Demo: Spectrum Access System on Cognitive Radio Network Testbed

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ABSTRACT

Radio[1] frequency (RF) spectrum is transitioning from exclusive licensed to shared use in many bands. We demonstrate our design and implementation of a spectrum access system (SAS), which allows centrally coordinated access to shared spectrum. It shows how resources are requested by the radios and how the SAS tracks spectrum occupation and grants or denies access to requesting nodes. The open-source software framework is readily installed on Virginia Tech's cognitive radio network (CORNET) testbed, a remotely-accessible wireless research platform of large scale.

CCS CONCEPTS

• Networks → Network components → Wireless access points, base stations and infrastructure → Cognitive radios

KEYWORDS

Spectrum access system (SAS), Software-defined radio, Testbed

1 INTRODUCTION

The available radio frequency (RF) spectrum required for broadband radio communication is diminishing as the number of users and the number of wireless devices increase. The current spectrum regulations where spectrum bands are licensed to specific primary users (PUs) for exclusive use, make spectrum resources scarce for other users who need to communicate. It has been shown that the legacy primary users are underutilizing the provided resources [1]. Underutilization of resources and a boom in spectrum demand has led to the concept of spectrum sharing. Although there are multiple variations of spectrum sharing, generally the PU retains the highest priority for a given channel, but the same spectrum can be used by secondary users (SUs) when the PU is not transmitting. This symbiotic relationship requires that the SUs continuously sense the spectrum and opportunistically access it when and where available.

Different approaches of spectrum sharing have been developed to address the needs for an optimum coexistence between the PUs and the SUs. These include: (1) having individual cognitive radios (CR) opportunistically accessing free channels, (2) having a system consisting of a group of secondary CRs that share spectrum information among themselves and access spectrum in a decentralized way, (3) having a centralized CR that acts as the spectrum access system (SAS) by collecting spectrum information from the SUs or sensing nodes and allocating available spectrum to SUs upon request [2].

Research that analyzes the performance of each of the above methods is theoretical and based on the different PU and SU interaction models. There have been demonstrations of individual CRs that are able to coexist with a PU, but very few practical solutions exist for the second and third approaches.

We are creating a framework that can be used to perform an experimental evaluation of the performance of the SAS in different scenarios in which the PU and the SUs need to effectively coexist in limited spectrum. Initially, we are focusing on the Federal Communications Commission (FCC) proposed 3.5 GHz band for the experimental demonstrations.

In this demo, we demonstrate the functioning of our open-source SAS that is able to leverage a cluster of CRs. The demonstration employs a collection of software-defined radios (SDRs) that communicate with the central node for gaining spectrum access grants.

2 SYSTEM OVERVIEW

2.1 Hardware

The open-source SAS has been installed on Virginia Tech's cognitive radio network (CORNET) testbed. This testbed consists of 48 networked SDRs with 30 additional nodes currently being deployed. A node consists of a computer and universal software radio peripheral (USRP) by Ettus Research. All nodes are remotely accessible and only require registration. Fig. 1 shows the locations of the USRPs and their availabilities in the four-story building [4]. The current 48 computers that execute the radios' digital-signal processing chains and the SAS software, among others, are located in the server room [3].

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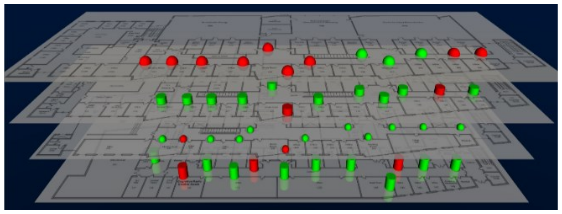

Figure 1: CORNET testbed floor plan.

2.2 Software

The CRs need to provide certain functionalities to create a stable cluster of nodes that act as an effective SAS-controlled network. These functionalities include:

Environment Sensing Capability (ESC): The CRs are able to sense shared spectrum bands and evaluate whether the channel is available or not. The SU sends this information to the SAS which makes the final decision on the availability of the channel. For a cluster of CRs, all relevant information from the SUs is aggregated at the SAS. To improve the sensing, some of the nodes on CORNET are assigned as sensing nodes for the SAS. The only function of the sensing nodes is to provide spectrum information to the SAS in a specific area. The overall sensing capability of the system is a function of the number and distribution of SUs and dedicated sensing nodes. Sensing is currently carried out using GNU Radio flow graphs.

Radio Environment Map (REM): A REM is a database that contains information about RF spectrum use, radio transceiver locations, and other relevant radio parameters and policies. Each CR in the network has an internal database that stores all spectrum information obtained by that node. This ensures that decisions on the future availability of a spectrum channel are the result of predictions based on both current and past observations. All CRs have local databases, but the SAS has a global database that combines the information from all other nodes.

SAS: This is the central node with access to the global REM. It combines and processes information from SUs, PUs, if available, and ESCs, to make decisions on channel availability. It assigns available channels to SUs upon request for a certain period. If a PU initiates transmission, the SAS reassigns channels to prevent interference to the PUs.

Although a CR could include additional capabilities, those listed above are the main functionalities needed by the SAS to be able to protect the PUs while allocating channels to SUs that need them.

3 DEMONSTRATION

CORNET provides the functionalities descried in Section 2.2. The system is set up in such a way that one node acts as the SAS, whereas the other nodes are sensing nodes that gather spectrum information. In the vicinity of a sensing node, another node is assigned to be an SU that needs to access the channel. This SU also senses spectrum and provides its observation to the SAS. If an SU needs access to a channel for transmission, it requests one from the SAS, which uses the information stored in the global REM to respond to the SU. SUs are scattered across the testbed. Some of the nodes are assigned as PUs that transmit at random times, which is realistic since the PUs have priority over these channels and do not need to coordinate with the SAS.

The job of the SAS is to maintain a harmonious relation between the SUs and the PUs while making sure that the SUs maintain a certain Quality of Service with little to no interference to the PUs. The SAS has no a-priori information about the PUs and their transmission patters, but rather relies on the SUs' ESCs.

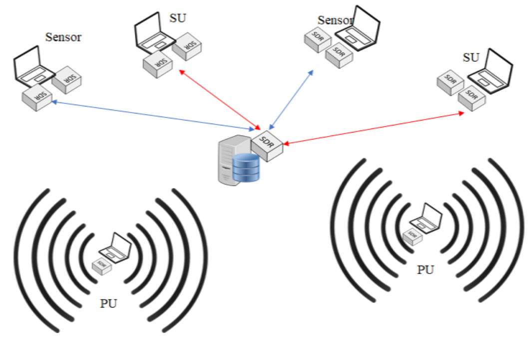

Figure 2: Experimental setup.

We will remotely login to the CORNET testbed and demonstrate the various functionalities of the SAS in different scenarios. Fig. 2 illustrates the experimental setup. We will illustrate the contents of the REM and how the different sensing nodes react to the presence of a PU. The demo will also showcase channel requests and the corresponding responses to these requests.

3 DEMONSTRATION REQUIREMENTS

The demonstration requires an Internet. We also request a monitor or projector with HDMI or VGA to showcase the functionalities of the SAS during the experiment.

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