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Elasticsearch

Sizing and Capacity Planning

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Let's make sizing simple!

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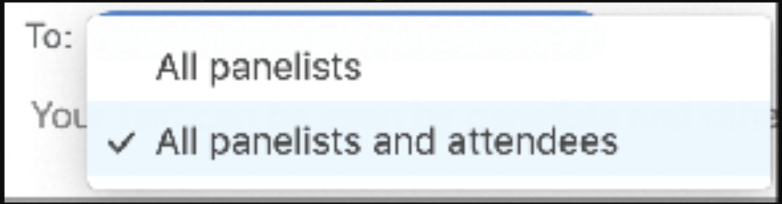
Housekeeping & Logistics

- Attendees are automatically muted when joining Zoom
- **Q+A** will be at the end of the webinar
- Ask questions for us in the **Zoom chat** during the webinar
    - Chat settings to: **All panelists and attendees**



    - Ask more questions on our discuss forum: **discuss.elastic.co**
- **Recording** will be available after the webinar and emailed to all registrants

Why Elastic?

Why Elastic?

SCALE

Distributed by design

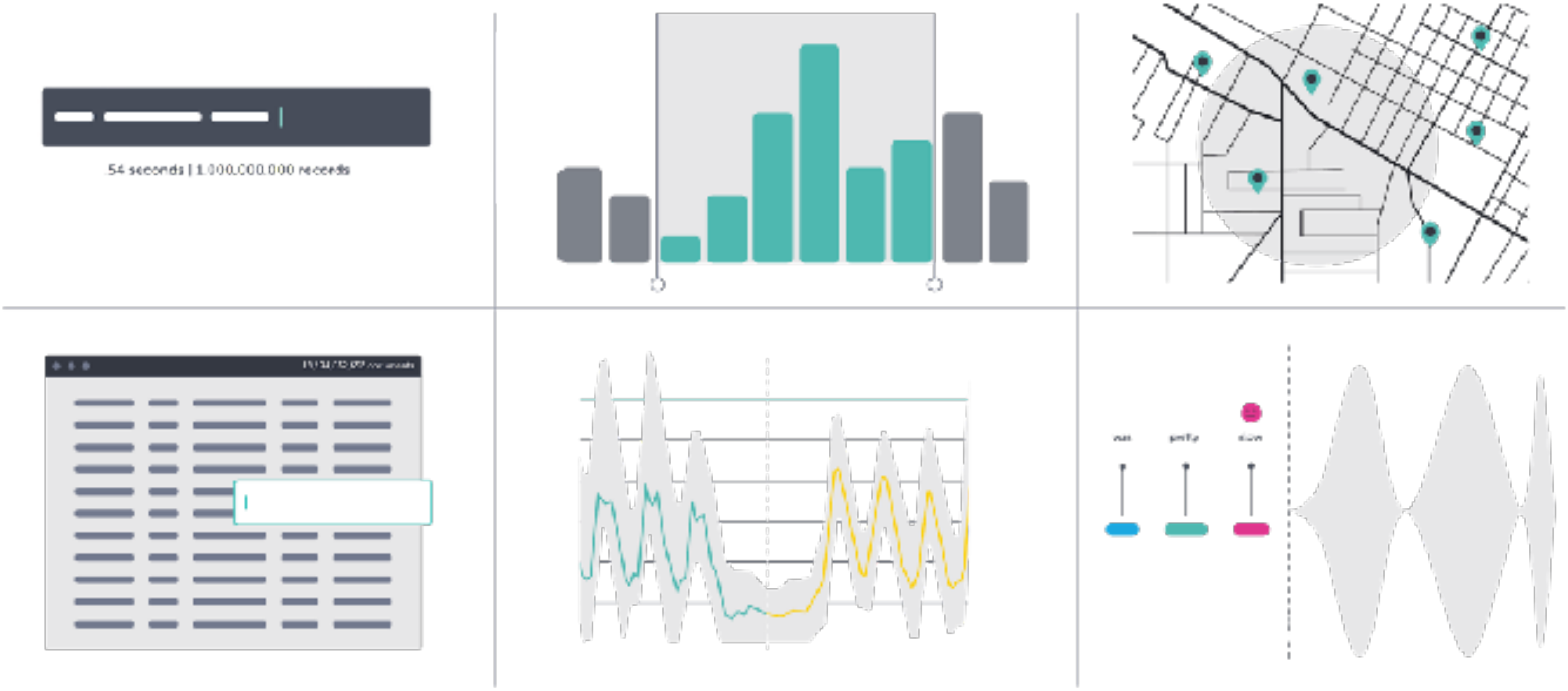
SPEED

Find matches in milliseconds

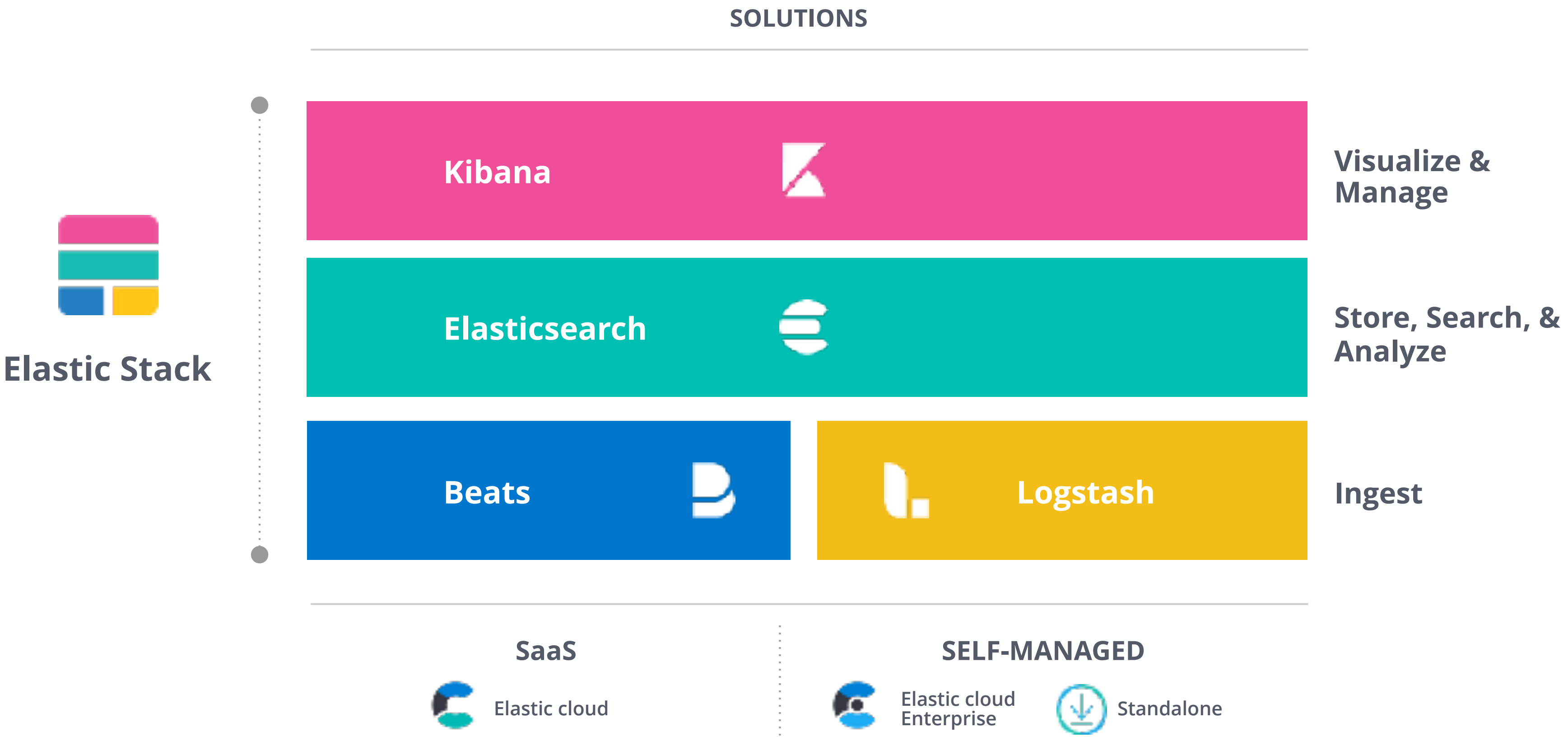
RELEVANCE

Get highly relevant results

Search is a Foundation



Elastic Stack



Elastic Deployment Models

Elastic Managed + Orchestration → Self-Managed + Orchestration → Self-Managed

Elastic Cloud
Elasticsearch Service

The official fully managed Elastic Stack solution.

Available on AWS, GCP, and Azure.

Elastic Cloud
Enterprise

Orchestrate the Elastic Stack on your infrastructure.

Deploy anywhere.

Self-Managed

Download and administer the Elastic Stack on your infrastructure.

Deploy anywhere.

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Webinar Overview

Overview

Let’s master the art of capacity planning for Elasticsearch.

Elasticsearch is the heart of the Elastic Stack.

Any production deployment of the Elastic Stack should be guided by capacity planning for Elasticsearch. Whether you use it for logs, metrics, traces, or search, and whether you run it yourself or in our cloud, you need to plan the infrastructure and configuration of Elasticsearch to ensure the health and performance of your deployment.

Overview

Let’s master the art of capacity planning for Elasticsearch.

Webinar Goals

Capacity planning is about estimating the type and amount of resources required to operate an Elasticsearch deployment. By the end of this webinar you will know:

- Basic computing resources
- Architecture, behaviors, and resource demands of Elasticsearch
- Methodologies to estimate the requirements of an Elasticsearch deployment

Preface

Computing Resources

The Four Basic Computing Resources

Storage

Where data persists

e.g. Words in a book

Memory

Where data is buffered

e.g. Words you read

Compute

Where data is processed

e.g. Analyzing the words

Network

Where data is transferred

e.g. Speaking the words

Storage Resources

Storage

Where data persists

e.g. Words in a book

Storage Media

Solid State Drives (SSDs) offer best performance for “hot” workloads.

Hard Disk Drives (HDDs) are economic for “warm” and “frozen” storage.

RAID0 can improve performance.

RAID is optional as Elastic defaults to N+1 shard replication. Standard performant RAID configurations are acceptable for hardware level high-availability (e.g. RAID 1/10/50 etc.)

Storage Attachment

Recommendations

- Direct Attached Storage (DAS)
- Storage Area Network (SAN)
- Hyperconverged

  (Recommended minimum ~ 3Gb/s, 250Mb/s)

Avoid

- Network Attached Storage (NAS)

  e.g. SMB, NFS, AFP. Network protocol overhead, latency, and costly storage abstraction layers make this a poor choice for Elasticsearch.

Memory Resources

Memory

Where data is buffered

e.g. Words you read

How Elasticsearch Uses Memory

JVM Heap Stores metadata about the cluster, indices, shards, segments, and fielddata. This should be **50% of available RAM**, and up to a **maximum of 30GB RAM** to avoid garbage collection.

OS Cache Elasticsearch will use the remainder of available memory to cache data, improving performance dramatically by avoiding disk reads during full-text search, aggregations on doc values, and sorts.

Compute Resources

Compute

Where data is processed

e.g. Analyzing the words

How Elasticsearch Uses Compute

Elasticsearch processes data in many ways that can be computationally expensive.

Elasticsearch nodes have **thread pools** and **thread queues** that utilize the available compute resources. The quantity and performance of CPU cores governs the average **speed** and peak **throughput** of data operations in Elasticsearch.

Network Resources

Network

Where data is transferred

e.g. Speaking the words

How Elasticsearch Uses Network

Bandwidth is rarely a resource that constrains Elasticsearch. For very large deployments, the amount of data transfer for ingest, search, or replication between nodes can cause **network saturation**. In these cases, network connectivity can be upgraded to higher speeds, or the Elastic deployment can be split into two or more clusters and then searched as a single logical unit using **cross-cluster search** (CCS).

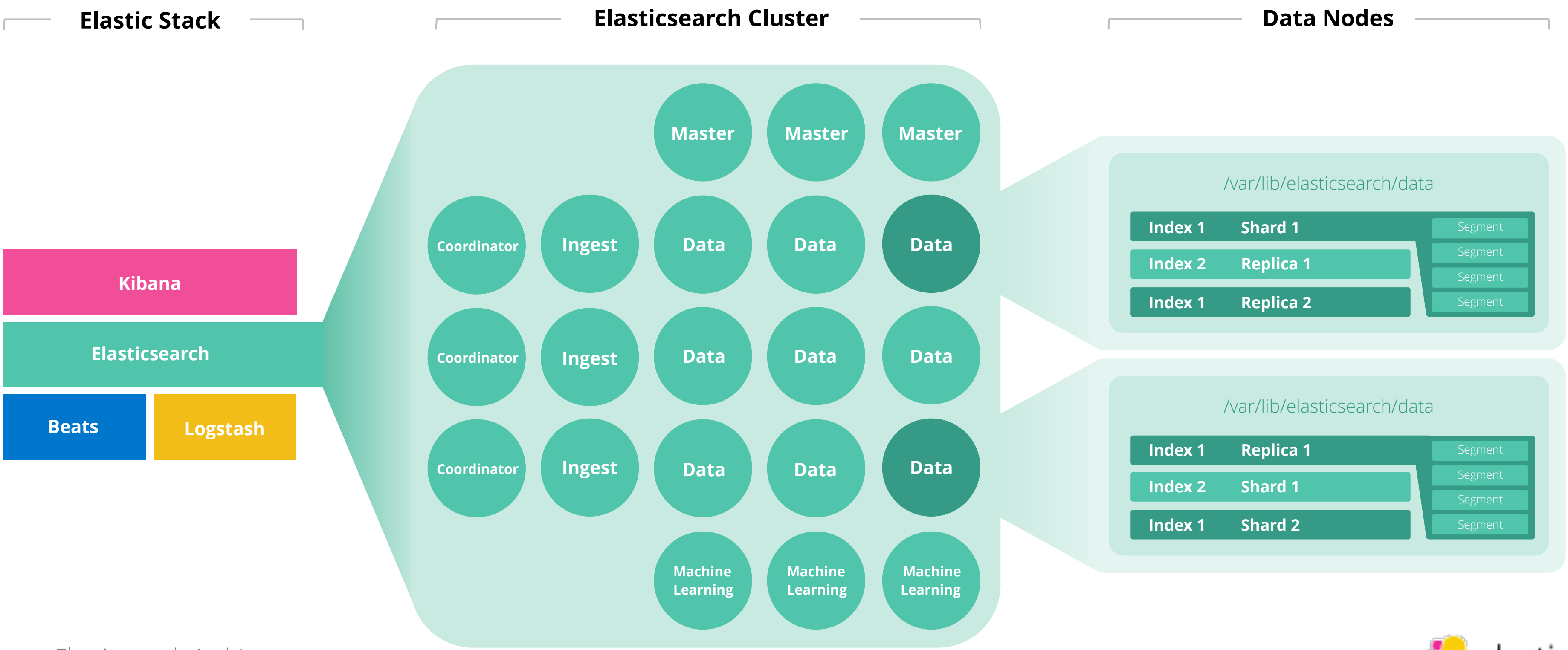
Elasticsearch

Architecture

Terminology

Cluster	A **group of nodes** that work together to operate Elasticsearch.
Node	A **Java process** that runs the Elasticsearch software.
Index	A **group of shards** that form a logical data store.
Shard	A **Lucene index** that stores and processes a portion of an Elasticsearch index.
Segment	A **Lucene segment** that immutably stores a portion of a Lucene index.
Document	A **record** that is submitted to and retrieved from an Elasticsearch index.

Architecture



Nodes

Role	Description	Resources			
		Storage	Memory	Compute	Network
Data	Indexes, stores, and searches data	**Extreme**	**High**	**High**	**Medium**
Master	Manages cluster state	Low	Low	Low	Low
Ingest	Transforms inbound data	Low	**Medium**	**High**	**Medium**
Machine Learning	Processes machine learning models	Low	**Extreme**	**Extreme**	**Medium**
Coordinator	Delegates requests and merges search results	Low	**Medium**	**Medium**	**Medium**

Elasticsearch

Data Operations

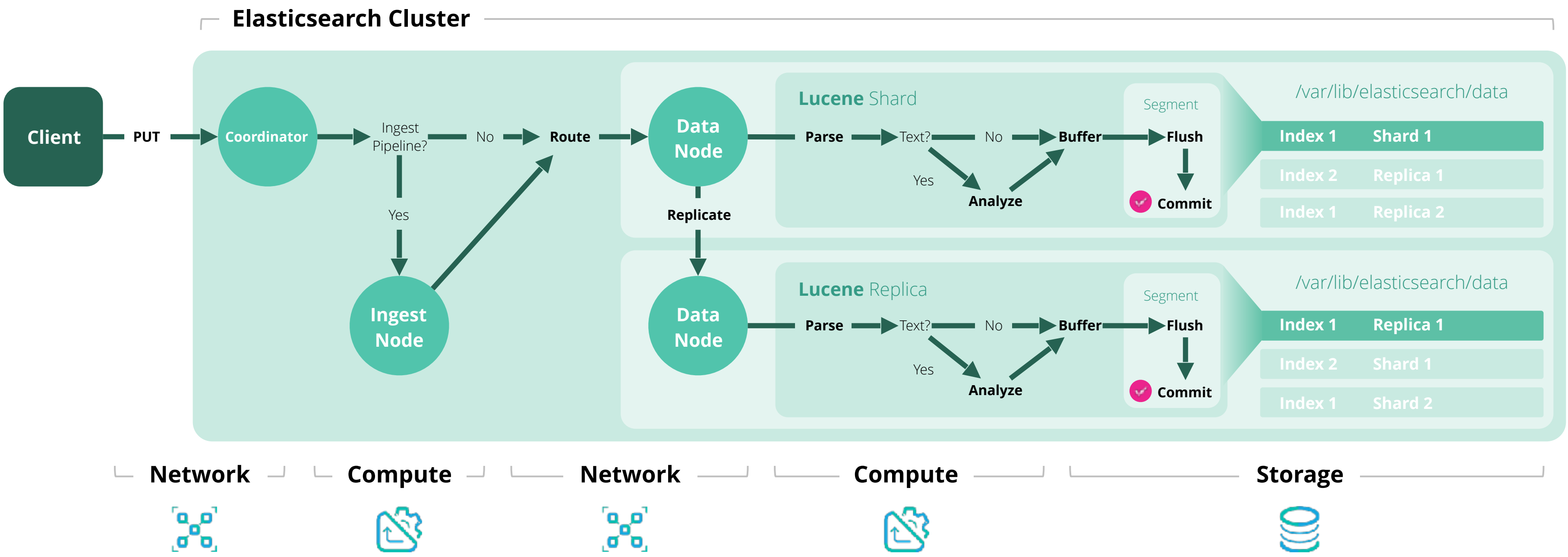
The Four Basic Data Operations

There are four basic data operations in Elasticsearch. Each operation has its own resource demands.

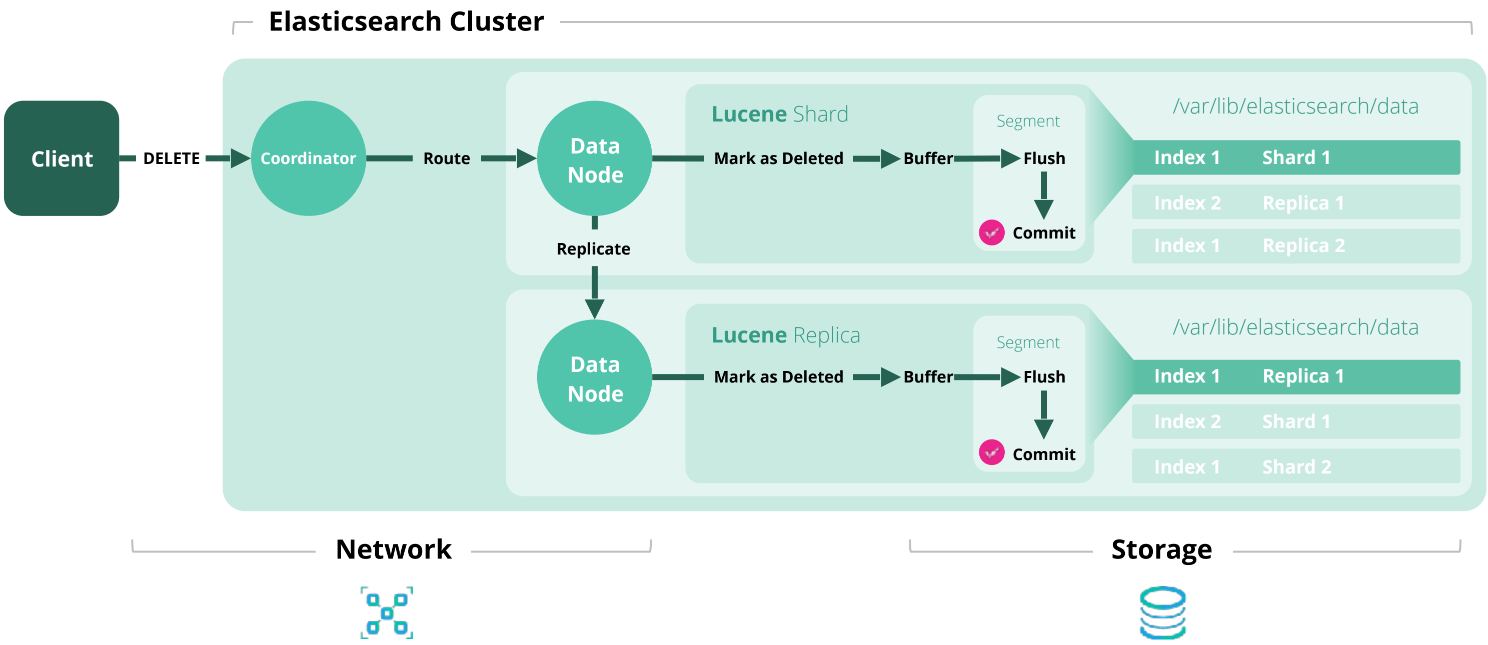
Every use case makes use of these operations, but they will favor some operations over others.

Index	Processing a document and storing it in an index for future retrieval.
Delete	Removing a document from an index.
Update	Removing a document and indexing a replacement document.
Search	Retrieving one or more documents or aggregates from one or more indices.

Index Operations: Data Processing Flow



Delete Operations: Data Processing Flow



Update Operations: Data Processing Flow

Documents are immutable in Elasticsearch. When Elasticsearch updates a document, it deletes the original document and indexes the new, updated document.[1] The two operations are performed atomically in each Lucene shard.[3] This incurs the costs of a **delete** and **index** operation, except it does not invoke any ingest pipelines.

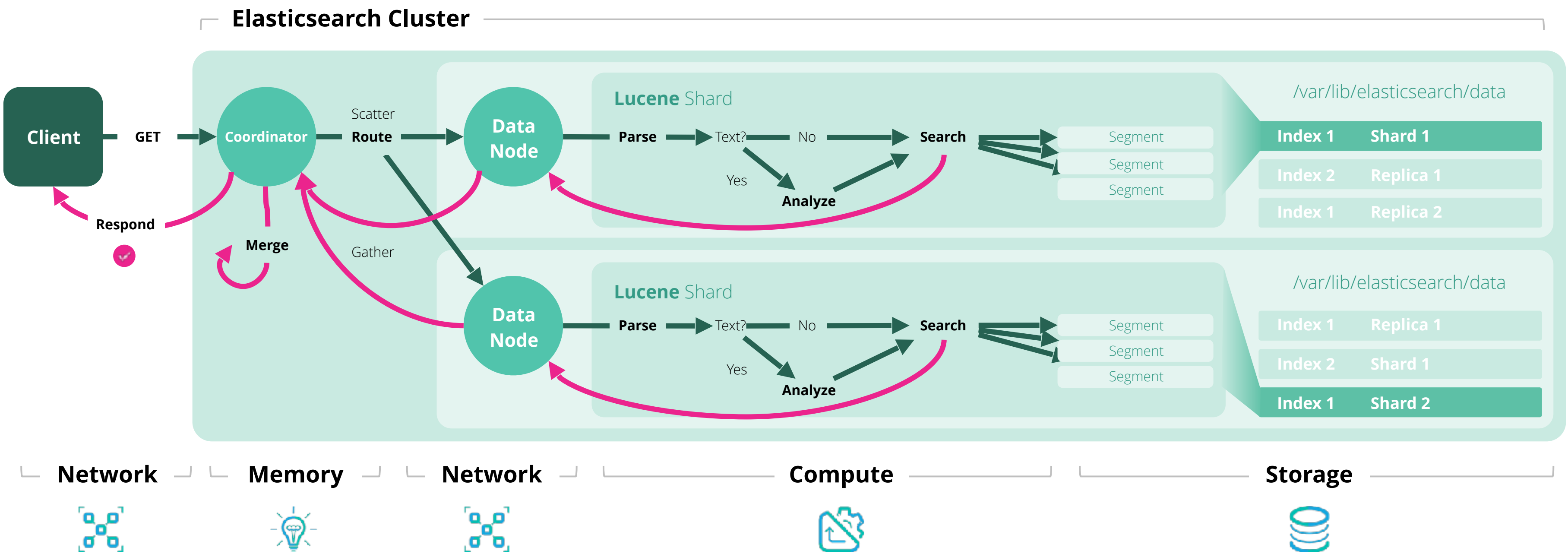
Update = Delete + (Index - Ingest Pipeline)

Search Operations

“Search” is a generic term for information retrieval. Elasticsearch has various retrieval capabilities, including but not limited to full-text searches, range searches, scripted searches, and aggregations. Search speed and throughput are affected by many variables including the configurations of the cluster, indices, queries, and hardware. Realistic capacity planning depends on **empirical testing** after applying the **best practices** for optimizing those configurations.

Elasticsearch executes searches in phases known informally as **scatter, search, gather, and merge**.

Search Operations: Data Processing Flow



Use Cases

There are a few conventional usage patterns of Elasticsearch. Each favors one of the basic operations.

Index Heavy	Use cases that favor index operations	Logging, Metrics, Security, APM
Search Heavy	Use cases that favor search operations	App Search, Site Search, Analytics
Update Heavy	Use cases that favor update operations	Caching, Systems of Record
Hybrid	Use cases that favor multiple operations	Transactions Search

We will review the sizing methodologies for these use cases later in the workshop.

Elasticsearch

Indexing Behaviors

Overview

The following processes are applied to data on ingest.

JSON Conversion	Data can be larger or smaller on disk due to the format it is stored in.
Indexing	Data can be processed and indexed in various structures.
Compression	Data can be compressed for greater storage efficiency.
Replication	Data can be copied for greater fault tolerance and search throughput.

JSON Conversion

A Verbose Syntax

Elasticsearch stores the original document in the `_source` field in JSON format. JSON is more verbose than common delimited formats such as CSV, because each value is paired with the name of the field. The size of a log record from a delimited file could double or more. By contrast, JSON is less verbose than some formats such as XML.

It's Optional

Logging use cases require the `_source` field to return the source of truth for an event. Metrics use cases can discard the `_source` field because analysis is always done on aggregations of indexed fields, with no single record being important to look at.

Original **47 Bytes**

```
2018-02-14T12:30:45 192.168.1.1 200 /index.html
```

JSON **89 Bytes**

```
{
  "timestamp": "2018-02-14T12:30:45",
  "ip": "192.168.1.1",
  "response": 200,
  "url": "/index.html"
}
```

Indexing

Data Structures

Elasticsearch indexes values in various data structures. Each data type has its own storage characteristics.

Many Ways to Index

Some values can be indexed in multiple ways. String values are often indexed twice – once as a `keyword` for aggregations and once as `text` for full-text search. Values prone to error and ambiguity such as names and addresses can be indexed in multiple ways to support different search strategies.

Original **4 Values**

```
2018-02-14T12:30:45 192.168.1.1 200 /index.html
```

Indexed **6 Values**

date	2018-02-14T12:30:45
keyword	192.168.1.1
text	1:2 168:1 192:1
integer	200
keyword	/index.html
text	index:1 html:1

Compression

Elasticsearch can compress data using one of two different compression algorithms: LZ4 (the default) and DEFLATE, which saves up to 15% additional space at the expense of added compute time compared to LZ4. Typically Elasticsearch can compress data by 20 – 30%.

Shard Replication

Storage

Elasticsearch can replicate shards once or multiple times across data nodes to improve fault tolerance and search throughput. Each replica shard is a full copy of its primary shard.

Index and Search Throughput

Logging and metrics use cases typically have one replica shard, which is the minimum to ensure fault tolerance while minimizing the number of writes. Search use cases often have more replica shards to increase search throughput.

Complete Example

What you sent

```
2018-02-14T12:30:45 192.168.1.1 200 /index.html
```

What was stored

Primary	_source	`{"timestamp":"2018-02-14T12:30:45","ip":"192.168.1.1","response":200,"url":"/index.html"}`	➔ Compression
	Indexed values	`2018-02-14T12:30:45|192.168.1.1|1:2 168:1 192:1|200|/index.html|index:1 html:1`	➔ Compression
Replica 1	_source	`{"timestamp":"2018-02-14T12:30:45","ip":"192.168.1.1","response":200,"url":"/index.html"}`	➔ Compression
	Indexed values	`2018-02-14T12:30:45|192.168.1.1|1:2 168:1 192:1|200|/index.html|index:1 html:1`	➔ Compression
Replica n	…	…	…

Elasticsearch

Sizing Methodologies

Sizing Methodologies

There are two basic sizing methodologies that span the major use cases of Elasticsearch.

Volume Estimating the storage and memory resources required to store the expected amount of **data** and **shards** for each tier of the cluster.

Throughput Estimating the memory, compute, and network resources required to process the expected **operations** at the expected **latencies** and **throughput** for each operation and for each tier of the cluster.

Volume Sizing: Data Volume

Discovery Questions

- How much raw data (GB) will you index per day?
- How many days will you retain the data?
- What is the net expansion factor of the data?

  JSON Factor * Indexing Factor * Compression Factor
- How many replica shards will you enforce?
- How much memory will you allocate per data node?
- What will be your memory:data ratio?

Constants

- Reserve +15% to stay under the disk watermarks.
- Reserve +5% for margin of error and background activities.
- Reserve the equivalent of a data node to handle failure.

Total Data (GB)	=	Raw data (GB) per day * Number of days retained * Net expansion factor * (Number of replicas + 1)
Total Storage (GB)	=	Total Data (GB) * (1 + 0.15 Disk watermark threshold + 0.05 Margin of error)
Total Data Nodes	=	ROUNDUP(Total Storage (GB) / Memory per data node / Memory:data ratio) + 1 Data node for failover capacity

Volume Sizing: Shard Volume

Discovery Questions

- How many index patterns will you create?
- How many primary and replica shards will you configure?
- At what time interval will you rotate the indices, if at all?
- How long will you retain the indices?
- How much memory will you allocate per data node?

Constants

- Do not exceed 20 shards per GB of JVM Heap.
- Do not exceed 50GB per shard.

Tip Collapse small daily indices into weekly or monthly indices to reduce shard count. Split large (>50GB) daily indices into hourly indices or increase the number of primary shards.

Total Shards	=	Number of index patterns * Number of primaries * (Number of replicas + 1) * Total intervals of retention
Total Data Nodes	=	ROUNDUP(Total shards / (20 * Memory per data node))

Throughput Sizing: Search Operations

Search use cases have targets for **search response time** and **search throughput** in addition to the storage capacity. These targets can demand more memory and compute resources.

Too many variables affect search response time to predict how any given capacity plan will affect it. But by empirically testing search response time and estimating the expected search throughput, we can estimate the required resources of the cluster to meet those demands.

Throughput Sizing: Search Operations

Discovery Questions

- What is your peak number of searches per second?
- What is your average search response time in milliseconds?
- How many cores and threads per core are on your data nodes?

Theory of the Approach

Rather than determine how resources will affect search speed, treat search speed as a constant by measuring it on your planned hardware. Then determine how many cores are needed in the cluster to process the expected peak search throughput. Ultimately the goal is to prevent the thread pool queues from growing faster than they are consumed. With insufficient compute resources, search requests risk being dropped.

Peak Threads	=	ROUNDUP(Peak searches per second * Average search response time in milliseconds / 1000 Milliseconds)
Thread Pool Size	=	ROUNDUP((Physical cores per node * Threads per core * 3 / 2) + 1)
Total Data Nodes	=	ROUNDUP(Peak threads / Thread pool size)

Hot, Warm, Frozen

Elasticsearch can use **shard allocation awareness** to allocate shards on specific hardware.

Index heavy use cases often use this to store indices on **Hot**, **Warm**, and **Frozen** tiers of hardware,

and then schedule the migration of those indices from hot to warm to frozen to deleted or archived.

This is an economical way to store lots of data while optimizing performance for more recent data.

During capacity planning, each tier must be sized independently and then combined.

Tier	Goal	Example Storage	Example Memory:Storage Ratio
Hot	Optimize for search	SSD DAS/SAN (>200Gb/s)	1:30
Warm	Optimize for storage	HDD DAS/SAN (~100Gb/s)	1:160
Frozen	Optimize for archives	Cheapest DAS/SAN (<100Gb/s)	1:1000+

Beware of recovery failures with this much data per node

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Dedicated Nodes

Elasticsearch nodes perform one or multiple roles. Often it makes sense to assign one role per node. You can optimize the hardware for each role and prevent nodes from competing for resources.

Master	Dedicated master nodes help ensure the stability of clusters by preventing other nodes from consuming any of their resources.
Ingest	Ingest nodes that run many pipelines or use many processors will demand extra compute resources.
Machine Learning	Machine learning nodes that run many jobs or use many splits, buckets, or complex aggregations will demand extra memory and compute resources.
Coordinator	Dedicated coordinating nodes can benefit hybrid use cases by offloading the merge phase of searches from data nodes that are constantly indexing.

Overall

A proper sizing takes the following steps:

1. For each applicable tier – **Hot**, **Warm**, **Frozen** – determine the largest of the following sizes:
   - Data volume
   - Shard volume
   - Indexing throughput
   - Search throughput
2. Combine the sizes of each tier
3. Make decisions on any dedicated nodes – Master, Coordinator, Ingest, Machine Learning

Additional Resources

Elastic Training

Empowering Your People

Immersive Learning

Lab-based exercises and knowledge checks to help master new skills

Solution-based Curriculum

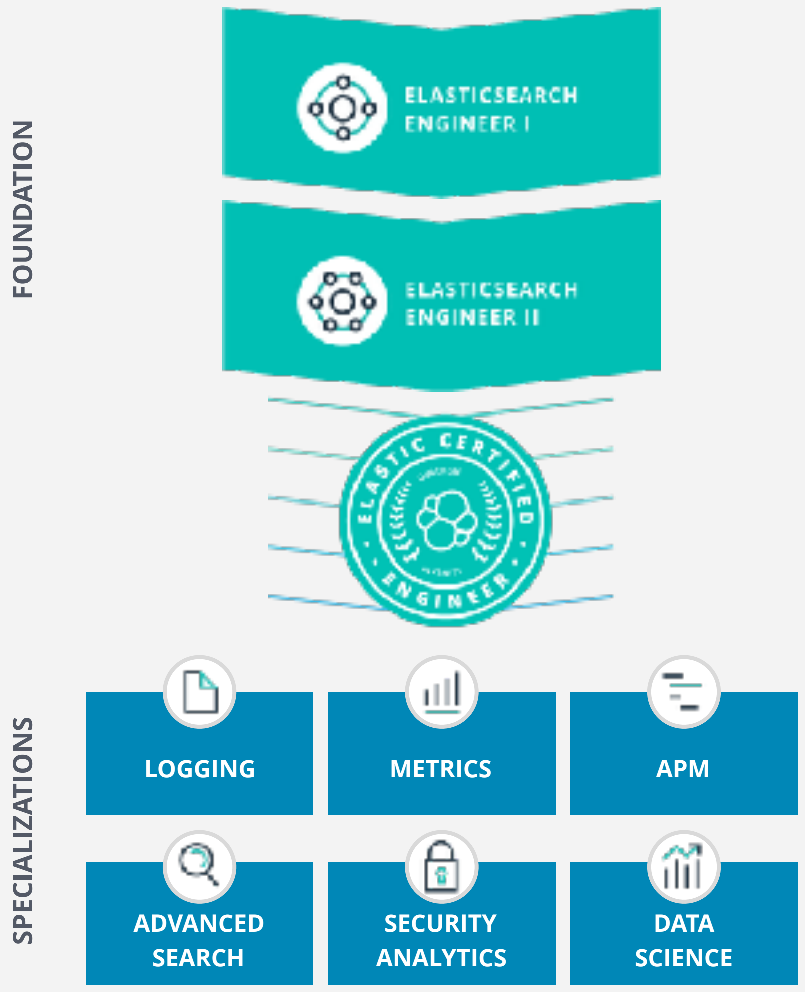
Real-world examples and common use cases

Experienced Instructors

Expertly trained and deeply rooted in everything Elastic

Performance-based Certification

Apply practical knowledge to real-world use cases, in real-time



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Q+A

Additional Resources

Forums	https://discuss.elastic.co
Cloud	https://www.elastic.co/products/elasticsearch/service
Cloud Hardware	https://www.elastic.co/guide/en/cloud/current/ec-reference-hardware.html
Products + Solutions	https://www.elastic.co/products