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An Introduction to Apache Spark
Big Data Madison: 29 July 2014

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Red Hat, Inc.

About me

- At Red Hat for almost 6 years, working on distributed computing
- Currently contributing to Spark, active Fedora packager and sponsor
- Before Red Hat: concurrency and program analysis research

Forecast

- Background
- Resilient Distributed Datasets
- Spark Libraries
- Community Overview

Background

Processing data in 2005

- MapReduce paper applied very old ideas to distributed data processing
- Hadoop provided open-source MR and distributed FS implementations
- MR allows scale-out on commodity clusters for some real problems

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Hadoop and MR shortcomings

- MR works well for batch jobs; suffers for iterative or interactive ones
- Special-purpose extensions for machine learning, query, etc.
- MR model is not a natural fit for many programmers or programs

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MAHOUT

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DATA SCIENTIST TIME: $460/8 HOURS
EC2 C3 LARGE INSTANCE: $0.84/8 HOURS

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Apache Spark

- Introduced in 2009; donated to Apache in 2013; 1.0 release in 2014
- Based on a fundamental abstraction rather than an execution model
- Supports in-memory computing and a wide range of problems

Spark is general

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Spark is general

Graph

Spark core

redhat.

Spark is general

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Spark is general

Graph | SQL | ML | Streaming

Spark core

ad hoc

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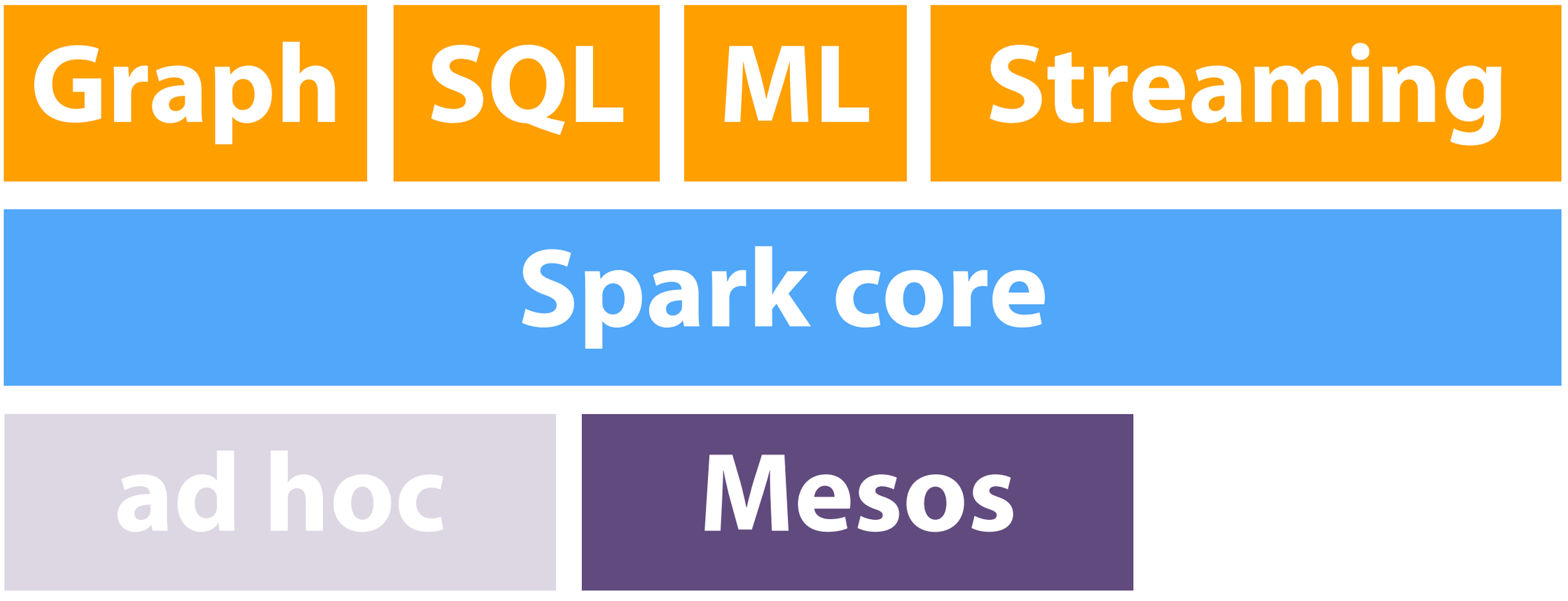
Spark is general



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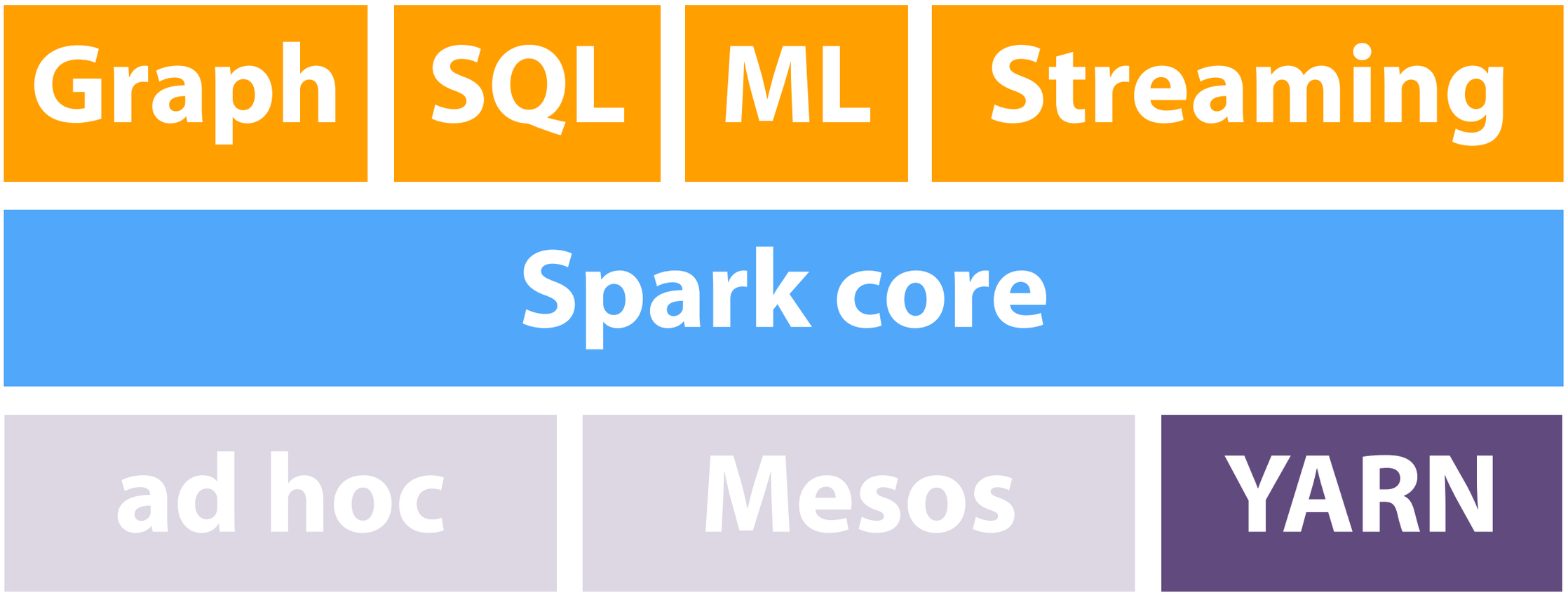

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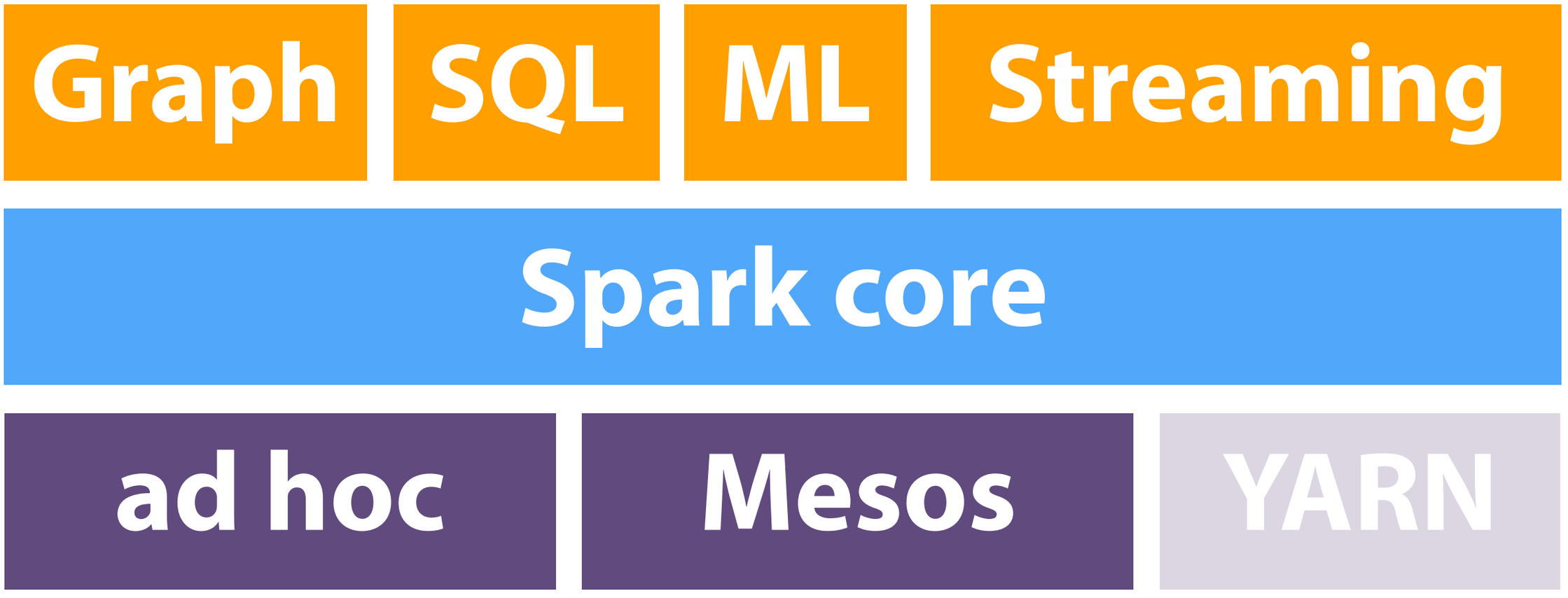
Spark is general

APIS FOR SCALA, JAVA, PYTHON, AND R
(3RD-PARTY BINDINGS FOR CLOJURE ET AL.)



RDDs

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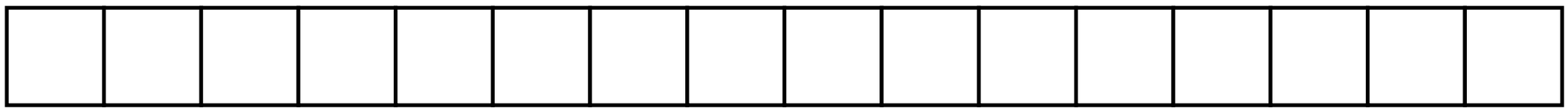
Resilient distributed datasets



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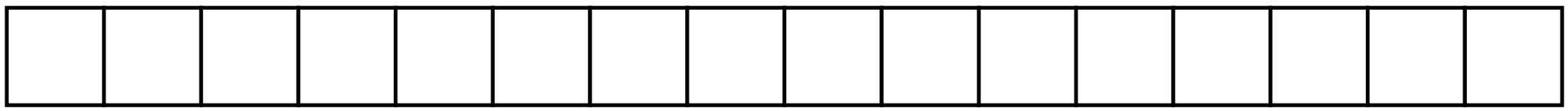

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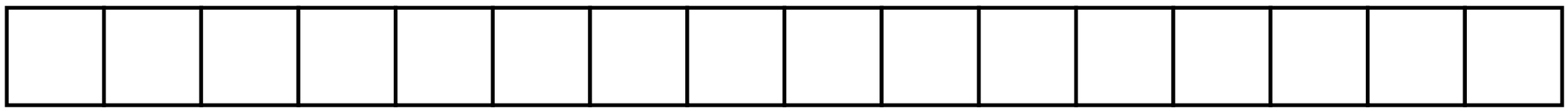

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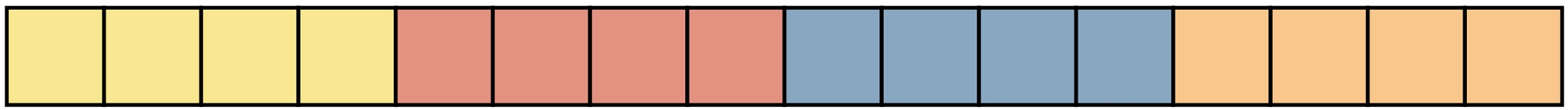

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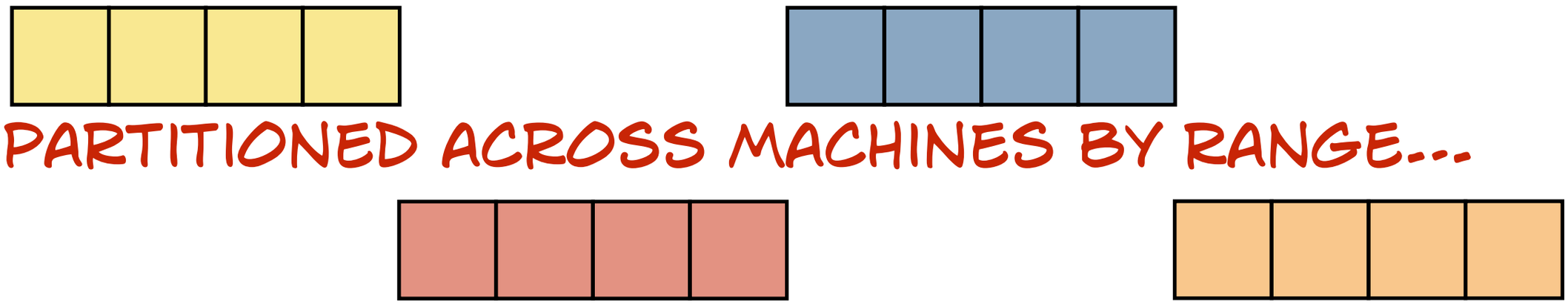

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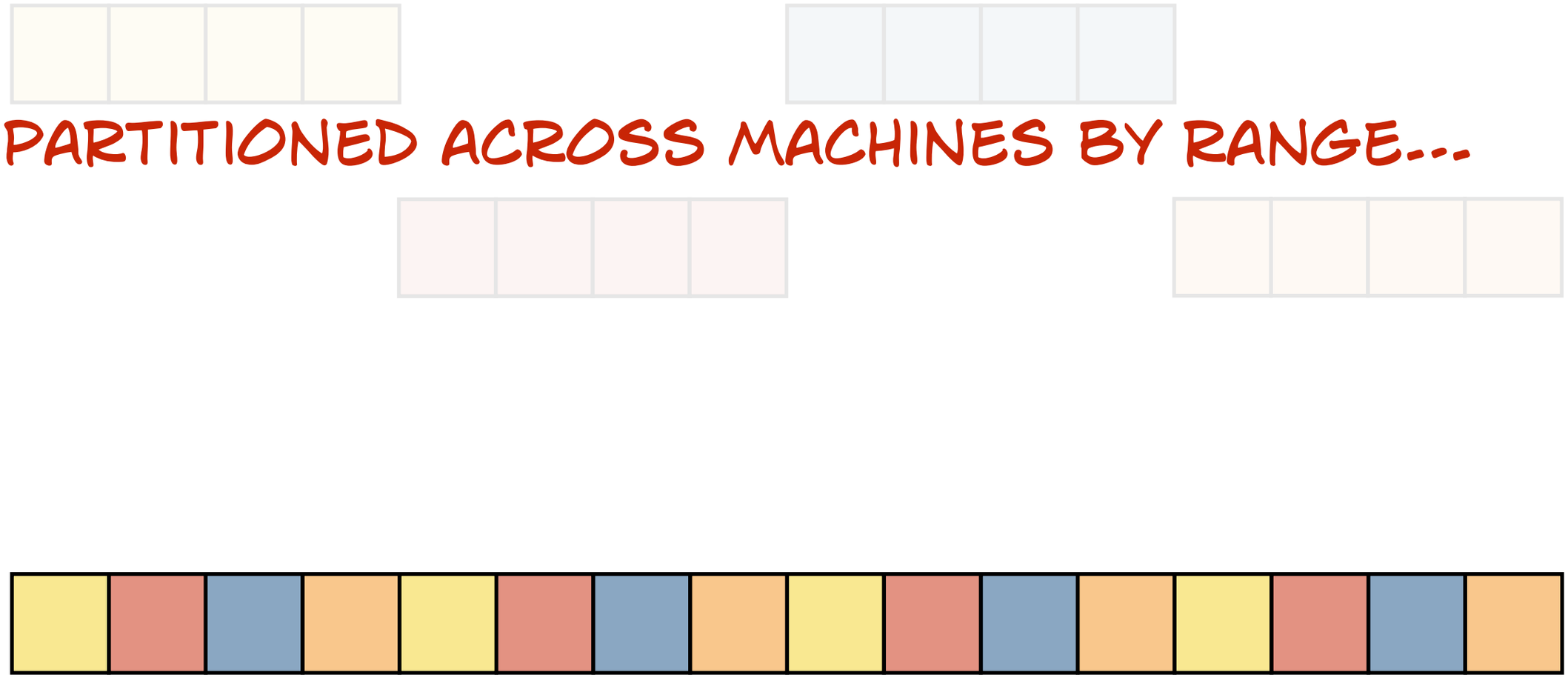

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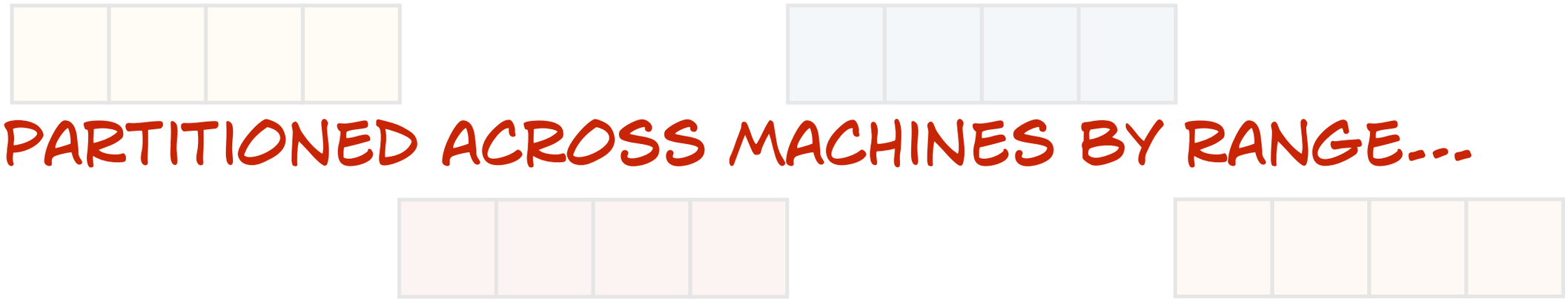
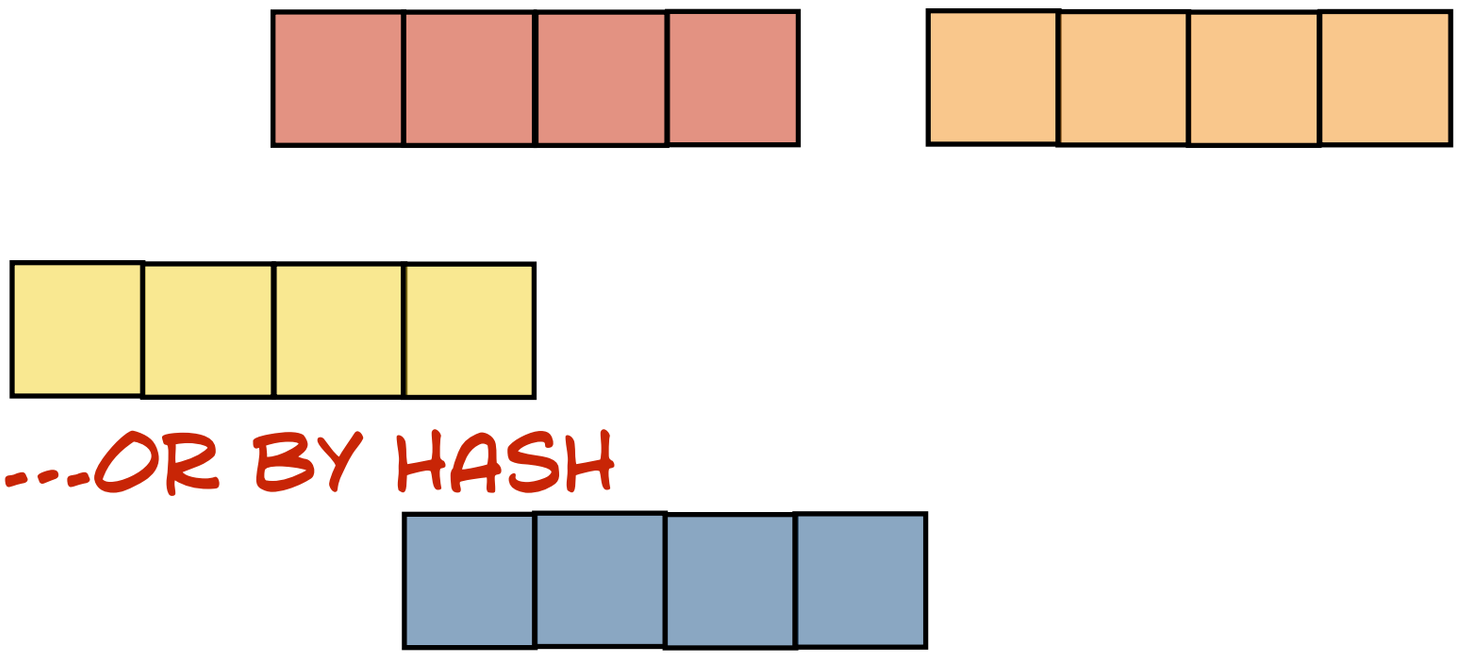


PARTITIONED ACROSS MACHINES BY RANGE...



...OR BY HASH

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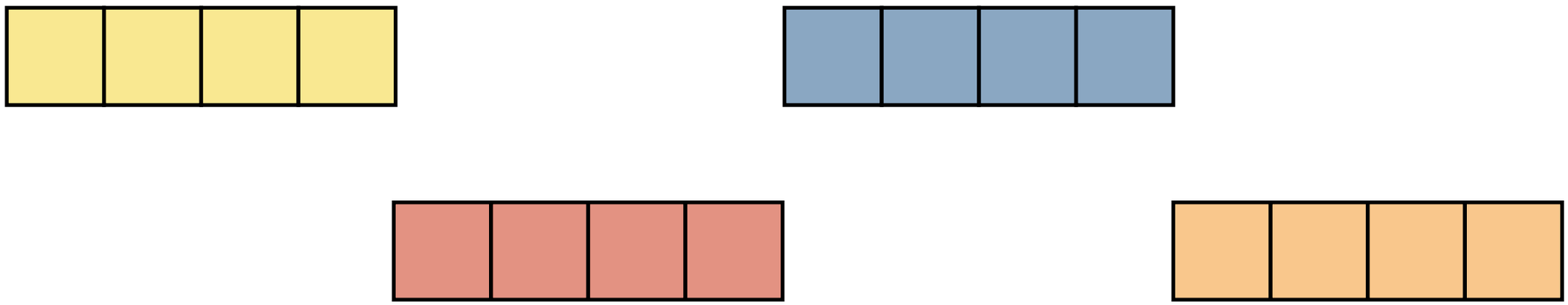
Resilient distributed datasets



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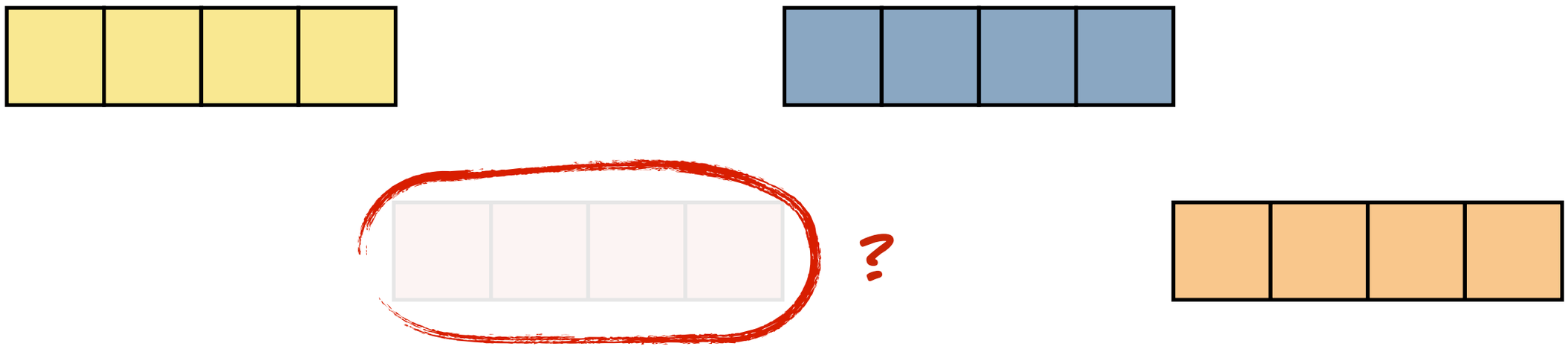
Resilient distributed datasets



FAILURES MEAN PARTITIONS CAN DISAPPEAR...

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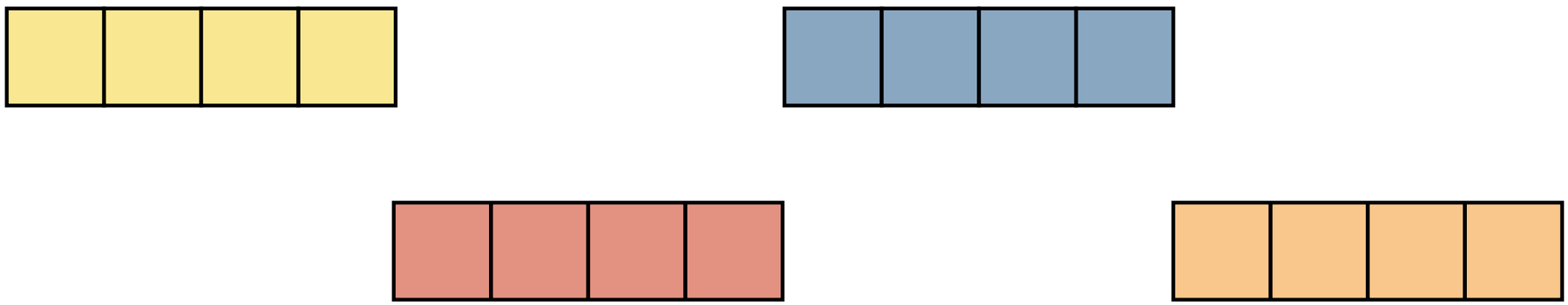
Resilient distributed datasets



FAILURES MEAN PARTITIONS CAN DISAPPEAR...

...BUT THEY CAN BE RECONSTRUCTED!

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RDDs are partitioned, immutable, lazy collections

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RDDs are partitioned, immutable, lazy collections

TRANSFORMATIONS CREATE NEW RDDS
THAT ENCODE A DEPENDENCY DAG

ACTIONS RESULT IN EXECUTING CLUSTER
JOBS & RETURN VALUES TO THE DRIVER

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RDDs (more formally)

- A set of partitions
- Lineage information
- A function to compute partitions from parent partitions
- A partitioning strategy
- Preferred locations for partitions

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(THESE ARE OPTIONAL)

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Creating RDDs

- **From a collection:** `parallelize()`
- **…a local or remote file:** `textFile()`
- **…or HDFS:** `hadoopFile(); sequenceFile();objectFile()`
- **(These all act lazily)**

RDD[T] transformations

- `map(f: T=>U): RDD[U]`
- `flatMap(f: T=>Seq[U]): RDD[U]`
- `filter(f: T=>Boolean): RDD[T]`
- `distinct(): RDD[T]`
- `keyBy(f: T=>K): RDD[(K, T)]`

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RDD[(K,V)] transformations

- `sortByKey(): RDD[(K,V)]`
- `groupByKey(): RDD[(K,Seq[V])]`
- `reduceByKey(f: (V,V)=>V): RDD[(K,V)]`
- `join(other: RDD[(K,W)]): RDD[(K,(V,W))]`

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...AND MANY OTHERS INCLUDING CARTESIAN PRODUCT, COGROUP, SET OPERATIONS, ETC.

Other RDD transformations

- **Explicitly** `repartition` **and shuffle or** `coalesce` **to fewer partitions**
- **Provide hints to** `cache` **an intermediate RDD in memory or** `persist` **it to memory and/or disk**

(REMEMBER: ALL TRANSFORMATIONS ARE LAZY)

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RDD[T] actions

- `collect(): Array[T]`
- `count(): Long`
- `reduce(f: (T,T)=>T): T`
- `saveAsTextFile(path)`
- `saveAsSequenceFile(path)`

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RDD[T] actions

(REMEMBER: ALL ACTIONS ARE EAGER)

- `collect(): Array[T]`
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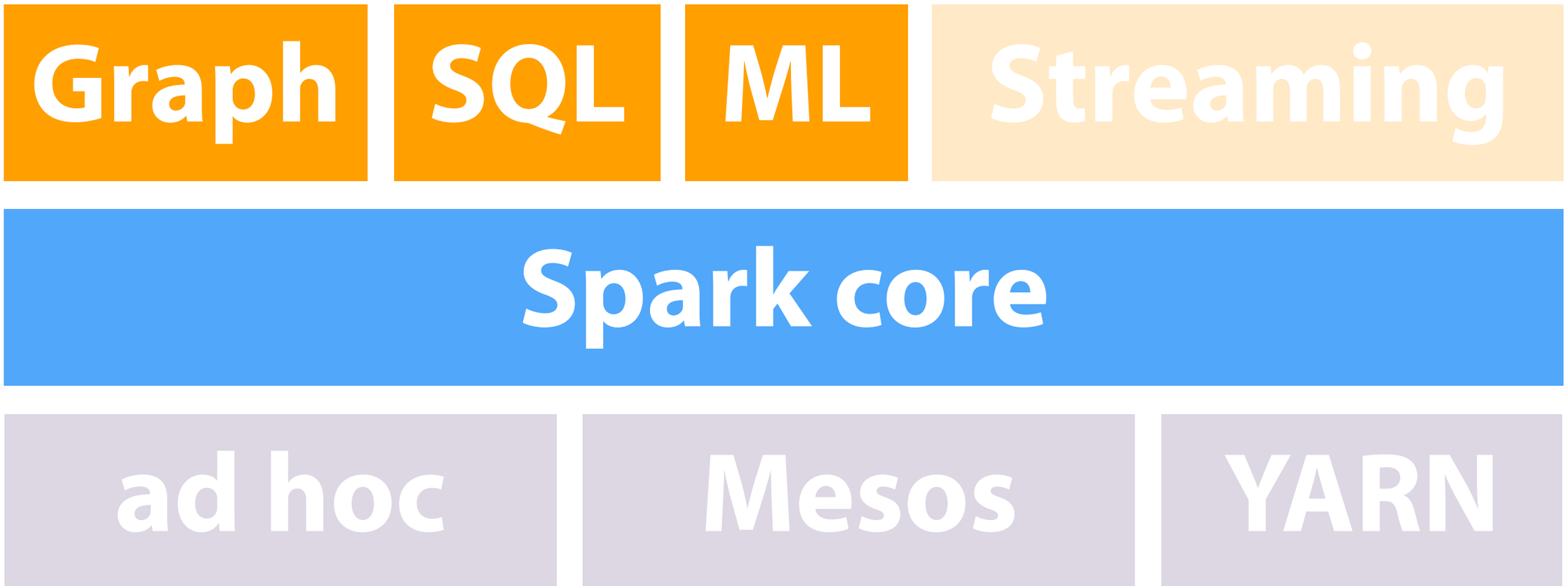
Example: word count in Spark

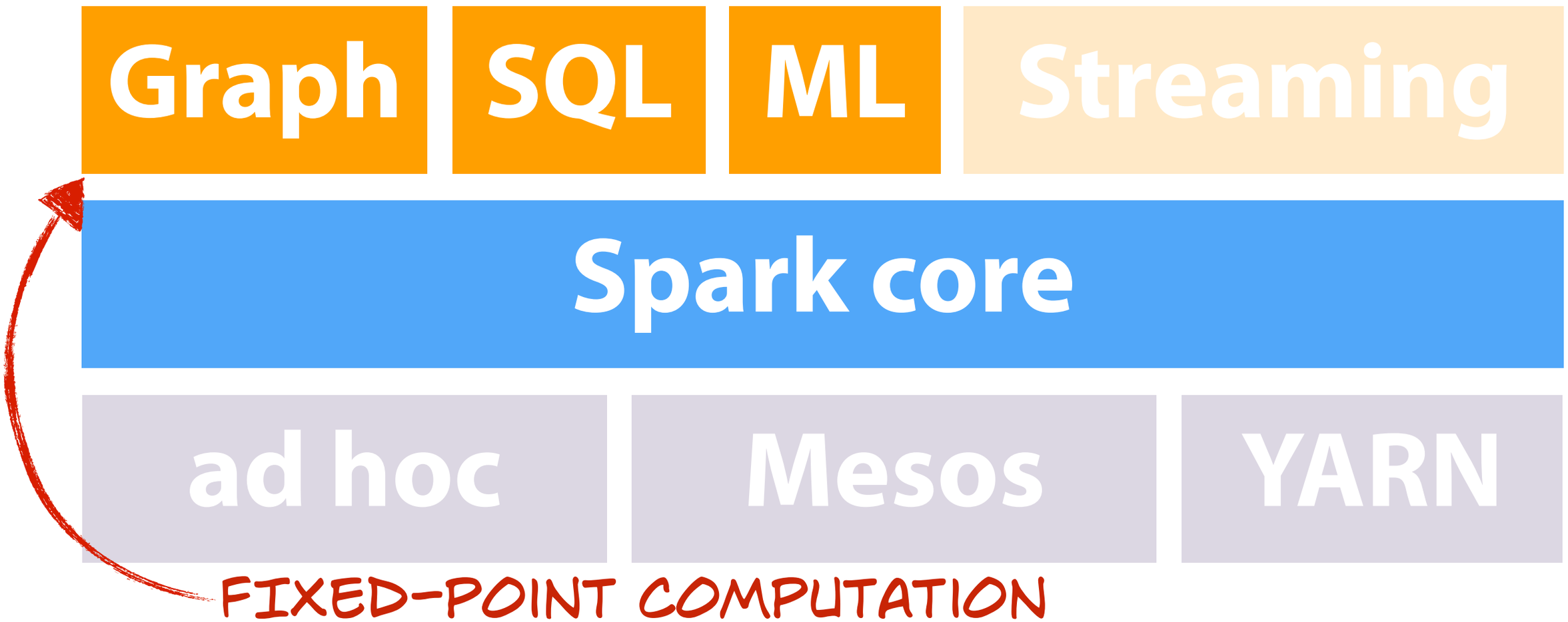
```
val file = spark.textFile("hdfs://...")

val counts = file.flatMap(line =>
                  line.split(" "))
                 .map(word => (word, 1))
                 .reduceByKey(_ + _)

counts.saveAsTextFile("hdfs://...")
```

Libraries

Spark libraries



Spark libraries



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Spark libraries

QUERY EXECUTION

Graph | SQL | ML | Streaming

Spark core

ad hoc | Mesos | YARN

FIXED-POINT COMPUTATION

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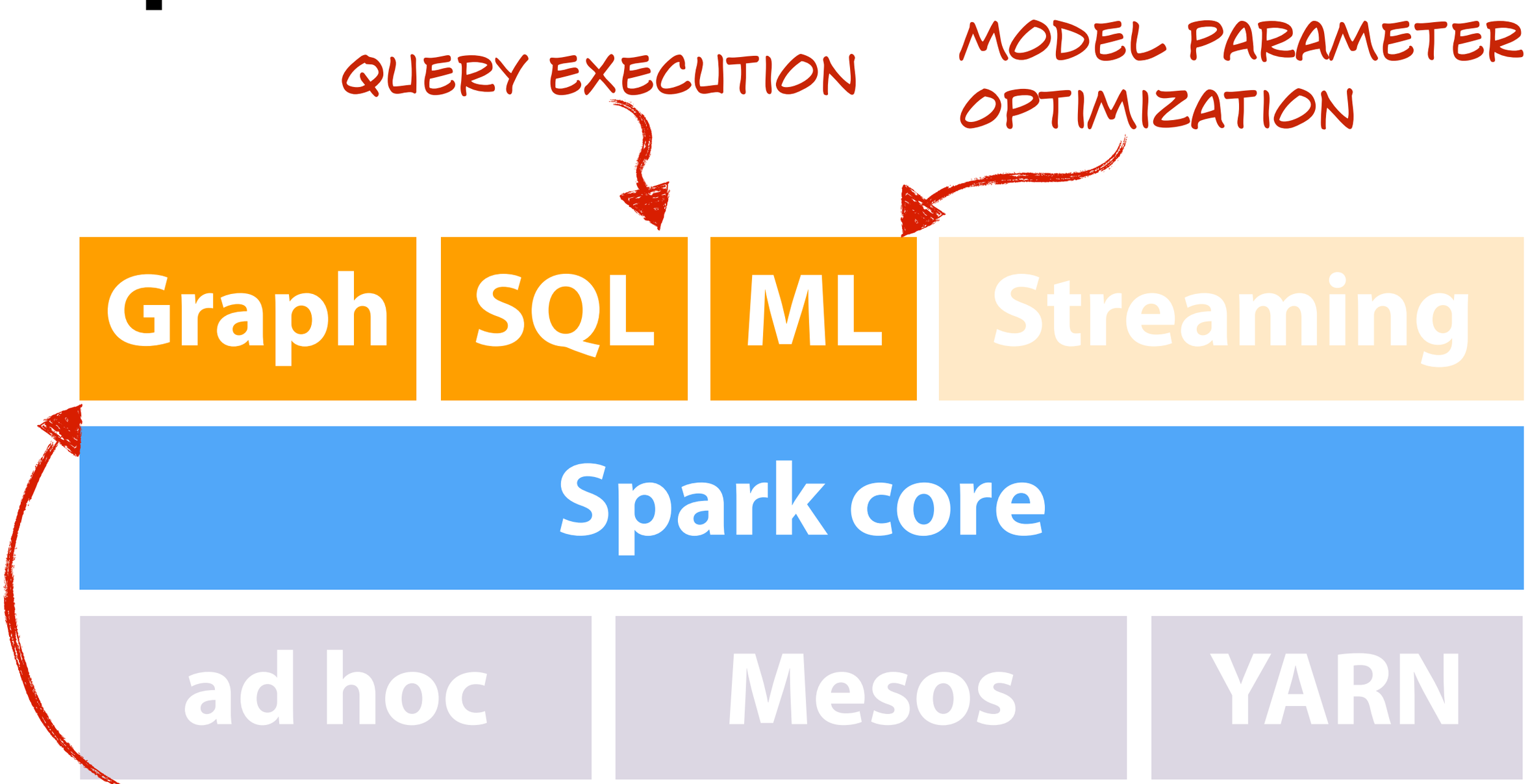
Spark libraries



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Spark libraries

QUERY EXECUTION

MODEL PARAMETER OPTIMIZATION

Graph | SQL | ML | Streaming

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FIXED-POINT COMPUTATION

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Spark MLlib

- Implementations of classic learning algorithms on data in RDDs
- Regression, classification, clustering, recommendation, filtering, etc.
- High performance due to caching, in-memory execution

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Spark SQL features

- SchemaRDD type
- Catalyst: a relational algebra analysis/optimization framework
- SQL and HiveQL implementations; Hive warehouse support
- LINQ-style embedded query DSL

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Spark SQL example

```
case class Trackpoint(lat: Double,
  lon: Double, ts: Long) {}
```

```
// assume points is an RDD of Trackpoints
points.registerAsTable("points")

val results =
  sql("""select * from points
         where ts > max(ts) - 600""")
```

Spark Streaming

- **Goal: use the same abstraction for streaming as for batch or interactive**
- ***Discretized stream* abstraction: streams as sequences of RDDs**

Community & Applications

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Developer community

- https://github.com/apache/spark
- First open-source release in 2010
- 121k lines of code
- 300+ contributors all-time; 80+ in the last month
- Active and friendly mailing list

User community

- Spark Summit: established in 2013; growing and expanding
- Lots of cool applications (BI, medical, geospatial, security, fun)
- Many learning resources

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MORE THAN 2X AS BIG IN '14

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SPARK SUMMIT EAST: NYC 2015

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http://spark-summit.org/2014/agenda

Thanks!

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