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Transformer-based Model for the Semantic Parsing of Error Messages in Distributed Computing Systems in High Energy Physics

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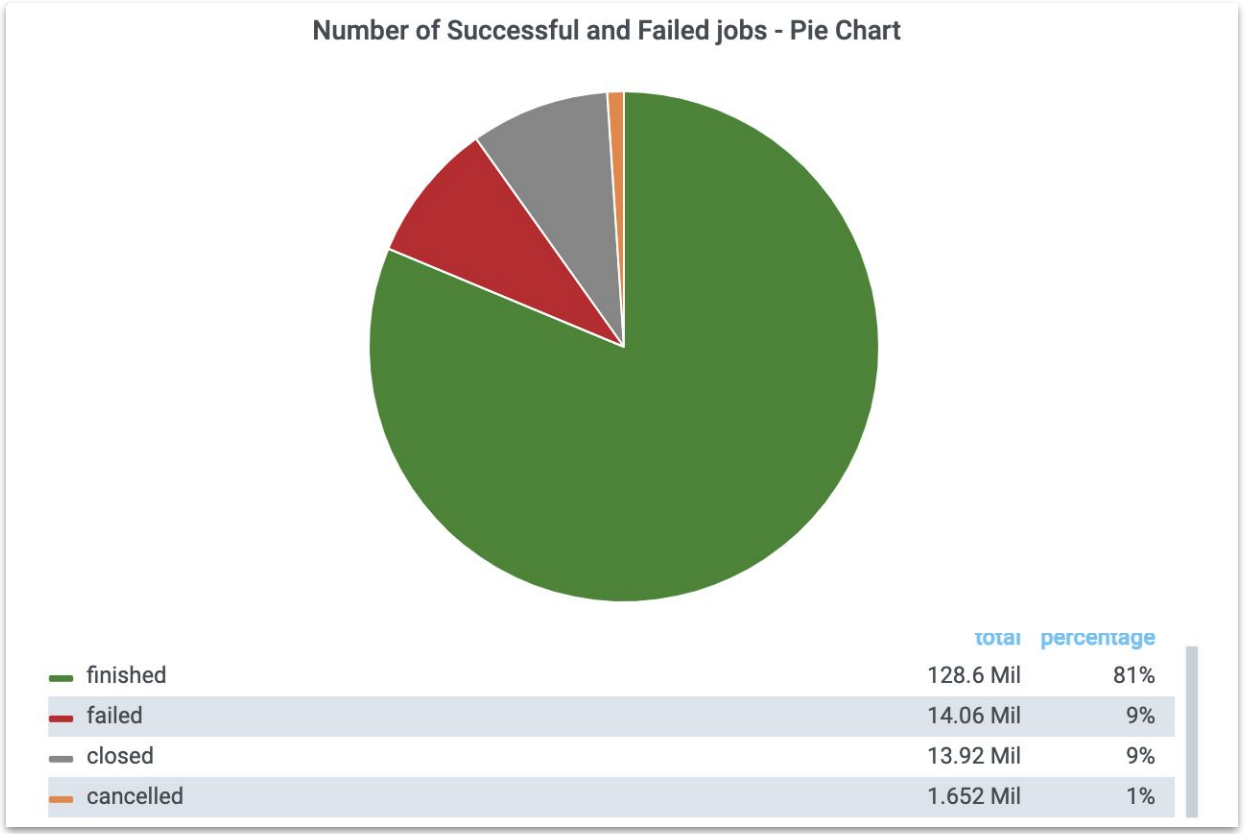
Outline

- Current situation of error messages analysis for ATLAS experiment
- ClusterLogs framework structure
- Usage of BERT for error message annotation
- New ClusterLogs structure and results
- Future plans

Introduction

- Modern scientific experiments are supported by complex distributed computing infrastructure. Detection and analysis of data processing faults and errors is one of the most challenging monitoring tasks for such a huge environment.
- ***ClusterLogs*** is a part of Operational Intelligence Project at CERN. The goal of OI is to reduce the cost of computing operations. ClusterLogs in particular is devoted to the minimization of human effort for repetitive tasks of error messages analysis by increasing the level of automation.
  - Talk "Preparing distributed computing operations for the HLLHC era with Operational Intelligence" at the vCHEP'2021 International conference.
- Initially ***ClusterLogs*** was developed for the automated categorization of failed ATLAS computing jobs using textual error messages.

ATLAS PanDA WMS



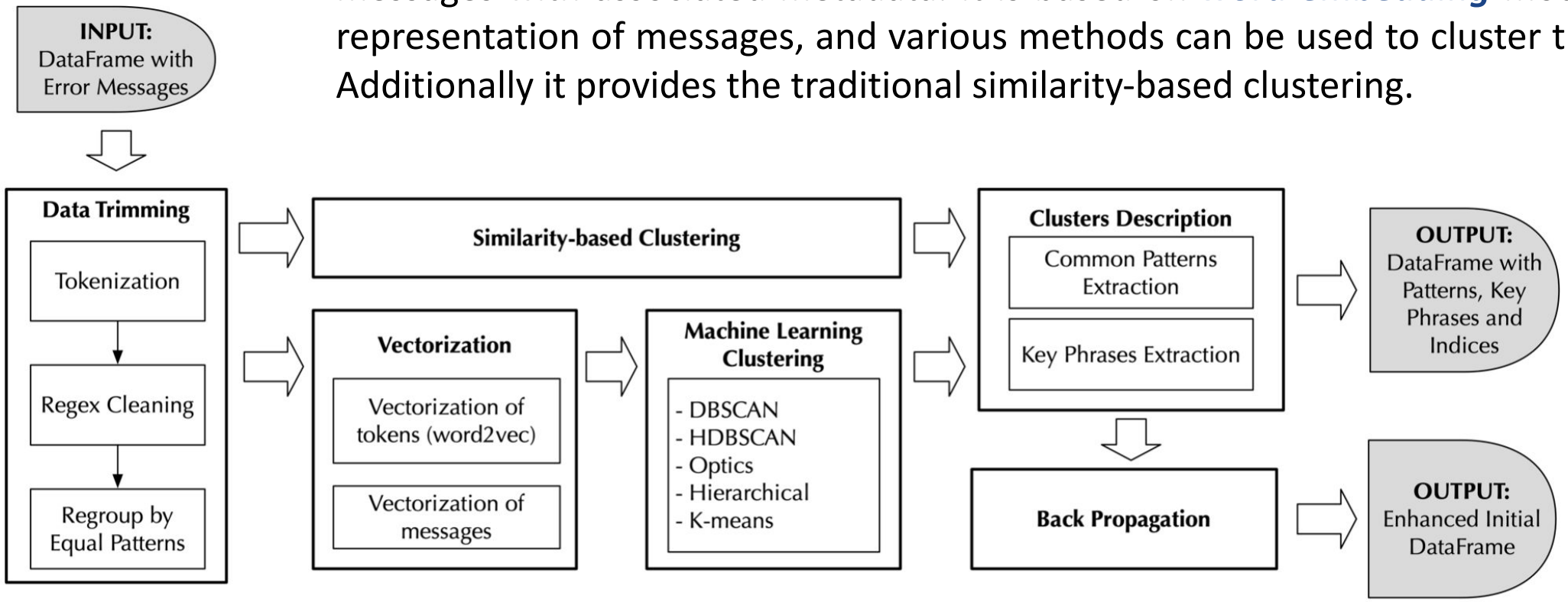
- *PanDA Workload Management System* is responsible for the execution of computing jobs. Its database registers all computing jobs, including error messages for failed jobs extracted from the corresponding log files.
- Average number of failed jobs for one year is 9%, which is ~14 M of error messages.

Challenges of error analysis

- ATLAS PanDA has multiple categories of failures *(pilot, execution, supervisor, ddm, brokerage, jobdispatcher, taskbuffer)*, each having dozens of textual patterns of error messages (that might be not known in advance, especially for the execution errors where messages are written by users)
- Categorization of error messages is performed by human experts. Each detected textual pattern is associated with the numeric code
  - Error messages with ***known category and structure*** can be analyzed within the ELK stack
- Computing infrastructure is evolving and ***new error conditions emerges***
- ***Automated error messages categorization*** will ensure improving the efficiency of the monitoring and free human experts from the need to dig into a large number of messages manually

ClusterLogs structure

ClusterLogs is a framework that allows to automatically cluster multi-source error messages with associated metadata. It is based on ***word embedding*** model for vector representation of messages, and various methods can be used to cluster these vectors. Additionally it provides the traditional similarity-based clustering.



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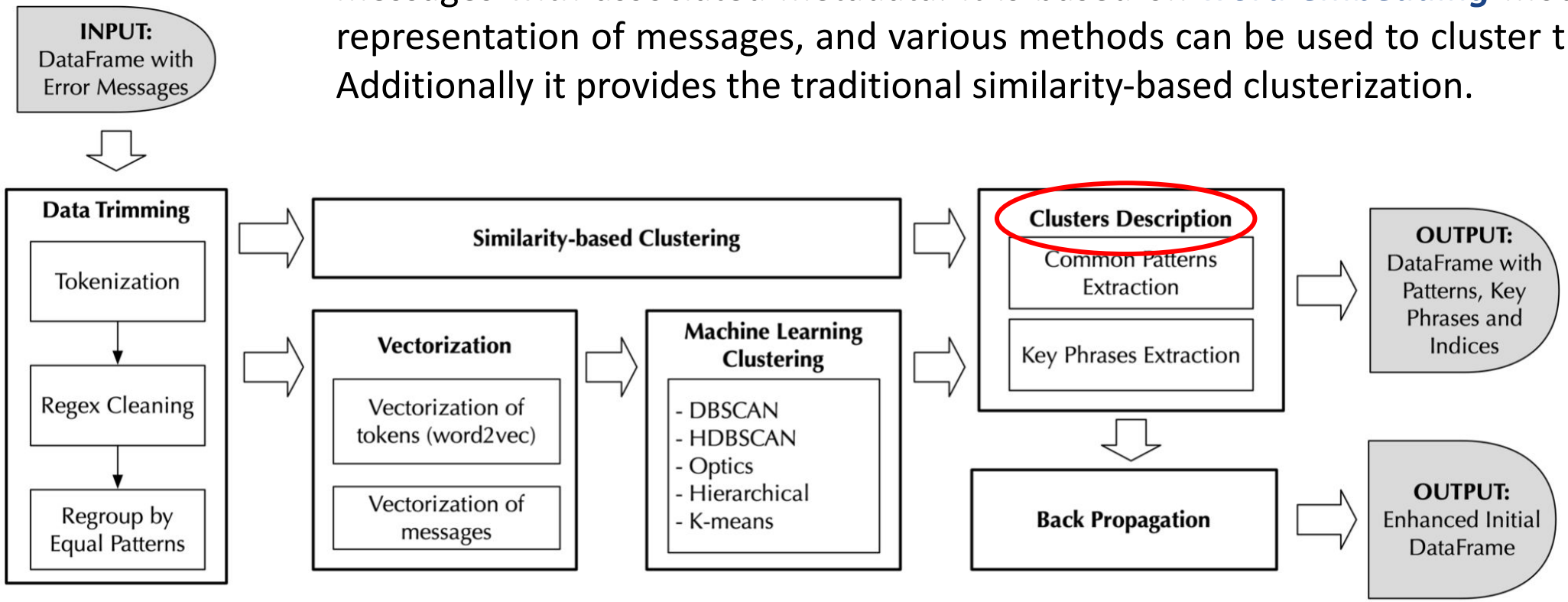
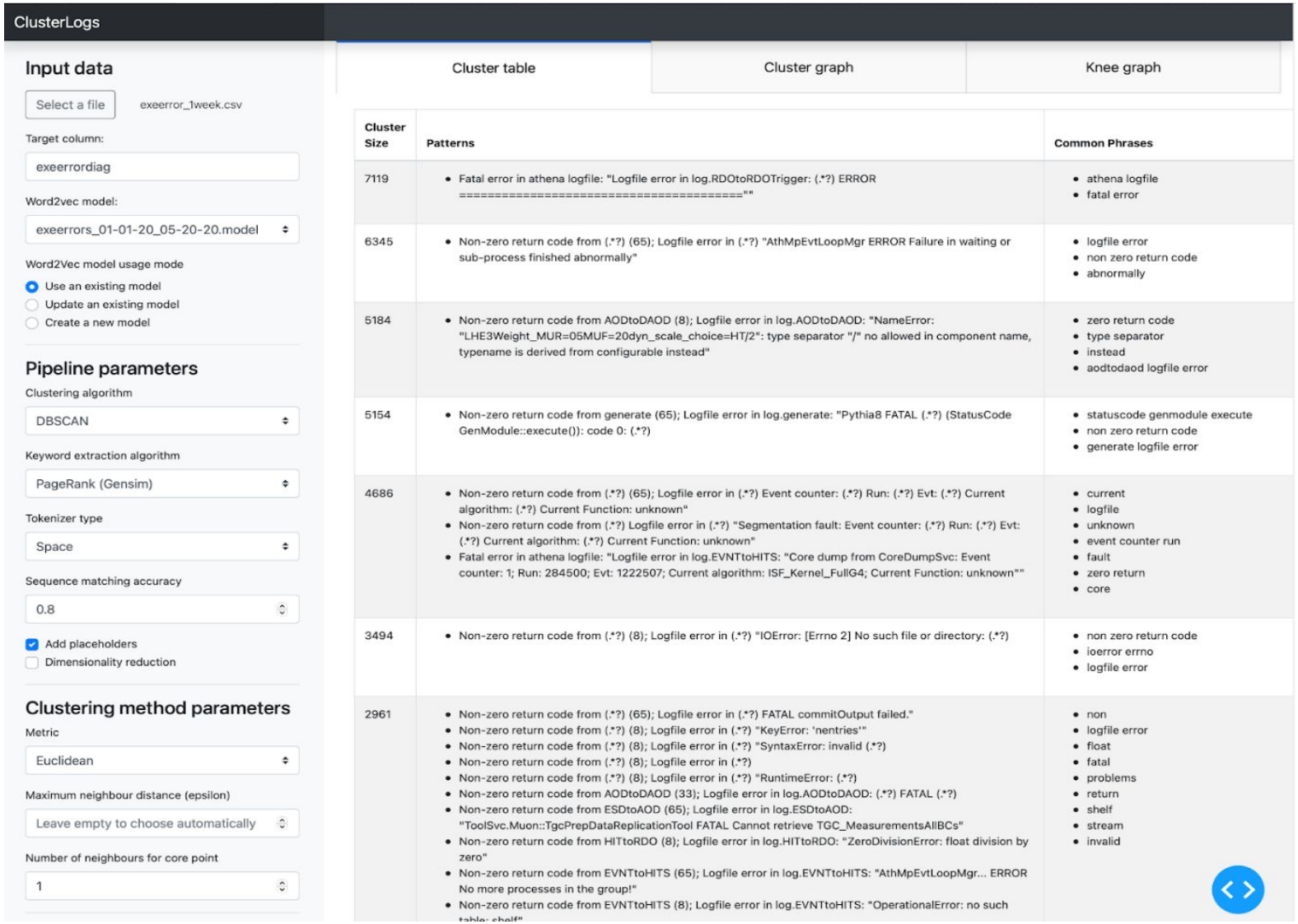


*Current research is aimed at the improvement of the **Clusters Description** using the transformer-based BERT model of error messages.*

ClusterLogs Current Results



(+) Each cluster can be described by one or multiple messages templates, combined by the textual and partially semantic similarity
(+) Common Phrases may help to extract the most significant parts of all messages in a cluster

(-) Messages often consists of the significant and not significant parts. Not significant parts may interfere with proper clustering.
(-) Common Phrases not always reflect the meaning of error condition.

BERT and Error Message Annotation

- **BERT (Bidirectional Encoder Representations from Transformers)** is a machine learning model for natural language processing published by Google in 2018 that achieved state-of-the-art performance on a number of tasks
- We included a Sentence-BERT model in ClusterLogs as an alternative vectorization method for error messages
- We also fine-tuned BERT model on a small dataset of less than 1000 messages to use it for significant part extraction from error messages

Examples of significant part annotation

Non-zero return code from (.*?) — Meaningless
Logfile error in (.*?) — Meaningless
"
PoolSvc FATAL Failed to setup POOL File Catalog — Meaningful
."

Fatal error in athena logfile — Meaningless
: "
Logfile error in (.*?) — Meaningless
"
IOVDbSvc ERROR Could not retrieve COOL data for folder (.*?) tag validityKeys [[],[]] — Meaningful
""

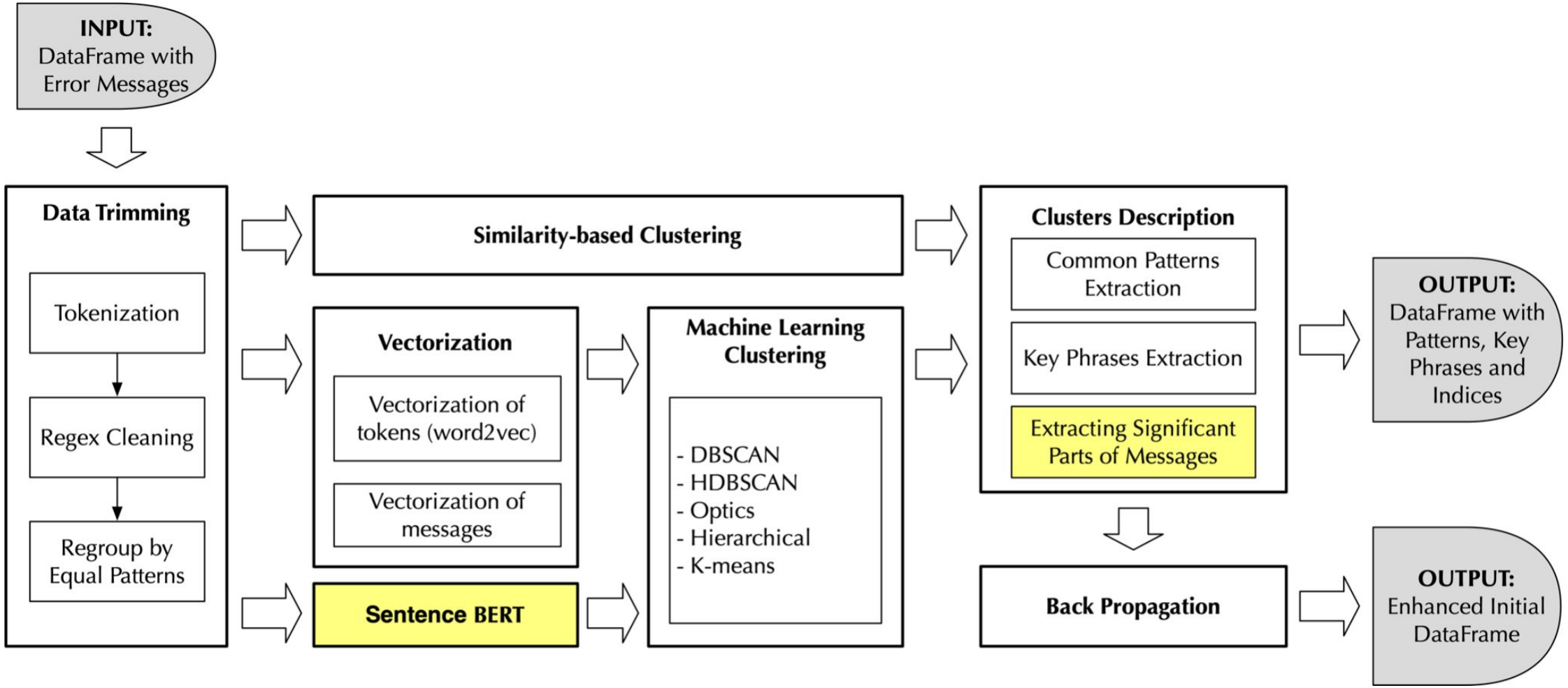
Non-zero return code from EVNTtoHITS (65) — Meaningless
;
Logfile error in log.EVNTtoHITS — Meaningless
: "
ISF_ParticleBro... FATAL isf >> Could not fill initial particle container. Abort — Meaningful
."

Fatal error in athena logfile — Meaningless
: "
Logfile error in log.EVNTtoHITS — Meaningless
: "
FastCaloSimPara... ERROR TFCSLateralShapeParametrizationHitChain::simulate(): Ehit negative Ehit=-0.765332 — Meaningful

Relevant part extraction examples

6345	• Non-zero return code from (.*?) Logfile error in (.*?) "AthMpEvtLoopMgr ERROR Failure in waiting or sub-process finished abnormally"	• AthMpEvtLoopMgr ERROR Failure in waiting or sub-process finished abnormally
5184	• Non-zero return code from AODtoDAOD (8); Logfile error in log.AODtoDAOD: "NameError: "LHE3Weight_MUR=05MUF=20dyn_scale_choice=HT/2": type separator "/" no allowed in component name, typename is derived from configurable instead"	• NameError: "LHE3Weight_MUR=05MUF=20dyn_scale_choice=HT/2": type separator "/" no allowed in component name, typename is derived from configurable instead
3715	• Non-zero return code from (.*?) (8); Logfile error in (.*?) "IOError: [Errno 2] No such file or directory: (.*?) • Non-zero return code from generate (8); Logfile error in log.generate: "RuntimeError: No output LHEF file produced by Powheg. Terminating job."	• IOError: [Errno 2] No such file or directory: (.*?) • RuntimeError: No output LHEF file produced by Powheg. Terminating job
2704	• Fatal error in athena logfile: "G4 exception at line (.*?) (see jobReport for further details)"	• G4 exception at line (.*?) (see jobReport for further details)
1721	• Non-zero return code from AODtoDAOD (33); Logfile error in log.AODtoDAOD: (.*?) FATAL Failed to retrieve tool (.*?) = (.*?) • Non-zero return code from POOLMergeAthenaMPAOD0 (64); Logfile error in log.POOLMergeAthenaMPAOD0: "ToolSvc.CaloTrackingGeometryBuilder FATAL Failed to retrieve tool LArVolumeBuilder = PublicToolHandle('LAr::LArVolumeBuilder/LArV (truncated)	• (.*?) FATAL Failed to retrieve tool (.*?) = (.*?) • .POOLMergeAthenaMPAOD0: "ToolSvc.CaloTrackingGeometryBuilder FATAL Failed to retrieve tool LArVolumeBuilder = PublicToolHandle('LAr::LArVolumeBuilder/LArV (truncated)
1592	• (.*?) got a SIGABRT signal (exit code 134); Logfile error in (.*?) "Segmentation fault: Event counter: 0; Run: unknown; Evt: unknown; Current algorithm: <NONE>; Current Function: unknown" • AODtoDAOD got a SIGABRT signal (exit code 134); Logfile error in log.AODtoDAOD: "Core dump from CoreDumpSvc: Event counter: (.*?) Run: (.*?) Evt: (.*?) Current algorithm: (.*?) Current Function: unknown"	• Segmentation fault: Event counter: 0; Run: unknown; Evt: unknown; Current algorithm: <NONE>; Current Function: unknown • Core dump from CoreDumpSvc: Event counter: (.*?) Run: (.*?) Evt: (.*?) Current algorithm: (.*?) Current Function: unknown
648	• Non-zero return code from (.*?) Logfile error in (.*?) FATAL Unable to apply Inner Detector alignments" • Non-zero return code from AODMerge (65); Logfile error in log.AODMerge: "DataHeaderCnv FATAL Failed to write DataHeaderForm = (.*?)	• FATAL Unable to apply Inner Detector alignments • DataHeaderCnv FATAL Failed to write DataHeaderForm = (.*?)

Updated ClusterLogs Structure



Conclusion and Future Plans

- BERT model for extraction of a significant part from error messages was included into the ***ClusterLogs*** framework.
- The results showed that a small annotated dataset of <1000 messages was sufficient for the task of extracting a significant part of message, if it exists, in almost all cases.

- This model can be used to extract the relevant part of messages before clustering, which should greatly enhance the accuracy of error message categorization.
- ClusterLogs will be tested to categorize jobs by error messages. And the results will be compared with the human experts' decisions about categories and numerical codes of error templates.