Stream All the Things!

Architectures for Data that Never Ends

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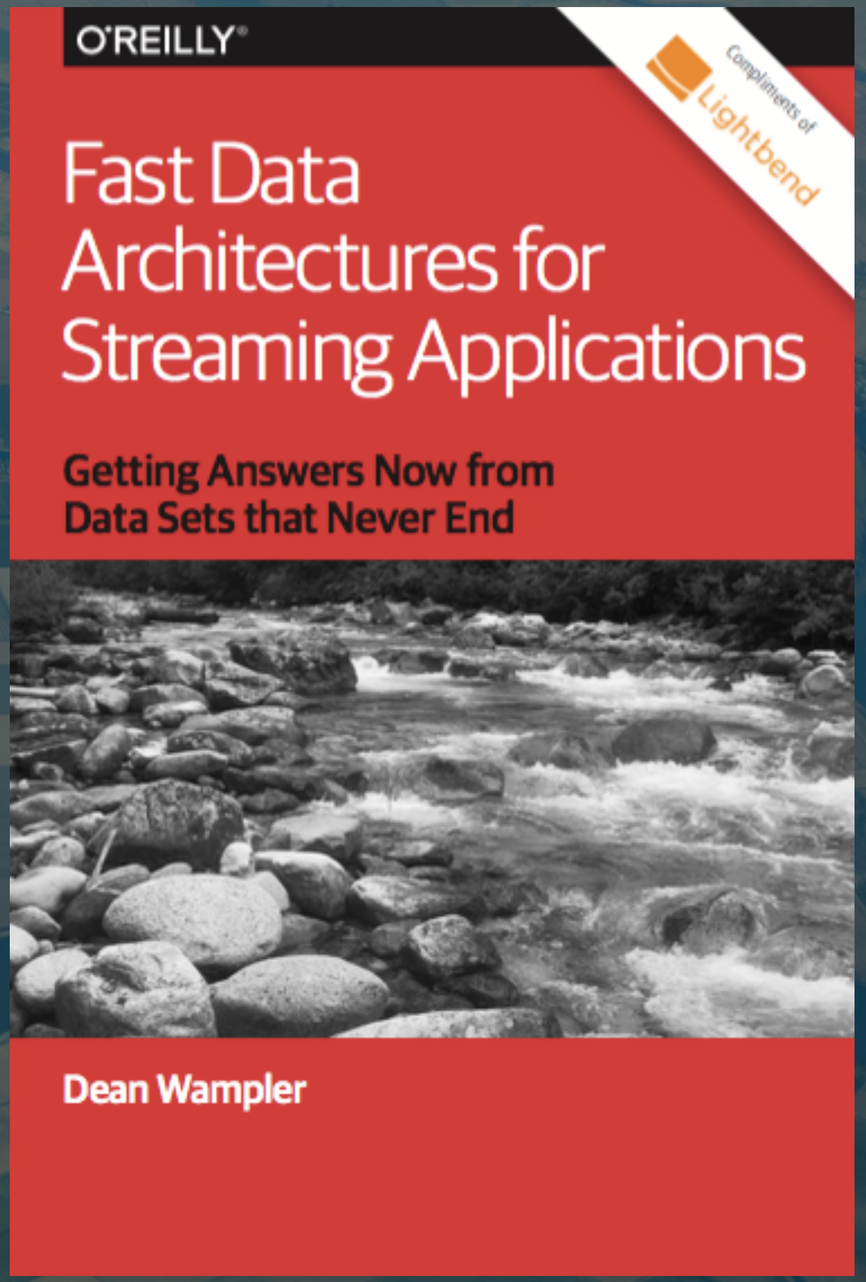
@deanwampler

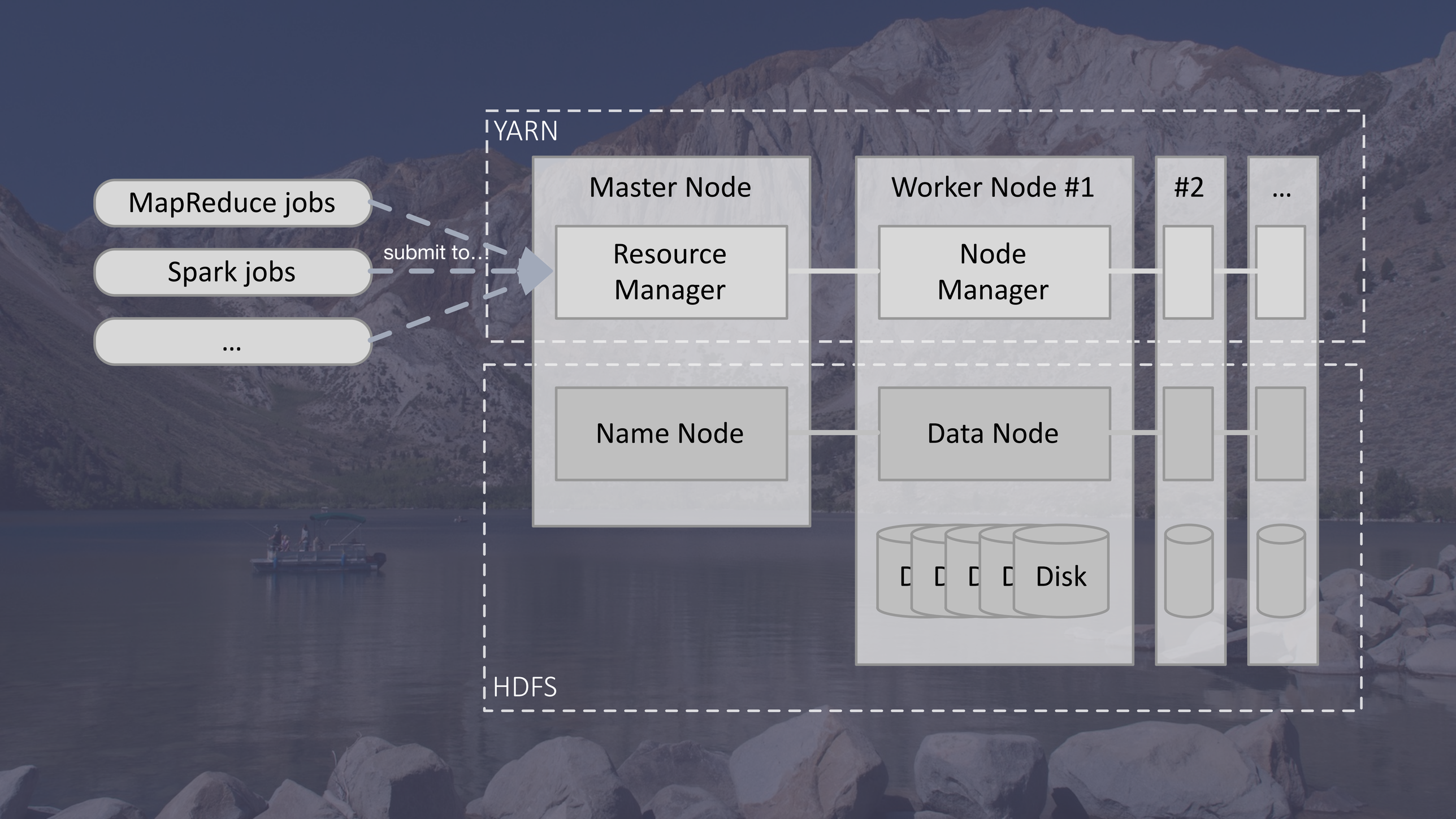
Free as in 🍺

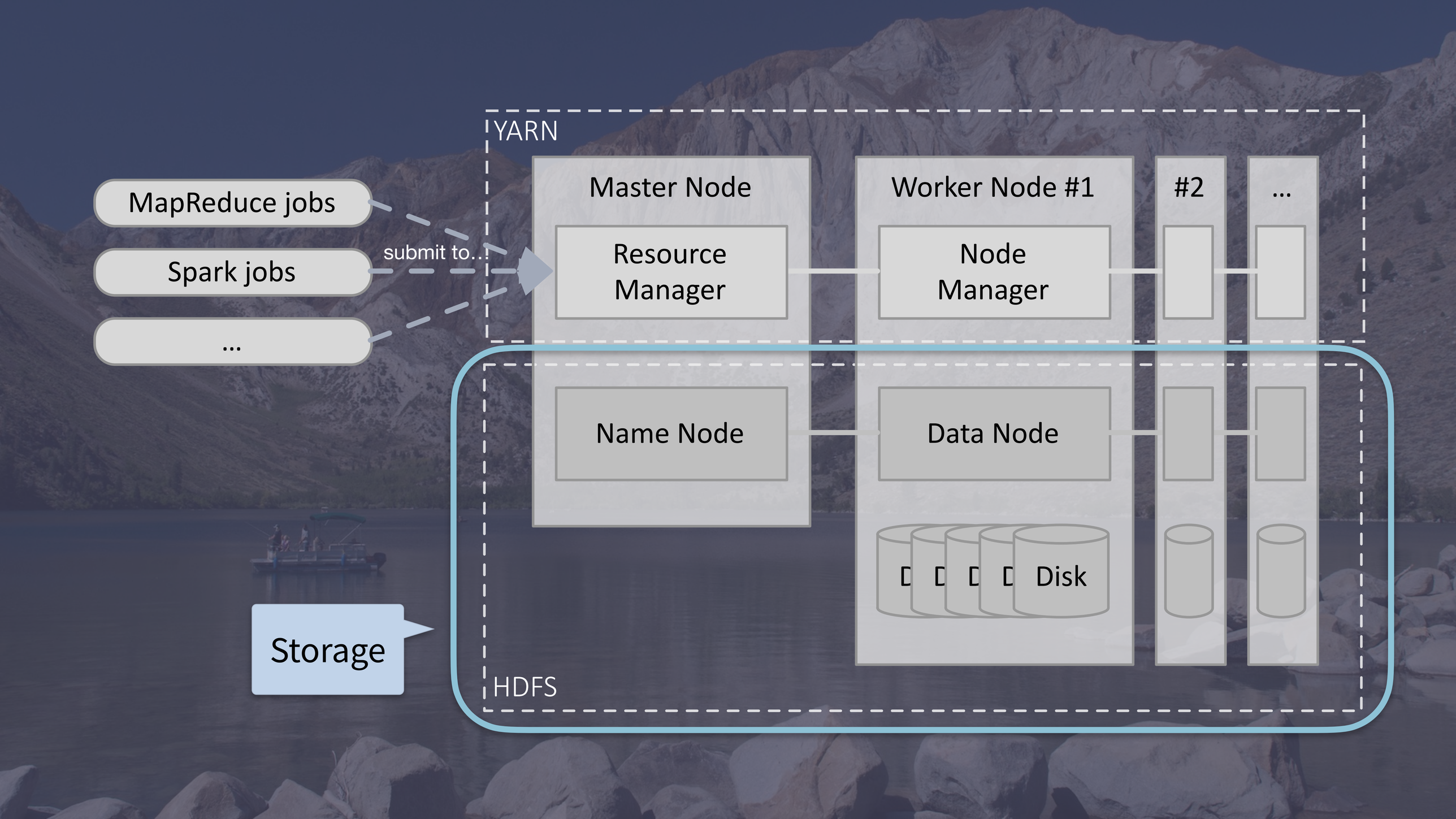
go.lightbend.com/fast-data-architectures-for-streaming-applications-oreilly-2nd-edition




Streaming
in Context…

Hadoop: Classic Batch Architecture


YARN
MapReduce jobs
Spark jobs
…
submit to…
Master Node
Resource Manager
Worker Node #1
Node Manager
#2
…
Name Node
Data Node
Disk
HDFS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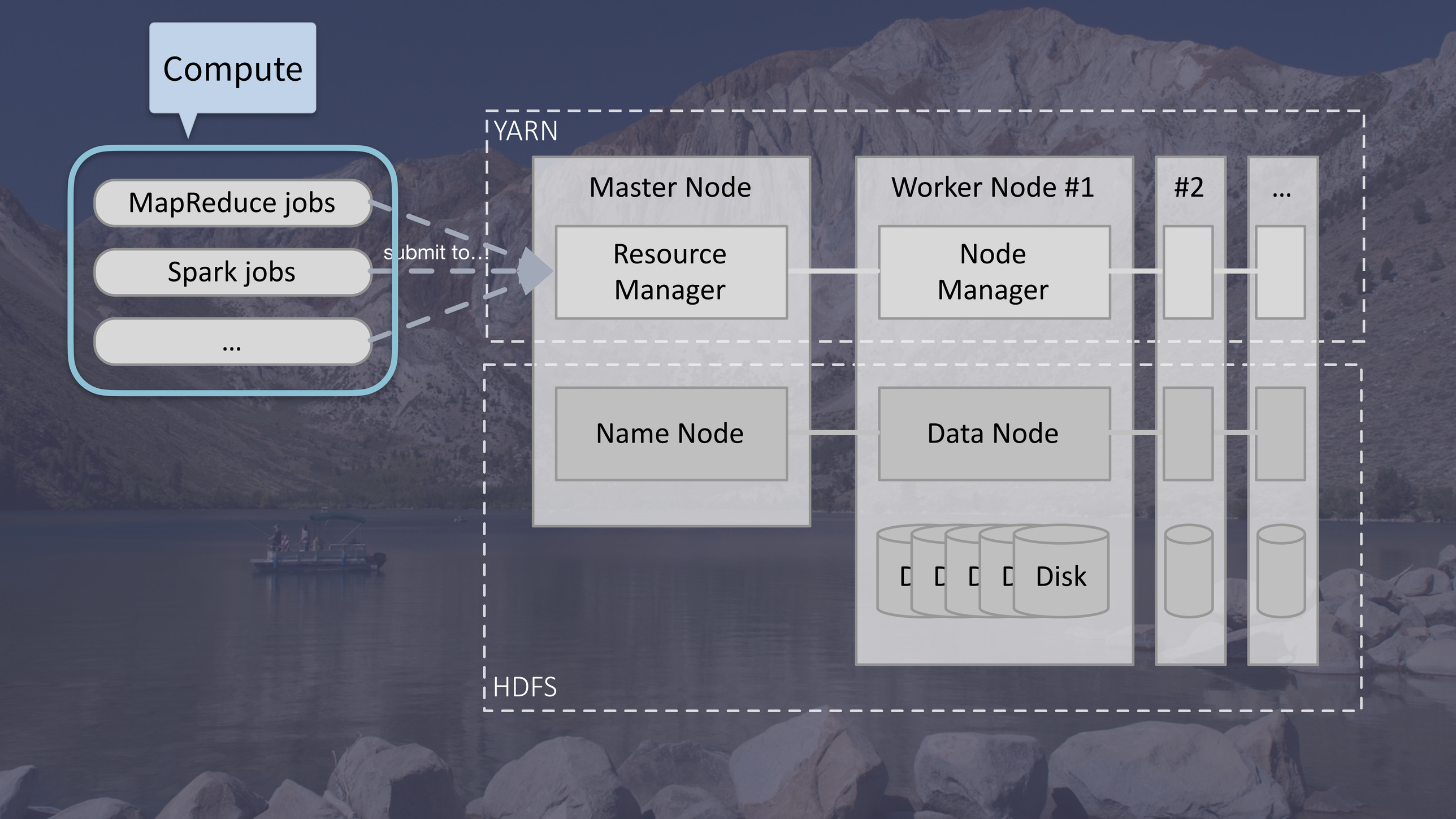
Compute
MapReduce jobs
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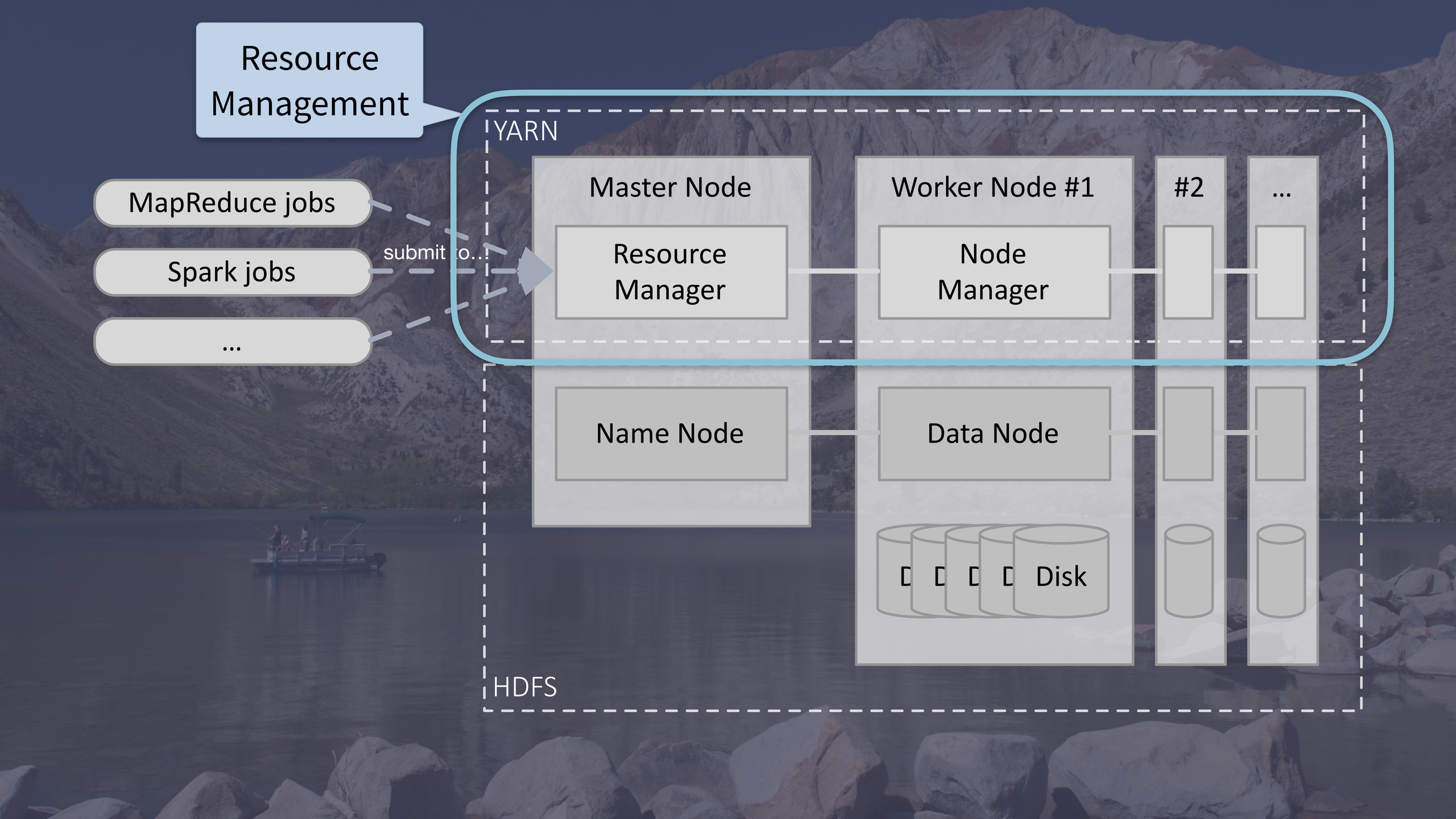
Resource Management
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Spark jobs
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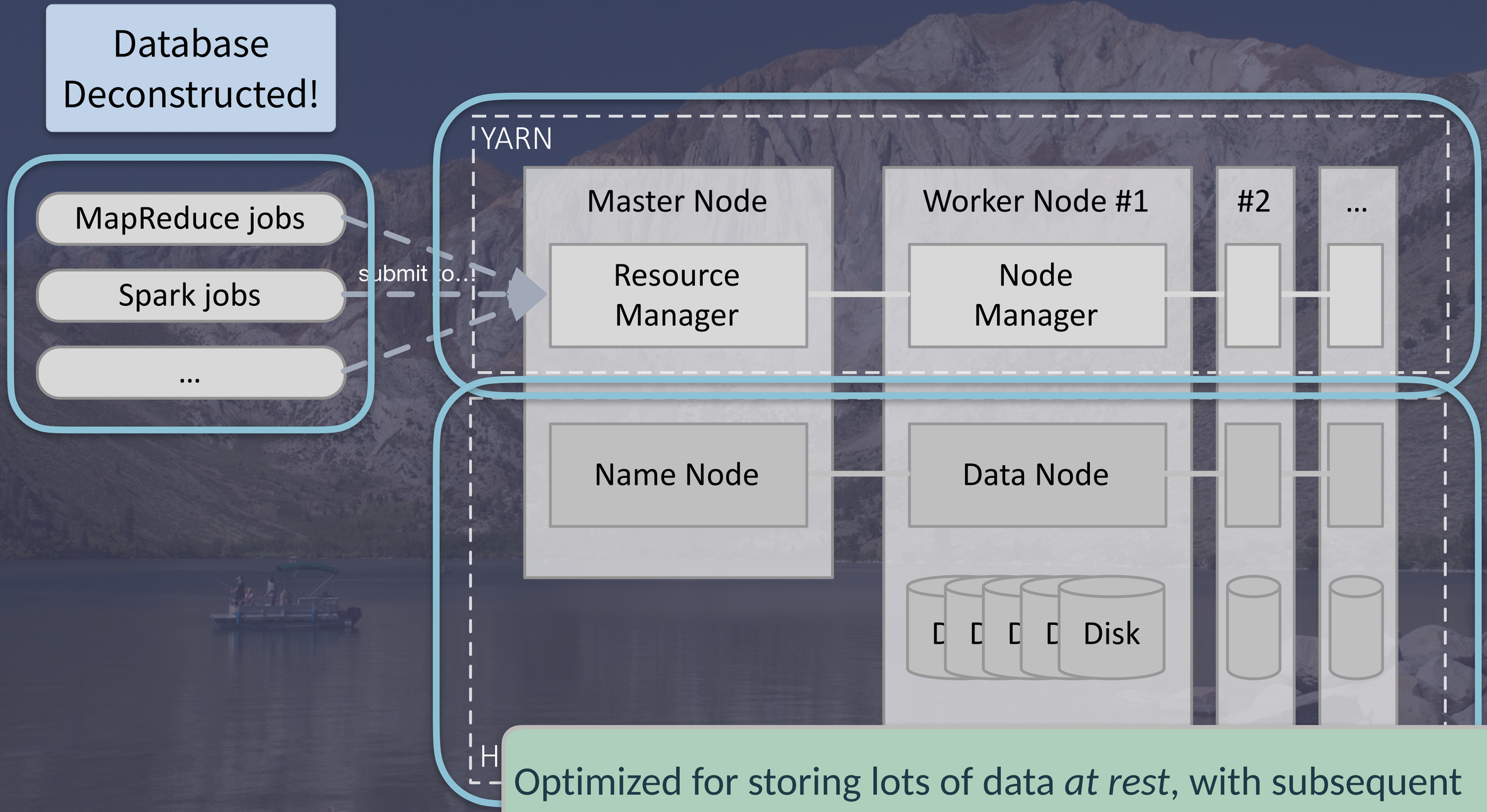
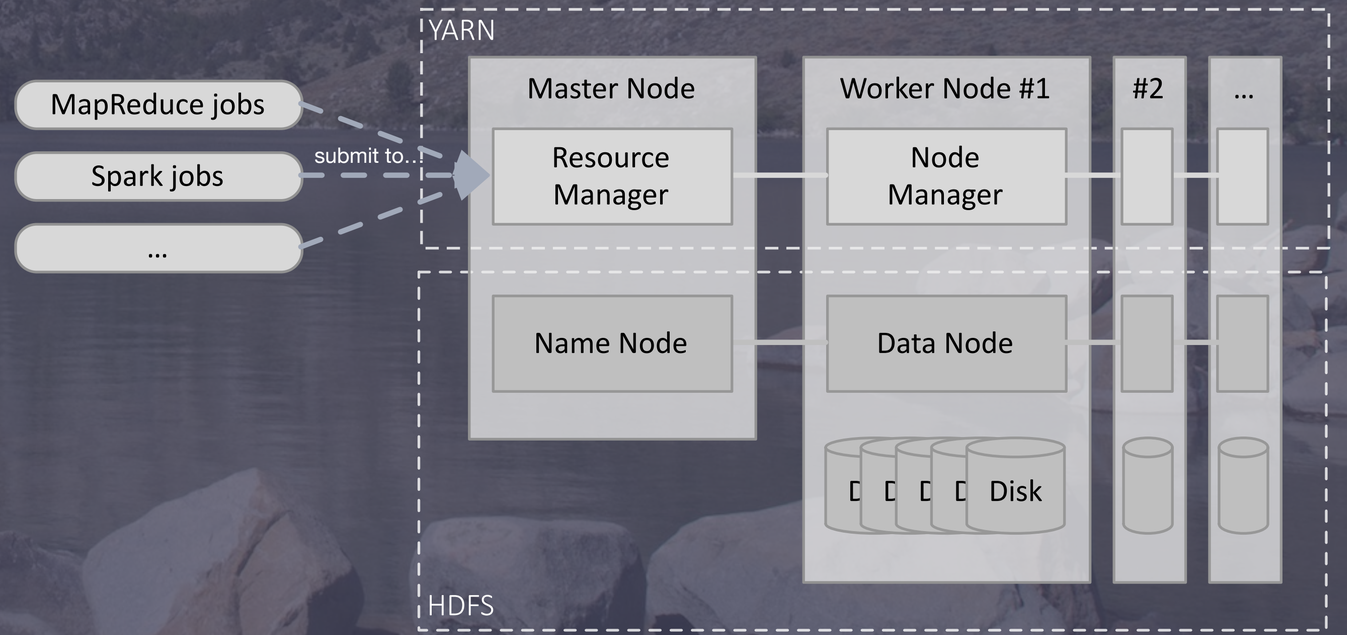
Database Deconstructed!

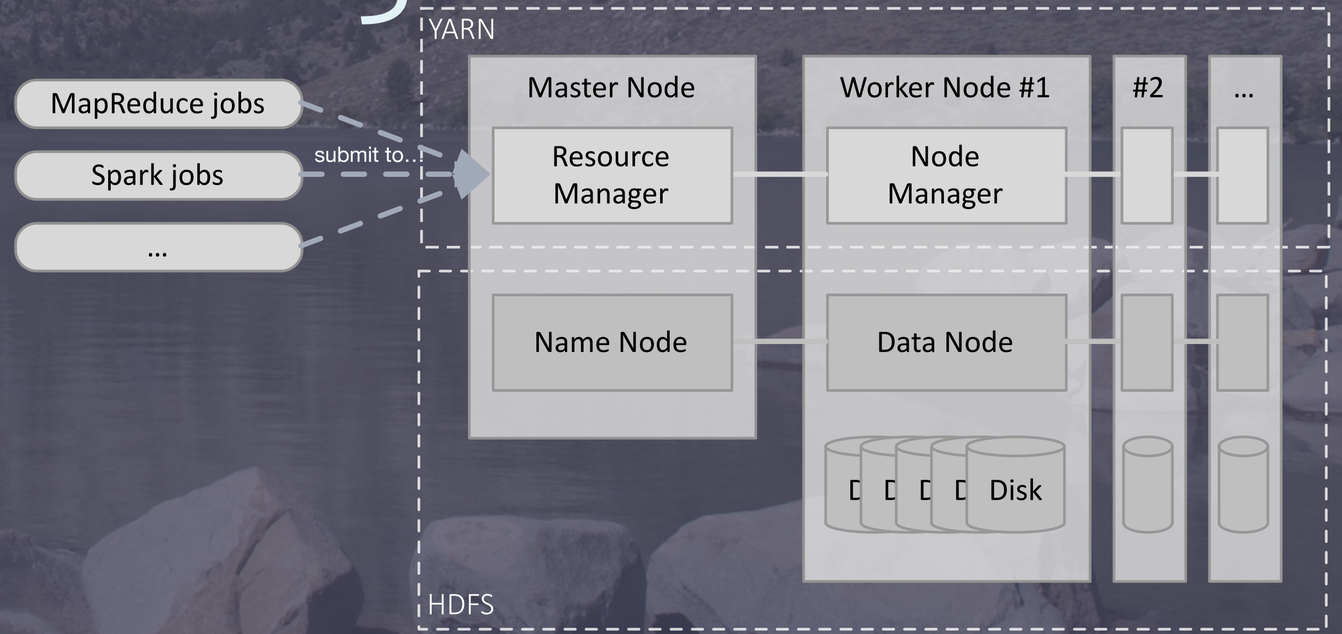


Optimized for storing lots of data *at rest*, with subsequent processing, but not optimized for data *in motion*.

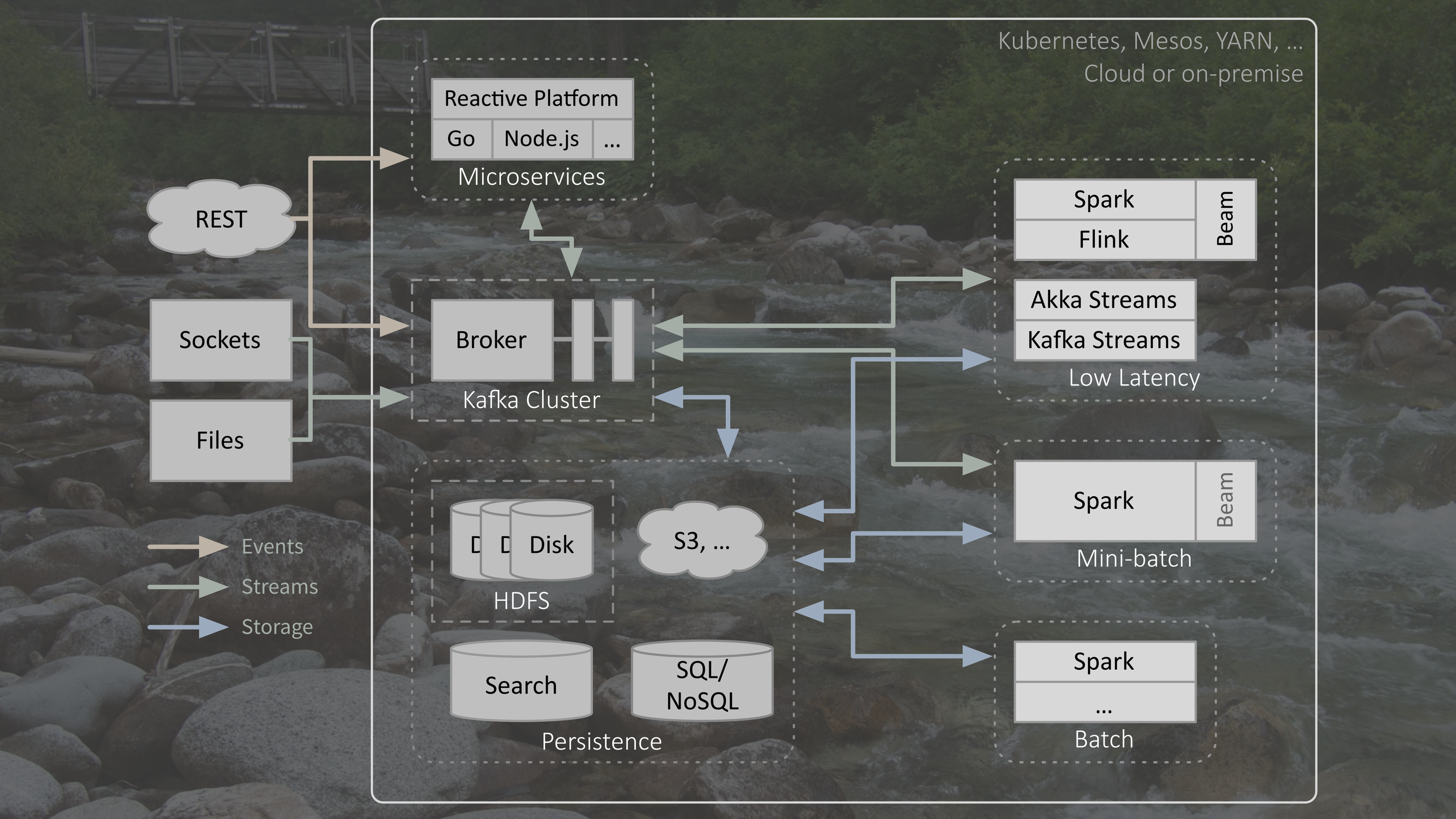
- Characteristics
  - Batch and interactive queries
  - Massive storage - HDFS is the data "backplane"
    - Integrate jobs through HDFS
  - Multiuser jobs



- Use Cases
  - Data warehouse replacement
  - Interactive exploration
  - Offline ML model training
  - …



New Streaming, “Fast Data” Architecture


Kubernetes, Mesos, YARN, ...
Cloud or on-premise
Reactive Platform
Go
Node.js
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Microservices
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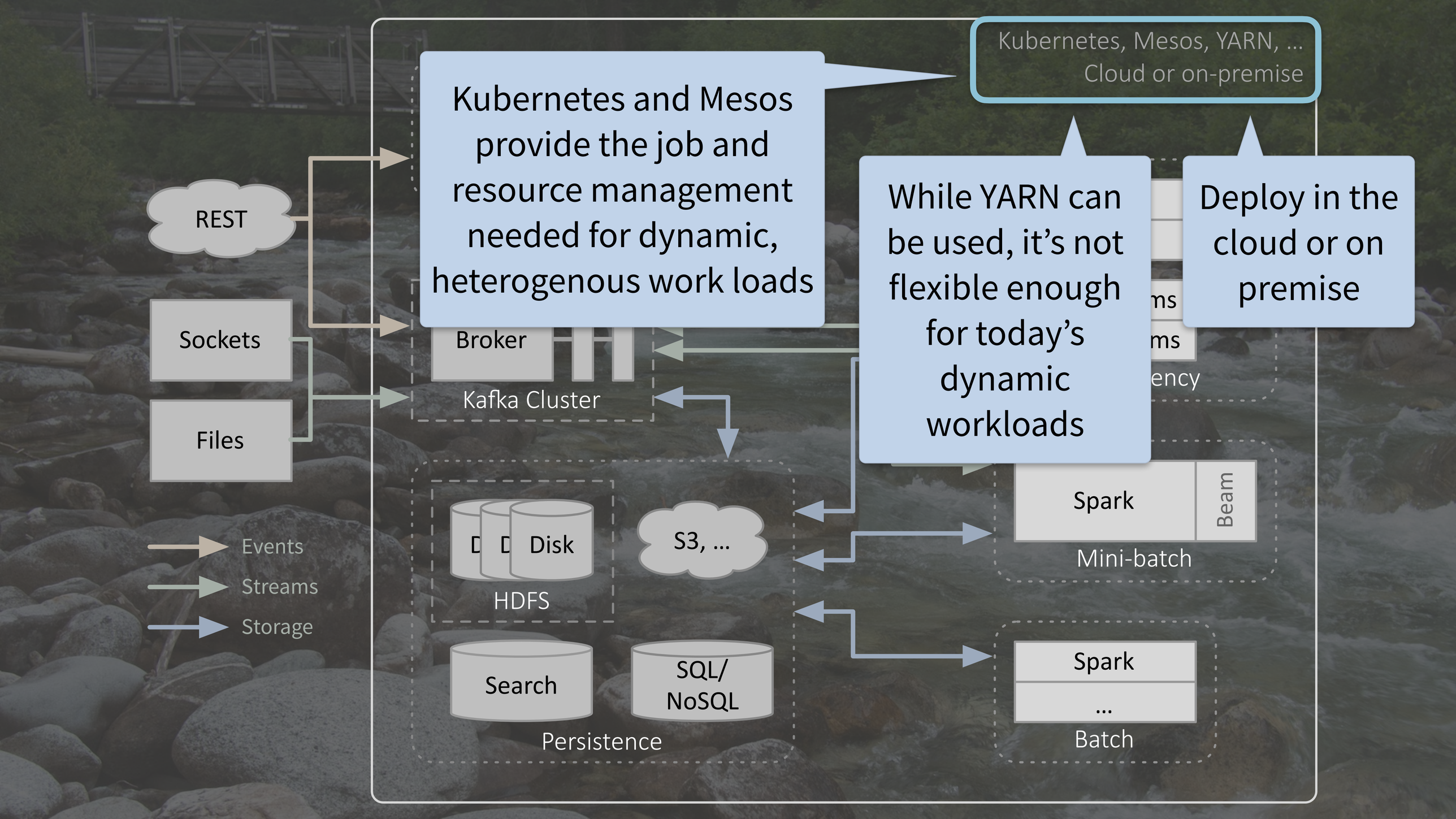
Kubernetes, Mesos, YARN, …
Cloud or on-premise
Kubernetes and Mesos provide the job and resource management needed for dynamic, heterogenous work loads
While YARN can be used, it's not flexible enough for today's dynamic workloads
Deploy in the cloud or on premise
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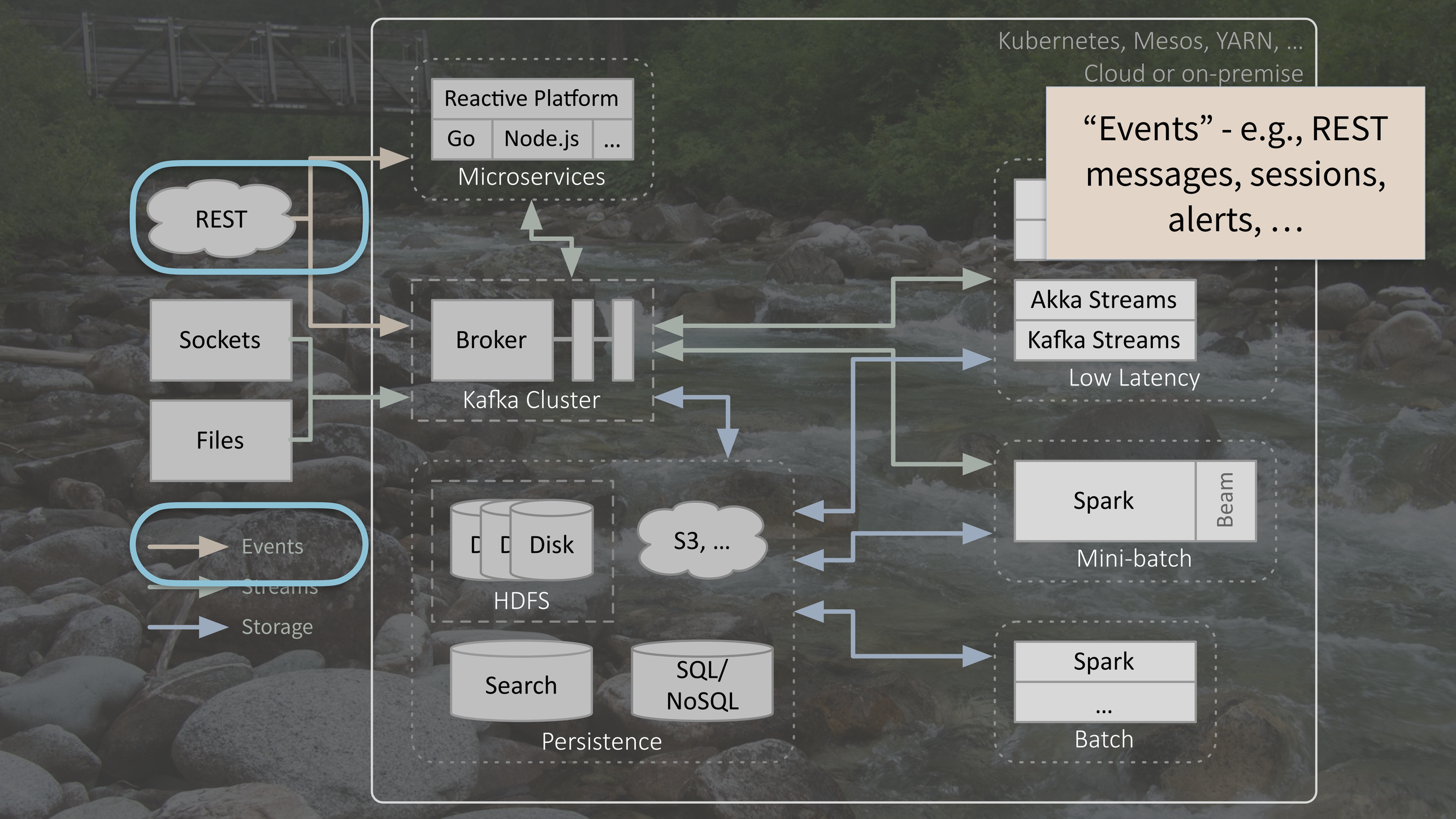
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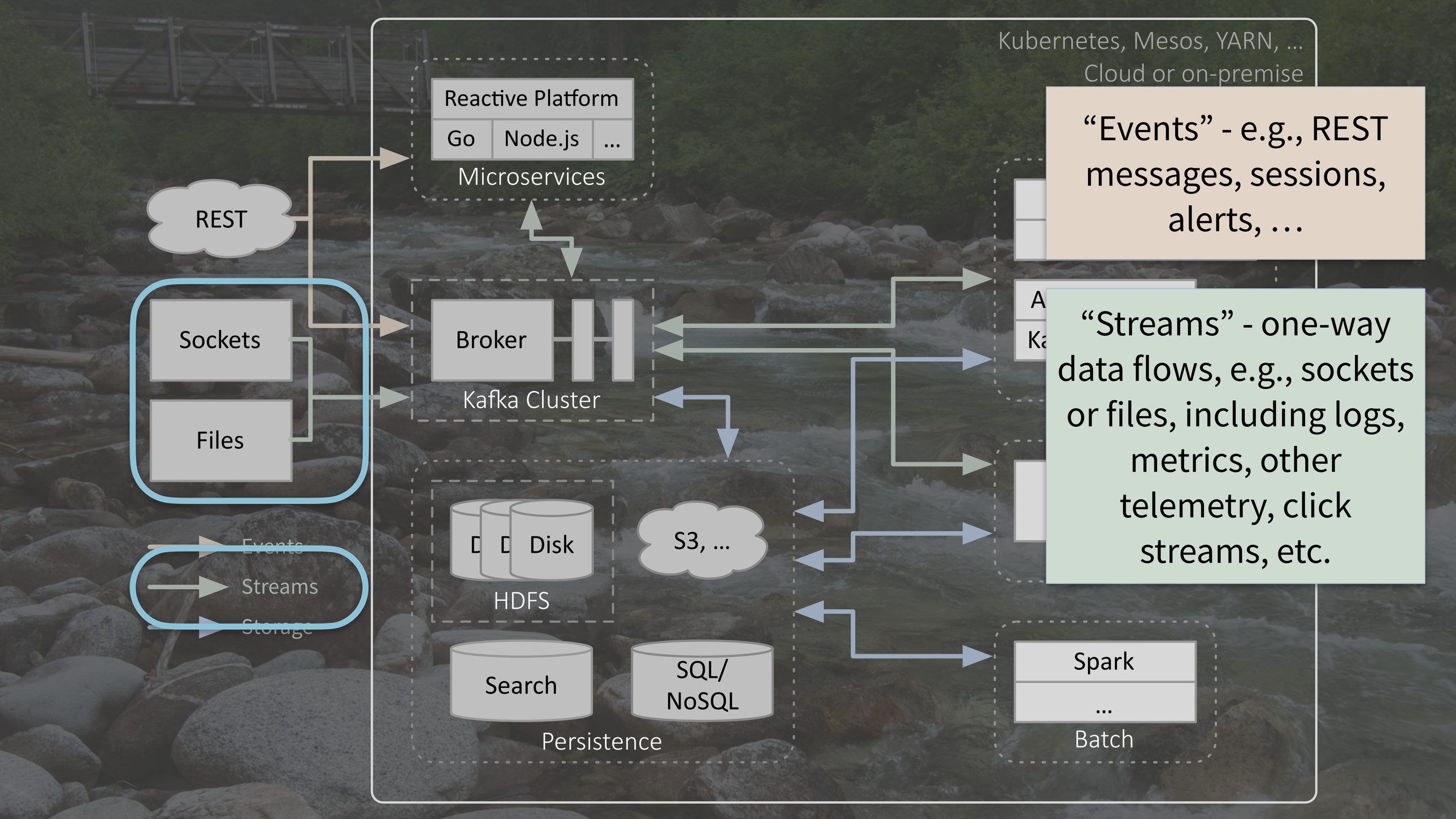
“Events” - e.g., REST messages, sessions, alerts, …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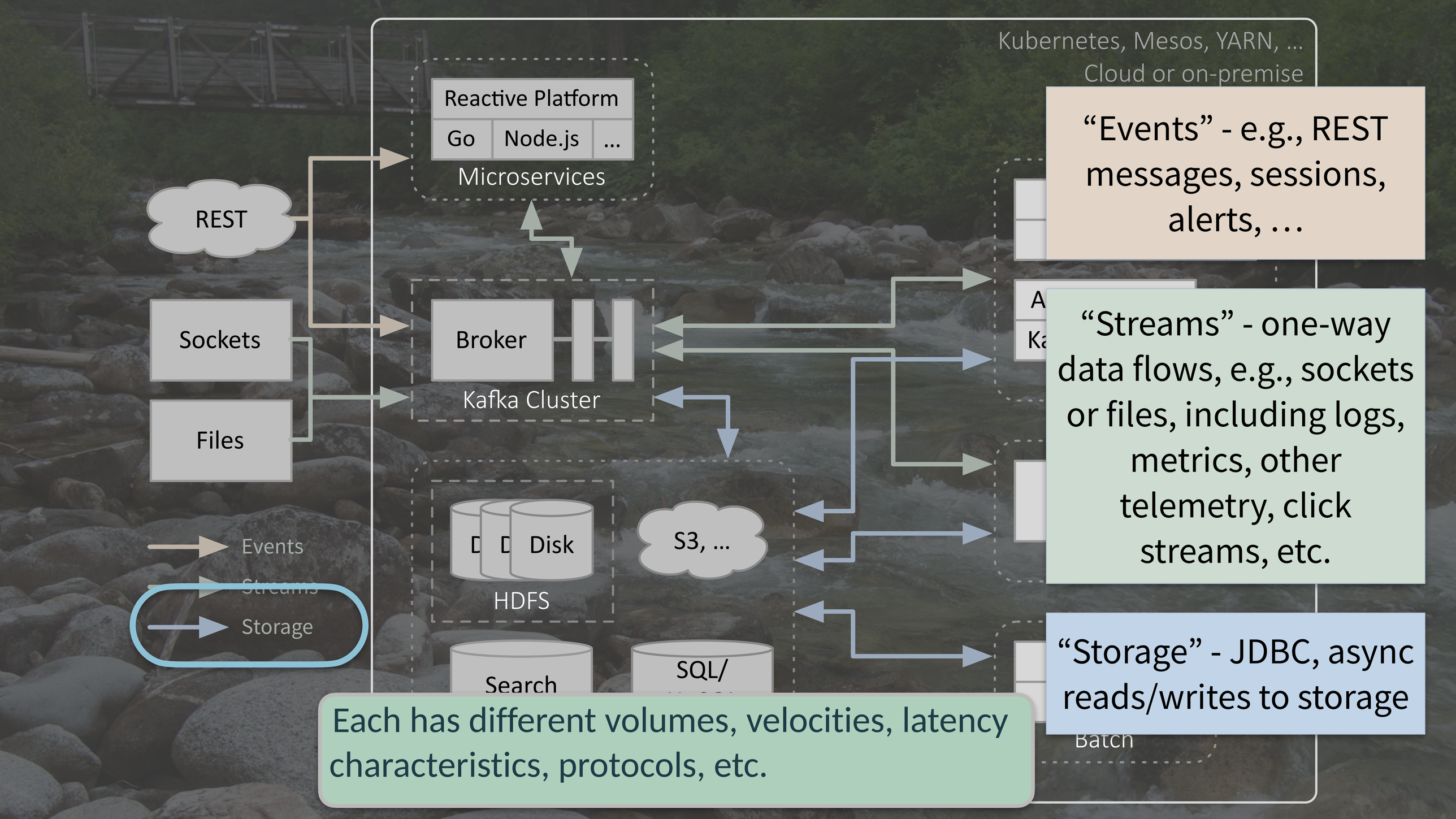
“Events” - e.g., REST messages, sessions, alerts, …
“Streams” - one-way data flows, e.g., sockets or files, including logs, metrics, other telemetry, click streams, etc.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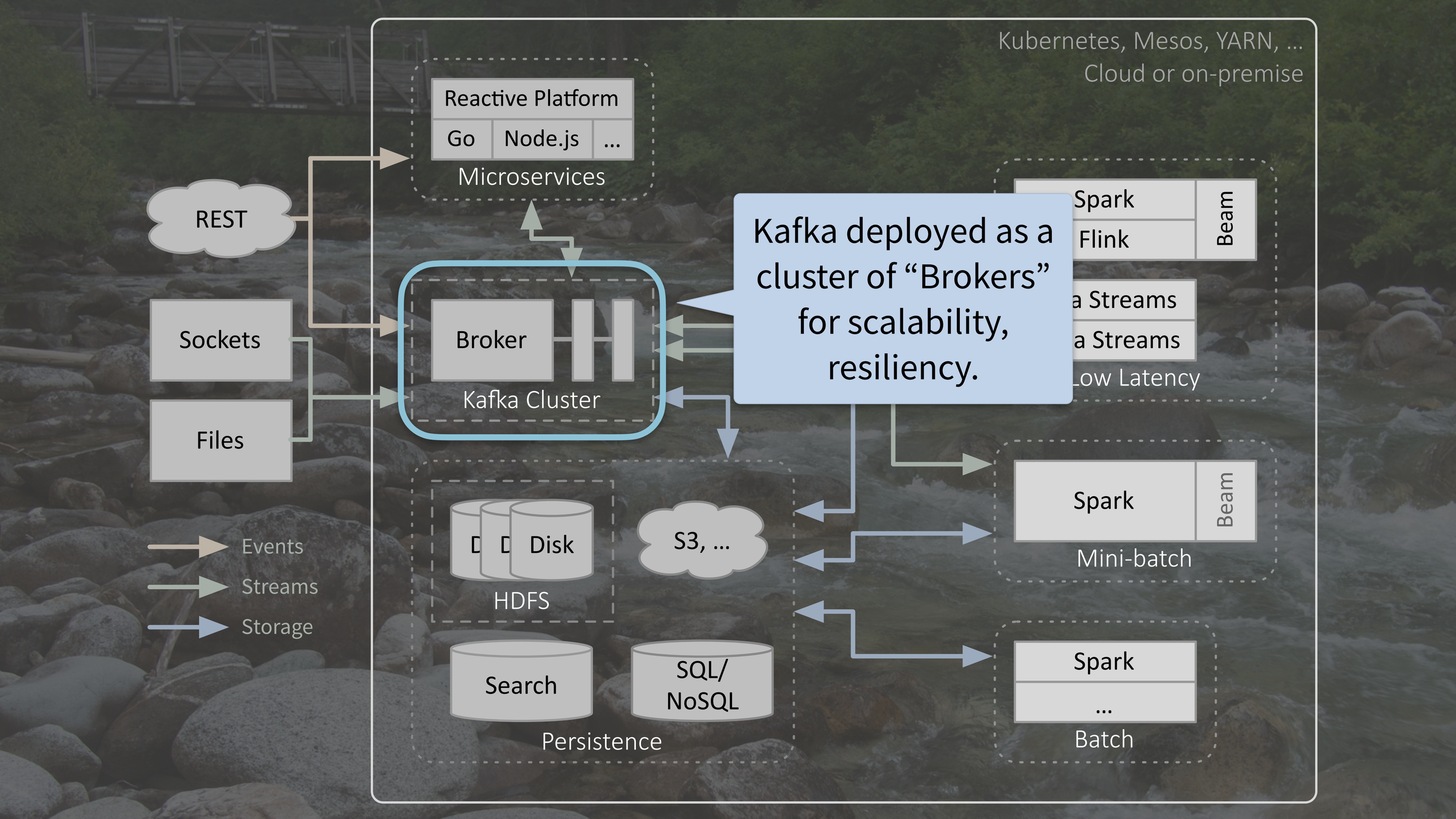
“Events” - e.g., REST messages, sessions, alerts, …
“Streams” - one-way data flows, e.g., sockets or files, including logs, metrics, other telemetry, click streams, etc.
“Storage” - JDBC, async reads/writes to storage
Each has different volumes, velocities, latency characteristics, protocols, etc.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Kafka Cluster
Kafka deployed as a cluster of “Brokers” for scalability, resiliency.
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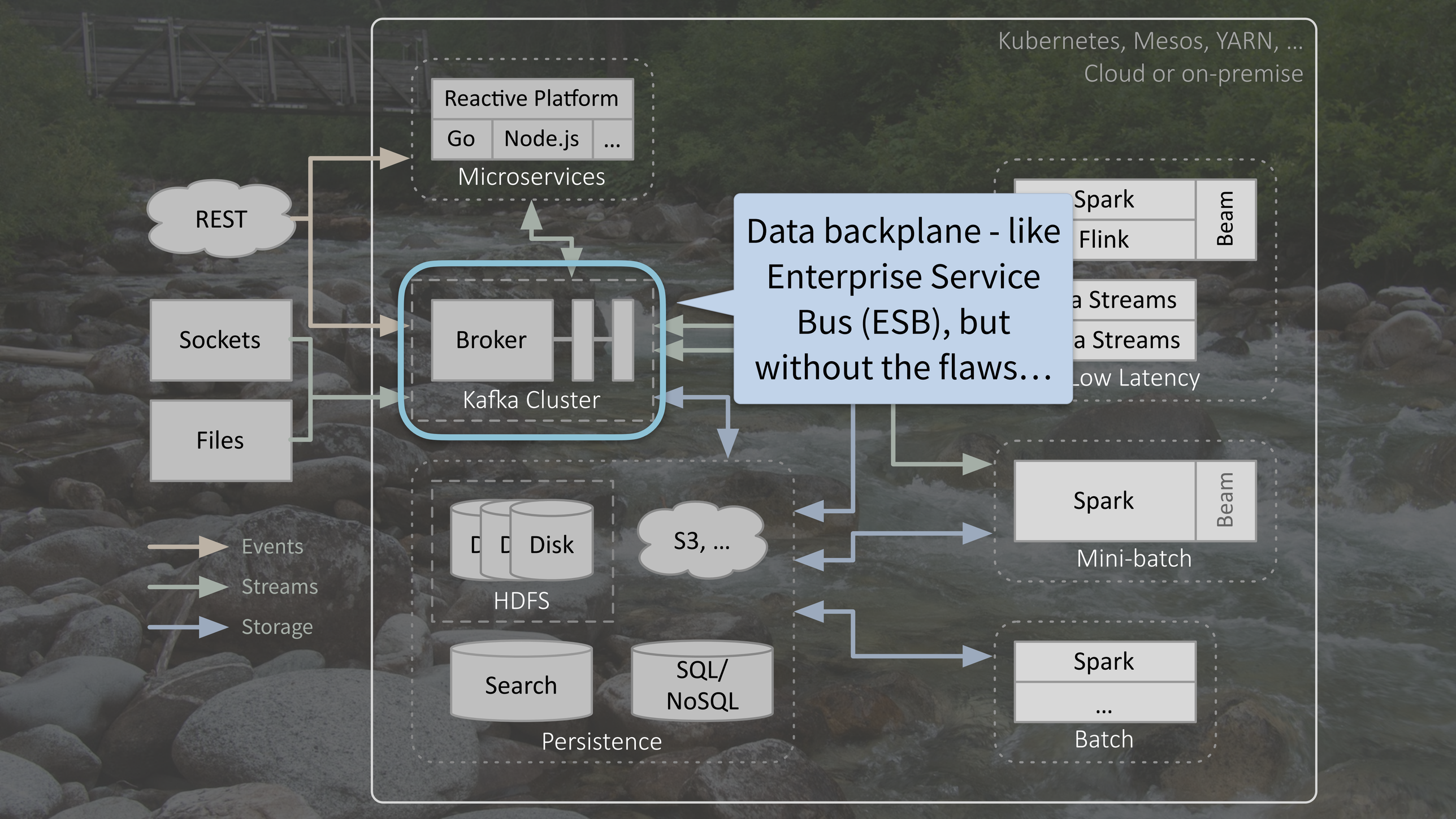
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Data backplane - like Enterprise Service Bus (ESB), but without the flaws…
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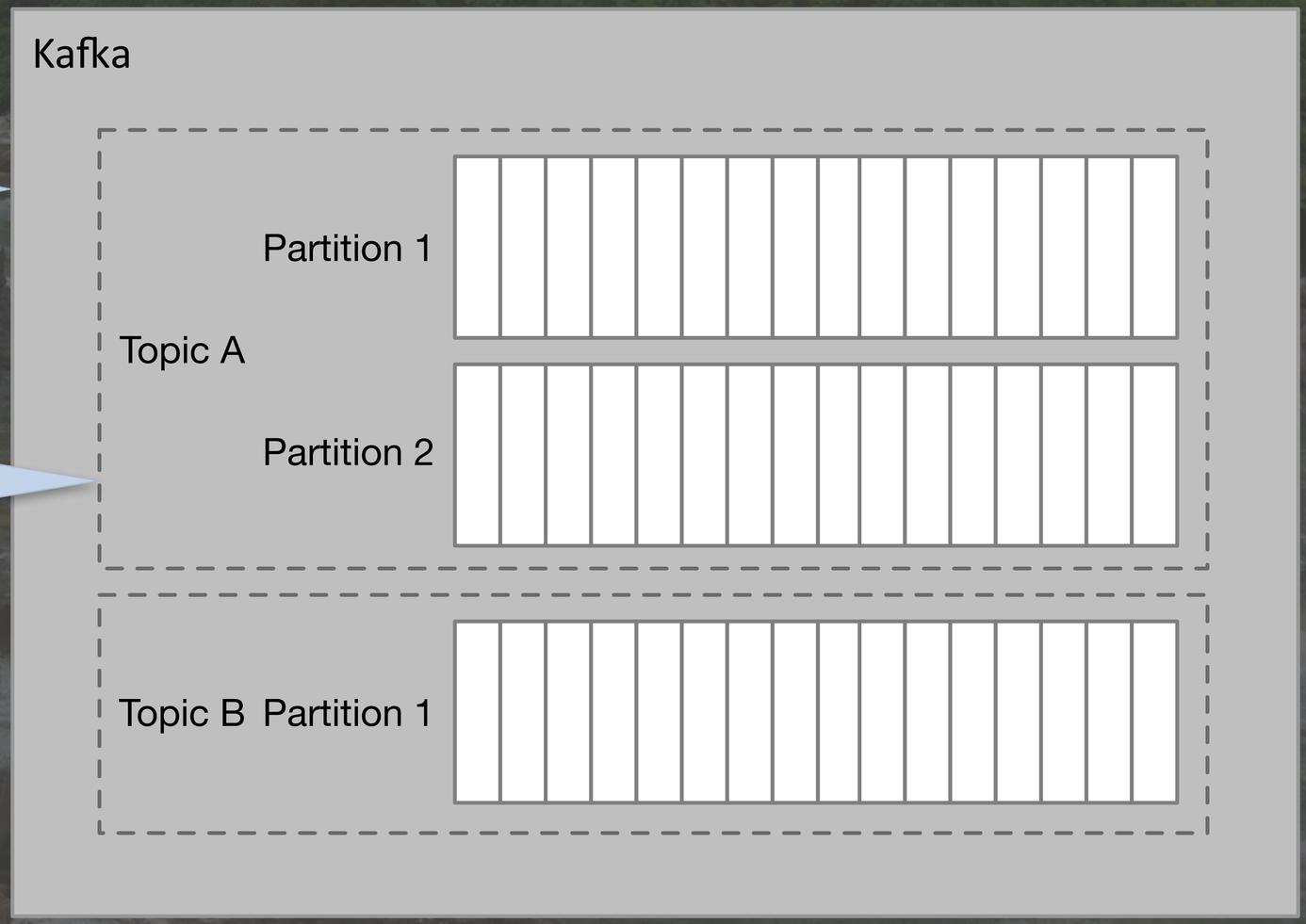
Why Kafka?

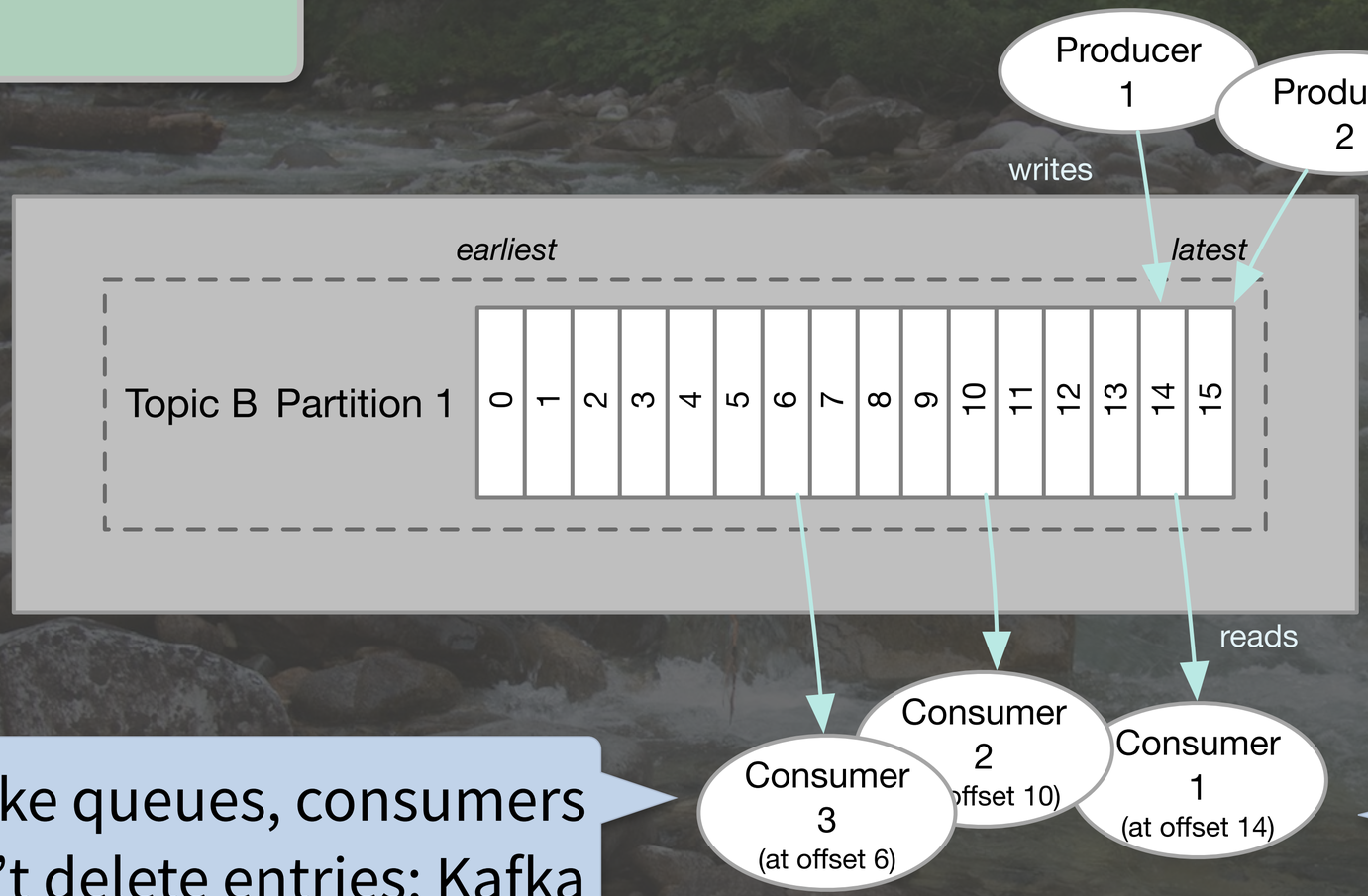
Organized into topics

Topics are partitioned, replicated, and distributed



Why Kafka?

Logs, *not* queues!

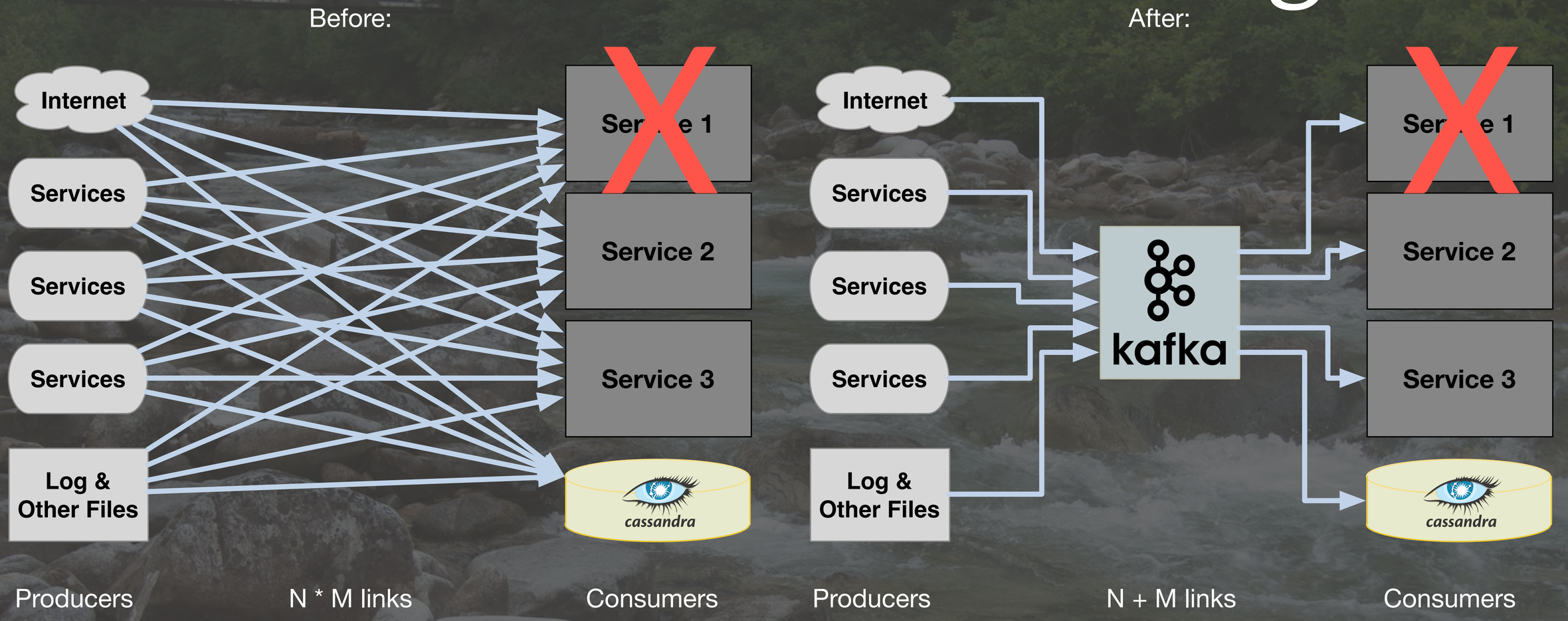


M Producers

N Consumers, who start reading where they want

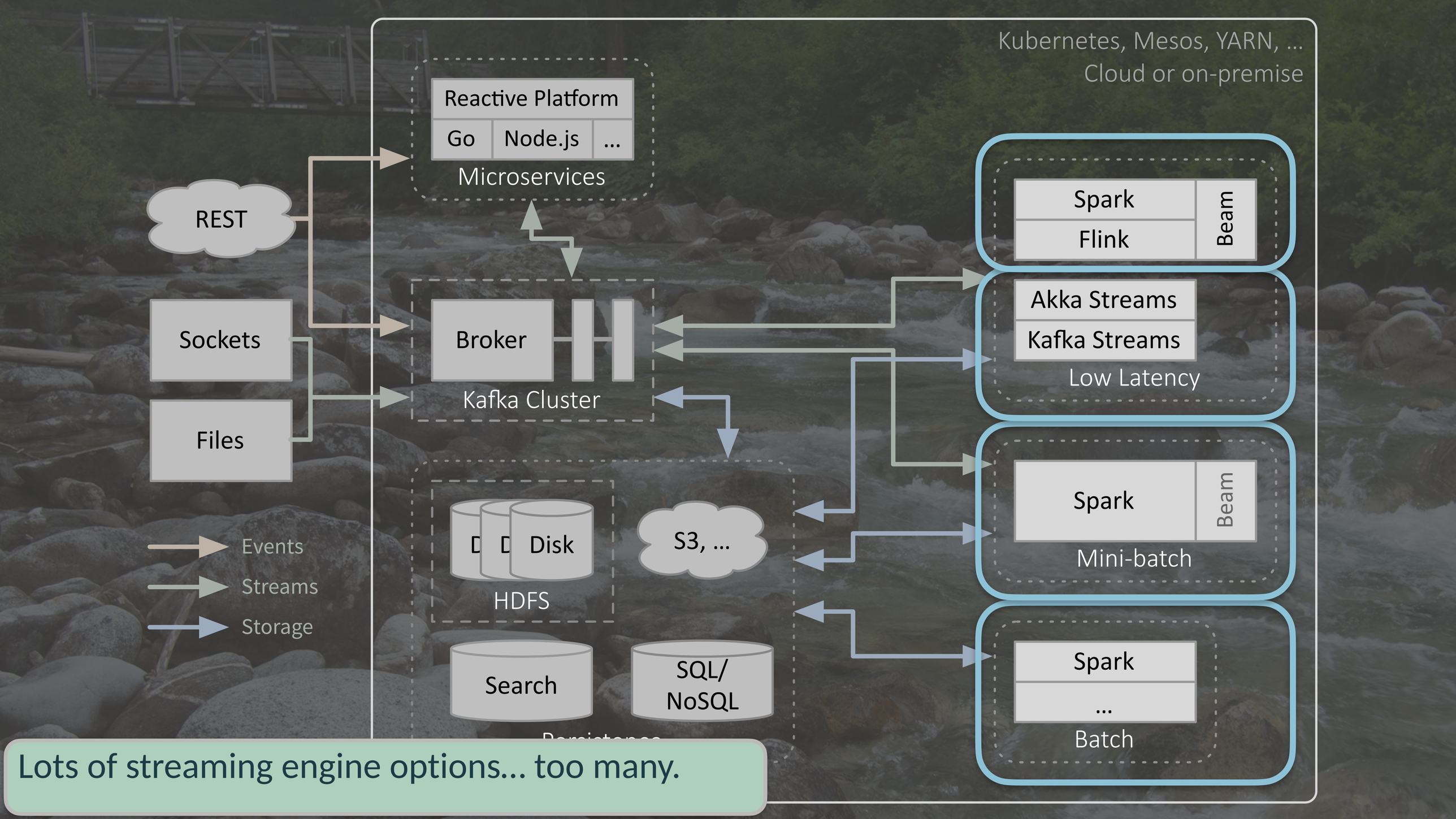
Unlike queues, consumers don't delete entries; Kafka manages their lifecycles

Using Kafka



Messy and fragile; what if “Service 1” goes down?

Simpler and more robust! Loss of Service 1 means no data loss.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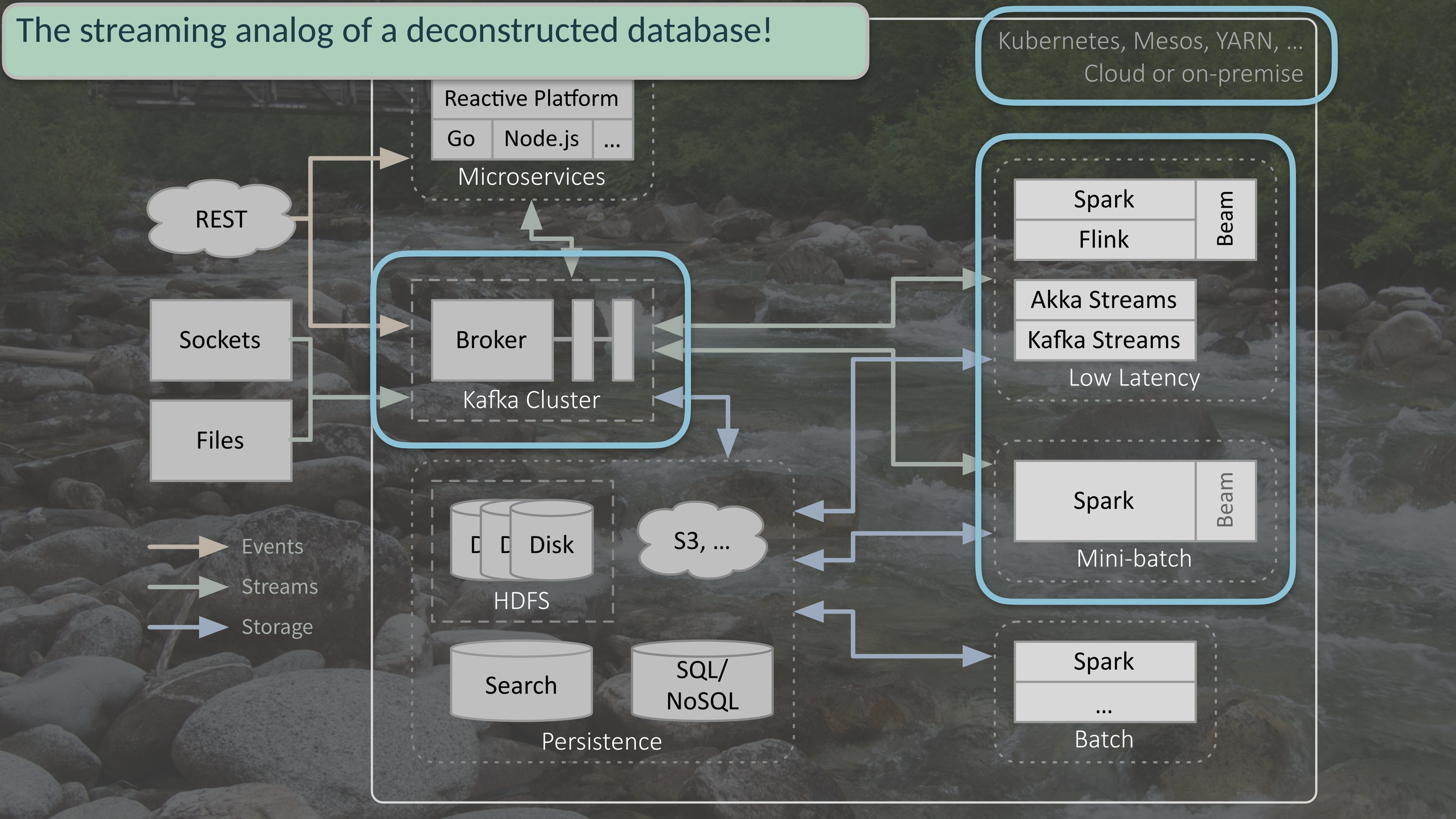
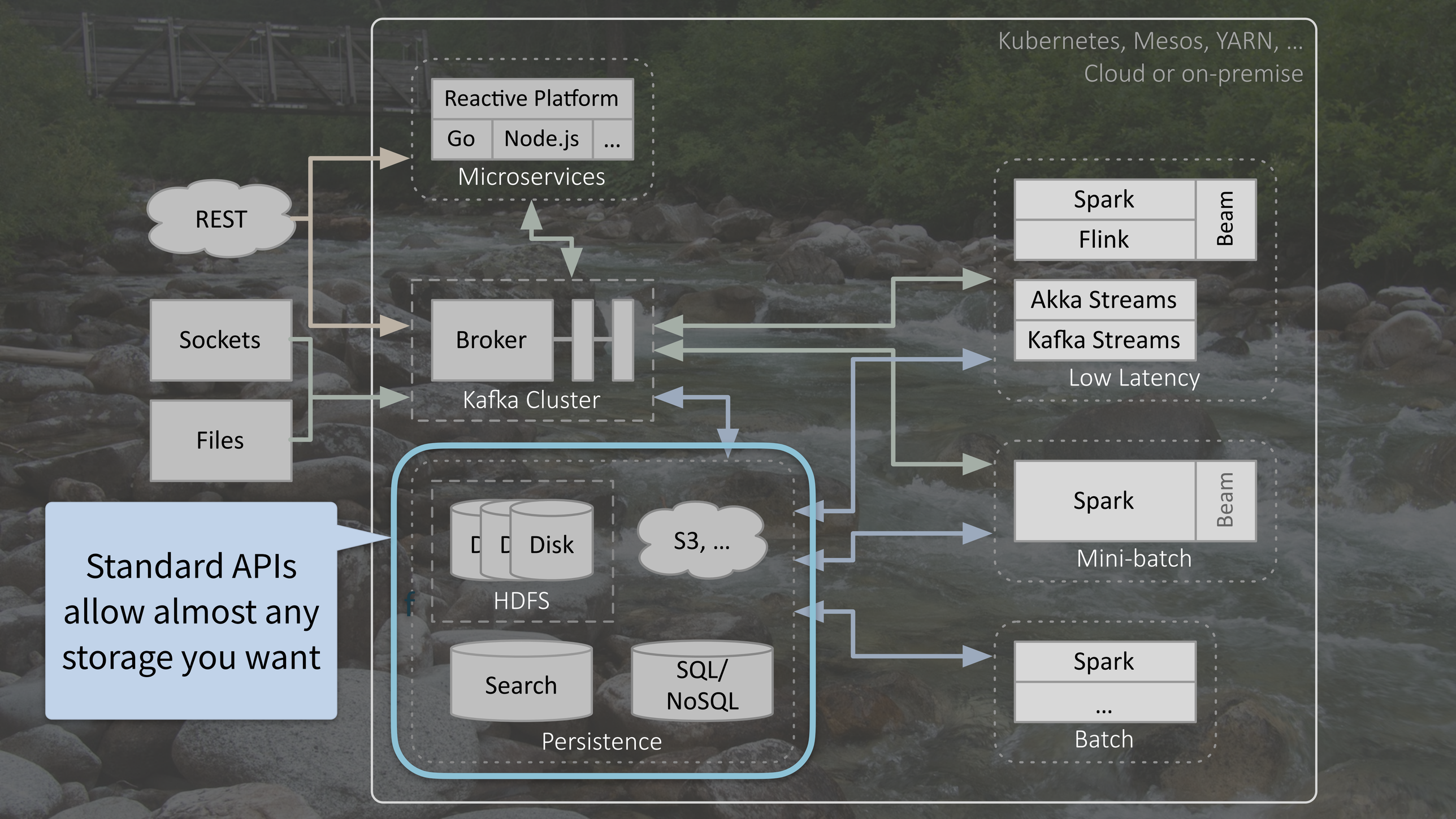
Lots of streaming engine options... too many.

The streaming analog of a deconstructed database!

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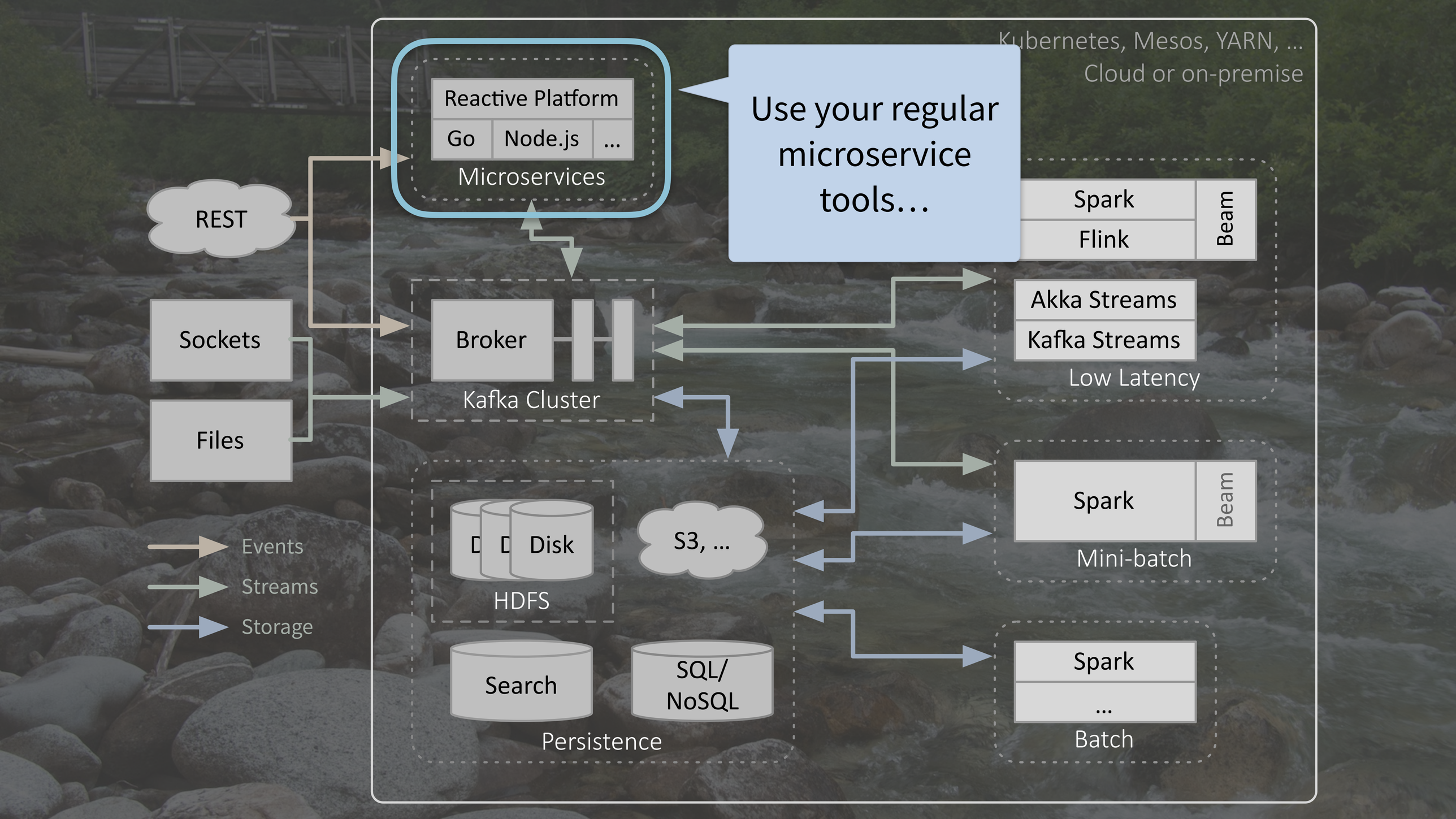
Persistence
Standard APIs
allow almost any
storage you want


Kubernetes, Mesos, YARN, …
Cloud or on-premise
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Node.js
…
Microservices
Use your regular microservice tools…
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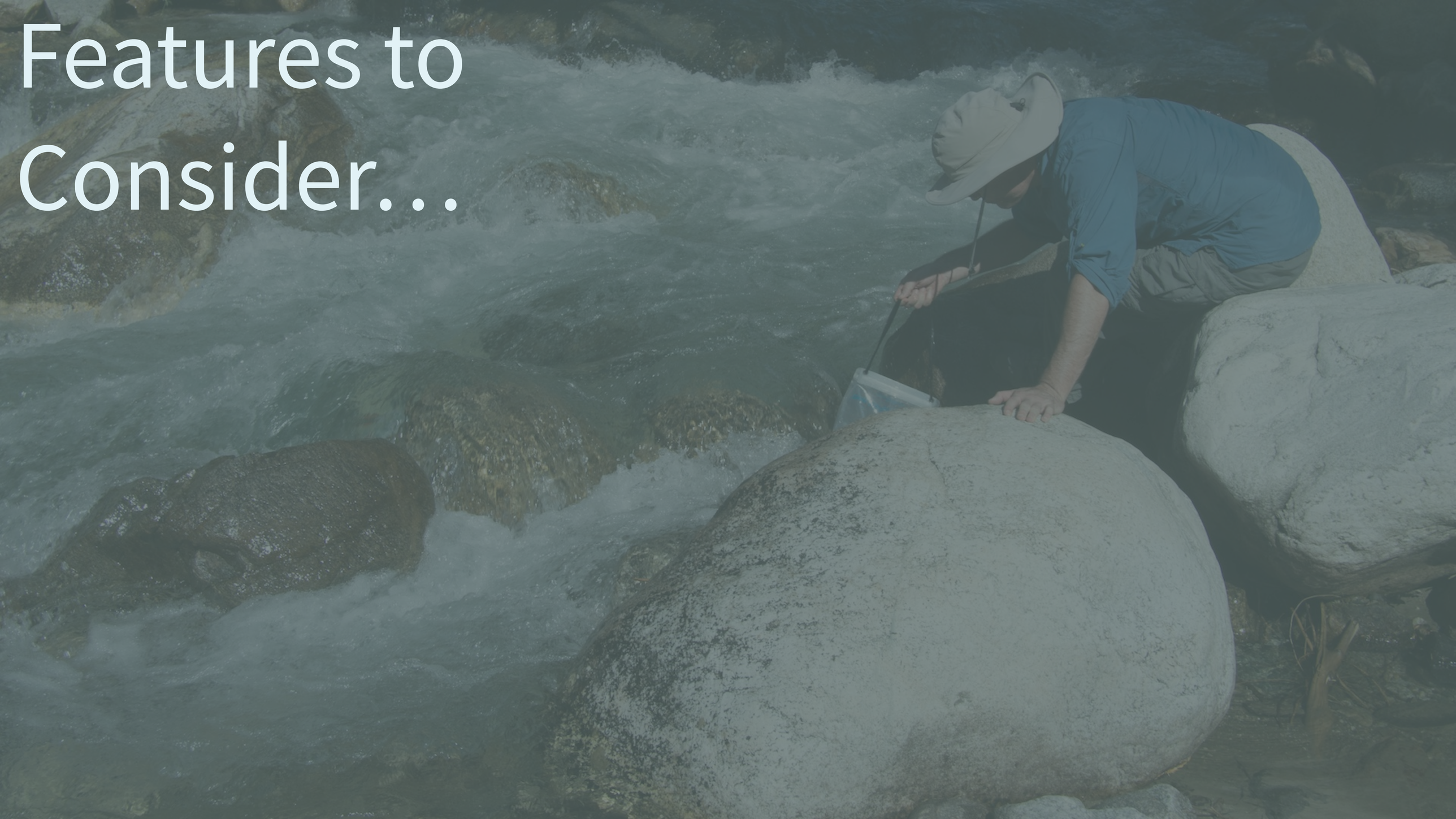
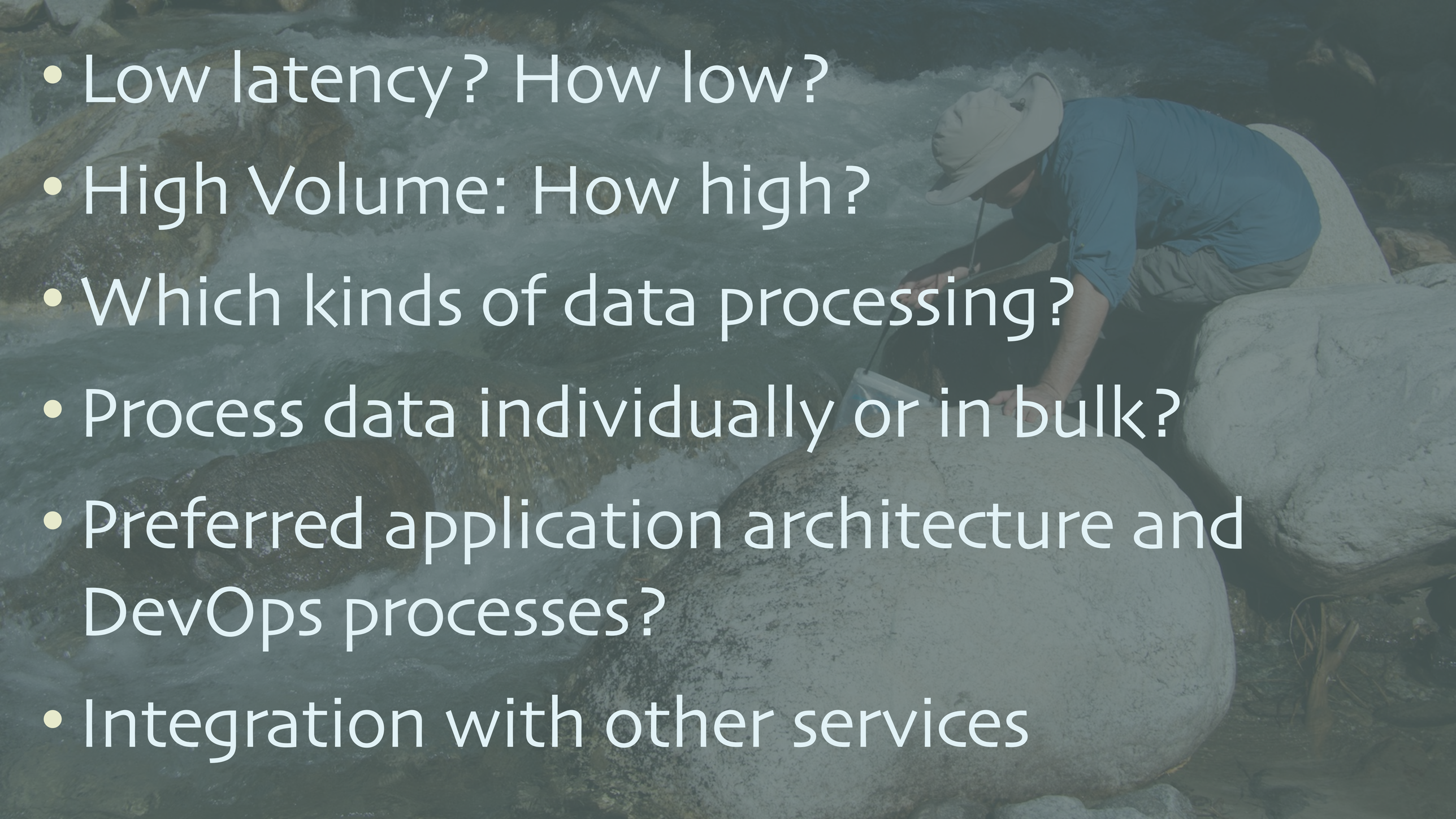
Streaming Engines

Features to Consider…

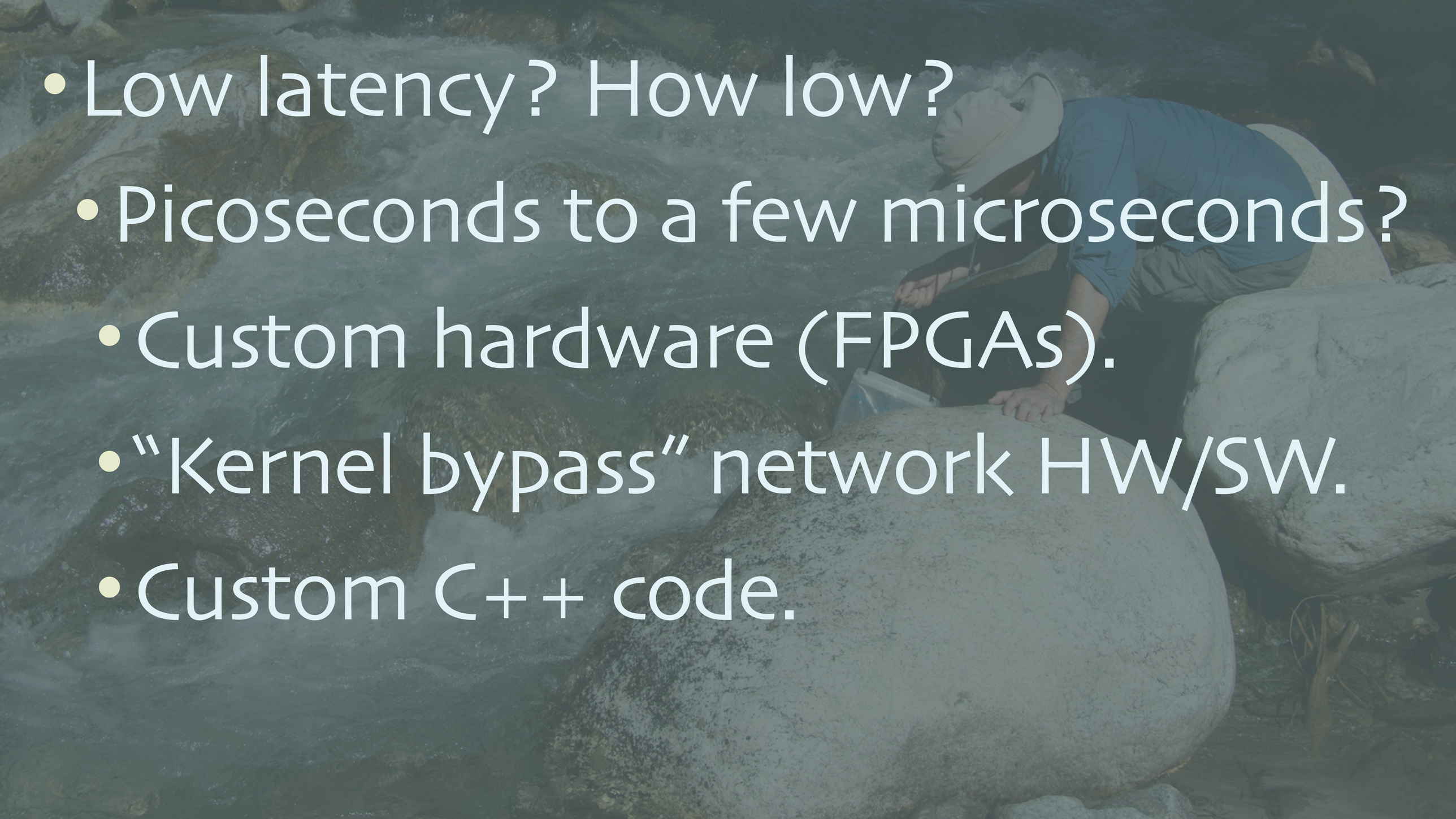




- Low latency? How low?
- High Volume: How high?
- Which kinds of data processing?
- Process data individually or in bulk?
- Preferred application architecture and DevOps processes?
- Integration with other services

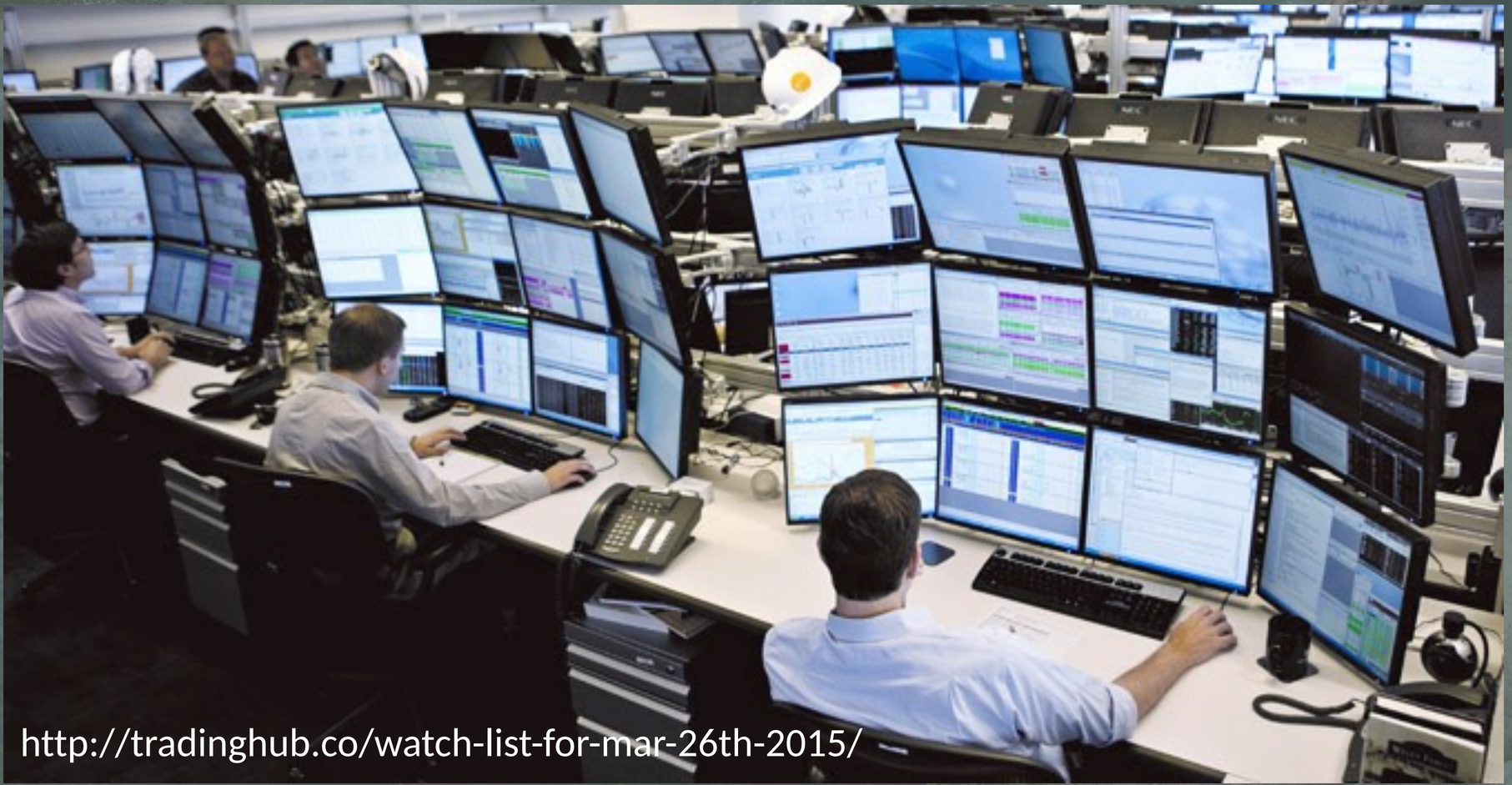
- Low latency? How low?

- Low latency? How low?
  - Picoseconds to a few microseconds?



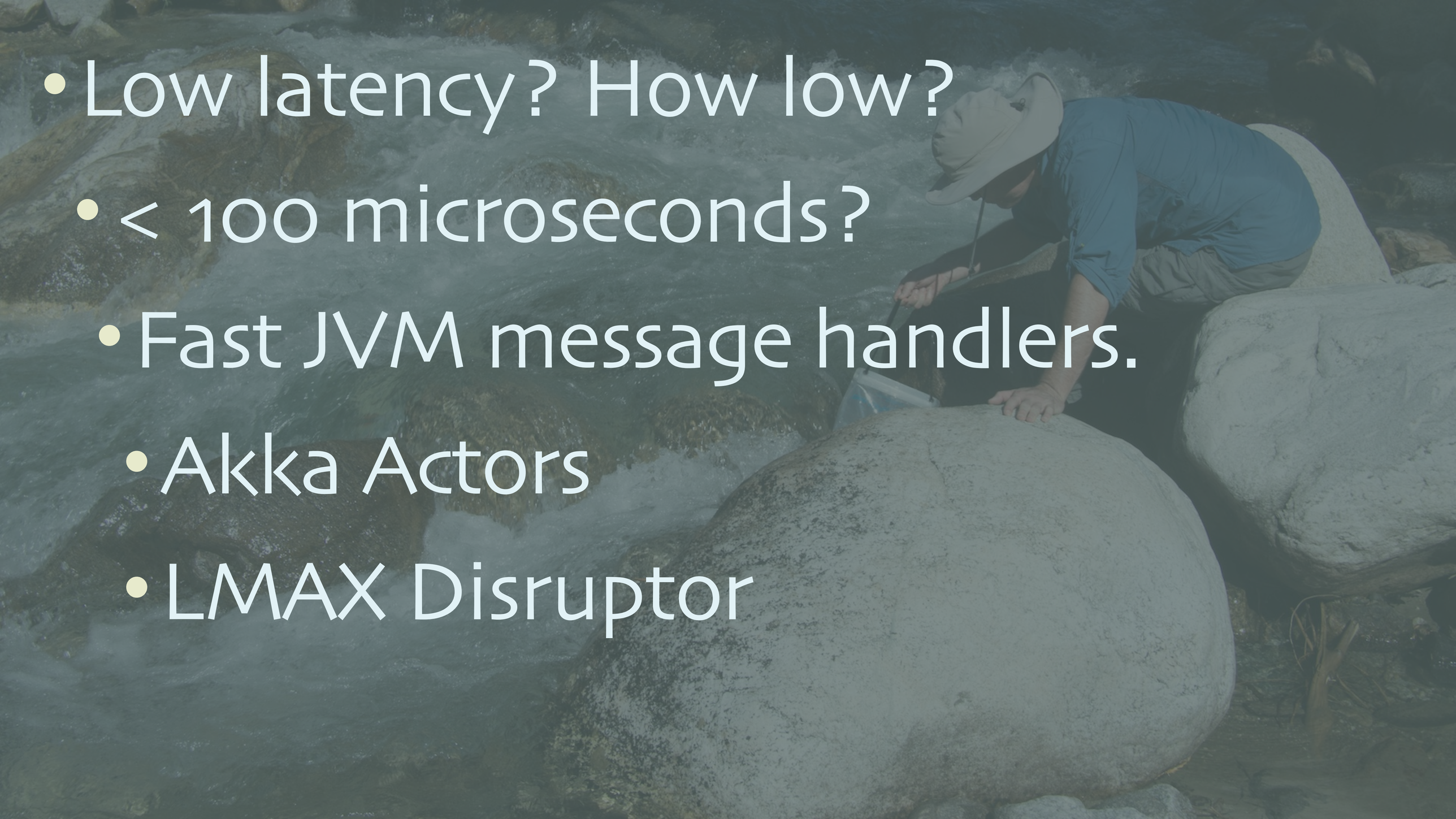
- Low latency? How low?
  - Picoseconds to a few microseconds?
    - Custom hardware (FPGAs).
    - “Kernel bypass” network HW/SW.
    - Custom C++ code.

- Low latency? How low?
  - < 100 microseconds?



http://tradinghub.co/watch-list-for-mar-26th-2015/

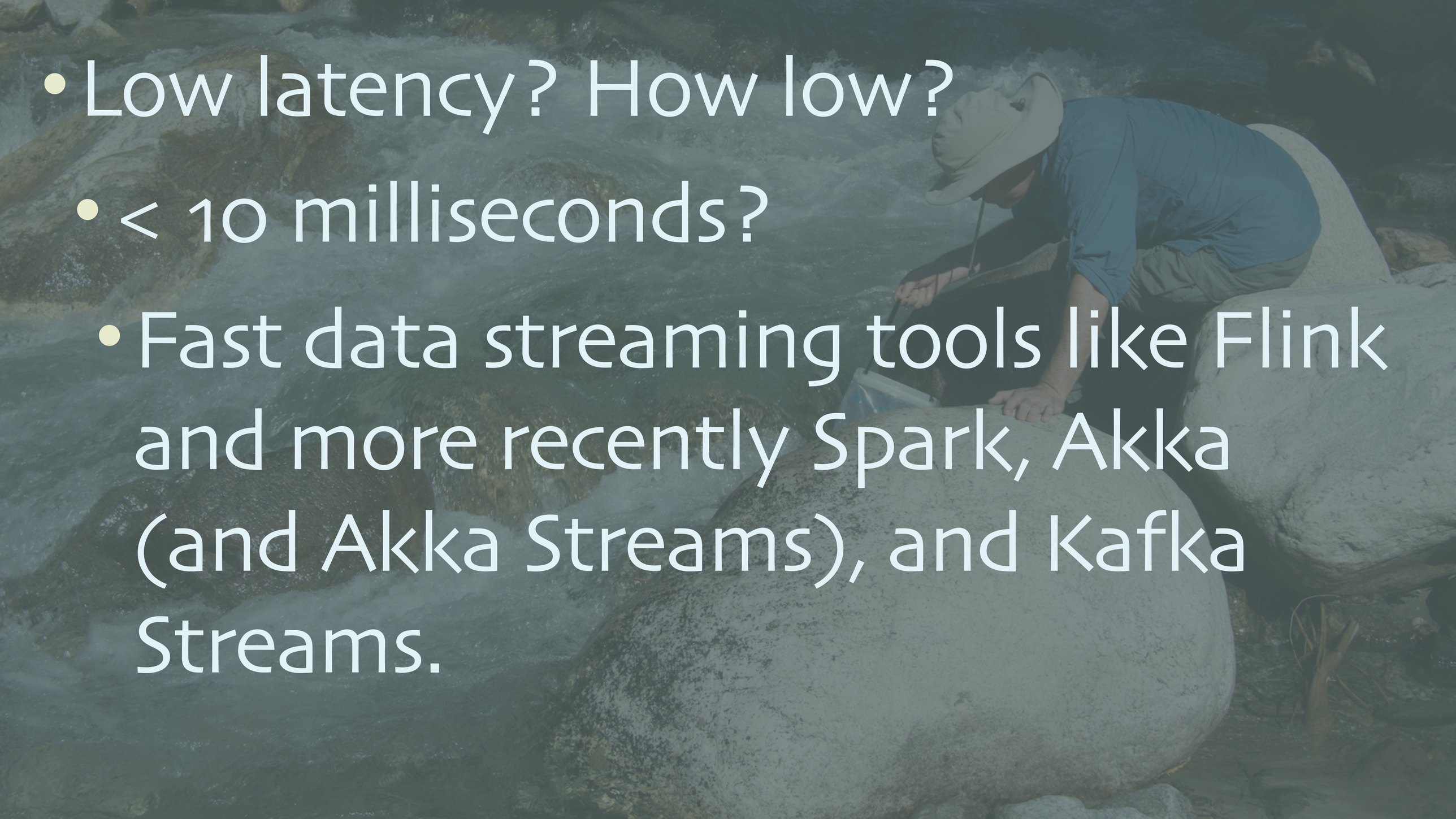
http://www.usa.philips.com/



- Low latency? How low?
  - < 100 microseconds?
    - Fast JVM message handlers.
      - Akka Actors
      - LMAX Disruptor

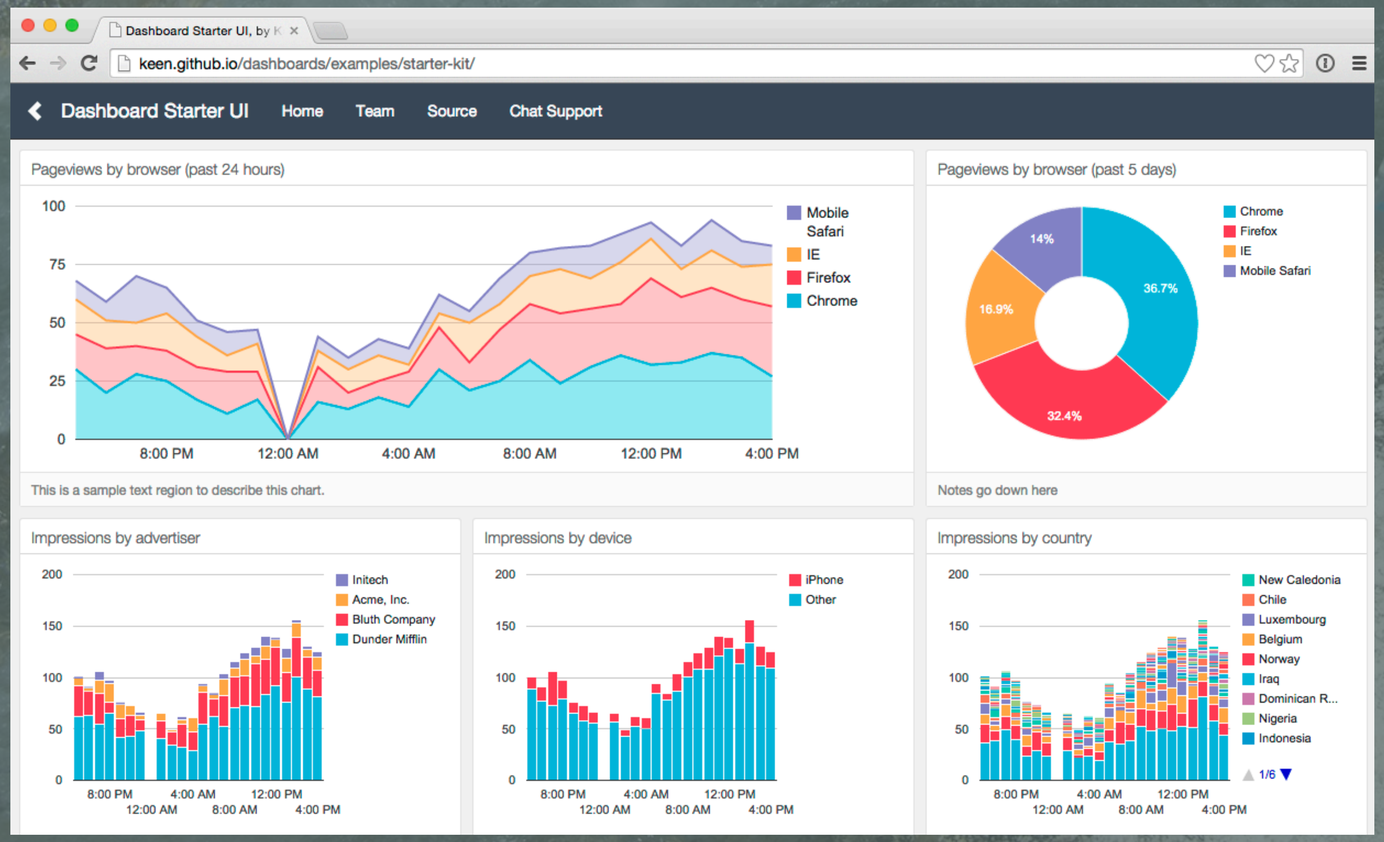
- Low latency? How low?
  - < 10 milliseconds?

http://money.cnn.com/2017/05/12/pf/credit-card-mistakes/index.html



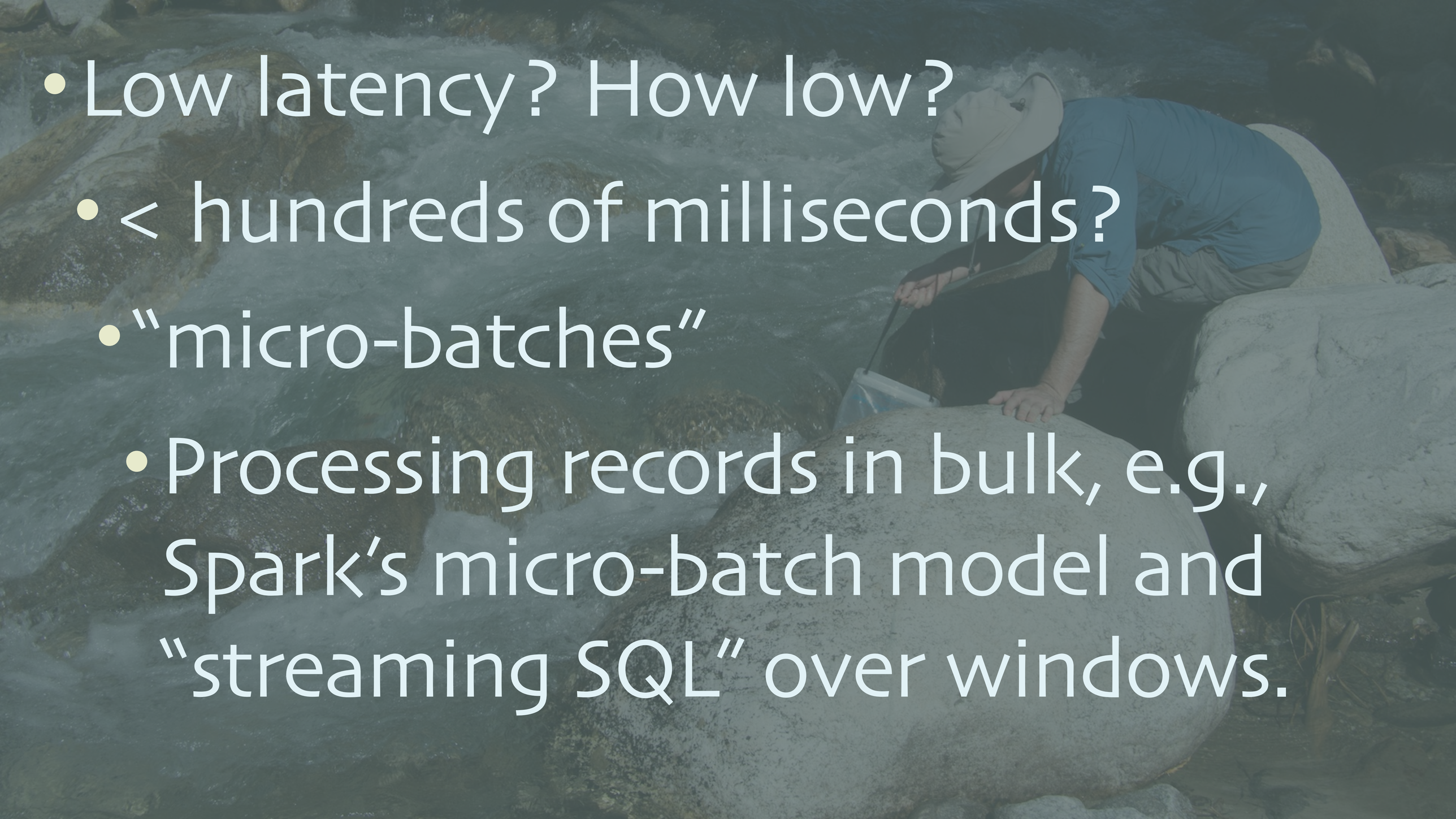
- Low latency? How low?
  - < 10 milliseconds?
    - Fast data streaming tools like Flink and more recently Spark, Akka (and Akka Streams), and Kafka Streams.

- Low latency? How low?
- < hundreds of milliseconds?



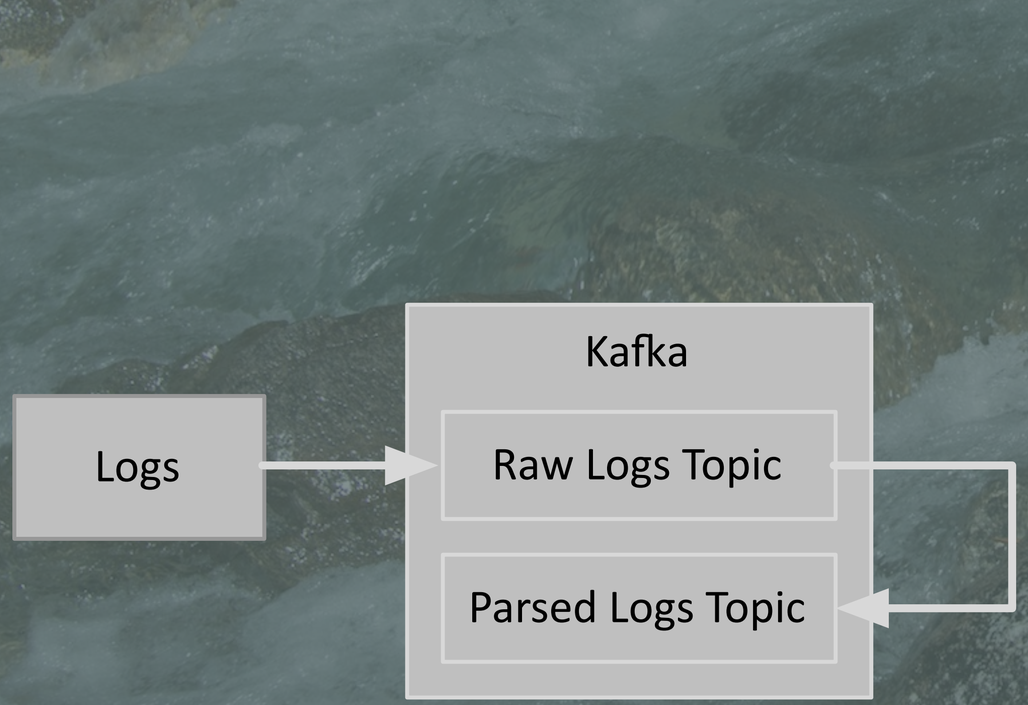
https://github.com/keen/dashboards

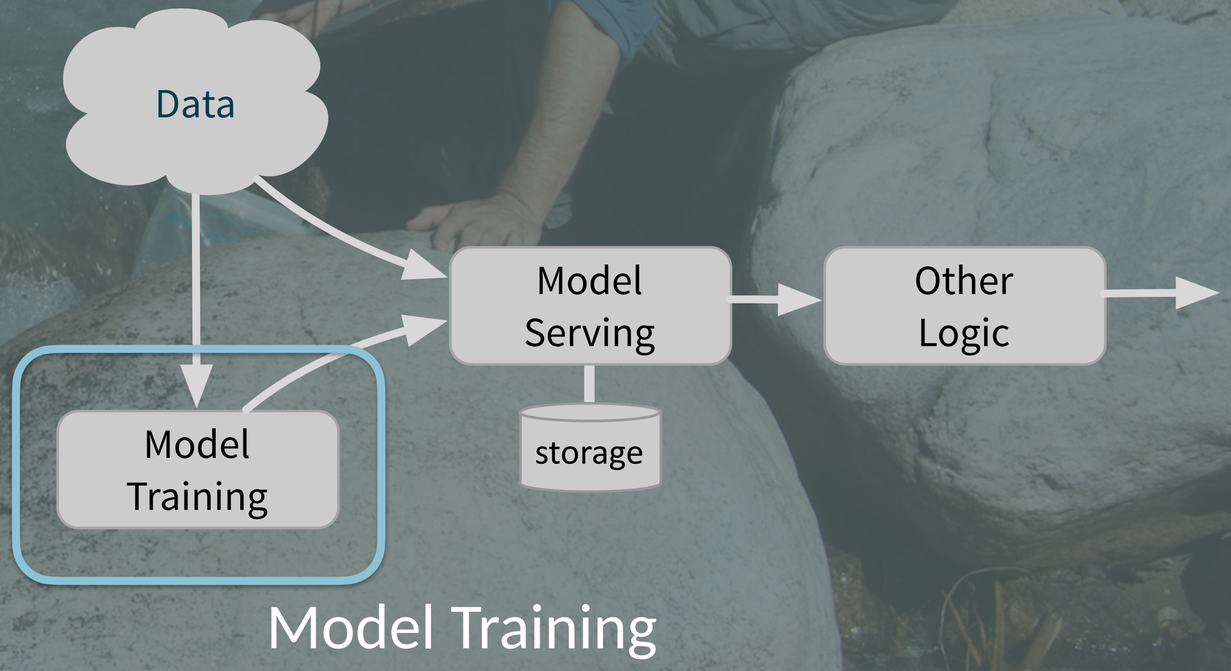
https://www.coursera.org/learn/machine-learning

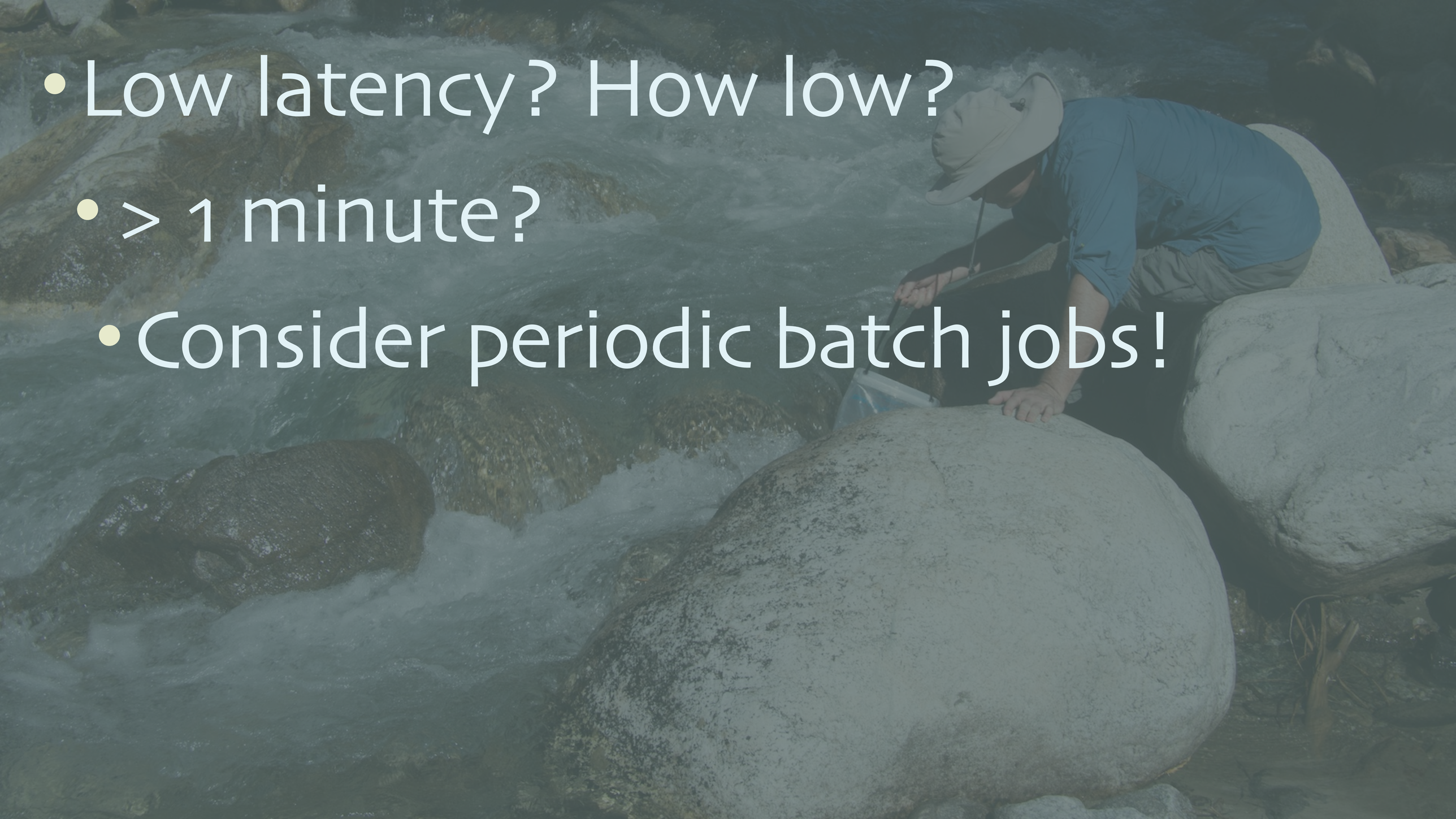


- Low latency? How low?
  - < hundreds of milliseconds?
    - "micro-batches"
      - Processing records in bulk, e.g., Spark's micro-batch model and "streaming SQL" over windows.

- Low latency? How low?
  - < 1 second to minutes?



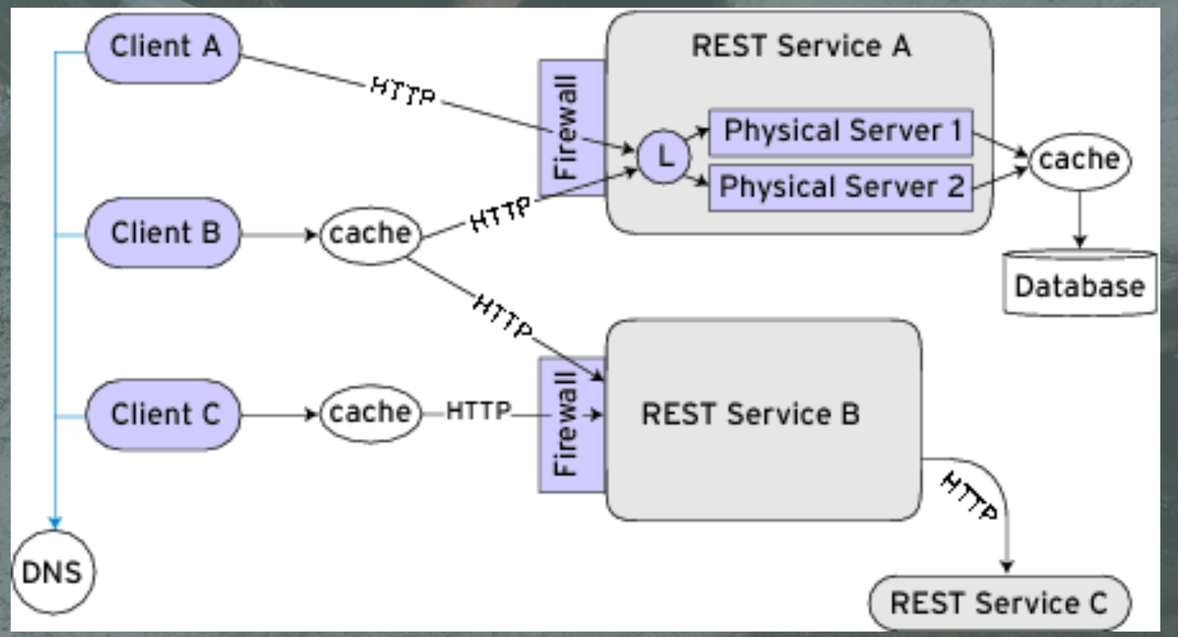




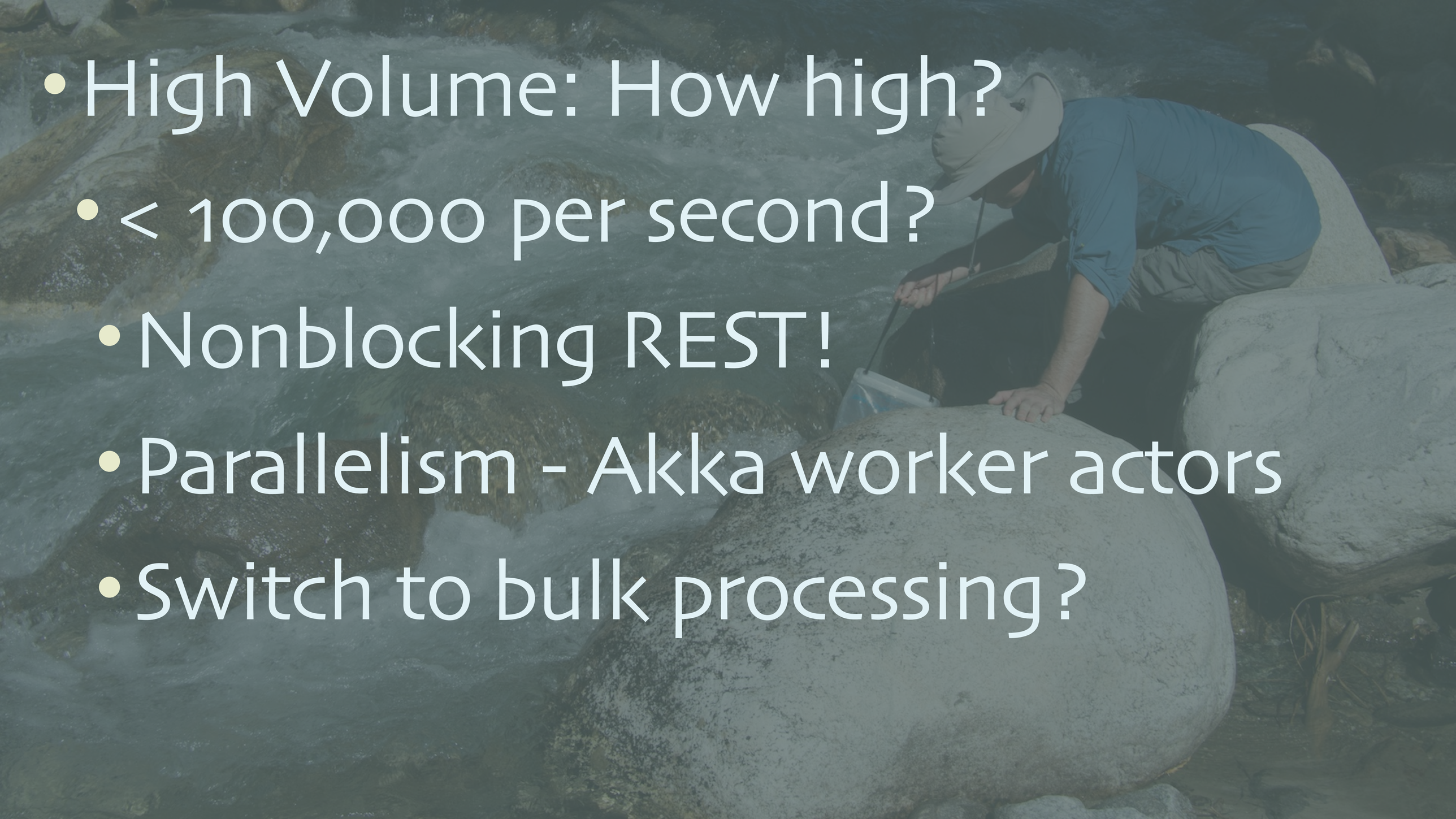
- Low latency? How low?
  - > 1 minute?
    - Consider periodic batch jobs!

- High Volume: How high?

- High Volume: How high?
  - < 10,000 events/second?
    - REST
    - One at a time…



http://www.drdobbs.com/web-development/soa-web-services-and-restful-systems/199902676



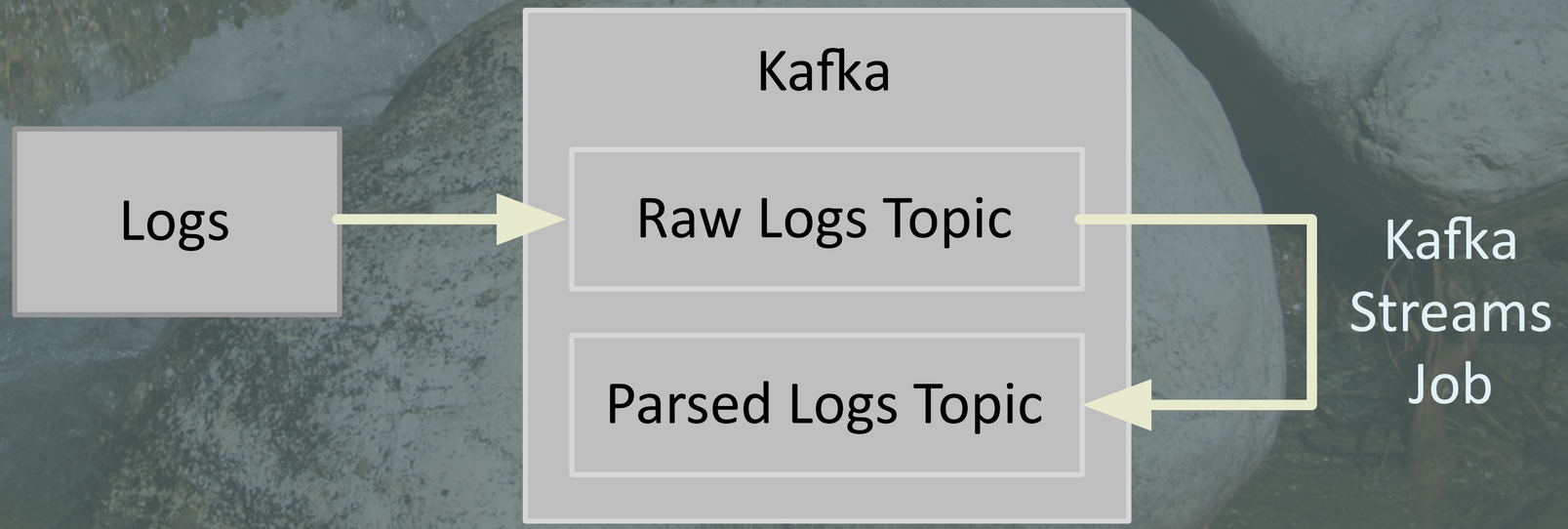
- High Volume: How high?
  - < 100,000 per second?
    - Nonblocking REST!
    - Parallelism - Akka worker actors
    - Switch to bulk processing?

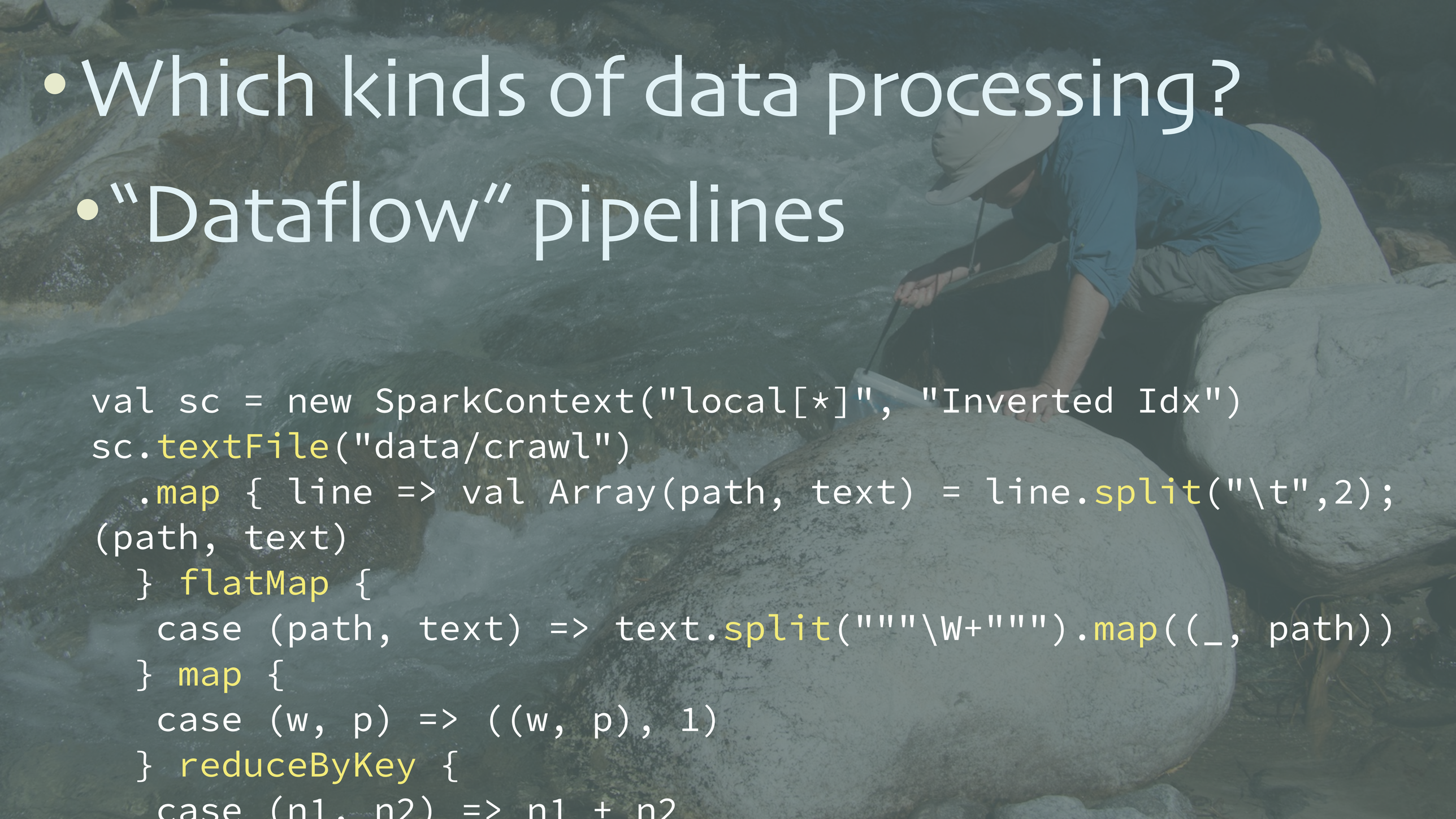
- High Volume: How high?
  - 1,000,000s per second?
    - Flink or Spark Streaming
    - Process in bulk

https://store.nest.com/product/thermostat/

- Which kinds of data processing?

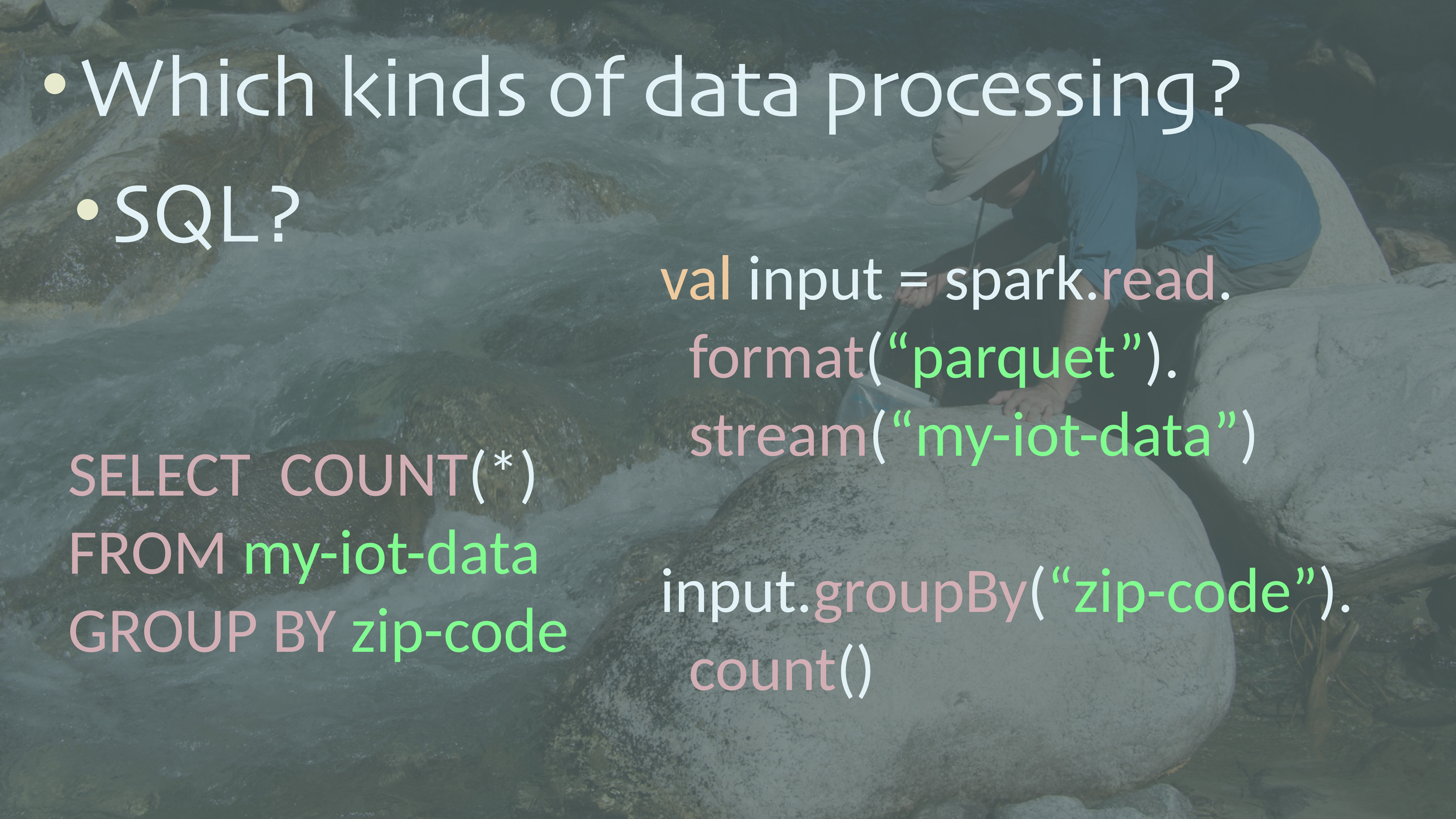
- Which kinds of data processing?
- Extract, transform, and load (ETL)?





- Which kinds of data processing?
- "Dataflow" pipelines

```
val sc = new SparkContext("local[*]", "Inverted Idx")
sc.textFile("data/crawl")
  .map { line => val Array(path, text) = line.split("\t",2);
(path, text)
  } flatMap {
   case (path, text) => text.split("""\W+""").map((_, path))
  } map {
   case (w, p) => ((w, p), 1)
  } reduceByKey {
   case (n1, n2) => n1 + n2
```

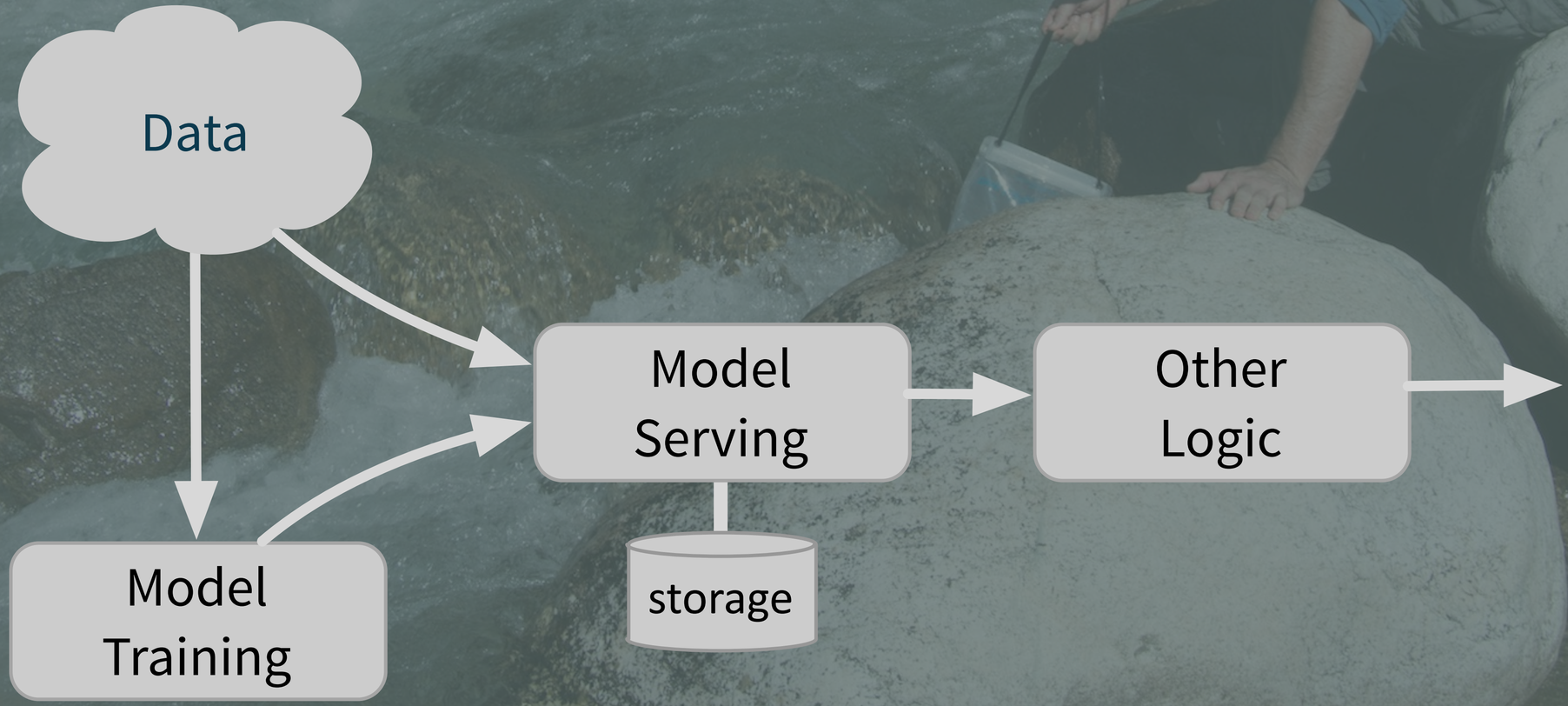


- Which kinds of data processing?
  - SQL?

```
SELECT  COUNT(*)
FROM my-iot-data
GROUP BY zip-code
```

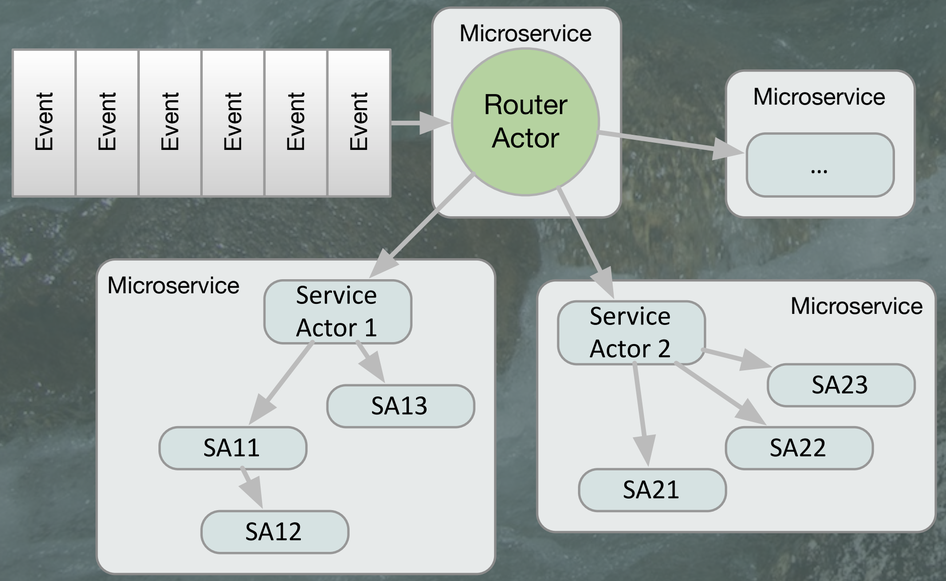
```
val input = spark.read.
  format(“parquet”).
  stream(“my-iot-data”)

input.groupBy(“zip-code”).
  count()
```

- Which kinds of data processing?
- Train and serve ML models?



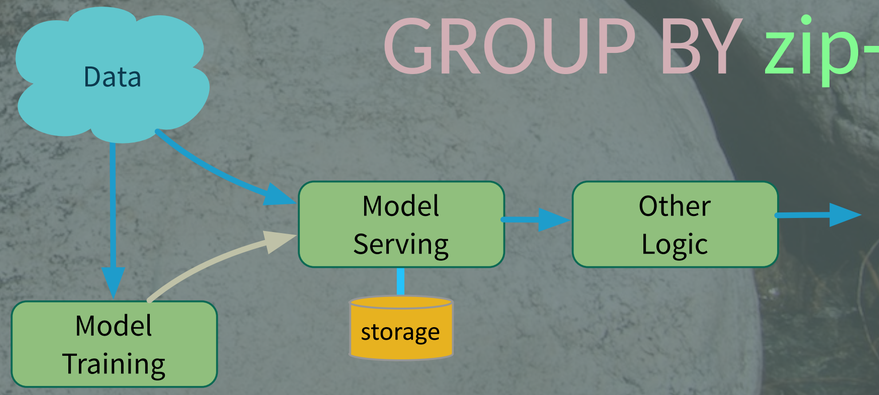
• Process data individually or in bulk?

Event-driven µ-services



"Record-centric" µ-services

```
SELECT  COUNT(*)
FROM my-iot-data
GROUP BY zip-code
```

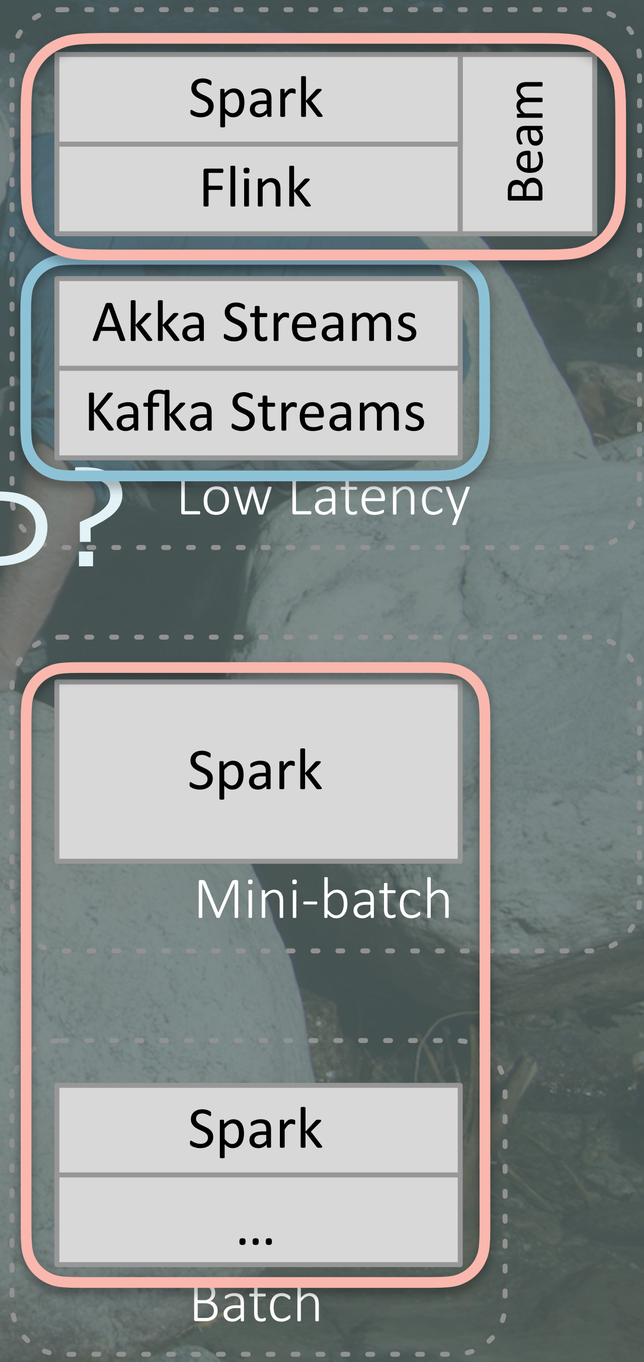


Events

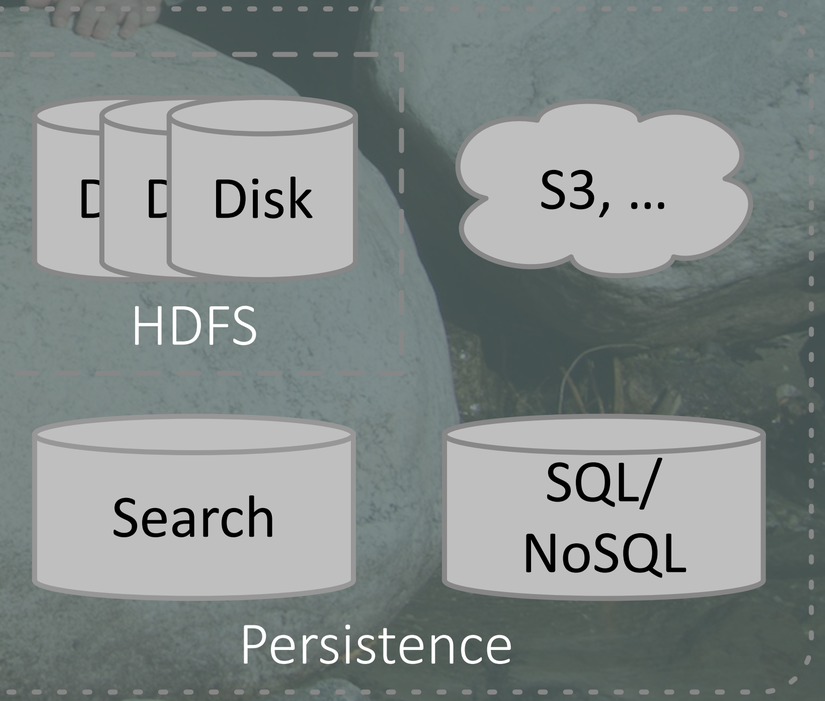
Records

- Preferred application architecture?
- Streaming library in an app?
- or, distributed services running your job?

Already have a microservices-based, DevOps CI/CD workflow? Stream processing with microservices may fit better into your environment!



- Integration with other tools.
  - Akka, Flink, & Spark integrate with Databases, Kafka, file systems, REST, …
  - Kafka Streams only read & write Kafka topics.



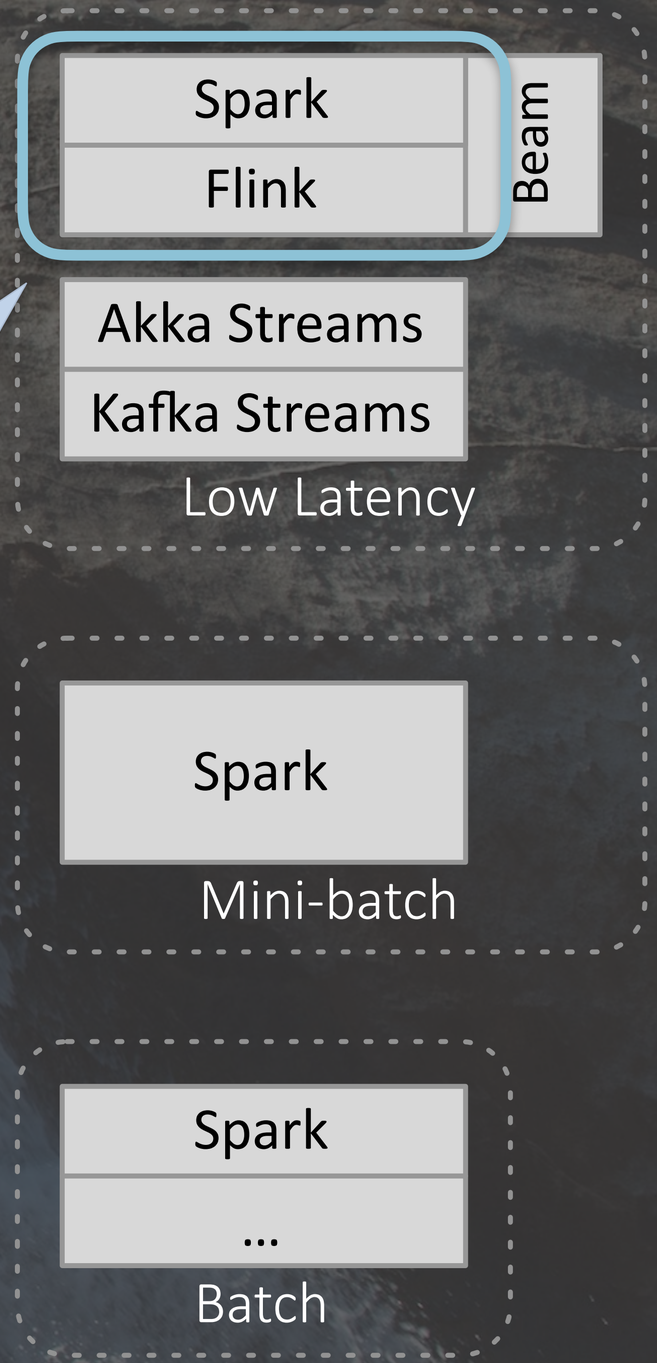
Best of Breed Streaming Engines


Spark
Flink
Beam
Akka Streams
Kafka Streams
Low Latency
Spark
Mini-batch
Spark
...
Batch

The streaming engines form two groups:

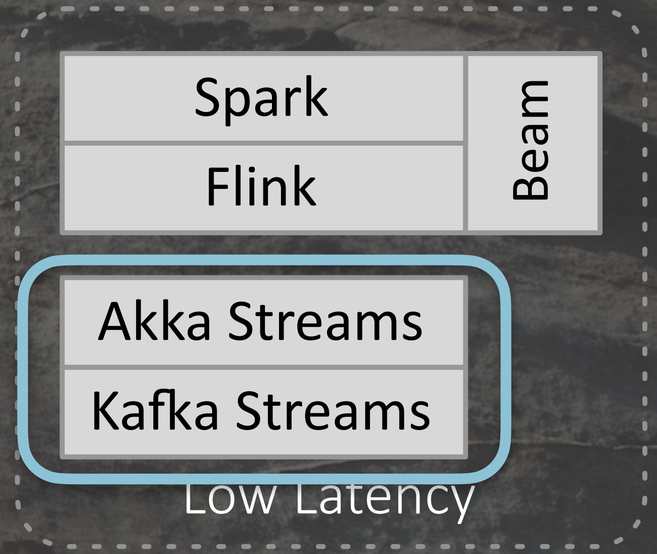
Run as distributed services

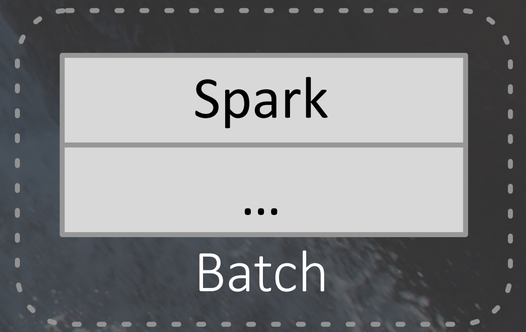
You submit jobs, they are partitioned into tasks



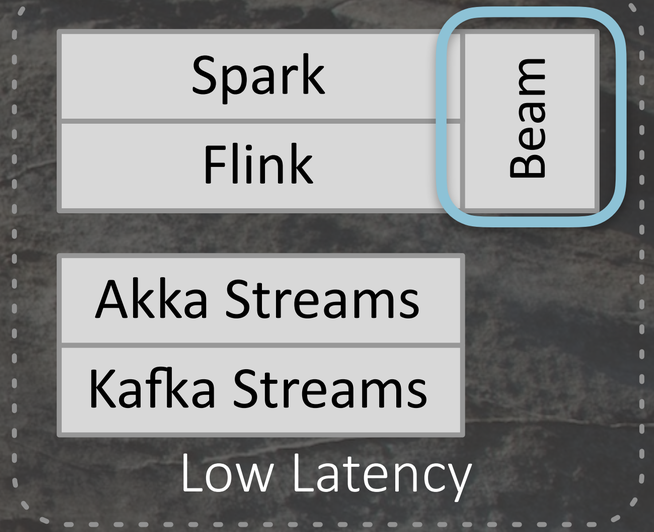
The streaming engines form two groups:

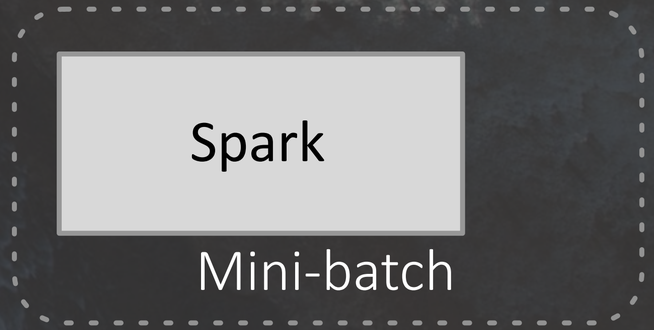
Libraries you embed in your microservices

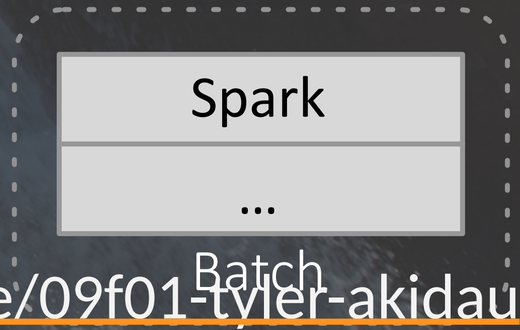




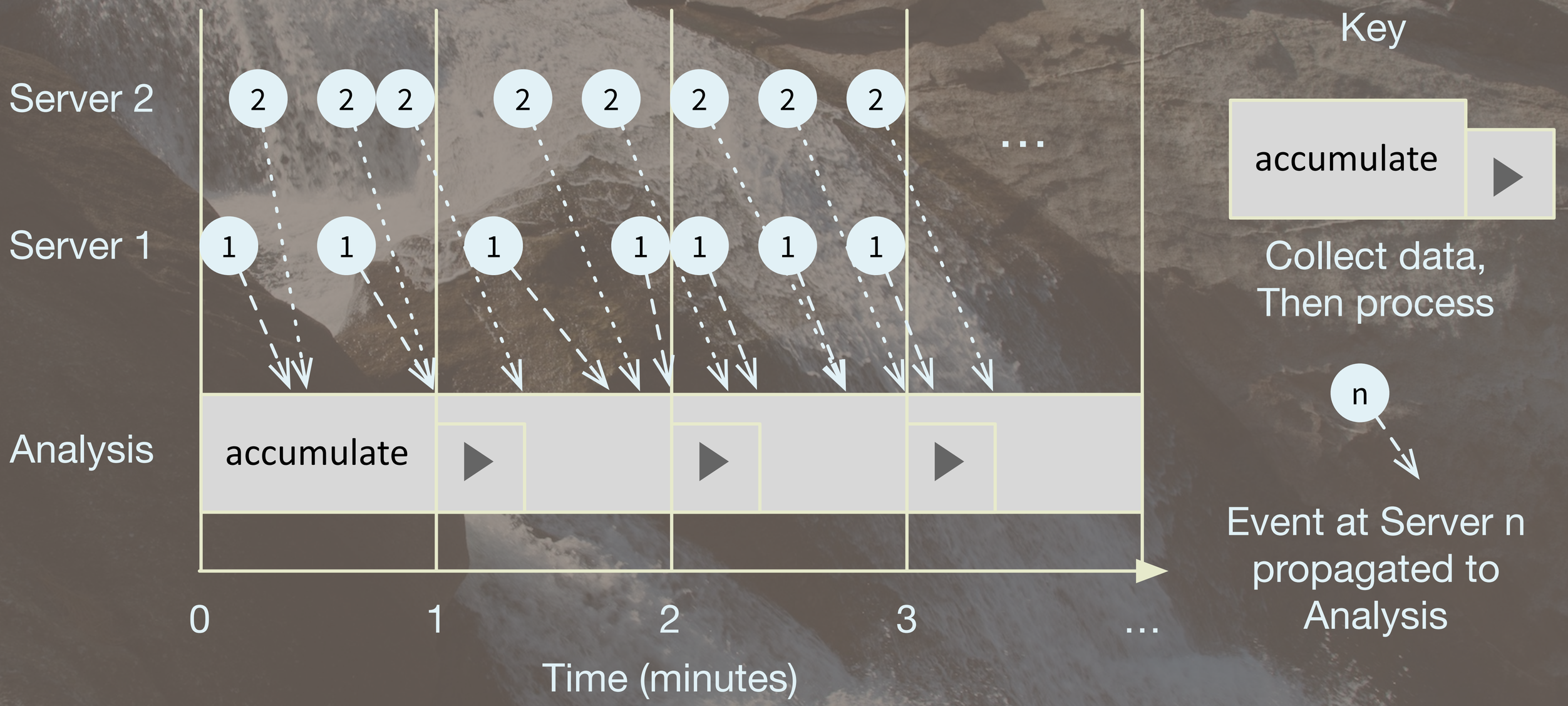
- Apache Beam
  - (Google Dataflow)
  - Requires a "runner"
  - Most sophisticated streaming semantics



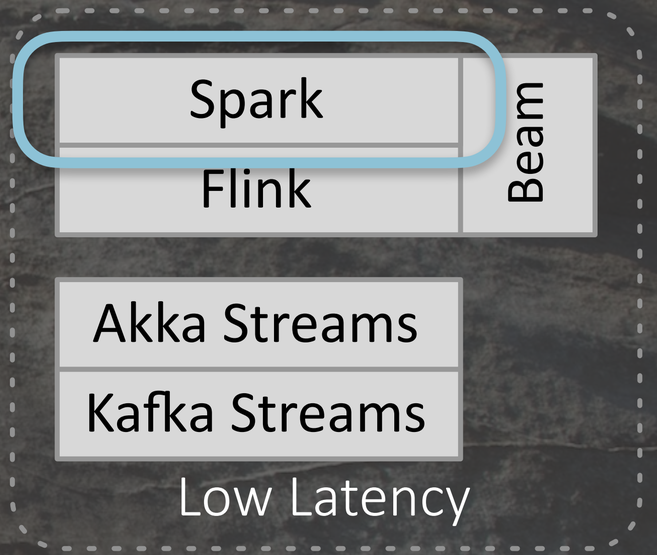


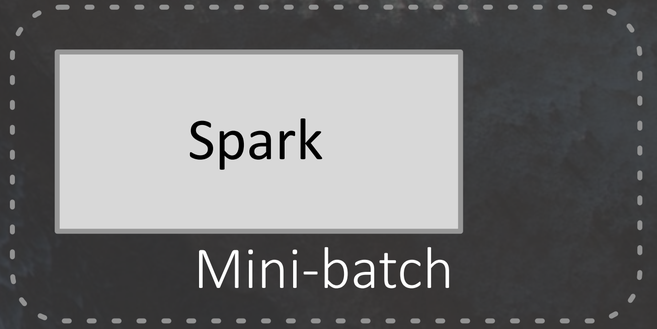


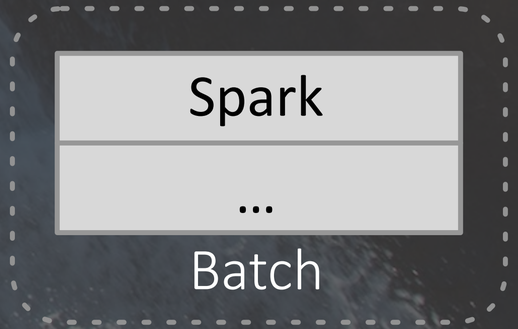
See these blog posts: https://www.oreilly.com/people/09f01-tyler-akidau


Server 2
Server 1
Analysis
accumulate
2
1
...
0
1
2
3
...
Time (minutes)
Key
accumulate
Collect data,
Then process
n
Event at Server n
propagated to
Analysis

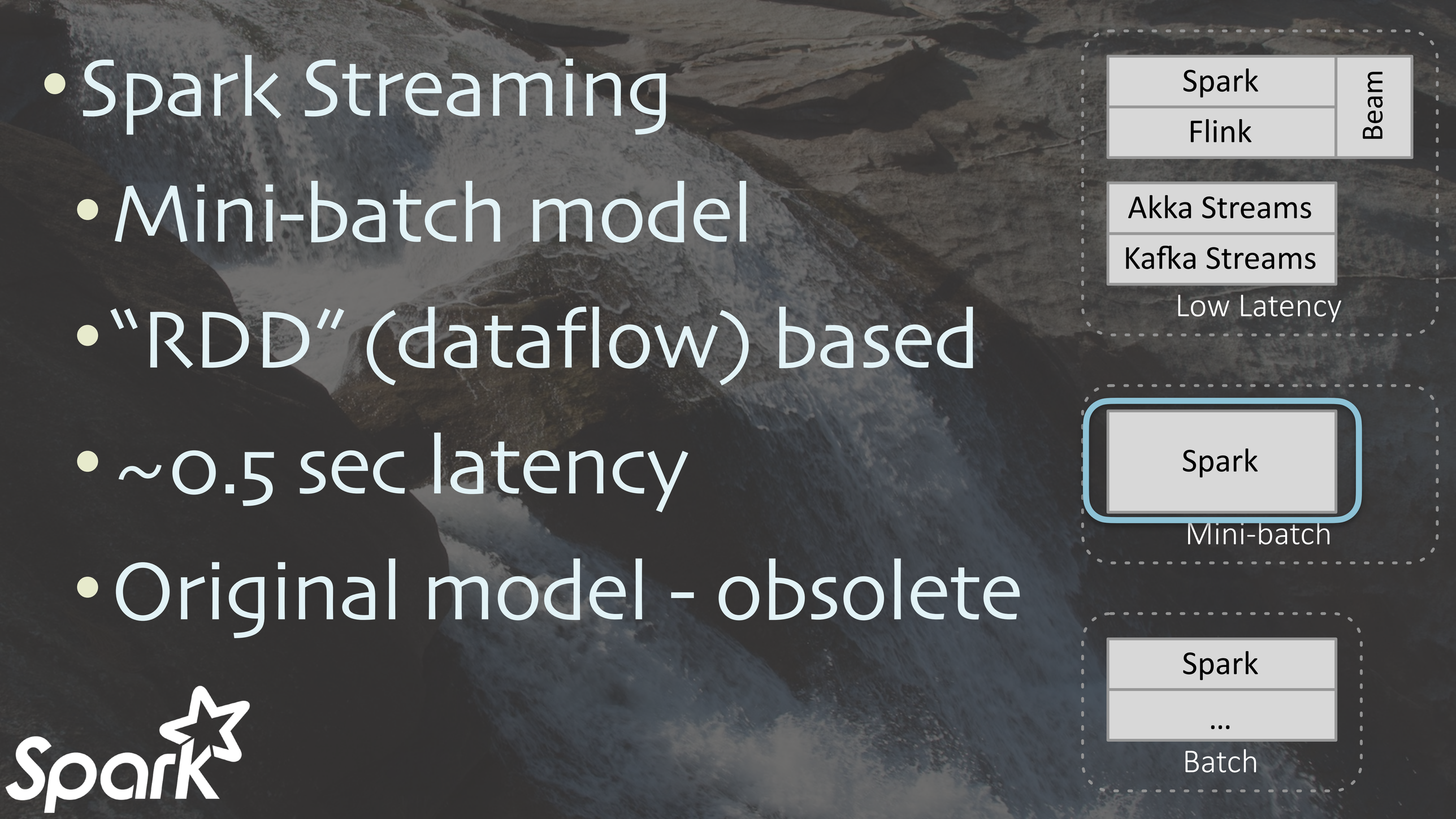
- Spark Structured Streaming
  - "Dataset" - SQL
  - Millisecond latency
  - Ideal for Rich SQL, ML.



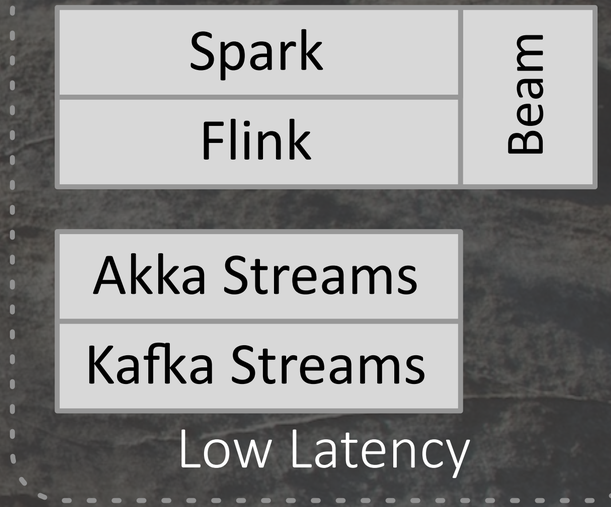


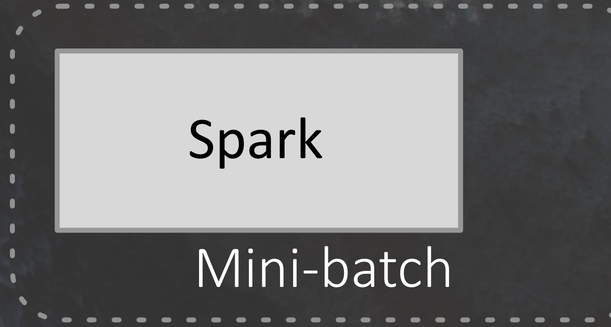


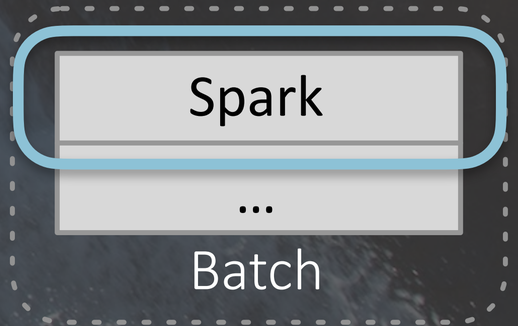
- Spark Streaming
- Mini-batch model
- "RDD" (dataflow) based
- ~0.5 sec latency
- Original model - obsolete



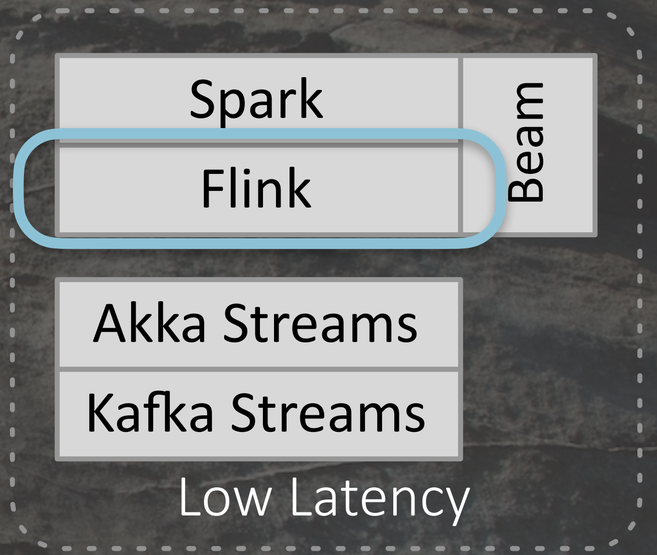
- Spark Batch
- Same Dataset and RDD features as streaming.
- Massive scalability
- Excellent performance

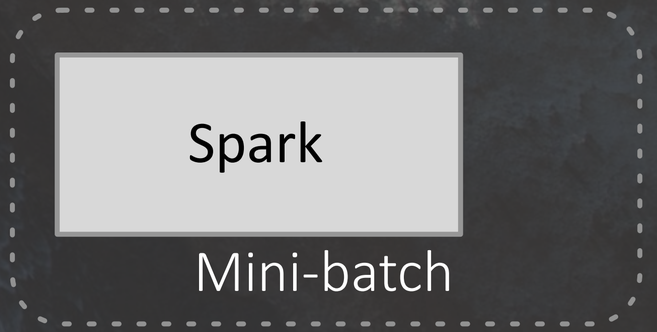


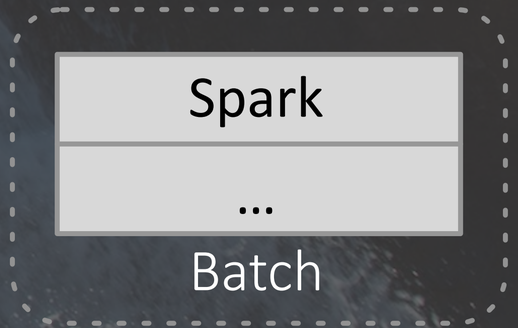




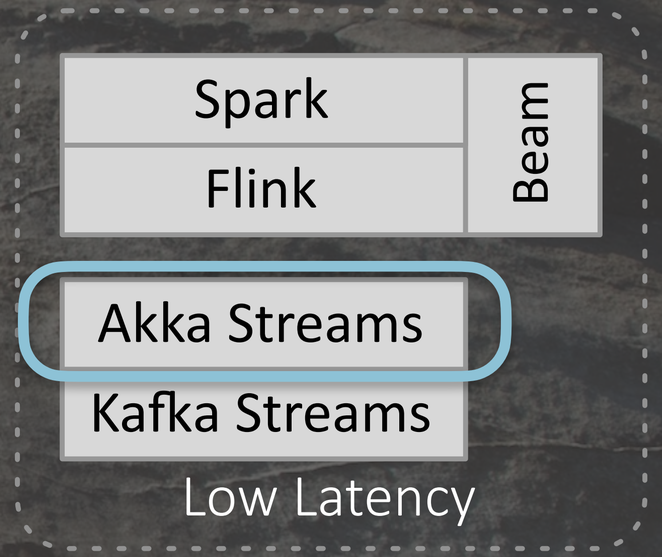
- Apache Flink
  - High volume, low latency
  - Sophisticated streaming (Beam) semantics
  - SQL, evolving ML support

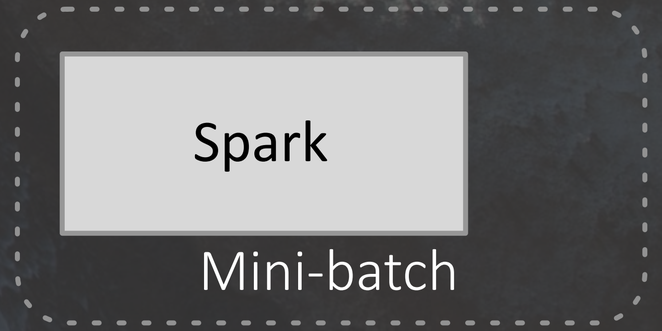


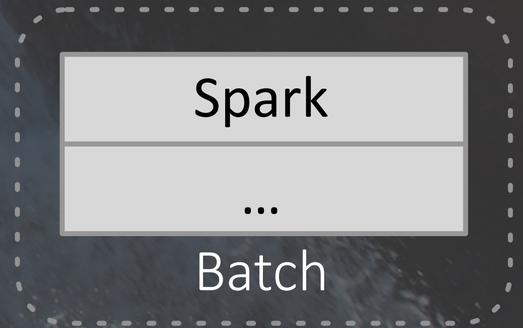




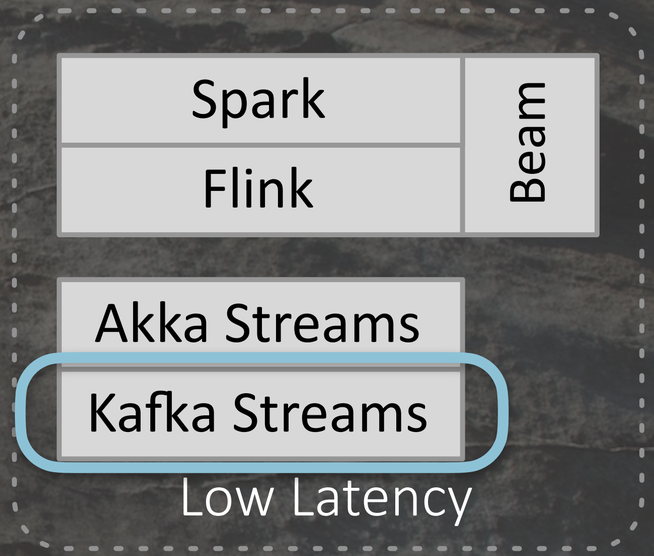
- Akka Streams
  - Low latency
  - Complex Event Processing
    - Efficient, per event
    - Mid-volume pipelines

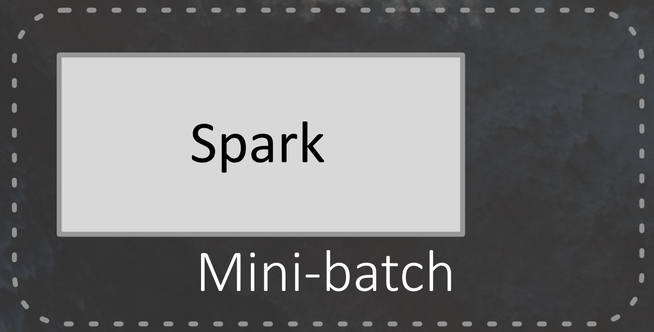


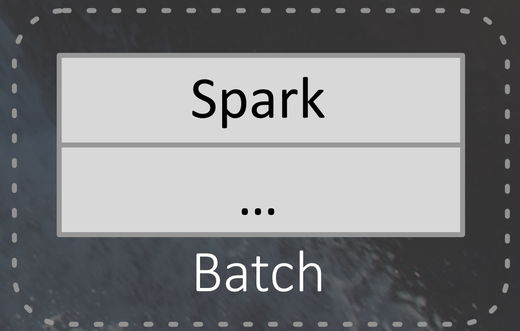




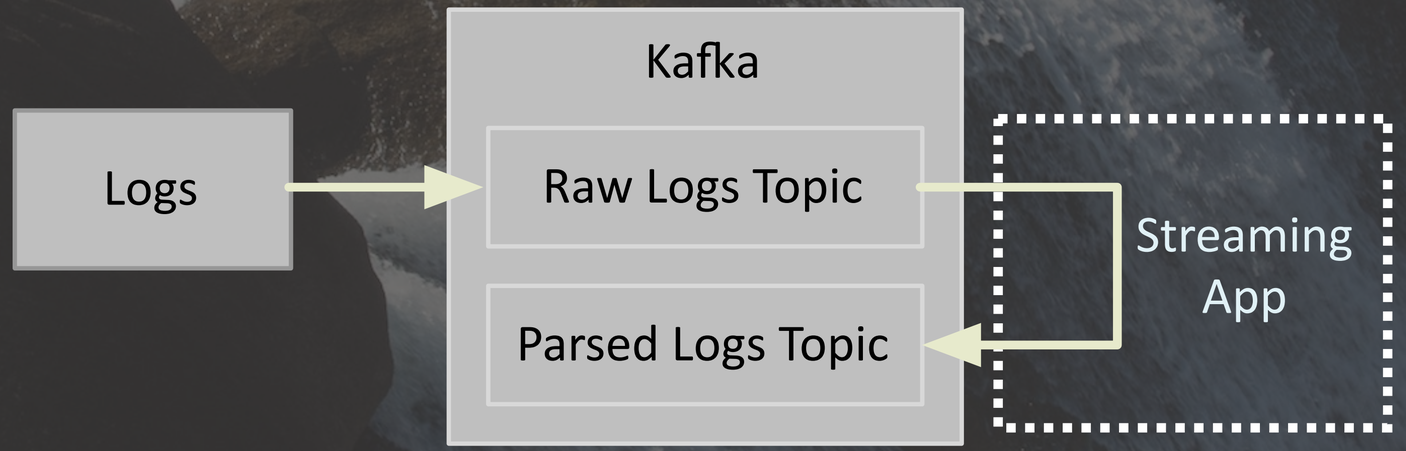
- Kafka Streams
  - Low overhead Kafka topic processing
  - Ideal for ETL and aggregations

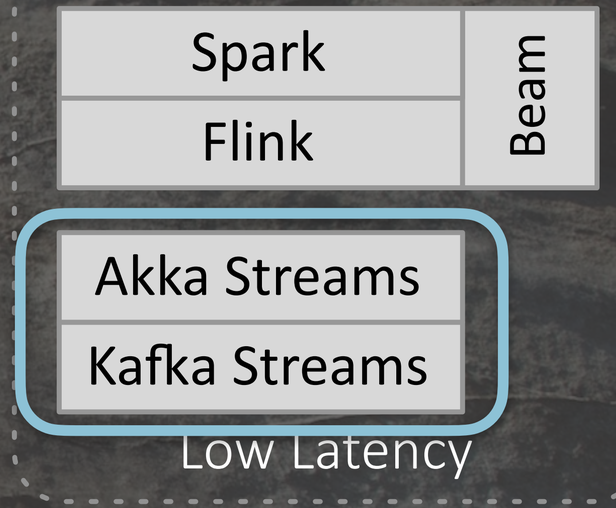


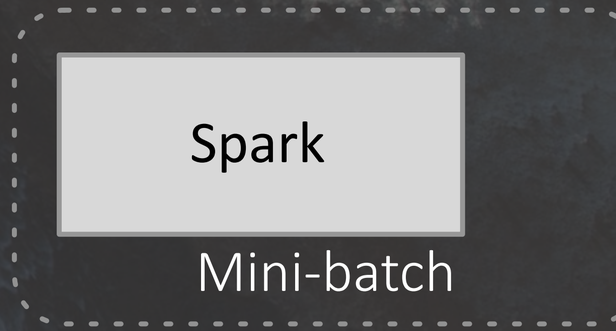


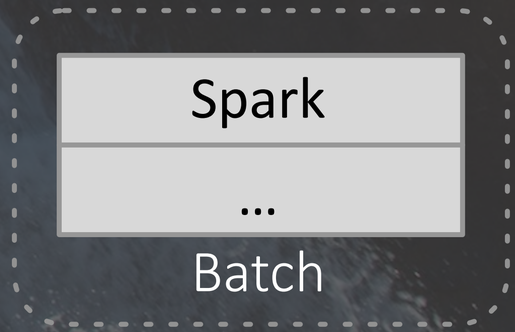


- Akka and Kafka Streams
  - "Exactly once" with transactions

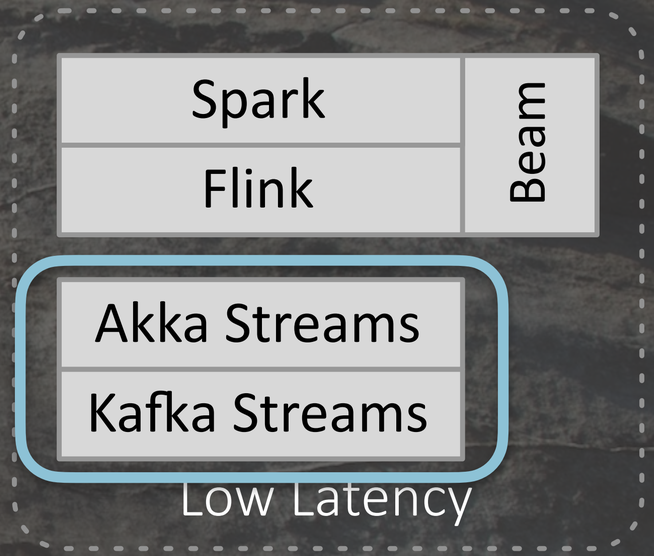


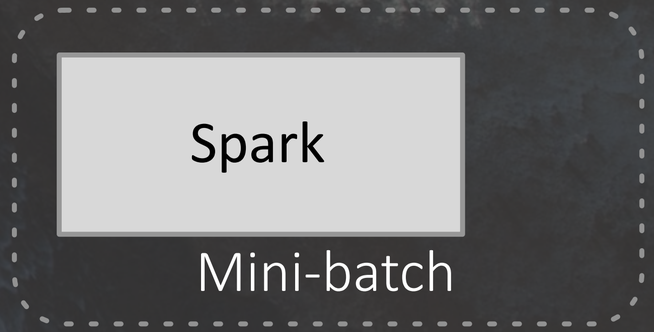


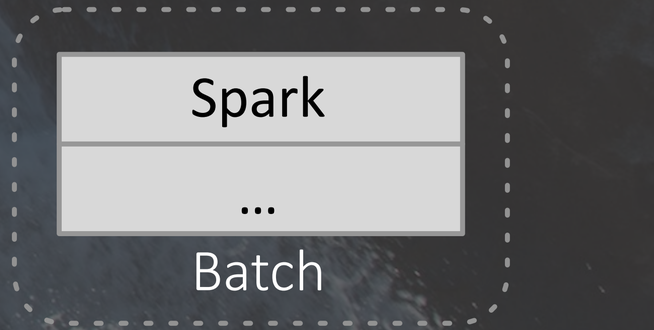




- Akka and Kafka Streams
  - Neither have built-in support for state checkpointing



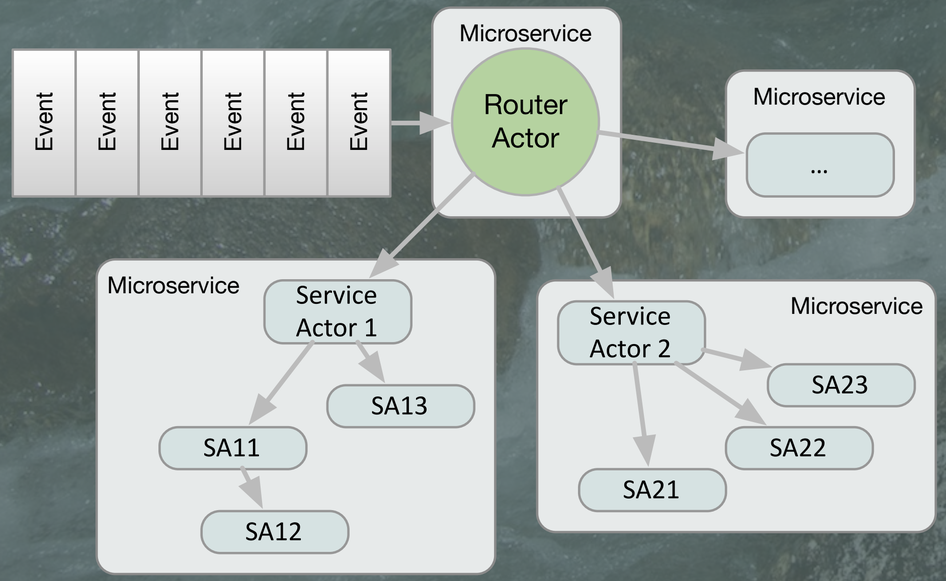




• Process data individually or in bulk?

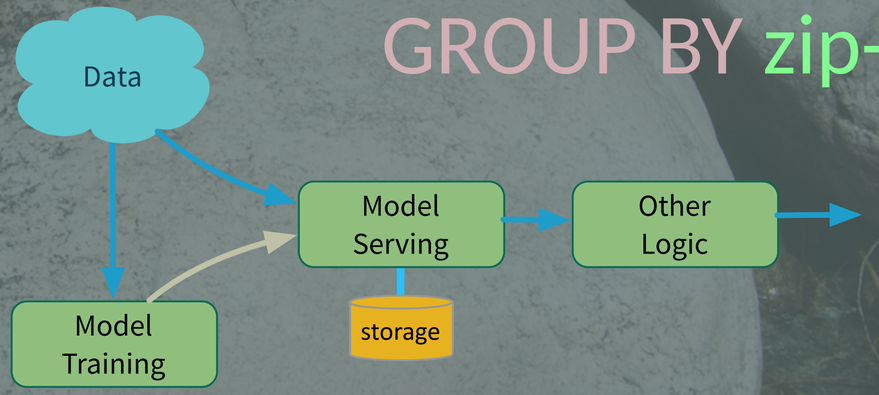
Each grew out of one end of this spectrum…

Event-driven µ-services



• "Record-centric" µ-services

```
SELECT  COUNT(*)
FROM my-iot-data
GROUP BY zip-code
```

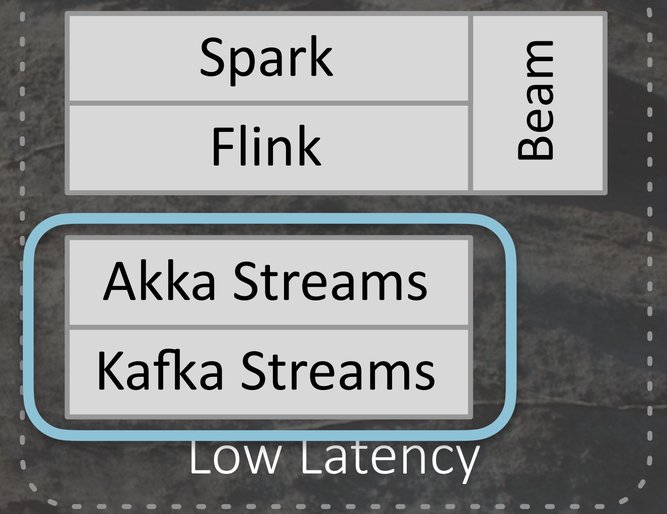


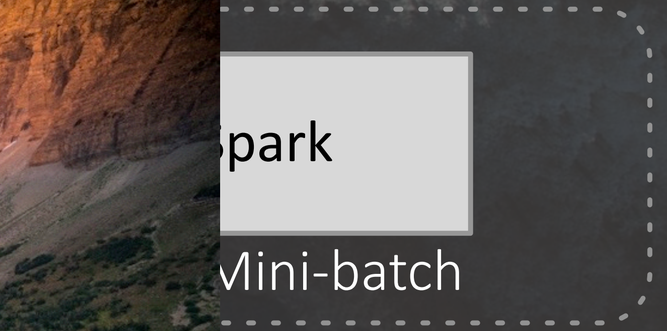
Events

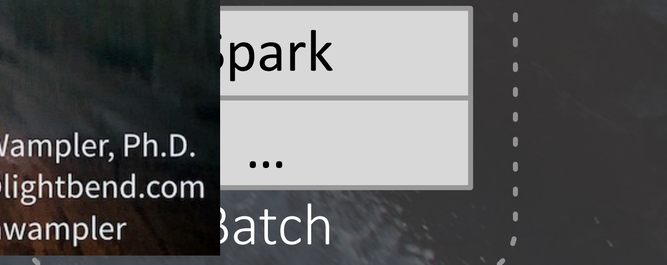
Records

• Akka Streams vs. Kafka Streams talk

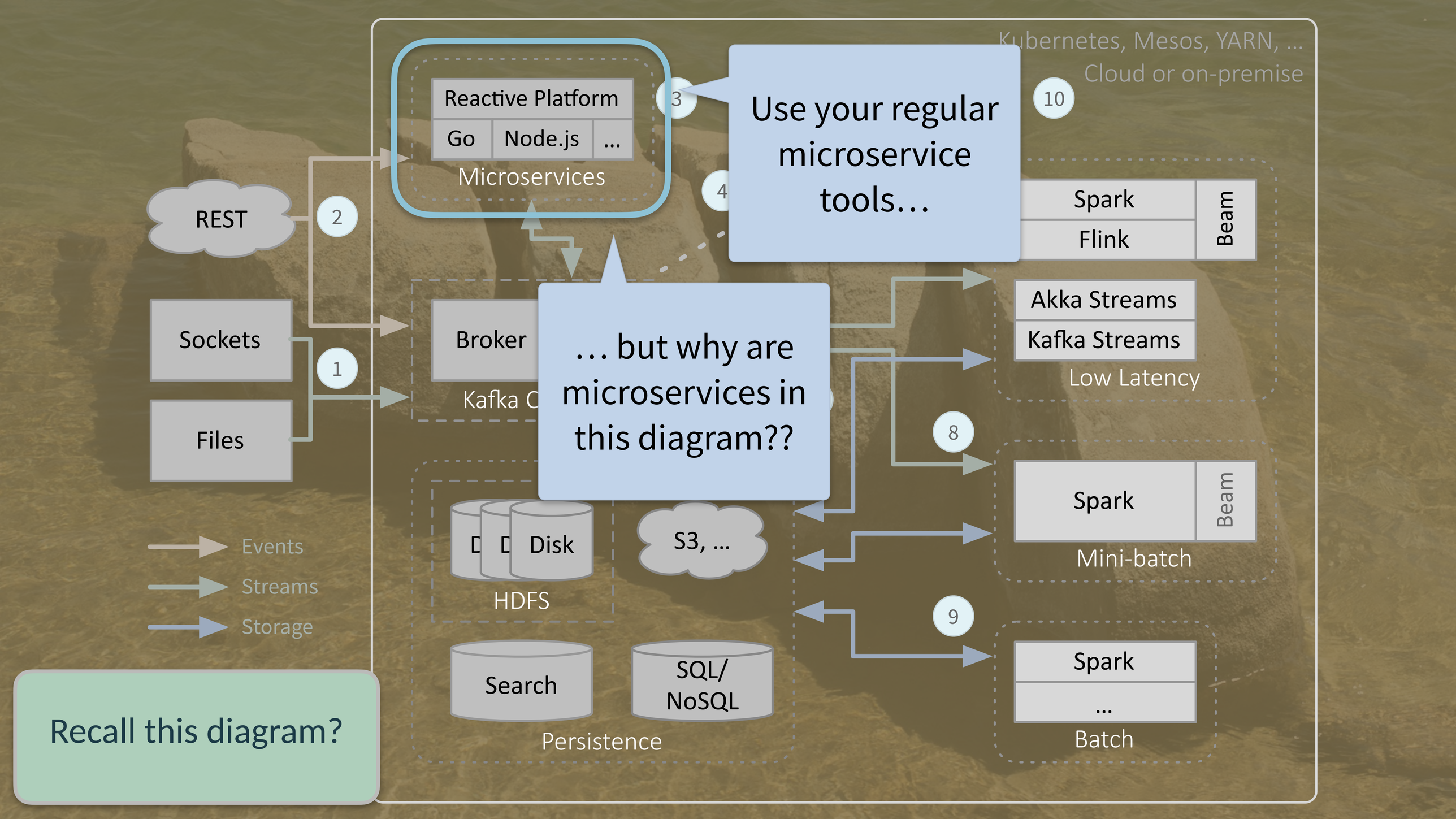
- Also at polyglotprogramming.com/talks/



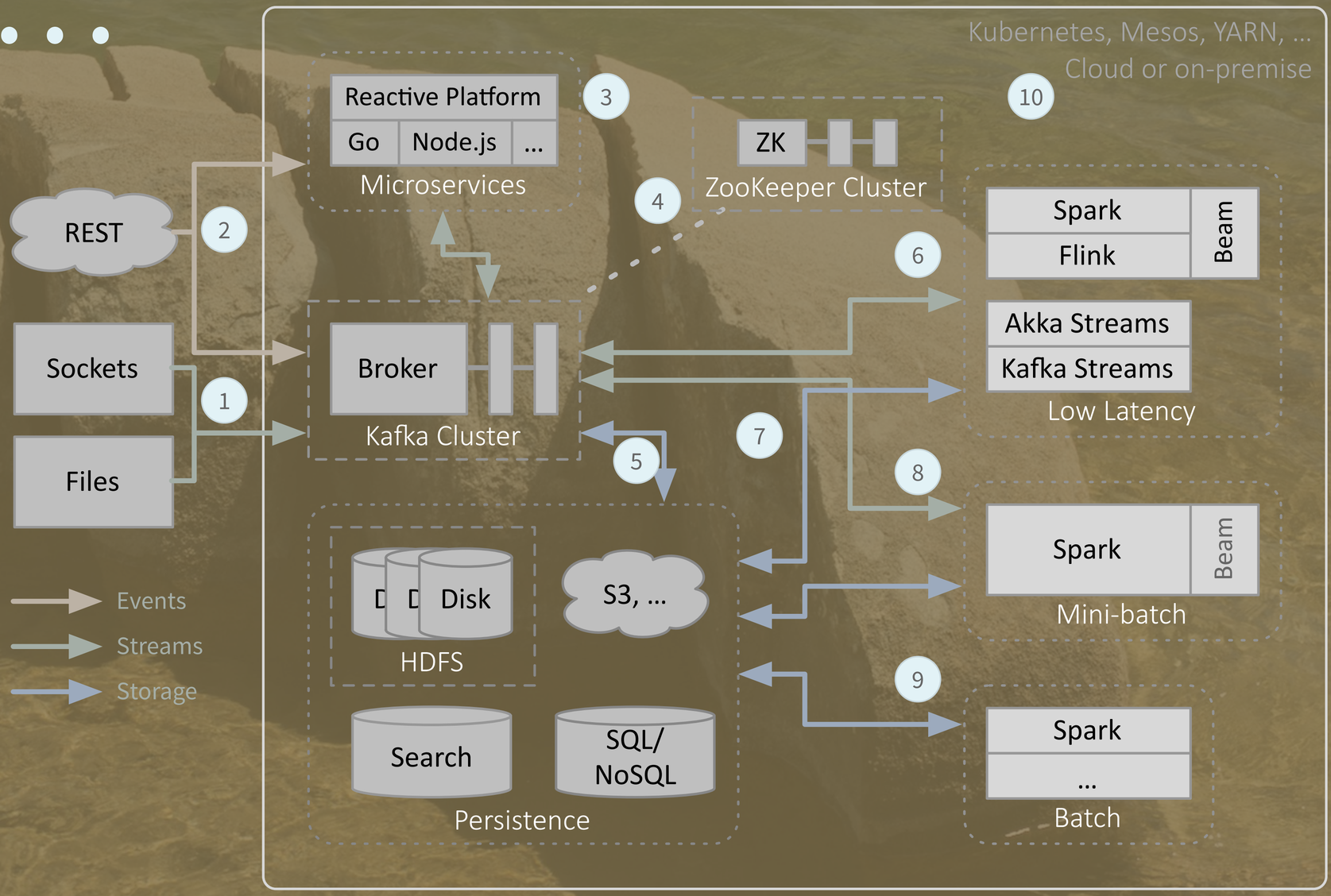




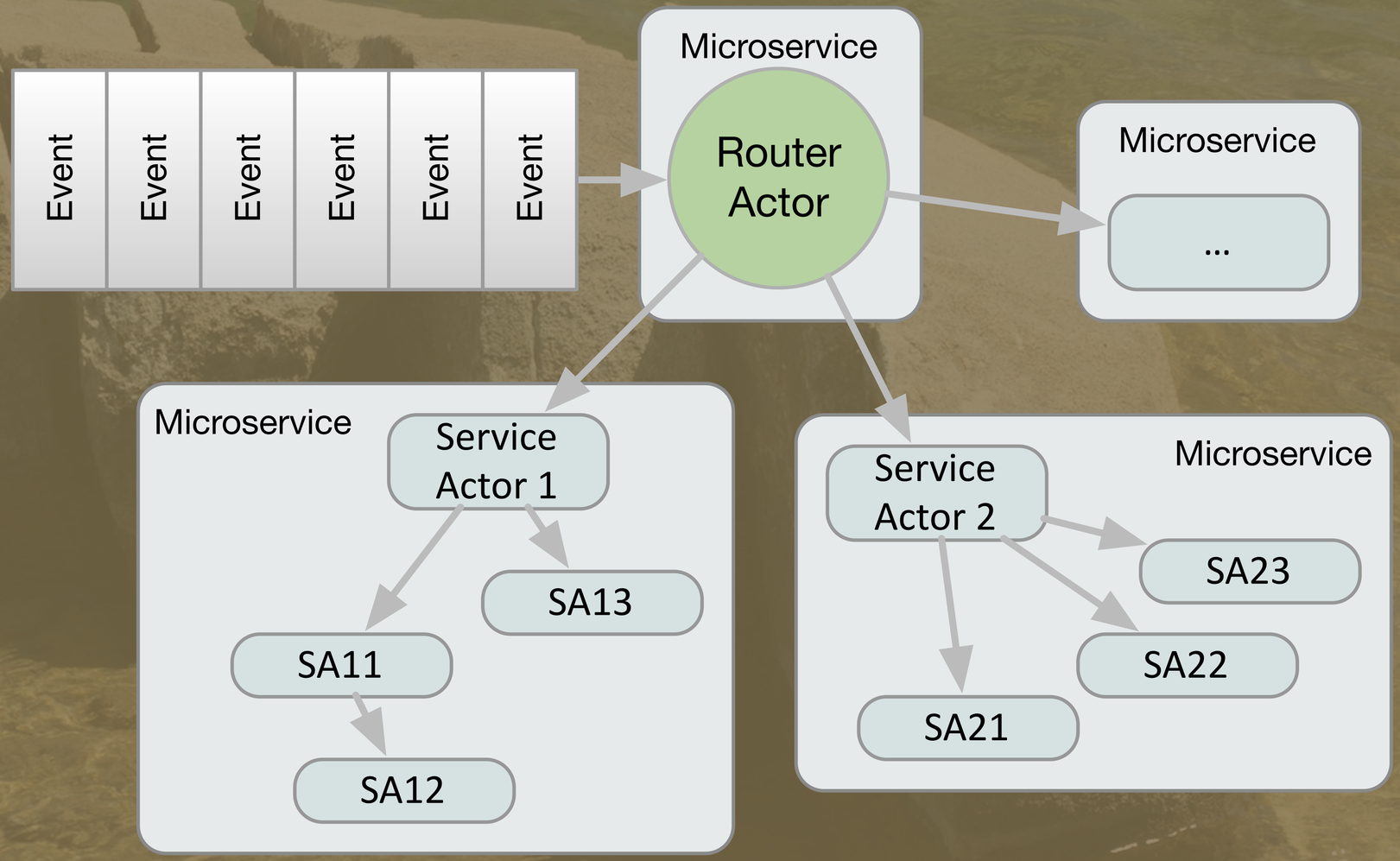
Microservices and Fast Data


Kubernetes, Mesos, YARN, …
Cloud or on-premise
Reactive Platform
Go
Node.js
…
Microservices
3
Use your regular microservice tools…
10
4
REST
2
Sockets
1
Files
Broker
Kafka C
… but why are microservices in this diagram??
Spark
Flink
Beam
Akka Streams
Kafka Streams
Low Latency
8
Spark
Beam
Mini-batch
9
Spark
…
Batch
Disk
HDFS
S3, …
Search
SQL/
NoSQL
Persistence
Events
Streams
Storage
Recall this diagram?

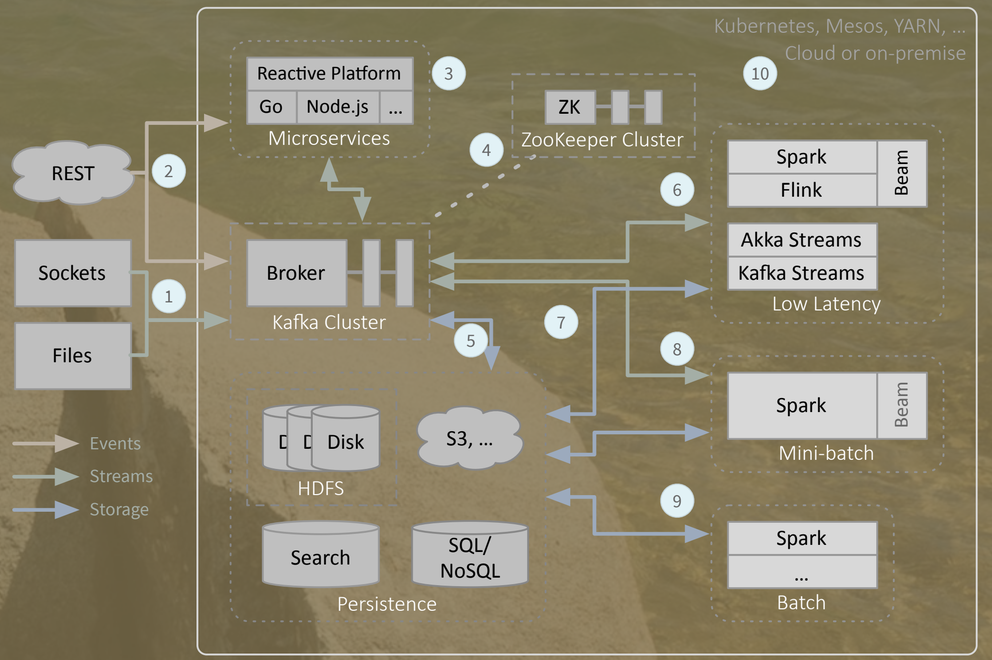
How is this…

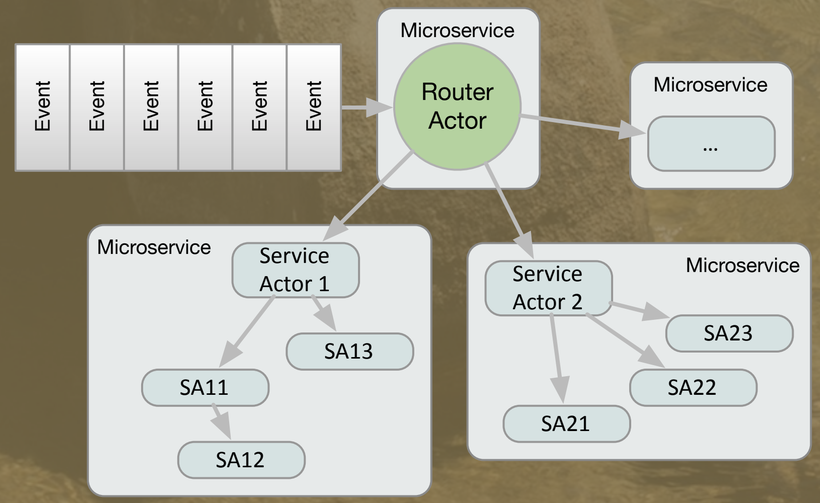

Kubernetes, Mesos, YARN, …
Cloud or on-premise
10
Reactive Platform
Go
Node.js
…
Microservices
3
ZK
ZooKeeper Cluster
4
REST
2
Sockets
1
Files
Broker
Kafka Cluster
5
6
Spark
Flink
Beam
Akka Streams
Kafka Streams
Low Latency
7
8
Spark
Beam
Mini-batch
Disk
HDFS
S3, …
9
Search
SQL/
NoSQL
Persistence
Spark
…
Batch
Events
Streams
Storage

… like this?

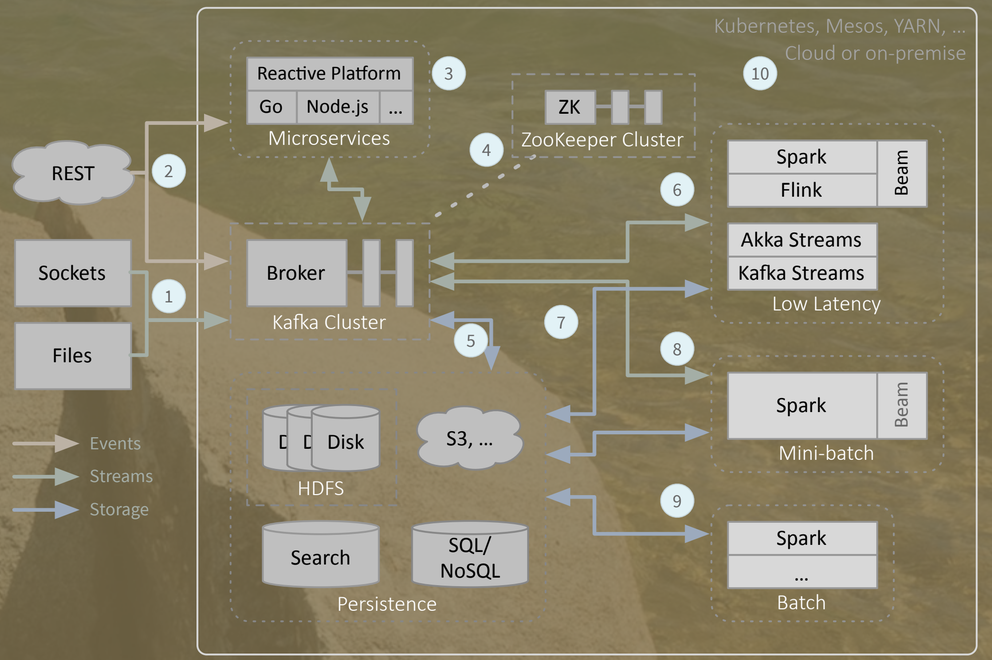

Event
Event
Event
Event
Event
Event
Microservice
Router Actor
Microservice
...
Microservice
Service Actor 1
SA13
SA11
SA12
Microservice
Service Actor 2
SA23
SA22
SA21

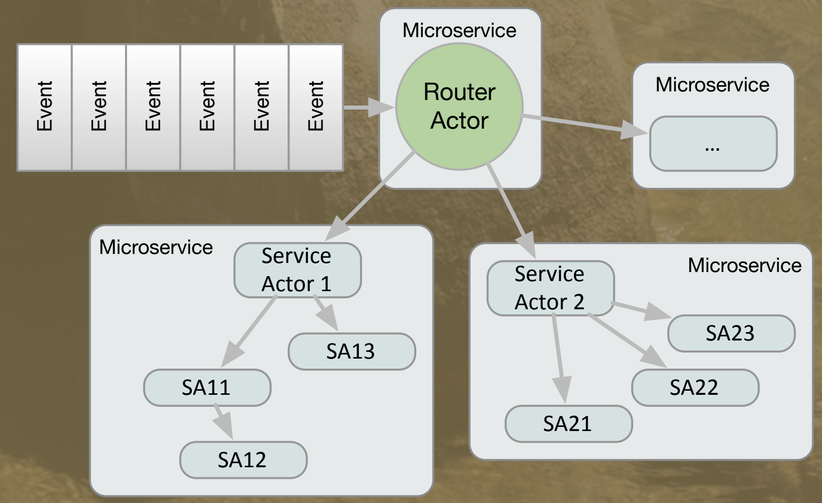
- A data app / microservice:
  - A single responsibility.
  - …



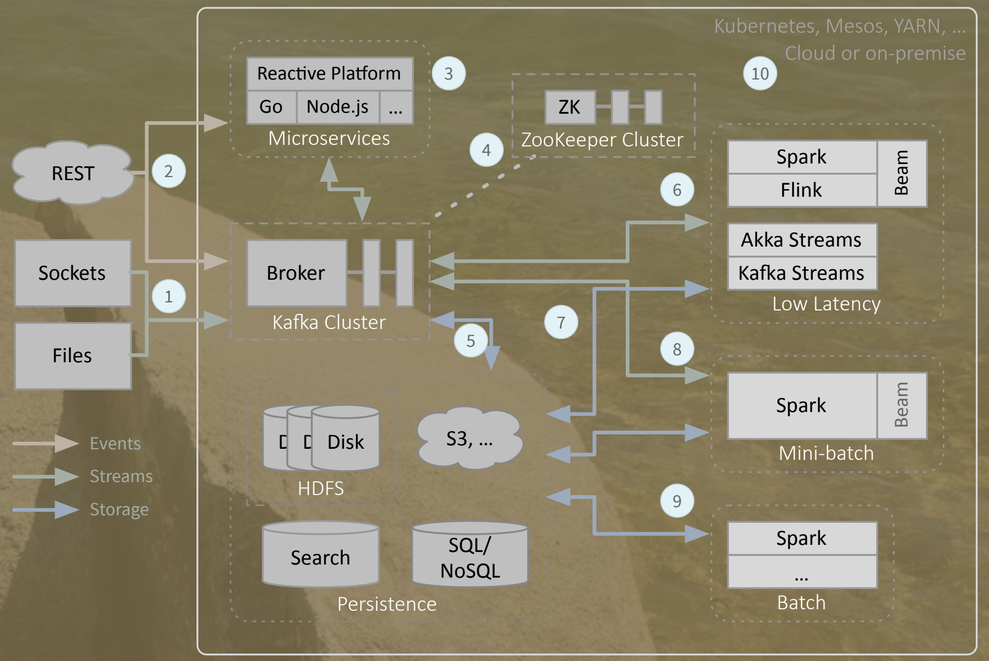


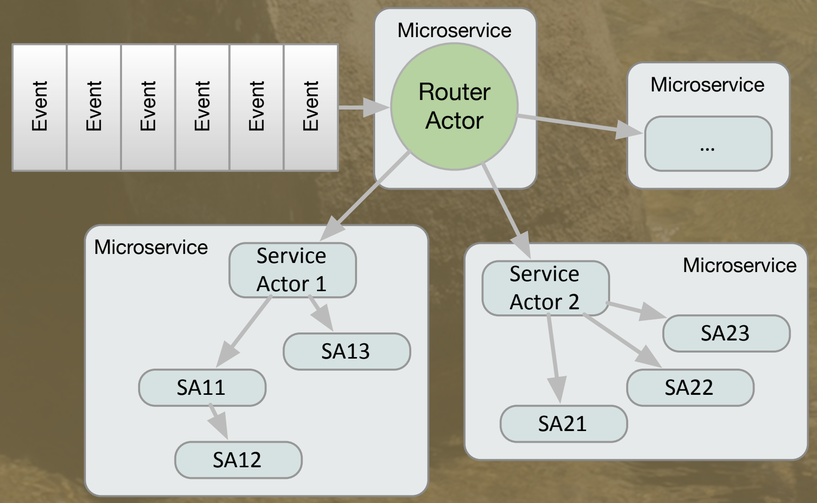
- A data app / microservice:
  - A single responsibility.
  - The input never ends.





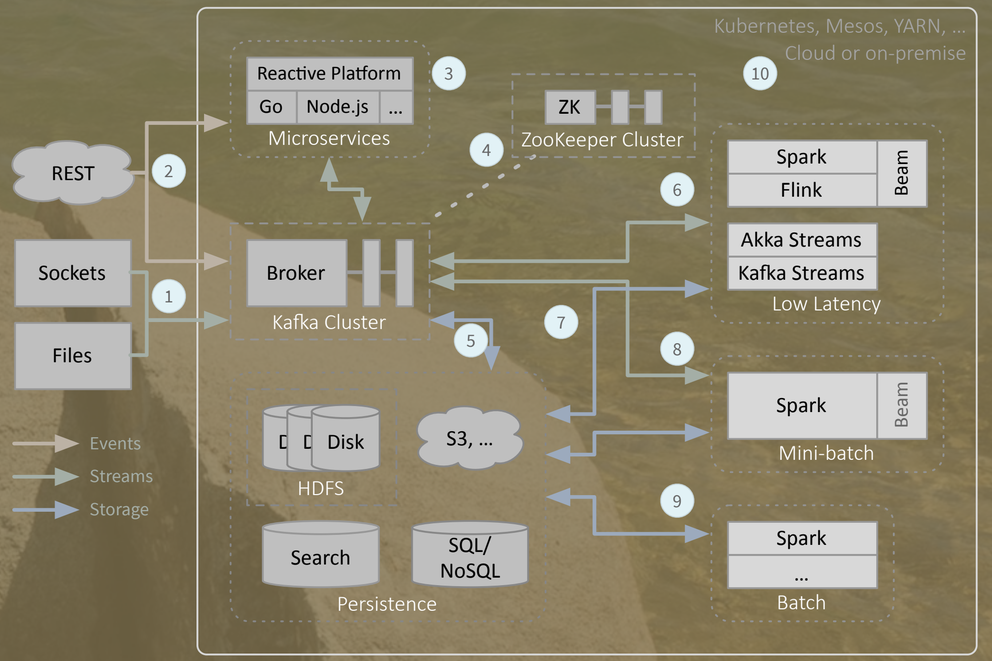
- A data app/microservice:
  - A single responsibility.
  - The input never ends.
    - So, both must be available, responsive, resilient, & scalable. I.e., reactive

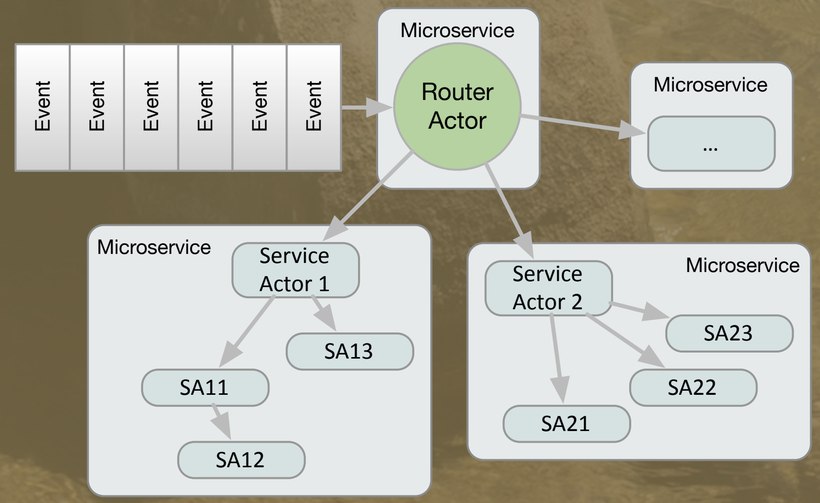




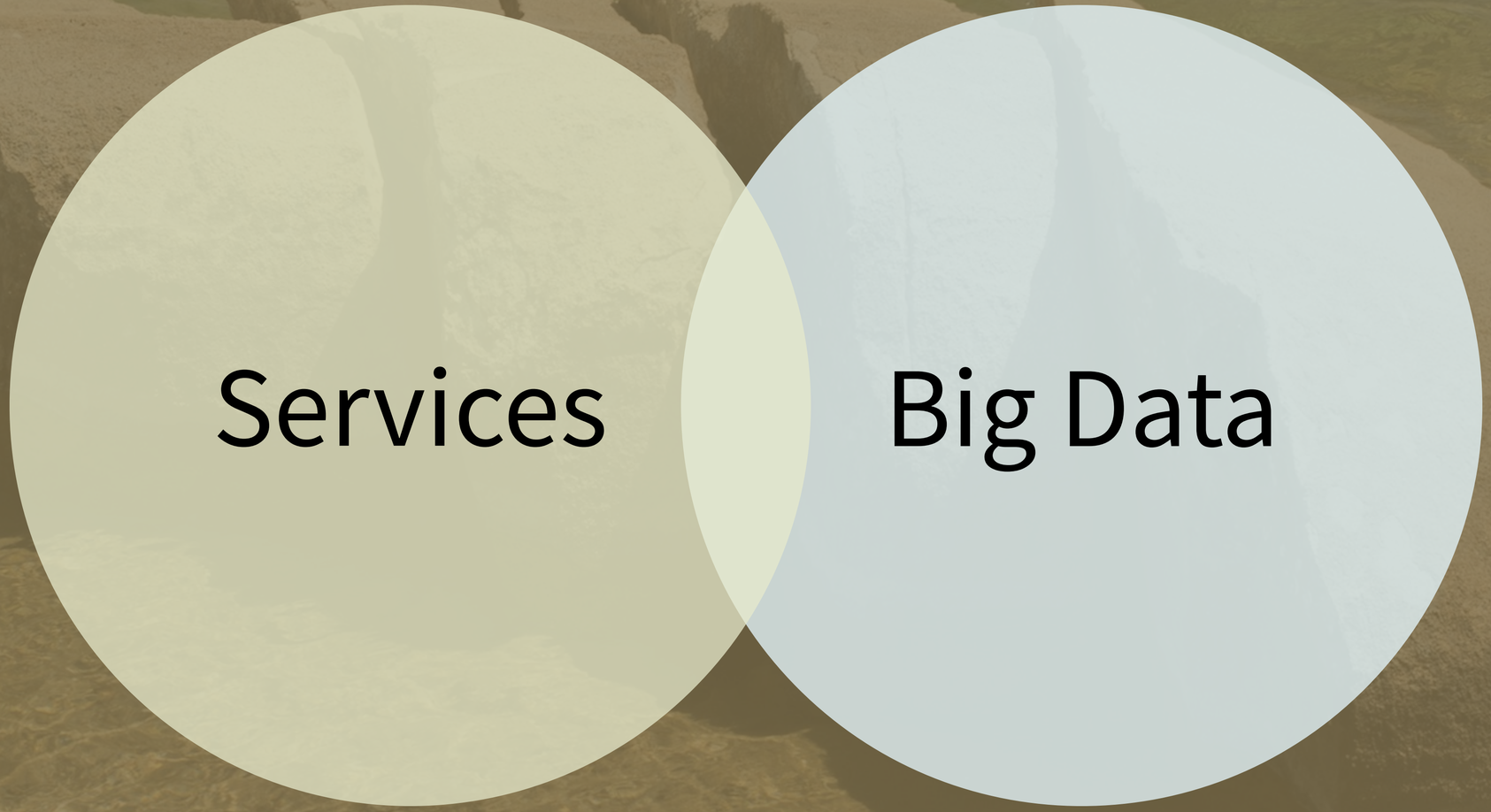
http://www.reactivemanifesto.org/

- Going the other way, "small" microservice architectures become data-centric, as the data grows.





The Recent Past



Some Overlap: Concerns, Architecture

The Present

Microservices
& *Fast* Data

Much More Overlap

The Future?

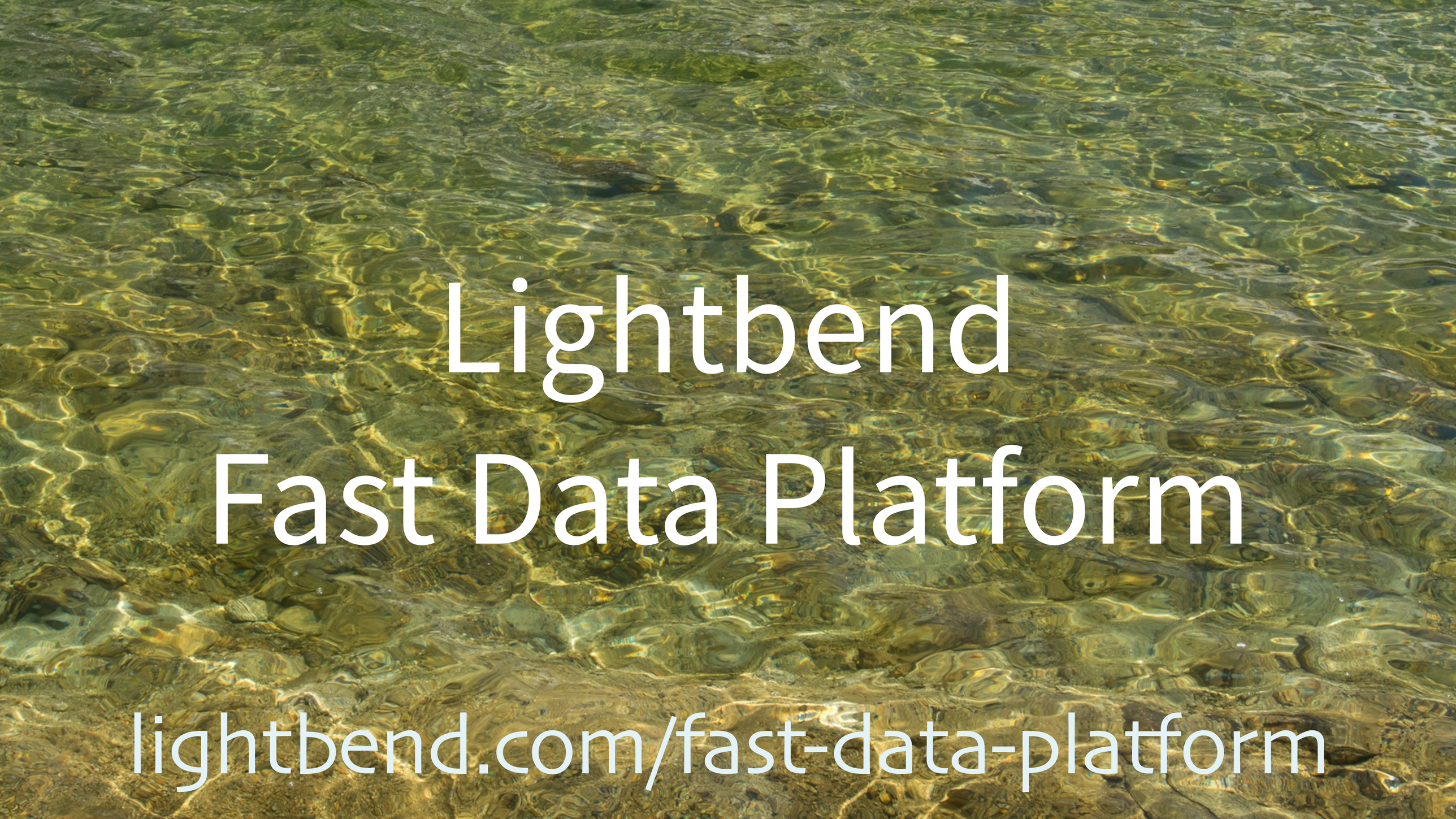
Why? Since streams process data incrementally, there is less need for large-scale tools like Spark, Flink

… and using microservices for everything simplifies development, deployment, and operations

Microservices *for* Fast Data

Unclear if this helps bridge the divide between data science and data engineering

Much more microservice focused?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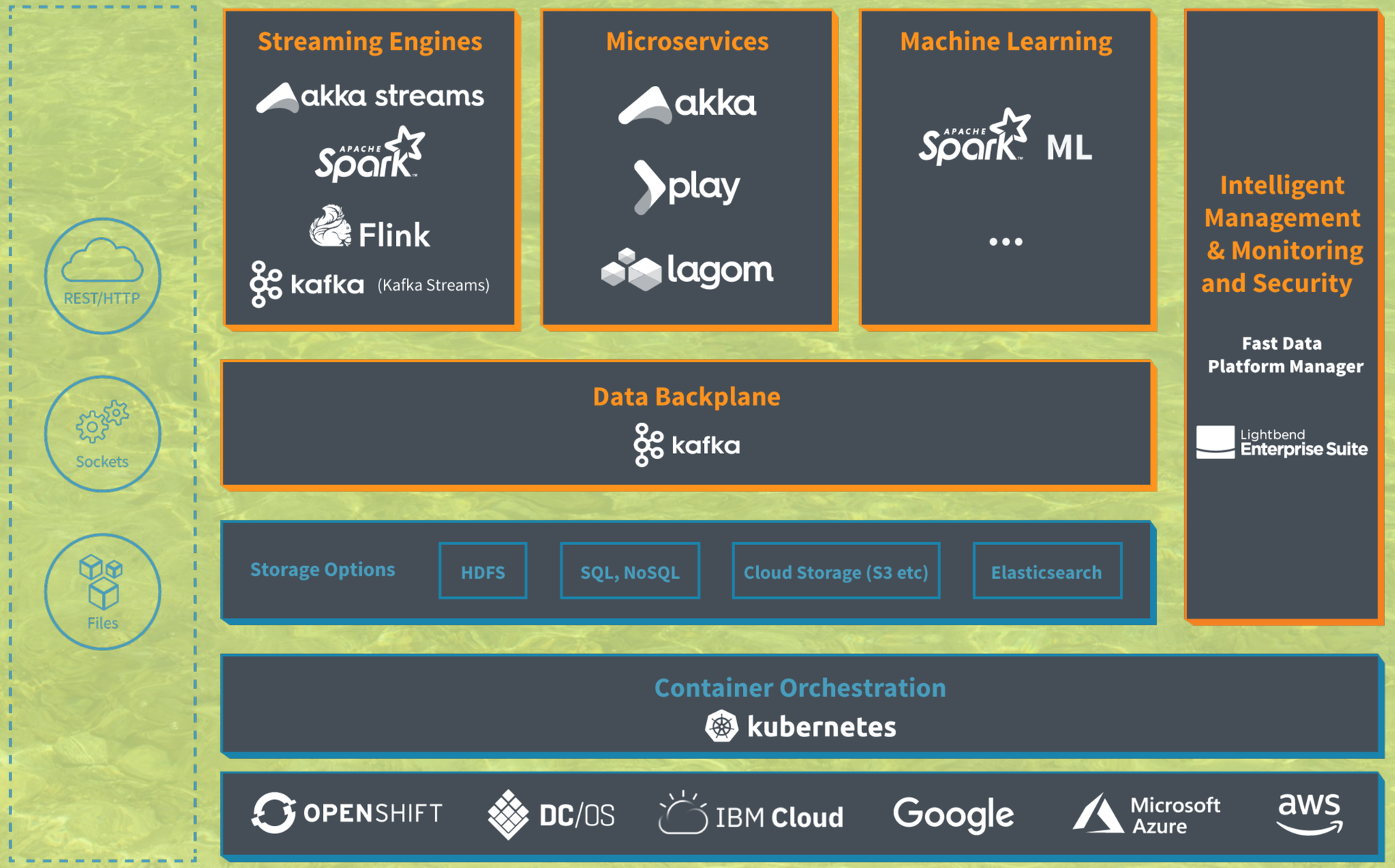

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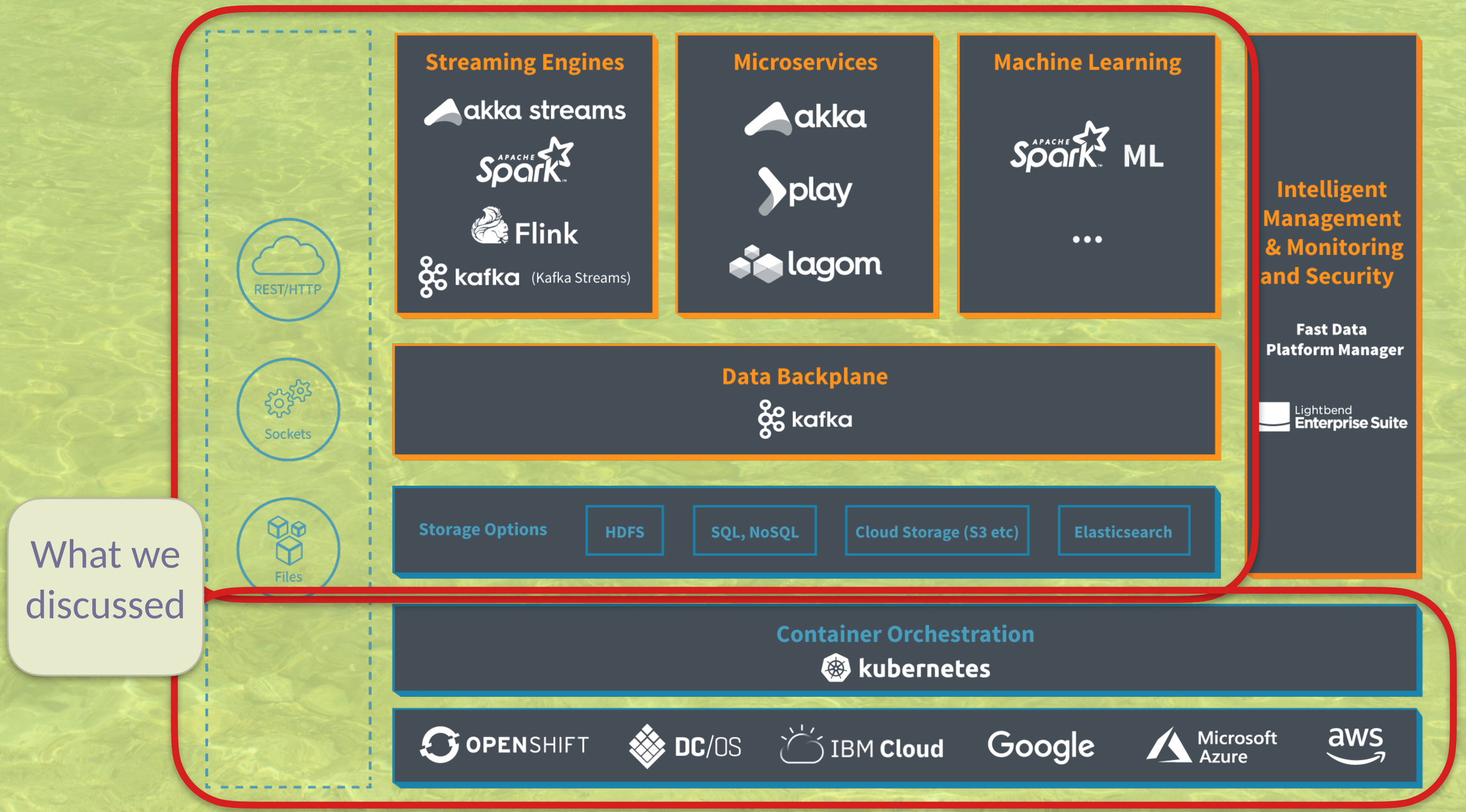

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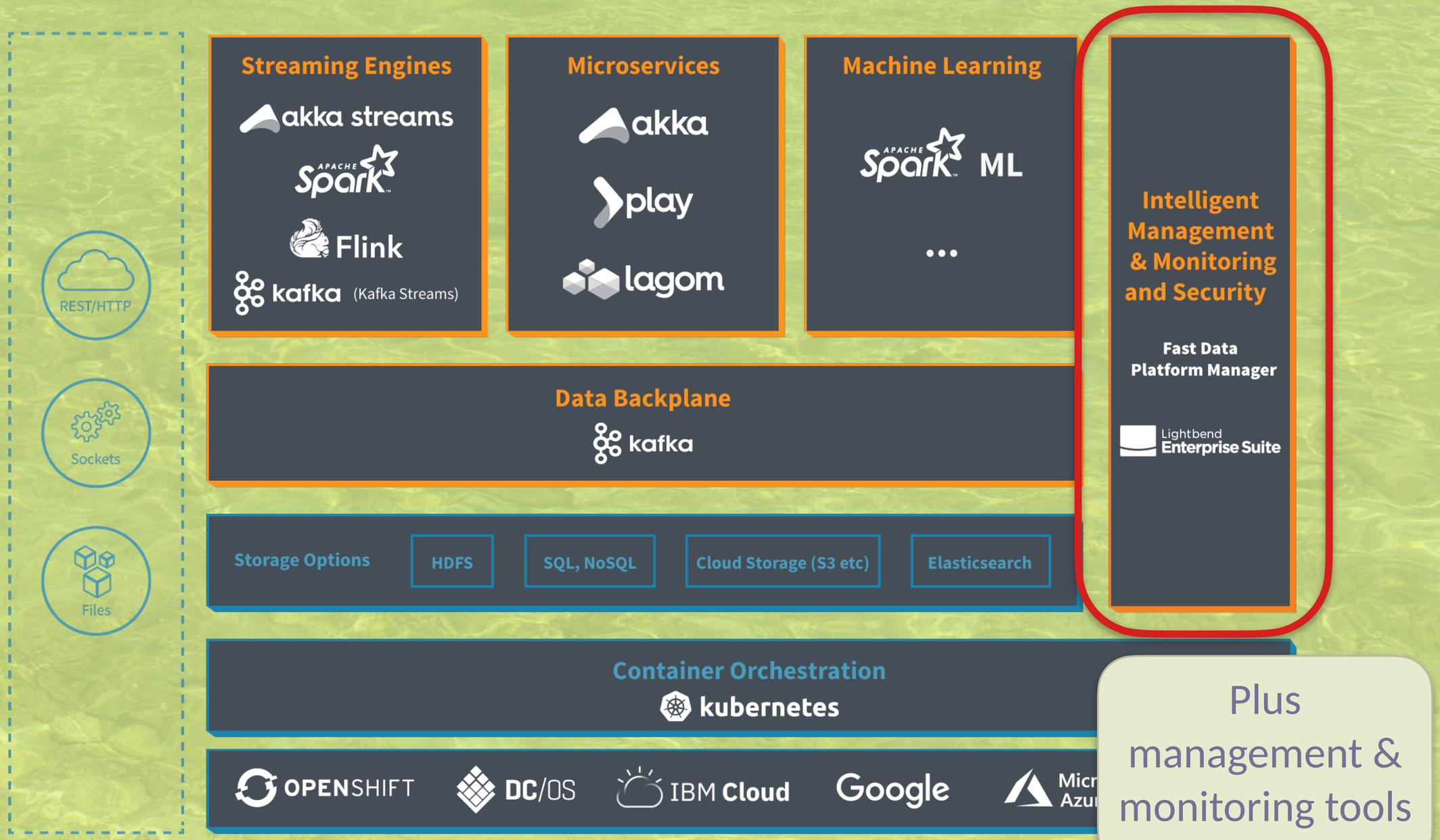

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Questions?

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