URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Spectrum Characterization and Sharing Activities at the Hat Creek Radio Observatory

David DeBoer*(1), Kevin Gifford(2), Arvind Aradhya(2), Andrew Clegg(3), Wael Farah(4), Cole Forrester(1), Mark Lofquist(1), Alexander W. Pollak(4), Mark Ruzindana(1), Andrew Siemion(1), Zeraki-Tobias Stover(1), Stefan Tschimben(2), Georgiana Weihe(2),
(1) University of California, Berkeley, CA USA; e-mail: ddeboer@berkeley.edu, crforrester@berkeley.edu, mruzinda@berkeley.edu, siemion@berkeley.edu, ztgstover@berkeley.edu
(2) University of Colorado, Boulder, CO USA; e-mail: kevin.gifford@colorado.edu, arvind.aradhya@colorado.edu, Mark.Lofquist@colorado.edu, Stefan.Tschimben@colorado.edu, Georgiana.Weihe@Colorado.EDU
(3) Google, 1600 Amphitheatre Parkway, Mountain View, CA USA; e-mail: aclegg@google.com
(4) SETI Institute, 189 Bernardo Ave, Mountain View, CA, USA; e-mail: wfarah@seti.org, apollak@seti.org

Current mechanisms of protecting and enabling radio astronomy observations rely primarily on locating observatories well away from sources of radio frequency interference[1] and leveraging frequency allocations to the extent possible. Such allocations however tend to encompass only a small amount of the required spectral real estate, although the frequency allocations are, at least theoretically, always available. Conceptually, a figure-of-merit would be

$$FOM_o = f_o \times L_o \times \mathbf{1} \tag{1}$$

where f_o, L_o and $\mathbf{1}$ represent respectively the limited and static frequency allocation, the observatory location and the full amount of time these are available (i.e. theoretically all the time, notwithstanding satellite overpasses and out-of-band and rogue emissions). A more dynamic model is being explored whereby spectral occupancy could be controlled based on scheduled observations in conjunction with active users. It is very early in this development, but conceptually this "National Radio Dynamic Zone" (NRDZ) approach would have a conceptual figure-of-merit of

$$FOM_t = F(t) \times L(t) \times \tau(t) \tag{2}$$

where $F(t), L(t)$ and $\tau(t)$ are respectively the spectral occupancy band for viable observing, the locations with varying protection and the (less-than-full-time) times when the occupancy allows viable observing in that band. All are functions of time based on some market model of scheduling. Note that a change in the model (the current one of which has been in use for many decades) does imply a degree of risk, especially in this era of burgeoning spectrum use. However, it is likely that in the long run, viable scientific passive use will require some degree of dynamic protection scheduling.

With funding from the National Science Foundation, a partnership between the University of Colorado Boulder, the University of California Berkeley, the SETI Institute and Google is conducting measurements and investigating spectrum sharing techniques to be deployed at the Hat Creek Radio Observatory (HCRO). The goal is to help determine and quantify future spectrum sharing approaches as outlined above, which will become increasingly necessary as spectrum usage continues to increase and policy seeks to accommodate use of this important resource. These activities will lead to deployment of a prototype National Radio Dynamic Zone (NRDZ) at HCRO including a test Spectrum Access System (SAS) with Google.

The work takes place primarily under two NSF SWIFT awards, one of which seeks to quantify the problem by taking measurements at the observatory and explore more general concepts of specturm sharing (Passive and Active Spectrum Sharing - PASS), and one that focusses more on observing in the midst of satellite interference (Radio Astronomy Dynamic Satellite Interference and Spectrum Sharing - RADYSIS). The program will provide open source RF datasets and tools for analysis to promote community-wide collaboration, as well as look at a standardized spectrum sharing format with tools optimized for RFI investigation, characterization and sharing purposes. RADYSIS will prototype and deploy dynamic sharing mechanisms and quantitatively evaluate applicability to bi-lateral spectrum sharing. RADYSIS will include earth-orbiting, passive-sensing satellites into a generalized spectrum sharing architecture.

[1] Note however that satellites are everywhere and tend to be the "great equalizers" for locations.