Voltage Level Data Management in Software Radar Systems

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We will discuss voltage level data management in the context of networked coherent software radio technology for remote sensing of the ionosphere. Using networks of advanced software radio systems it is possible to make observations of the ionosphere with both wide spatial coverage and simultaneous high resolution in space and time. Such observations can be made using a variety of techniques such as active and passive multi-static radar imaging, satellite beacon observations of TEC and scintillation, spectral monitoring, and signal time difference of arrival. To fully exploit the potential of software radio for networks for space science applications it is necessary to manage and manipulate large quantities of data at the voltage level.

Instruments which focus on the direct storage and manipulation of voltage level data have seen growing use in the community. This is driven by the availability of rapidly increasing computing power and data storage capacities combined with the flexibility offered by retaining the voltages representing an RF signal. Some production quality radar systems have taken this approach for many years while others have applied it for specific applications. For example with the Millstone Hill IS Radar we have been archiving voltage level data since 2001 and taking data for specific experiments with our earlier Vampire system since 1998. Our recent experience with the ISIS Array has made clear a number of challenges which need to be addressed to make our Software Radar voltage management capability robust enough for use in other application areas. There have also been discussions in the wider community about establishing a standard for voltage level data to enable more interoperability in signal processing and analysis software.

Manipulation of voltage level data is a key technique underlying our Software Radar systems. This is not so simple as just recording samples from an A/D converter in a convenient format. While such an approach might be sufficient for focused applications it falls short in systems which require precise configuration tracking or where the complexity of the data is high. Significant meta-data is usually necessary to understand the context in which RF signals are digitized and their associated geophysical meaning. This includes both the nature of the system which takes the data, details of synchronization, the net effect of prior analog and digital processing stages, and the particular stages and revisions of software which have been applied to the data. Hardware and software bugs can and do introduce problems in voltage level data streams which can often be corrected if sufficient contextual information is available.

A widely useful format for voltage level data management will address the needs of both pulsed and CW systems. It must also be applicable to modern systems such as AMISR where individual pulses may have dynamically varying meta-data such as the underlying beam code and related radar pointing direction. Additionally a robust standard for voltage level data must be built on a standard and high quality data format. We see HDF5 as this format due to a number of factors including the quality of the protocol, its widespread use, support for many platforms and languages, and good documentation. HDF5 has key technical features which give it an edge over other possible formats. Examples of these features include robust namespace support, variable size data chunks, high speed parallel I/O, a new packet table API for streaming data, and the ability to manipulate extremely large file sizes.

We will discuss the area of voltage level data management in light of our experience with the Millstone Hill IS radar system and the ISIS Array. We will describe a general voltage level data protocol and the meta-data content that is necessary for understanding the meaning of the voltages stored in this protocol. We will also discuss the organization and management of the data for transport, long term persistence, and namespace control.