Data transport for the SKA

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The Square Kilometre Array (SKA) will be the world's largest and most sensitive radio telescope. It will address fundamental unanswered questions about our Universe including how the first stars and galaxies formed after the big bang, how dark energy is accelerating the expansion of the Universe, the role of magnetism in the cosmos, the nature of gravity, and the search for life beyond Earth. In this paper we discuss the work of the Signal and Data Transport (SaDT) Consortium in producing a design that addresses both the data transport and timing distribution challenges posed by this transformational instrument.

The astronomical data network is itself split into 3 sub-systems which have very different requirements:

a. The Digital Data Backhaul (DDBH) network transports signals from the receptors to the Central Signal Processor (CSP). The key issues here are that hundreds of end-points for the network must be accommodated and that the telescope configuration calls for very different distribution distances, requiring different technical solutions.

b. The CSP network transports data products from the CSP to the Science Data Processor (SDP). The data rate out of the CSP is comparable to that going into it and now the data must be transported ~900km out of the desert to a high performance computer.

c. The SDP network distributes data from the SDP to the regional SKA Data Centres. The data rate out of SDP is much reduced, but still substantial. However, there is now a requirement that this data now be distributed over inter-continental distances for use by astronomers.

In addition, this data transport network must be implemented in both South Africa and Australia and must address the different data rates, different number of receptors and different data products from the components of the overall SKA located at these two sites.

We also discuss the SKA's Synchronisation and Timing (SAT) network, which must address a number of different requirements. For imaging work, the SKA will work as an interferometer and so it is essential that phase coherence is maintained across the whole telescope. This implies that a pico-second accuracy frequency and clock signal must be distributed from a central clock to all the receptors. In addition, some of the experiments, in particular pulsar timing for gravity wave detection and tests of General Relativity, have stringent long term timing specifications. These equate to a level of 10ns accuracy over a period of 10 years.

We outline the preliminary design for the sub-systems that address these requirements which comprise:

- The SKA Clock Ensemble, which consists of three Active hydrogen masers. A master and back-up timescale are formed from the frequency references of two of these masers. The third allows for a "three cornered hat" approach to be adopted where the short and medium term stability of each maser to be determined.
- The System for the Time and Frequency Reference signals (STFR). This is an active frequency compensation scheme that differences a single pass 2GHz signal, locked to the SKA Clock ensemble, with a double pass 1 GHz signal locked to a "flywheel" crystal oscillator at the antenna. This produces a 1 GHz reference signal at each antenna that has had the phase changes introduced by distortions in the optical fibre removed.