Computational Infrastructure for the Monitoring System of the Cherenkov Telescope Array

INAF USCVIII - Calcolo Critico

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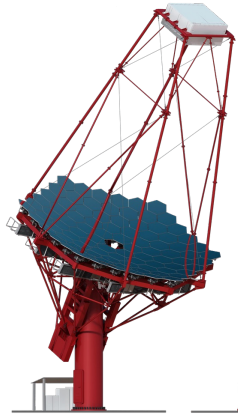
Cherenkov Telescope Array

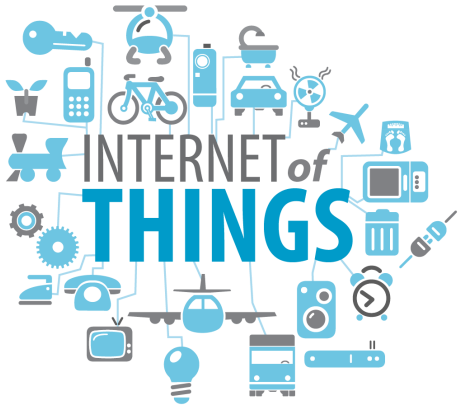
More than **100** telescopes deployed at the **2** hemispheres of Earth



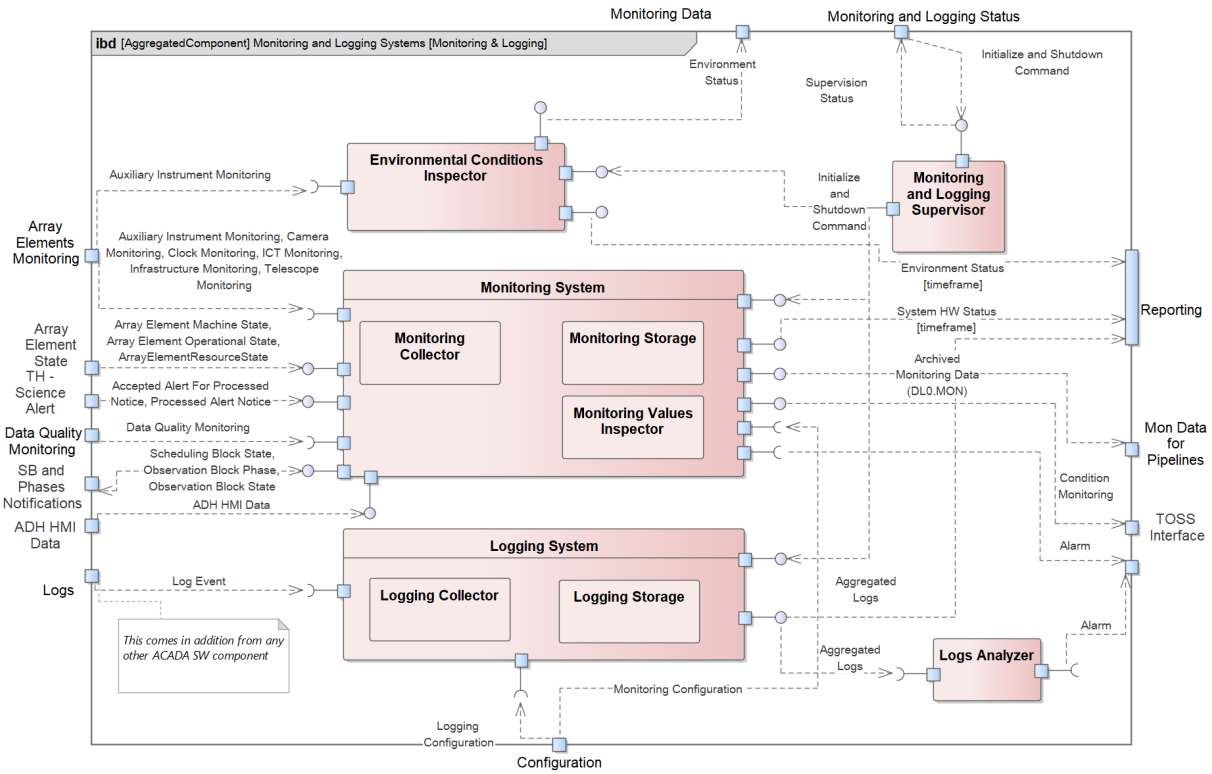
- **Large-Sized Telescope** (LST): ~23 m; ~50 tonnes; ~20 sec for repositioning
- **Medium-Sized Telescope** (MST): ~12 m; “workhorse” of CTA with sensitivity in its core energy range
- **Small-Sized Telescope** (SST): ~4 m; sensitive to the highest energies

CTA N + CTA S = **CTA Observatory** (CTAO): the first ground-based gamma-ray *proposal-driven* observatory open to the *worldwide* astronomical and particle physics communities

Monitoring System (MON)



- Large throughput
- Scalability
- Partition tolerance
- Availability



Monitoring Data as Big Data

Expected **~200.000 monitoring points** sampled at a maximum rate of **5 Hz** for a maximum throughput of **~1.26 Gbps**, including logging

–> Volume and Velocity

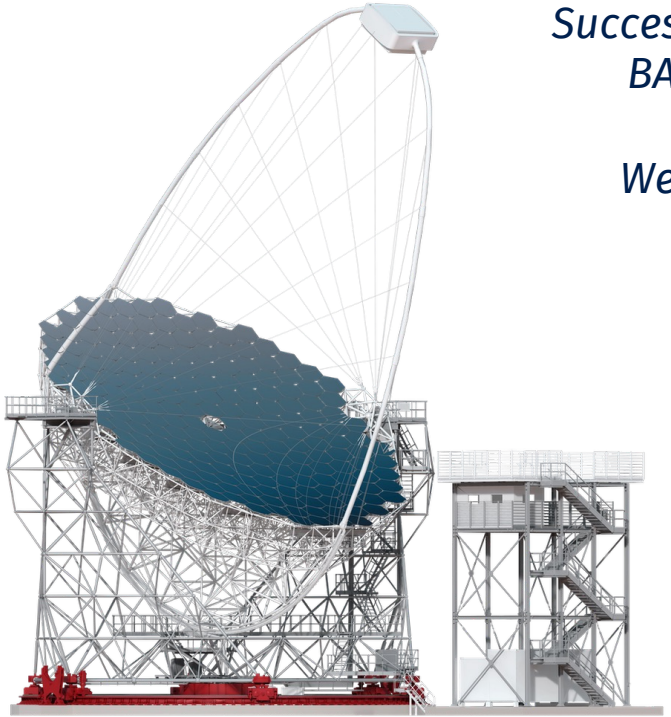
Different data sources collected via **different protocols**

–> Variety

Provide a **solid framework** for identifying **measurement systematics** and **maintenance issues**

–> Value and Veracity

Goal Achieved: LST Integration



Successfully monitored BACI Properties and Weather Station

```
[
  "AMC/Unit_AMC_Master",
  "AMC/Unit_AMC_PSF",
  "AMC",
  "Drive",
  "Camera/Unit_UCTS",
  "Camera/Unit_TIB",
  "Camera",
  "Camera/Unit_ECC",
  "Camera/Unit_CLUS",
  "Camera/Unit_CBOX",
  "Auxiliary/Unit_Encoders",
  "Auxiliary/Unit_Power",
  "Auxiliary",
  "Auxiliary/Unit_RemotePowerCtrl",
  "Auxiliary/Unit_IM",
  "Auxiliary/Unit_DM",
  "Auxiliary/Unit_LoadPins",
  "Auxiliary/Unit_Torque",
  "Auxiliary/Unit_CDM",
  "DataBroker/Unit_WAGO_UC",
  "DataBroker/Unit_WS",
  "DataBroker",
  "LSTCamera",
  "LSTTelescopeManager",
  "LSTStructure"
]
```

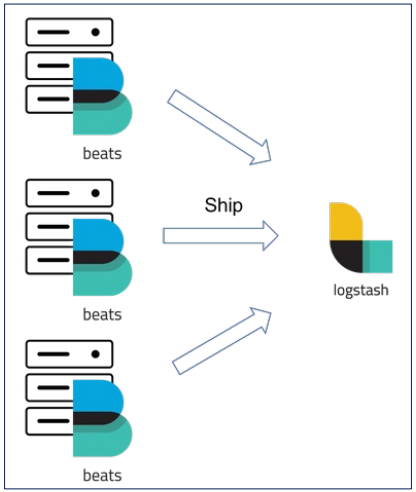
Technologies Adopted

Queue: Apache Kafka

Logging: Elastic Filebeats and Logstash

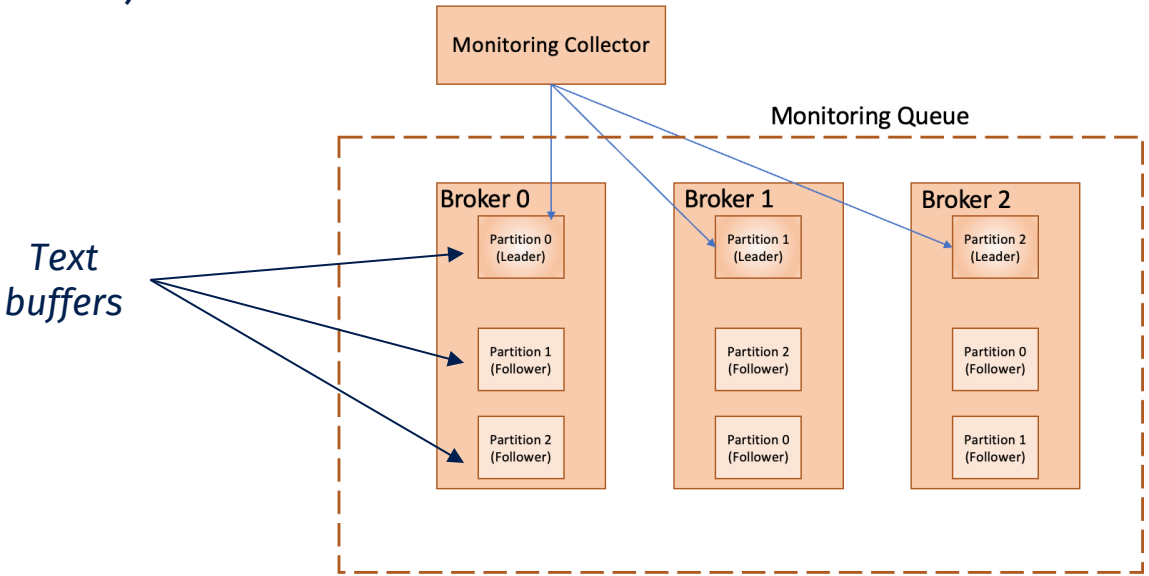
Data serialization: Apache Avro

Storage: Apache Cassandra



Queue Architecture

Collected values are written to a dedicated **Kafka topic** that is spread across *partitions* and *replicated* on different queue systems (**Kafka brokers**)



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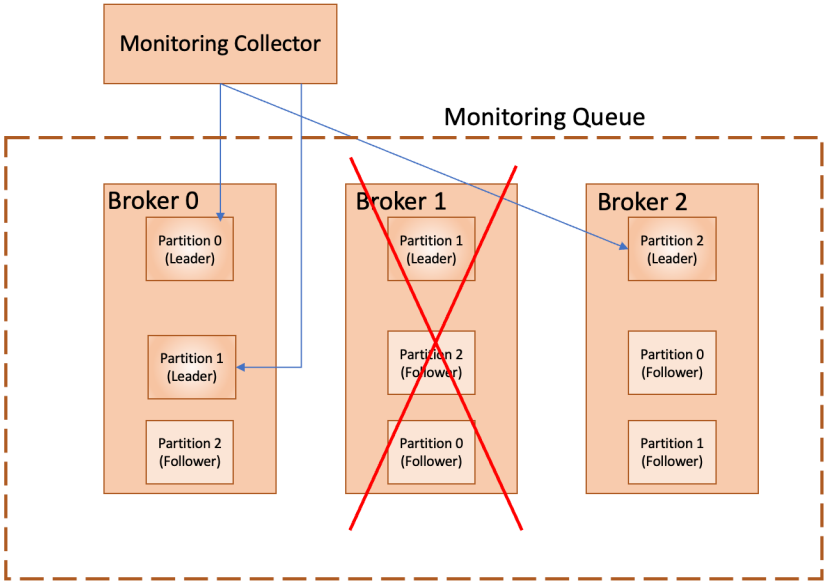

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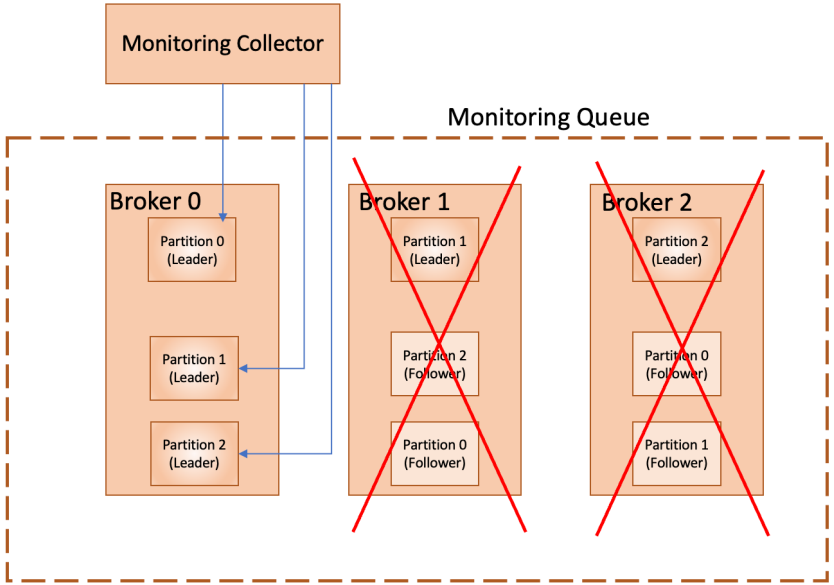
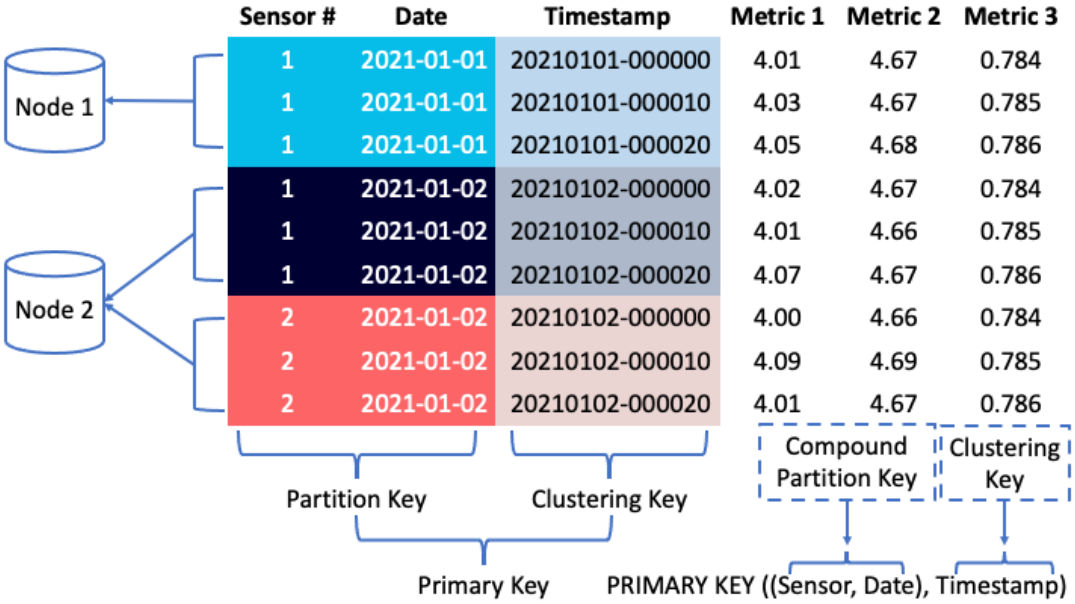


Storage Architecture

PartitionKey					
<assembly>:<name>	<server_timestamp>:serial_number	<server_timestamp>:source_timestamp	<server_timestamp>:units	<server_timestamp>:env_id	<server_timestamp>:data
	<serial_number>	<source_timestamp>	<units>	<env_id>	<data>



Read and write operations are performed using a primary key on a **Cassandra table**.

The **partition key** defines a unique set of rows that is managed within a node of the cluster.

Hardware Requirements

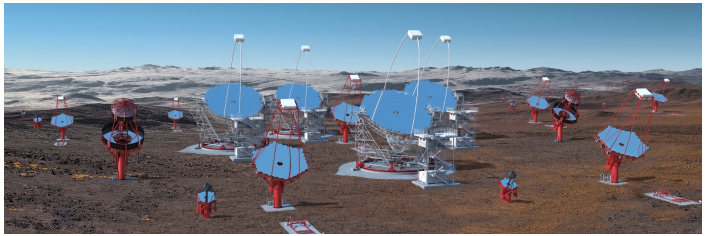
MONITORING CTAO-S Baseline Configuration

- LST: 4
- MST: 25
- SST: 70

99 telescopes

616 monitoring points per single telescope

Rendering credit: Gabriel Pérez Diaz, IAC / Marc-André Besel, CTAO



- Both Queue and Storage require large I/O throughput

Assuming 16 CPU cores per node:

- 6 nodes for the Queue
- 6 nodes for the Storage
- 1 node for the Schema Registry
- 1 node for the Logging Aggregator

14 nodes and 224 cores

Hardware Requirements

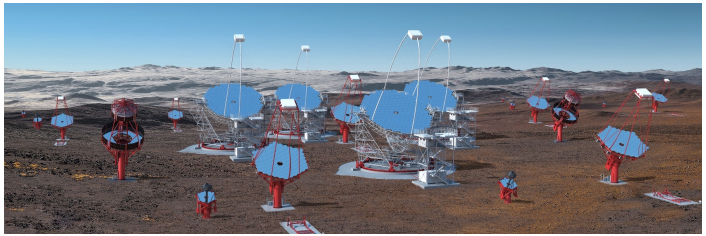
ALARM CTAO-S Baseline Configuration

- LST: 4
- MST: 25
- SST: 70

} 99 telescopes

220 monitoring points per single telescope

Rendering credit: Gabriel Pérez Diaz, IAC / Marc-André Besel, CTAO



- Both Queue and Storage require large I/O throughput

Assuming 16 CPU cores per node:

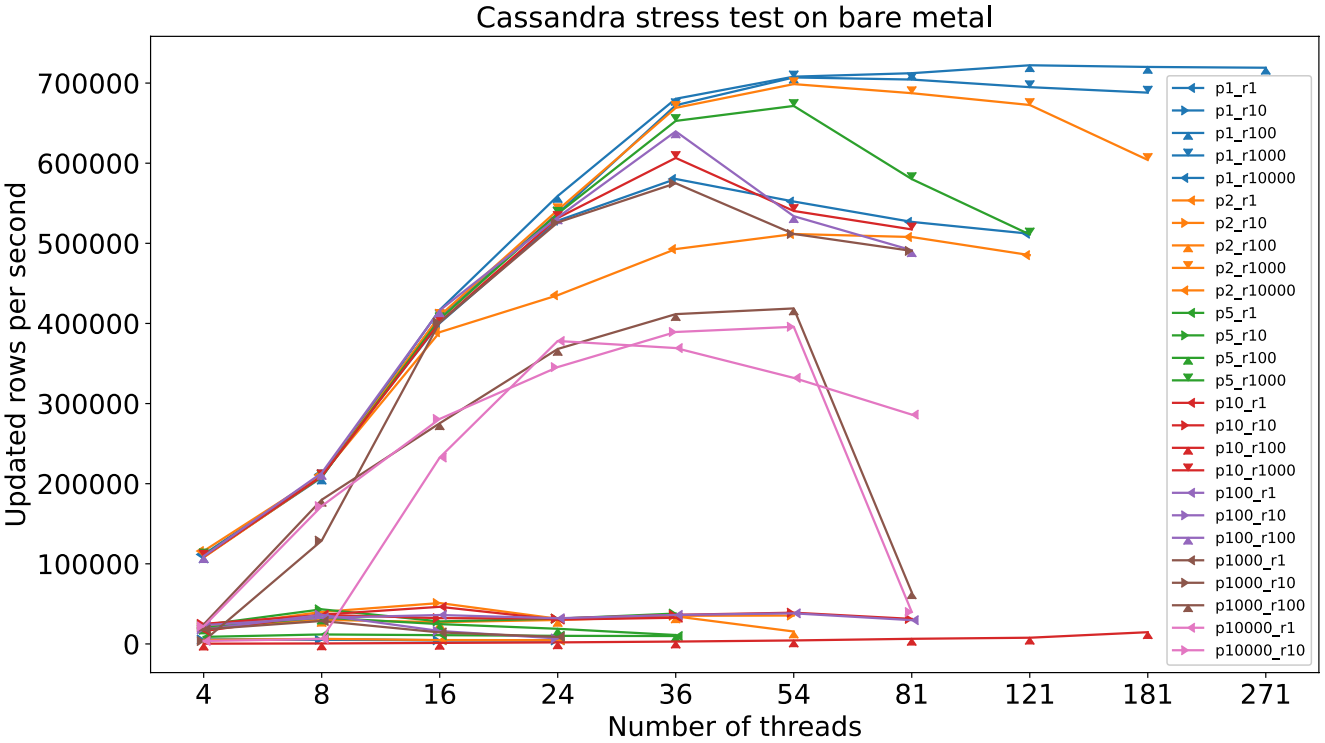
- 3 nodes for the Queue
- 1 node for the Storage
- 1 node for the Integrated Alarm System (IAS)

} 5 nodes and 80 cores

The End

Thanks for your attention

Storage Architecture



Hardware Requirements

MONITORING CTAO-N Baseline Configuration

- LST: 4
- MST: 15
- SST: 0

} 19 telescopes

181 monitoring points per single telescope

Rendering credit: Gabriel Pérez Diaz, IAC

- Both Queue and Storage require large I/O throughput

Assuming 16 CPU cores per node:

- 1 node for the Queue
- 1 node for the Storage
- 1 node for the Schema Registry
- 1 node for the Logging Aggregator

} 4 nodes and 64 cores

Hardware Requirements

ALARM CTAO-N Baseline Configuration

- LST: 4
- MST: 15
- SST: 0

} 19 telescopes

65 alarm points per single telescope

Rendering credit: Gabriel Pérez Diaz, IAC

- Both Queue and Storage require large I/O throughput

Assuming 16 CPU cores per node:

- 1 node for the Queue
- 1 node for the Storage
- 1 node for the Integrated Alarm System (IAS)

} 3 nodes and 48 cores