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SCARF

CONTAINER-BASED APPROACH TO CLOUD-SCALE DIGITAL FORENSICS

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OVERVIEW

- Motivation for building SCARF
- Previous work
- SCARF goals
- SCARF design
- SCARF architecture and walkthrough
- Results of testing

MOTIVATION

- Massive amounts of data to investigate, only getting worse
- As SSD, NVMe, and other speedy drives become popular, current generation of tools won't perform at speed
  - Spinning disks have masked a processing bottleneck
- Current forensic tools aren’t built for scale

VARIOUS DISKS FOR SALE (AUG 2017)

Spinning Disks		
$	Size (TB)	$/TB
199.99	8	24.99
109.99	4	27.50
89.99	3	30.00

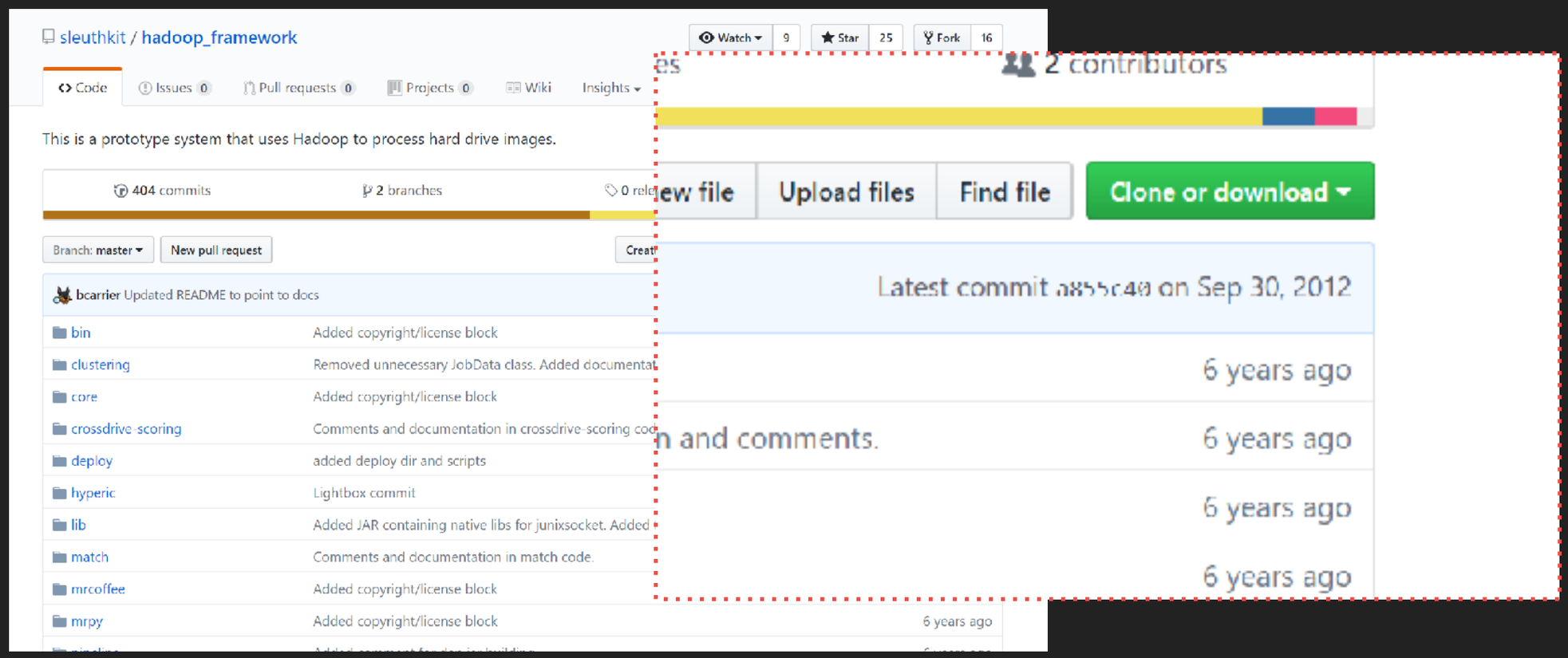
Solid State		
$	Size (GB)	$/TB
274.99	1024	274.99
179.99	512	359.98

NVMe		
$	Size (GB)	$/TB
127.99	250	512.96
199.99	512	399.98
447.88	1024	447.88

USB Drives		
$	Size (GB)	$/TB
6.99	32	223.68
40.99	128	327.92
61.17	256	244.68

OBVIOUS PROBLEM, SO WHAT HAVE OTHERS DONE

- Sleuthkit Hadoop abandoned, but map/reduce isn't a good fit anyway - we want to process *streaming* data
- Hansken project at Netherlands Forensic Institute not open source



CONTAINERS

- Core idea is not new - *jail*
- We can think of as easy-to-implement, low-cost modules for specific tasks
  - Task examples - hashing, ExifTools, BulkExtractor
- Most importantly: **containers can be SCALED**
- Docker is the choice here - others can be used (rkt, LXD, Kubernetes)
  - Kubernetes was initially used

SCARF: GOALS

- **SCA**lable **R**ealtime **F**orensics
- **Top priority** is to *effectively* throw more hardware at any dataset
- Ability to incorporate existing forensic tools
- Stream processing - start get answers before a full target read
- Ultimately, we want to process at IO speed
  - If we can read from SSD at 500MB/s, want to analyze at 500MB/s

SCARF: DESIGN

- SCARF is a *framework* built to support digital forensics
  - **Distributed** - can throw more hardware at the problem
  - **Extensible** - can use existing tools (BulkExtractor, Tika)
  - **Accountable** - keeps track of executed and failed ‘tasks’
  - **Retrievable** - keeps results in scalable database for real time queries
- Open Source

SCARF: DISTRIBUTED EXTENSIBLE ACCOUNTABLE RETRIEVABLE

- Utilize **Docker** for individual containers
- Docker Swarm for scaling
- How is distribution achieved?
  - As data is streamed in from forensic target (ex. HDD), it will be evenly distributed to Cluster Nodes
  - When Cluster Nodes execute tasks, they distribute them to '**Worker**' containers
  - DNS round-robin for task distribution
  - Different workers for different tasks
  - Scale up containers based on priority, easily!
    - `docker service scale exiftools=96`

DOCKERFILE SAMPLE

```
1.  FROM anapsix/alpine-java
2.  MAINTAINER Wurstmeister
3.  RUN apk add --update unzip wget curl docker jq coreutils

5.  ENV KAFKA_VERSION="0.10.1.0" SCALA_VERSION="2.11"
6.  tar xfz /tmp/kafka_${SCALA_VERSION}-${KAFKA_VERSION}.tgz -C /opt
  VOLUME ["/kafka"]
7.  ENV KAFKA_HOME /opt/kafka_${SCALA_VERSION}-${KAFKA_VERSION}

9.  ADD start-kafka.sh /usr/bin/start-kafka.sh
10. ADD broker-list.sh /usr/bin/broker-list.sh
11. ADD create-topics.sh /usr/bin/create-topics.sh

13. # The scripts need to have executable permission
14. RUN chmod a+x /usr/bin/start-kafka.sh && \
15.   chmod a+x /usr/bin/broker-list.sh && \
16.   chmod a+x /usr/bin/create-topics.sh

18. CMD ["start-kafka.sh"]
```

SCARF: DISTRIBUTED EXTENSIBLE ACCOUNTABLE RETRIEVABLE

- Easily design new containers for forensic tools
- We call it 'dockerizing'
- Idea is to wrap forensic tools with a container, and expose an RPC method
  - RPC method takes raw data as a parameter, yields result as JSON
- Implemented ‘dockerization’ of Yahoo's *OpenNSFW* in a matter of minutes

SCARF: DISTRIBUTED EXTENSIBLE ACCOUNTABLE RETRIEVABLE

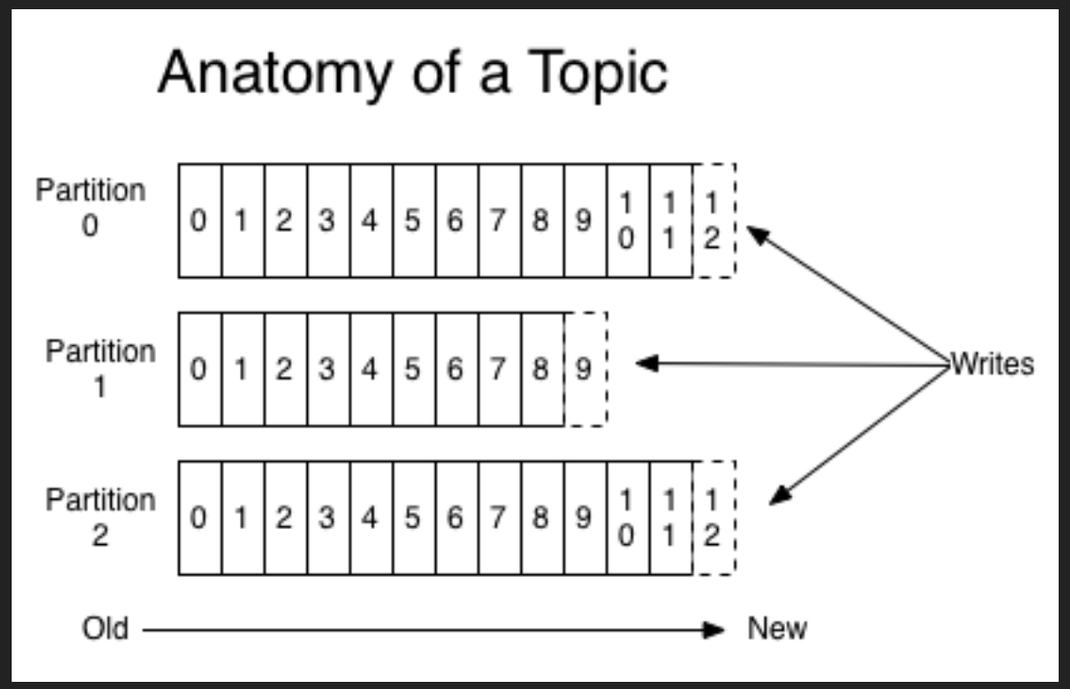
- Actual ExifTool invocation:

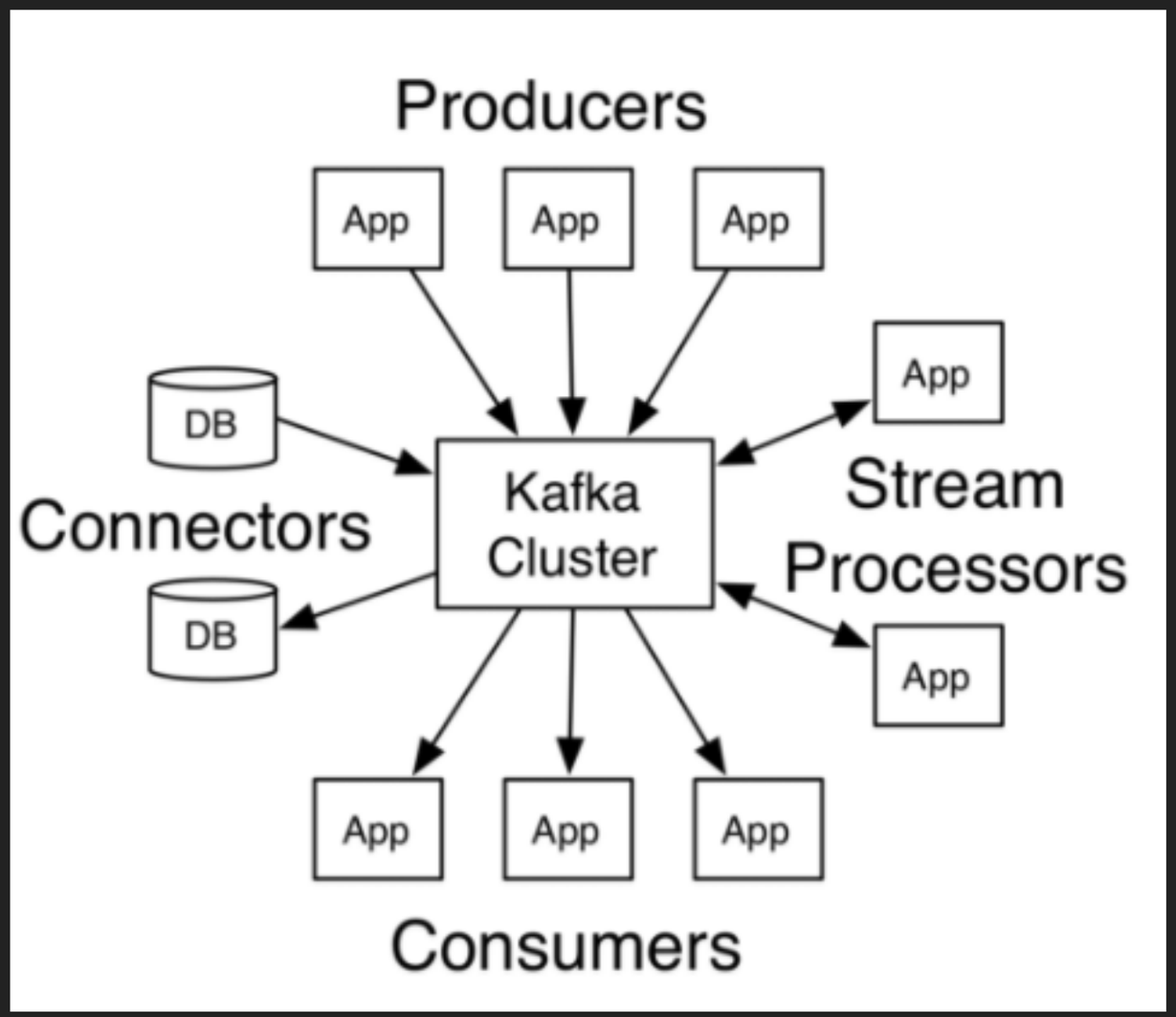
```
1. func (t *RPC) Execute(args *Args, reply *string) {
2.     toolPath := "/usr/bin/exiftool"
3.     // Setup the shell command to launch ExifTool
4.     opts := []string{"-"}
5.     cmd := exec.Command(toolPath, opts)
6.     cmd.Stdin = bytes.NewReader(args.Data)
7.     var out bytes.Buffer
8.     cmd.Stdout = &out
9.     err := cmd.Run()
10.    // - debug output fmt.Println(out.String())
11.    *reply = out.String()
12.}
```

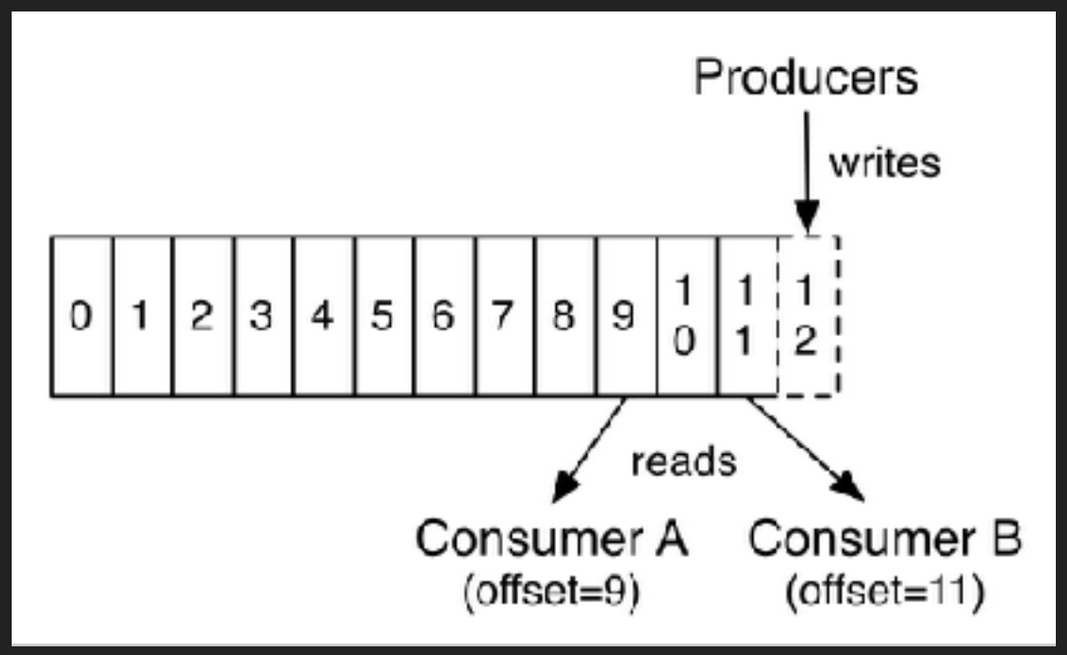
SCARF: DISTRIBUTED EXTENSIBLE ACCOUNTABLE RETRIEVABLE

- At large scale we can expect to encounter errors frequently. So, we need to track each task to ensure completion
- We utilize **Apache Kafka** to track issued and completed tasks
  - Ex: {taskID: 5, taskName: MD5, fileID: 89500}
- Kafka itself is distributed, avoiding a single point of failure

KAFKA AND MESSAGE LOGS







SCARF: DISTRIBUTED EXTENSIBLE ACCOUNTABLE RETRIEVABLE

- At scale, we can expect to have a large results dataset
- ElasticSearch provides a scalable, distributed database
  - Again, allows us to throw more hardware at the problem while being resilient to failure
- Importantly, ElasticSearch distribution allows us to query indexed data with *minimal response time*
- Schema-less allows flexibility

ELASTICSEARCH – INSERT TO DATABASE

```
PUT /scarf/file/85000
{
  "id": 85000,
  "filenames" : ["Lord-of-the-Flies.pdf"],
  "Createtime": 1501875401,
  "Modifytime": 1501875401,
  "Accesstime": 1501875401,
  "Emodifytime": 1501875401,
  "Fflags": "",
  "Flags": "",
  "Filesize": 285166,
  "Dataruns": []
}
```

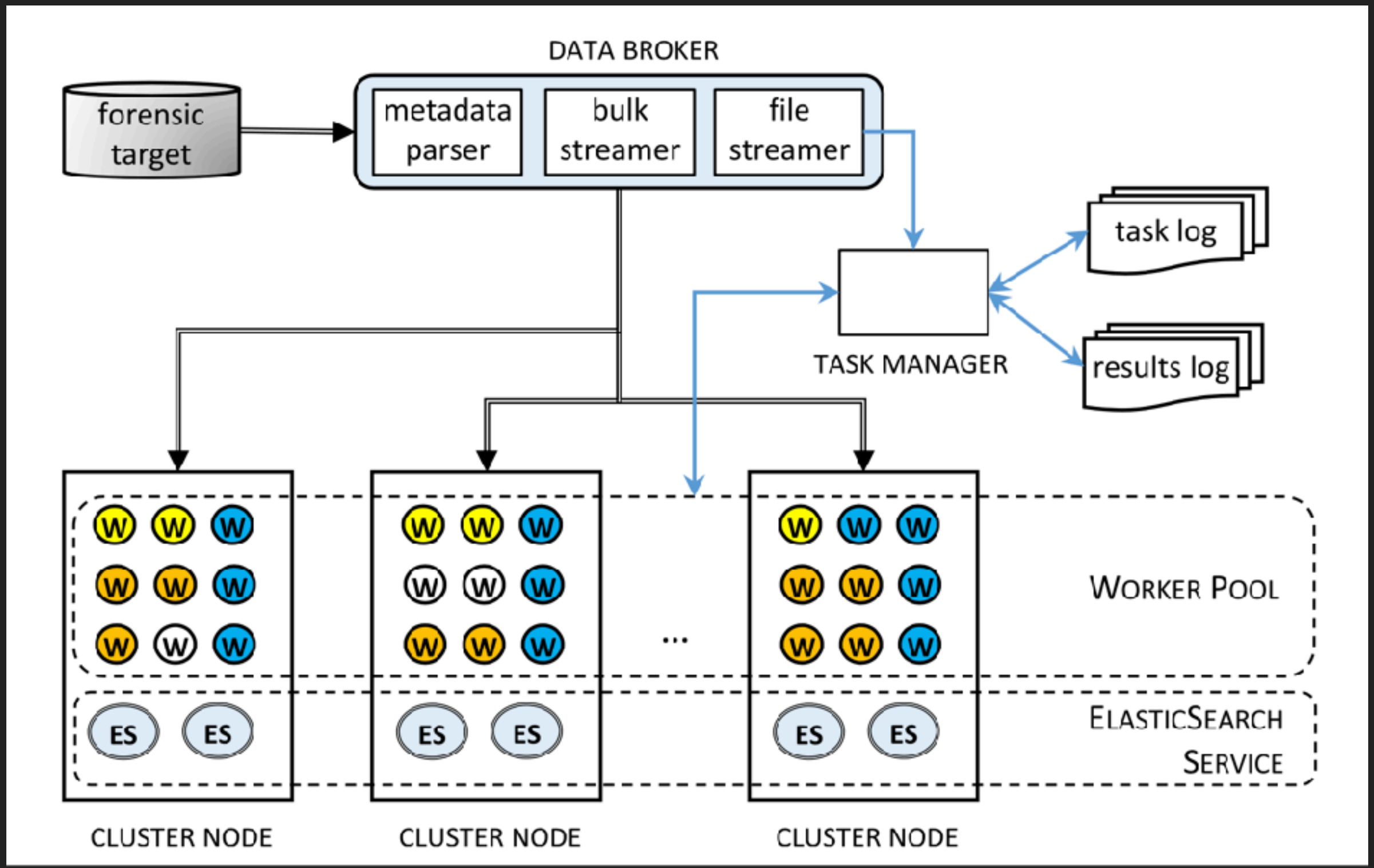
SCARF: DESIGN

- SCARF is a *framework* built to support digital forensics
  - **Distributed** - Docker Swarm
  - **Extensible** - Docker Container + RPC method
  - **Accountable** - Apache Kafka
  - **Retrievable** - ElasticSearch
- Open Source

ARCHITECTURE – HOW DO THE PIECES FIT TOGETHER?

- Task - operation on a specified file, e.g. SHA1 on 'flower.jpg'
- Broker - handles reading of forensic data
- Worker - container for a task, e.g. BulkExtractor container
- Task Manager - coordinates task logs
  - Logs - used to track individual 'tasks' sent to workers
- ElasticSearch - stores metadata of forensic target and any results from workers

SCARF: SCALABALE REALTIME FORENSICS



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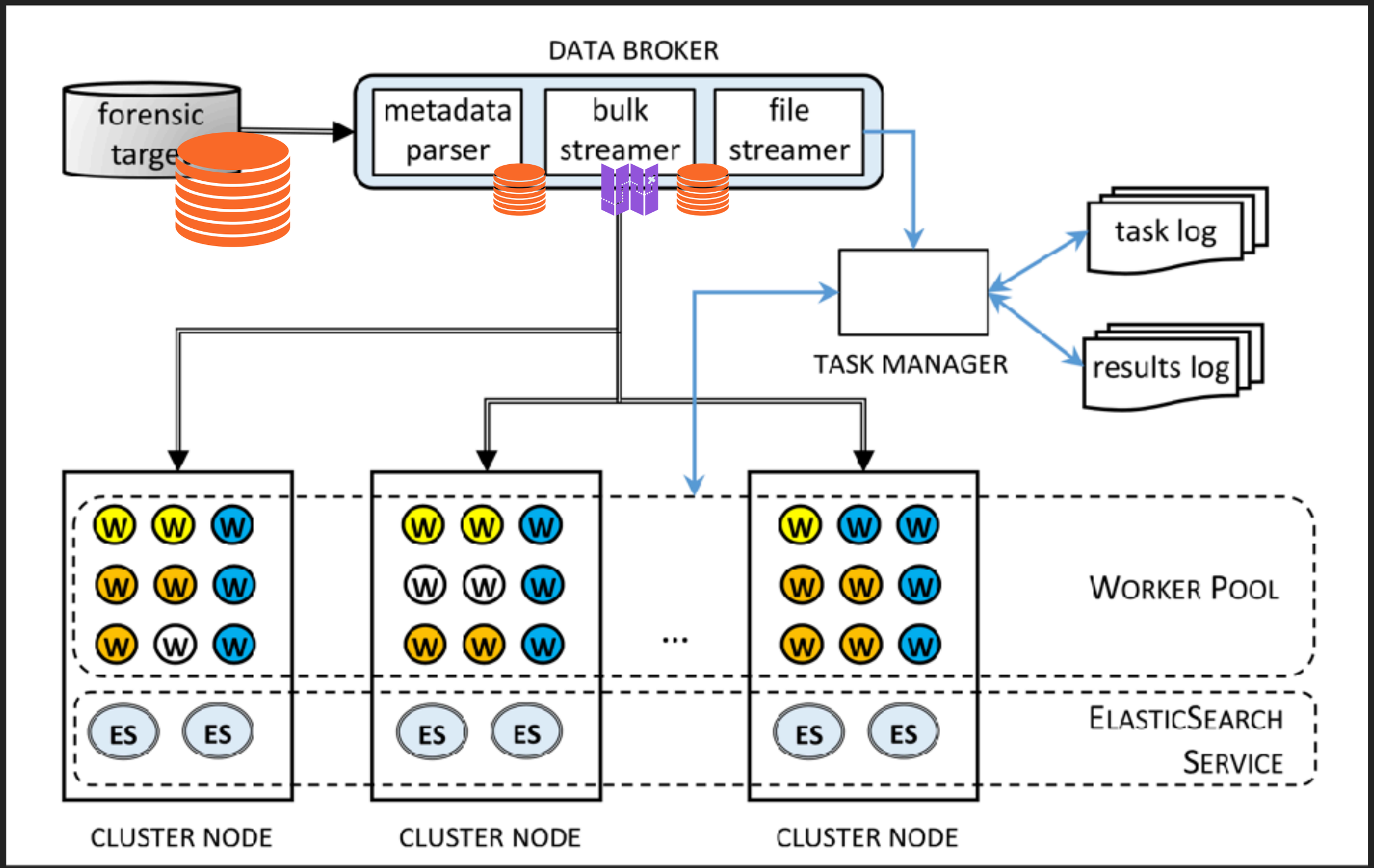

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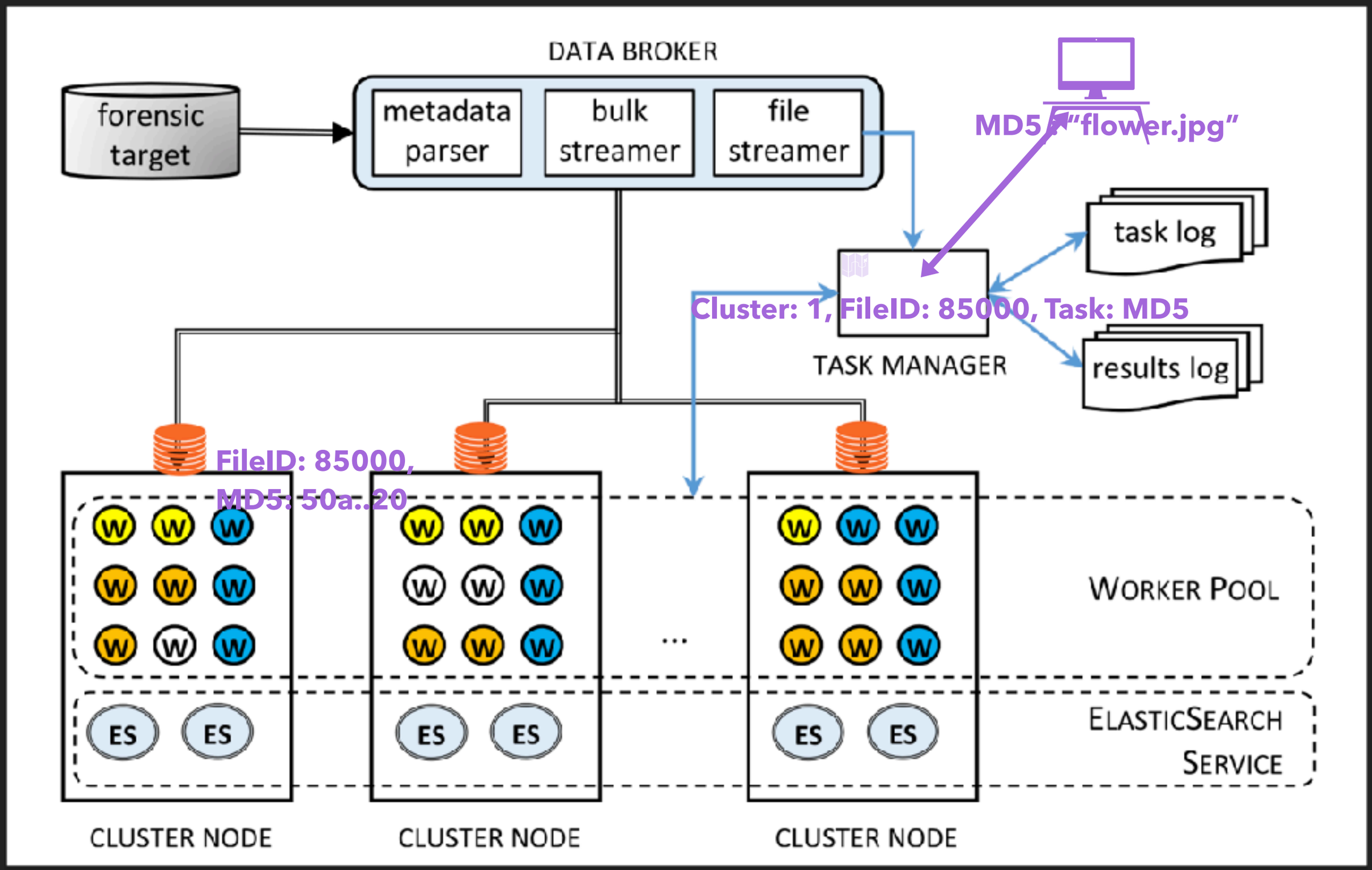

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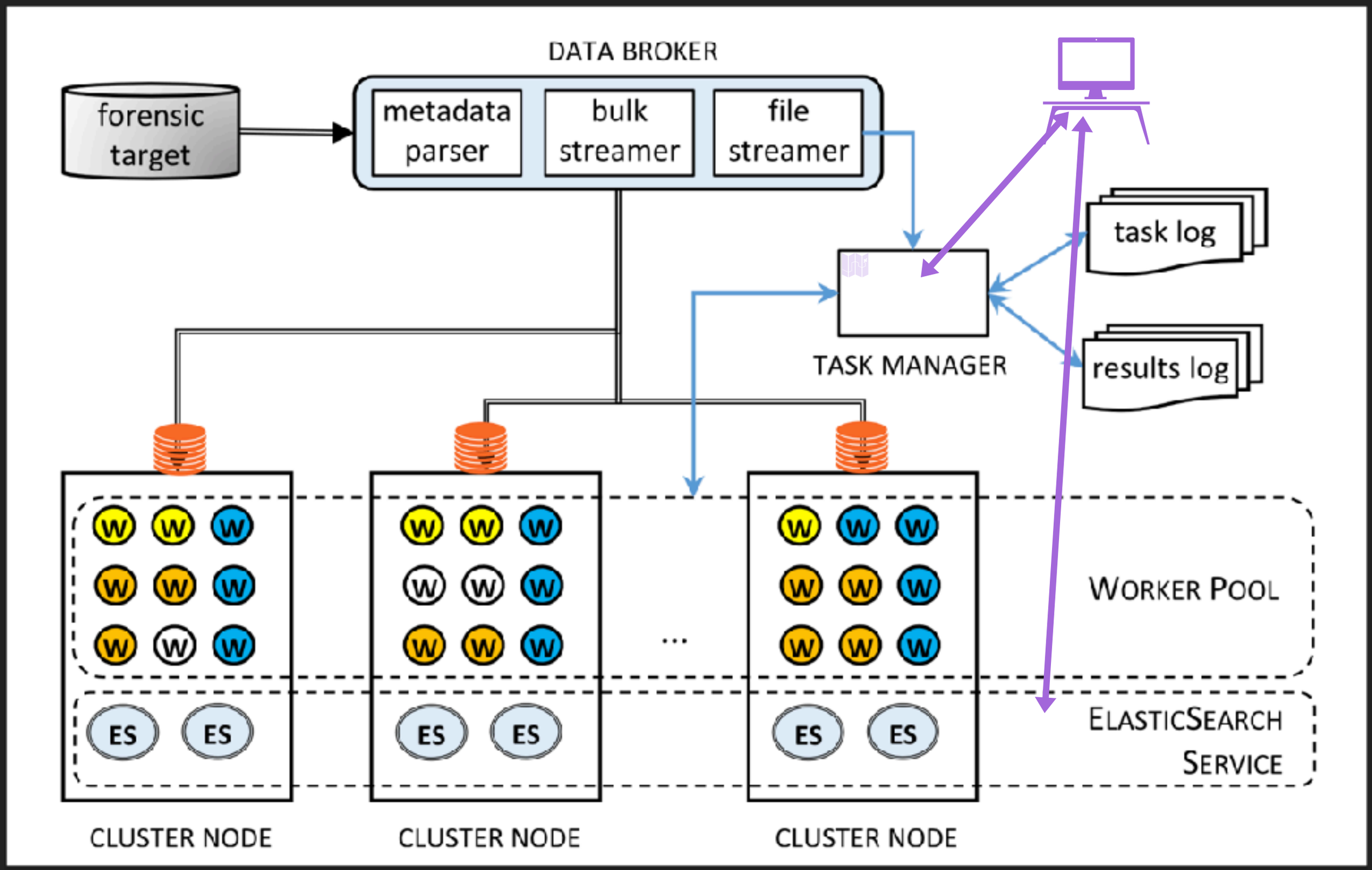


STATUS

- Supports NTFS images
- Broker: Raw, File-based
- Workers:
  - MD5
  - SHA1
  - Apache Tika
  - Yahoo OpenNSFW
  - ExifTools
  - BulkExtractor

TESTING IT OUT

- Dataset:

  200GB from govdocs corpus

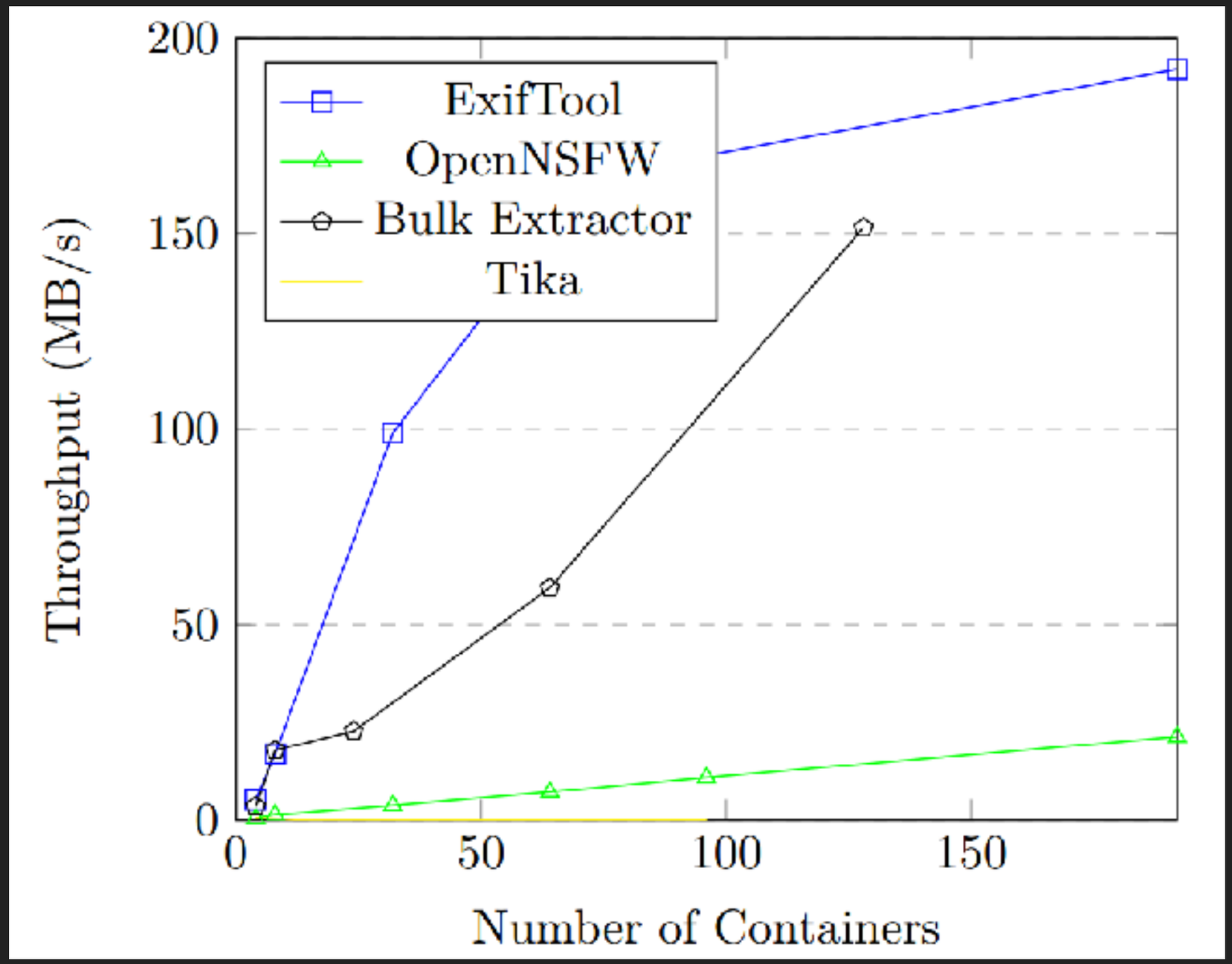
- Older Server:

  4 nodes

  24 cores each

  256GB RAM each

- 96 total CPUs



NUMBERS

SHA1 # containers	4	8	32	48	96	192
MB/s	345	857	924	985	948	992

OpenNSFW # containers	4	8	32	64	96	192
MB/s	0.4	1.4	3.8	7.2	10.9	21.3

ExifTools # containers	4	8	32	64	96	192
MB/s	5.2	17	99	151	170	192
Per container	1.3	2.1	3.1	2.4	1.8	1

NUMBERS

Tika # containers	4	12	24	48	96	192
MB/s	0.5	1.1	2.4	3.5	5.8	6.7
Per container	0.13	0.09	0.10	0.07	0.06	0.03

BulkExtractor # containers	4	12	24	48	64	128
MB/s	3.5	17.9	22.7	54.8	59.4	151.5
Per container	0.9	1.5	0.9	1.1	0.9	1.2

SCREENSHOTS

```
PUT /scarf/file/85000
{
  "id": 85000,
  "filenames" : ["Lord-of-the-Flies.pdf"],
  "Createtime": 1501875401,
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  "Accesstime": 1501875401,
  "Emodifytime": 1501875401,
  "Fflags": "",
  "Flags": "",
  "Filesize": 285166,
  "Dataruns": []
}
```
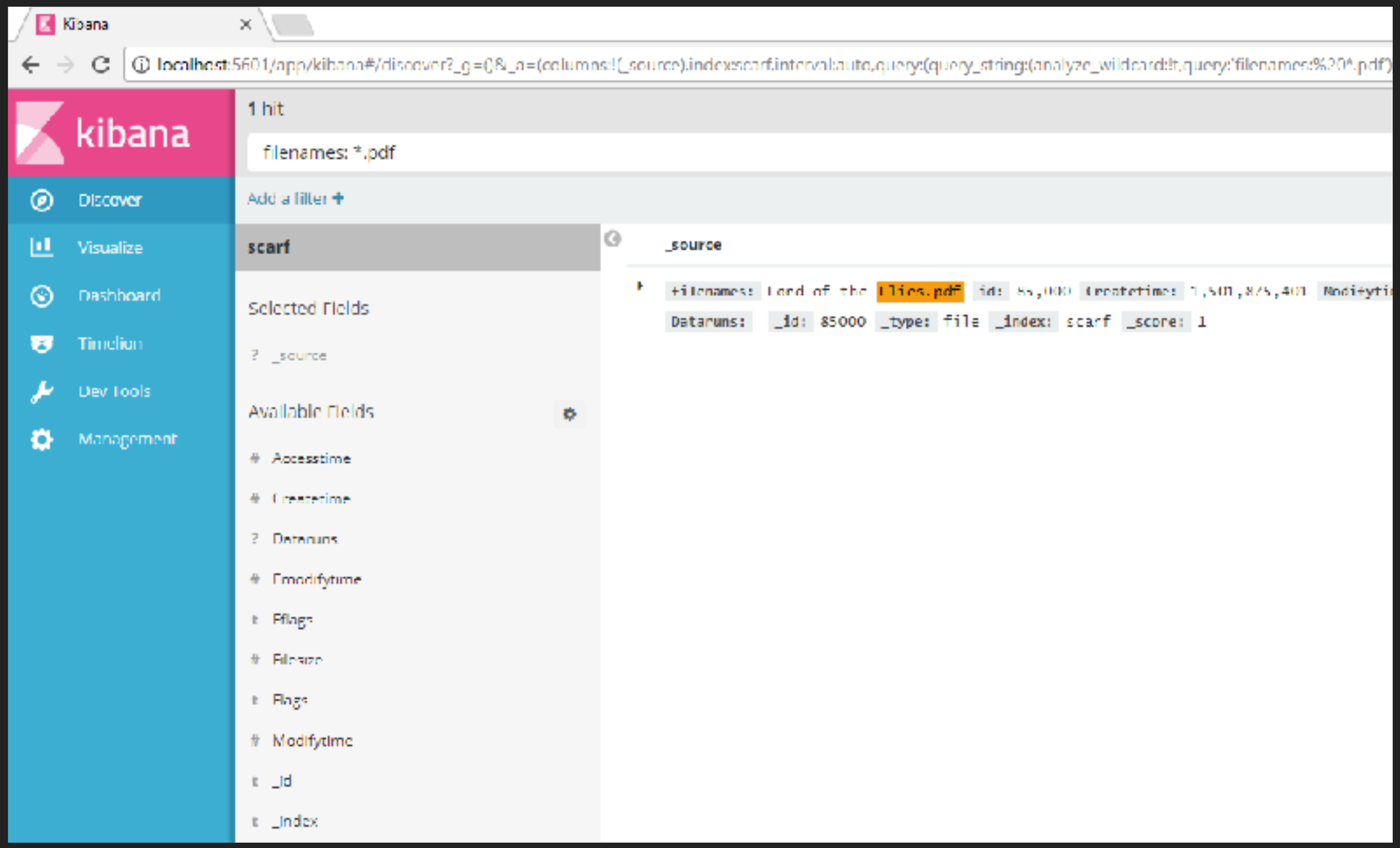
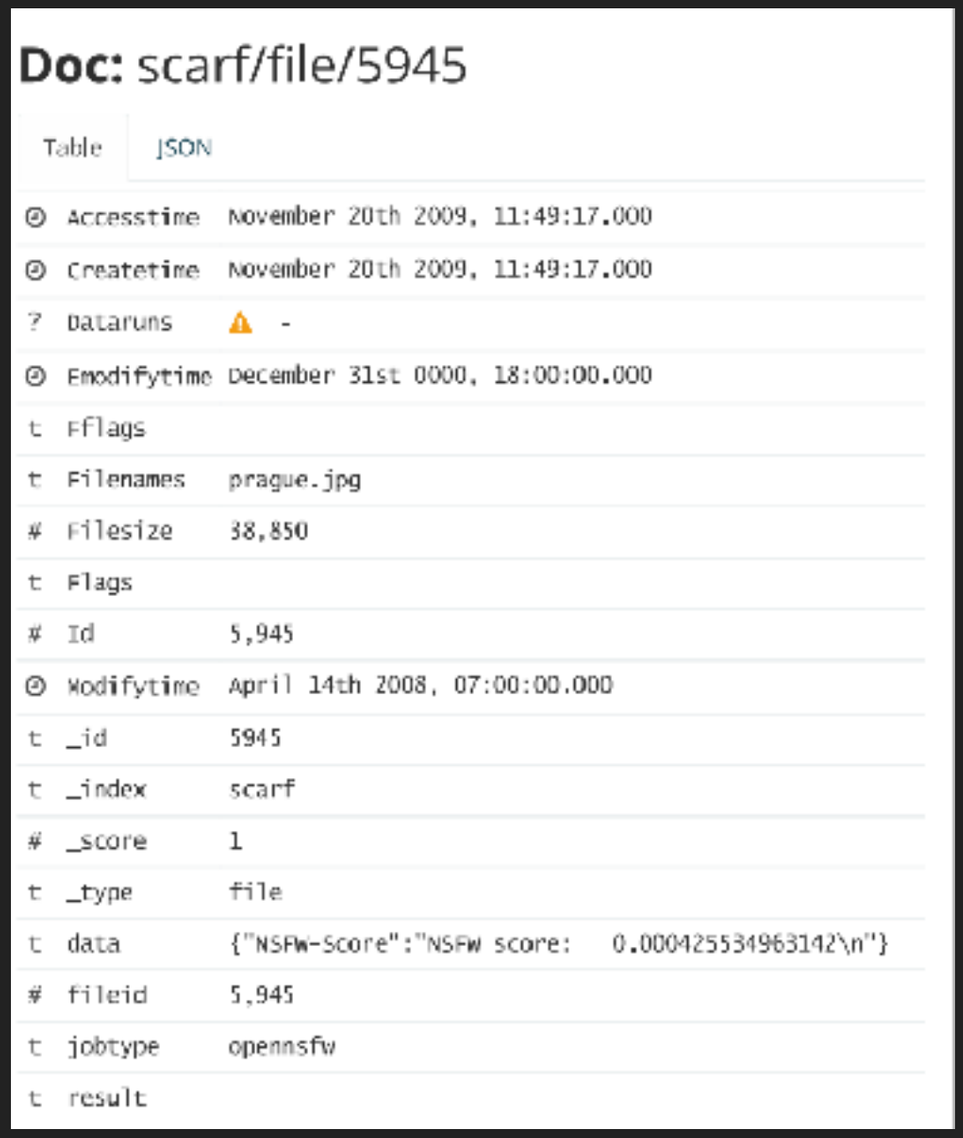

SCREENSHOTS



Searching for all PDFs

SCREENSHOTS

EXIFTool Results



OpenNSFW

NEXT STEPS

- Improve operator ease-of-use (with GUI)
- Increase size of forensic targets
- Investigate Tika performance bottleneck
- Deploy to AWS/Azure
- Investigate security and throughput implications
- Smarter distribution among workers (currently round robin)

SUMMARY

- SCARF is a *framework* designed to scale to demands of digital forensic investigations
- Incorporate existing tools!!
- On an older, 4-node cluster, tests show increased overall throughput with an increased number of containers
  - BulkExtractor up to 150MB/s
- Newer 4-node cluster shows significant increase in throughput
  - 180% increase for ExifTools throughput, 80% for Tika, and 64% for OpenNSFW

QUESTIONS?