Facilitating Spectrum Sharing Between Passive and Active Users at a Prototype National Radio Dynamic Zone (NRDZ)

Arvind Aradhya[(1)], Andrew Clegg[(4)], David DeBoer[(2)], Elliot Eichen[(1)], Wael Farah[(3)], Cole Forrester[(2)], Kevin Gifford[(1)], Sylvia Llosa[(1)], Mark Lofquist[(1)], Eloise Morris[(1)], Nicholas Papadopoulos[(1)], Bo Pearce[(3)], Alexander Pollak[(3)], Mark Ruzindana[(2)], Brockton Stover[(1)], Stefan Tschimben[(1)], Georgiana Weihe[(1)]

(1) University of Colorado, Boulder, CO 80309, USA
(2) University of California, Berkeley CA 94720, USA
(3) SETI Institute, 189 Bernardo Ave, Mountain View, CA 94043, USA
(4) Google, 1600 Amphitheatre Parkway, Mountain View, CA 94043, USA

A team comprising the University of Colorado, Boulder (CUB), the Hat Creek Radio Observatory (HCRO) and UC Berkeley (UCB) is presently engaged in National Science Foundation (NSF) funded research and development of various tools to facilitate co-existence of active and passive users of the electromagnetic spectrum, within a prototype National Radio Dynamic Zone (NRDZ) – centred around the Allen Telescope Array (ATA) at HCRO.

Six Software-Defined-Radio (SDR) based auxiliary sensors – equipped with omnidirectional antennas, and RF front end amplifiers – setup in close proximity to the ATA, are collecting data in order to characterize both the ambient RF (Radio-Frequency) environment around HCRO, as well as the departures from this baseline which signify interference events. This data is first processed, then archived in an on-site server, and is subsequently visualised via a user-friendly graphical dashboard which provides RF situational awareness. An automated system status monitor, and RFI (Radio Frequency Interference) alerting mechanism are also integrated within this infrastructure. The sensors are currently being calibrated (and future versions are being designed with in-situ calibration) enabling the potential use of independently recorded interference data within Radio Astronomy (RA) signal processing pipelines, for RFI excision from the instrument recorded data.

The exponential growth in the number of Non-Geo-Stationary Orbit (NGSO) satellites as part of internet provisioning constellations has led to large growth in the instances of RFI experienced by nearly all RA facilities, despite their remote locations which geographically situates them away from anthropogenic noise sources. This occurs even when these space-based operators are compliant with existing Federal Communications Commission (FCC) regulations (DiVruno, F., 2023b). Our team has created (and are constantly curating) a satellite database that combines the orbital ephemerides of all known actively transmitting satellites, with their RF transmitter parameters. Additionally, in concurrent development, is a Satellite Orbit Pre-Prediction (SOPP) tool that interfaces with HCRO's observing scripts which control the ATA and can identify satellite-free observation windows (or windows with the least number of potential satellite pass RFI events). This is expected to contribute significantly to effective source-queuing that can minimise the interference to observations. A converse problem is where orbital, passive microwave radiometers – which are extensively used for Earth remote sensing and feeding into numerical weather prediction models – are interfered with by terrestrial emissions. A second tool being developed, mirrors the SOPP framework, and tracks the region of sensitivity of such a radiometer while it sweeps over Earth, allowing the determination of the specific commercial wireless transmitters, which might interfere with the observations.

It is the hope that SOPP, this tool; and the RFI Alerting system, in concert with co-operative active users of the spectrum – satellite-based and terrestrial respectively – could honour a passive user's request for primacy of spectral allocation in the spatio-temporal window, and thereby demonstrate a proof-of-concept architecture for true bi-directional spectrum sharing.

We provide a brief overview of the design and development of these tools and proceed to highlight the turnkey demonstrations of these systems, both in controlled experiments, as well as statistical monitoring of the 'wild' RF environment. The results are encouraging and demonstrate a particular feasible realisation of dynamic sharing between different kinds of stakeholders.