Scalable, Reconfigurable FX Correlator for Radio Astronomy

Signal Flow

**Antennas**
The signals from multiple high bandwidth dishes are amplified and routed directly to digitizers.

**IBOBs**
Internet Break-out Boards
- 2Gs/s 8bit digitizers
- 200Mhz band extracted digitally
- 2048 channel FFT
- Reformat for Ethernet network

**10Gbps Ethernet Switches**
- Commercial, off-the-shelf switches
- CX-4 connectors
- 10G base-T coming soon

**BEE2s**
Berkeley Emulation Engines
- Perform correlations of all baselines
- Integrate samples
- Results over standard Ethernet

Interferometry
In order to improve sensitivity, telescopes require a larger collection area. Instead of using a single, large dish which is expensive to construct and complicated to maneuver, modern radio telescopes use interferometric arrays of smaller dishes. This has the added advantage of being able to view a larger area of the sky simultaneously. Arrays are cheaper and simpler to construct and more flexible than single large antennas.

Correlation Problem
Interferometric arrays require the antennas’ signals be phased together to form a coherent picture of the sky. This process is called correlation and involves multiplying each antenna’s signal with every other antenna’s. The complexity of this calculation scales with the number of antennas squared. Furthermore, it is a difficult signal routing problem since every antenna must be able to exchange data with every other antenna.

Solution
Traditionally, the interconnect has been complicated, using custom ASICs. This project aims to use reconfigurable hardware and commercial, off the shelf network switches to perform the same function. Furthermore, we aim to simplify and reduce typical development time of a correlator from 5 to 10 years to one year.

Software and Firmware

The firmware programming language makes use of CASPER’s open-source DSP library built on MATLAB Simulink. It is a graphical language that compiles logic operations on data streams into FPGA firmware. UDP output packets are received and written to disk in MIRIAD UVIO file format.