

# CMS dataset replica monitoring

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**Abstract.** TODO

## 1. Introduction

The CMS experiment produces huge amount of data. To control workflows on the LHC Computing Grid Tiers metadata is collected. Data mining efforts are of crucial importance to see how CMS did succesful operations and to allow optimizations and system behaviuor predictions (TODO//Ref). This paper concentrates on analysis of specific set of information - dataset block replicas storage occupation. CMS data are recorded in files which are organized in datasets and blocks. Datasets are set of files with common physics content, and have a size ranging from a few files and few GBs to several hundred thousand files and hundred TBs depending on the physics definition. Datasets are divided into groups of files called blocks to simplify data management; each block has a typical size of 100-1000 files and 100 GB-1 TB. The CMS data management system PhEDEx distributes the data to tens of sites and tracks in its Oracle database the location of every replica of every block produced by CMS. Since the PhEDEx database only contains the current status of the block replicas, to preserve historical evolution of space occupation daily snapshots are exported of the PhEDEx block replica information to Hadoop file system (TODO//Ref). This paper suggests an effective and flexible approach to analyse and visualize the storage occupation of block replicas.

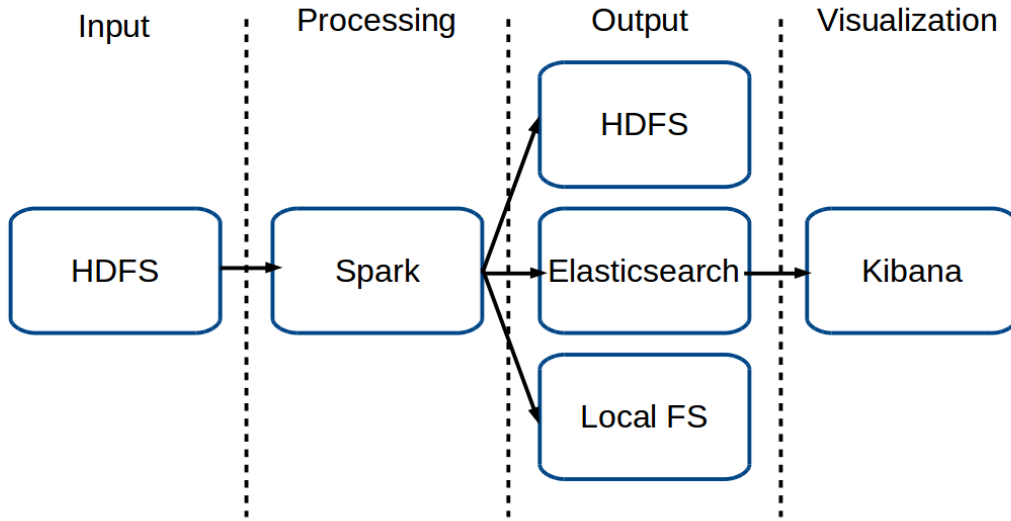
## 2. Structure

The structure of data analysis contains of four main steps: reading data, processing data, storing results and visualizing results. For each of the steps certain technologies were used. The basic structure of monitoring is shown in figure 1.

## 3. Input, processing and output

Block replicas data snapshot has a size ranging from 2 to 3.5 gigabytes and currently expanding. Considering long term solution it was decided to keep this data and export daily snapshots in hadoop file system. It provides advantages of scalability, effectiveness and resilience to failure.

Block replicas snapshot contains many informative fields which cannot be analysed all at once. To fix this issue system had to provide a mean of reducing data dimensions. Dynamic aggregation is the core of this approach which lets reduce complexity of data for every service execution. Service allows to define one or more grouping keys, one or more result values and for each result value aggregation type can be specified. Aggregations include basic operations such



**Figure 1.** Structure of CMS dataset block replica monitoring system

as sum, count, min, max, first, last, mean. For better data analysis two extra operations were implemented: day average which simply sums all results fields and divides it by distinct count of days and delta operation which shows data movement between sites in customizable date periods. Approach also suggests data ordering and data filtering (by one or more fields) features. For text field filtering regular expressions were used. It allows to reduce non-informative amount of information to a minimum value. As efficiency was one of the main goals of the approach, to implement processing module Spark (TODO//ref) technology was chosen. It allowed to make a use of existing CMS network infrastructure and provided advantages of distributed computing and memory processing. Related to study (TODO//ref) dataframes and sparkSQL were used instead of rdds and map/reduce for performance improvements. All algorithms in aggregation process were implemented in manner that reduces data shuffling through the network as much as possible (shuffling large amounts of data results in performance issues).

Proposed approach suggests few possibilities to store results. Every of them is supposed to be used for specific purposes.

- Hadoop file system. Should be used for long-term storage.
- Local file system. Should be used for quick aggregations stored in personal environment. Aggregation abstraction level should be chosen appropriately in order to get small files. This option requires data collection to master node and might fill all available memory on master node.
- Elasticsearch resource. Should be used with data that needs to be visualized. Configurability is one of the most important goals of the approach, so elasticsearch has dedicated configuration file with options to configure node, port and resource(index/type). Using third-party package (TODO//ref) allowed to make direct connection from spark to elasticsearch resource without a need to have an extra step. When writing data to elasticsearch extra field "origin" is added to schema. As service can be run for different purposes (cronjob or custom execution) extra field helps to solve data distinction issues. It is also very important for Kibana visualization to filter proper data for dashboards.

#### 4. Performance

Having good performance on data processing was one of the most important goals of this approach. Using different measures to achieve this goal allowed service to reduce processing time to a minimum. As different aggregations have different performance results we provide two performance figures on different aggregations (sum is considered to be low-cost operation and delta is considered to be computationally expensive operation). It is worth mentioning that both aggregations was processed in yarn mode. Given resources are written in the performance table.

- Group keys: now, node, user group, acquisition era, data tier, node kind
- Result fields: node bytes, destination bytes
- Aggregations: sum, sum
- Output: hadoop file system

**Table 1.** Performance of basic aggregations

Interval	Input	Cores	Memory	Output	Duration
1 day	3GB	65	361472MB	600KB	1.6min
1 month	100GB	65	361472MB	18MB	4.3min
3 months	310GB	65	361472MB	52MB	9.7min
1 year	1.1TB	65	361472MB	186MB	28min

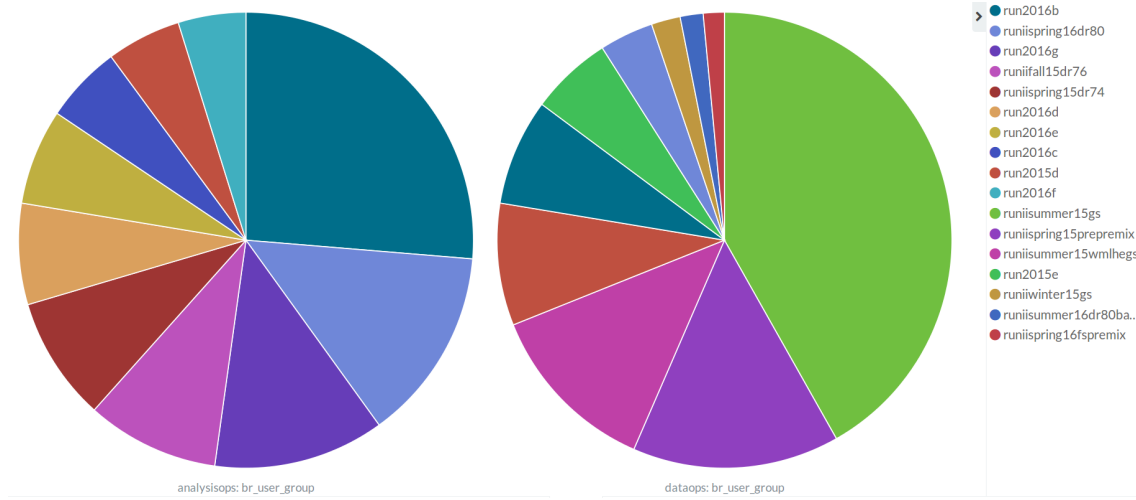
- Group keys: now, node name
- Result fields: node bytes
- Aggregations: delta
- Interval: 1
- Output: hadoop file system

**Table 2.** Performance of delta aggregations

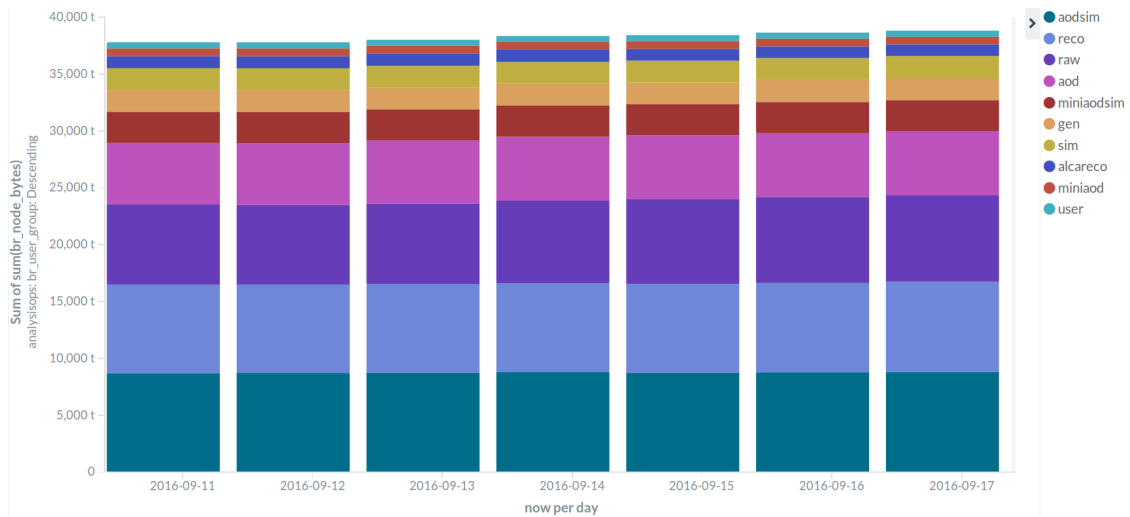
Interval	Input	Cores	Memory	Output	Duration
2 days	5GB	65	361472MB	12.7KB	2.5min
7 days	20GB	65	361472MB	41.6KB	4min
1 month	90GB	65	361472MB	189.2KB	8.5min
6 months	500GB	65	361472MB	1MB	35min

#### 5. Visualization

Structure of analysis service allows to reduce the complexity of visualization process to a minimal level. Having data in elasticsearch resource lets to use visualization technologies built on top of it. In this approach Kibana (TODO//ref) was used. From programmatic perspective Kibana configuration is the only process that needs to be done. Analytic himself then can make searches, visualizations and compose dashboards to fulfil his own needs. One of the example usage of



**Figure 2.** Kibana visualization of block replicas data (current)



**Figure 3.** Kibana visualization of block replicas data (historical)

kibana can be seen in figure 2. It simply shows two user groups (analysisops, dataops) storage distribution of top 10 storage consuming acquisition eras.

Another example in figure 3 shows data distribution of top 10 storage consuming data tiers. It is visualized in time perspective.

## 6. Conclusions

Proposed approach helps to analyze data by reducing its dimensions (aggregation) and visualizing it. It has three main advantages. First of all, it is very efficient as it is build on top of Spark which allows distributed computing using executors memory instead of disk. Also, it is fully-covered. By using this approach analytic can get everything from raw data in hadoop file system to visualizations and dashboards in kibana. Lastly, it is highly configurable. If an analytic wants to look at data from different perspective all he need to do is to change service parameters. By doing that he gets different aggregations, different results written in hdfs

and elasticsearch, different visualizations and dashboards in Kibana. All of this without a need to change the service itself.

## References

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## References

- [1] IOP Publishing is to grateful Mark A Caprio, Center for Theoretical Physics, Yale University, for permission to include the `iopart-num` B<sub>I</sub>B<sub>T</sub><sub>E</sub>Xpackage (version 2.0, December 21, 2006) with this documentation. Updates and new releases of `iopart-num` can be found on [www.ctan.org](http://www.ctan.org) (CTAN).