdle consists of developing a software-defined Collaborative Intelligent Radio Network (CIRN) that can spectrally coexist and collaborate with a DARPA supplied software defined radio bot network. Both your radio network and the bot network will consist of three nodes which must successfully deliver IP traffic over a shared RF channel. Just as in the SC2 competition, the objective of the Entrance Hurdle is to optimize the total combined use of the spectrum by both radio networks. To facilitate optimizing joint spectrum capacity and minimizing interference, your team's network is able to collaboratively exchange information with the bot network via a "wired" collaboration channel.

The Entrance Hurdle scenario is shown below in Figure 1. Detailed information on channel characteristics, bandwidths, and power levels can be found at <https://github.com/spectrumcollaborationchallenge/phase3-hurdle/releases/latest>. In the Phase 3 Entrance Hurdle both your network and the bot network will be given identical IP traffic flows which mimic an FTP file transfer. Both networks must successfully deliver this IP traffic over a shared wireless channel with a bandwidth on the order of 1 MHz. To ensure the broadest possible participation and underscore the importance of artificial intelligence in the program, no actual RF hardware is required to participate in this hurdle. Instead all RF will be implemented as streams of baseband data in GNU Radio (described below).

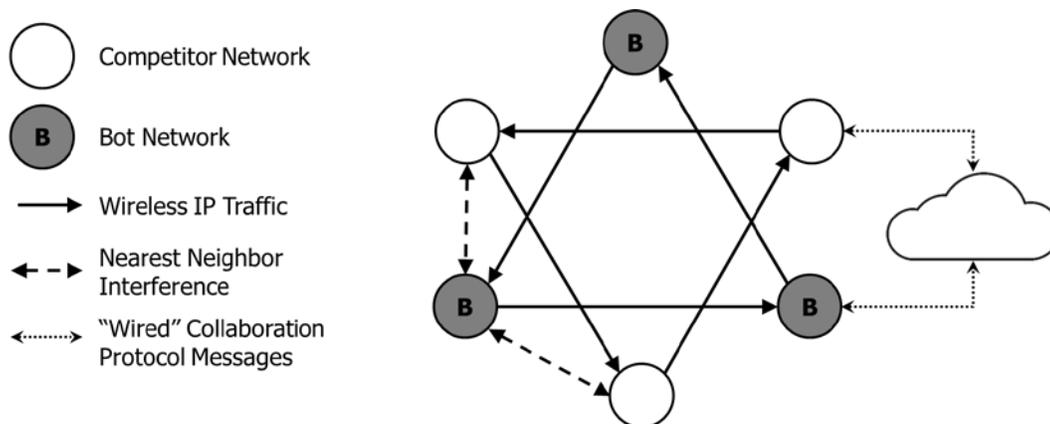


Figure 1 – Graphical depiction of the Phase 2 Entrance Hurdle

**Entrance Hurdle Completion Criteria:** Successful completion of the Entrance Hurdle is defined as both networks achieving 85% of the Bot Network's nominal throughput. The most current metrics for Bot Network throughput are available at <https://github.com/spectrumcollaborationchallenge/phase3-hurdle/releases/latest>.

### 3 Schedule

The schedule for the Phase 3 Entrance Hurdles is as follows.

2 Nov 2018	Initial Revision of Phase 3 Entrance Hurdle container released <ul style="list-style-type: none"><li>• Revision 1 of this document</li><li>• Practice version of DARPA bot network</li><li>• Hurdle version of DARPA bot network (JerkBot)</li></ul> Submission window opens <ul style="list-style-type: none"><li>• Submissions accepted on first come, first served basis</li></ul>
11 Jan 2019	Submission window closes <ul style="list-style-type: none"><li>• DARPA will accept additional Entrance Hurdle submissions on a first-come first-serve basis until the close of this window or until all participation slots are filled, whichever comes first.</li></ul>
18 Jan 2019	Evaluation result notification <ul style="list-style-type: none"><li>• Teams which submitted by <b>11 Jan 2019</b> will be notified if their submission passed</li></ul> <p><i>Note: DARPA will evaluate submissions received before 11 Jan 2019 on a rolling basis and will send notifications for these early submissions as they are evaluated.</i></p>

Teams which successfully complete the Phase 3 Hurdle will be given credentials to access the Colosseum infrastructure and the Colosseum Helpdesk. New Phase 3 teams will not be able to participate in any Phase 2 scrimmages or in Preliminary Event 2. New Phase 3 teams will be able to begin practicing with other teams at the start of Phase 3.

### 4 Hurdle Infrastructure

The Phase 3 Hurdle is a simplified version of a scenario teams would see in the SC2 competition, using a software environment closely modeled on the actual SC2 Colosseum. This section gives an overview of the Hurdle Infrastructure. Detailed information can be found on the SC2 docs page ([SpectrumCollaborationChallenge.com/documents/](http://SpectrumCollaborationChallenge.com/documents/)).

Each node in a radio network may exchange IP packets with its two peer nodes. Each node is responsible for routing packets to the appropriate peer. The bot network and competitor network will never be given traffic intended to be delivered to the other network. Traffic is provided to each radio node the same way as it is in Colosseum, via a set of traffic generators (see Figure 2).

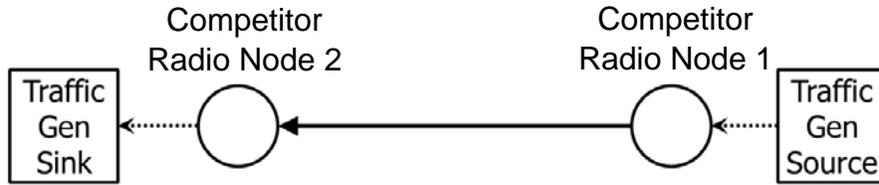


Figure 2 – Example traffic flow. From right to left: 1) IP traffic generated by the source delivered to the competitor radio node, 2) competitor radio node modulates and delivers packet via RF channel, 3) competitor radio receives packet via RF channel and demodulates, 4) competitor radio forwards traffic to sink to complete delivery

To permit the widest possible participation, no actual radio hardware is required to execute the entrance hurdle. Instead, the RF channel is implemented as a real time streaming interface of complex baseband samples using GNU Radio. The RF channel supports both bursty and continuously streaming transmissions. All node transmissions will be combined in an environment simulator provided by DARPA and sent back as a continuous stream of complex samples in real time. Teams have access to example interface code and the source code for the environment simulator in the Phase 3 Entrance Hurdle GitHub repository ([github.com/SpectrumCollaborationChallenge/phase3-hurdle](https://github.com/SpectrumCollaborationChallenge/phase3-hurdle)). The example interface to the RF channel is implemented in a set of GNU Radio blocks intended to mimic the usrp\_source and usrp\_sink blocks.

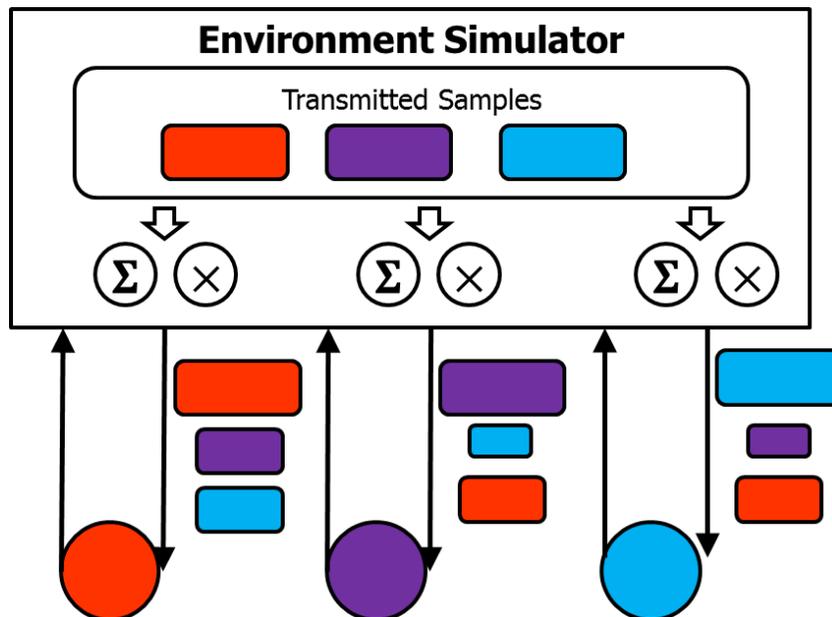


Figure 3 – The environment simulator mimics Colosseum’s channel emulator. Radio nodes (shown in colored circles) “transmit” digital samples which the environment emulator scales and sums properly to provide to all other radios in the simulation

Competitor networks must collaborate with the DARPA provided bot networks using the Phase 3 Hurdle Collaboration Protocol to exchange information about their respective RF resource needs, utilization and achieved network performance. This interaction will not

occur over RF. A dedicated interface for network-to-network collaboration referred to as the Collaboration Channel will be provided (as shown in Figure 1).

To put emphasis on the collaborative aspects of the competition, the Hurdle version of the bot network (JerkBot) will not automatically reduce its use of spectrum resources due to over the air interference. This behavior encourage teams to use the Collaboration Protocol to collaborate with the bot network to collaboratively optimize the spectrum.

## **5 Logistics**

All interactions between teams and DARPA required to complete the Hurdles will occur remotely via email and the SC2 website. No in-person meetings or webinars are planned.

All teams must be registered in order to gain access to hurdle infrastructure software and ultimately to submit their solutions. Teams may register at the following link:

[SpectrumCollaborationChallenge.com/register-for-phase-3-open-track](https://SpectrumCollaborationChallenge.com/register-for-phase-3-open-track)

Upon registering teams will be granted access to Amazon cloud storage containing hurdle infrastructure, as well as storage to submit solutions to the Entrance Hurdle. The Phase 3 Entrance Hurdle will be executed using an LXC container that encapsulates the emulated Colosseum networking infrastructure, RF environment simulator, bot network, and traffic generators. Competitor's solutions must be in the form of a single LXC container that incorporates their software defined radio application. The competitor solution container will be evaluated within the Phase 3 Entrance Hurdle environment.

This document provides only a high level summary of the Phase 3 Hurdle Logistics. Additional documents will be posted on the SC2 documents page providing the necessary technical details for executing the hurdles:

[SpectrumCollaborationChallenge.com/hurdles/](https://SpectrumCollaborationChallenge.com/hurdles/)