DATABRICKS

A Deeper Understanding of Spark's Internals

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07/01/2014

This Talk

- Goal: Understanding how Spark runs, focus on performance

- Major core components:
  - Execution Model
  - The Shuffle
  - Caching

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Why understand internals?

Goal: Find number of distinct names per “first letter”

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  .groupByKey()

  .mapValues(names => names.toSet.size)

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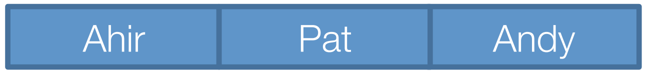

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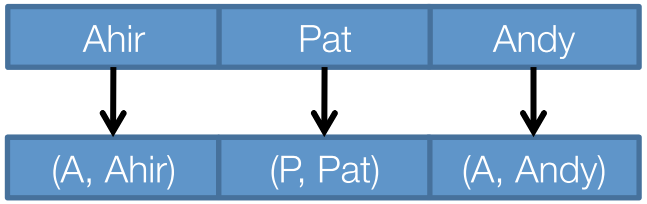

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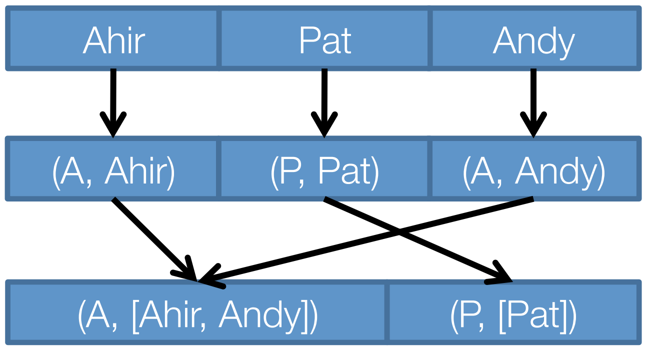

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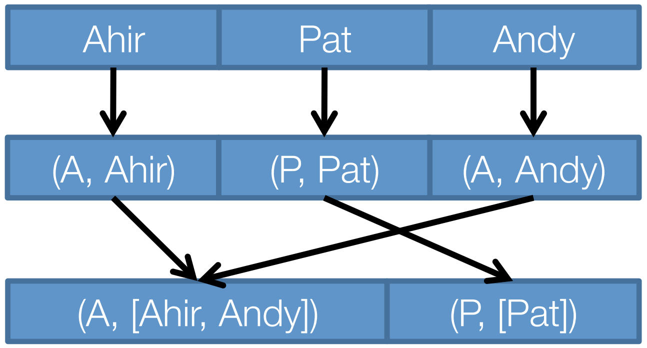

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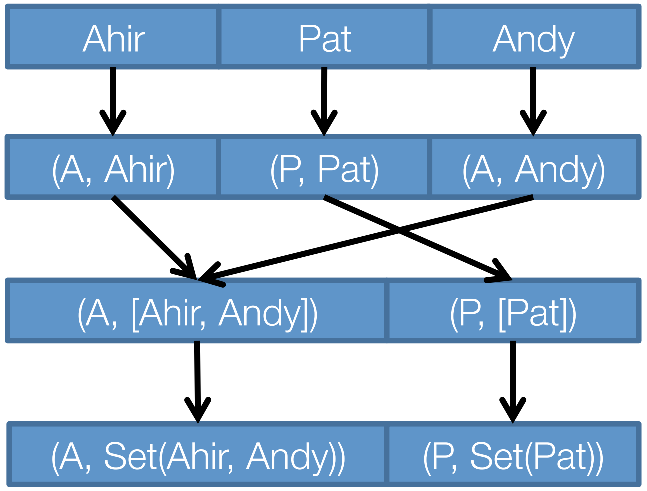

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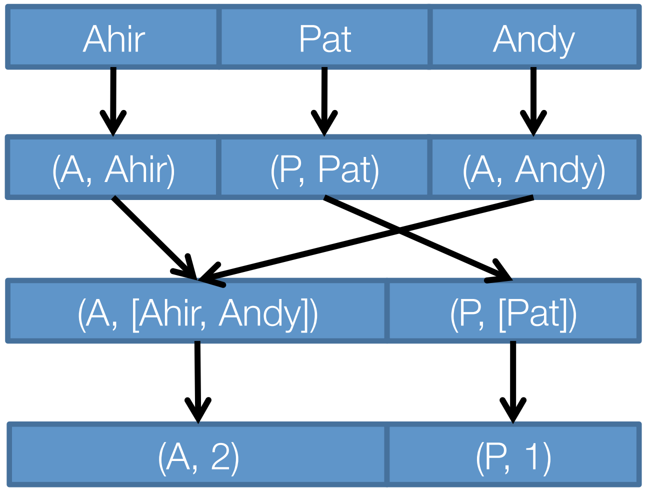

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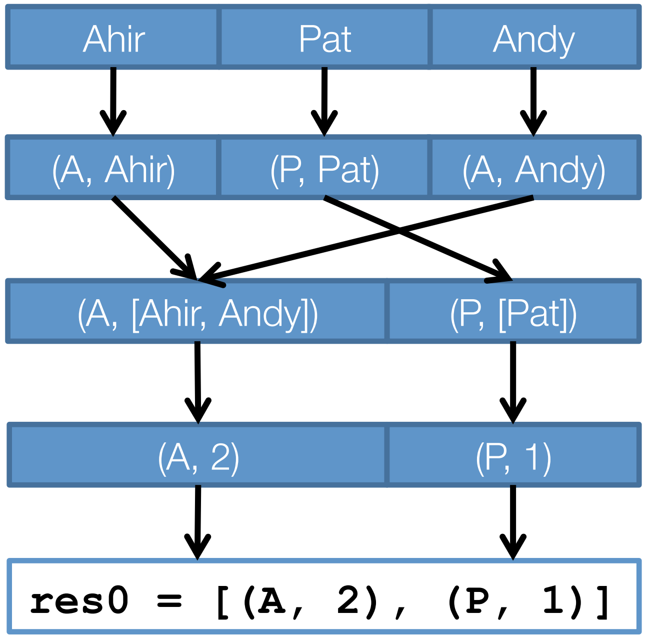
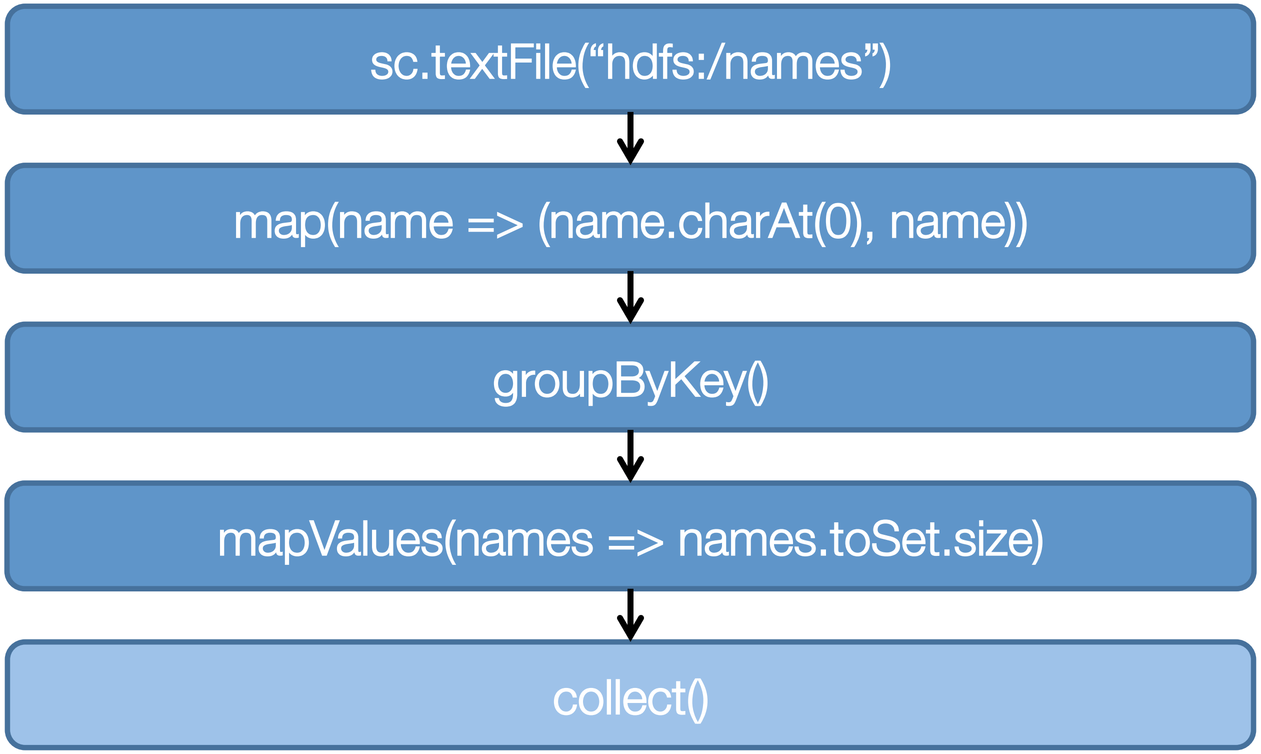


Spark Execution Model

1. Create DAG of RDDs to represent computation
2. Create logical execution plan for DAG
3. Schedule and execute individual tasks

Step 1: Create RDDs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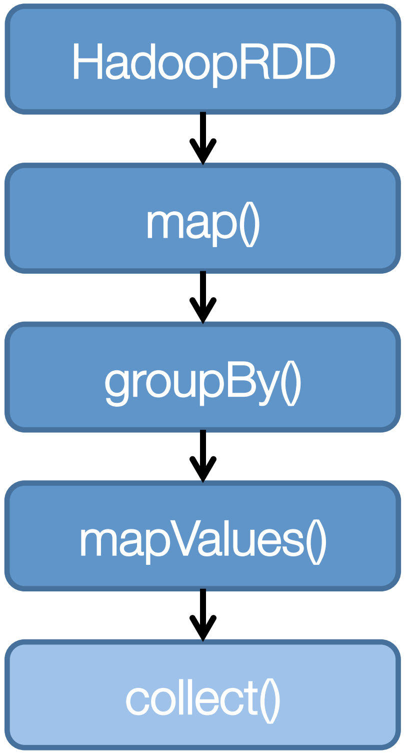
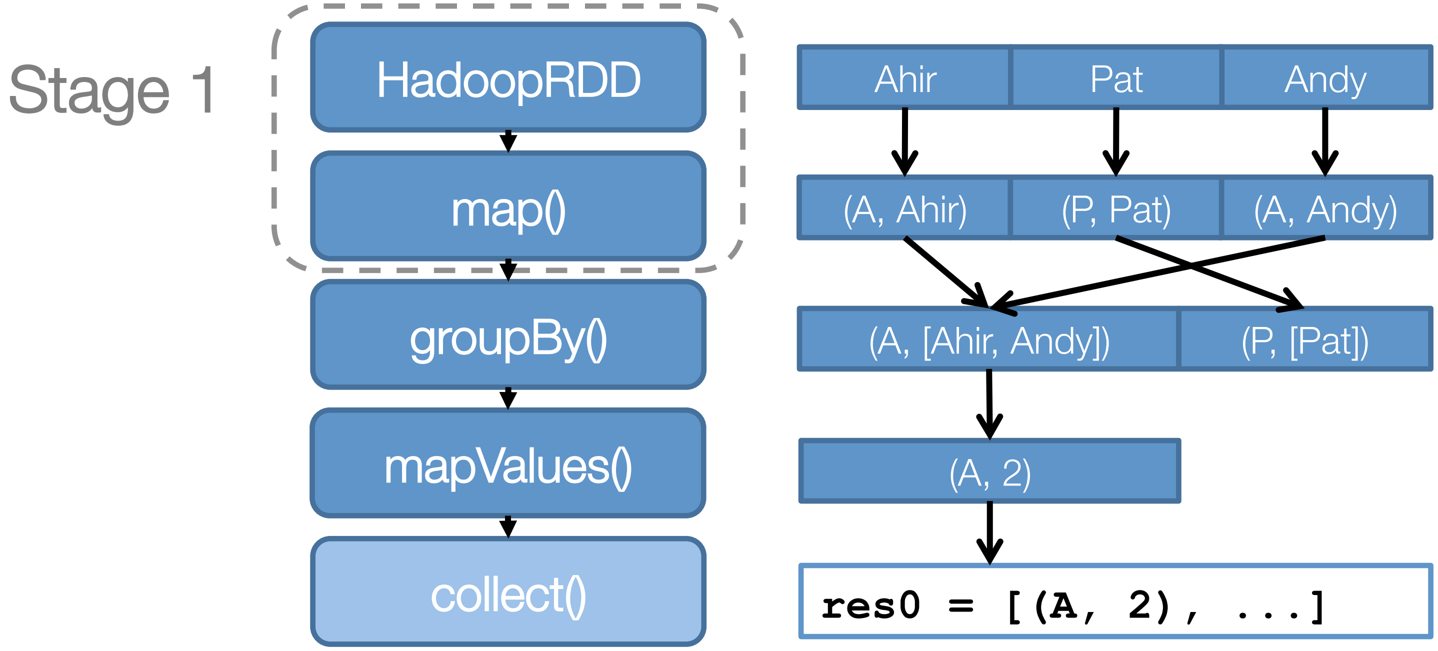


Step 2: Create execution plan

- Pipeline as much as possible
- Split into "**stages**" based on need to reorganize data



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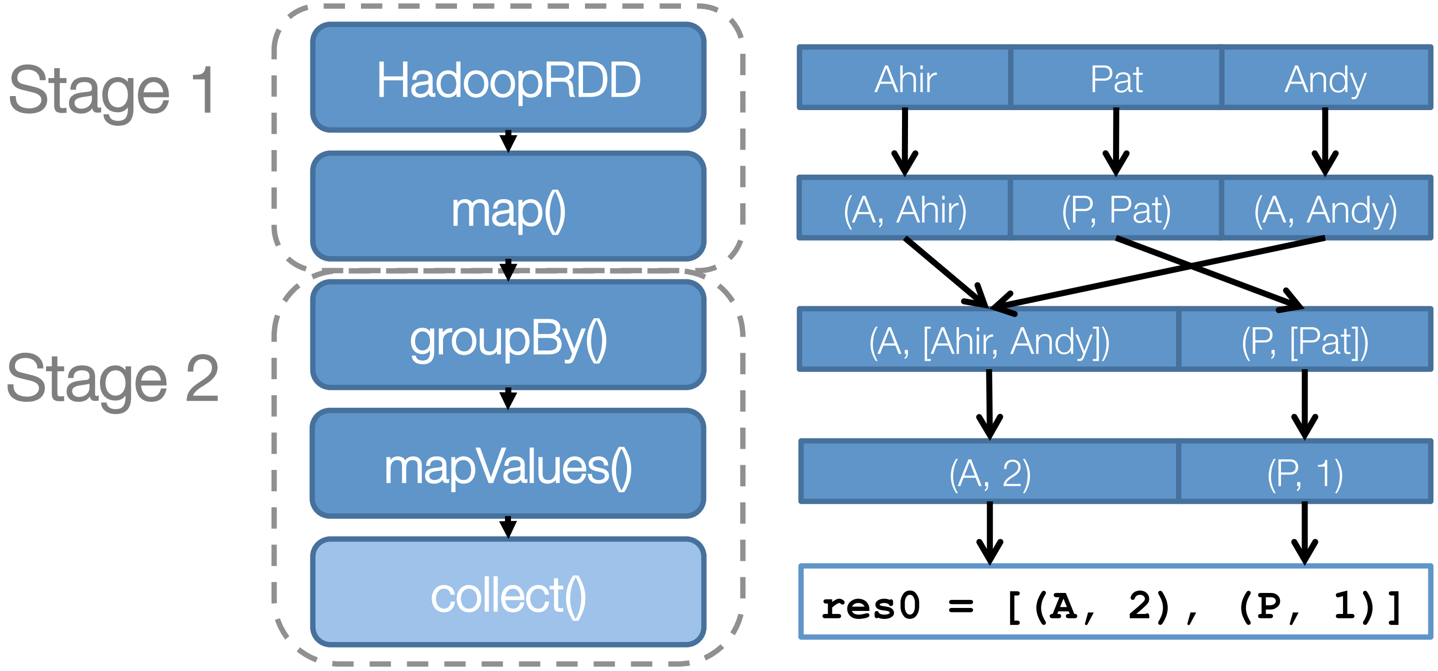
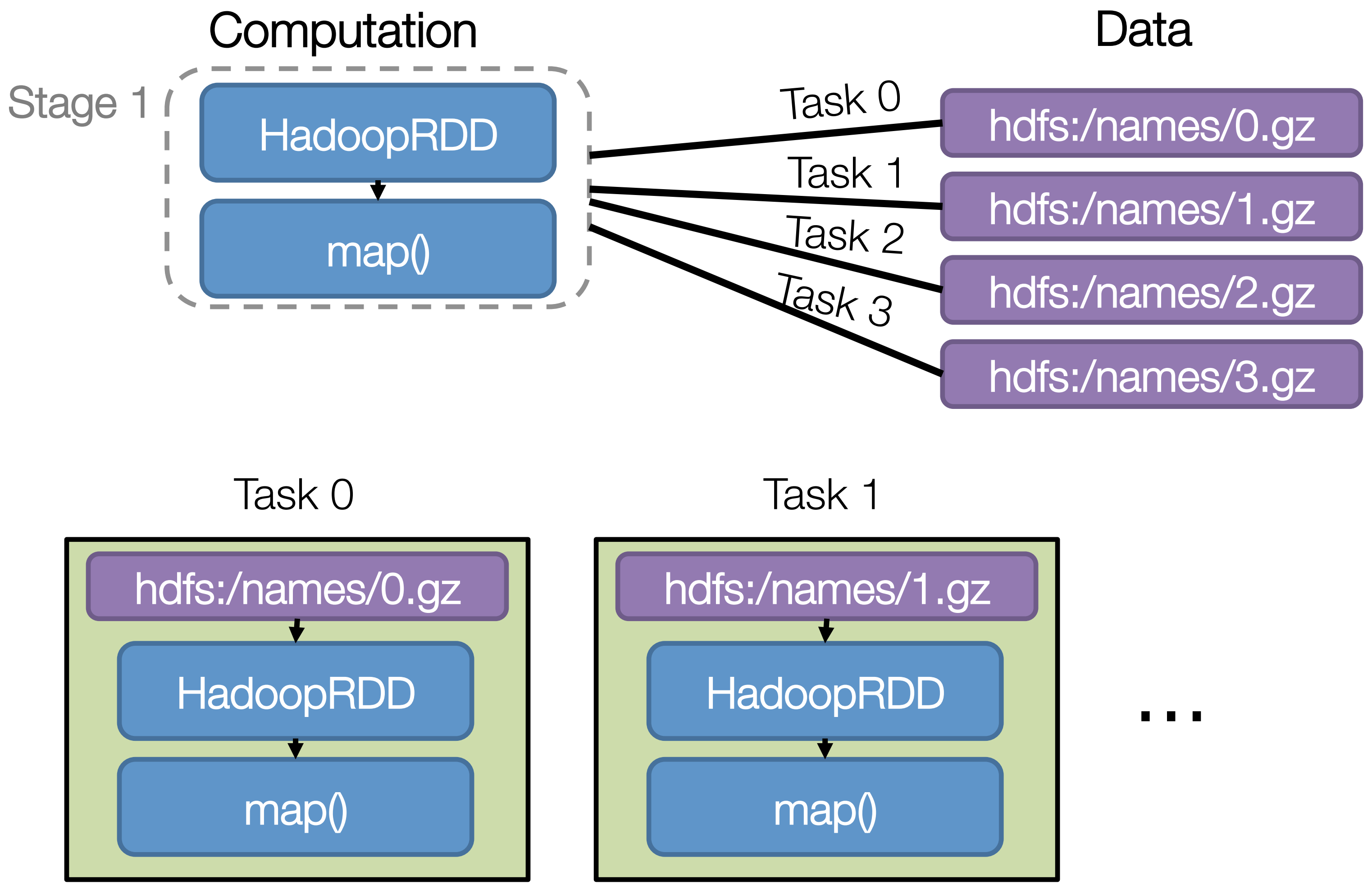


```
res0 = [(A, 2), (P, 1)]
```

Step 3: Schedule tasks

- Split each stage into **tasks**
- A task is data + computation
- Execute all tasks within a stage before moving on

Step 3: Schedule tasks



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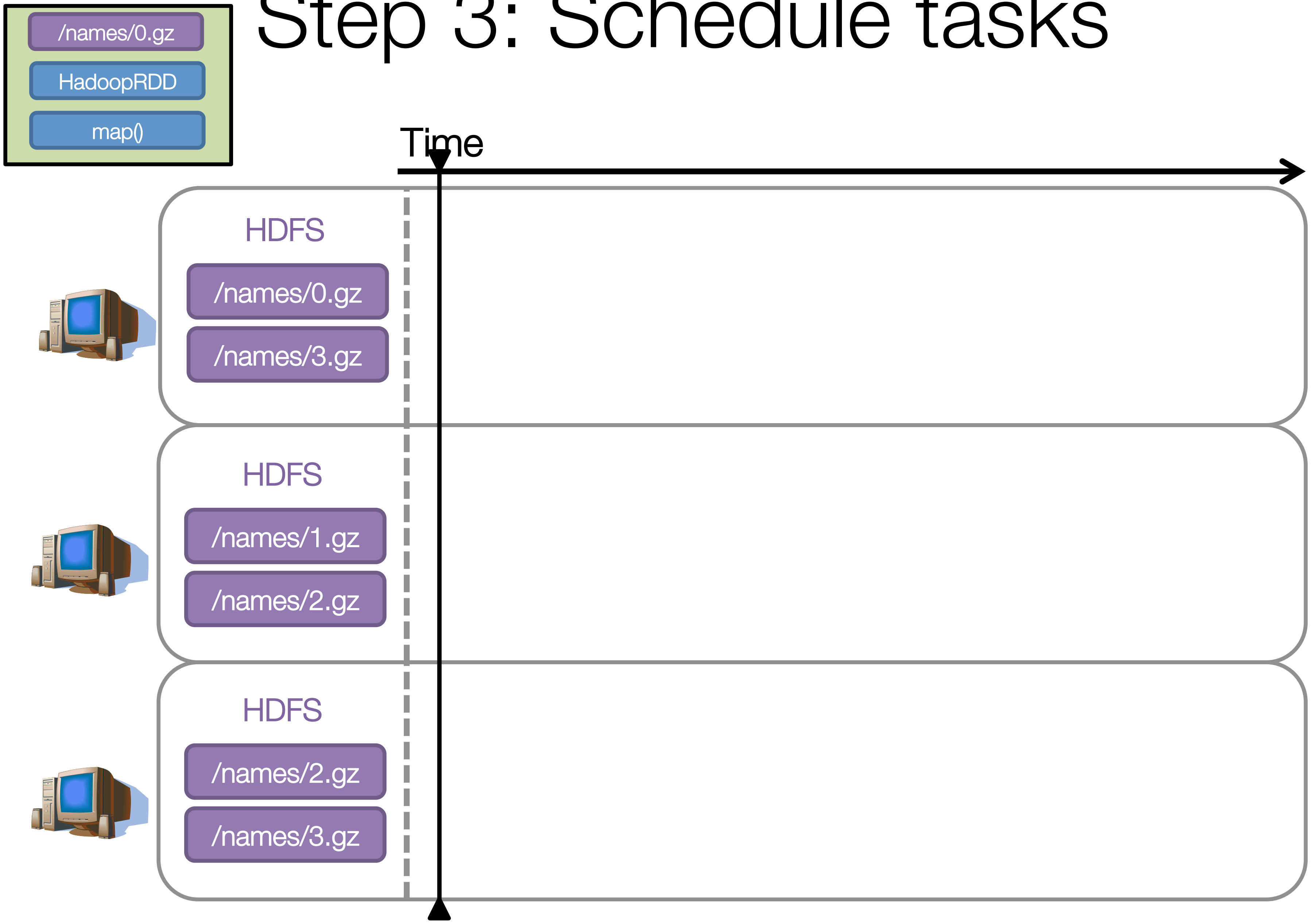

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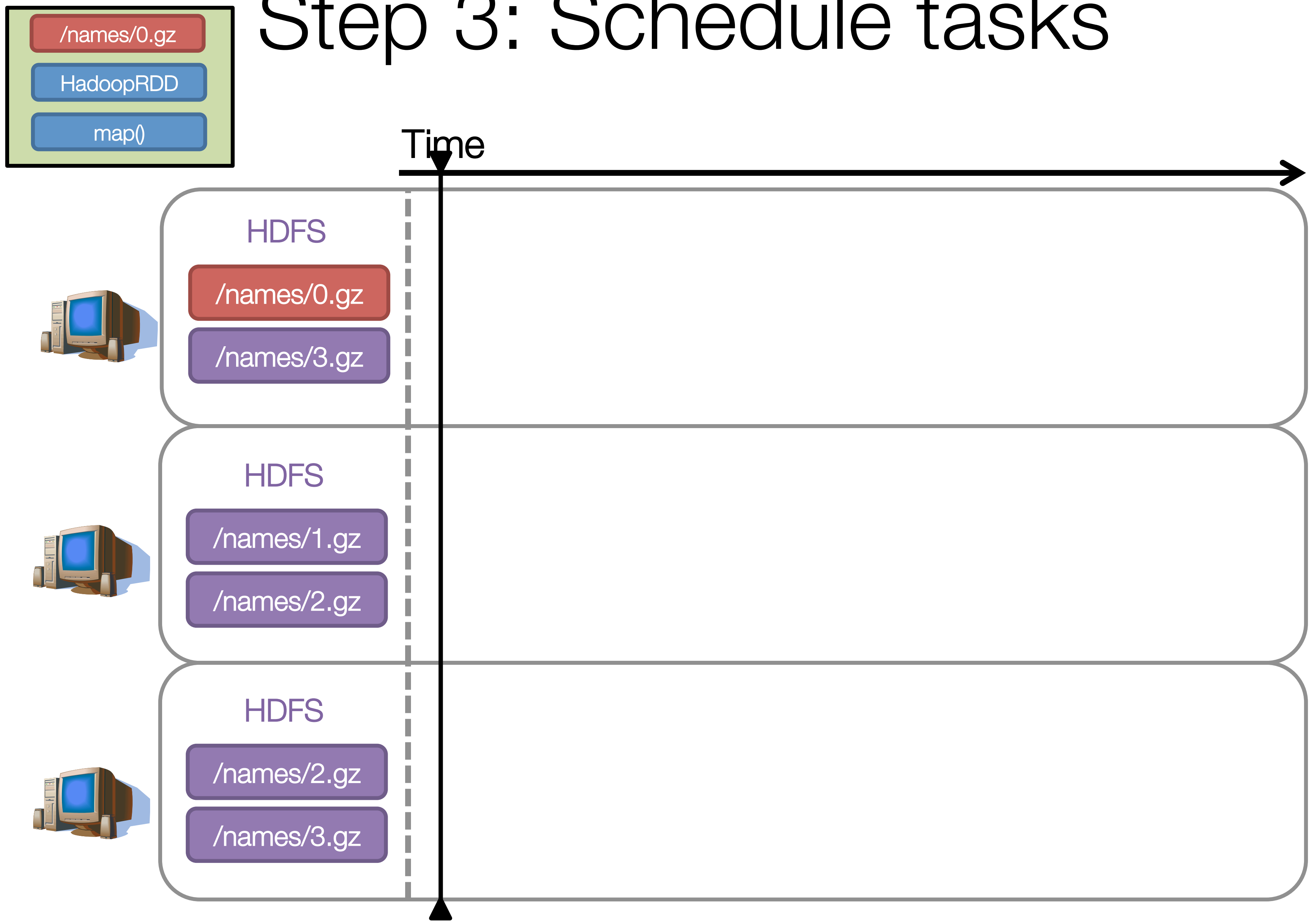

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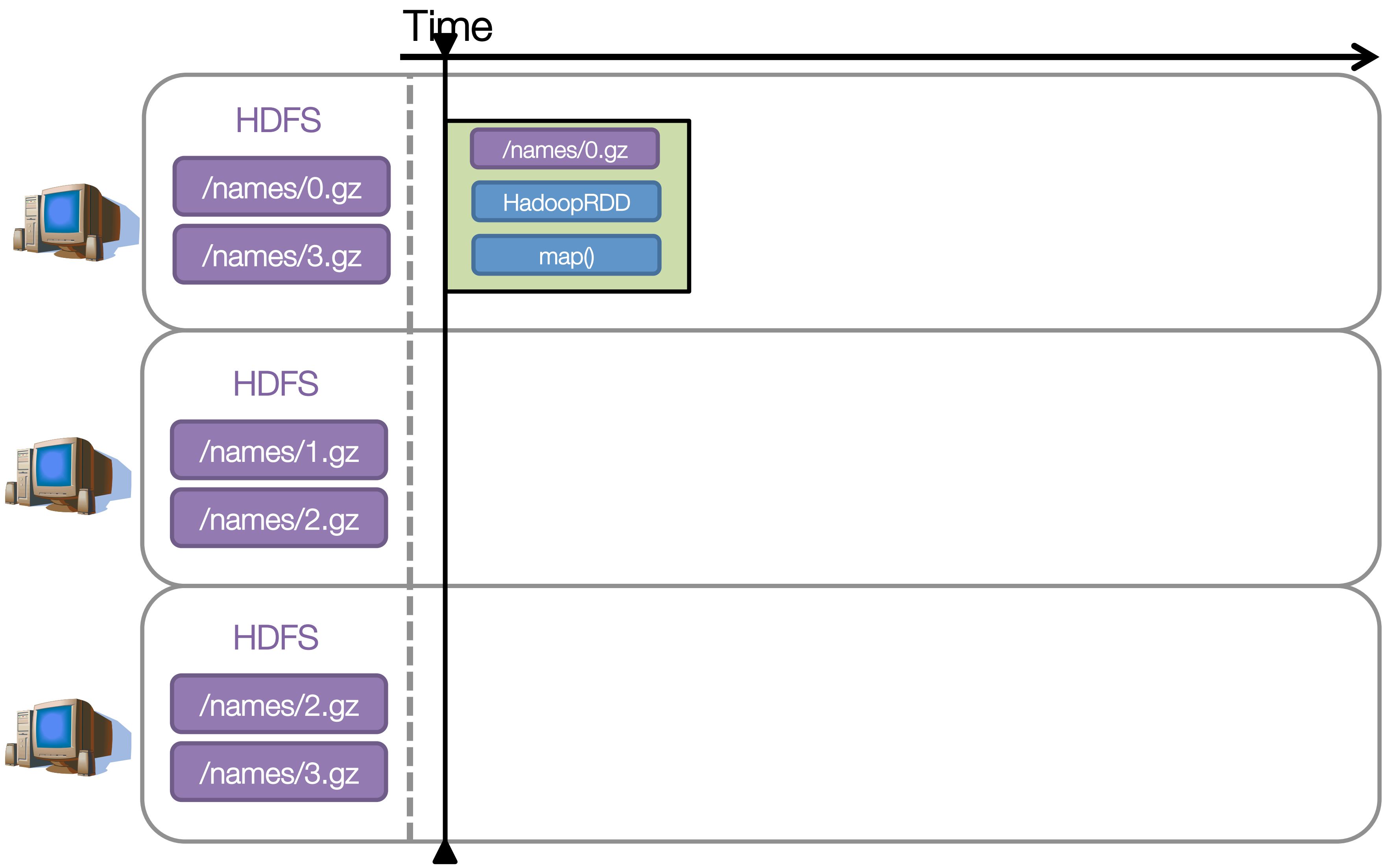

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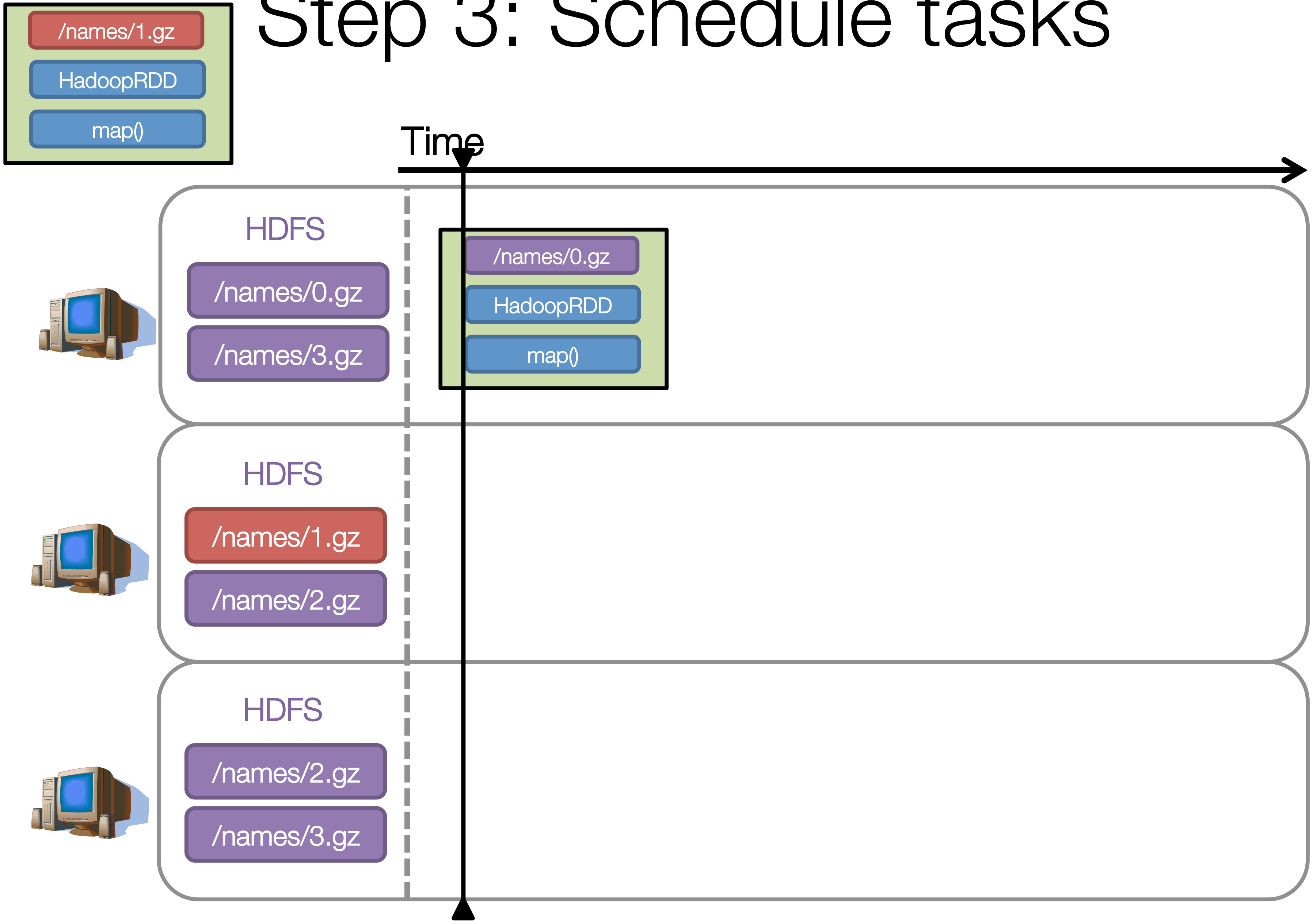

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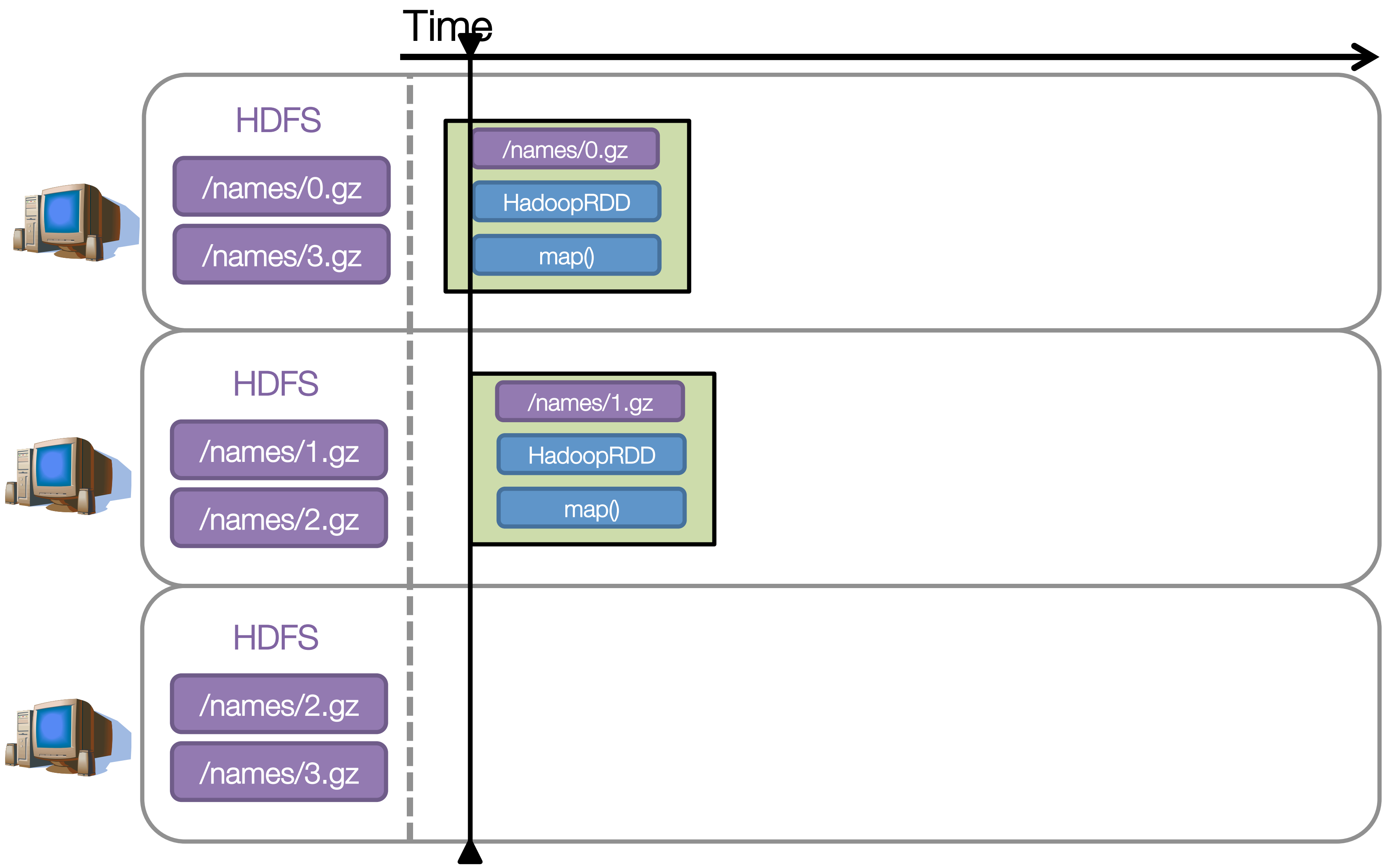

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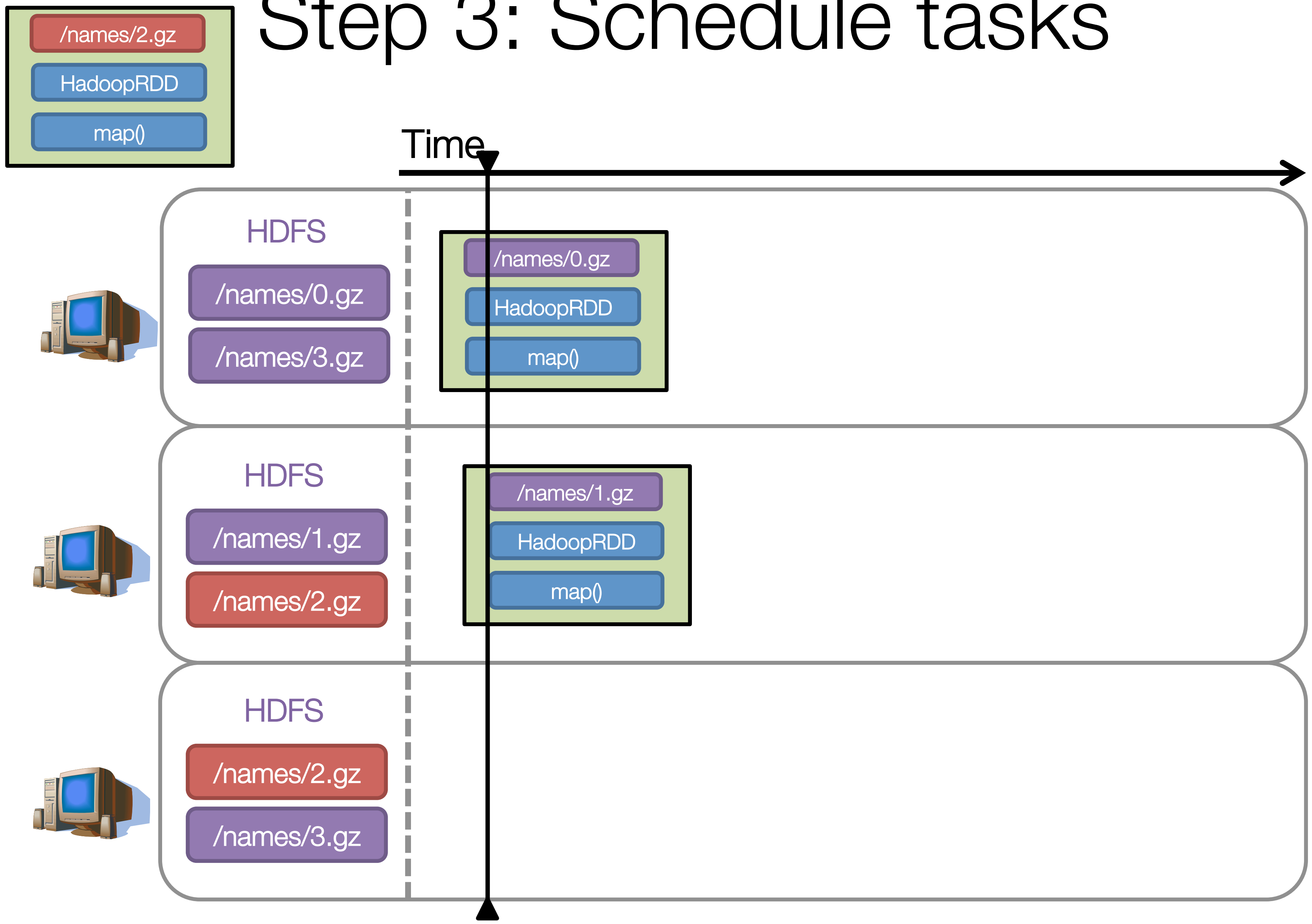

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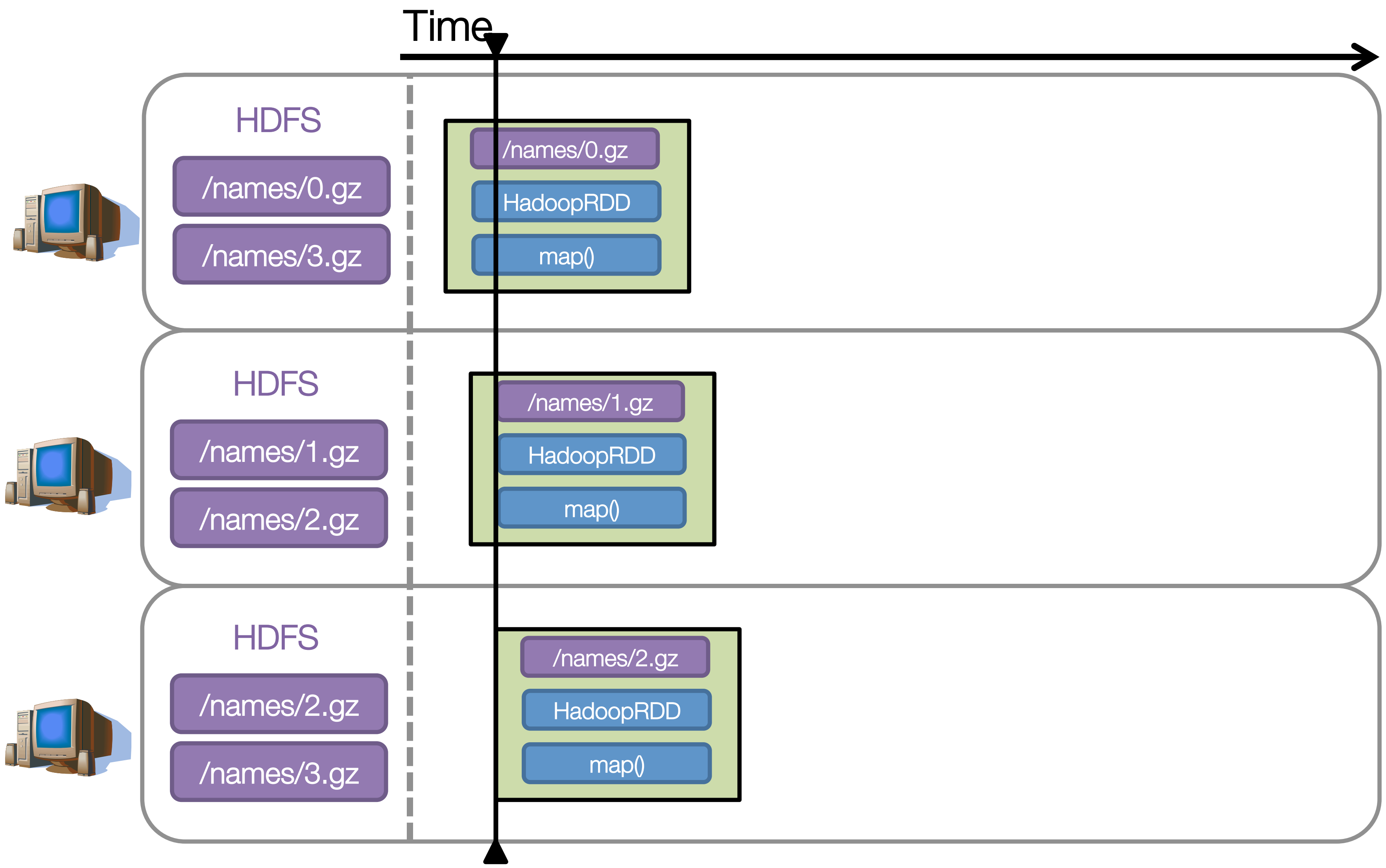

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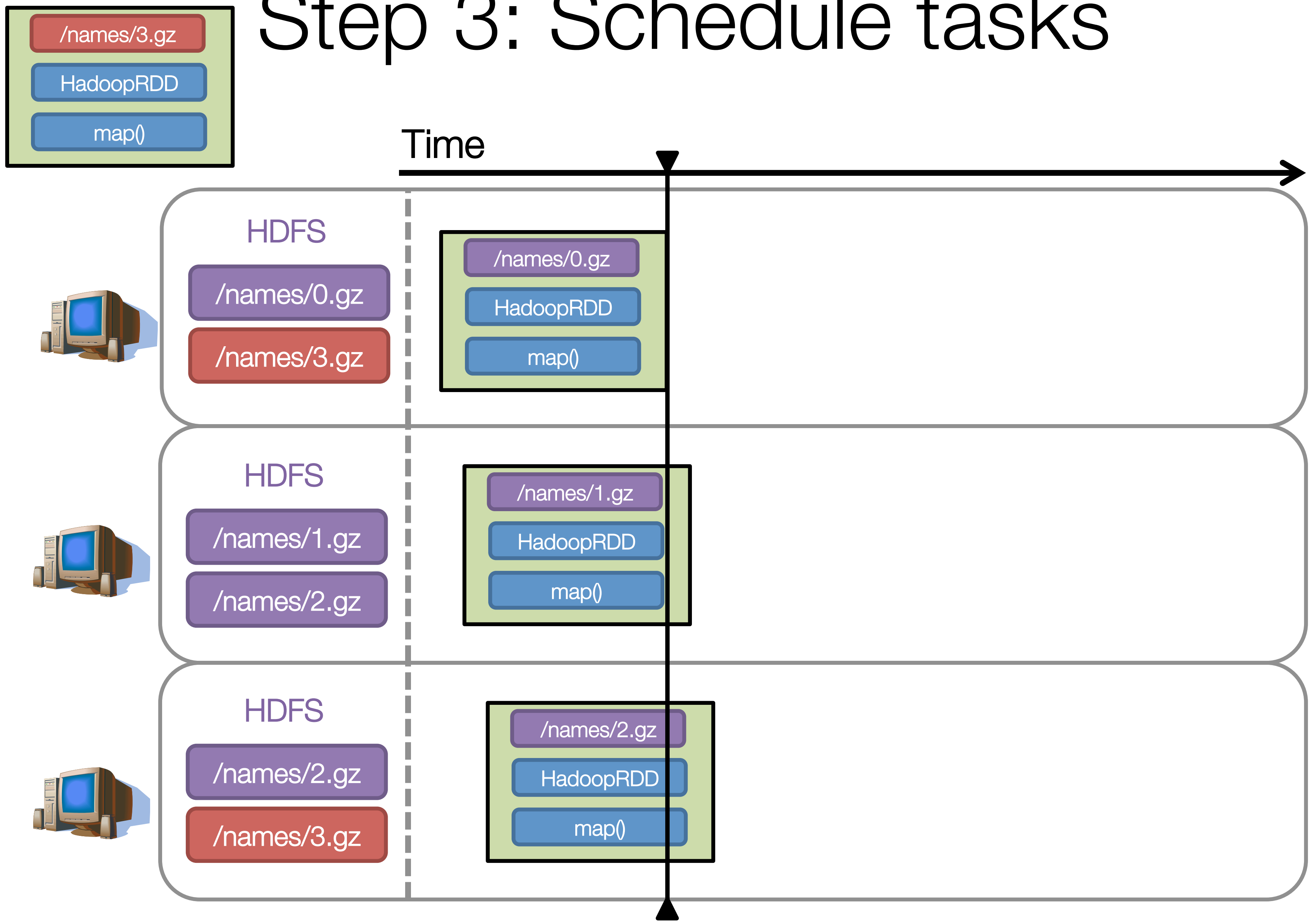

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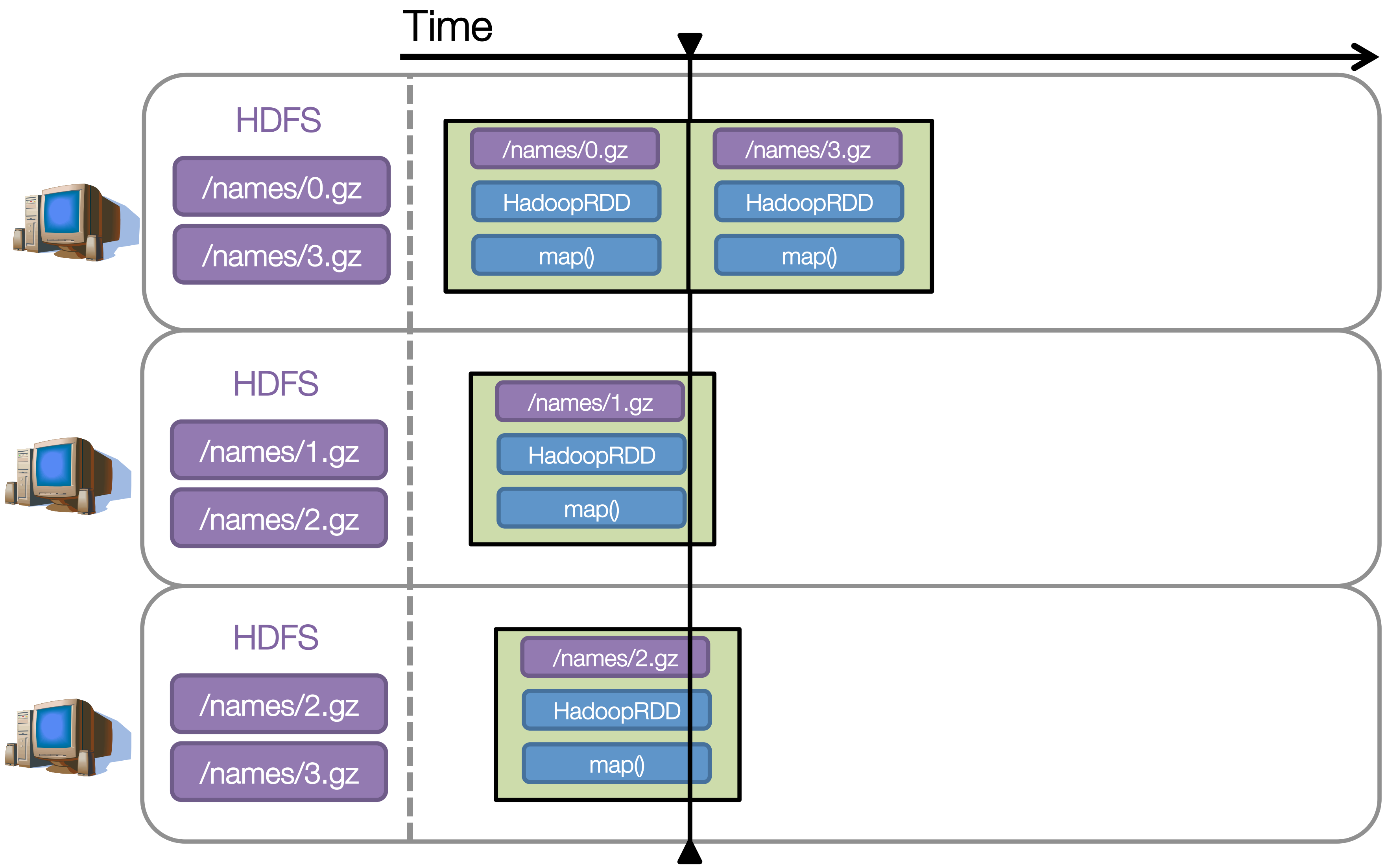

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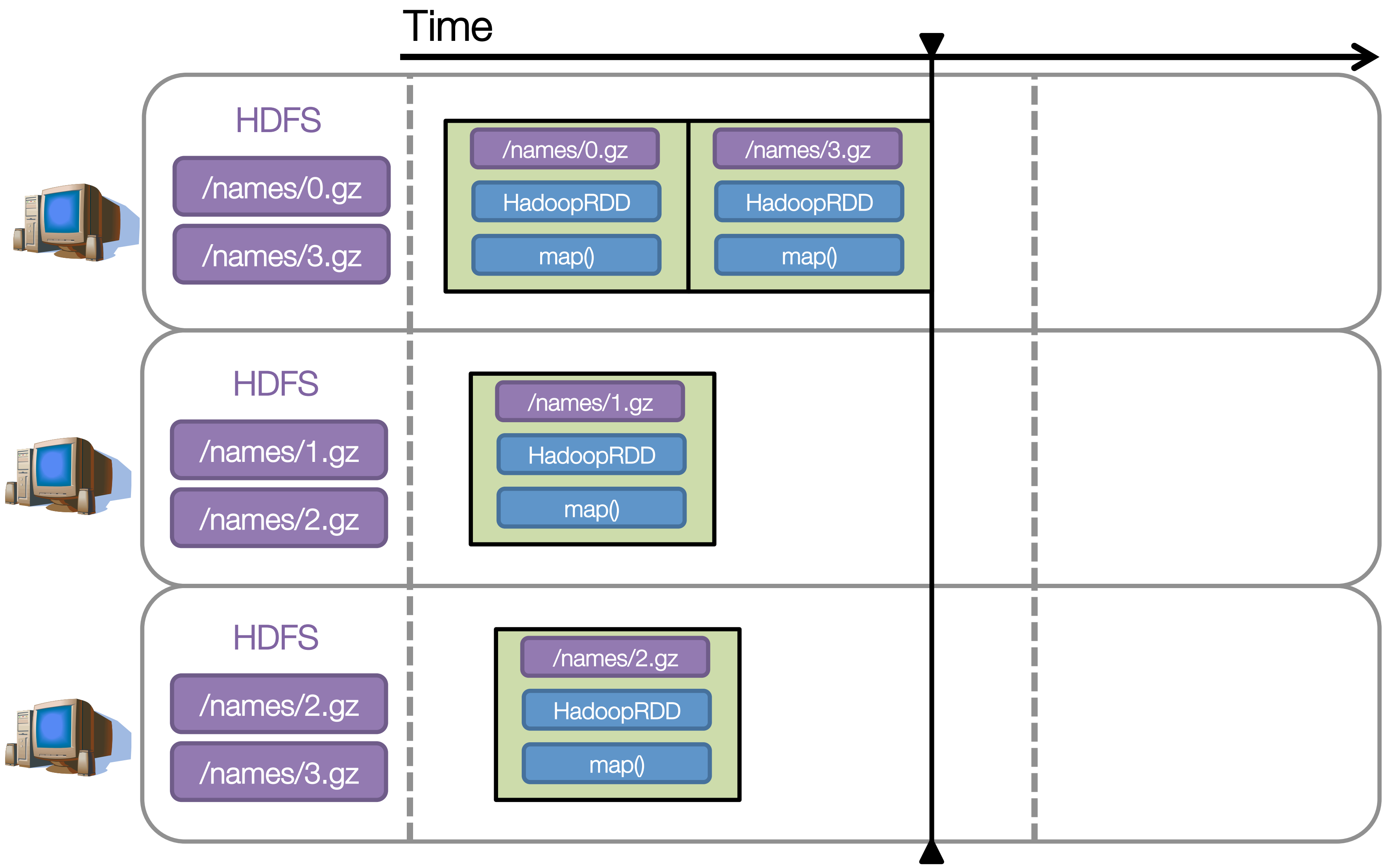
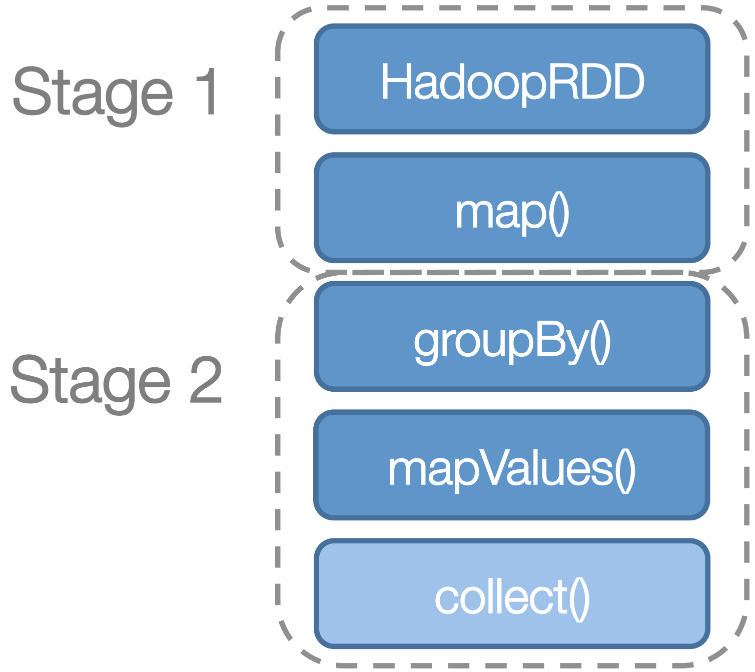
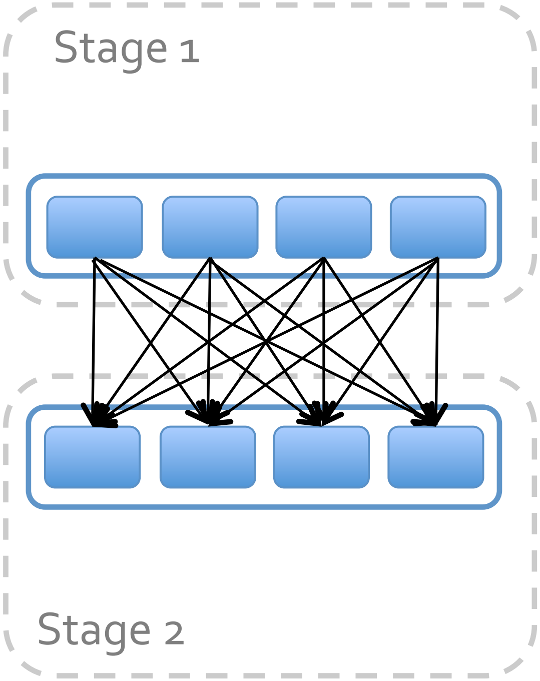


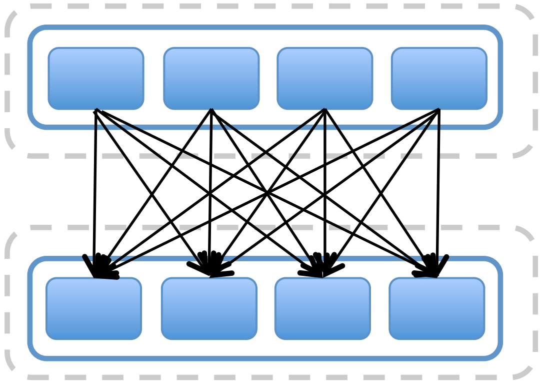
The Shuffle



The Shuffle

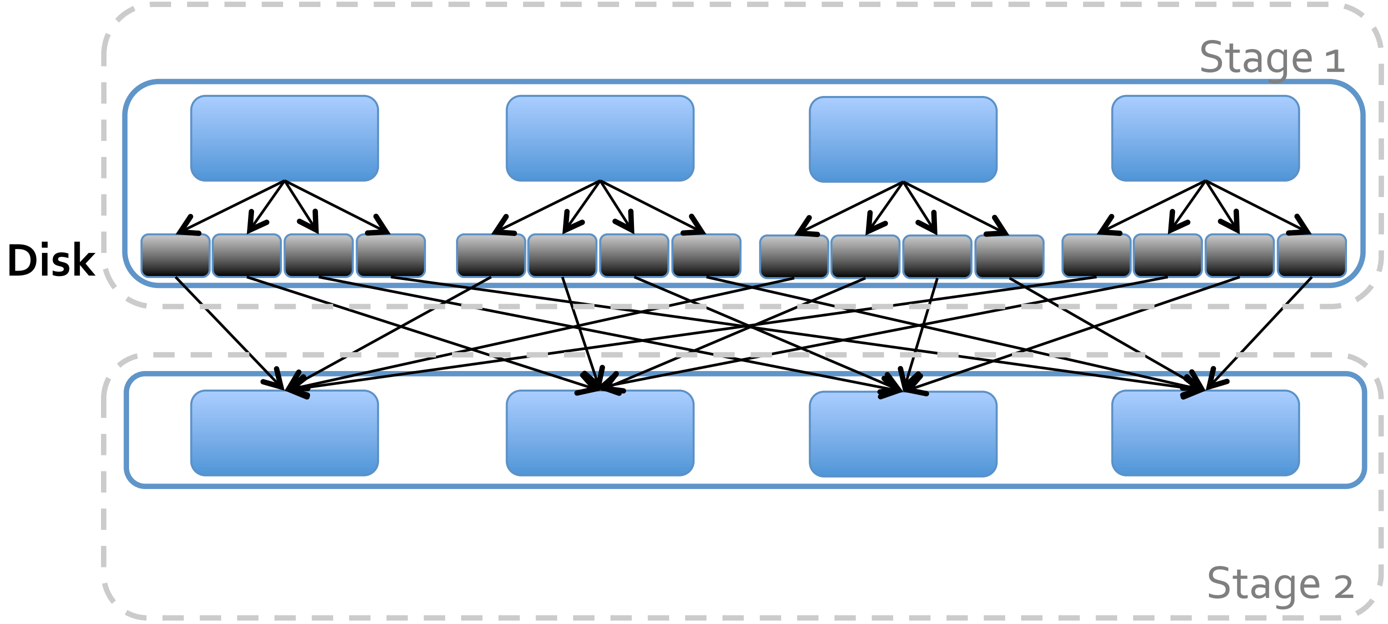
- Redistributes data among partitions
- Hash keys into buckets
- Optimizations:
  - Avoided when possible, if data is already properly partitioned
  - Partial aggregation reduces data movement





The Shuffle

- Pull-based, not push-based
- Write intermediate files to disk



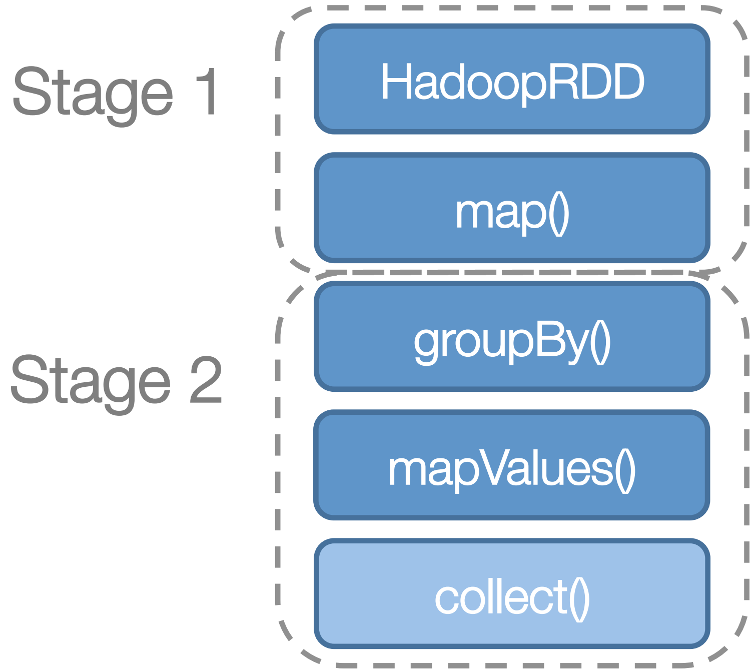
Execution of a groupBy()

- Build hash map within each partition

  A => [Arsalan, Aaron, Andrew, Andrew, Andy, Ahir, Ali, …],
  E => [Erin, Earl, Ed, …]
  …

- Note: Can spill across keys, but a single key-value pair must fit in memory

Done!



What went wrong?

- Too few partitions to get good concurrency
- Large per-key groupBy()
- Shipped all data across the cluster

Common issue checklist

1. Ensure enough partitions for concurrency
2. Minimize memory consumption (esp. of sorting and large keys in groupBys)
3. Minimize amount of data shuffled
4. Know the standard library

1 & 2 are about tuning number of partitions!

Importance of Partition Tuning

- Main issue: too few partitions
  - Less concurrency
  - More susceptible to data skew
  - Increased memory pressure for groupBy, reduceByKey, sortByKey, etc.
- Secondary issue: too many partitions
- Need "reasonable number" of partitions
  - Commonly between 100 and 10,000 partitions
  - Lower bound: At least ~2x number of cores in cluster
  - Upper bound: Ensure tasks take at least 100ms

Memory Problems

- Symptoms:
  - Inexplicably bad performance
  - Inexplicable executor/machine failures
    (can indicate too many shuffle files too)
- Diagnosis:
  - Set spark.executor.extraJavaOptions to include
    - -XX:+PrintGCDetails
    - -XX:+HeapDumpOnOutOfMemoryError
  - Check dmesg for oom-killer logs
- Resolution:
  - Increase spark.executor.memory
  - Increase number of partitions
  - Re-evaluate program structure (!)

Fixing our mistakes

```
sc.textFile(“hdfs:/names”)
  .map(name => (name.charAt(0), name))
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Fixing our mistakes

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sc.textFile(“hdfs:/names”)
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```
sc.textFile("hdfs:/names")
  .distinct(numPartitions = 6)
  .map(name => (name.charAt(0), 1))
  .reduceByKey(_ + _)
  .collect()
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