Flexible, deployable radio instruments using RAPID hardware and Digital RF software

Ryan Volz*, Frank D. Lind, John Swoboda, and Philip J. Erickson
MIT Haystack Observatory, Westford, MA, USA

Radio instruments have long been specialized, limited to narrow bandwidths and locations, due to hardware, processing, and logistical constraints. Fortunately, the modern confluence of technologies has made flexible, deployable radio instruments not only possible but affordable. Current software-defined radios can sample large bandwidths over wide frequency ranges, solid-state disks can handle the accompanying large rate and amount of data, general purpose computing can process the data for any desired result, and solar and battery power can allow the entire package to be deployed anywhere. The goal of MIT Haystack Observatory's RAPID (Radio Array of Portable Interferometric Detectors) project has been to fuse these hardware technologies into a cohesive platform for use in radio sensor systems with wide-ranging applications. Each RAPID unit consists of a broadband antenna and solar panels mounted on a base containing a data acquisition unit, an energy control unit, and batteries. Without remote access and limited by local storage, units can be deployed on a campaign basis; with an ethernet, wireless, or satellite connection for data transfer, semi-permanent deployment is possible. On the software side, the Digital RF project provides a standard for time-tagged radio data and metadata that can form the base layer for a flexible processing pipeline. The standard encompasses the HDF5 data format for self-documenting archival storage and an indexing scheme to enable constant-time sample lookup. Accompanying Python, C, and MATLAB software packages handle reading and writing and provide optional integration with GNU Radio flowgraphs and common software-defined radios. Together or individually, RAPID and Digital RF can be used to build radio sensors for a variety of applications: interferometric arrays for radio astronomy and passive radar, satellite beacon receivers for TEC mapping or ionospheric tomography, HF receivers for ionospheric sounding or networks of meteor radars, and many more. This talk will describe the RAPID hardware and Digital RF software, outline concepts for some of the aforementioned applications enabled by these technologies, and emphasize how future deployments can employ crowd sourcing and public participation to increase community engagement.