An Efficient Solution for Processing Skewed MapReduce Jobs

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Hoscar 2015

Work presented in :
**** Int. Conf. on Database and Expert Systems Applications (DEXA), 2015***
**** Int. Conf. On Very Large DataBases (VLDB), 2015***

Overview

- The Context
- The Problem
- FP-Hadoop
  - Foundation
  - How does FP-Hadoop work?
  - Experimental evaluation
- Conclusions

MapReduce : A Framework for Bigdata Processing

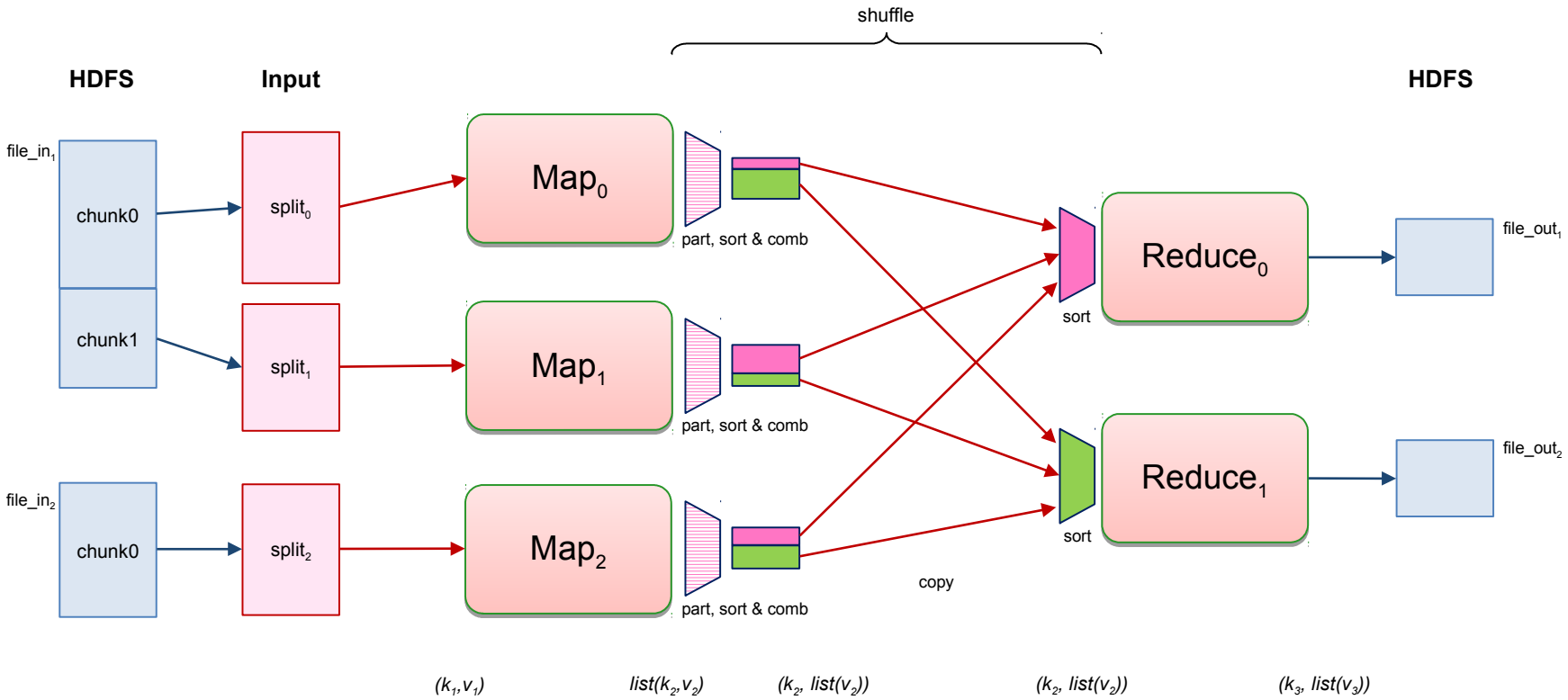
- *Programming model and framework*
  - Big data parallel processing in data centers
    - e.g., PageRank, inverted index
  - Automatic parallelization, distribution and fault tolerance

- Proposed by Google [OSDI 04]
  - Executed on top of Google File System (GFS)
- Inspired Apache project ▭ Hadoop

MapReduce Programming Model

- Data consists of
  - (key, value) pairs, aka tuples
- Functions
  - map: $(k_1,v_1) \rightarrow list(k_2,v_2)$
  - reduce: $(k_2, list(v_2)) \rightarrow list(k_3,v_3)$
  - Optionally
    - combine: $(k_2, list(v_2)) \rightarrow (k_2, list(v_2))$

MapReduce Job Execution

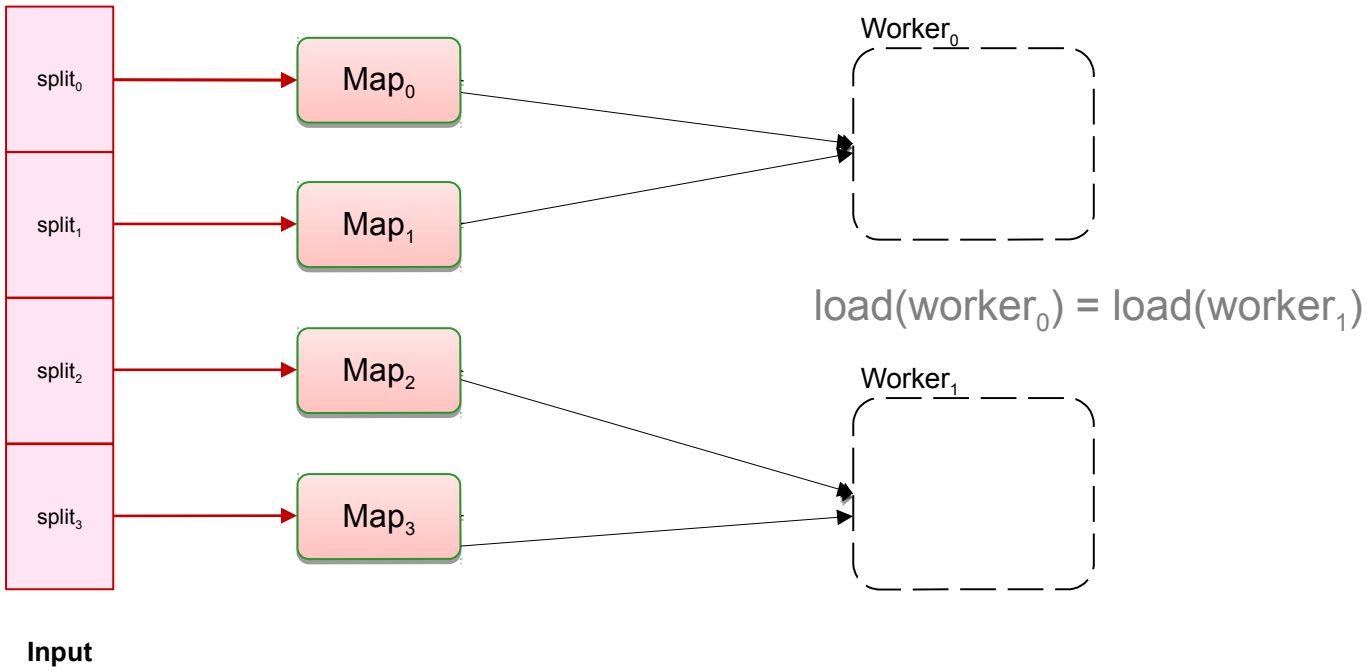


How Load Is Distributed to Workers?

- Map phase
  - Input data is divided into splits of similar size
  - Splits are assigned to map tasks
    - Assigned independently to free workers
- Reduce phase
  - Intermediate keys assigned to partitions
  - Partitions assigned tor reduce tasks
    - Assigned independently to free workers

How Load Is Distributed to Workers?

- Map phase



How Load Is Distributed to Workers?

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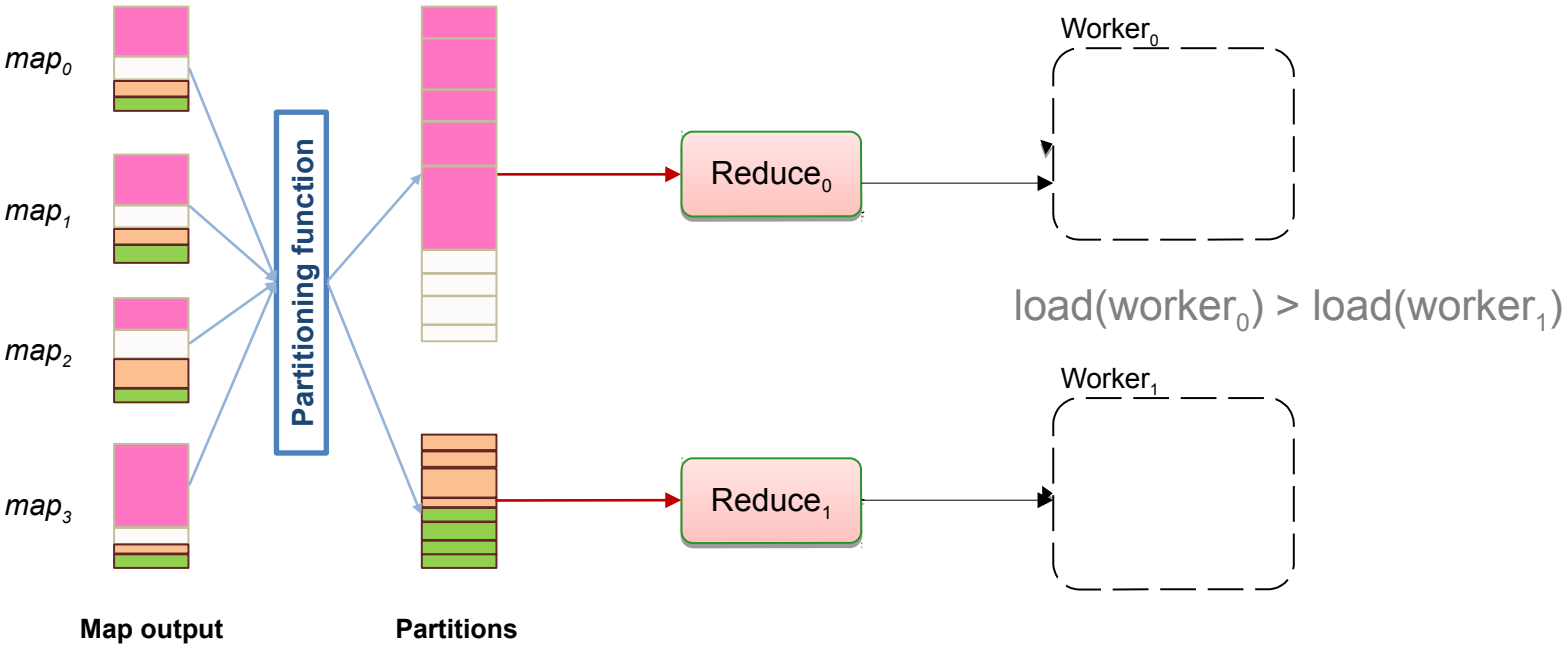


Problem: Data Skew

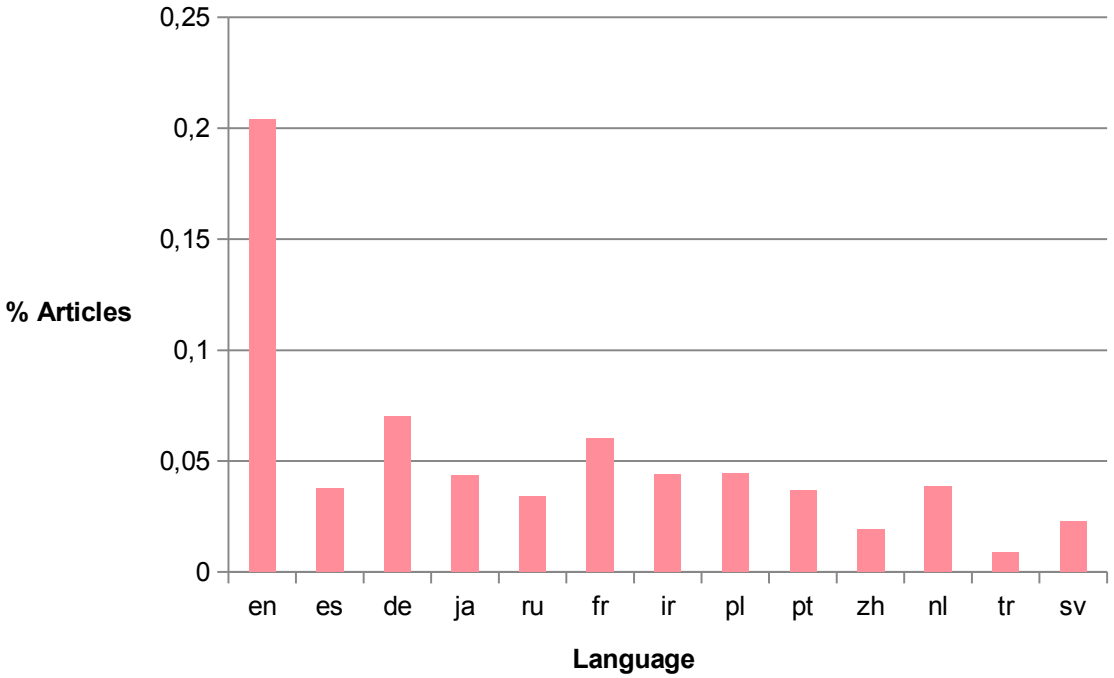
- Load balancing problem
  - Some reduce tasks receive more data to process
  - Thus, *parallelism is not complete*

- Causes
  - Bad partitioning function

    May be solved but needs *a priori* knowledge*
  - Popular keys
    - Hard to solve : data of each key should be sent to the same worker

Motivating Example

- Wikipedia **number** of articles per language



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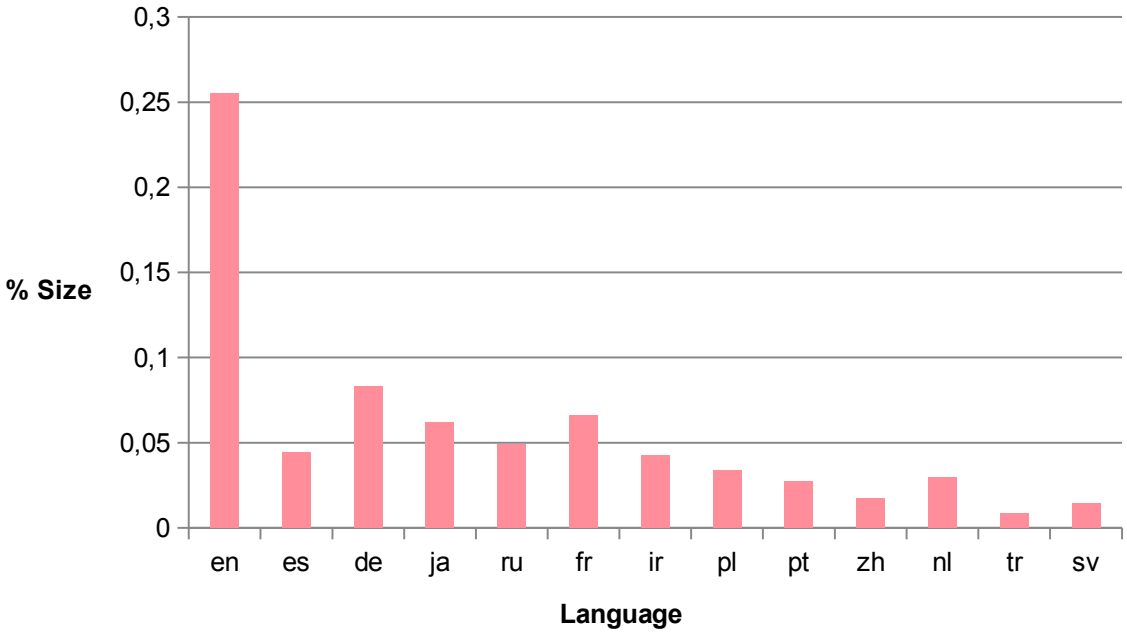
- Wikipedia **size** per language



FP-HADOOP

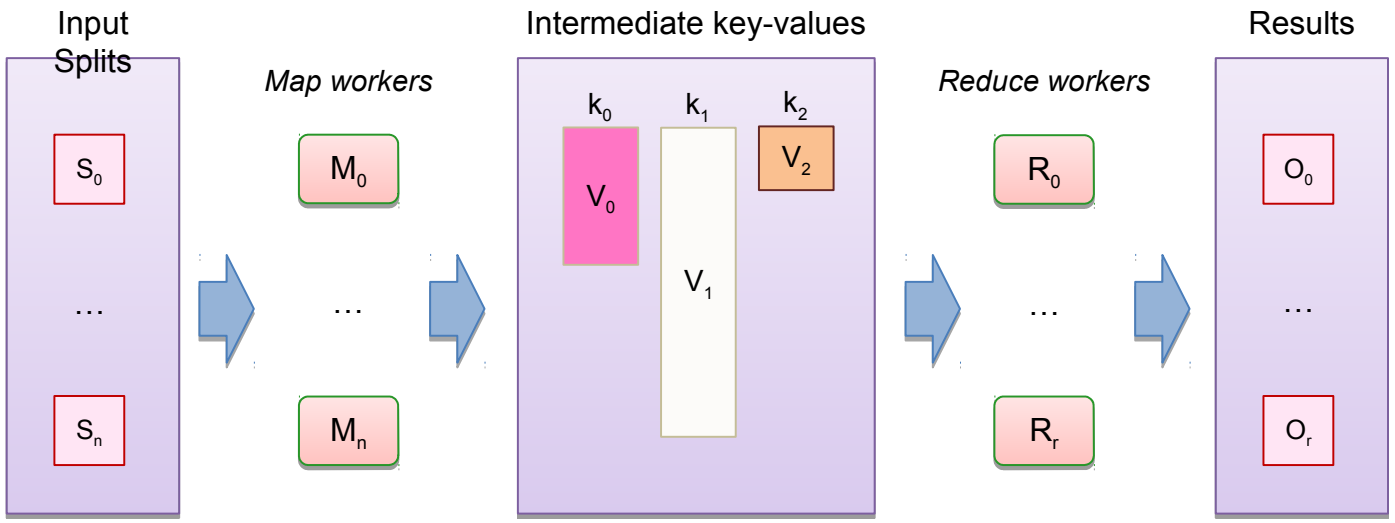
FP-Hadoop: Foundation

- Main idea
  - Workers collaborate in the processing of intermediate key
  - Obtain maximum parallelism

- FP-Hadoop: 3 phases
  - Map : unchanged
  - **Intermediate reduce (IR)**
    - IR tasks process *bounded splits* (IR splits) of intermediate data
    - *Iterative*: Popular keys generate several waves of IR tasks
  - Final Reduce (FR) : same as original reduce

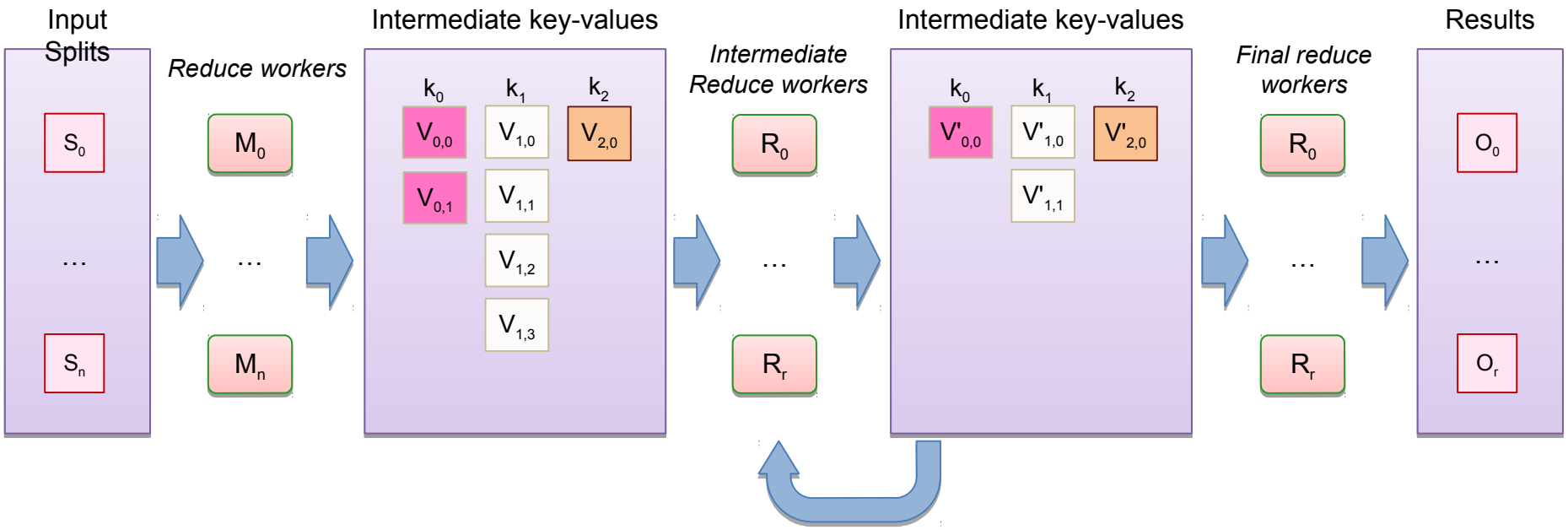
FP-Hadoop: Foundation

- Job processing with **Hadoop**



FP-Hadoop: Foundation

- Job execution with **FP-Hadoop**

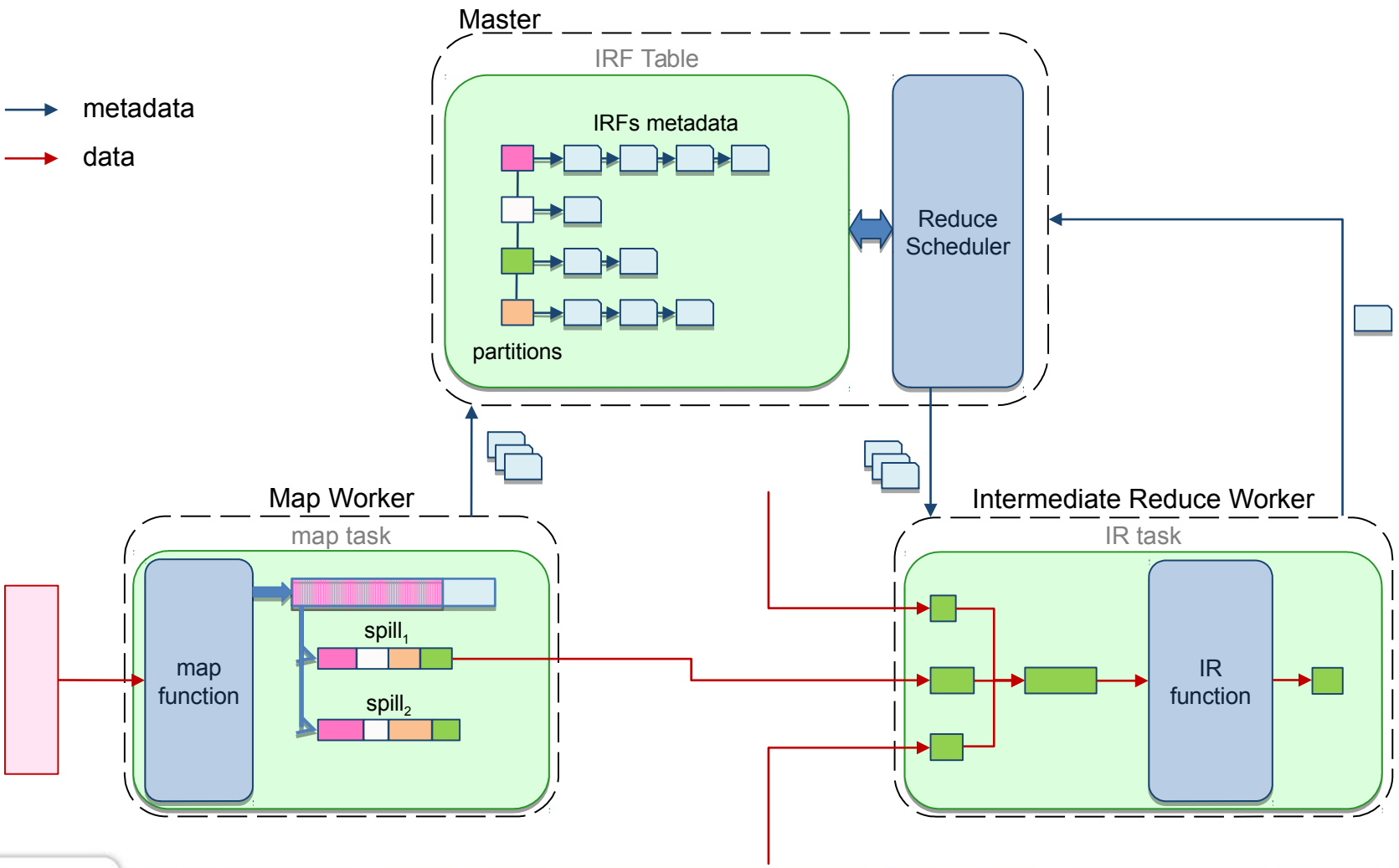


HOW DOES FP-HADOOP WORK?

Dynamic Generation of IR Splits

- **IR Split**
  - Unit of processing in the intermediate phase
    - 1 IR split ▭ 1 IR task
  - Bounded: min and max size
  - Composed of *IR fragments*
    - 1 IRF = 1 partition in map output spills
- Reduce scheduler
  - Generates IR splits from IR fragments
  - Dynamically generate and assign IR split when free worker

Dynamic Generation of IR Splits



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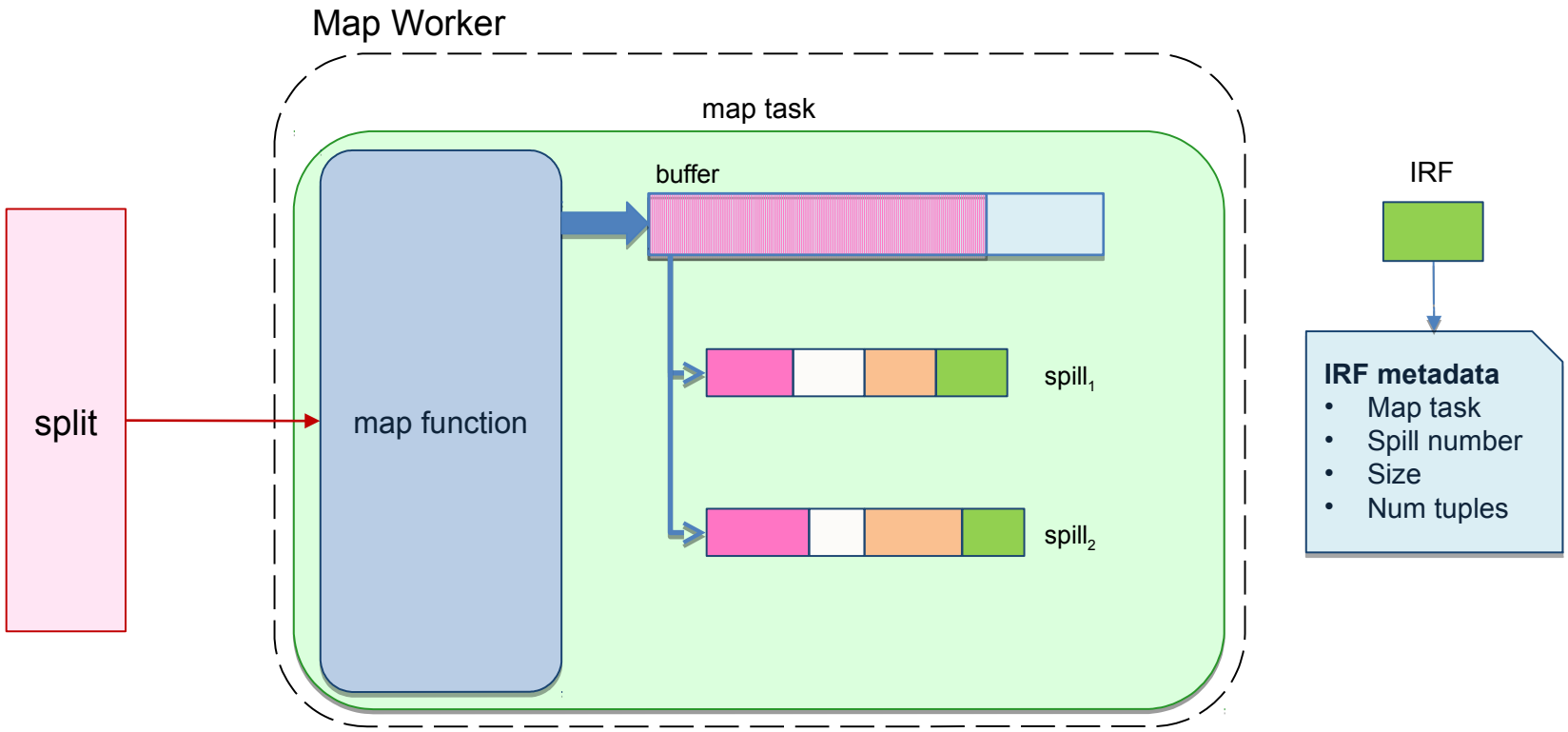
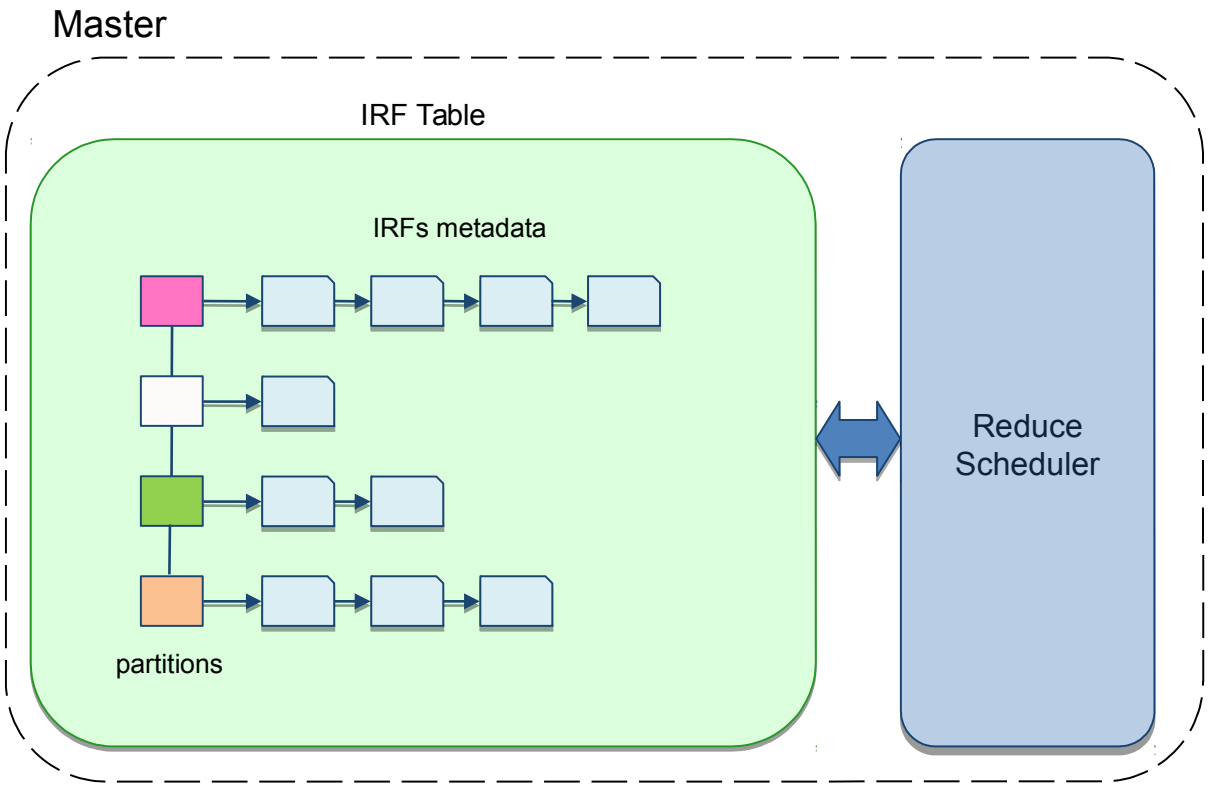


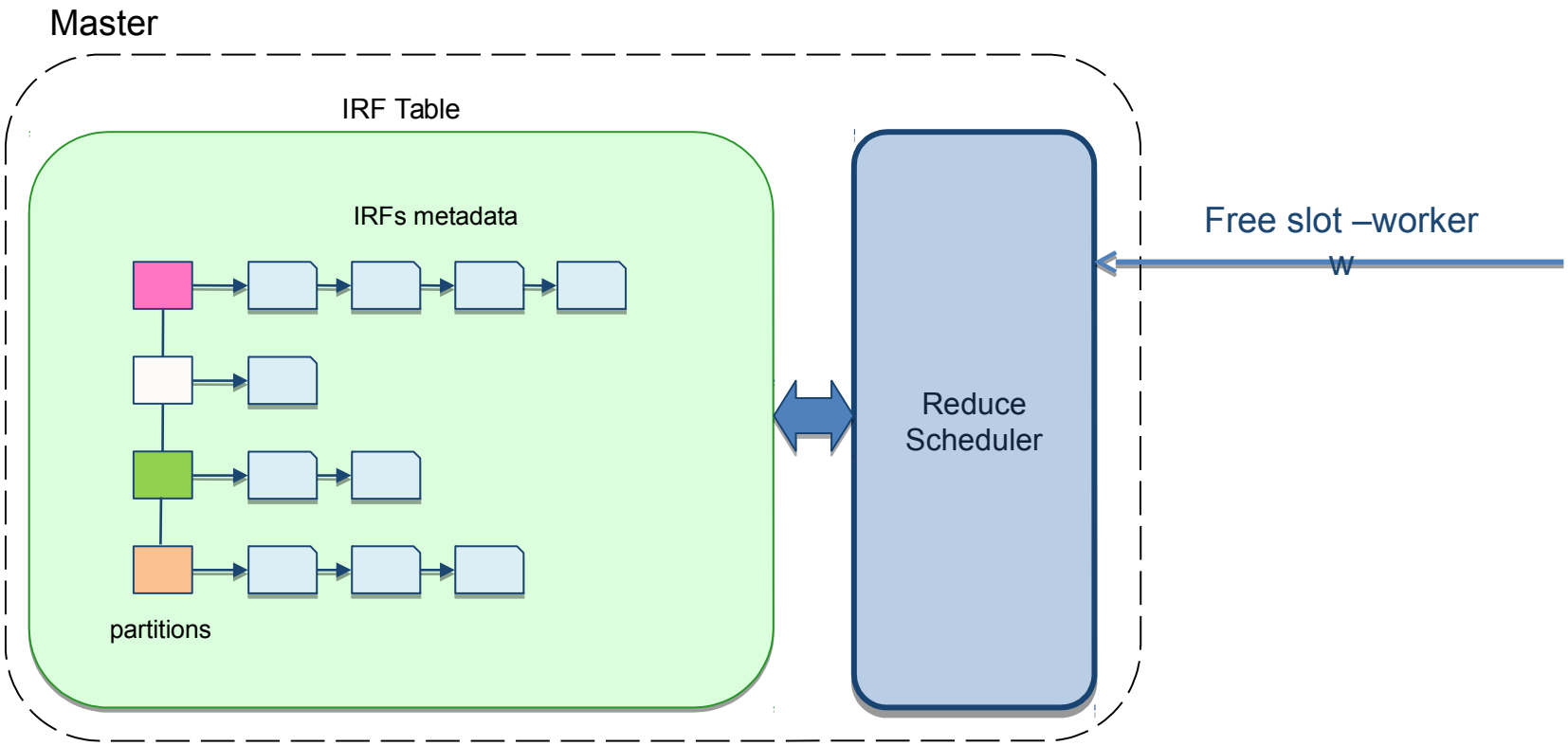
IRF fragments and metadata

Dynamic Generation of IR Splits



IR Split creation and scheduling

Dynamic Generation of IR Splits



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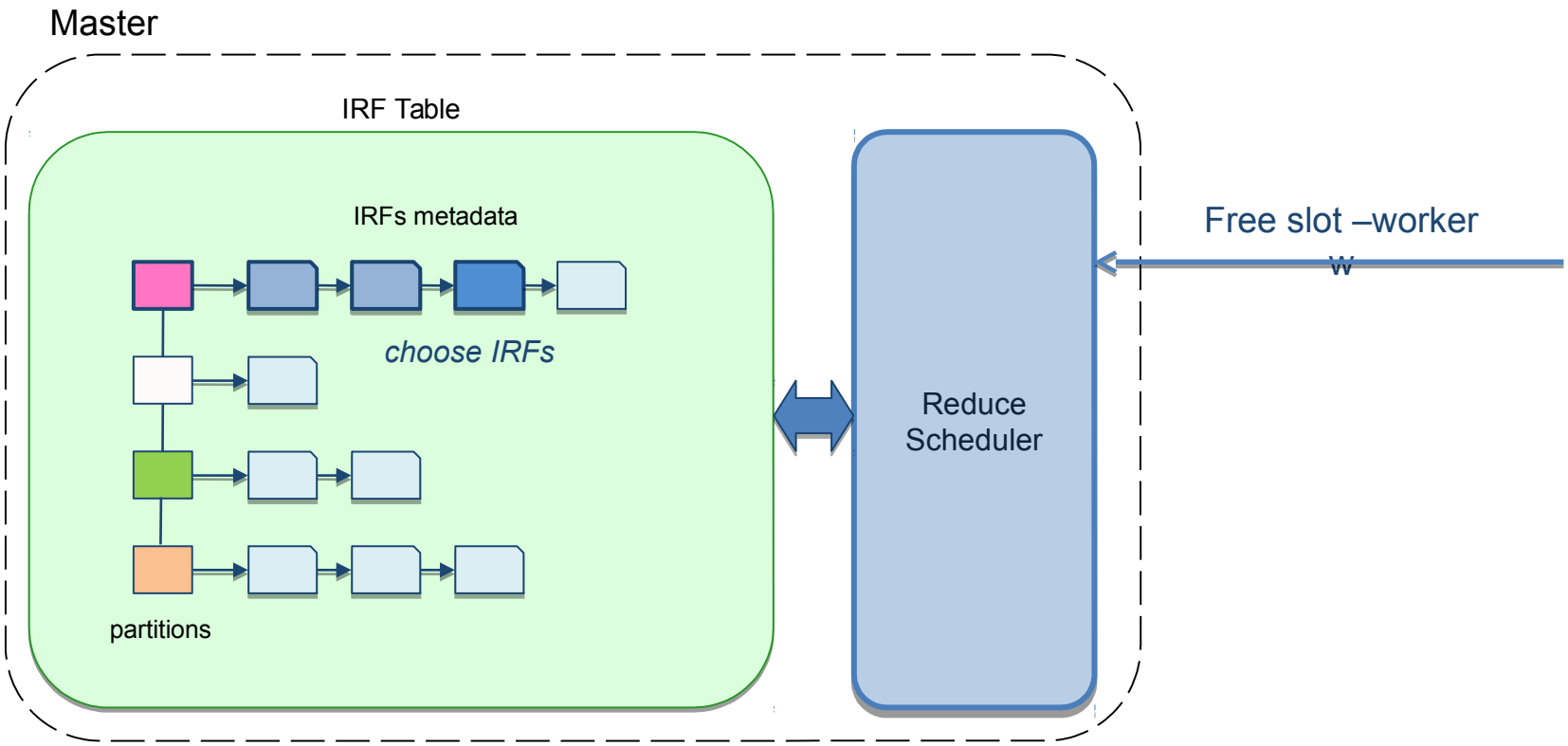

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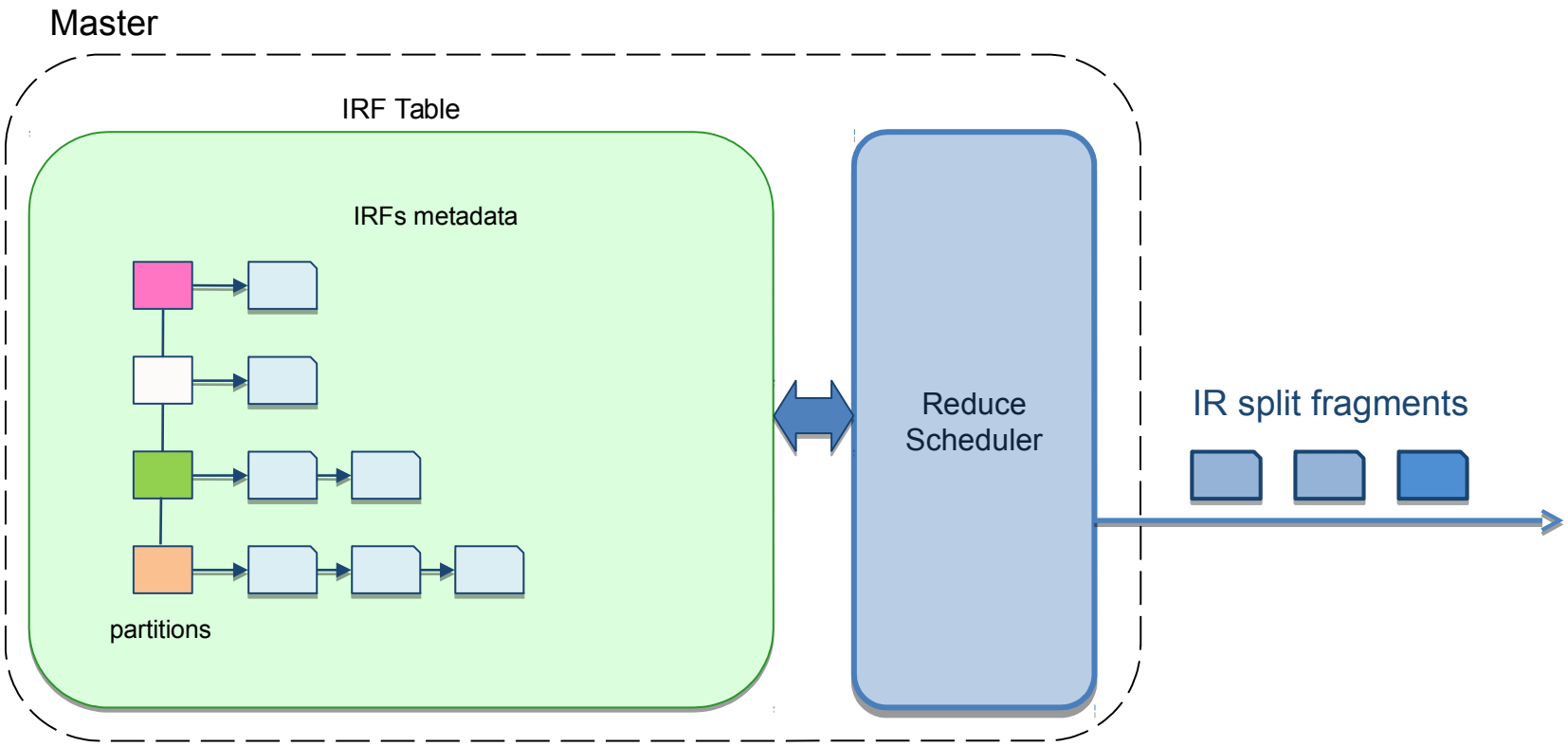

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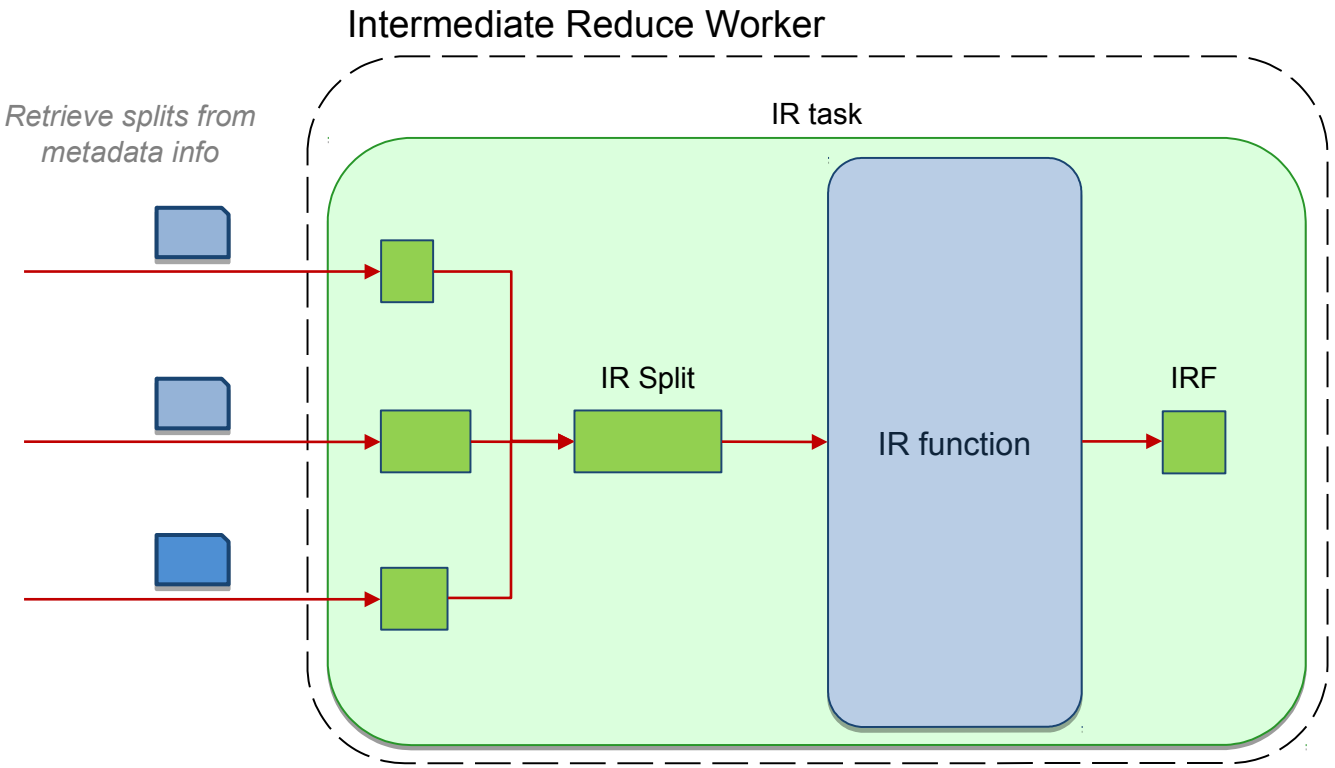
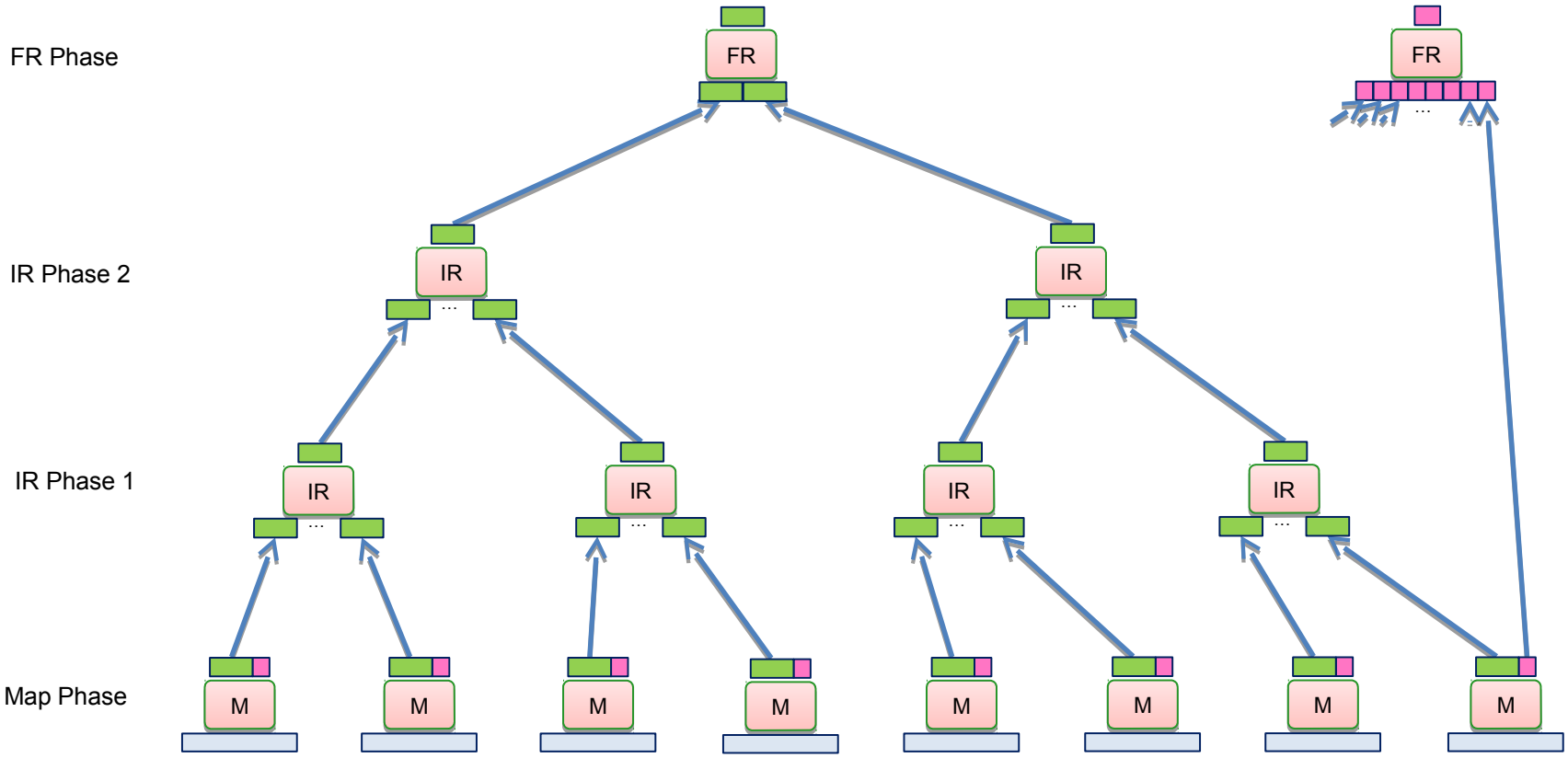


IR Split processing

Scheduling

- Reduce scheduler specifies
  1. When a partition goes to FR
  2. Which partition is chosen
  3. Which IRFs are chosen within the partition
- Implemented strategies
  - . Greedy (default)
    - Biggest partition is given priority
    - Select IR fragments until `maxIRSize` is chosen
  - . Locality-aware
    - Partition with highest amount of local data
    - Local IR fragments are chosen first

Iterative Reduce Phase



EXPERIMENTAL EVALUATION

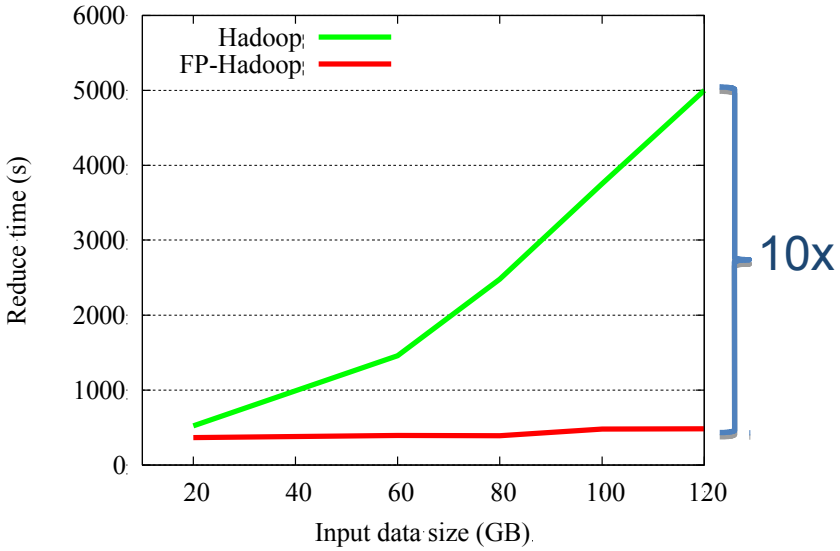
Configuration

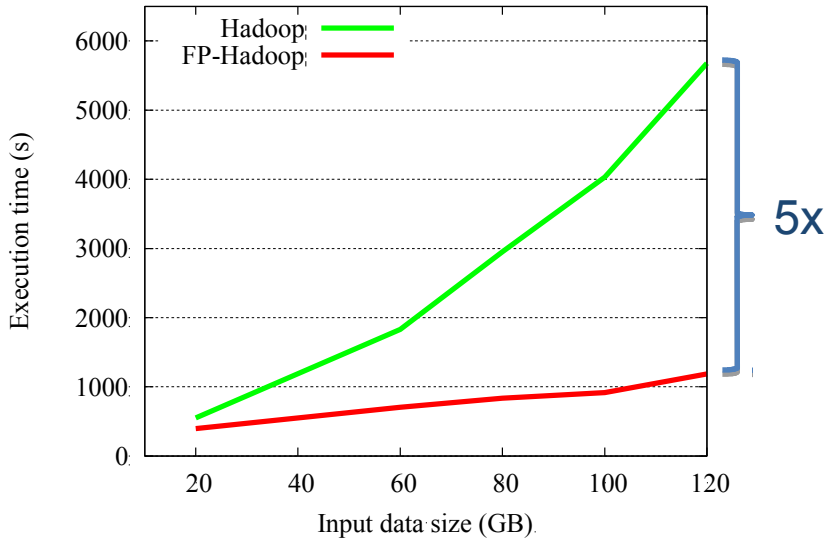
- Platform and setup
  - FP-Hadoop as prototype
  - Real-tests in G5k platform
- Metrics
  - Execution time
  - Reduce time

Queries

- Top-k % (TK)
  - k% most popular articles
  - *Datasets*
    - Synthetic from Zipfian distribution
      - f(I, S, N), S: skew, N: number of classes
    - Wikipedia article views statistics
- Inverted Index (II)
  - *Dataset*: English Wikipedia articles
  - *Dataset*: PLD graph from Web Data Commons
- WordCount (WC)
  - *Dataset*: synthetic, generated with `RandomWriter`

Scalability

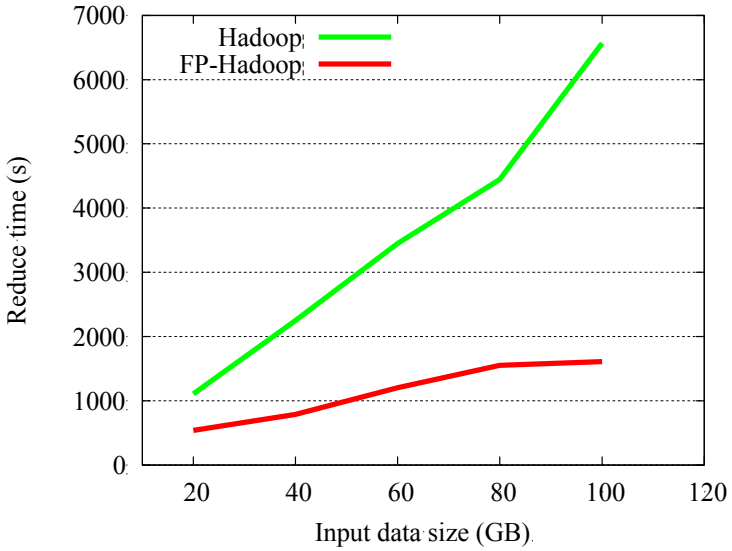


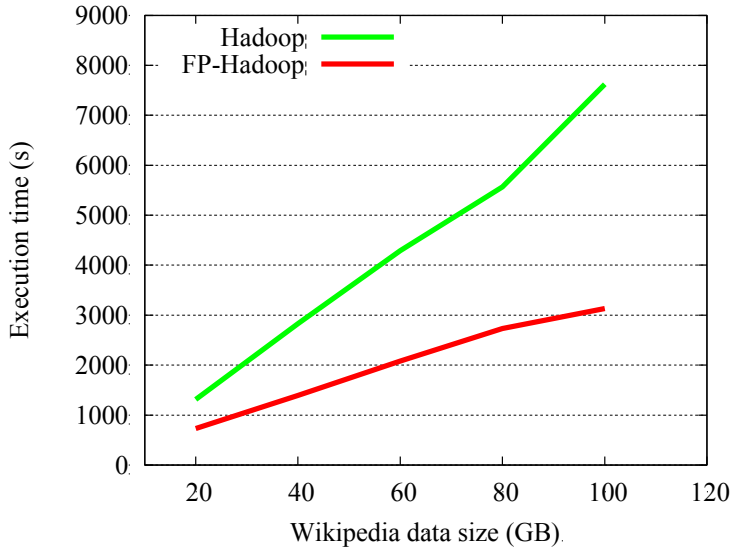


+ size : + speedup

Synthetic dataset; N = 10, S = 1; nodes = 20

Scalability

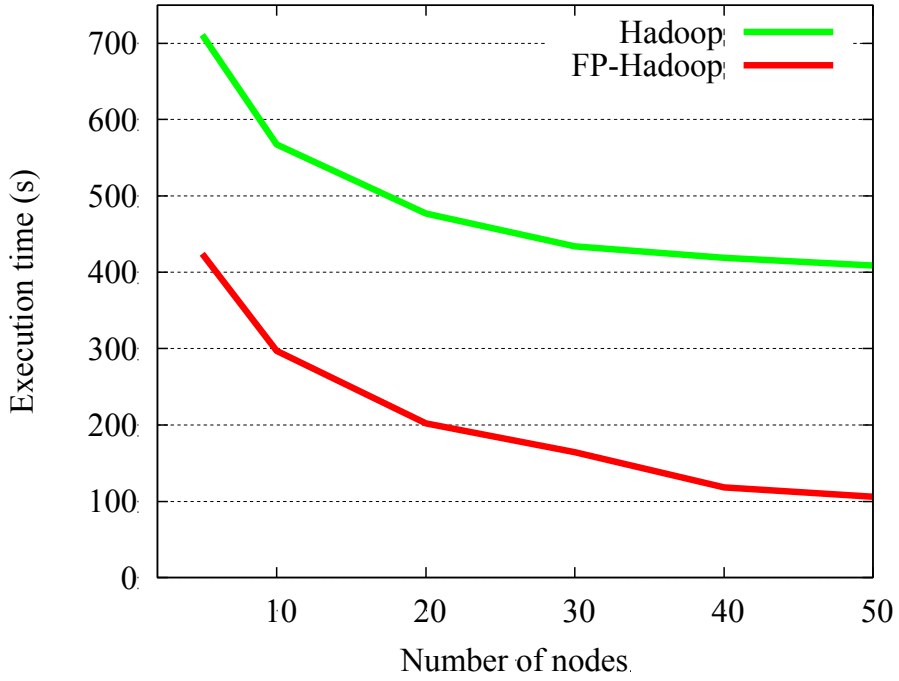




+ size : + speedup

Real dataset: Wikipedia article accesses; nodes = 20

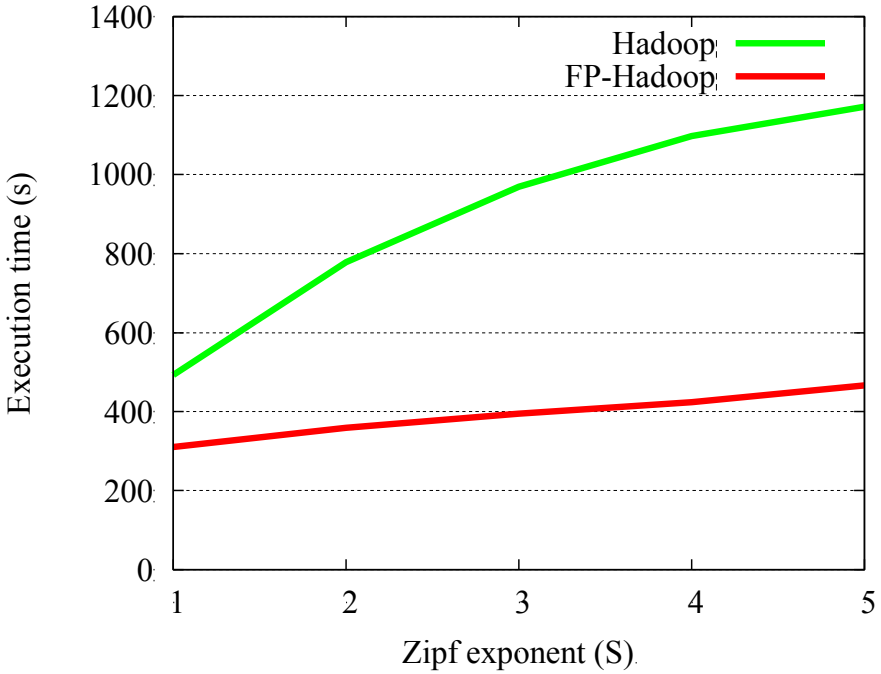
Cluster Size



+ nodes : + speedup

Synthetic dataset; N = 10, S = 1

Effect of Skew



+ skew : + speedup

Synthetic dataset; N = 10, S = 1; nodes = 20

Conclusions

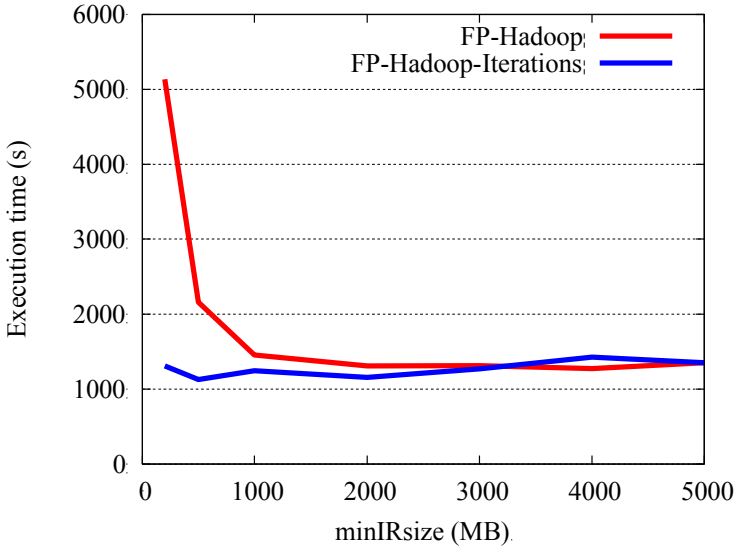
- FP-Hadoop features
  - Parallel reducing of each intermediate key
  - Distributed IR Split construction
    - Based on user-defined scheduling strategy
  - Hierarchical iterative execution
  - Non-overwhelming reduce

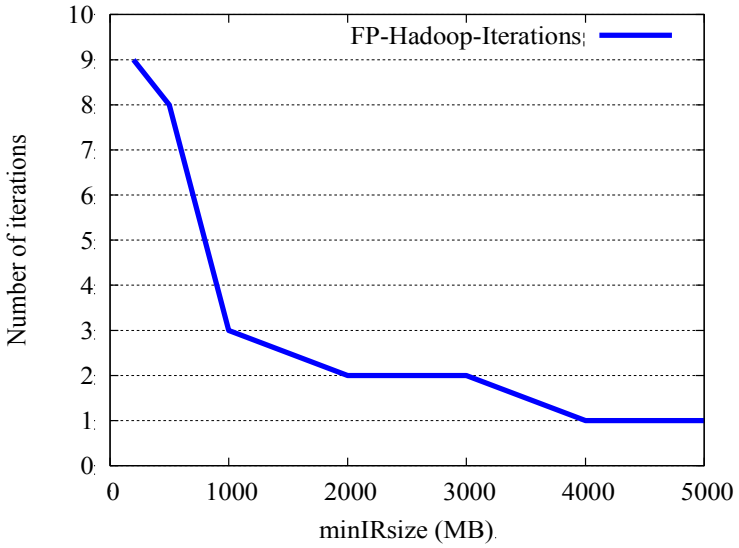
- Experimental evaluation
  - Significant gains that increase with
    - Size
    - Parallelism
    - Skew

QUESTIONS?

BACK-UP SLIDES

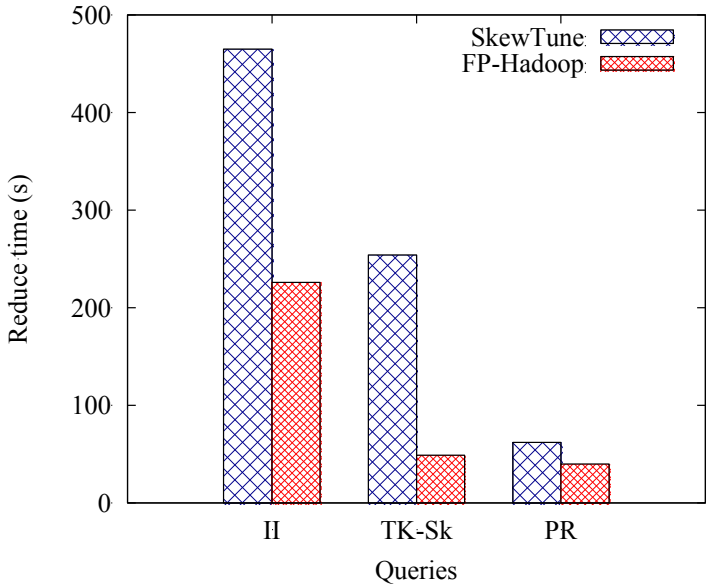
Results: Iterations and IR Split size

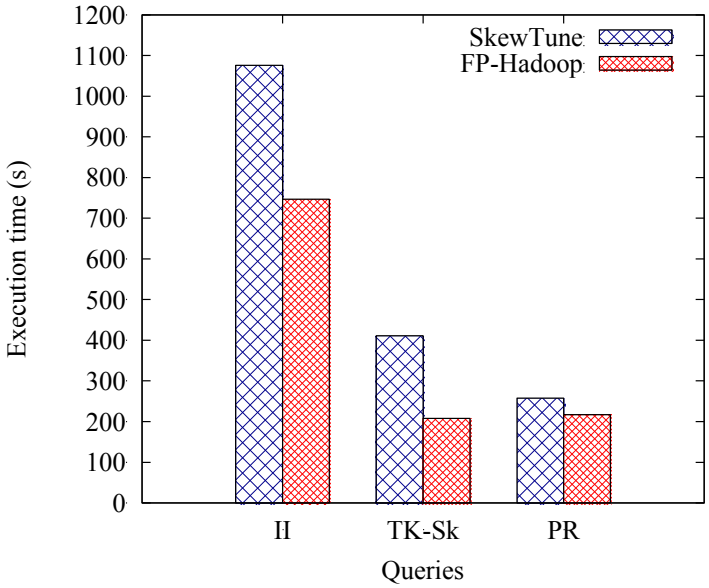




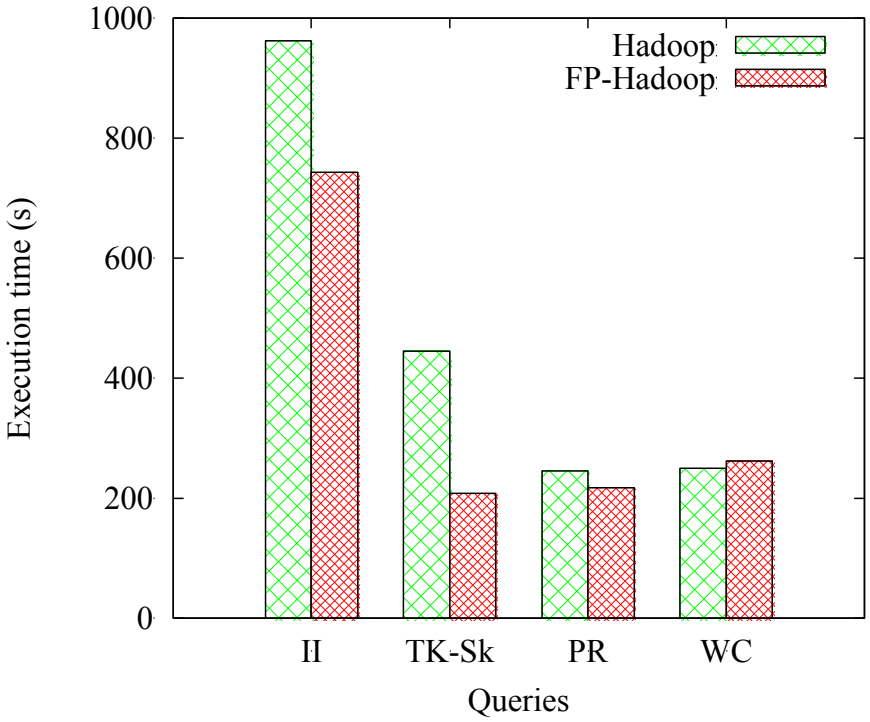
Synthetic dataset; N = 10, S = 1; Input = 20GB

Results: Comparison with SkewTune





Different Queries



nodes = 20