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Unsupervised Error Logs Clusterization

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The Key Objectives of Error Logs Clusterization

- ❑ Error logs are a fruitful source of information to diagnose and explore failures
- ❑ Diagnosing failures is a challenging problem as it requires the analysis of large amounts of textual log data without well-defined structure
- ❑ Existing approach: Human experts interpret detected log errors and create the rules (patterns of regular expressions) manually
 - ❖ Time-consuming
 - ❖ Doesn't allow to identify previously unknown error conditions automatically
- ✓ A possible solution:
 - ✓ to **cluster log errors** using methods of unsupervised text clusterization

Error Logs Exploratory Study

- ATLAS BigPanDA jobs archive
 - ~5K exeerrordia unique messages
- Requirements
 - Performance, suitable for the real-time applications
 - Unknown number of clusters
 - Capture outliers
 - Minimization of human intervention in the process of clusterization
 - automatic detection of clusterization parameters

Strings Clusterization Pipeline

This is the first line of
this text example.

This is the second line
of the same text.



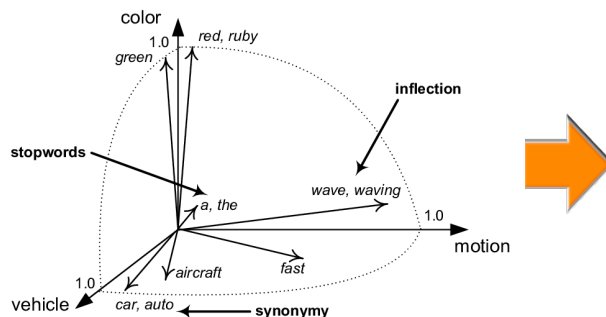
Stage 1: Tokenization



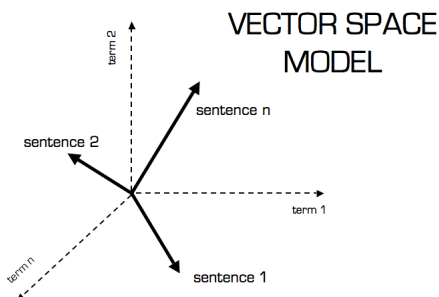
Stage 2: Vector Space Model of Words

Word vectors	Dimensions			
	dog	-0.4	0.37	0.02
	cat	-0.15	-0.02	-0.23
	lion	0.19	-0.4	0.35
	tiger	-0.08	0.31	0.56
	elephant	-0.04	-0.09	0.11
	cheetah	0.27	-0.28	-0.2
	monkey	-0.02	-0.67	-0.21
	rabbit	-0.04	-0.3	-0.18
	mouse	0.09	-0.46	-0.35
	rat	0.21	-0.48	-0.56

Words as multidimensional
numerical vectors, characterized
by a set of features,
representing context, meaning,
semantic, frequency of the
words



Stage 3: Vector Space Model of Sentences



Stage 4: Clusterization

Stage 1: Tokenization by Spaces and Punctuation

'Fatal error in athena logfile: "G4 exception at line 28172 (see jobReport for further details)'"

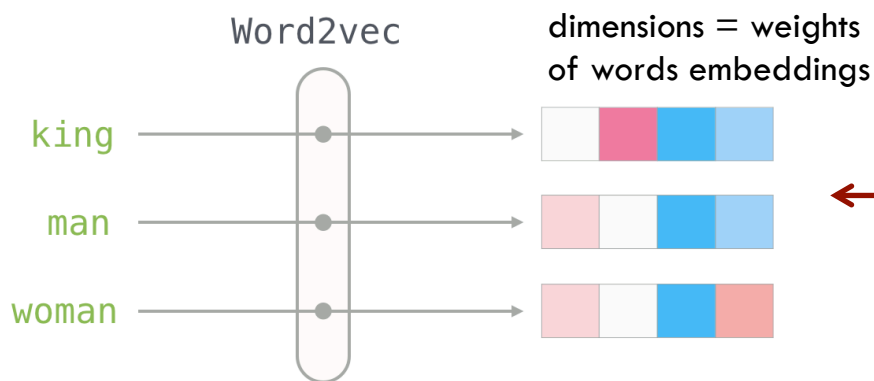


Fatal	error	in	athena	logfile	:	G4	exception	line	at
28172	(	see	jobReport	for	further	details)		

To preserve structural information of error messages we include all punctuation and stop words in vocabulary.

Stage 2: Vector Space Model with Word2Vec (1 / 2)

- **The idea of Word2Vec** – meaning of a word can be inferred by the company it keeps



Dimensions (features) represents the variables, assigned to the words.

The selection of these features are not manual, it is **automatic** by using hidden layer in the training process.

Depending of the corpus the most useful dimensions are selected.

Neural network

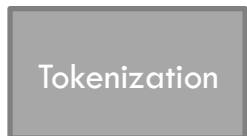
CBOW – predicts word by neighbors

Skip-gram – predicts neighbors by given word

Stage 2: Vector Space Model with Word2Vec (2/2)

gensim.word2vec / python

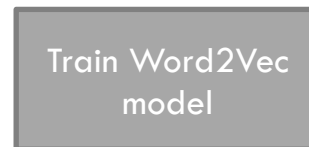
Array of error messages



$X \sim 10\,000$
(size of vocabulary)



Error messages as
array of tokens



Word2Vec – vector
representations in 100-
dimensional space for each
token in vocabulary

size – size of the vector
to represent each token
(=100)

min_count –
minimum frequency
count of words (=1)

window – max distance
between target token
and its neighbors (=5)

Word2Vec Model
(10 000 * 100)

	f1	f2	...	f100
token1	0.98	0.33	...	...
token2	0.65	0.78	...	...
...
tokenX	...	...	...	...

Stage 3: Word2Vec to Sentence2Vec Model

Advantages:

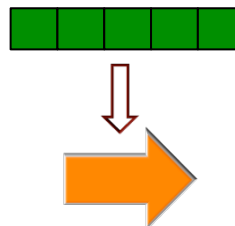
- Word2Vec retains the semantic meaning of different words in a document
- The context information is not lost
- The size of embedding vector is very small

Word2Vec Model
(10 000 * 100)

	f1	f2	...	f100
token1	0.98	0.33	...	...
token2	0.65	0.78	...	...
...
tokenX	...	...	...	...

Word2Vec – vector representations in 100-dimensional space for each token in vocabulary.

Error messages as array of tokens



Sentence2Vec Model
(5 000 x 100)

	f0	f1	...	f100
msg1	0.98	0.33	...	...
msg2	0.65	0.78	...	...
...
msgN	...	...	...	...

Sentence2Vec – mathematical average of the word vector representations of all the words in the sentence.

Stage 4: DBSCAN Clusterization

- ❑ Does not require to specify the exact amount of clusters in advance
- ❑ Good at identifying outliers

min_samples

the minimum number of points to form a dense region

min_samples = 1 guarantees that each outlier will be put in a separate cluster

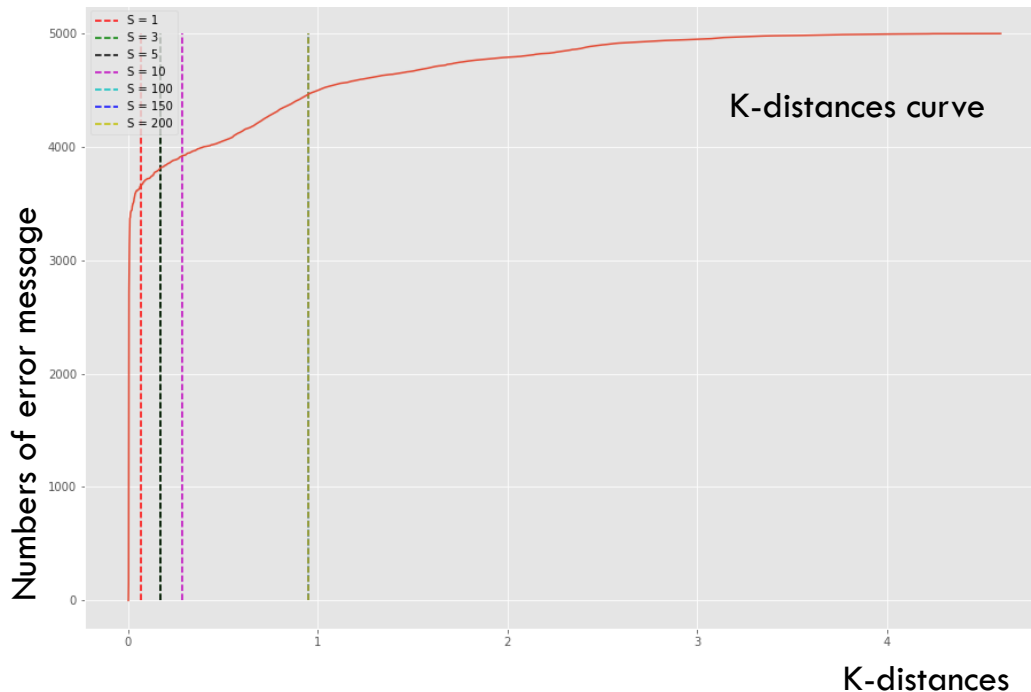
epsilon

specifies how close points should be to each other to be considered as part of a cluster

- 1) Calculate the average of the distances of every object to its k-neighbors
 $k = \sqrt{n}$, where n is the number of objects in dataset (rule of thumb)
- 2) Sort k-distances in an ascending order
- 3) Display k-distance curve
- 4) Find a knee where a sharp change occurs

Automatic Detection of Knee for K-distance Curve

- **Kneed** is a python library allowing to detect knees for curves automatically
- It shows knees graphically and returns knee points



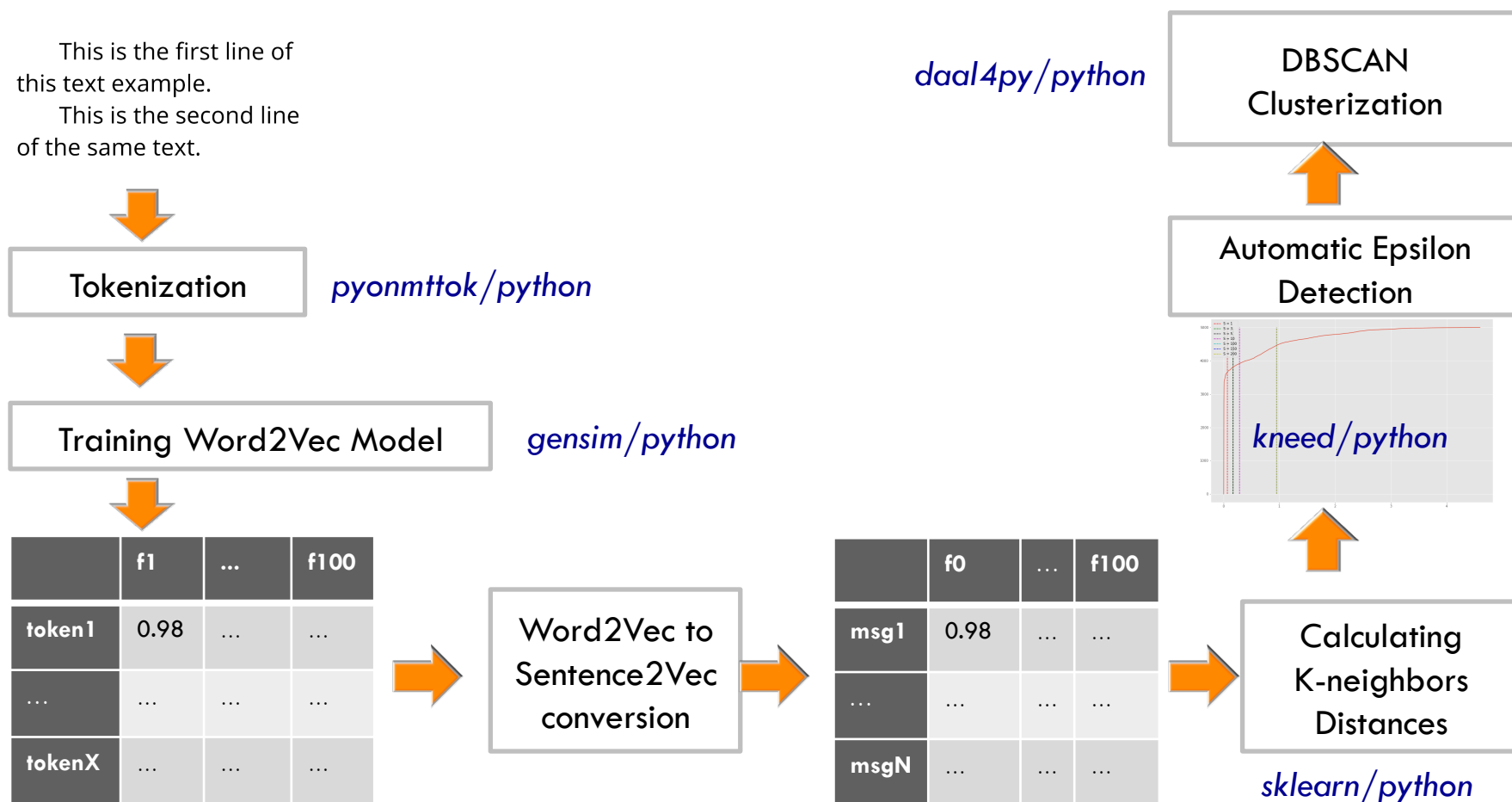
[0.06899074925405664,
0.17418354191659477,
0.17418354191659477,
0.2850125475866659,
0.9484519887921964,
0.9484519887921964,
0.9484519887921964]



DBSCAN(min_samples=1, **eps=0.94**)

Error Logs Clusterization Pipeline

This is the first line of
this text example.
This is the second line
of the same text.



Clusterization of 5K Error Logs Results

71 clusters with ~30 outliers

cluster_name	first_entry	cluster_size	mean_length	std_lengt	mean_similarity	std_similarity
2	Failed in data staging: Failed to prepare dest...	1667	498.0	16.0	87.0	3.0
4	Non-zero return code from AODtoDAOD (65); Long...	692	109.0	1.0	95.0	4.0
1	RAWtoESD got a SIGABRT signal (exit code 134);...	674	202.0	9.0	72.0	5.0
3	Fatal error in athena logfile: "G4 exception a...	402	95.0	0.0	96.0	0.0
0	File HITS.11364416._001738.pool.root.1 did not...	381	72.0	13.0	79.0	8.0
9	Non-zero return code from AtlasG4Tf (3); Logfi...	335	167.0	38.0	53.0	4.0
5	Failed in data staging: Failed to prepare dest...	114	477.0	51.0	77.0	6.0
6	Non-zero return code from HITtoRDO (8); Logfil...	103	156.0	10.0	91.0	7.0
7	Non-zero return code from ESDtoAOD (65); Logfi...	97	209.0	25.0	69.0	7.0
10	Failed in data staging: Failed to prepare dest...	93	480.0	37.0	68.0	9.0
8	ESDtoAOD got a SIGKILL signal (exit code 137);...	41	176.0	27.0	61.0	5.0
15	Failed in data staging: Could not resolve any ...	39	222.0	3.0	97.0	5.0
25	RDOtoRDOTrigger got a SIGABRT signal (exit cod...	35	116.0	5.0	85.0	2.0
13	POOLMergeAthenaMPDESDMPHOJET0 got a SIGTERM si...	33	48.0	5.0	78.0	3.0
17	Fatal error in athena logfile: "Logfile error ...	31	171.0	32.0	53.0	3.0
11	Non-zero return code from POOLMergeAthenaMPDES...	31	42.0	6.0	79.0	3.0
21	Fatal error in athena logfile: "Long ERROR mes...	25	100.0	1.0	97.0	1.0
27	Fatal error in athena logfile: "Logfile error ...	23	158.0	1.0	97.0	0.0
20	Failed in data staging: Failed checking source...	21	448.0	34.0	62.0	6.0
12	Input file argument MC15.304628.Pythia8EvtGen_...	18	122.0	39.0	79.0	8.0

Cluster 2 – Similarity 87%

- **'Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/93/3c/HITS.12906983._038218.pool.root.1:checksumtype=adler32:checksumvalue=af5f8f08: **Failed to prepare destination: Temporary service error: Error looking up space tokens matching description (Proxy expired); Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/70/95/log.129',
- **'Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/a3/82/HITS.12906983._031991.pool.root.1:checksumtype=adler32:checksumvalue=bd47a313: **Failed to prepare destination: Temporary service error: Error looking up space tokens matching description (Proxy expired); Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/9a/f5/log.129',
- **'Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/a5/27/HITS.12906983._044192.pool.root.1:checksumtype=adler32:checksumvalue=3c2cc879: **Failed to prepare destination: Temporary service error: Error looking up space tokens matching description (Proxy expired); Failed in data staging: Failed to prepare destination** srm://srm.ndgf.org:8443/srm/managerv2?SFN=/atlas/disk/atlasdatadisk/rucio/mc16_13TeV/b8/fd/log.129',

Cluster 4 – Similarity 95%

- 'Non-zero return code from HITtoRDO (65); Long FATAL message at line 17188 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 5958 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 6066 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 5205 (see jobReport for further details)',
- 'Non-zero return code from HITtoRDO (65); Long FATAL message at line 22284 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 27386 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 6043 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 6339 (see jobReport for further details)',
- 'Non-zero return code from AODtoDAOD (65); Long FATAL message at line 6288 (see jobReport for further details)',

Cluster 1 – Similarity 72%

- 'RAWtoESD got a SIGABRT signal (exit code 134); Logfile error in log.RAWtoESD: "Segmentation fault: Event counter: 77; Run: 222525; Evt: 2577; Current algorithm: MTFSteering; Current Function: unknown",
- 'Non-zero return code from HITtoRDO (65); Logfile error in log.HITtoRDO: "Segmentation fault: Event counter: 205; Run: 300000; Evt: 803662; Current algorithm: <NONE>; Current Function: unknown",
- 'RAWtoESD got a SIGSEGV signal (exit code 139); Logfile error in log.RAWtoESD: "Segmentation fault: Event counter: 21; Run: 251363; Evt: 20401572; Current algorithm: MuonCombinedAlg; Current Function: unknown",
- 'Non-zero return code from RAWtoESD (65); Logfile error in log.RAWtoESD: "Segmentation fault: Event counter: 23; Run: 300000; Evt: 49274629; Current algorithm: <NONE>; Current Function: unknown",
- 'RAWtoESD got a SIGSEGV signal (exit code 139); Logfile error in log.RAWtoESD: "Segmentation fault: Event counter: 8; Run: 222525; Evt: 2198; Current algorithm: MTFSteering; Current Function: unknown",

Cluster 12– Similarity 79%

- 'Input file argument /cvmfs/atlas-nightlies.cern.ch/repo/data/data-art/DerivationFrameworkART/data17_13TeV.00327342.physics_Main.merge.AOD.f838_m1824._lb0300._0001.1 globbed to NO input files - probably the file(s) are missing',
- 'Input file argument testRTT.RDO.pool.root globbed to NO input files - probably the file(s) are missing',
- 'Input file argument AOD_13TeV_PhysVal.pool.root globbed to NO input files - probably the file(s) are missing',
- 'Input file argument MCtest_ttbar.digit.pool.root globbed to NO input files - probably the file(s) are missing',
- 'Input file argument \${TRN_OUTPUT0/L} globbed to NO input files - probably the file(s) are missing',
- "Input file argument(s) ['389716.NoFilter.evgen.root'] globbed to NO input files - probably the file(s) are missing",
- 'Input file argument myAOD_express_1.AOD.pool.root globbed to NO input files - probably the file(s) are missing',
- 'Input file argument AOD.pool.root globbed to NO input files - probably the file(s) are missing',

Cluster 16 – Similarity 37%

- "Failed in data staging: Failed writing to destination: file:/ceph/grid/cache/data/9b/fecc21c035f04eedaa5d470251161d4149241f : Can't write to destination: File exists: Failed to create file /ceph/grid/cache/data/9b/fecc21c035f04eedaa5d470251161d4149241f; Failed in data staging: Failed writing to destination: file:/ceph/grid/cache/data/8c/70223081e536cc6ae39464d5f96b7ed5dbba52 : Can't write to destination: File exists: Failed to create file /ceph/grid/cache/data/8c/70223081e536cc6ae39464d5f96b7ed5",**
- "Failed in data staging: Failed writing to destination: file:/ceph/grid/cache/data/ef/b20ef87a05395a8ff2133d95778a140cf7eef1 : Can't write to destination: File exists: Failed to create file /ceph/grid/cache/data/ef/b20ef87a05395a8ff2133d95778a140cf7eef1",**
- "Failed in data staging: Failed writing to destination: file:/ceph/grid/cache/data/b2/fb8323e8cb87c2b8a89ab3931d73465c373d04 : Can't write to destination: File exists: Failed to create file /ceph/grid/cache/data/b2/fb8323e8cb87c2b8a89ab3931d73465c373d04",**

cluster_name	first_entry	cluster_size	mean_length	std_lengt	mean_similarity	std_similarity
16	Failed in data staging: Failed writing to dest...	11	299.0	100.0	37.0	4.0

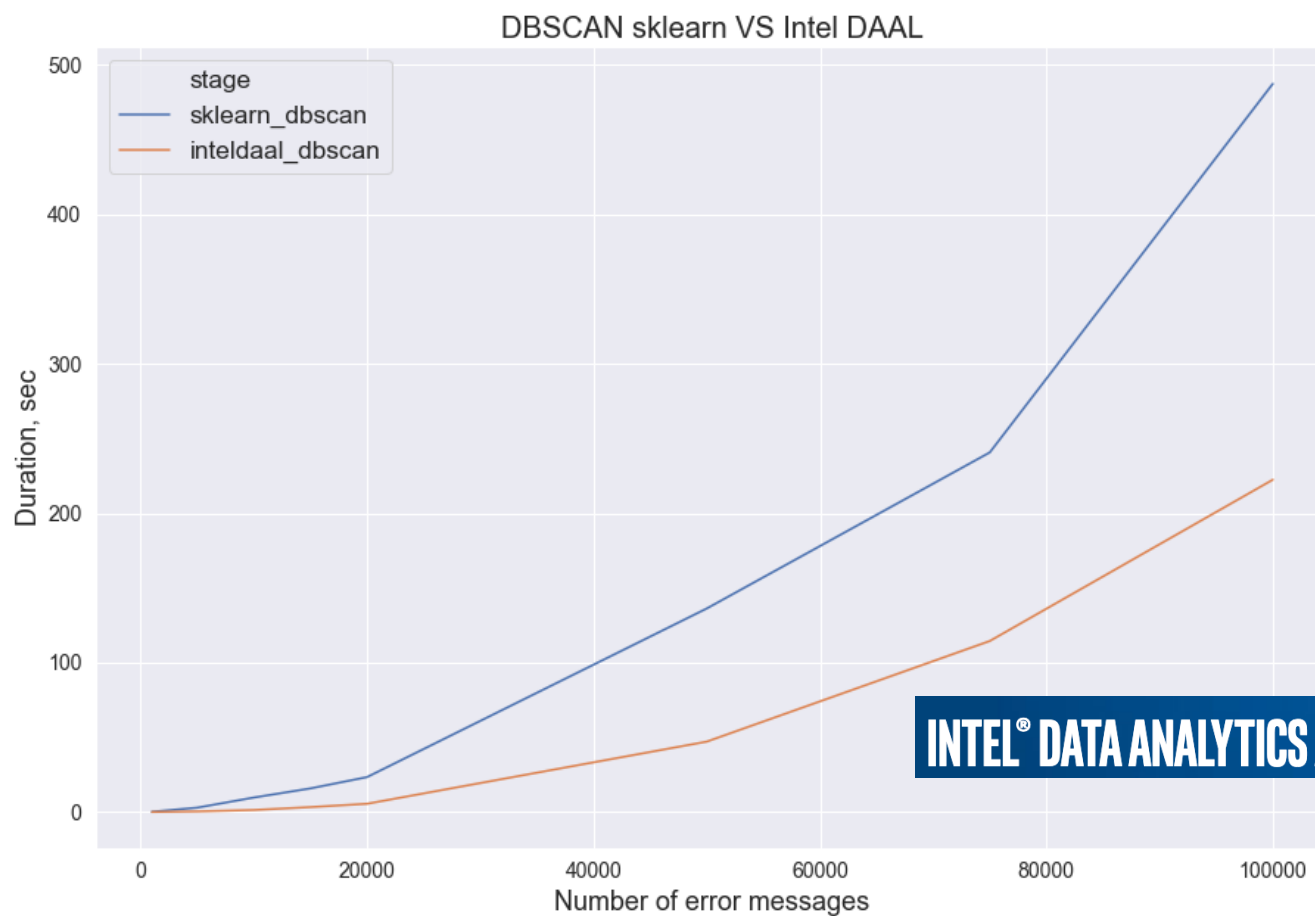
Outliers

cluster_name	first_entry	cluster_size	mean_length	std_lengt	mean_similarity	std_similarity
69	File already exist	1	18.0	0.0	100.0	0.0
51	Event count check for DAOD_FTAG2 to DAOD_FTAG2...	1	256.0	0.0	100.0	0.0
24	Failed in data staging: Checksum mismatch	1	41.0	0.0	100.0	0.0
49	LRMS error: (-1) Job missing from SLURM	1	39.0	0.0	100.0	0.0
48	Fatal error in athena logfile: "Logfile error ...	1	122.0	0.0	100.0	0.0
47	TRF_ENV | "athena.py not found in PATH=/cvmfs/...	1	250.0	0.0	100.0	0.0
42	OK	1	2.0	0.0	100.0	0.0
45	Fatal error in athena logfile: "Core dump at l...	1	91.0	0.0	100.0	0.0
44	Get error: Staging input file failed	1	36.0	0.0	100.0	0.0
43	Put error: File copy timed out	1	30.0	0.0	100.0	0.0
36	AODtoDAOD got a SIGBUS signal (exit code 135);...	1	124.0	0.0	100.0	0.0
14	TRF_SVRINIT | "Could not get TileHWID helper!"...	1	239.0	0.0	100.0	0.0
53	TRF_UNKNOWN | "Unable to build inputFileSummar...	1	116.0	0.0	100.0	0.0
52	Get error: Input file staging timed out	1	39.0	0.0	100.0	0.0
64	TRF_UNKNOWN | "in sysInitialize(): standard st...	1	250.0	0.0	100.0	0.0
55	Error reading user generated output file list	1	45.0	0.0	100.0	0.0
56	File test.EVNT.pool.root might be missing	1	41.0	0.0	100.0	0.0

Benchmarks

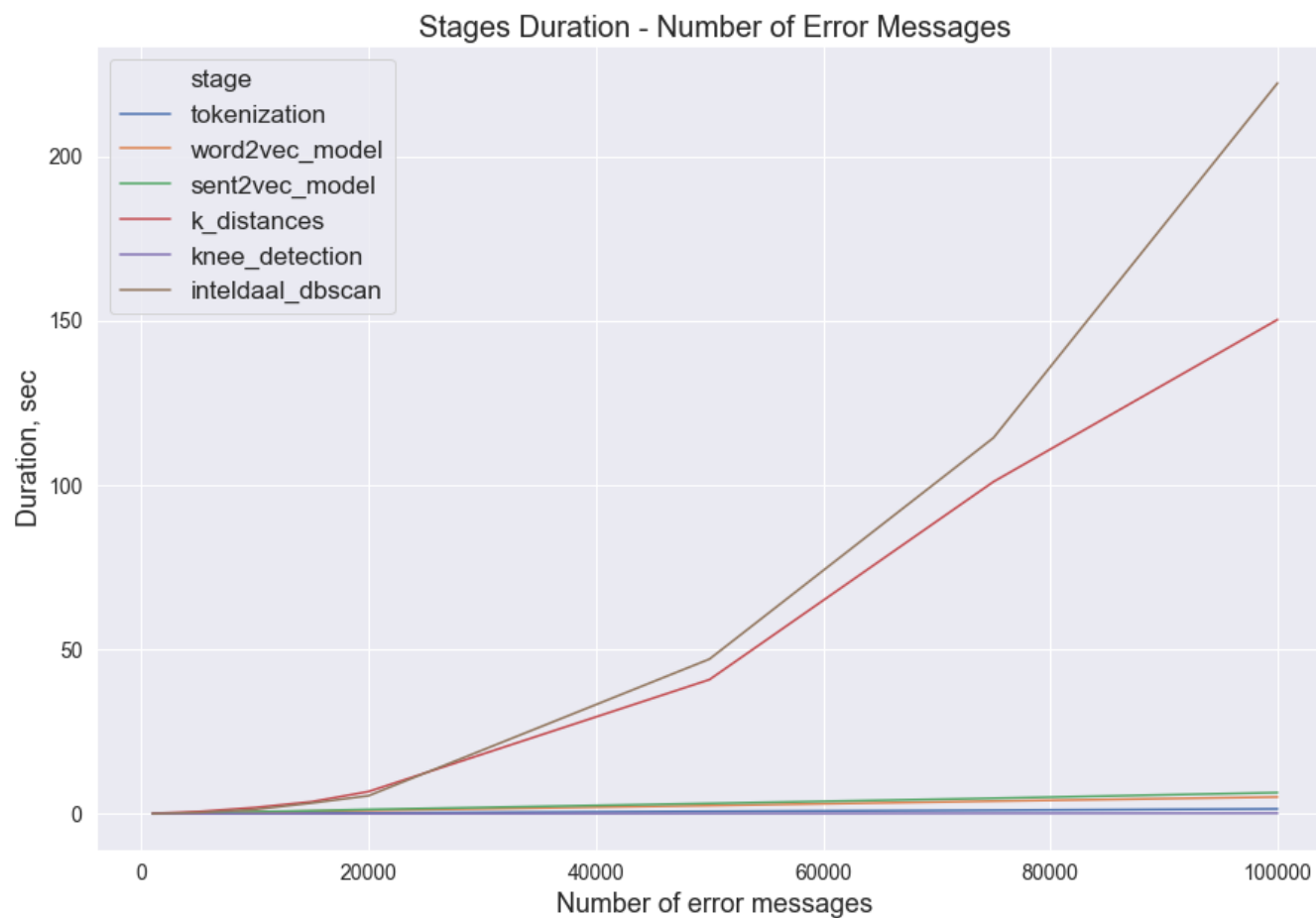
On data sample size up to 100K error log messages

DBSCAN sklearn / Intel DAAL



INTEL® DATA ANALYTICS ACCELERATION LIBRARY

Benchmarks



Conclusion

- ▣ Unsupervised clusterization of error log messages with Word2Vec + DBSCAN with automatic detection of epsilon gives good results in quality and performance for up to 10K error logs
- ▣ Next steps:
 - Clear error log messages from unnecessary numbers, UUIDs in paths
 - Provide performance and quality tests on data from ES@Chicago for different time ranges: 1h, 6h, 12h, 24h, 36h,...
 - Manual analysis of the clusterization results
 - Try another clusterization algorithms and compare results against the DBSCAN
 - Performance optimization of k-distance search algorithm (ANN C++)
 - Deploy clusterization module at GitHub for collective use

Resources

- ▣ **Word Embeddings** - <http://colah.github.io/posts/2014-07-NLP-RNNs-Representations>
- ▣ **Word2Vec** - <https://github.com/RaRe-Technologies/gensim>
- ▣ **Intel DAAL** - <https://software.intel.com/en-us/daal>
- ▣ **Kneed** - <https://github.com/arvkevi/kneed>
- ▣ **ANN library** - <http://www.cs.umd.edu/~mount/ANN/>

Acknowledgements

- ▣ This work has been supported by the RSCF grant No. 18-71-10003
- ▣ Thanks for Ilija Vukotic for reasonable comments on this study

Additional Slides

Other methods of strings clusterization

Strings Clusterization Pipeline without Preprocessing

Array of error messages



Levenshtein
distances



Distance Matrix (5000 x 5000)

	msg1	msg2	msg3
msg1	0	10	50
msg2	10	0	1
msg3	50	1	0



Clusterization



Groups of similar
strings and
outliers

finding the number of edits (**insert** | **delete** | **replace**)
which will transform one string to another

String 1	String 2	Levenshtein distance
aaa	aaa	0
aaa	aba	1
aaa	abcdefg	6

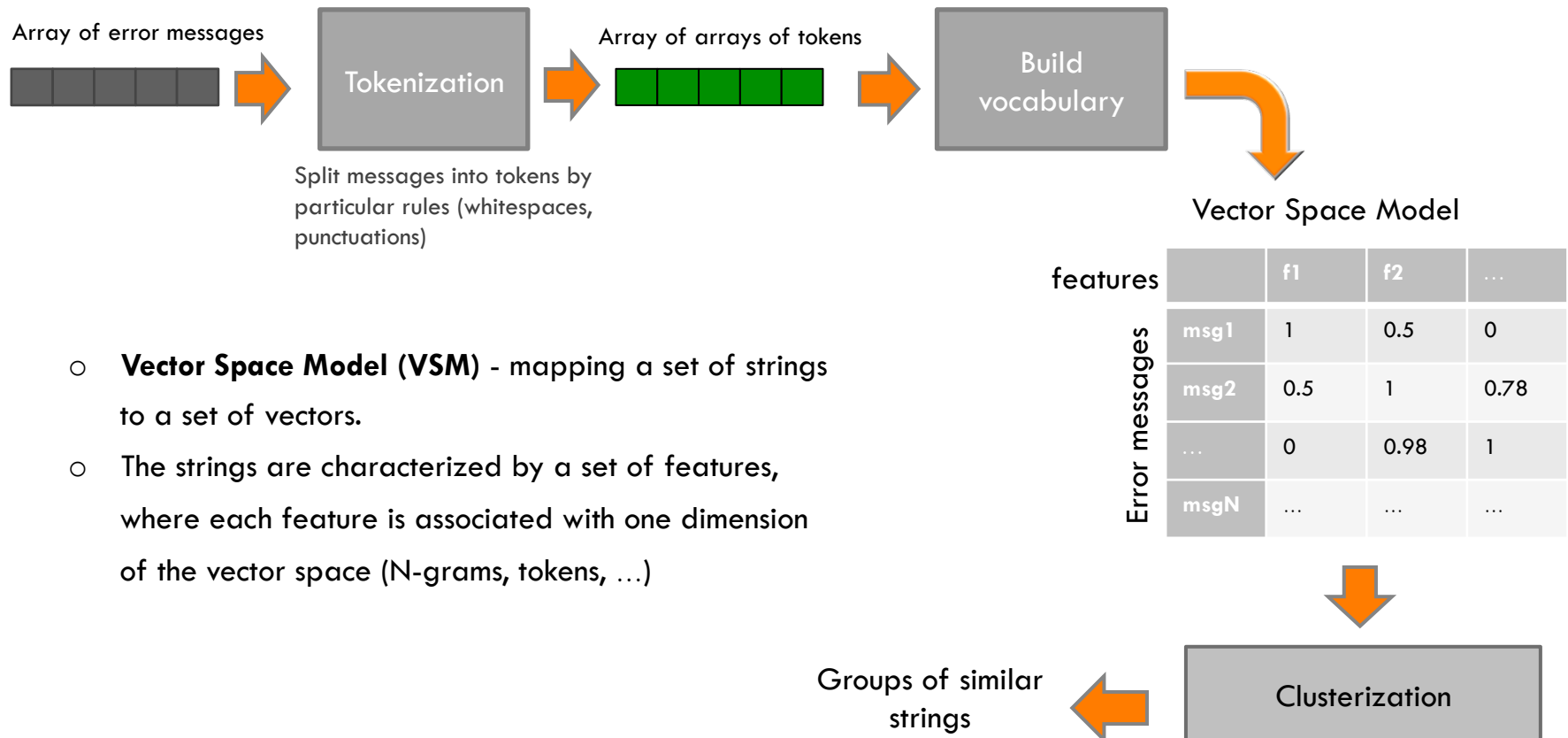
❑ Advantages:

- No need for text preprocessing

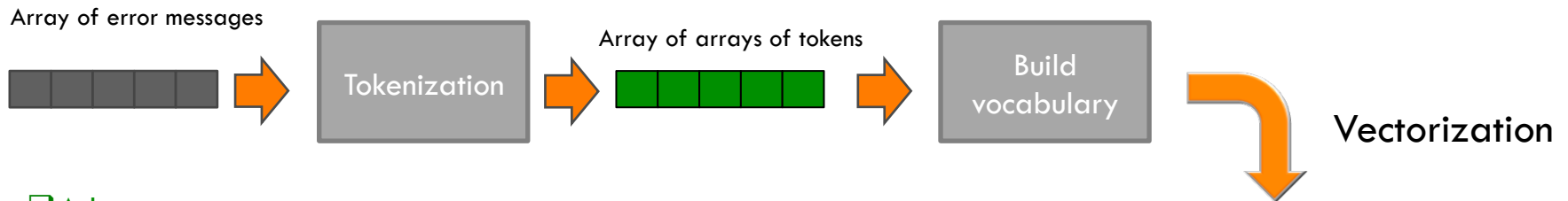
❑ Disadvantages:

- Levenshtein distances are calculated very slowly
- Levenshtein distances don't take into account strings structure
- Clusterization results suffer of noise

Strings Clusterization Pipeline **with** Preprocessing



Vector Space Model = TF-IDF + Cosine Similarity



Advantages:

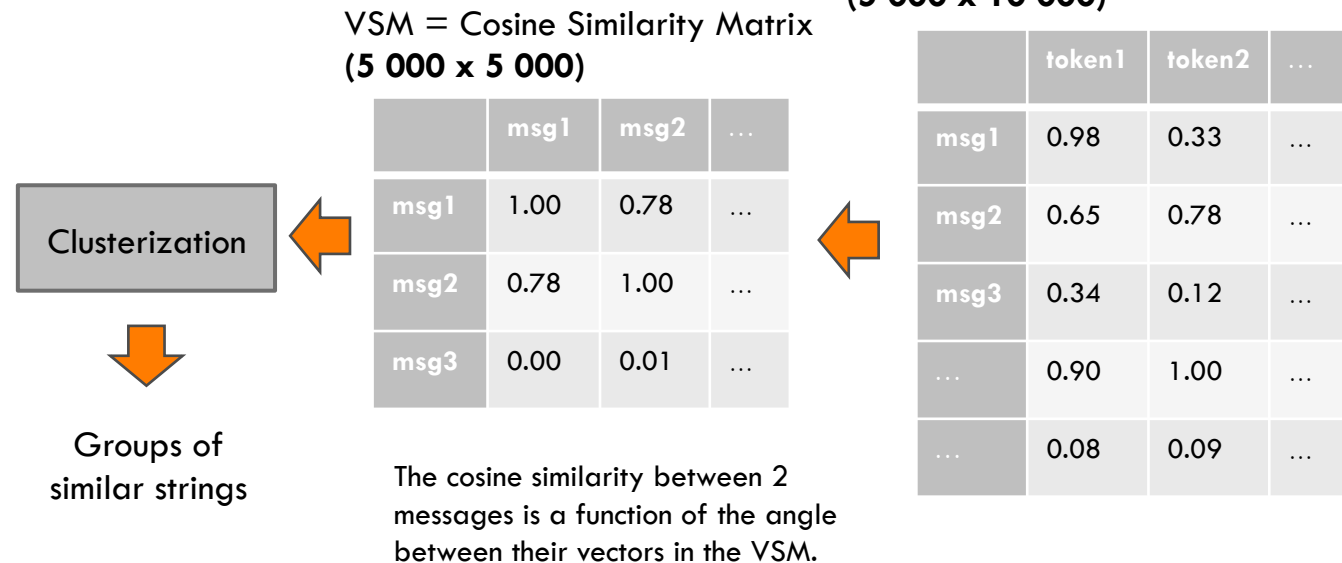
- Good at performance as log messages strings are not very long

Disadvantages:

TF-IDF limitations

- ignores tokens order and structure of messages
- In most cases it generates large sparse matrix (due to large vocabulary)

The resulting VSM are not satisfied for error logs, where structure of messages is crucial.



Tokenization Benchmark

