Centralized Log Management with Elastic Stack

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Outline

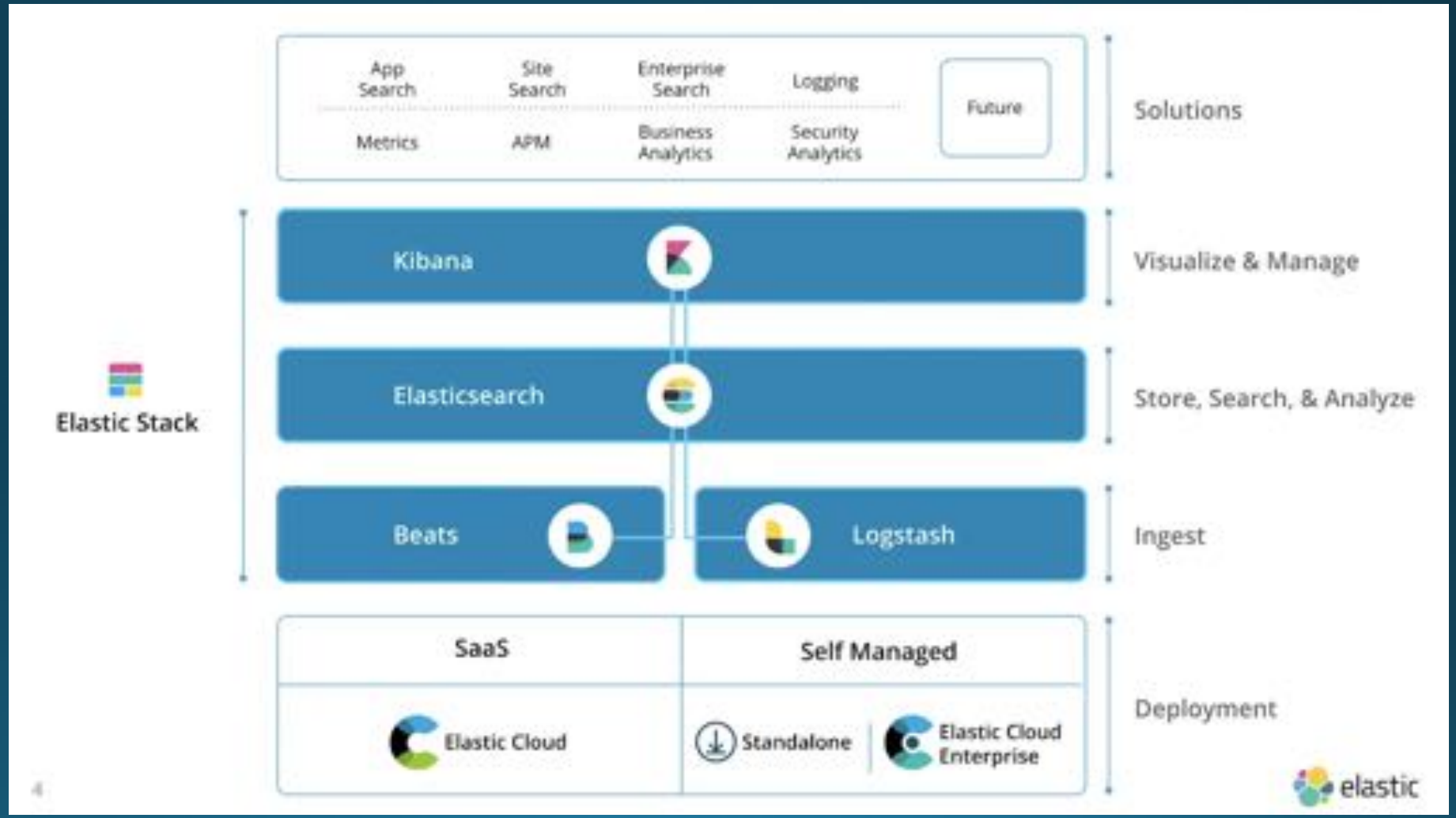
- Problem Statement
- Elastic Stack
- Log Management Service
  - Architecture Design
  - Implementation Details
  - Advanced Design
- Querying Data
- Data Backup/Restore
- Management & Monitoring Tools

Problem Statement

- Context
  - In Microservices architecture, an application consists of multiple services and service instances that are running on multiple machines.
  - Each service instance generates writes information about what it is doing to a log file.
- Problem
  - How to query information related to system operation from the data efficiently.
  - How to troubleshoot bugs from multiple log files
- Solution
  - Build a log management service with Elastic Stack, because it is a mature and complete open source tool.

What is the ELK Stack?

The ELK Stack is a collection of multiple open-source products, all developed, managed and maintained by Elastic.

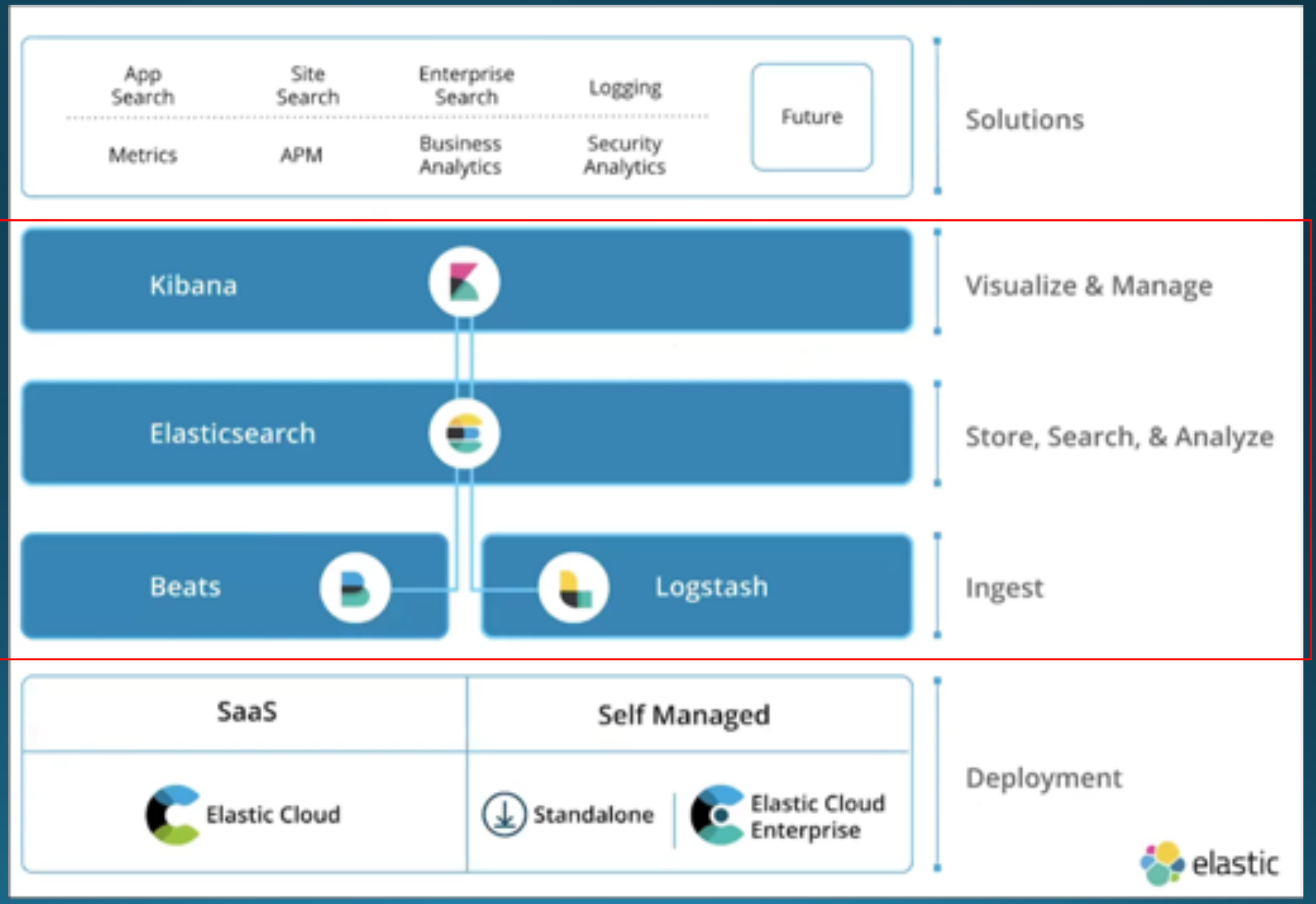


ref

What is the ELK Stack?

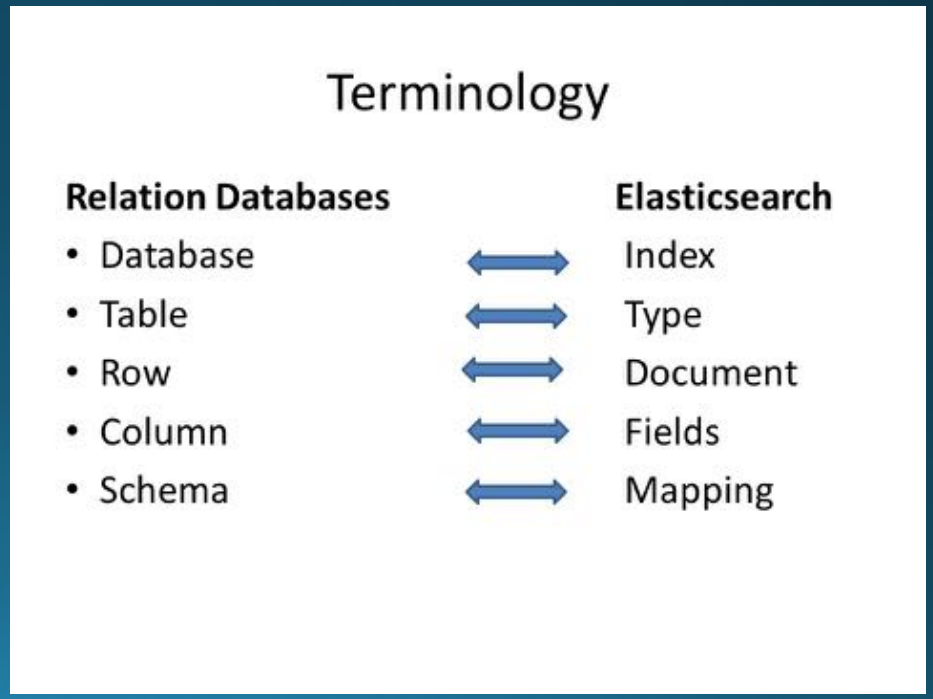
However, we only need to use the following modules for this solution.

- **Beats**: agents to ship log data
- **Logstash**: processing log data
- **Elasticsearch**: storing log data
- **Kibana**: UI for visualizing



Elasticsearch Basic Concepts

- Index
  - An index contains one or multiple types
  - An Elasticsearch index is an independent chunk of document and stored on the disk in the same set of files
- Type
  - A type can be thought of as a table in a RDB
  - A type has one or more documents
- Document
  - A document is normally a JSON representation of your data

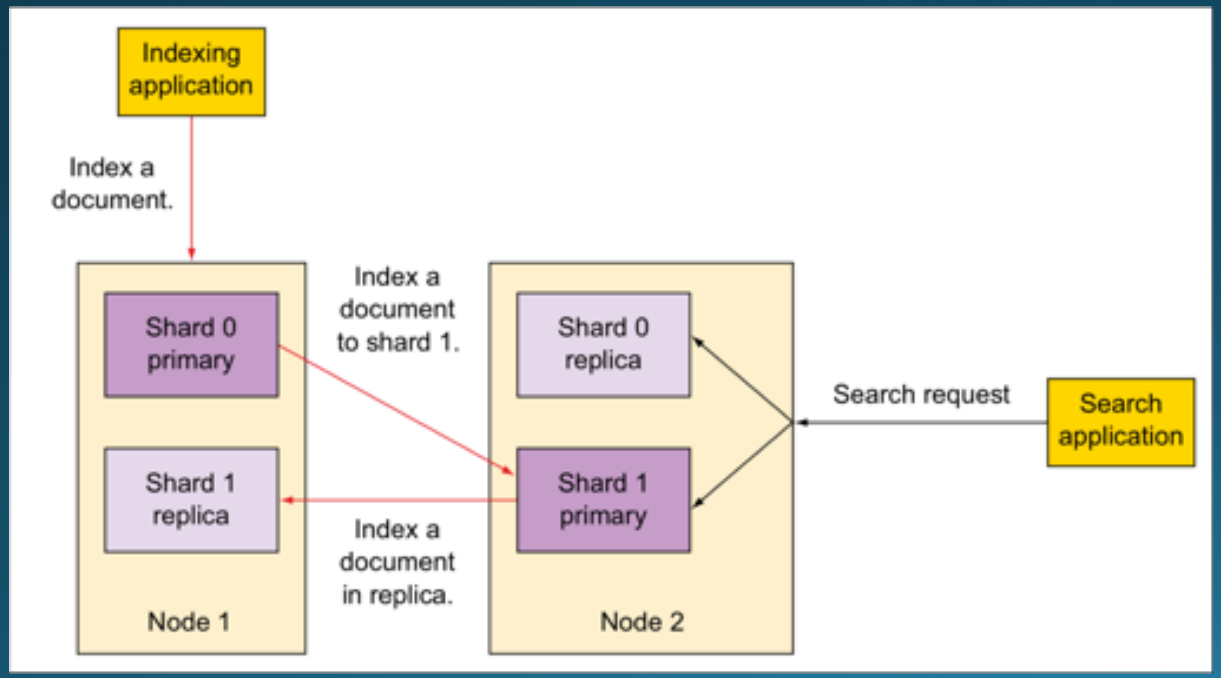


Elasticsearch Basic Concepts

- Cluster
  - A cluster has one or more nodes. Clusters are identified by their names. (default cluster name= elasticsearch)
- Node
  - A node is an instance of Elasticsearch
  - Multiple nodes can join the same cluster. With a cluster of multiple nodes, the same data can be spread across multiple servers.
- Shard
  - An index can be divided into shards.
  - There are two types of shards
    - primary
    - replica

Elasticsearch Basic Concepts

- Node types
  - **Master node:** in charge of cluster management
  - **Data node**: Data nodes hold data and perform CRUD, search, and aggregations.
  - **Ingest node**: for pre-processing documents before indexing
  - **Machine learning node**



Each document, when indexed, is first added to the primary shard and then to one or more replica shards

ref Elasticsearch in action 2015

Elasticsearch Basic Concepts

- Minimum master nodes
  - We can specify a property that Elasticsearch evaluates to find out the minimum number of nodes that are needed as master eligible

- Split Brain Problem
  - To avoid this problem, we can use ***discovery.zen.minimum_master_nodes*** setting for cluster setup.
  - The value of this setting can be derived as: **(Total number of nodes / 2) + 1**

    For example: If we have 4 nodes, so we should keep this value to 3

    discovery.zen.minimum_master_nodes=3

Log Management Architecture Design

Data processing flow:

1. Filebeat will ship all the logs to Logstash

2. Logstash transform data format and output to Elasticsearch

3. view logs on Kibana and query by specific field

Implementation Details

Installing Elastic Stack using Docker Compose

```yaml
version: '2.2'
services:
  elasticsearch:
    image: docker.elastic.co/elasticsearch/elasticsearch:7.0.0
    container_name: es01
    environment:
      - node.name=es01
      - cluster.initial_master_nodes=es01
      - cluster.name=docker-cluster
      - bootstrap.memory_lock=true
      - "ES_JAVA_OPTS=-Xms512m -Xmx512m"
    ulimits:
      memlock:
        soft: -1
        hard: -1
    volumes:
      - esdata01:/usr/share/elasticsearch/data
    ports:
      - 9200:9200
    networks:
      - esnet
  kibana:
    container_name: kibana
    image: docker.elastic.co/kibana/kibana:7.0.0
    environment:
      ELASTICSEARCH_HOSTS: http://es01:9200
    ports:
      - 5601:5601
    networks:
      - esnet
  logstash:
    container_name: logstash
    image: docker.elastic.co/logstash/logstash:7.0.0
    volumes:
      - /tmp/pipeline:/usr/share/logstash/pipeline/
      - /tmp/input:/tmp/input
    networks:
      - esnet
```

Implementation Details

- Filebeat
  - is a lightweight log data shipper for local files
  - monitors all the logs in the log directory and forwards to Logstash
  - configuration:

```
filebeat.inputs:
- type: log
  enabled: true
  paths:
    - /tmp/log/api.log
  multiline:
    pattern: '(^.+Exception: .+)|(^\s+at .+)|(^\s+... \d+ more)
    negate: false
    match: after
  fields:
    index: api
    doc: spring-boot
output.logstash:
  hosts: ["localhost:5044"]
```

Because Java stack traces consist of multiple lines, so we need consolidate these lines into a single event in Filebeat

Logstash output sends events directly to Logstash by TCP

Implementation Details

- Logstash
  - An open source, server-side data processing pipeline that ingests data from a multitude of sources, transforms it, and then sends it to your favorite “stash.”
  - configuration:

The Logstash event processing pipeline has three stages:

1. input
2. filters (optional)
3. outputs

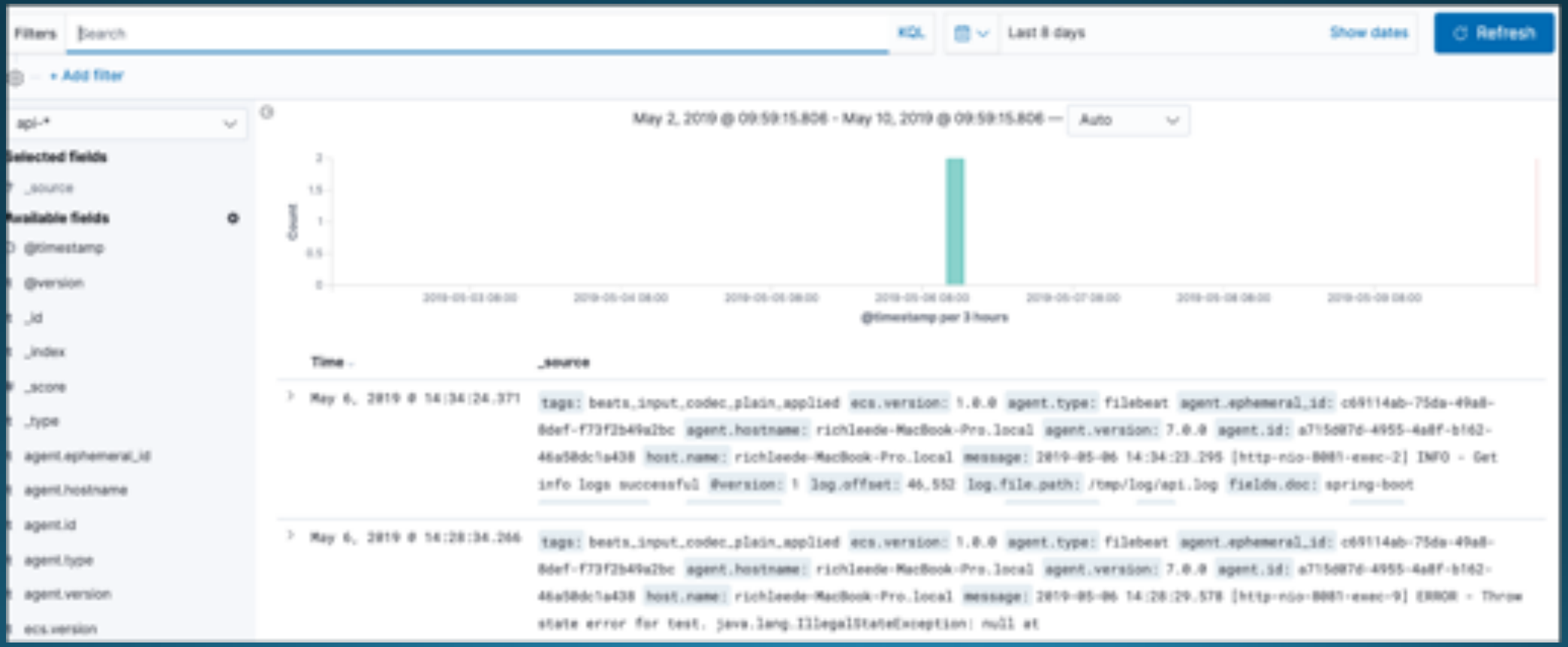
```
input {
  beats {
    port => "5044"
  }
}

filter {
  #If log line contains tab character followed by 'at' then we will tag that entry as stacktrace
  if [message] =~ "\tat" {
    grok {
      match => ["message", "^(\tat)"]
      add_tag => ["stacktrace"]
    }
  }
}

output {
  stdout { codec => rubydebug }
  elasticsearch {
    hosts => [ "localhost:9200" ]
    index => "%{[fields][index]}-%{+YYYY.MM.dd}"
  }
}
```

Implementation Details

- Kibana
  - The Discover page allows you to perform different types of searches on the log data.



Advanced Design for Large Amounts of Logs

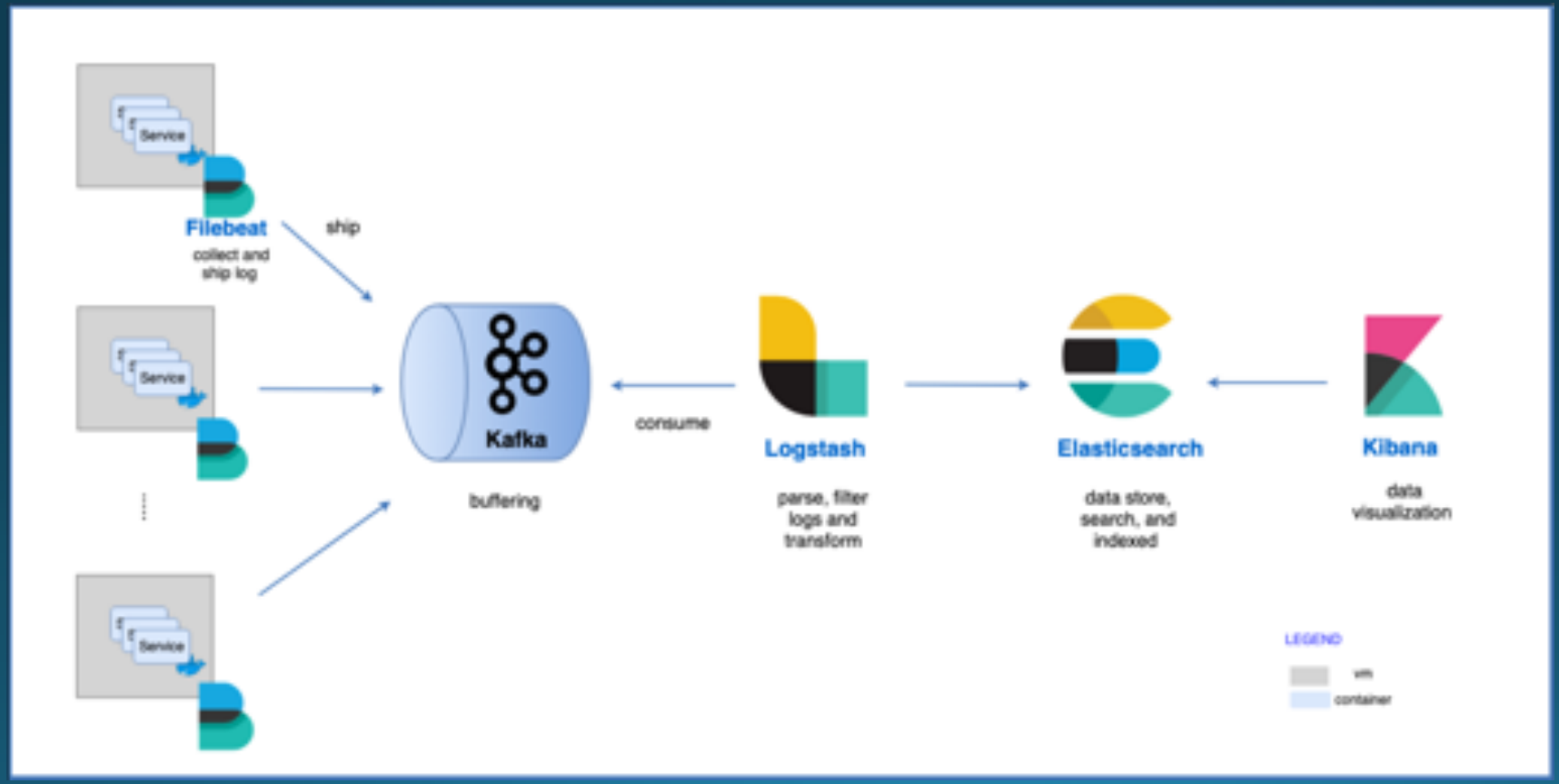
- Context:
  - When the service increases, the amount of data in the log will become larger
  - Following a production incident, logs can suddenly surge
- Problem:
  - The receiving end (Logstash or Elasticsearch) will be the main bottleneck.
  - Suddenly surge logs will overwhelm your logging infrastructure.
- Solution:
  - To protect Logstash and Elasticsearch against such data bursts, users deploy buffering mechanisms to act as message brokers.

Advanced Design for Large Amounts of Logs

- Apache Kafka is a Publish-Subscribe messaging system, originated at Linkedin in 2009, open sourced in 2011. Apache Kafka has some characteristics such as:
  - Kafka was designed to be distributed inherently. This makes Kakfa be very easy to scale out.
  - High throughput, high performance
  - Guarantee the fault-tolerant in term of machine failure.

Advanced Design for Large Amounts of Logs

- Apache Kafka is the most common broker solution deployed together the ELK Stack.
- Usually, Kafka is deployed between the shipper and the indexer, acting as an entrypoint for the data being collected



Advanced Design for Large Amounts of Logs

- Logstash config: aggregates the data from the Kafka topic, processes it and ships to Elasticsearch.

```
input {
  kafka {
    bootstrap_servers => "localhost:9092"
    topics => "apache"
    }
}

filter {
    grok {
      match => { "message" => "%{COMBINEDAPACHELOG}" }
    }
    date {
    match => [ "timestamp" , "dd/MMM/yyyy:HH:mm:ss Z" ]
    }
  geoip {
      source => "clientip"
    }
}

output {
  elasticsearch {
    hosts => ["localhost:9200"]
  }
}
```

Logstash Kafka input plugin to define the Kafka host and the topic we want Logstash to pull from.

Advanced Design for Large Amounts of Logs

- Filebeat config: collects logs and forwards them to a Kafka topic.

```
filebeat.inputs:
- type: log
  enabled: true
  paths:
    - /var/log/apache2/access.log
output.kafka:
  codec.format:
    string: '%{[@timestamp]} %{[message]}'
  hosts: ["localhost:9092"]
  topic: apache
  partition.round_robin:
    reachable_only: false
  required_acks: 1
  compression: gzip
  max_message_bytes: 1000000
```

forward the data to Kafka server and the relevant topic

Querying Data

- Elasticsearch Query DSL
  - Get mapping field of index

```
curl -XGET 'http://localhost:9200/api-2019.05.06?pretty'
```

  - Get document by id

```
curl -XGET 'http://localhost:9200/api-2019.05.06/_doc/sxXZi20B-PgPWl1Y9Cl1?pretty=true'
```

  - URI Search

```
curl -XGET 'http://localhost:9200/api-2019.05.06    \
/_search?q=message:ERROR&from=0&size=10&sort=@timestamp:desc&pretty'
```

Querying Data

- Elasticsearch Query DSL
  - Request Body Search

```
curl -H "Content-Type: application/json"  \
-XGET 'http://localhost:9200/api-2019.05.06/_search?pretty' -d \
'{
   "query" : {
      "match" : { "message": "ERROR"}
   }
}'
```

  - Count query

```
curl -H "Content-Type: application/json" \
-XGET 'http://localhost:9200/api-2019.05.06/_doc/_count?pretty' -d \
'{
  "query" : {
    "term" : {"message" : "ERROR"}
  }
}'
```

Querying Data

- Elasticsearch Query DSL
  - Validate DSL

```
curl -H "Content-Type: application/json" \
-XGET 'http://localhost:9200/api-2019.05.06/_doc/_validate/query?pretty' -d \
'{
 "query" : {
  "term" : {"message" : "ERROR"}
 }
}'
```

result:

```
{
 "_shards" : {
  "total" : 1,
  "successful" : 1,
  "failed" : 0
 },
 "valid" : true
}
```

Querying Data

- Kibana
  - is the front end for Elasticsearch and provides visualizations for data, that can be used to search, view, and analyze data.
- Kibana User Interface
  - Discover
  - Visualize
  - Dashboard
- Kibana Query Language (KQL)
  - Release from version 6.3
  - If a default field is not set these terms will be matched against all fields

Querying Data

- Kibana Query Language (KQL)
  - Match query

    message:"info”
  - Token analyzer query

    message:"info error"
  - Multiple values query

    message:(info or error)
  - Wildcard query

    container.name: *api
  - Field exist querie

    fields.doc:*

Backing Up Data

- Backup Snapshot
  - Using the snapshot API to back up the cluster.
  - The current state and data in the cluster are saved in a shared repository.
  - The first snapshot is a complete copy of the data, but all subsequent snapshots are incremental backups

- There are several options to choose from for a repository:
  - Shared filesystem such as NAS
  - Azure Cloud
  - Amazon S3
  - HDFS

Backing Up Data

- Performing a cluster backup entails executing three steps:
  1. Define a repository (Instruct Elasticsearch on how you want the repository structured)
  2. Confirm the existence of the repository
  3. Execute the backup

- Backup/restore example:
  - Step1: Defining a new repository

```
curl -XPUT 'localhost:9200/_snapshot/foo_backup' -d
'{
 “type” : “fs”,  //shared file system type
 "settings" : {
  "location" : "/usr/share/elasticsearch/data/backups/foo_backup"
 }
}'
```

Backing Up Data

- Step2: Check the repository existence

```
curl -XGET 'localhost:9200/_snapshot/foo_backup?pretty'
```

- Step3: Create a snapshot of particular index (api-2019.05.23)

```
curl -XPUT 'localhost:9200/_snapshot/foo_backup/snapshot_api-2019.05.23' -d '
{
  "indices" : "api-2019.05.23”    //Comma-separated list of index names to snapshot
}'
```

- Step4: Monitoring snapshot progress

```
curl -XGET 'localhost:9200/_snapshot/foo_backup/snapshot_api-2019.05.23/_status'
```

Backing Up Data

- Step5: Retrieving information on the state of a given snapshot

```
curl -XGET 'localhost:9200/_snapshot/foo_backup/snapshot_api-2019.05.23'
```

response:


```
{
  "snapshots": [
    {
      "snapshot": "napshot_api-2019.05.23",
      "uuid": "knM5TEZrRxKhIqvpPQO74w",
      "version_id": 7000099,
      "version": "7.0.0",
      "indices": ["api-2019.05.23"],
      "include_global_state": true,
      "state": "SUCCESS",
      "start_time": "2019-05-24T06:30:11.737Z",
      "start_time_in_millis": 1558679411737,
      "end_time": "2019-05-24T06:30:11.791Z",
      "end_time_in_millis": 1558679411791,
      "duration_in_millis": 54,
      "failures": [],
      "shards": {
        "total": 1,
        "failed": 0,
        "successful": 1
      }
    }
  ]
}
```

Backing Up Data

- Step6: Restoring from a snapshot

  The default action is to restore all the indices present in the snapshot

```
curl -XPOST 'localhost:9200/_snapshot/foo_backup/snapshot_2/_restore'
```

or set wait_for_completion flag=true (executes in the foreground)

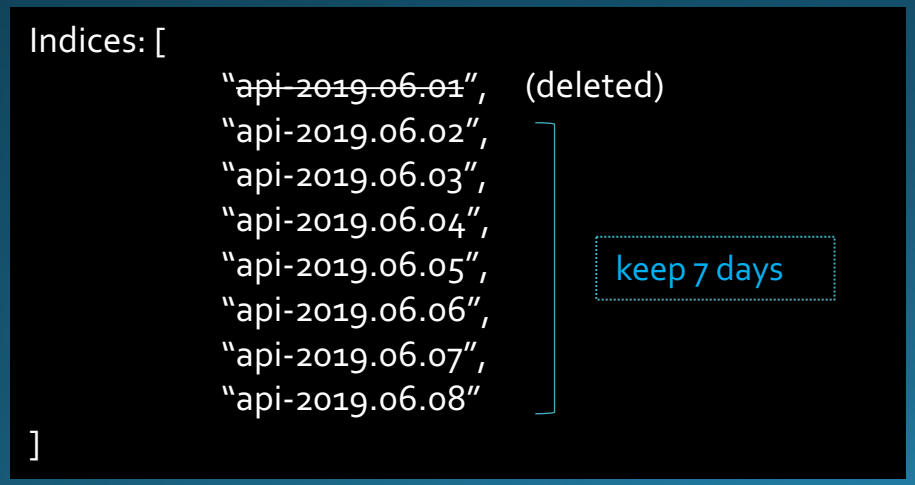
```
curl -XGET 'localhost:9200/_snapshot/foo_backup/snapshot_api-
2019.05.23'?wait_for_completion=true
```

Housekeeping Strategy

- Time-based indices
  - Index name pattern: <index_name>.**yyyy.MM.dd**
  - faster and reduces to remove documents and reduces memory CPU and overhead (delete by index directly)
  - large amounts of bulk deletions can result in large Lucene index segments

- Cron Job: delete the index seven days before every AM 2:00

For example: if housekeeping is 7 days and today is 2019/06/08, then delete 6/01 index



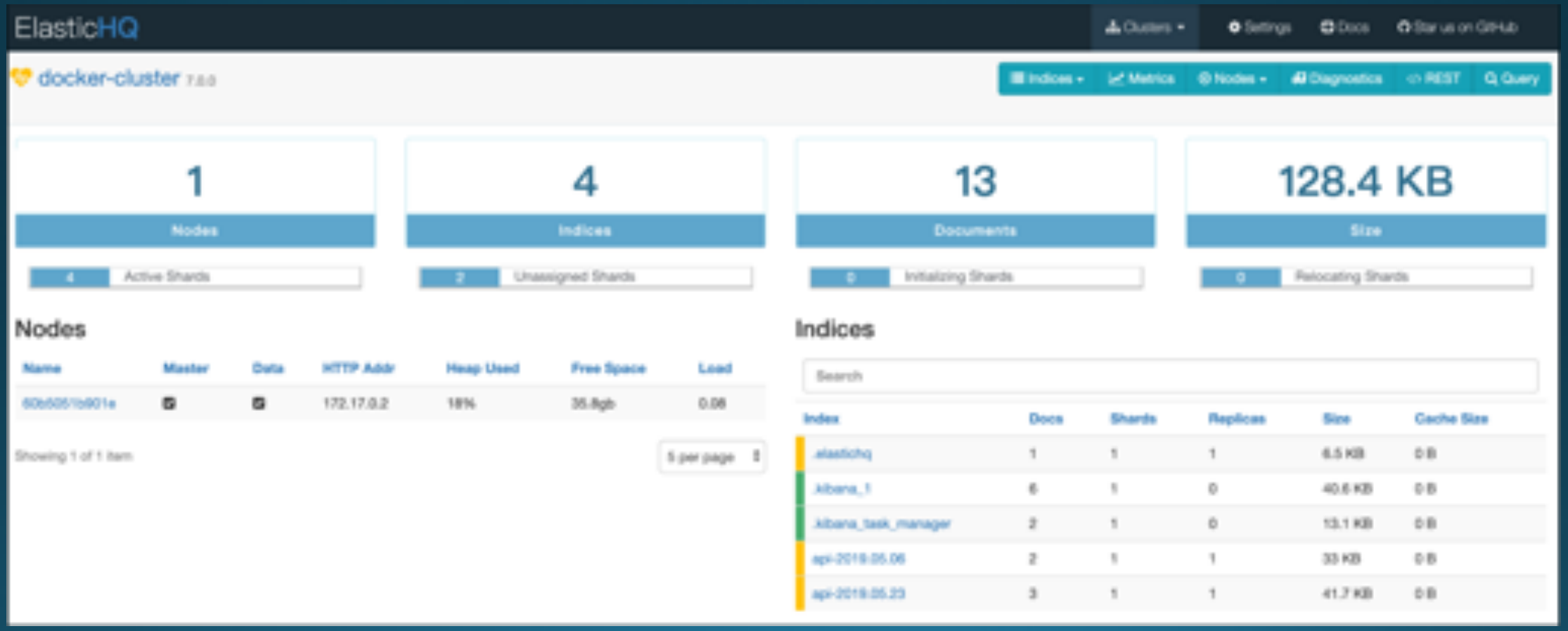
Management & Monitoring Tools

- Elasticsearch Admin GUI Tools:
  - ElasticHQ : as a monitoring and management platform for Elasticsearch clusters.
  - Cerebro: is a elasticsearch web admin tool built using Scala, Play Framework, AngularJS and Bootstrap.

ElasticHQ	Cerebro
Apache Software License	MIT License
Can monitor and manage many clusters at the same time	Observe the index shards allocation
Monitor and manage clusters, nodes, indices, aliases, and shards	Manage cluster settings, aliases and index templates
Easy-to-Use Querying capabilities	Create snapshot
Saves monitored clusters	

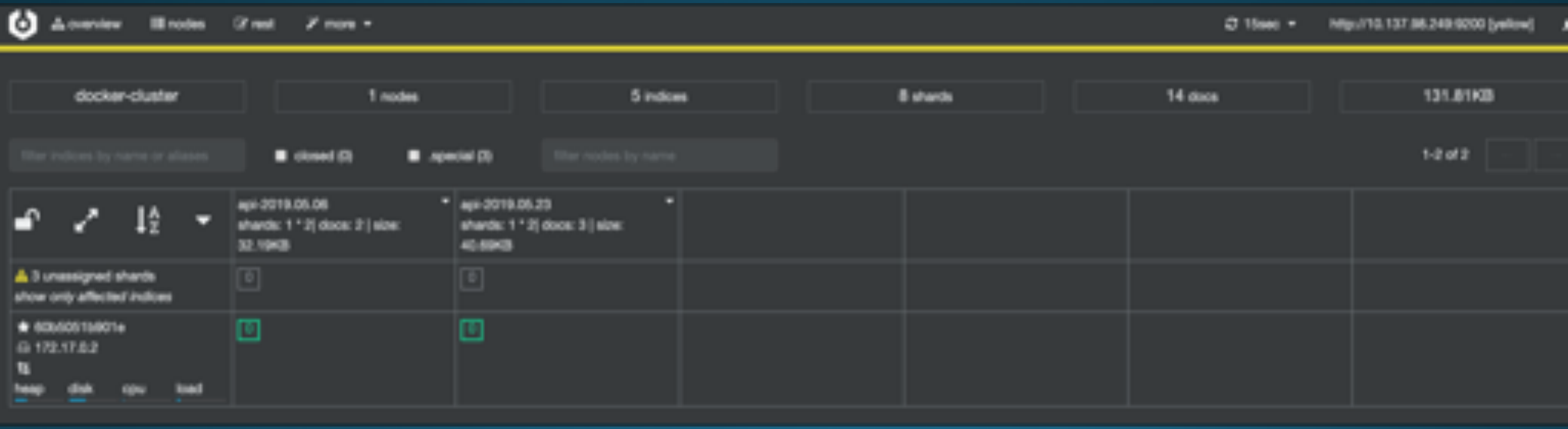
Management & Monitoring Tools

- ElasticHQ



Management & Monitoring Tools

- Cerebro



Management & Monitoring Tools

- Cerebro (snapshot management)