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The new architecture design of the Science Alert Generation pipeline of the Cherenkov Telescope Array Observatory

Cherenkov Telescope Array Observatory (CTAO) represents the next-generation facility for gamma-ray astronomy. It will be the largest gamma-ray observatory ever built, with sites in both the Northern and Southern Hemispheres. CTAO will provide extensive energy coverage from 20 GeV to 300 TeV, allowing us to advance our understanding of the universe significantly.

CTAO will issue scientific alerts on transient and variable phenomena to maximise its scientific impact; this requires a highly reliable and automated system for detecting and distributing candidate science alerts.

The Science Alert Generation (SAG) pipeline, a key system of the Array Control and Data Acquisition (ACADA) system, fulfils this role by processing data from telescope arrays in real-time through its data reconstruction (RECO), data quality monitoring (DQ), science monitoring (SCI) pipelines; the Supervisor (SUP) handles the dynamic operations and lifecycle, interfacing SAG with the rest of the ACADA subsystems.

The SAG pipeline will issue candidate science alerts to the Transients Handler system of ACADA within a 20s latency from the data being available, and will analyse the data on multiple time scales (from seconds to hours). Dedicated, highly optimised software and hardware architectures must be designed and tested to satisfy these stringent requirements and manage trigger rates of tens of kHz from both arrays.

In this work, we present the latest updates on the architecture of the SAG system.

The new architecture is designed to minimise the time needed to initiate analysis during multi-telescope observations, where different telescopes may begin tracking the target at varying times. For prompt analysis of an incoming science alert, it is essential to select and analyse only the data from the first telescopes in the sub-array that start tracking, while discarding the data from the slewing phase. Additionally, observation quality can be affected by atmospheric conditions, potential instrument or data flow degradation. The knowledge or estimation of such information is used by SAG to select good-quality events. To discriminate which data must be processed, the SUP retrieves information continuously about telescope status and environmental conditions from the Monitoring system, loading them into an appropriate database. Moreover, SUP features new centralised operations with the DataObserverProcessor, which involves loading event lists for DQ and SCI analyses, combining data quality results, with data flow status, environmental conditions and telescope information to identify good analysis time windows. The ability to discern which events to process is a mission-critical factor that directly impacts the overall quality of the results and the reliability of each science alert issuance.

Based on the experience gained over the years and the commitment to achieving optimal results in real-time processing, the SAG architecture is evolving, enhancing the interconnectivity of pipelines and communication within the ACADA system.

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