SKA CSP Controls: Technological Challenges

C.Baffa, E.Giani, S.Vrcic, M. Vela Nuñez

SKA Overview

The Square Kilometer Array (SKA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometer of collecting area. For SKA Phase 1, Australia will host the low-frequency instrument with more than 500 stations, each containing around 250 individual antennas, whilst South Africa will house an array of close to 200 dishes. The scale of the SKA represents a huge leap forward in both engineering and research & development towards building and delivering a unique instrument, with the detailed design and preparation now well under way. As one of the largest scientific endeavours in history, the SKA will bring together close to 100 organizations from 20 countries. Every aspect of the design and development of such a large and complex instrument requires state-of-the-art technology and innovative approach. This poster addresses some aspects of the SKA monitor and control system, and in particular describes the development and test results of the CSP Local Monitoring and Control prototype.

At the SKA workshop held in April 2015, the SKA monitor and control community has chosen TANGO Control System as a framework, for the implementation of the SKA monitor and control. This decision will have a large impact on Monitor and Control development of SKA. As work is on the way to incorporate TANGO Control System in SKA is in progress, we started to develop a prototype for the SKA Central Signal Processor to mitigate the associated risks. In particular we now have developed a uniform class schema proposal for the sub-Element systems of the SKA-CSP.

2 – SKA Central Signal Processor (CSP) Structure

The CSS_Mid comprises four design sub-elements (see illustration below):
1. Correlator and Beamformer (CSP_Mid.CBF)
2. Pulsar Search (CSP_Mid.PSS)
3. Pulsar Timing (CSP_Mid.PST)
4. Local Monitor and Control (CSP_Mid.LMC)

CSP_Mid.CBF performs two basic functions, correlation and beam-forming. It calculates full-polarization cross-correlation spectra with ~64,000 channels for every pair of antennas. The maximum data rate to the SDP arises when all 197 antennas are used together In this case is ~2.85 TBps.

The Pulse Search Engine accepts up to 1500 different beams. The engine searches each beam for pulsars and existing ephemeris.

For the "imaging mode" each pair of antennas in a sub-array is cross-correlated to produce full-polarization visibility spectra across the required bandwidth and number of channels. The visibility is packaged and transmitted to the Science Data Processor (SDP) which produces high-quality continuum and/or spectral-line images.

In the "non-imaging mode" a sub-array can form a number of tied-array beams and process data for each beam independently.

The telescope facilities for SKA1 have been defined as:
- SKA1_Low, a low-frequency aperture array to be built in Australia, and
- SKA1_Mid, a mid-frequency array of parabolic reflectors (dishes) to be built in South Africa.

In Illustration on the left there is a schematic representation of the SKA1_Mid Telescope. From the Monitor and control prospective the two facilities will be handled in a similar manner, with differences only in minor details. In the following we will refer to SKA1_Mid Data coming from Antennas are fed to the Central Signal Processor (CSP). CSP is in charge to collect, correlate, filter and analyze the observational data, according to the astronomical prescriptions for the current observation(s) coming from the Telescope Manager (TM). Processed data is then forwarded to the Science Data Processor for the final reduction and post-processing in order to obtain scientifically meaningful results.

3- Local Monitor and Control (LMC) Implementation

The main role of CSP.LMC is to provide a gateway to Telescope Manager, to make provision for TM to monitor and control CSP as a single entity, without being aware of the details of CSP implementation.

CSP.LMC consists of software running on COTS computers. A meeting of representatives of all LMC actors choose in 2015 to have a single software for the global Monitor and Control infrastructure and, as far as it will be convenient, also for the lower levels. In the same meeting the Open Source TANGO Controls framework was indicated as the most promising candidate. For the development of CSP.LMC software TANGO Controls is now used as infrastructure up to the possible lower level.

Phase 1 will make SKA 10 times larger!

4- Future Development

The development of a common approach for the design of SKA-CSP has been, and will be in the future, long and difficult, due to the complexity and size of SKA and the required reliability of operations. The harmonization process of SKA LMC development is still in progress. We believe that this effort will have a major positive impact on the global project.

Under the perspective to participate in TANGO community, the whole SKA project could contribute to expand the native TANGO features, in a win-win situation.