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Powering Monitoring Analytics with ELK stack

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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


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, ...)

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 Architecture Diagram]
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

```ruby
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

```
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

RESTful 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

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

Indexing a document

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

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

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

```json
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

```javascript
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 <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**

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>20.6mb</td>
<td>20.6mb</td>
</tr>
<tr>
<td>logstash-1998.05.01</td>
<td>5</td>
<td>1</td>
<td>1094910</td>
<td>0</td>
<td>205.8mb</td>
<td>205.8mb</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>Expression</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>lang:en</code></td>
<td>to just search inside a field named &quot;lang&quot;</td>
</tr>
<tr>
<td><code>lang:e?</code></td>
<td>wildcard expression</td>
</tr>
<tr>
<td><code>user.listed_count:[0 to 10]</code></td>
<td>range search on numeric fields</td>
</tr>
<tr>
<td><code>lang:ens</code></td>
<td>regular expression search (very slow)</td>
</tr>
</tbody>
</table>
**Kibana: visualize**

- **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 easy \(^1\), do it!

\(^1\)https://github.com/taskrabbit/elasticsearch-dump
Hands-on Lab