2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

SKA Aperture Array Digital Beamforming Technique

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The Square Kilometre Array (SKA) [1] telescope will be built in two phases: initially the SKA1 will include a large low frequency phased array operating from 50MHz to 350MHz (SKA1-Low) and the Full SKA will have a larger low frequency array and is anticipated to deploy a mid-frequency phased array, AA-mid, operating up to ~1.5GHz. The SKA1-Low array will have 131,072 antennas arranged as 512 stations of 256 antennas with a flexibly allocated bandwidth of 300MHz; this is anticipated to be extended to >1million antennas with a greater capability in numbers of beams and total usable bandwidth in the Full SKA. The AA-mid is even more ambitious with a possible "all-digital" implementation of up to 8 million antennas likely to be arranged in 1024 stations. The total processing required for AA-mid will be very high with ~1GHz bandwidth and hundreds of independent beams.

To implement this scale of beamforming at as low cost and low power as possible is challenging. The implementation planned for SKA1-Low and projected through to the Full SKA is to use mainstream IT components wherever possible. This benefits from the developments in the IT industry, which are continuing to reduce power consumption, increase levels of integration and capable of the configuration flexibility required of a very advanced radio telescope.

The beamforming approach is based around a very high speed Ethernet network which is able to link all the processing subsystems in a very flexible fashion, provide all the monitoring and control links and carry the essential calibration information to the high performance computing system which determines the corrections needed in real time.

The signal processing itself is based around the latest generations of FPGAs, programmable processing devices rather than custom devices. This enables modification of the functionality to include alternative observation strategies, updated calibration schemes etc.

The prototypes for SKA1-Low are being implemented and tested. The results are positive with the expectation of a hardware refresh being implemented in time for deployment in 2021.

1. The Square Kilometre Array, www.skatelescope.org