It Can Understand the Logs, Literally

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Outline

- Introduction to distributed system logs
- Challenges
- NLog: A NLP based log analysis approach
- Evaluation
- Conclusion

Logging in general

- Logging is a general approach to record events in a system
- System logs are critical for understanding and troubleshooting targeted systems

LOG4J 2.11.0 TM

SLF4J Simple Logging Facade for Java

splunk>

FLUME

Challenges in log analysis

- Large number of log files
- Rich information in log messages
  - Identifiers, entities, events, etc.
- Effectiveness in information extraction
  - A single log message contains multiple fields
  - Multiple log messages can contain information about the same object

A motivation example

```
Task 39 force spilling in-memory map to
disk and it will release 159.6 MB memory
```

- Existing approaches only extract identifiers and numeric values
- NLP approaches can extract events from logs

Logs in natural languages

Frameworks	**NL logs**	**Total logs**	**% of NL logs**
Yarn	84652	88628	99.5%
Spark	106686	106686	100%
MapReduce	85752	92648	92.6%
Average	**-**	**-**	**97.4%**

- Our observation finds that most logs of data analytics frameworks are written in a *natural language*

NLog

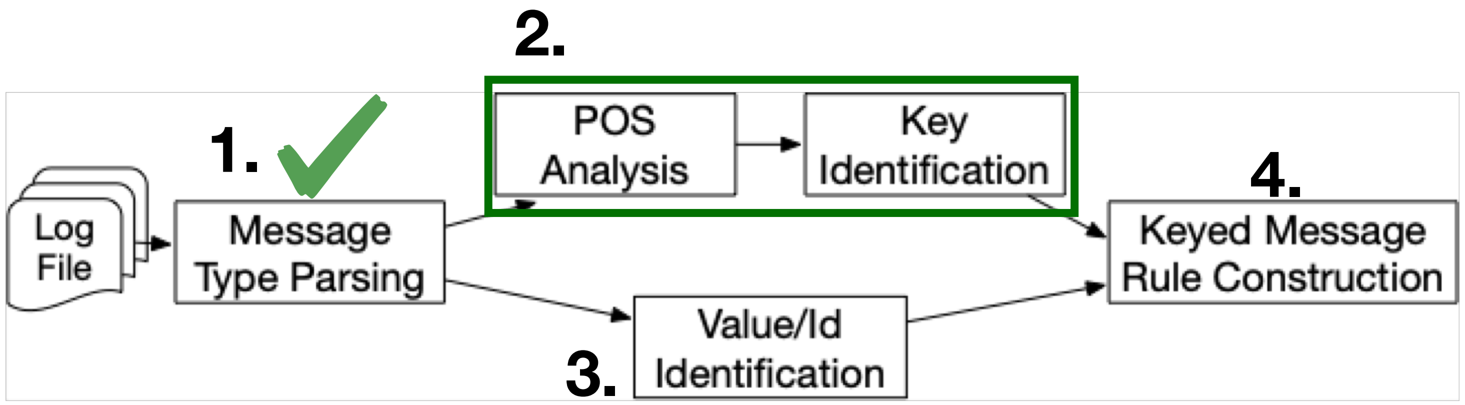
- NLog: a Natural Language Processing (NLP) based approach
- It can identify objects and events even without identifiers in logs
- Targeted systems: distributed data analytics frameworks

hadoop YARN

hadoop Map Reduce

APACHE Spark™

NLog overview



1. Message type parsing: a solved problem by Spell*

2. Identification of key objects

3. Finding identifiers and numeric values

4. Storing parsing results in keyed messages**

* **M. Du and F. Li,"Spell: Streaming parsing of system event logs" in** ***proc of ICDM'17.***

****A. Pi, W. Chen, X. Zhou, and M. Ji, "Profiling distributed systems in lightweight virtualized environments with logs and resource metrics" in** ***proc of HPDC'18***

Step 1: message type parsing

- Message type: the static string sequence of in a corresponding log printing statement

```
fetcher 4 about to shuffle               fetcher * about to shuffle
output of map attempt_1             →    output of map *
decomp: 1965 len 1969 to MEMORY          decomp: * len * to MEMORY
```

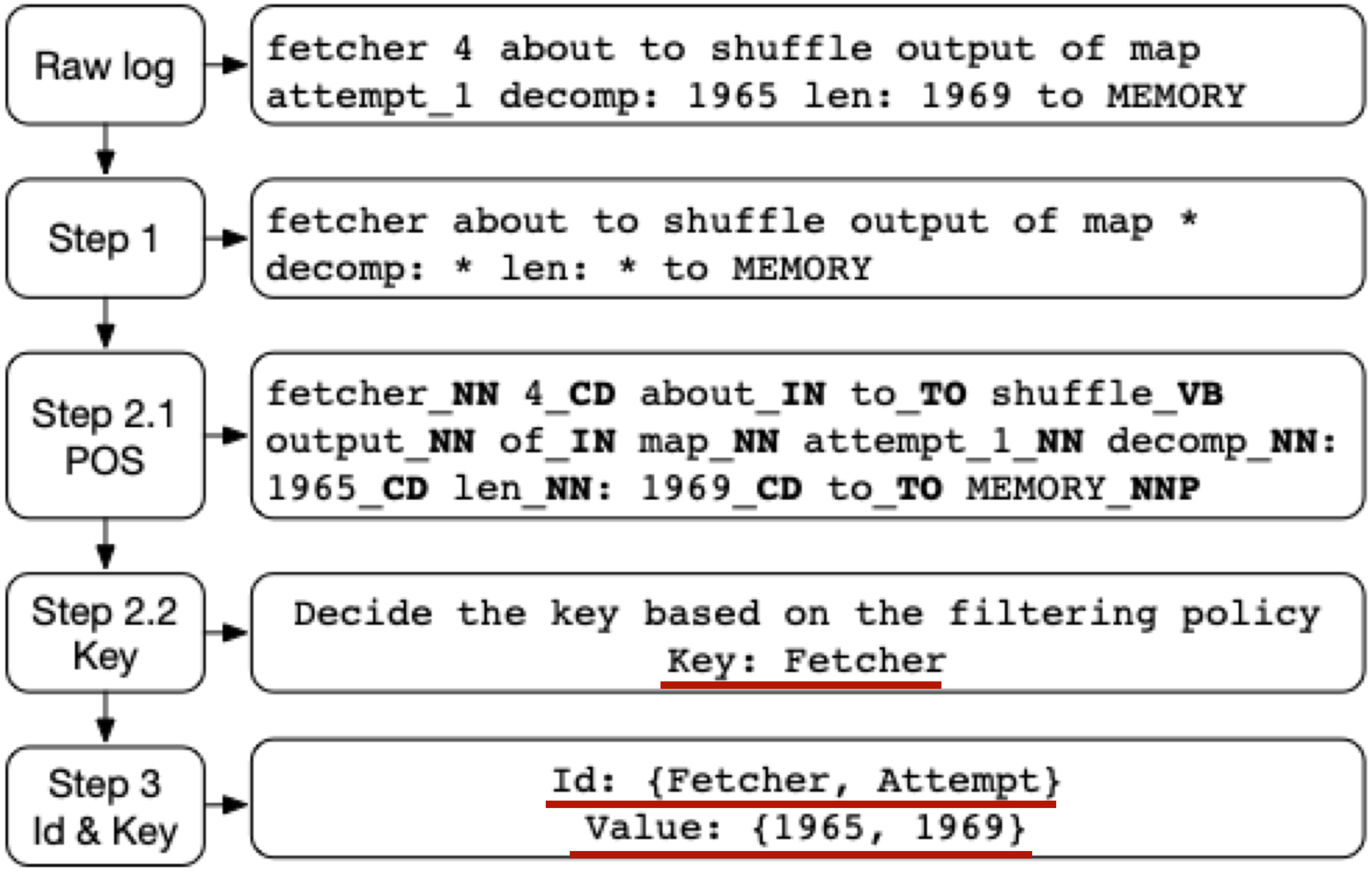
Step 2: objects & event extraction by NLP

- Part-of-speech analysis: tag each word in a log message with its part-of-speech
- Find all the noun words
- Filter noun words with a top α frequency
  - Key object words have higher frequencies
- Assign key objects as keys of a log message

Step 3: identifiers & values

- **Identifiers:** Numeric following a noun word
- **Values:** All other numeric value
    - Numeric values followed by units e.g. `kb` or `ms`

An example : put it all together



Raw log

```
fetcher 4 about to shuffle output of map
attempt_1 decomp: 1965 len: 1969 to MEMORY
```

Step 1

```
fetcher about to shuffle output of map *
decomp: * len: * to MEMORY
```

Step 2.1
POS

```
fetcher_NN 4_CD about_IN to_TO shuffle_VB
output_NN of_IN map_NN attempt_1_NN decomp_NN:
1965_CD len_NN: 1969_CD to_TO MEMORY_NNP
```

Step 2.2
Key

```
Decide the key based on the filtering policy
Key: Fetcher
```

Step 3
Id & Key

```
Id: {Fetcher, Attempt}
Value: {1965, 1969}
```

- The parsing results are in key-value format

- Users use queries on the results for troubleshooting purposes

Evaluation setup

- Setup
  - Evaluation is conducted on a 25-node cluster
  - Four Xeon E5-2640 v3 CPU and 128GB memory per node
  - Cluster is connected by 10-Gbps Ethernet
  - Yarn-3.0.0-alpha, Spark-2.1.0
- Log files
  - Randomly choose 20 MB of of 2GB files

Accuracy of object identification

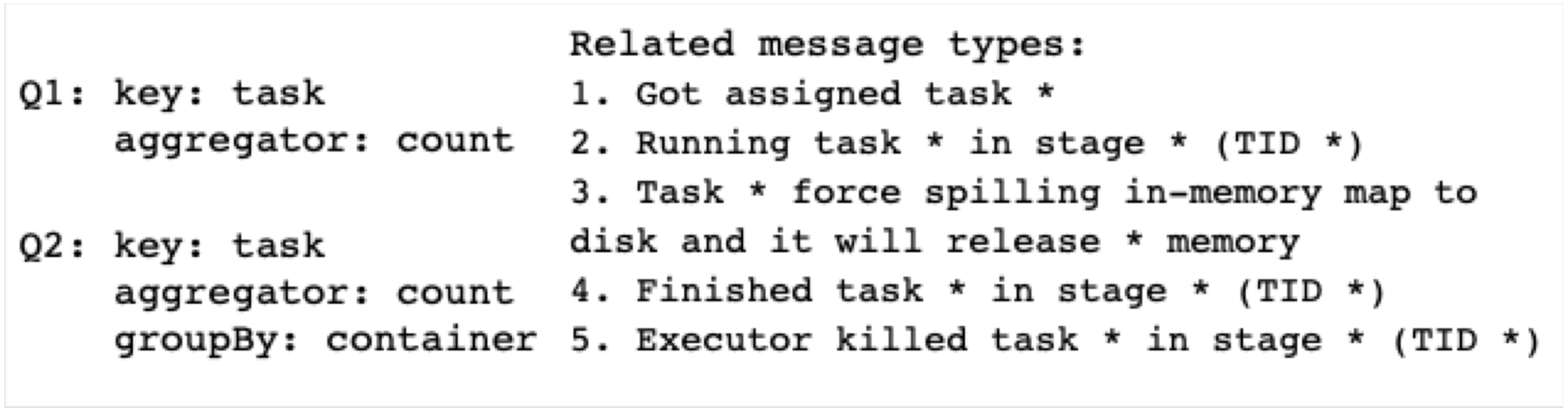
Frameworks	Total	Correct	Accuracy
Yarn	115	99	85.3%
Spark	34	32	94.1%
MapReduce	92	86	93.5%

- Inaccurate message types
  - All of its keys have too general meanings e.g. `service`
  - None of the keys includes the key objects

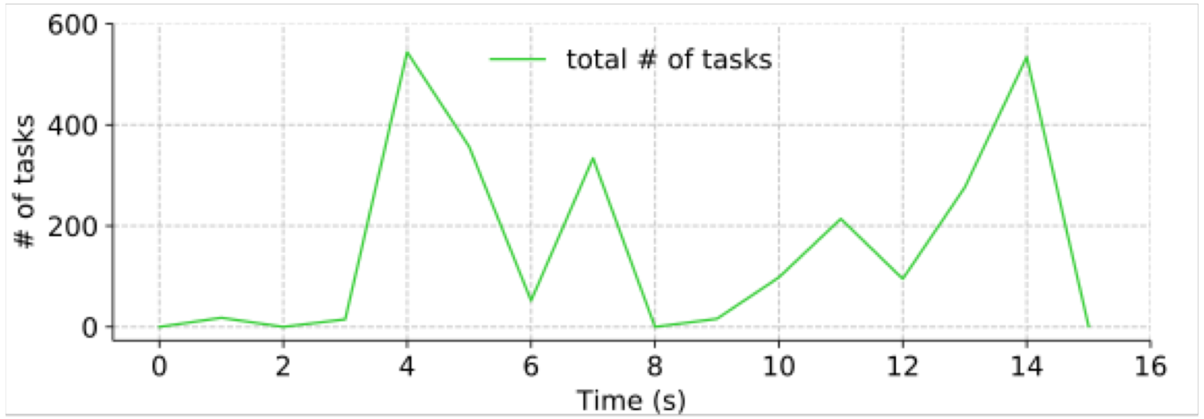
A case study

Spark TPC-H job

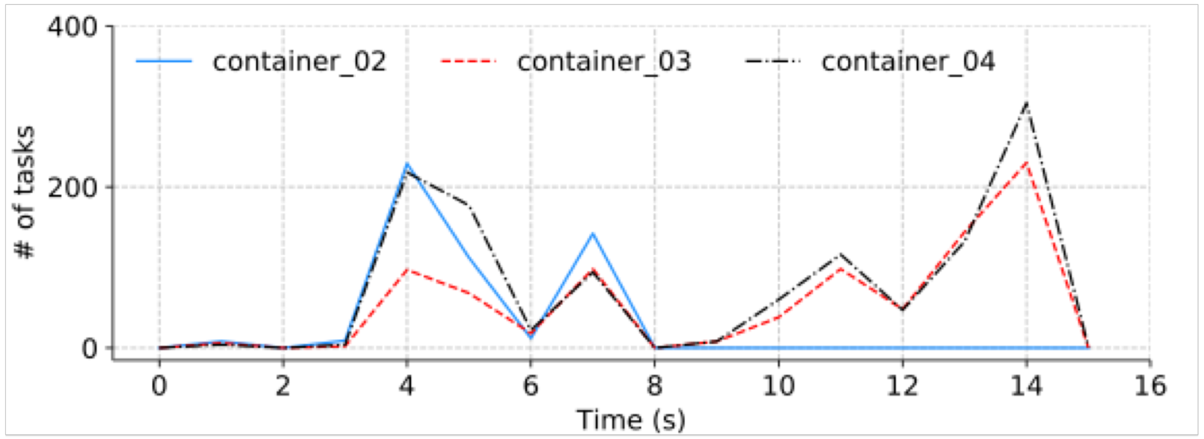
Inspect the number of tasks during job execution



```
                             Related message types:
Q1: key: task                1. Got assigned task *
    aggregator: count        2. Running task * in stage * (TID *)
                             3. Task * force spilling in-memory map to
Q2: key: task                disk and it will release * memory
    aggregator: count        4. Finished task * in stage * (TID *)
    groupBy: container 5. Executor killed task * in stage * (TID *)
```



Number of concurrently running tasks vary during job lifetime



Containers receive uneven number of tasks

The uneven task number distribution is caused by bug in Spark

Conclusion

- NLog, a NLP-based approach to identify key objects, identifiers and values in logs
- It is accurate in key object extraction
- It is helpful in understanding and troubleshooting targeted systems

IntelLog

- IntelLog: a comprehensive NLP-based log analysis approach
- Objectives:
    - Information extraction
    - Automatic workflow reconstruction
    - Automatic problem detection
- IntelLog will be published in HPDC’19, Phoenix, AZ, USA

Thank you!
Q & A