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Powering Monitoring Analytics with ELK stack

Abdelkader Lahmadi, Frédéric Beck

INRIA Nancy Grand Est,
University of Lorraine, France

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References

online Tutorials

- Elasticsearch Reference:
- Elasticsearch, The Definitive Guide:
- Logstash Reference:
- Kibana User Guide:

Books

Monitoring data

Machine-generated data

- Nagios logs
- Snort and suricata logs
- Web server and ssh logs
- Honeypots logs
- Network event logs: NetFlow, IPFIX, pcap traces

Snort log

[**] [1:2000537:6] ET SCAN NMAP -sS [**] [Classification: Attempted Information Leak]
TOS:0x0 ID:9963 IpLen:20 DgmLen:44 *****S* Seq: 0xF7D028A7 Ack: 0x0 Win: 0x800 TcpLen: 24
TCP Options (1) => MSS: 1160

Web server log

Monitoring data: properties

- Variety of data sources: flows, logs, pcap data
- Structure: structured, non-structured
- Massive volume: grow at Moore’s Law kinds of speeds

Who is looking into them?
- IT administrators
- Researchers and scientists

Why?
- Continuous monitoring tasks
- Extract useful information and insights: finding meaningful events leading to new discoveries
- Looking for a needle in a haystack: forensics and Incident Handling
- Data search, aggregation, correlation
- Predictive modelling, statistical analysis, anomaly detection
Traditional tools and techniques

Storage

- Text files, binary files
- Relational databases: MySQL, PostgreSQL, MS Access
- New trends: NoSQL databases (Redis, MongoDB, HBase, ...)

May 31st 2015, 15:44:06.039 com.whatsapp 10.29.12.166 50048 184.173.179.38 443
May 31st 2015, 15:55:40.268 com.facebook.orca 10.29.12.166 47236 31.13.64.3 443

Tools and commands

- SQL, Grep, sed, awk, cut, find, gnuplot
- Perl, Python, Shell

perl -p -e 's/\t/ /g' raw | cut -d ' ' -f5-
ELK Components

Elasticsearch Logstash Kibana

- end to end solution for logging, analytics, search and visualisation
Logstash: architecture

Event processing engine: data pipeline

- Inputs: collect data from variety of sources
- Filters: parse, process and enrich data
- Outputs: push data to a variety of destinations
Logstash: Inputs and codecs

Receive data from files, network, etc

- Network (TCP/UDP), File, syslog, stdin
- Redis, RabbitMQ, irc, Twitter, IMPA, xmpp
- syslog, ganglia, snmptrap, jmx, log4j

```json
input {
  file {
    path => "/var/log/messages"
    type => "syslog"
  }

  file {
    path => "/var/log/apache/access.log"
    type => "apache"
  }
}
```
Logstash: Filters

Enrich and process the event data

- grok, date, mutate, elapsed, ruby
- dns, geoip, useragent

```ruby
filter {
  grok {
    match => { "message" => "\{COMBINEDAPACHELOG\}" }
  }
  date {
    match => [ "timestamp" , "dd/MMM/yyyy:HH:mm:ss Z" ]
  }
}
```
Logstash: Outputs

Send event data to other systems

- file, stdout, tcp
- elasticsearch, MongoDB, email
- syslog, Ganglia

```ruby
output {
  stdout { codec => rubydebug }
  elasticsearch { host => localhost }
}
```
Elasticsearch: better than Grep!

Search engine
- Built on top of Apache Lucene: full-text-search engine library
- Schema-free
- JSON document oriented: store and REST API
- index, search, sort and filter documents

Distributed search and store
- scaling up (bigger servers) or scaling out (more servers)
- coping with failure: replication

RESTfull API
- store, fetch, alter, and delete data
- Easy backup with snapshot and restore
- No transactions nor rollback
Elasticsearch: glossary

- **Document**: main data unit used during indexing and searching, contains one or more fields
- **Field**: section of the document, a couple of name and value
- **Term**: unit of search representing a word from the text
- **Index**: named collection of documents (Like a database in a relational database)
- **type**: a class of similar documents (like a table in a relational database)
- **Inverted index**: data structure that maps the terms in the index to the documents
- **Shard**: a separate Apache Lucene index. Low level "worker" unit.
- **Replica**: an exact copy of a shard

Relational DB => Databases => Tables => Rows => Columns
Elasticsearch => Indices => Types => Documents => Fields
Elasticsearch: indexes and documents

Create Index

```bash
curl -XPUT 'localhost:9200/logs' -d {
  "settings": {
    "number_of_shards": 1,
    "number_of_replicas": 0
  }
}
```

Indexing a document

```bash
curl -XPUT 'localhost:9200/logs/apachelogs/1' -d {
  "clientip": "8.0.0.0",
  "verb": "GET",
  "request": "/images/comp_stage2_brc_topr.gif",
  "httpversion": "1.0",
  "response": "200",
  "bytes": "163"
}
```

Retrieving a document

```bash
curl -XGET 'localhost:9200/logs/apachelogs/1'
```
Elasticsearch: mapping

Define the schema of your documents

- Elasticsearch is able to dynamically generate a mapping of fields type
- It is better to provide your own mapping: date fields as dates, numeric fields as numbers string fields as full-text or exact-value strings

Create a mapping

curl -XPUT 'localhost:9200/logs' {
  "mappings": {
    "apachelogs": {
      "properties": {
        "clientip": {
          "type": "ip"
        },
        "verb": {
          "type": "string"
        },
        "request": {
          "type": "string"
        },
        "httpversion": {
          "type": "string"
        },
        "response": {
          "type": "string"
        }
      }
    }
  }
}
Elasticsearch: Querying

Search Lite

curl -XPUT 'localhost:9200/logs/apachelogs/_search'
curl -XPUT 'localhost:9200/logs/apachelogs/_search?q=response:200'

Search with Query DSL: match, filter, range

curl -XPUT 'localhost:9200/logs/apachelogs/_search' -d {
  "query" : {
    "match" : {
      "response" : "200"
    }
  }
}
curl -XPUT 'localhost:9200/logs/apachelogs/_search' -d {
  "query" : {
    "filtered" : {
      "filter" : {
        "range" : {
          "bytes" : { "gt" : 1024}
        }
      },
      "query" : {
        "match" : {
          "response" : "200"
        }
      }
    }
  }
}
Elasticsearch: Aggregation

Analyze and summarize data

- How many needles are in the haystack?
- What is the average length of the needles?
- What is the median length of the needles, broken down by manufacturer?
- How many needles were added to the haystack each month?

Buckets

- Collection of documents that meet a criterion

Metrics

- Statistics calculated on the documents in a bucket

SQL equivalent

```sql
SELECT COUNT(response) FROM table GROUP BY response
```

- COUNT(response) is equivalent to a metric
- GROUP BY response is equivalent to a bucket
Aggregation: buckets

- partitioning document based on criteria: by hour, by most-popular terms, by age ranges, by IP ranges

```bash
curl -XPUT 'localhost:9200/logs/apachelogs/_search?search_type=count' -d {
  "aggs": {
    "responses": {
      "terms": {
        "field": "response"
      }
    }
  }
}
```

- Aggregations are placed under the top-level aggs parameter (the longer aggregations will also work if you prefer that)
- We then name the aggregation whatever we want: responses, in this example
- Finally, we define a single bucket of type terms
- Setting search_type to count avoids executing the fetch phase of the search making the request more efficient
Aggregation: metrics

- metric calculated on those documents in each bucket: min, mean, max, quantiles

```bash
curl -XPUT 'localhost:9200/logs/apachelogs/_search?search_type=count'
  -d {
    "aggs": {
      "responses": {
        "terms": {
          "field": "response"
        },
        "aggs": {
          "avg_bytes": {
            "avg": {
              "field": "bytes"
            }
          }
        }
      }
    }
  }
```
**Aggregation: combining them**

An aggregation is a combination of buckets and metrics

- Partition document by client IP (bucket)
- Then partition each client bucket by verbe (bucket)
- Then partition each verbe bucket by response (bucket)
- Finally, calculate the average bytes for each response (metric)
- **Average bytes per \(<\text{client IP, verbe, response}>\)**

Many types are available

- terms
- range, date_range, ip_range
- histogram, date_histogram
- stats/avg, min, max, sum, percentiles
Kibana: visualisation

Data visualisation

- browser-based interface
- search, view, and interact with data stored in Elasticsearch indice
- charts, tables, and maps
- dashboards to display changes to Elasticsearch queries in real time
**Kibana: setting your index**

```bash
curl 'localhost:9200/_cat/indices?v'
```

<table>
<thead>
<tr>
<th>index</th>
<th>pri</th>
<th>rep</th>
<th>docs.count</th>
<th>docs.deleted</th>
<th>store.size pri</th>
<th>store.size</th>
</tr>
</thead>
<tbody>
<tr>
<td>logstash-1998.04.30</td>
<td>5</td>
<td>1</td>
<td>98434</td>
<td>0</td>
<td>20.6 mb</td>
<td>20.6 mb</td>
</tr>
<tr>
<td>logstash-1998.05.01</td>
<td>5</td>
<td>1</td>
<td>1094910</td>
<td>0</td>
<td>205.8 mb</td>
<td>205.8 mb</td>
</tr>
</tbody>
</table>

This page lists every field in the logstash-* index and the field's associated core type as recorded by Elasticsearch. While this list allows you to view the core type of each field, changing field types must be done using Elasticsearch’s Mapping API.

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>format</th>
<th>analyzed</th>
<th>indexed</th>
<th>controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>tags</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>host</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_source</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_index</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>path.raw</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@version</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tags.raw</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>message</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@timestamp</td>
<td>date</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_type</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>_id</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>host.raw</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>path</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>geoip.location</td>
<td>geo_point</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bytes</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clientip.raw</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clientip</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>response</td>
<td>string</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Kibana: discover

- Explore your data with access to every document
- Submit search query, filter the search
- Save and Load searches
## Kibana: search

### Query language

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lang:en</td>
<td>to just search inside a field named &quot;lang&quot;</td>
</tr>
<tr>
<td>lang:e?</td>
<td>wildcard expression</td>
</tr>
<tr>
<td>user.listed_count:[0 to 10]</td>
<td>range search on numeric fields</td>
</tr>
<tr>
<td>lang:ens</td>
<td>regular expression search (very slow)</td>
</tr>
</tbody>
</table>
Area chart: Displays a line chart with filled areas below the lines. The areas can be displayed stacked, overlapped, or some other variations.

Data table: Displays a table of aggregated data.

Line chart: Displays aggregated data as lines.

Markdown widget: Use the Markdown widget to display free-form information or instructions about your dashboard.

Metric: Displays one the result of a metric aggregation without buckets as a single large number.

Pie chart: Displays data as a pie with different slices for each bucket or as a donut (depending on your taste).

Tile map: Displays a map for results of a geohash aggregation.

Vertical bar chart: A chart with vertical bars for each bucket.
Kibana: dashboard

Displays a set of saved visualisations in groups

- Save, load and share dashboards
What else?

Elasticsearch is very active and evolving project

- Watchout when using the wildcard!
- Deleting a mapping deletes the data
- Respect procedures to update mappings
- Backup is easy¹, do it!

¹https://github.com/taskrabbit/elasticsearch-dump
Hands-on Lab