Index-Free Log Analytics with Kafka

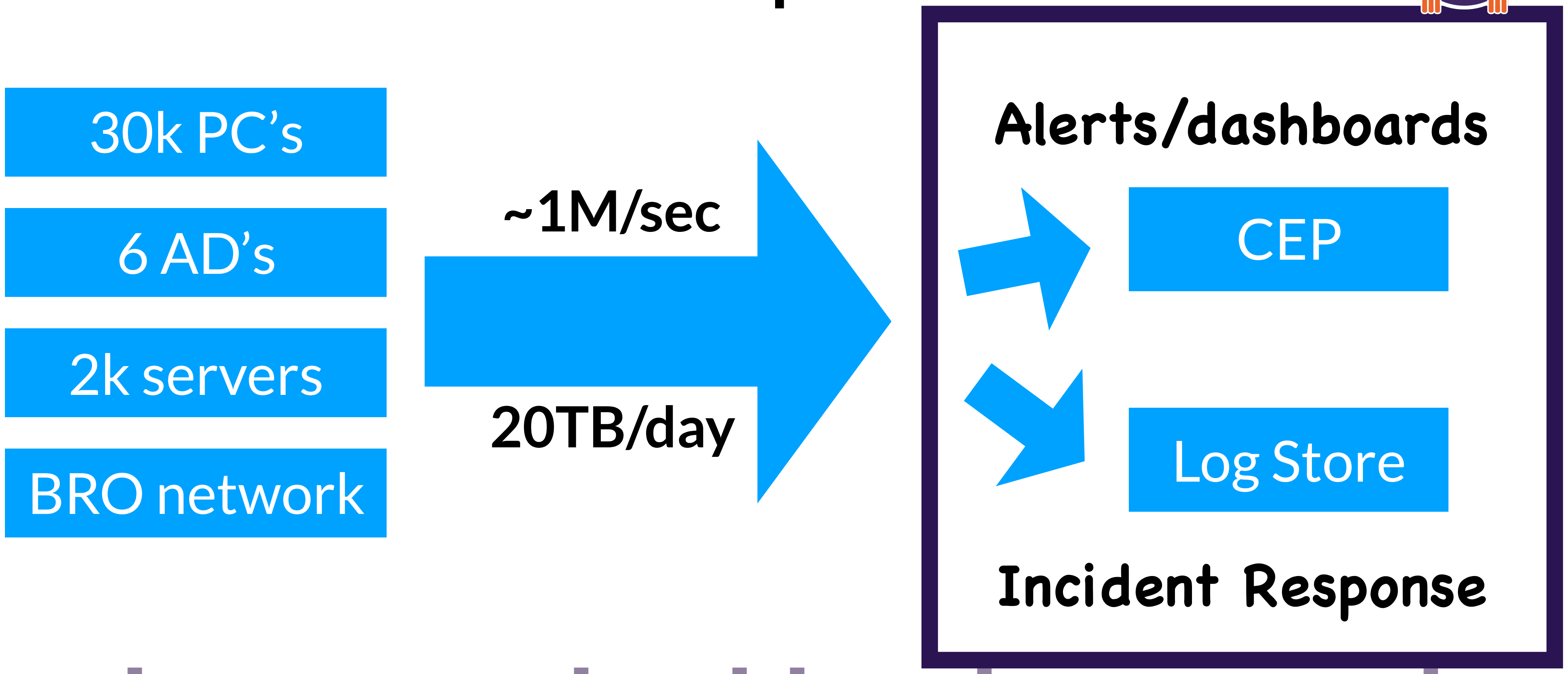
Kresten Krab Thorup, Humio CTO

Log Everything,
Answer Anything,
In Real-Time.

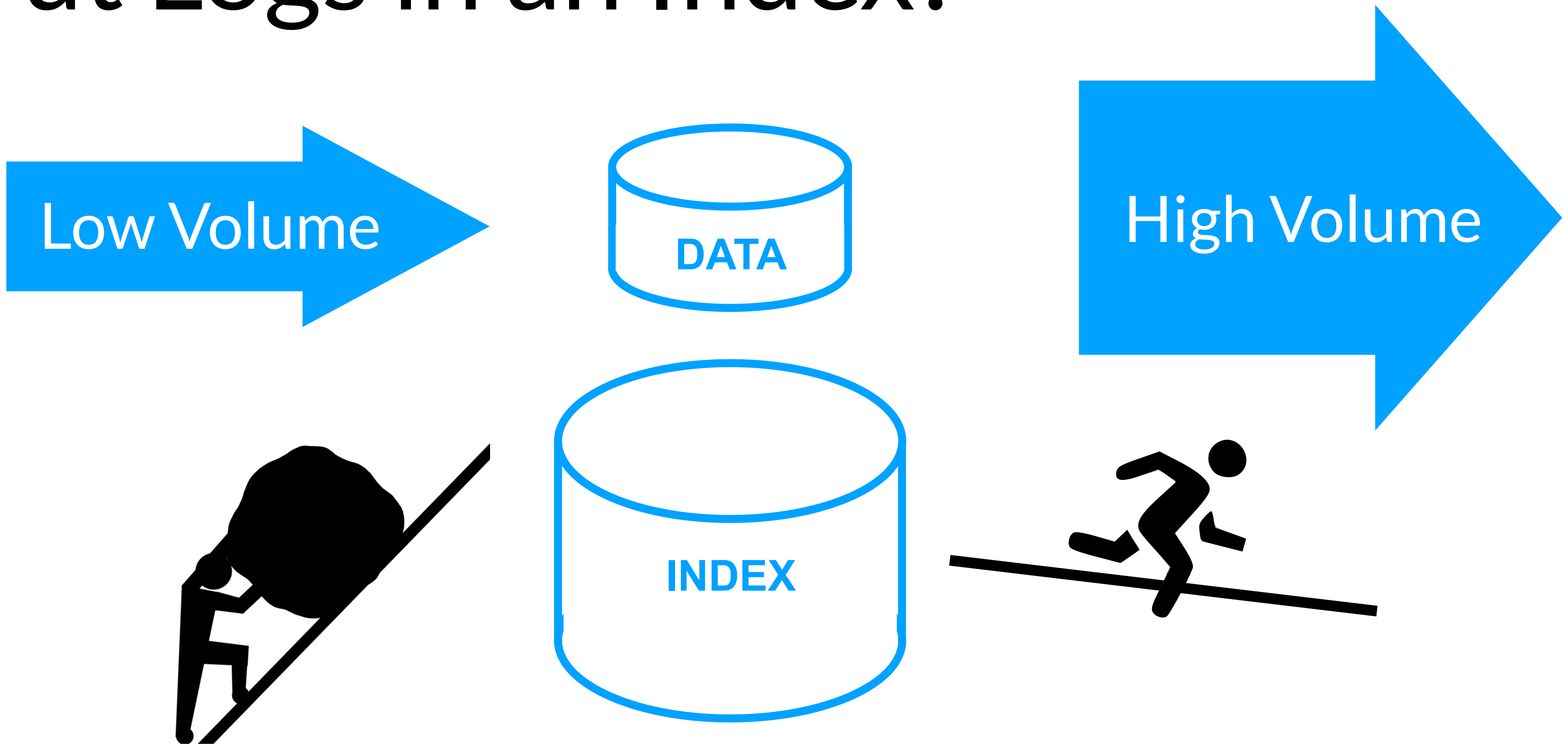
Log Analytics Wish List

- Record <u>everything</u> - TB's of data per day
- Interactive/<u>ad-hoc search</u> on historic data - 100's of TB
- Generate metrics and alerts from the logs in <u>real-time</u>
- Can be installed on-premises (privacy / security)
- Affordable - TCO (hardware, license, operations)

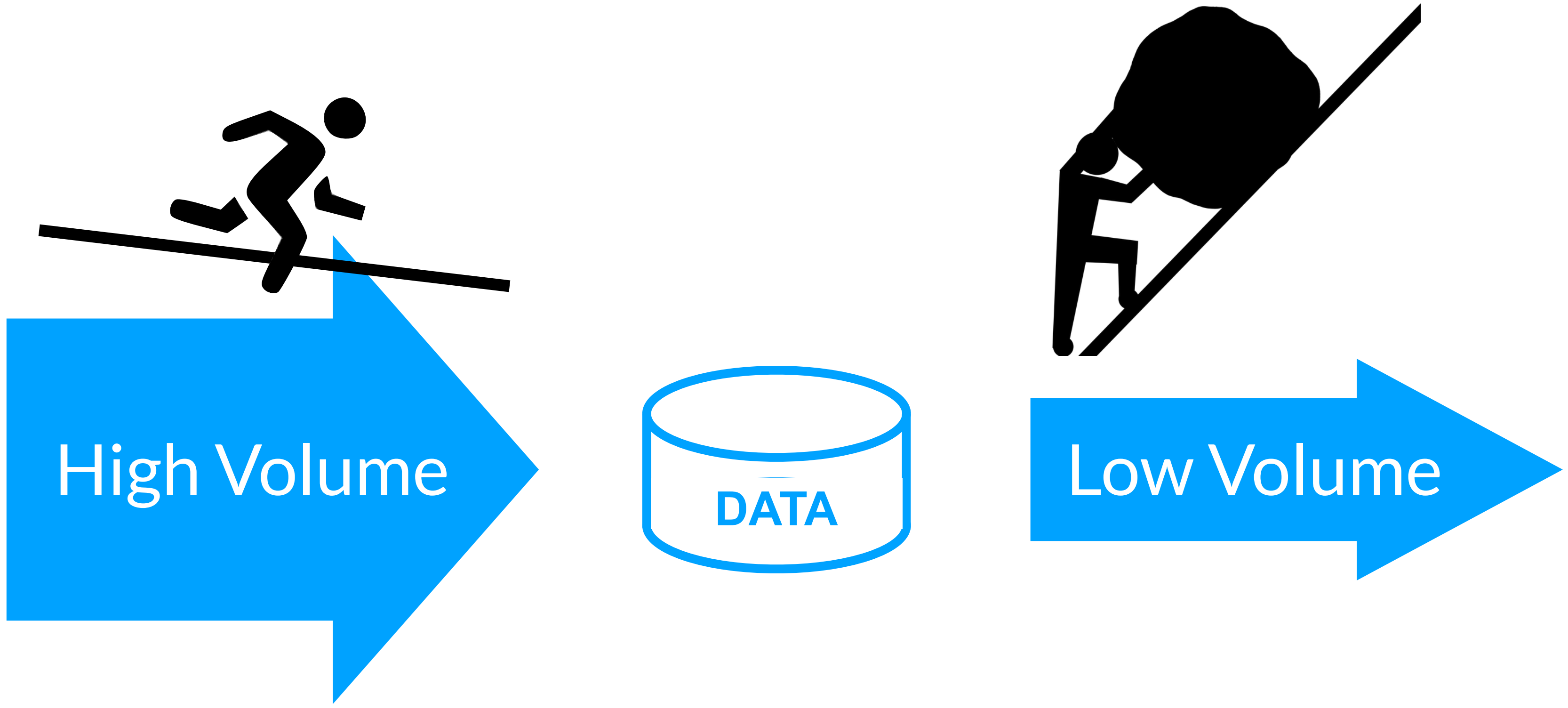
Data Driven SecOps



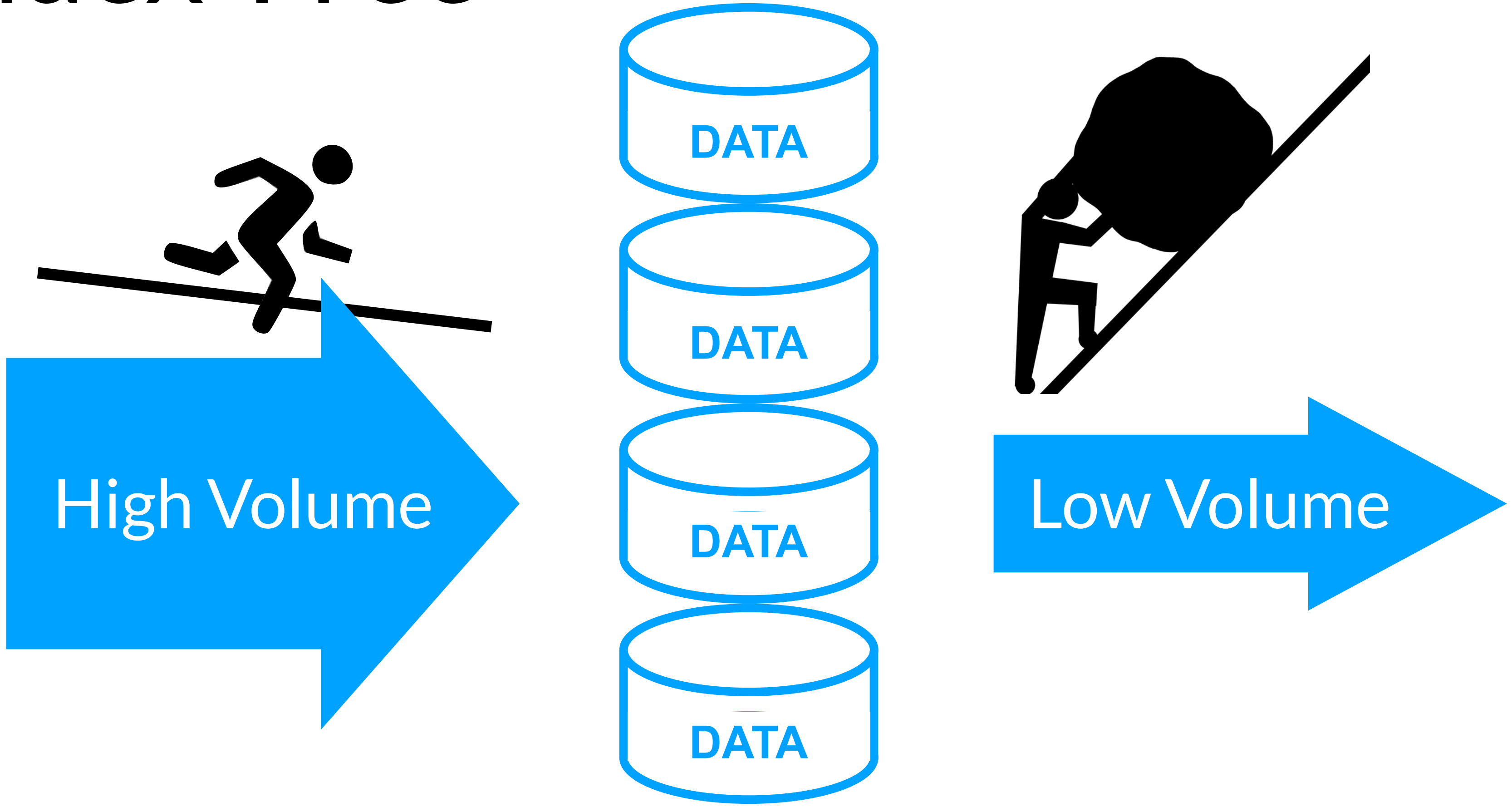
Put Logs in an Index?



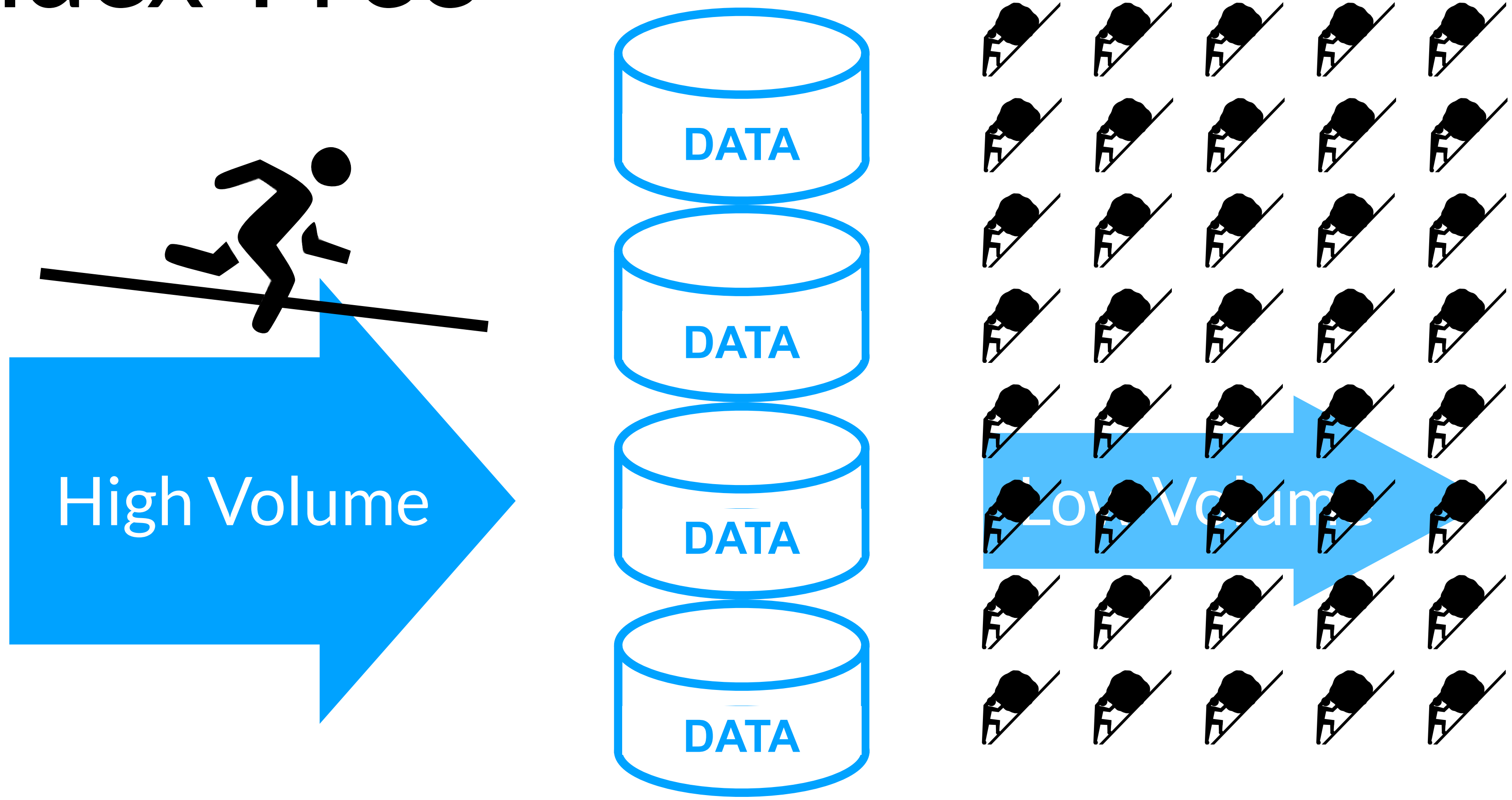
Index-Free



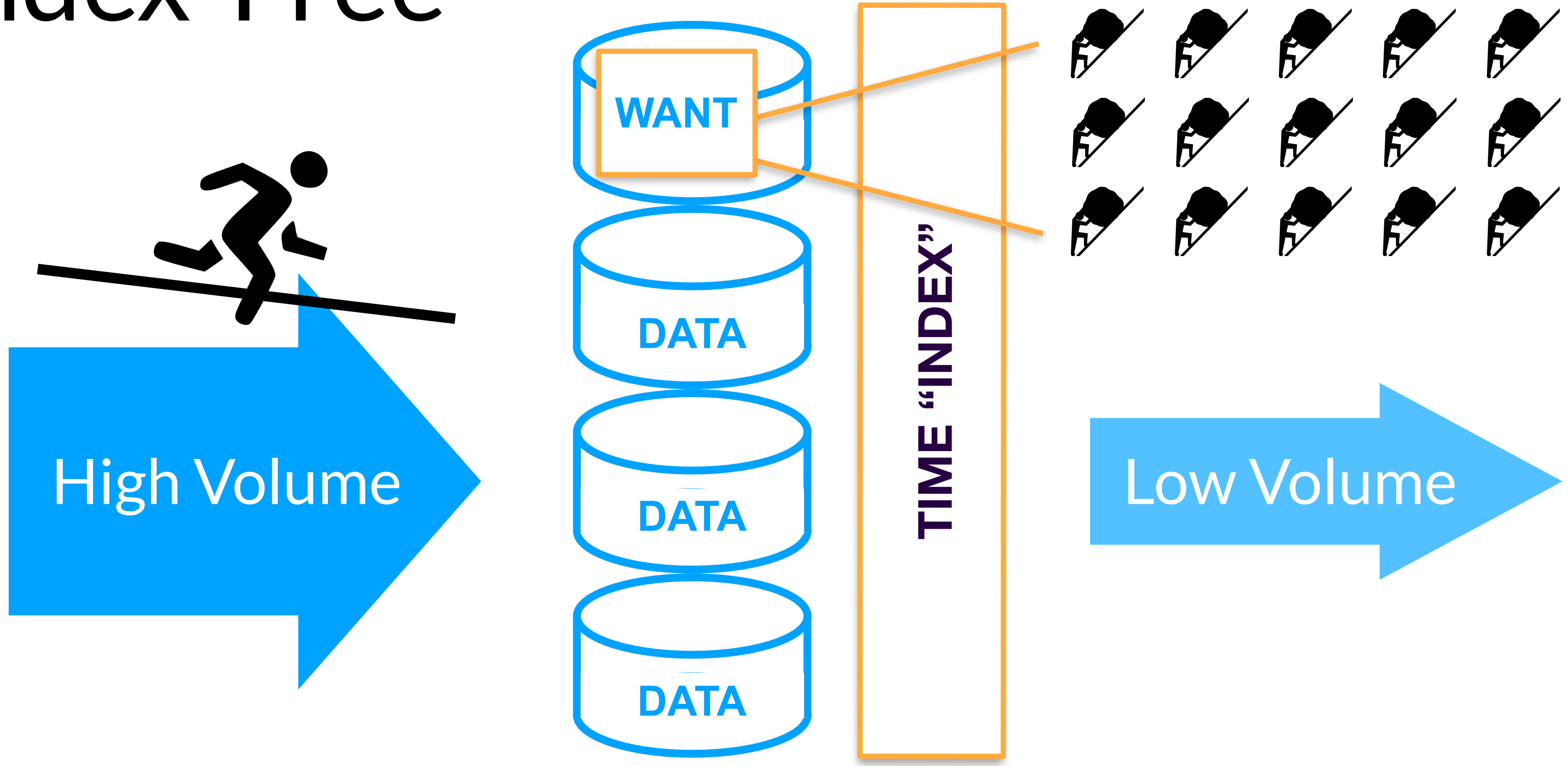
Index-Free



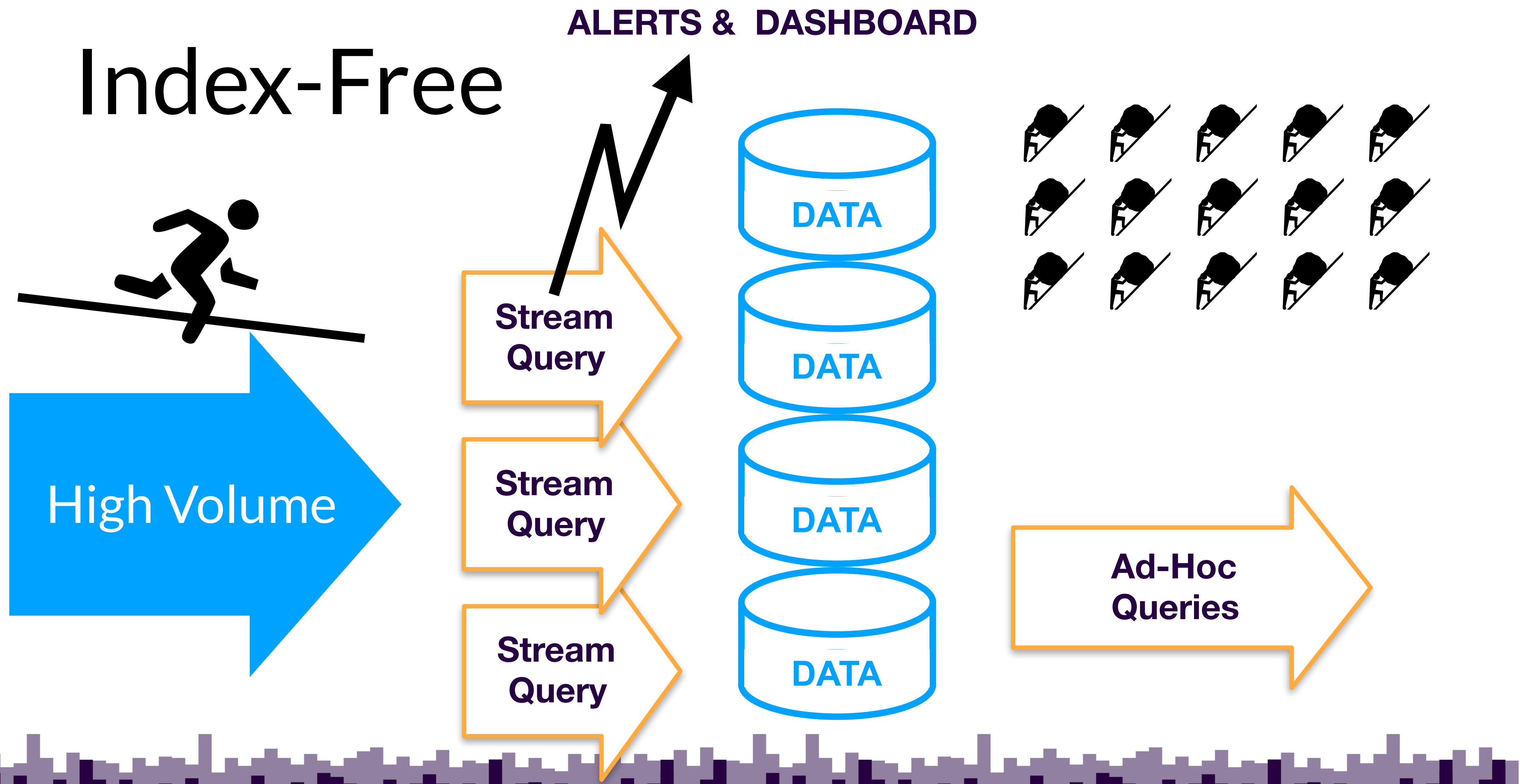
Index-Free



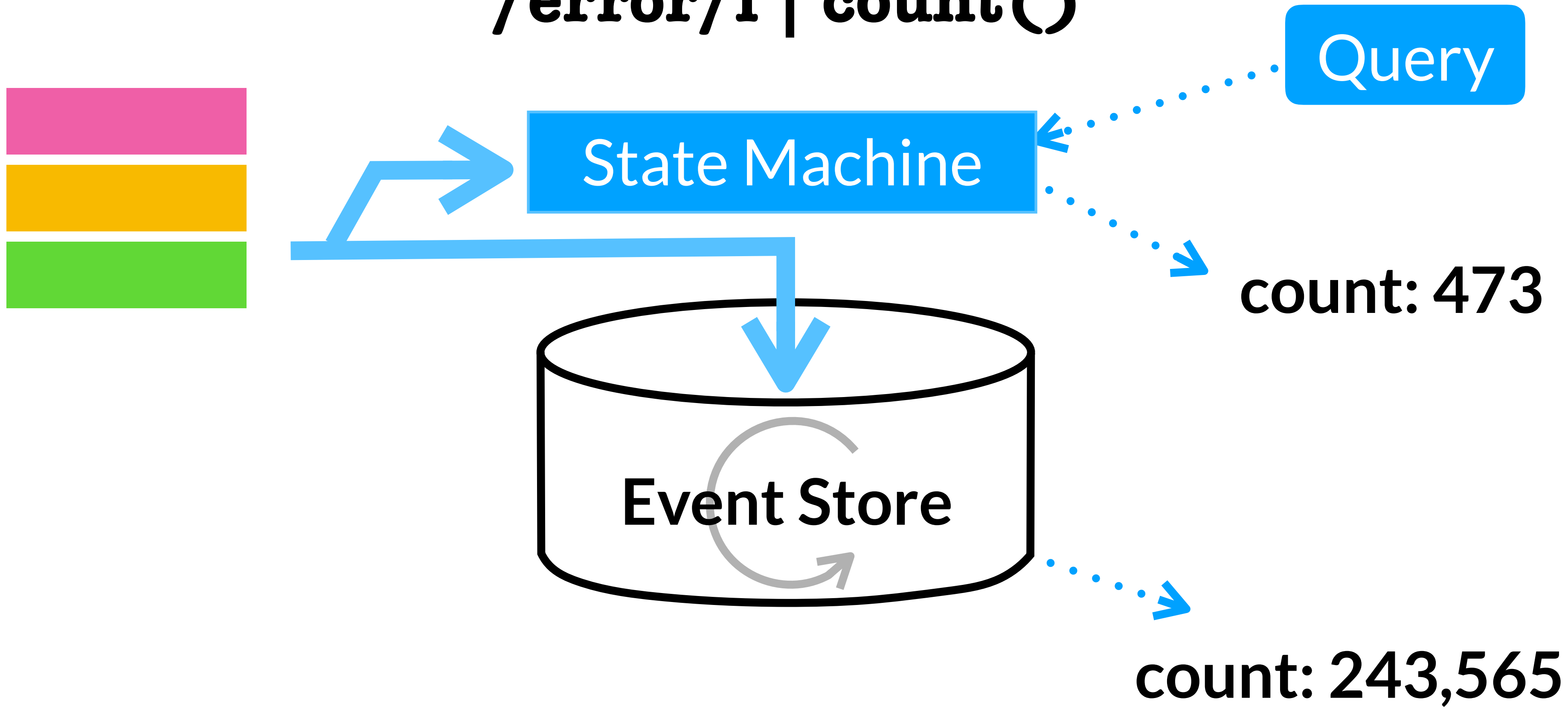
Index-Free



Index-Free


ALERTS & DASHBOARD
High Volume
Stream Query
Stream Query
Stream Query
DATA
DATA
DATA
DATA
Ad-Hoc Queries

/error/i | count()



Log Store Design

- **Build minimal index and compress data**

  Store order of magnitude more events

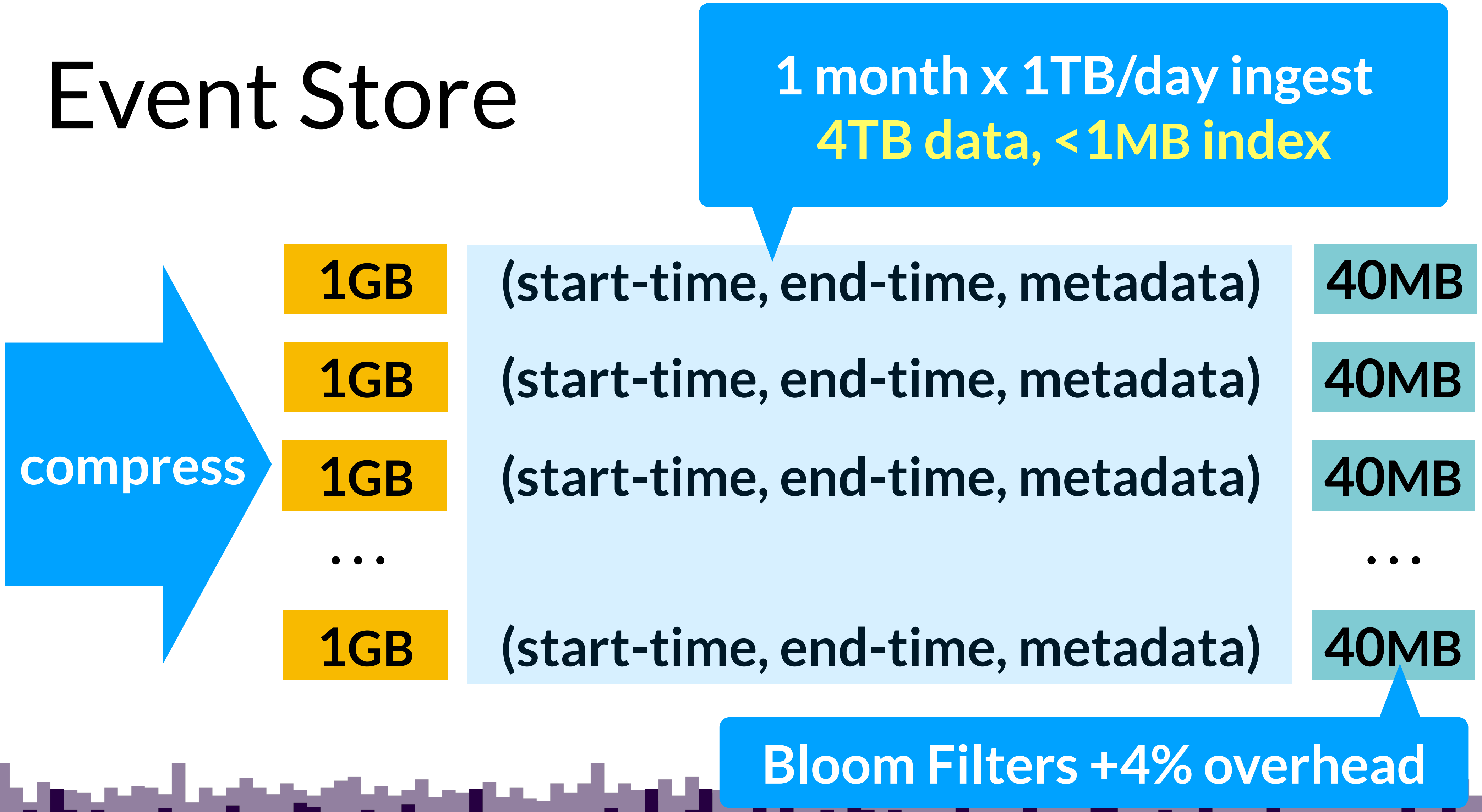
- **Fast “grep” for filtering events**

  Filtering and time/metadata selection reduces the problem space

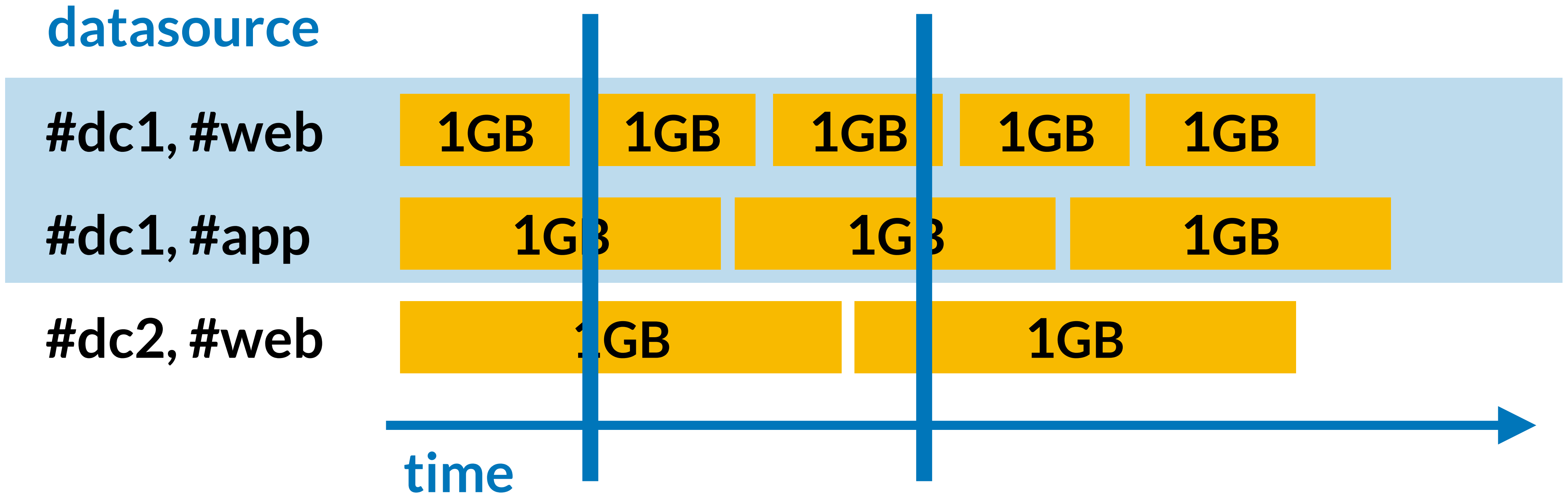
Event Store

10GB	(start-time, end-time, metadata)
10GB	(start-time, end-time, metadata)
10GB	(start-time, end-time, metadata)
...	
10GB	(start-time, end-time, metadata)

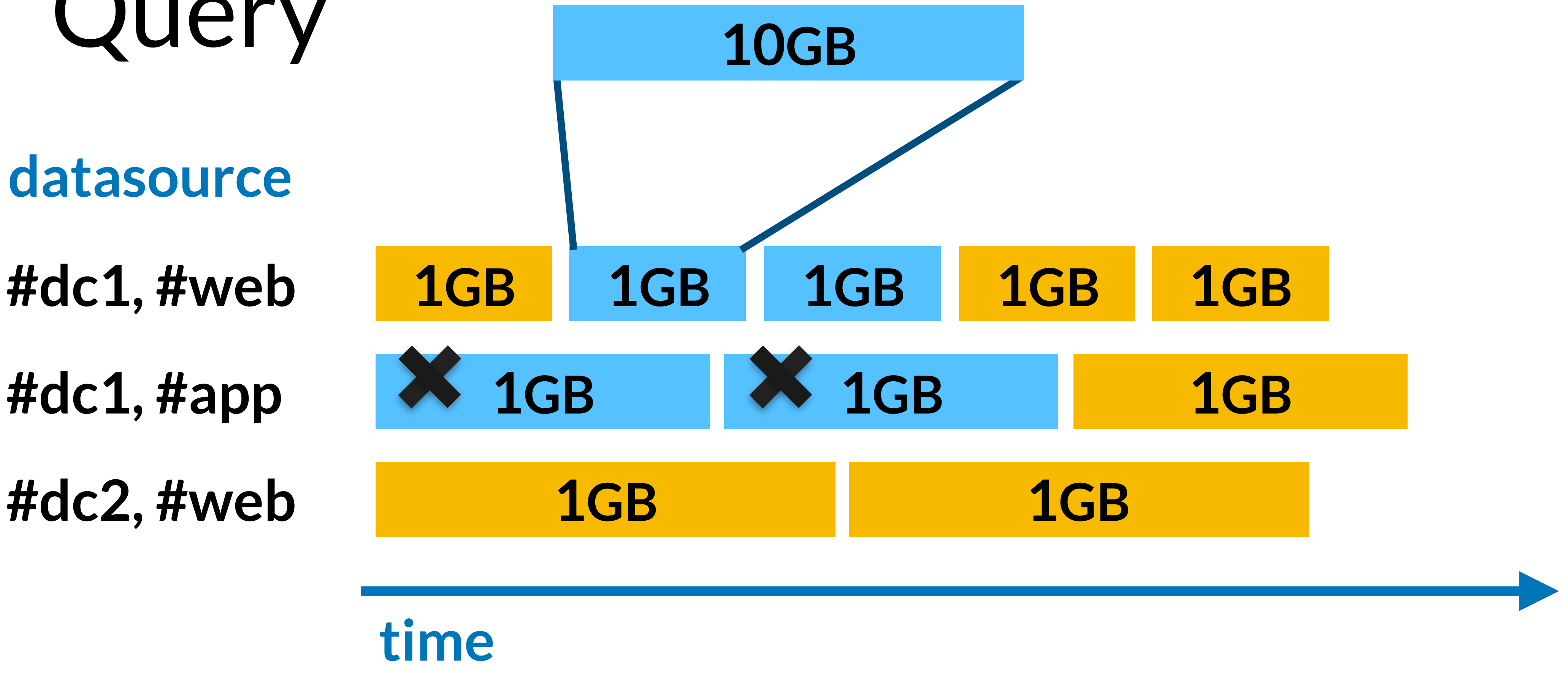
Event Store


1 month x 1TB/day ingest
4TB data, <1MB index
compress
1GB
(start-time, end-time, metadata)
40MB
1GB
(start-time, end-time, metadata)
40MB
1GB
(start-time, end-time, metadata)
40MB
...
...
1GB
(start-time, end-time, metadata)
40MB
Bloom Filters +4% overhead

Query


datasource
#dc1, #web
1GB
1GB
1GB
1GB
1GB
#dc1, #app
1GB
1GB
1GB
#dc2, #web
1GB
1GB
time

Query


10GB
datasource
#dc1, #web
1GB
1GB
1GB
1GB
1GB
#dc1, #app
1GB
1GB
1GB
#dc2, #web
1GB
1GB
time

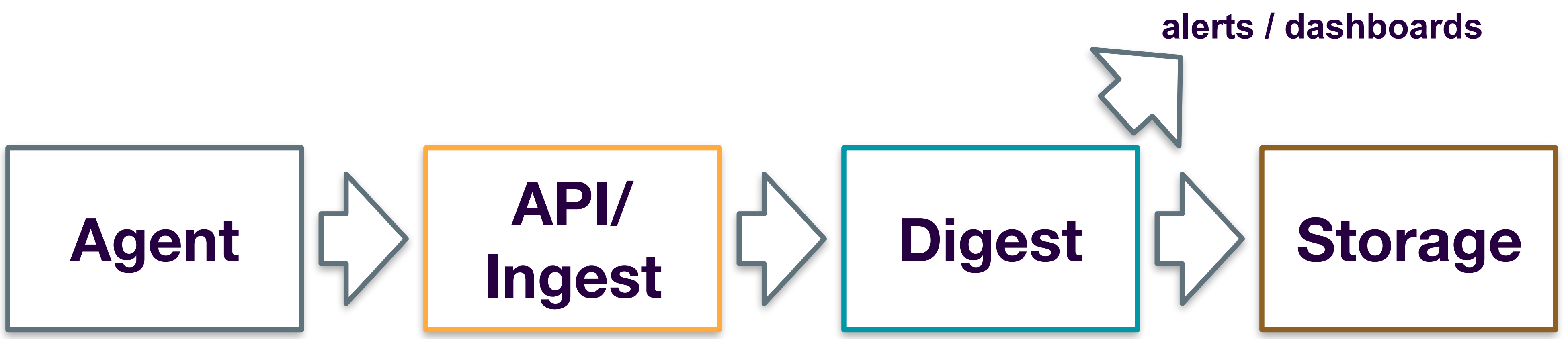
#IndexFreeLogging

Real-time Processing + **Brute-Force Search**

- "Materialized views" for dashboards/alerts.
- Processed when data is in-memory anyway.
- Fast response times for "known" queries.

- Shift CPU load to query time
- Data compression
- Filtering, not Indexing
- Requires "Full stack" ownership to perform

Humio Ingest Data Flow



- Send data

- HTTP/TCP API
- Authenticate
- Field Extraction

- Live queries
- Write segment files

- Replication

Use Kafka for the ‘hard parts’

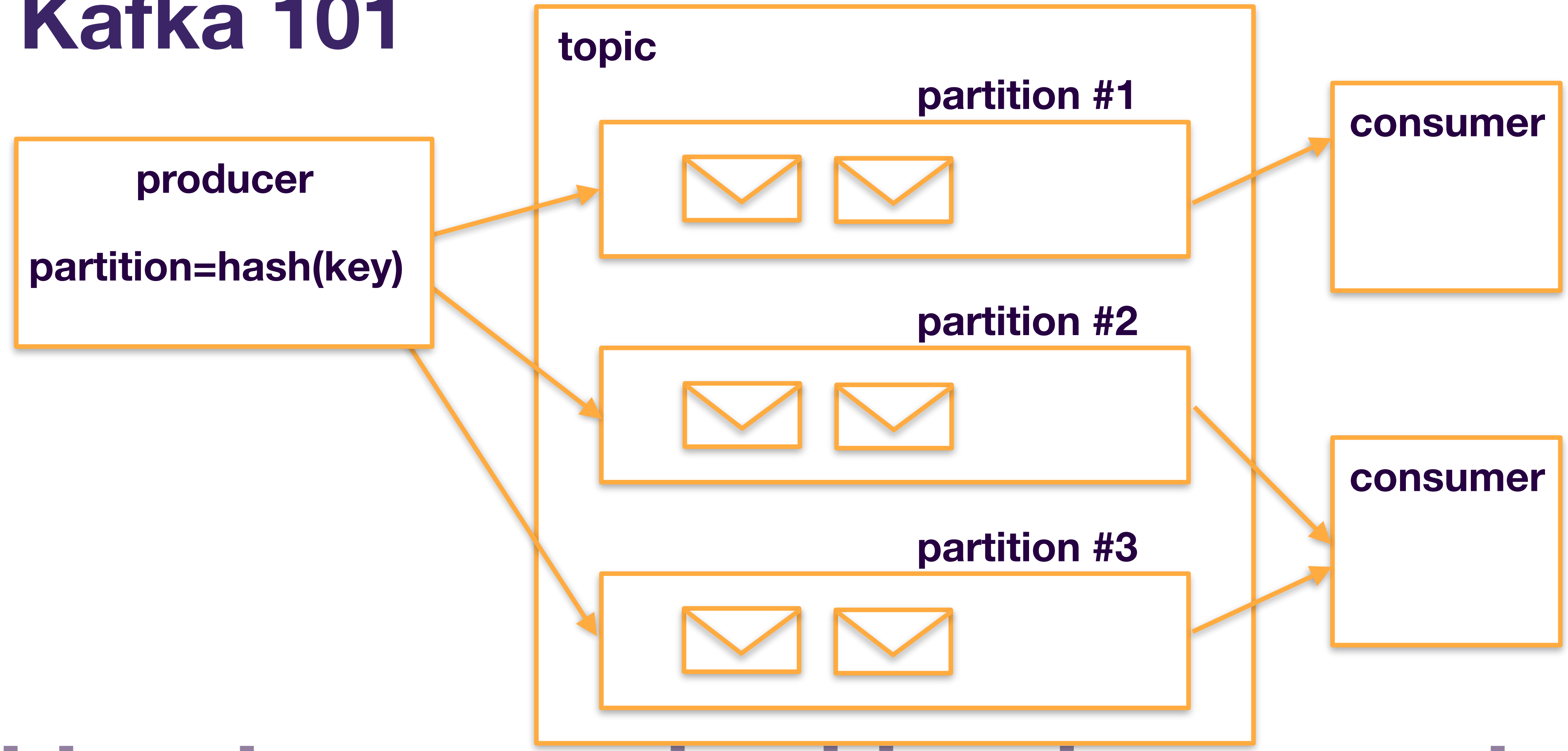
- Coordination
- Commit-log / ingest buffer

- No KSQL

Kafka 101

- Kafka is a <u>reliable</u> distributed log/queue system
- A Kafka queue consists of a number of partitions
- Messages within a partition are sequenced
- Partitions are replicated for durability
- Use ‘partition consumers’ to parallelise work

Kafka 101


topic
producer
partition=hash(key)
partition #1
partition #2
partition #3
consumer
consumer

Coordination ‘global data’

- Zookeeper-like system in-process
- All cluster node keep entire K/V set in memory
- Make decisions locally/fast without crossing a network boundary.
- Allows in-memory indexes of meta data.

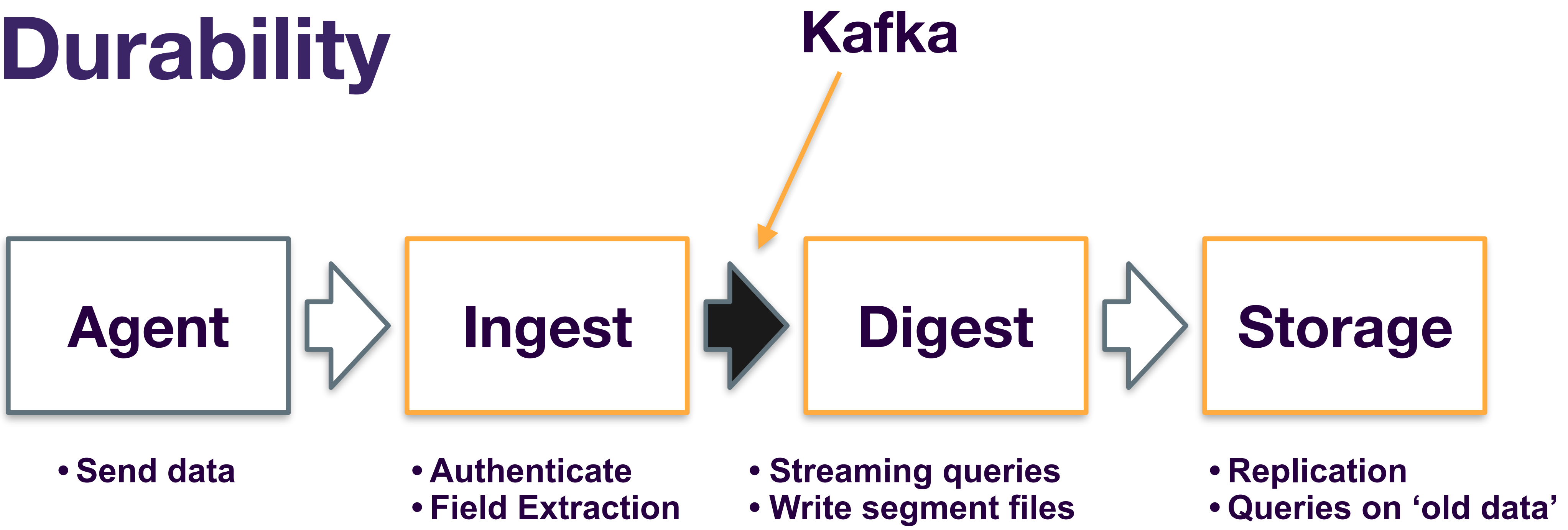
Coordination ‘global data’

- Coordinated via single-partition Kafka queue
- Ops-based CRDT-style event sourcing
- Bootstrap from snapshot from any node
- Kafka config: low latency

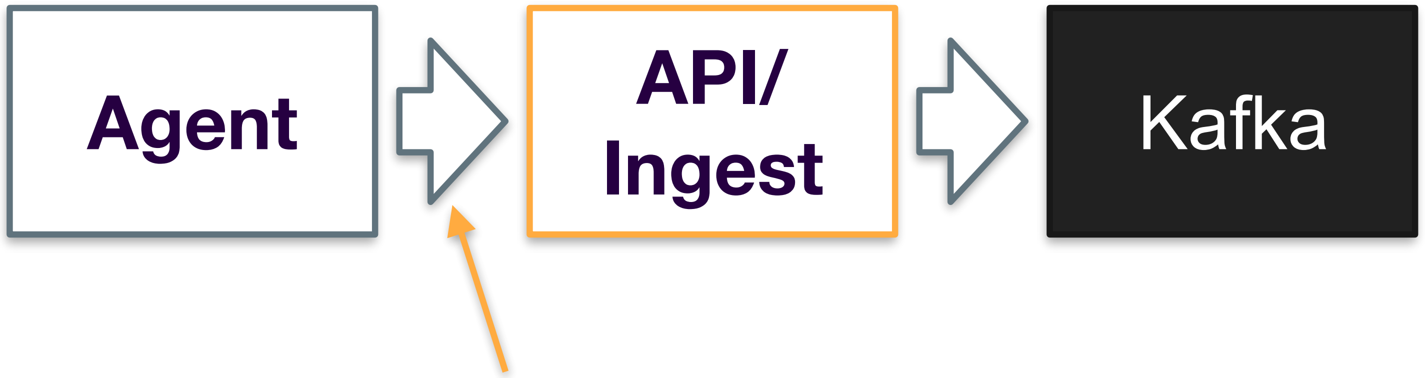
Durability

- Don’t loose people’s data.
- Control and manage data life expectancy
- Store, Replicate, Archive, Multi-tier Data storage

Durability


Kafka
Agent
Ingest
Digest
Storage
• Send data
• Authenticate
• Field Extraction
• Streaming queries
• Write segment files
• Replication
• Queries on ‘old data’

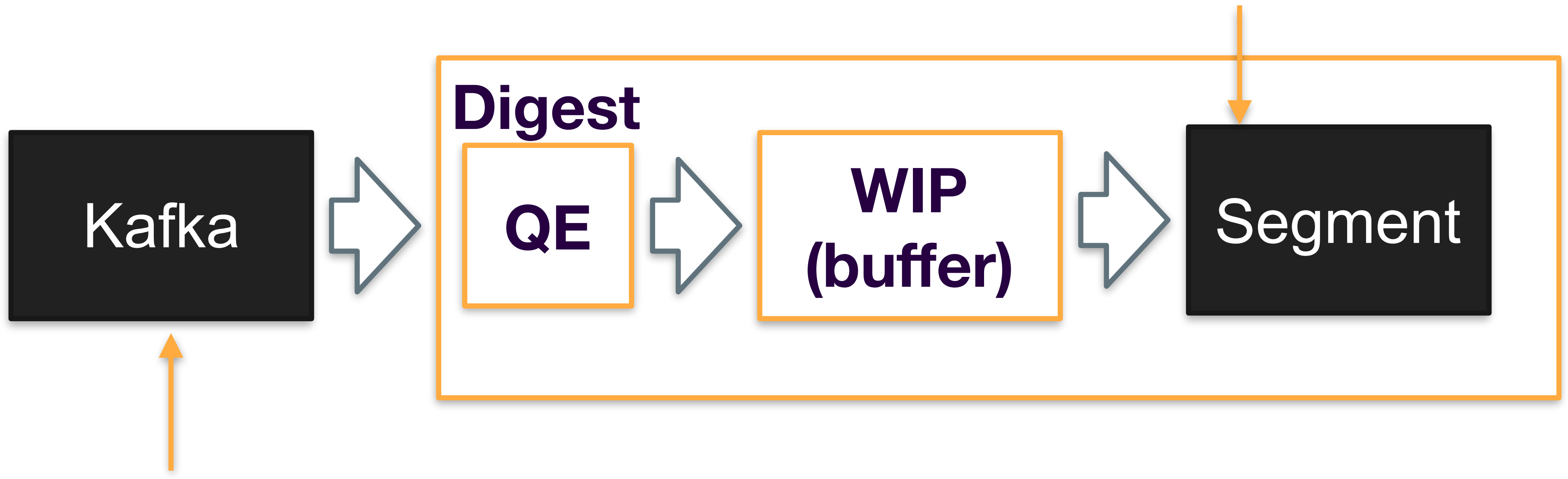
Durability



HTTP 200 response => Kafka ACK'ed the store

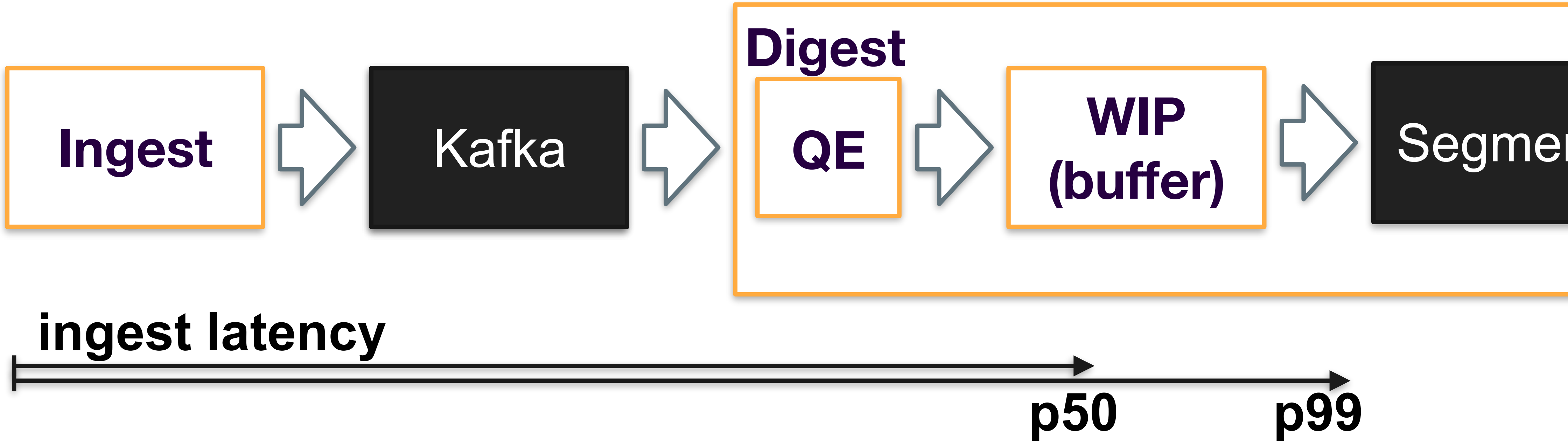
Durability

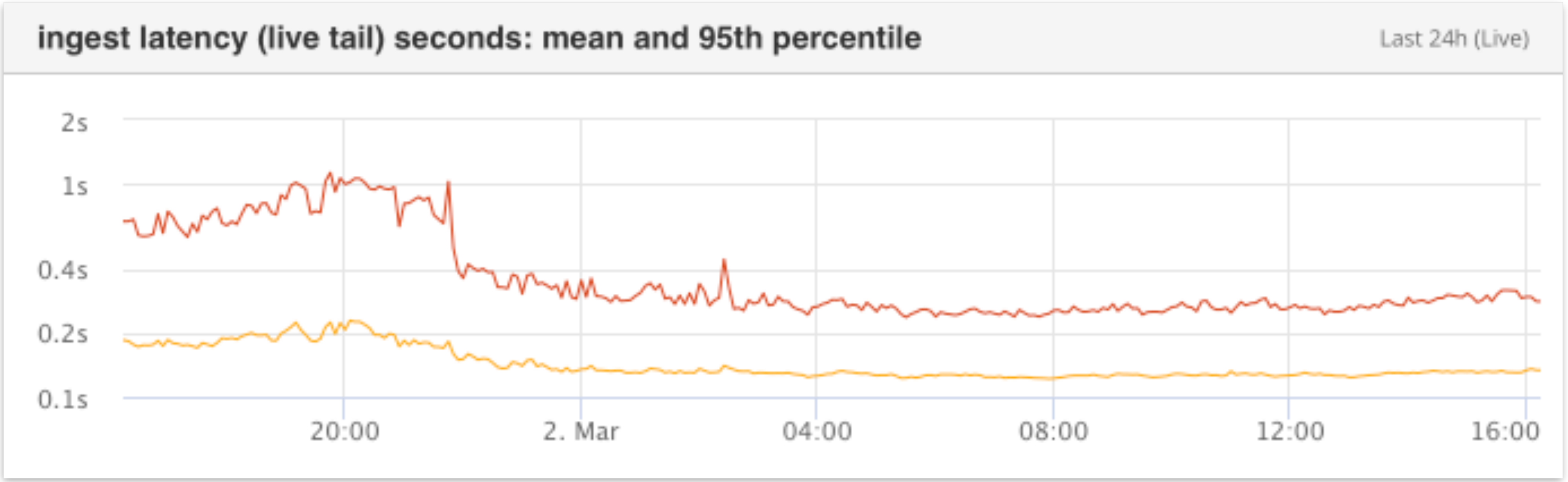
File records last consumed sequence number from disk



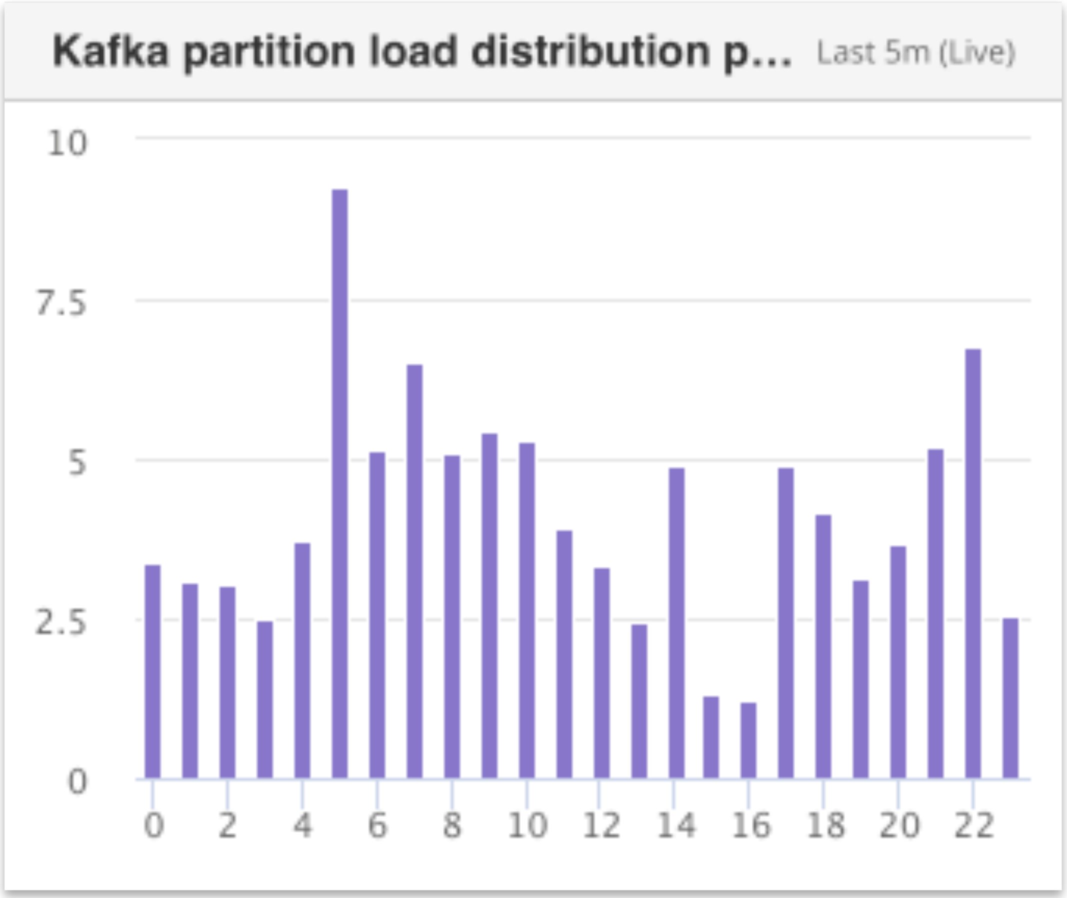
Retention must be long enough to deal with crash

Durability

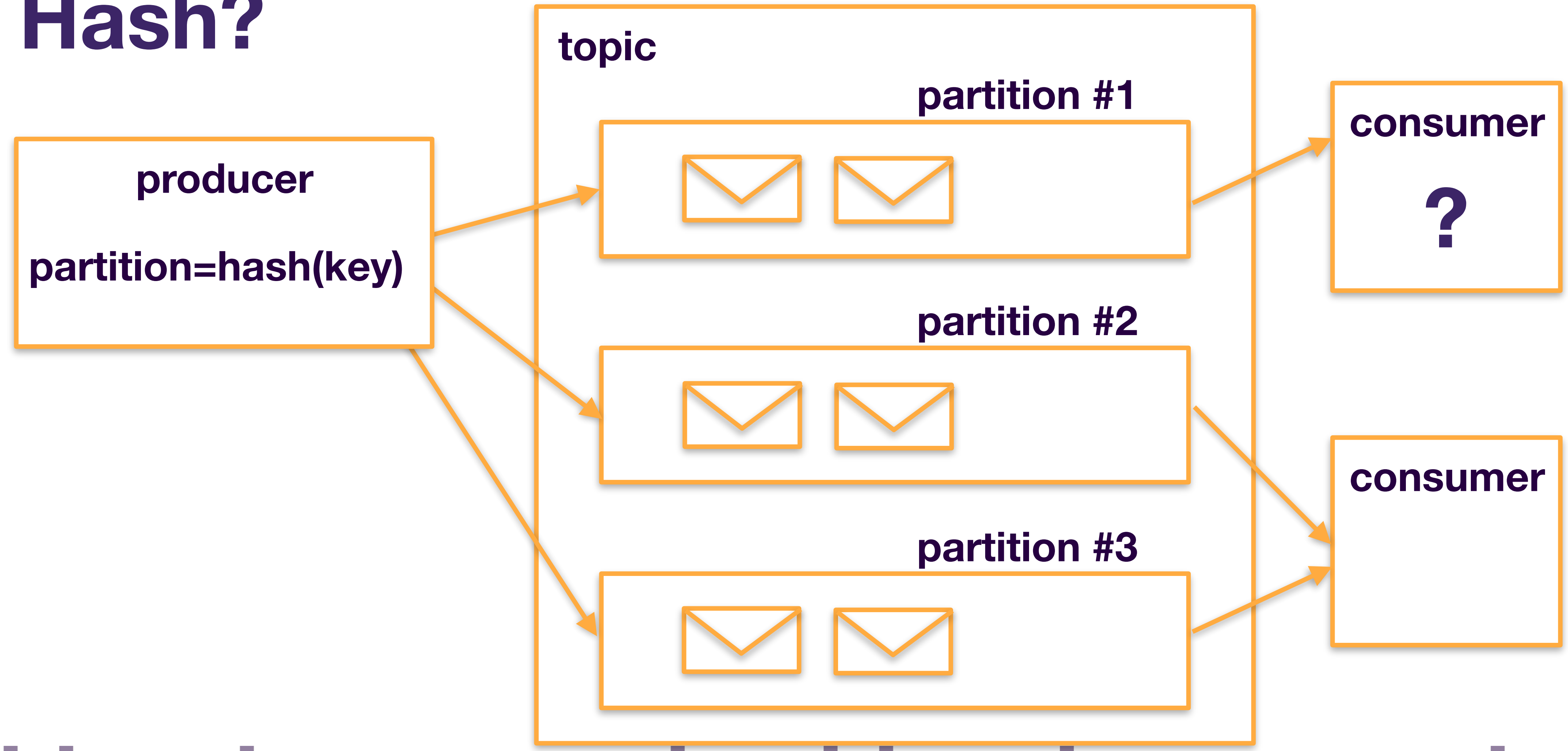

Ingest
Kafka
Digest
QE
WIP (buffer)
Segme
ingest latency
p50
p99


ingest latency (live tail) seconds: mean and 95th percentile
Last 24h (Live)
2s
1s
0.4s
0.2s
0.1s
20:00
2. Mar
04:00
08:00
12:00
16:00

Kafka partition load distribution p… Last 5m (Live)



Hash?

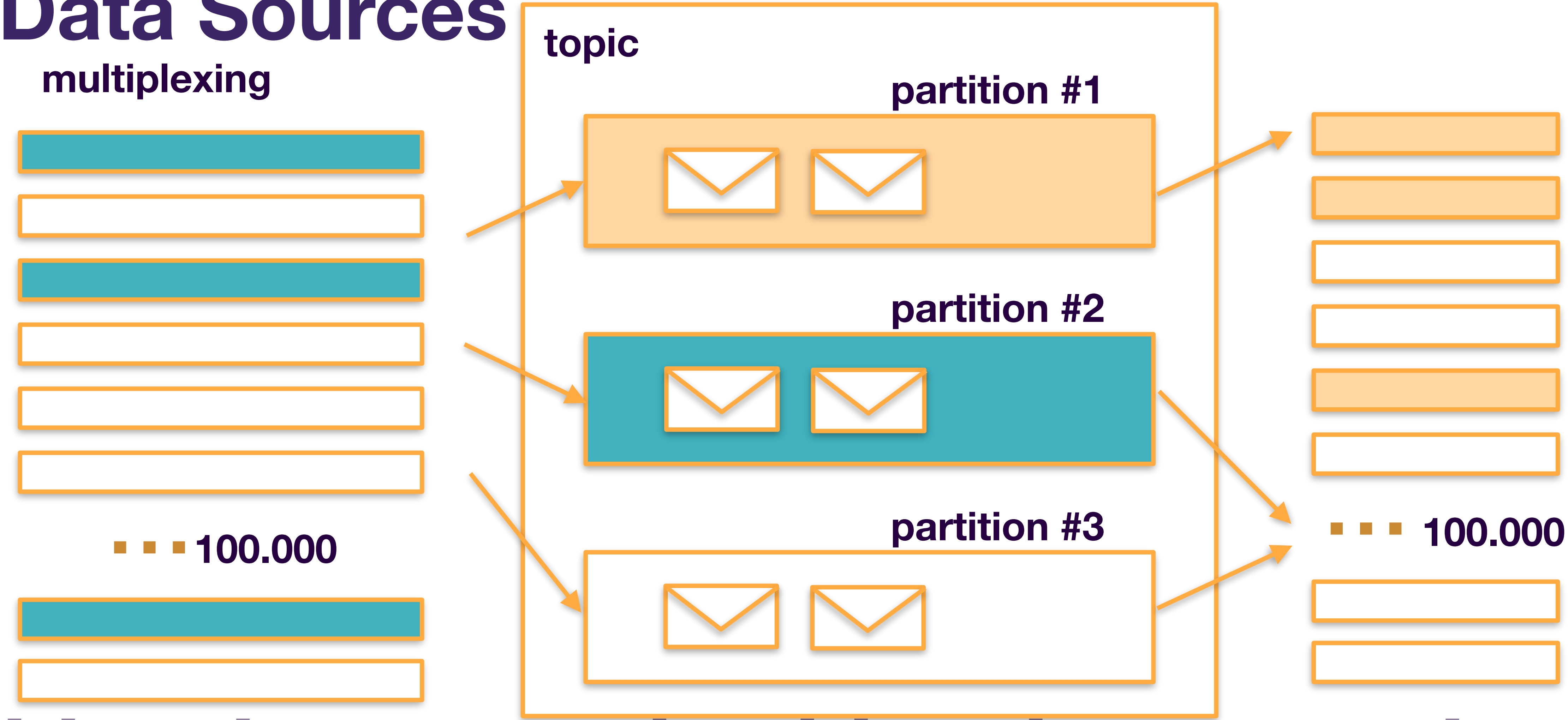

topic
producer
partition=hash(key)
partition #1
partition #2
partition #3
consumer
?
consumer

Consumers falling behind…

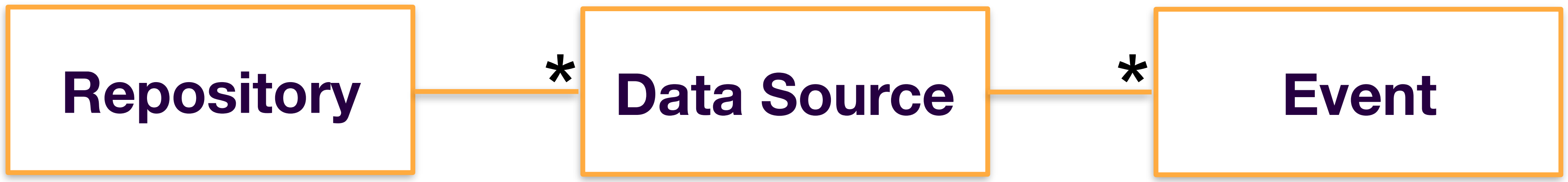
- Reasons:
    - Data volume
    - Processing time for real-time processing
- Measure ingest latency
- Increase parallelism when running 10s behind
    - Log scale (1, 2, 4, …) randomness added to key.

Data Sources

multiplexing



Data Model



- Storage limits
- User admin

- Time series identified by set of key-value 'tags'

- Timestamp + Map[String,String]

```
Hash (#type=accesslog,#host=ops01 )
```

High variability tags ‘auto grouping’

- Tags (hash key) may be chosen with large value domain
    - User name
    - IP-address

- This causes many datasources => growth in metadata, resource issues.

High variability tags ‘auto grouping’

- Tags (hash key) may be chosen with large value domain
    - User name
    - IP-address

- Humio sees this and hashes tag value into a smaller value domain before the Kafka partition hash.

High variability tags ‘auto grouping’

- For example, before Kafka ingest hash(“kresten”)

```
#user=kresten   =>    #user=13
```

  - Store the actual value ‘`kresten`’ in the event

- At query time, a search is then rewritten to search the data source `#user=13`, and re-filter based on values.

Humio

Multiplexing in Kafka

- Ideally, we would just have 100.000 dynamic topics that perform well and scales infinitely.
- In practice, you have to know your data, and control the sharding. Default Kafka configs work for many workloads, but for maximum utilisation you have to do go beyond defaults.
- Humio automates this problem for log data w/ tags.

Using Kafka in an on-prem Product

- Leverage the stability and fault tolerance of Kafka
- Large customers often have Kafka knowledge
- We provide kafka/zookeeper docker images
- Only real issue is Zookeper dependency
    - Often runs out of disk space in small setups

Other Issues

- Observed GC pauses in the JVM
- Kafka and HTTP libraries compress data
- JNI/GC interactions with `byte[]` can block global GC.
- We replaced both with custom compression
    - JLibGzip (gzip in pure Java)
    - Zstd and LZ4/JNI using DirectByteBuffer

Resetting Kafka/Zookeeper

- Kafka provides a ‘cluster id’ we can use as epoch
- All Kafka sequence numbers (offsets) are reset
- Recognise this situation, no replay beyond such a reset.

What about KSQL?

- Kafka now has KSQL which is in many ways similar to the engine we built
    - Humio moves computation to the data,
    - KSQL moves the data to the computation
- We provide interactive end-user friendly experience

Final thoughts

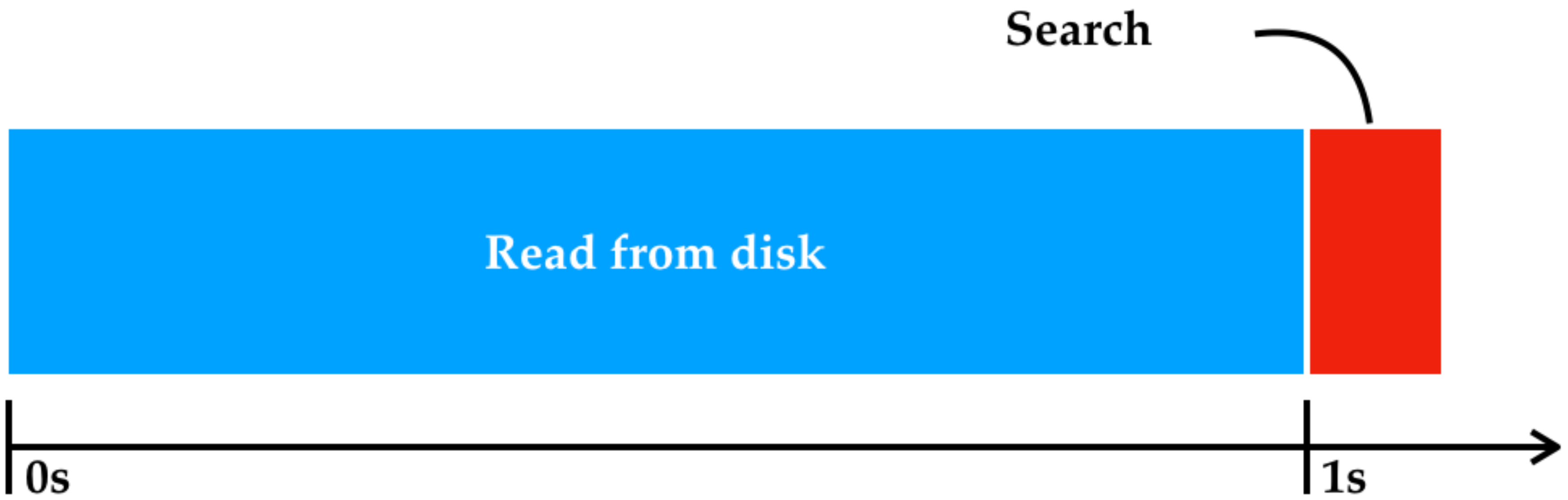
- With #IndexFreeLogging you can eat your cake and have it too: fast, useful, low footprint logging.

- Many difficult problems go away by deferring them to Kafka.

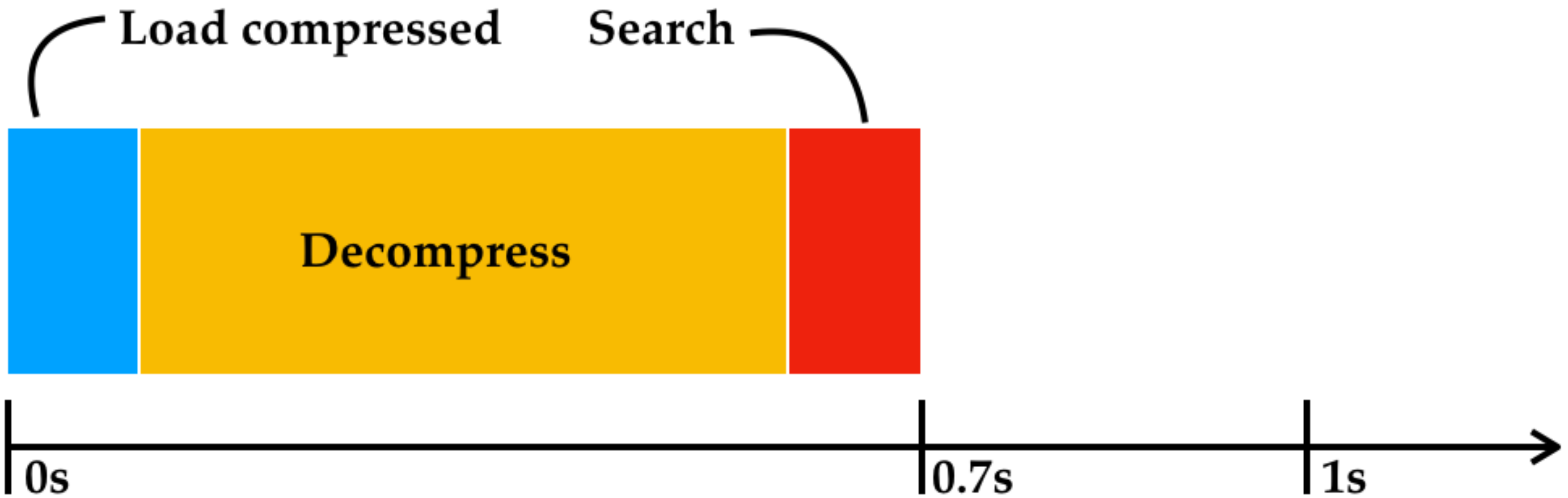
Thanks for your time.

Kresten Krab Thorup
Humio CTO

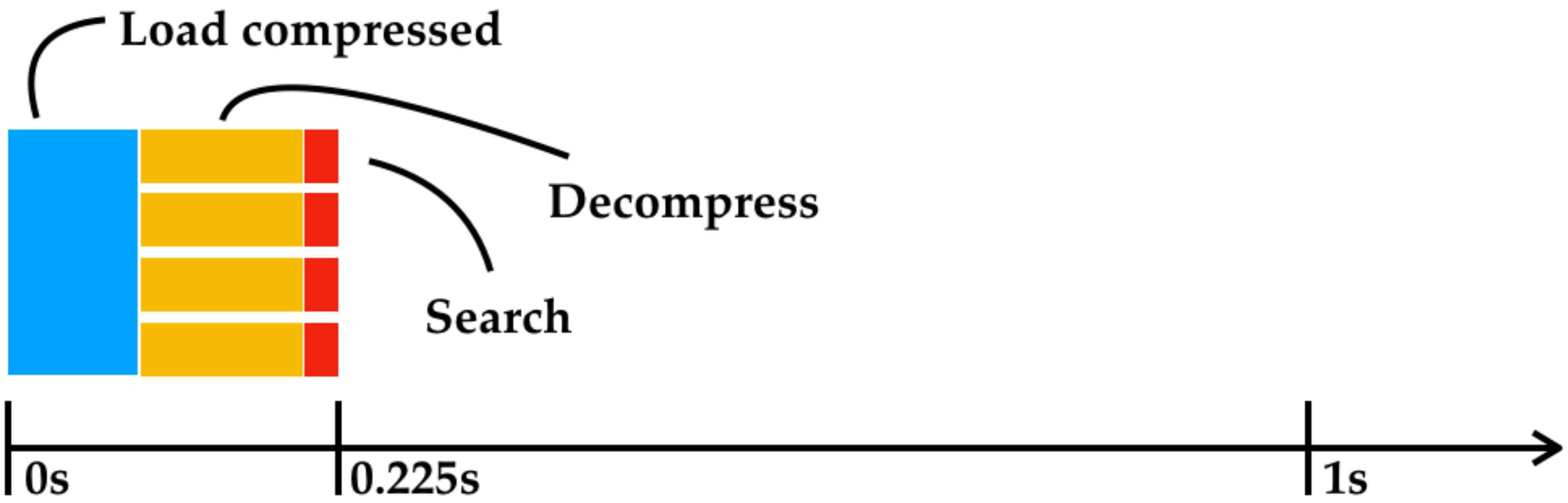
Filter 1GB data



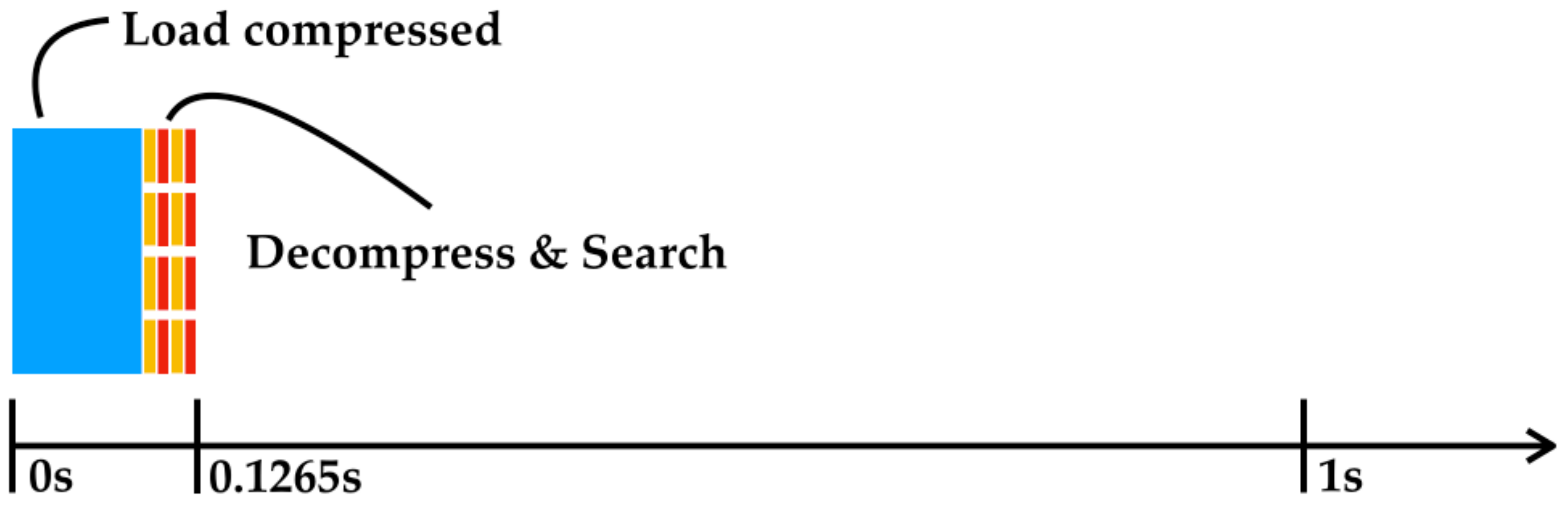
Filter 1GB data



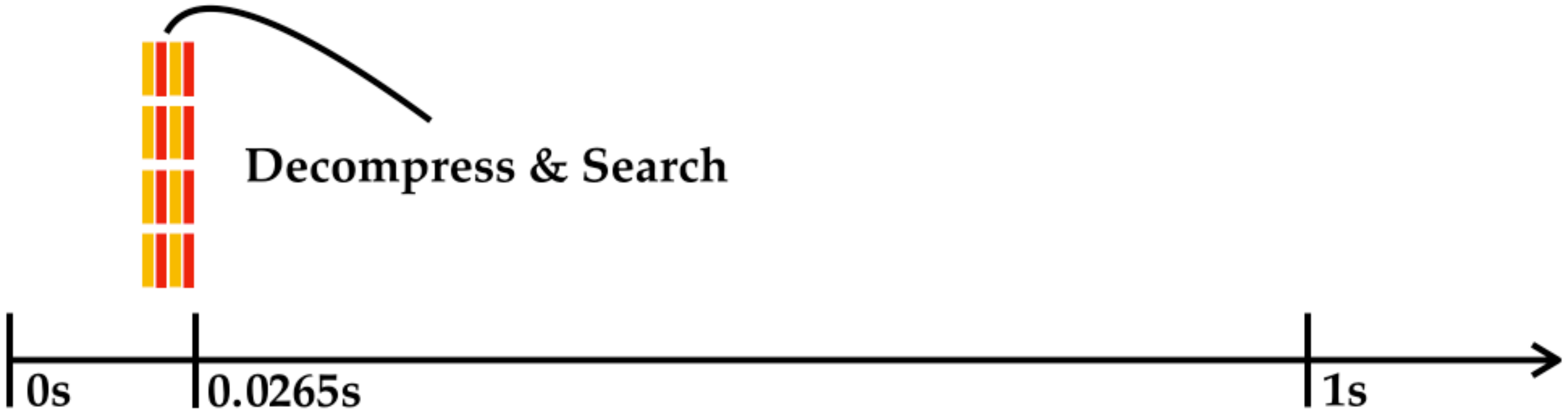
Filter 1GB data



Filter 1GB data



Filter 1GB data


Decompress & Search
0s
0.0265s
1s