

# Implementation of ATLAS Distributed Computing monitoring dashboards using InfluxDB and Grafana

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**Abstract.** For the last 10 years, the ATLAS Distributed Computing project has based its monitoring infrastructure on a set of custom designed dashboards provided by CERN. This system functioned very well for LHC Runs 1 and 2, but its maintenance has progressively become more difficult and the conditions for Run 3, starting in 2021, will be even more demanding; hence a more standard code base and more automatic operations are needed. A new infrastructure has been provided by CERN, based on InfluxDB as the data store and Grafana as the display environment. ATLAS has adapted and further developed its monitoring tools to use this infrastructure for data and workflow management monitoring and accounting dashboards, expanding the range of previous possibilities with the aim to achieve a single, simpler, environment for all monitoring applications. This document describes these tools and the data flows for monitoring and accounting.

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## 1 Introduction

The ATLAS [1] Distributed Computing (ADC) uses two core-systems to run jobs on the grid and manage the data - the workflow management system PanDA [2] and the distributed data management system Rucio [3]. For the efficient use of these systems and the available resources it is important to have extensive and coherent monitoring available. During the LHC Run 1 and Run 2 the monitoring and accounting systems were based on custom frameworks developed by CERN IT and ADC and had been in use for 10 years. These systems served well during that time but they started to show their age in several areas; in particular, the

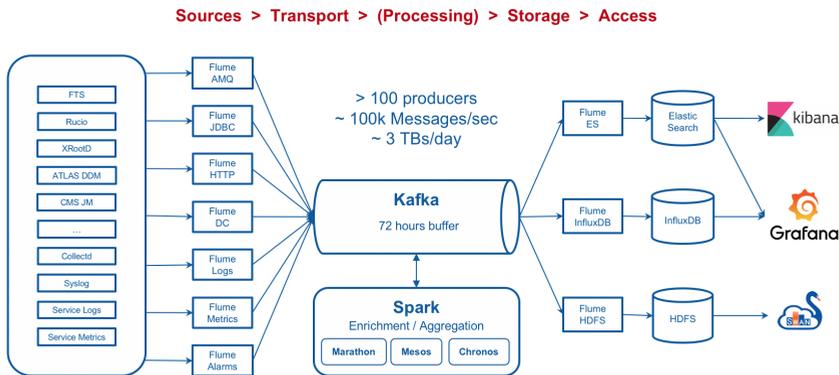
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data retrieval was slow because of the large amount of data stored in Oracle databases. The original developers had long left and with them a lot of the in-depth knowledge necessary to further optimise the system and the ability to quickly add new features to the monitoring. Therefore, an overhaul of the monitoring systems was necessary. In 2016 the CERN MonIT group started to build a new Unified Monitoring Infrastructure (UMA) based on open source technology [4]. The data collection, processing and display presented in this document are based on UMA.

## 2 The CERN MonIT Infrastructure

The CERN MonIT UMA, as shown in Figure 1, is based around Apache Kafka [5] and Spark [6] for data processing. Kafka is an open-source stream-processing platform and Spark is a distributed cluster-computing framework. Together they can be used to process data in real-time as it is streamed through the system. Various collectors are available, including some for standard protocols like Stomp, HTTP, Java Database Connectivity (JDBC), as well as custom collectors if necessary. The collectors ingest the data into the processing pipeline. The data are buffered in Kafka up to 72 hours and then Spark is used to enrich and aggregate the data. The processed data in turn are also written back to Kafka. From there, Flume collects and writes the data to the different available backends including InfluxDB [7], Elasticsearch [8] and the Hadoop File System (HDFS) [9]. Grafana [10] is the main tool used to create visualisation based on these data, but there is also the possibility to use Kibana [11] or the CERN Service for Web based Analysis (SWAN) [12]. Three types of dashboards are described in the next sections of this document, all with different data sources, processing and backends.



**Figure 1.** The CERN MonIT Unified Monitoring Architecture [13]

### 2.1 Data Sources for the ADC Dashboards

The first dashboard is the Distributed Data Management (DDM) transfer dashboard. For this the data are coming directly from Rucio or the Pilot [14]. For each successful or failed FTS file transfer Rucio sends out an event. The event includes information like filename, size, source / destination site, etc. It also includes an error description in case of failure. The events are sent to a central ActiveMQ (AMQ) [15] message broker. Furthermore, the PanDA Pilot creates traces for every file that has been used as input or output for a grid job. For simplicity for the sender, the traces are first sent to a central HTTP server which then in turn

forwards them to AMQ. On the monitoring side, a Flume [16] AMQ collector is used to ingest the data into Kafka.

The second dashboard is the DDM accounting dashboard. Here, the data are again coming from Rucio. A daily accounting job runs on Oracle to create a detailed report of the types of data currently registered in the Rucio catalogue, split by endpoint and metadata including project, datatype, physics stream, etc. Furthermore, the volume as reported by the storage is collected. All together this is then sent again to AMQ.

The last dashboard is the job accounting dashboard. In this case the data are collected directly from the different job tables in the PanDA database with the JDBC collector. This collector runs every 10 minutes and fetches a snapshot of the currently submitted, pending, running, finalising and completed jobs and sends them directly to Kafka. Depending on whether the database table represents a transient job state like submitted, pending, running and finalising or final states, either a full snapshot of the database table is collected or just the most recently finished jobs.

In addition, data are also collected from the ATLAS Grid Information System (AGIS) that is used to enrich the data for all three dashboards. The data are collected regularly from the AGIS Rest API in JSON and fed into Kafka.

## 2.2 Processing

All the processing is done using Spark Streaming on the data in Kafka. For the DDM transfer dashboard the events and traces are first unified to a common data format. After that each transfer is enriched with topology information from AGIS to get the source and destination site, cloud, country and tier. In the next step the data are aggregated in one minute bins by source and destination, activity, FTS host and protocol. Then, the number of successful and failed files and bytes is computed.

For the DDM accounting all aggregations are already done before the data are sent to UMA. The Spark job only enriches the accounting data with topology information similar to the DDM transfer data.

For job accounting the Spark job computes several items of additional information for each job. This includes classifications into ADC activities, calculation of wall times, mapping of error codes to actual error messages and again enrichment with topology and PanDA queue information from AGIS. In the next step the jobs are then aggregated in ten minute bins based on different fields such as the computing site, topology, job type, status, activity, error category, etc. This is again written back to Kafka. Due to delays in the reporting for completed jobs, the corresponding bins are continually updated for up to two hours.

## 2.3 Backends

For the ATLAS dashboard all three of the previously introduced data backends are used, depending on the type of data and the use case. The DDM transfer dashboard uses both InfluxDB and Elasticsearch. InfluxDB is used for the aggregated time-series data. The original one minute granularity is kept for 30 days. Then, the InfluxDB downsampling is used to create larger bins from one hour up to 30 days which in turn is kept for up to five years. In addition to the aggregated data, the raw Rucio events and traces enriched with topology are written to Elasticsearch. These are kept for 30 days.

The DDM accounting data are not spread out over the course of a day, but rather for each reported day a set of up to three million entries is sent to UMA. This was shown to be problematic for InfluxDB and therefore Elasticsearch has been selected as the backend. The data are kept there without any further aggregation over time for up to five years.

The job accounting dashboard again uses InfluxDB with different databases for the different job states. Similar to the DDM dashboard, the data are automatically aggregated.

Complementary to InfluxDB and Elasticsearch, all data are also written to HDFS for long term storage. The data are stored in JSON format and kept forever. It can be used for batch and data-intensive analytics workflow.

### **3 Dashboards**

This section describes the dashboards that are built using the processed data described earlier. All dashboards are available in a central Grafana instance provided by CERN MonIT. Grafana provides the functionality to organise dashboards in separate folders, where a folder can have different permissions for viewing and editing. For ADC there are three different folders: production, development and playground. The production folder contains the official and stable dashboards that should be used by the experts and shifters in daily operations or by management for reporting needs. These dashboards can be viewed by everyone but can only be changed by the admins of the ATLAS Grafana organisation. The development folder contains a copy of the production dashboards as well as completely new dashboards. The dashboards are used to develop and test new features. After period of evaluation they will be moved to production. Development dashboards can be changed by anyone with an editor role. Finally, the playground folder is open to anyone in the ATLAS organisation. All the same data sources used by production and development dashboards are available and users can either modify existing dashboards to fit their specific needs or create completely new ones.

#### **3.1 Transfer Dashboard**

The DDM transfer dashboard is mainly used by shifters and experts to monitor the worldwide transfer on the grid and find potential problems. Figure 2 shows an overview of this dashboard. The main entry point to the dashboard is the matrix showing the transfer efficiency between all source and destination clouds. Several grouping and selection variables are available to find problems. Besides the entry matrix, a lot of further visualisations are available including histograms with the transferred volume, number of successful and failed files and transfer throughput. All of them are also available for staging requests and deletion. Besides those visualisations, tables with detailed information for each transfer are also available, including direct links to the specific Rucio and FTS monitoring sites with information about the transferred file. Furthermore, the error messages for failed transfers are cleaned from specific information like hostname or IP so that they can be grouped to find common problems.

#### **3.2 Site Accounting**

The DDM site accounting dashboards are mainly interesting for operations and site admins. They basically provide histograms with the space usage evolution over time as shown in Figure 3. It is possible to overlay the information from the Rucio catalogue with the total and used space as reported by the storage system in order to measure storage occupancy and also to find possible consistency problems. Furthermore, it is possible to group the data by metadata like the datatype, physics streams, account, etc, to identify the type of data stored at a site. Additionally, these plots can be shown for single storage elements, all storage elements at a site, a cloud / country, tier or just an arbitrary set of sites.



**Figure 2.** Overview of the DDM Transfer Dashboard

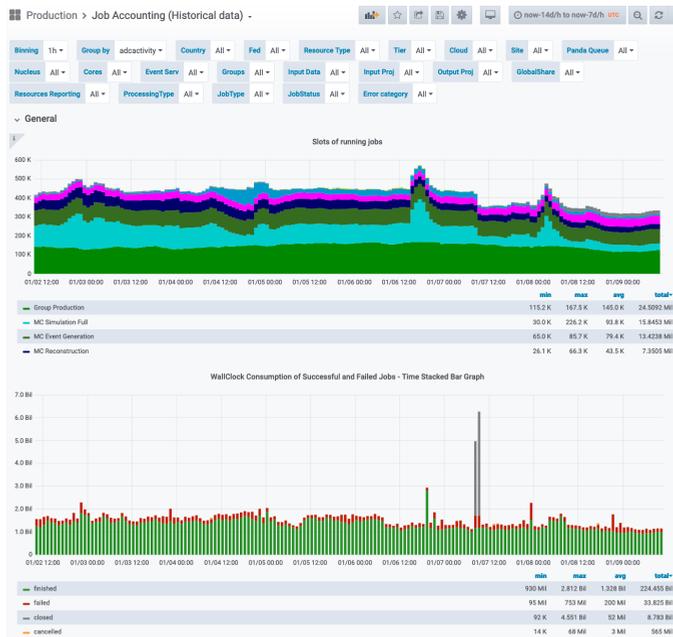
### 3.3 Job Accounting

The job accounting dashboard is used by shifters, experts and management. It is useful to spot problems with the workflow management system, as well as computing sites and to get the necessary plots for management reporting. The entry point, as shown in Figure 4, is an overview of the currently running jobs and the wall clock consumption of successful and failed jobs, which allows problems to be quickly identified. Further plots for the submitted, pending, finalising and completed jobs, with grouping and selections, are available similarly to the other two dashboards. Furthermore, there is information available regarding the federation pledges, HEP-SPEC06<sup>1</sup> numbers, CPU consumption and efficiency, the processed data and the resource utilization.

<sup>1</sup>HEP-wide benchmark for measuring CPU performance: <https://w3.hep.org/benchmarking.html>



**Figure 3.** Overview of the DDM Site Accounting Dashboard



**Figure 4.** Overview of the Job Accounting Dashboard

## 4 Summary

The work presented in this document was made possible by a joint effort of the CERN IT monitoring team and ADC. Removing the custom-built tools and relying on widely-used open source technologies brings several advantages: better scalability, better maintainability and an easier development of new features. But the new dashboards do not come without their own issues, such as the limited set of visualizations available in Grafana. Overall the new dashboards are a good improvement from the old ones and they will serve well in the upcoming LHC Run 3.

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