Computational Infrastructure for the Monitoring System of the Cherenkov Telescope Array

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cherenkov telescope array

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ABSTRACT

We hereby present the computational requirements of the infrastructure needed by the Monitoring System (MON) of the Cherenkov Telescope Array (CTA), which will be composed of hundreds of telescopes working together. Along with the scientific data, a large volume of housekeeping and auxiliary data coming from weather stations, instrumental sensors, logging files, etc., will be collected as well. MON acquires and stores monitoring points and logging information from the array elements, at each of the CTA sites. MON is designed and built in order to deal with big data time series and exploits some of the currently most advanced technologies in the field of the Internet of Things (IoT).

MONITORING DATA

The CTA Observatory (CTAO) will be the first ground-based gamma-ray proposal-driven observatory open to the worldwide astronomical and particle physics communities. It will be composed of more than one hundred telescopes deployed at the two hemispheres of Earth. We expect a data throughput of ~1.26 Gbps, including logging.

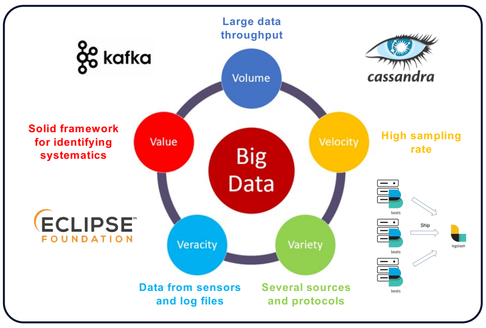

Fig. 1: The monitoring data as a Big Data and IoT framework.

MON ARCHITECTURE

The Monitoring System is responsible for *monitoring* and *logging* the overall array system through the acquisition of monitoring and logging points from the elements of the array, and for making these data immediately available for the operator interface and for quick-look quality checks, as well as to store them for later detailed inspection. Quality requirements such as reliability, performance, scalability, and availability are of fundamental importance. MON exploits some of the most advanced architecture in the field of IoT and Big Data (Fig. 1).

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THE QUEUE AND STORAGE COMPONENTS

To satisfy requirements on fault tolerance, high throughput, and scalability, the collected values are written to a dedicated *Kafka topic*. The topic is spread across three *partitions* and the architecture allows writing in three different queue systems simultaneously (*Kafka brokers*). We plan to use three brokers, running on different nodes. Each partition is replicated automatically with a mechanism Leader-Follower (Fig. 2). If one or two brokers fail a new leader is elected among the available and synchronized followers and the Monitoring System can continue collecting and archiving monitoring values. As for the data Storage, read and write operations are performed using a *primary key* on a *Cassandra table*. The partition key defines a unique set of rows that are managed within a node of the cluster. Replicas are managed by means of a peer-to-peer architecture.

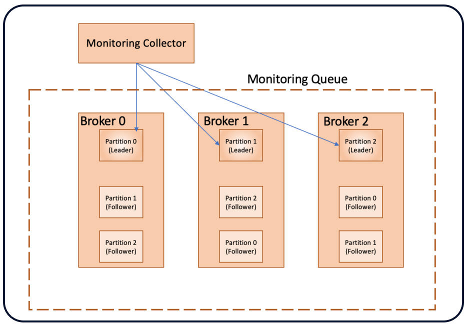

Fig. 2: Representation of the Broker Architecture for MON Queue.

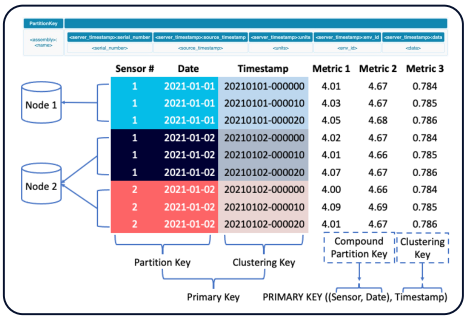

Fig. 3: The Monitoring Data Model and the Storage Mechanism.

CTAO-S CONFIGURATION

The baseline telescope configuration at the Southern Hemisphere in the Atacama Desert (Chile) foresees the deployment of 99 telescopes (four LST, twenty-five MST, and seventy SST) for which we expect to collect about 616 monitoring points per single telescope. To address such a data throughput, we require at least 14 nodes and 224 cores (assuming 16 CPU cores per node). Also, dedicated machines are required for the Alarm System (AAS), which will be based on a quite similar architecture with the addition of the Integrated Alarm System (IAS). In this case, we estimate a need for 5 nodes and 80 cores. Node distribution is reported in Table 1.

	Queue	Storage	Log Aggregator	IAS	Schema registry
Monitoring	6	6	1	-	1
Alarm	3	1	-	1	

Table 1: Node distribution dedicated to MON and AAS subcomponents.

References:

1) A. Costa, K. Munari, F. Incardona, et al., «The Monitoring, Logging, and Alarm System for the Cherenkov Telescope Array», 2021; 2) The CTA Consortium, «Science with the Cherenkov Telescope Array», 2019; 3) F. Incardona, A. Costa, K. Munari et al., «Optimization of the storage database for the Monitoring System of the Cherenkov Telescope Array», 2021; 4) A. Costa, et al., «Big Data Architectures for Logging and Monitoring Large Scale Telescope Arrays», 2020; 5) A. Caproni, and E. Schmid, «The Integrated Alarm System for the ALMA observatory», 2017.