Overview

Understand what happens behind the scenes in a MapReduce task

Control the number of mappers and reducers

Improve parallelism by using a Combiner after the map phase

Know the constraints involved in using combiners

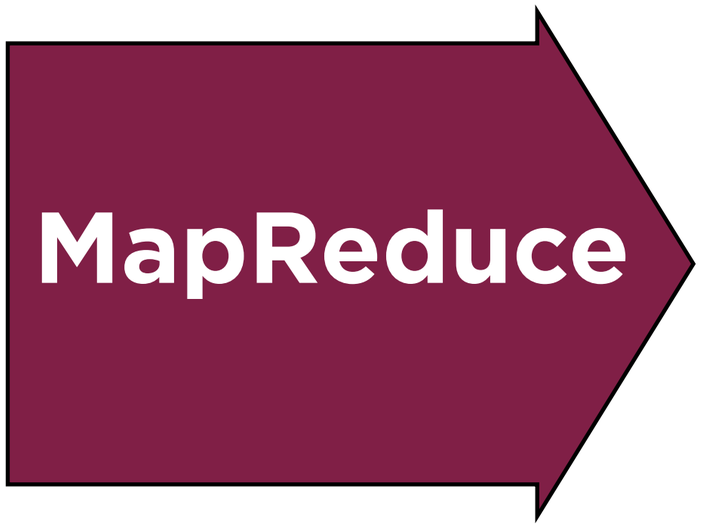
Key Insight Behind MapReduce

Many data processing tasks can be expressed in this form

Building a User-ViewCount Map

Data is originally captured in this form

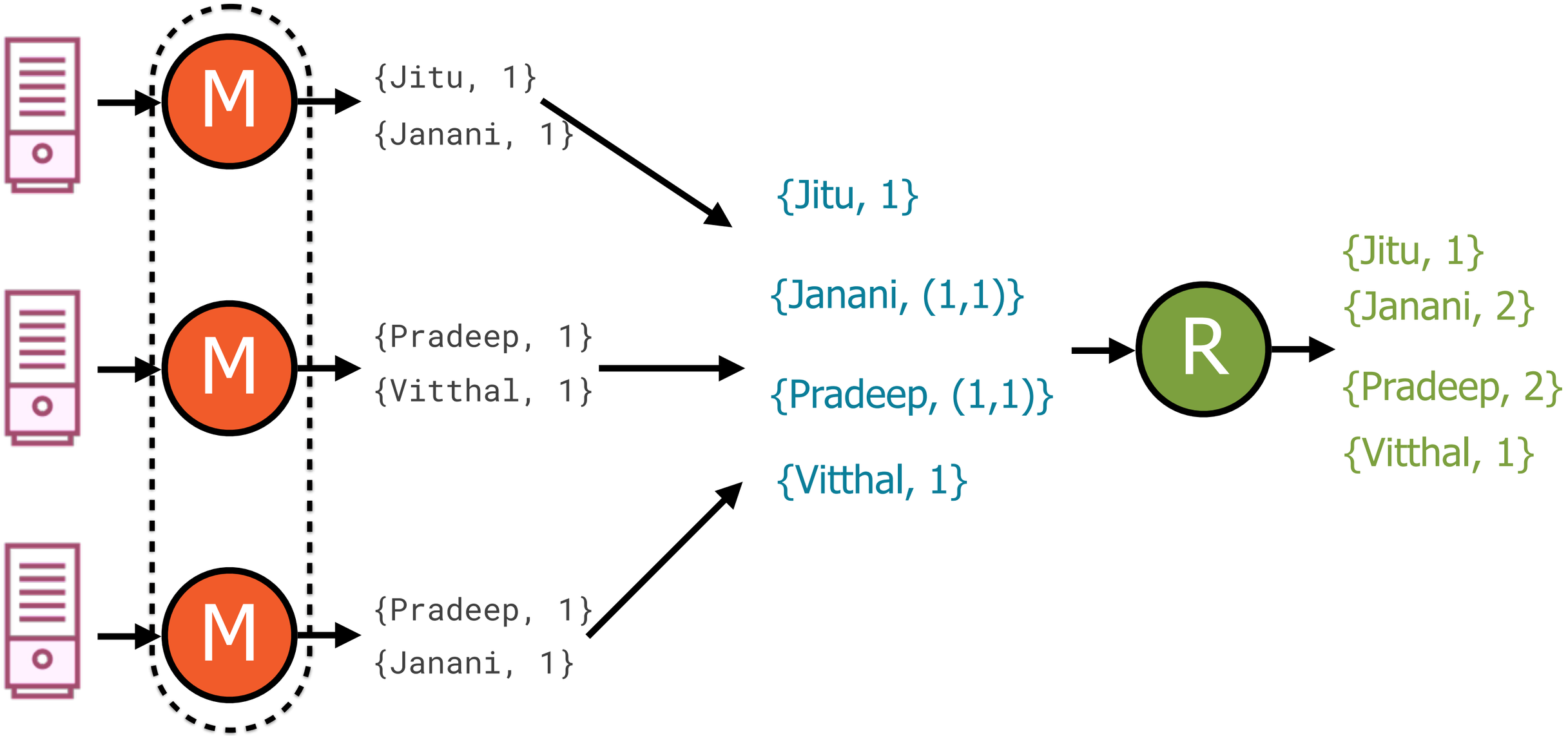
View ID	From Member	To Member
1	Janani	Jitu
2	Swetha	Janani
3	Shreya	Pradeep
4	Jitu	Vitthal
5	Shreya	Janani
6	Jitu	Pradeep



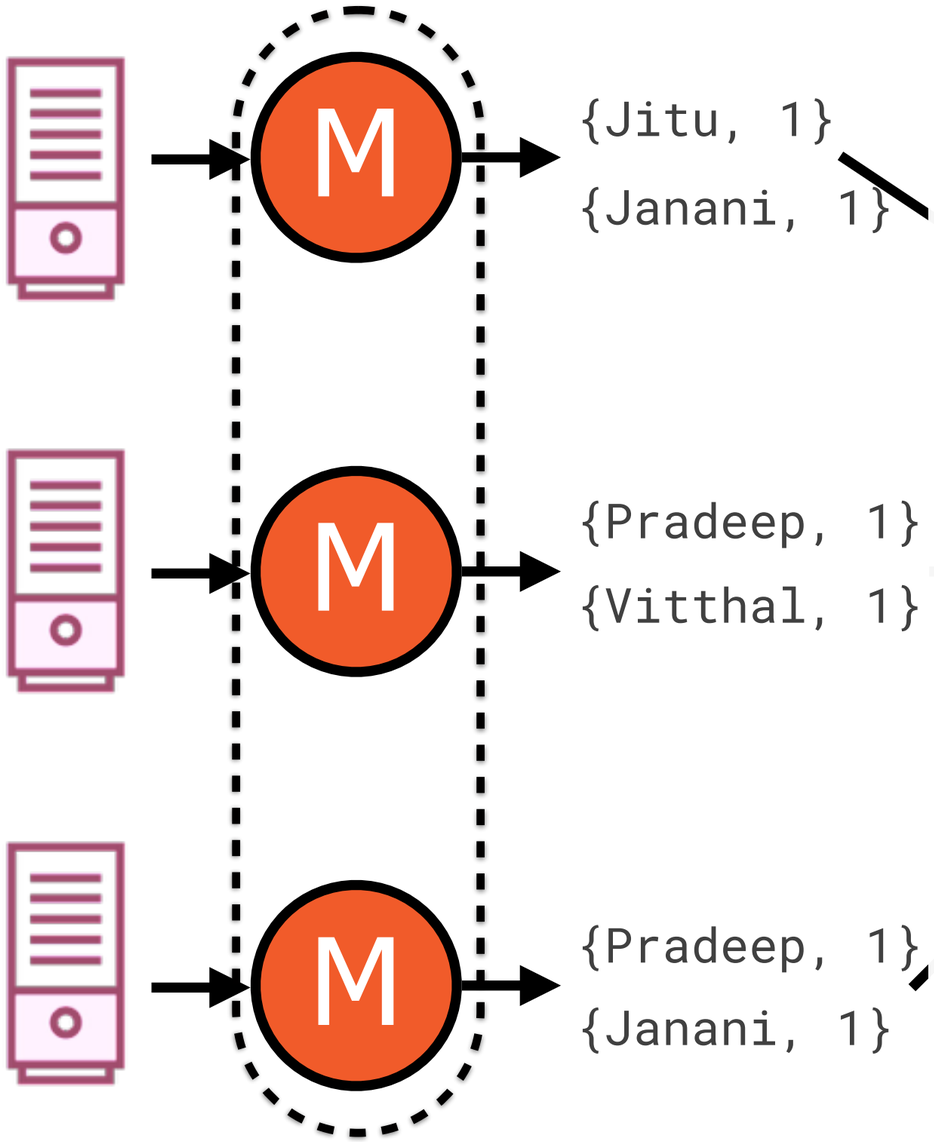
User-ViewCount Map

Member	# Profile Views
Janani	50
Swetha	15
Vitthal	22
Shreya	23
Jitu	32
Pradeep	10

Typical MapReduce Flow



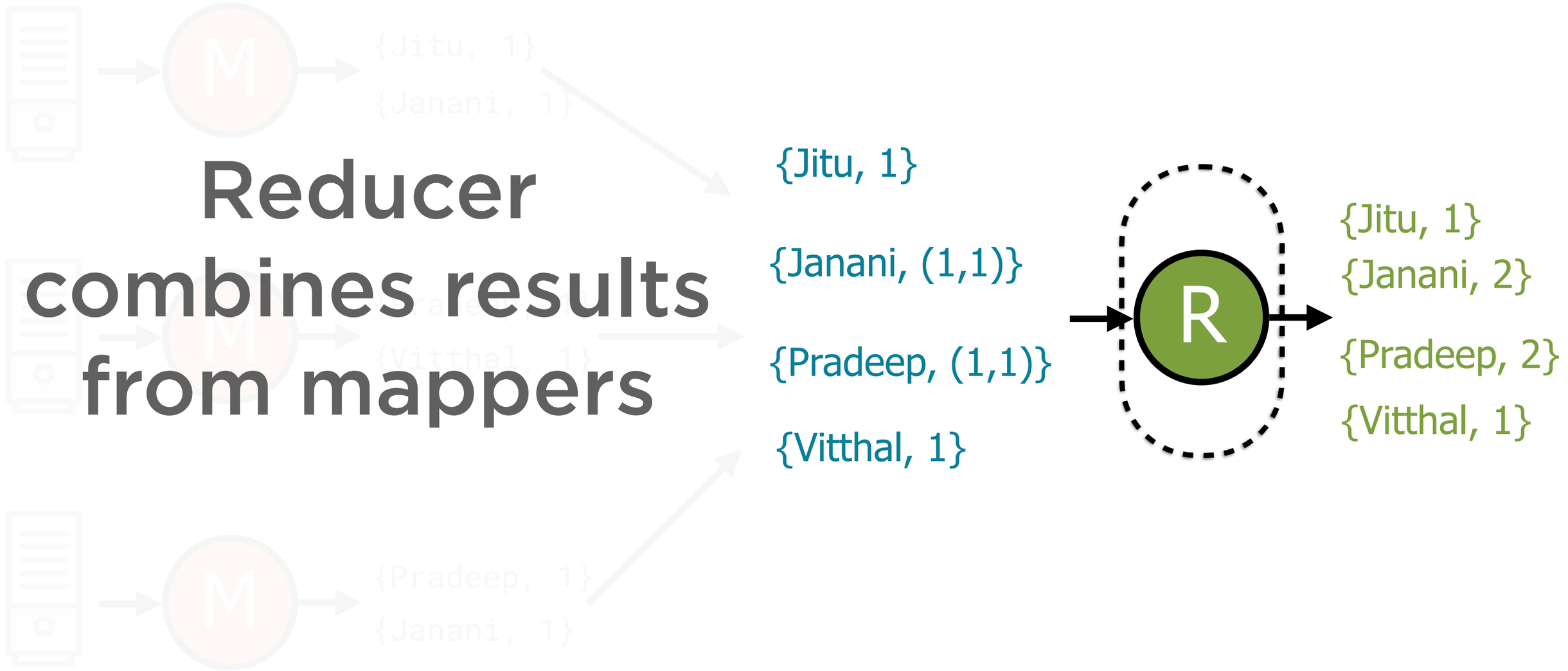
Typical MapReduce Flow



Mappers that work in parallel on data partitions

Typical MapReduce Flow

Reducer combines results from mappers



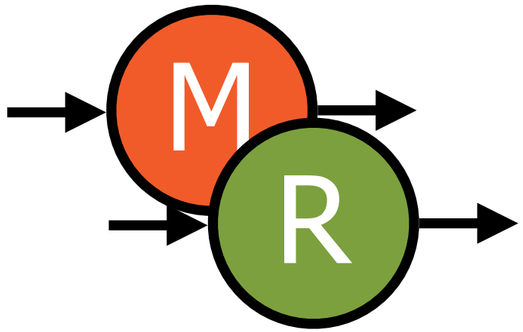
Typical MapReduce Flow

Mappers and reducers are "processes" that run on individual nodes in a cluster

Typical MapReduce Flow

The programmer defines the logic of the Map and Reduce steps in a MapReduce Job

Typical MapReduce Flow



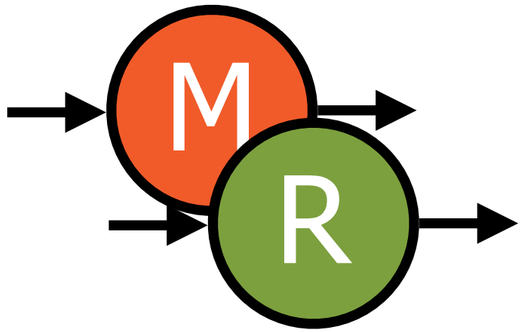
The MapReduce job is submitted to a cluster

Typical MapReduce Flow

The cluster is managed by a piece of software called a Cluster Manager

In the case of Hadoop 2.0, YARN is the cluster manager

Typical MapReduce Flow



The cluster manager launches mapper and reducer processes...

... on different nodes in the cluster

How many mappers and reducers are launched?

Number of Mappers/Reducers

Number of mappers = number of data partitions

Number of Mappers/Reducers

View ID	From Member	To Member
1	Janani	Jitu
2	Swetha	Janani
3	Shreya	Pradeep
4	Jitu	Vitthal
5	Shreya	Janani
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Number of Mappers/Reducers

View ID	From Member	To Member
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View ID	From Member	To Member
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4	Jitu	Vitthal

View ID	From Member	To Member
5	Shreya	Janani
6	Jitu	Pradeep

Number of Mappers/Reducers

Number of mappers = number of data partitions

number of data partitions

Decided by the storage system

Cannot be controlled by the user

Storage system for Hadoop is HDFS

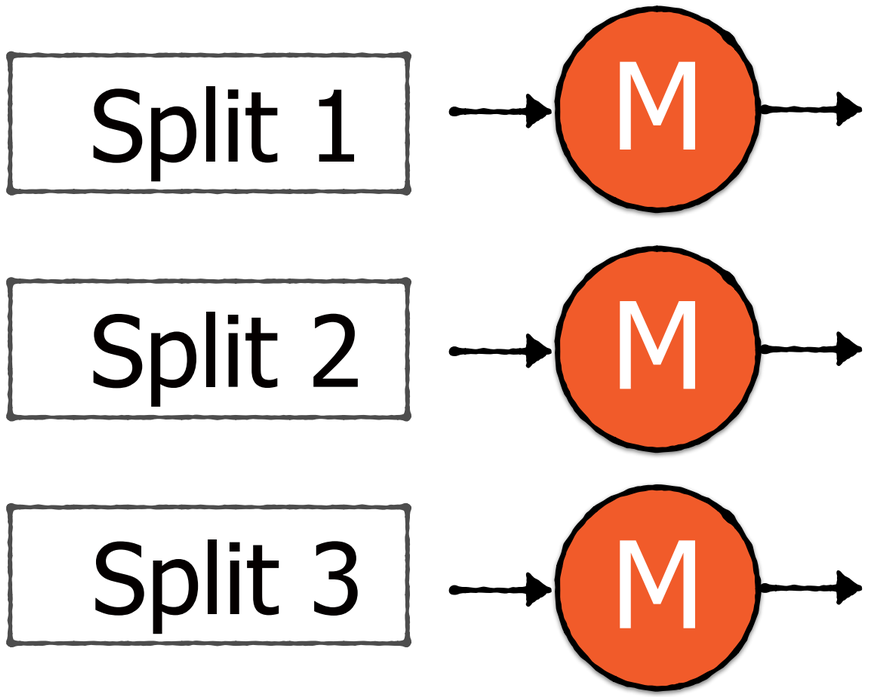
Number of Mappers/Reducers

Number of reducers = 1 (by default)

Controlled by the user

Optimizes performance

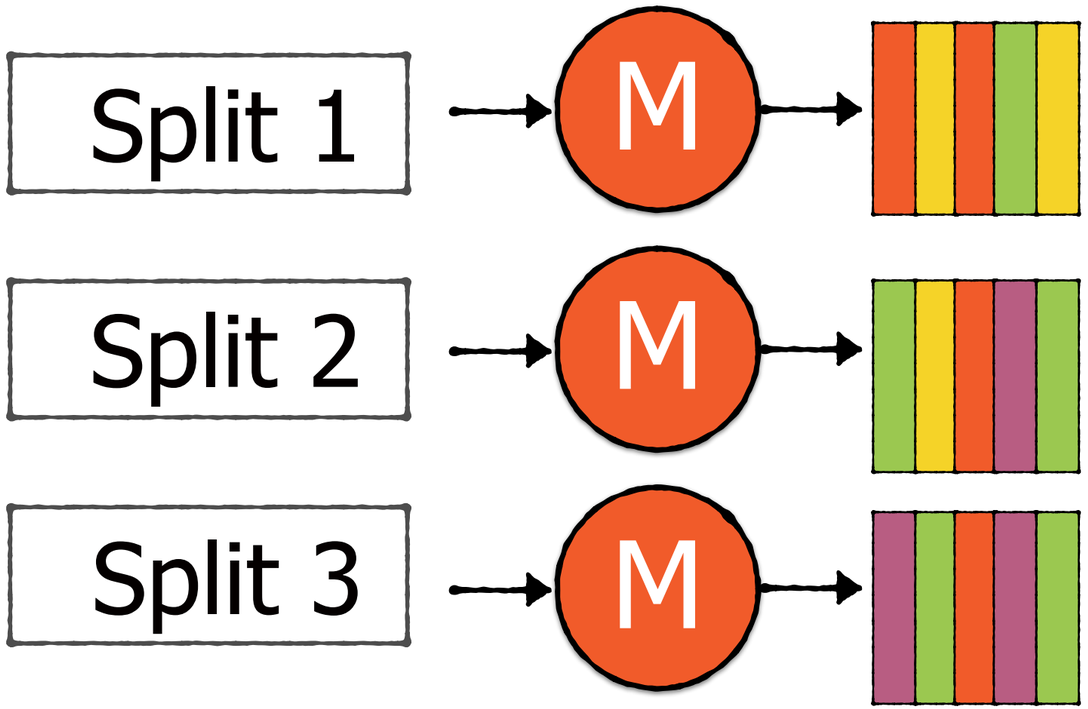
Behind the Scenes



Say our input dataset had been split into 3 blocks by the underlying storage system

There will 3 mappers

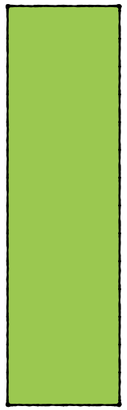
Behind the Scenes



Mappers emit {key, value} pairs

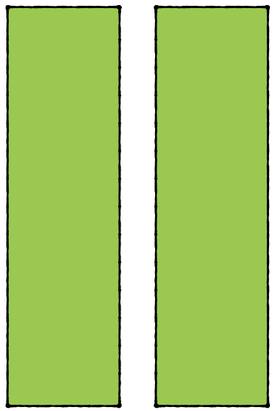
Behind the Scenes

A {key, value} pair

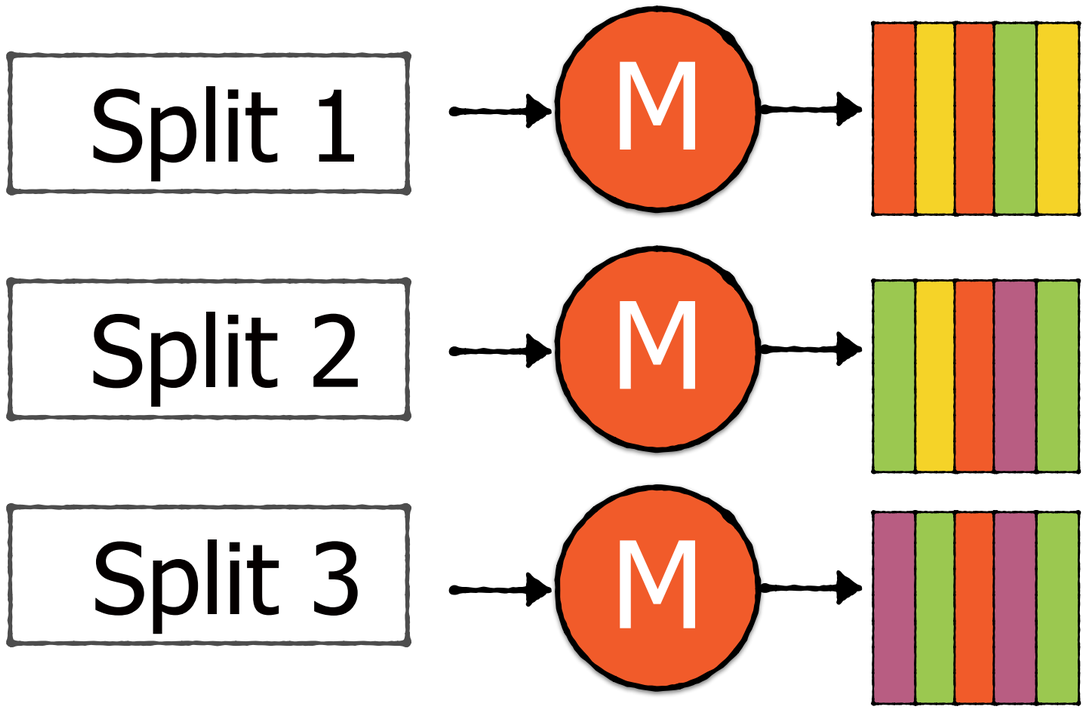


Behind the Scenes

Pairs with the same key

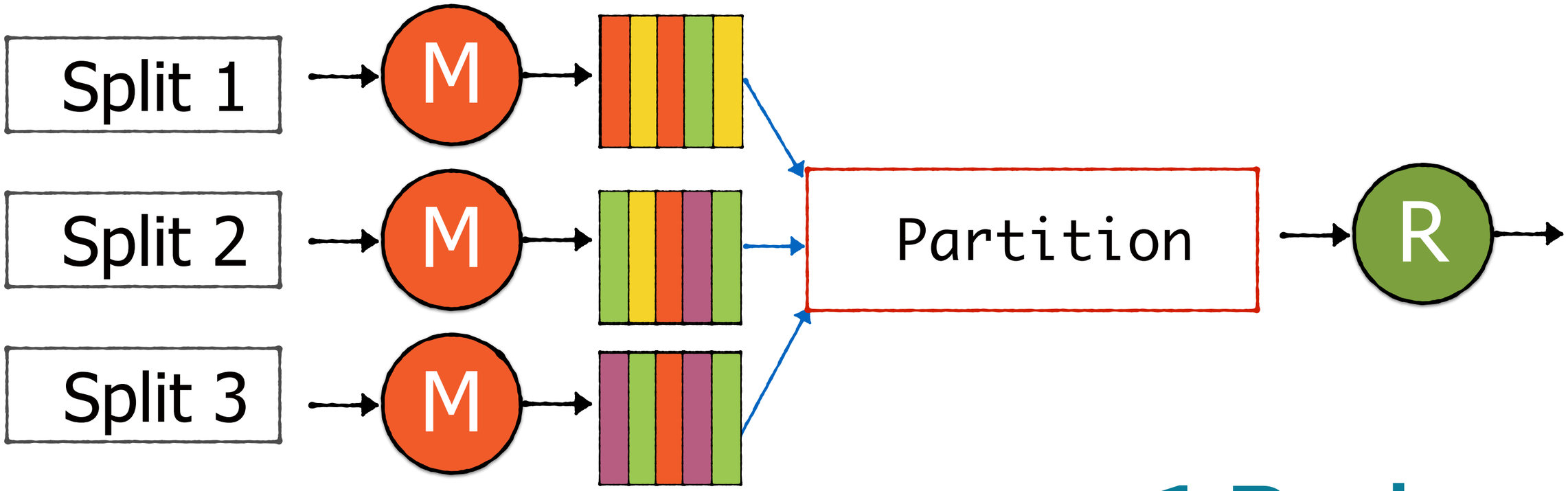


Behind the Scenes



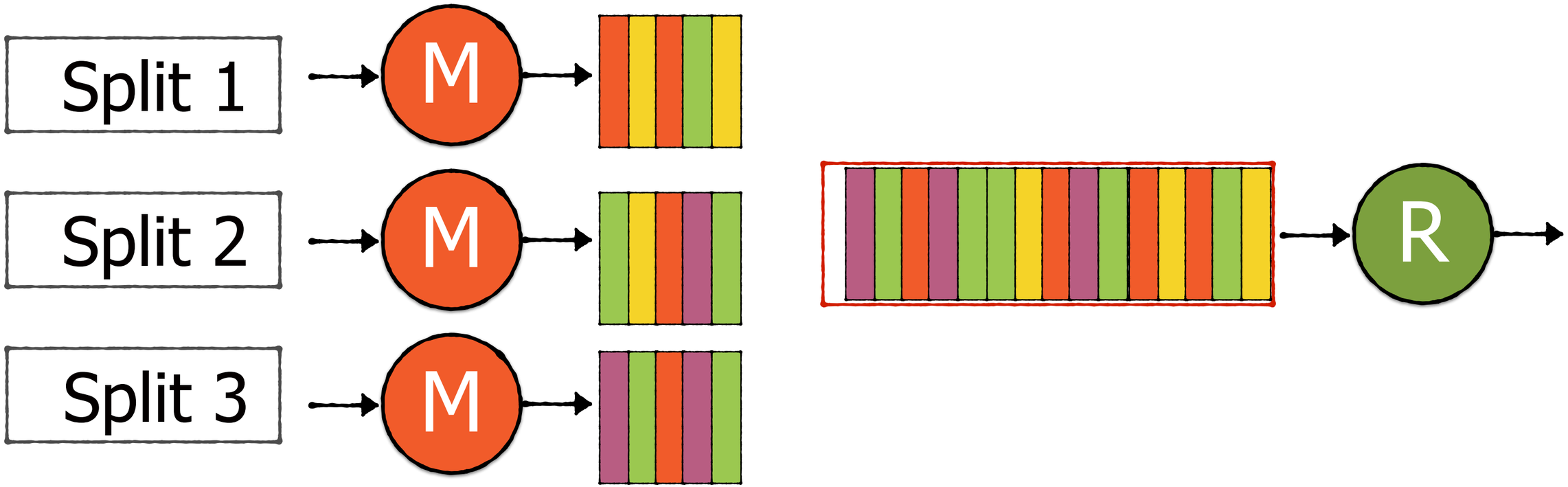
What happens next depends on the number of reducers

Behind the Scenes

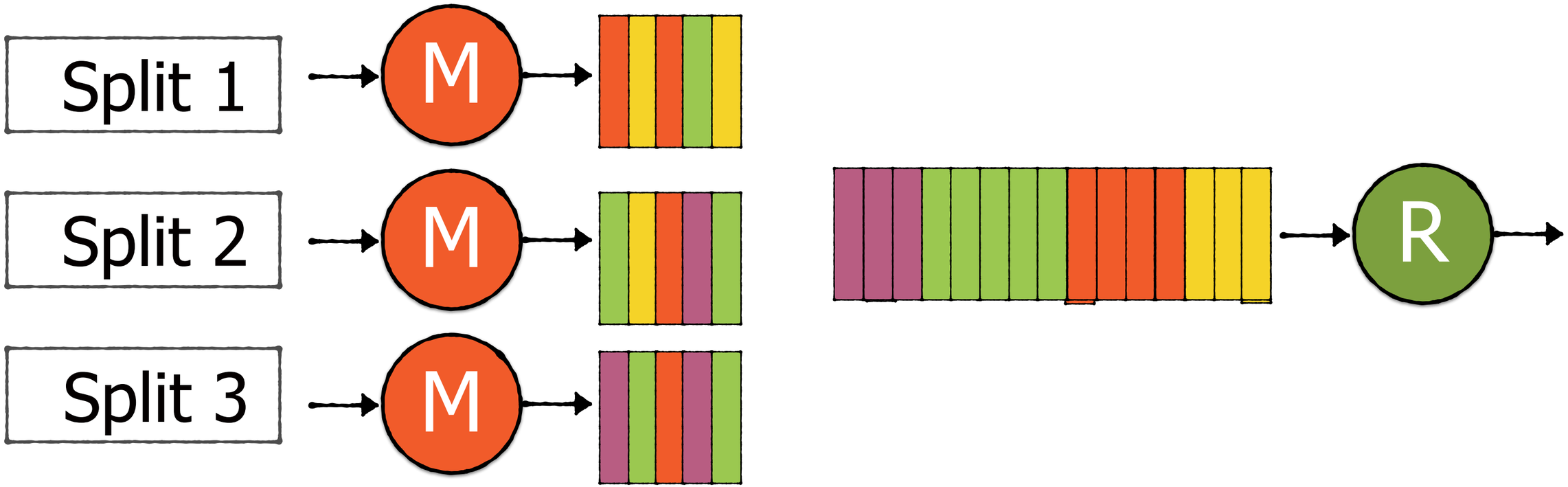


1 Reducer

Behind the Scenes

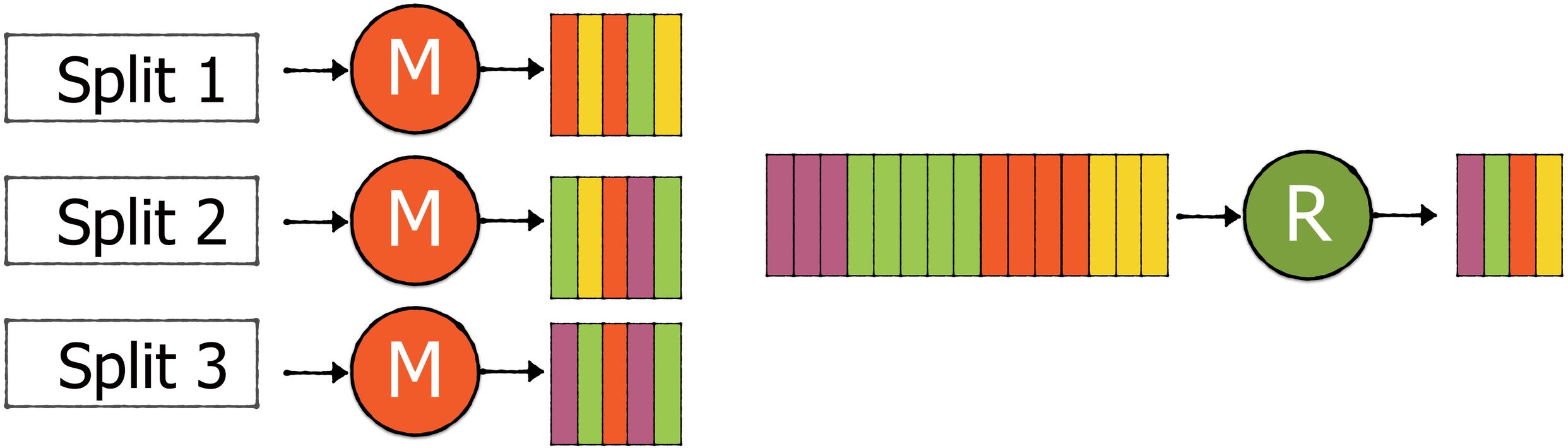


Behind the Scenes



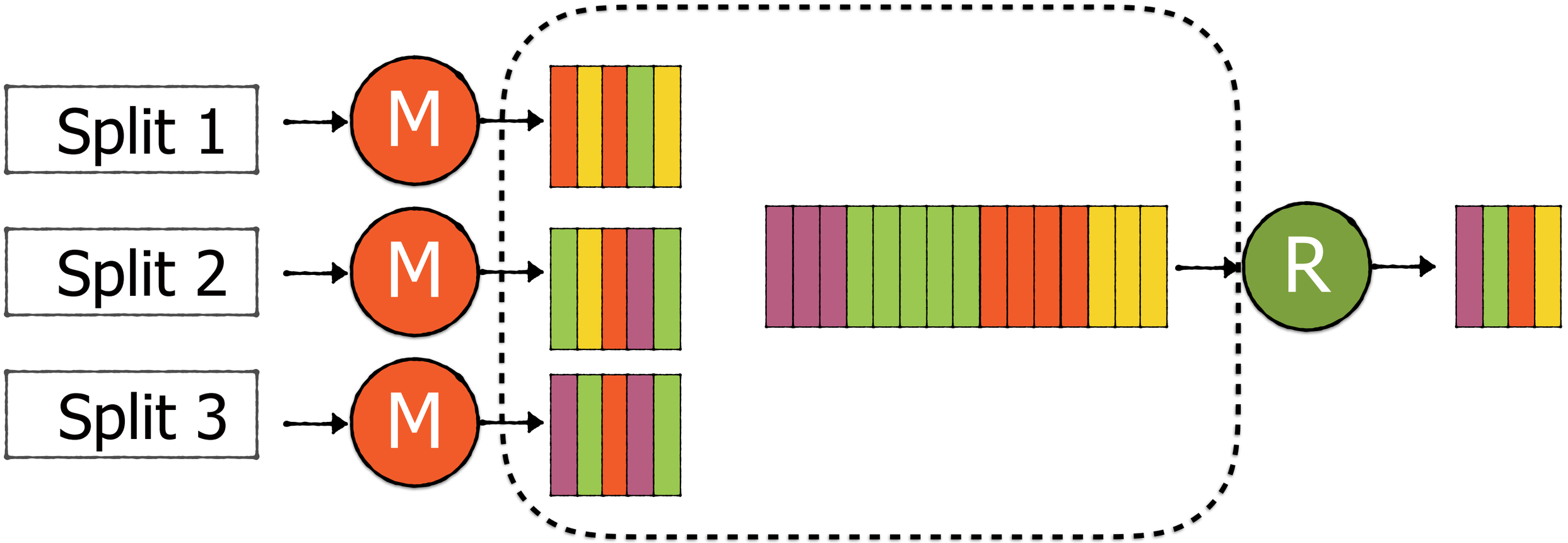
Sort the pairs based on the key

Behind the Scenes



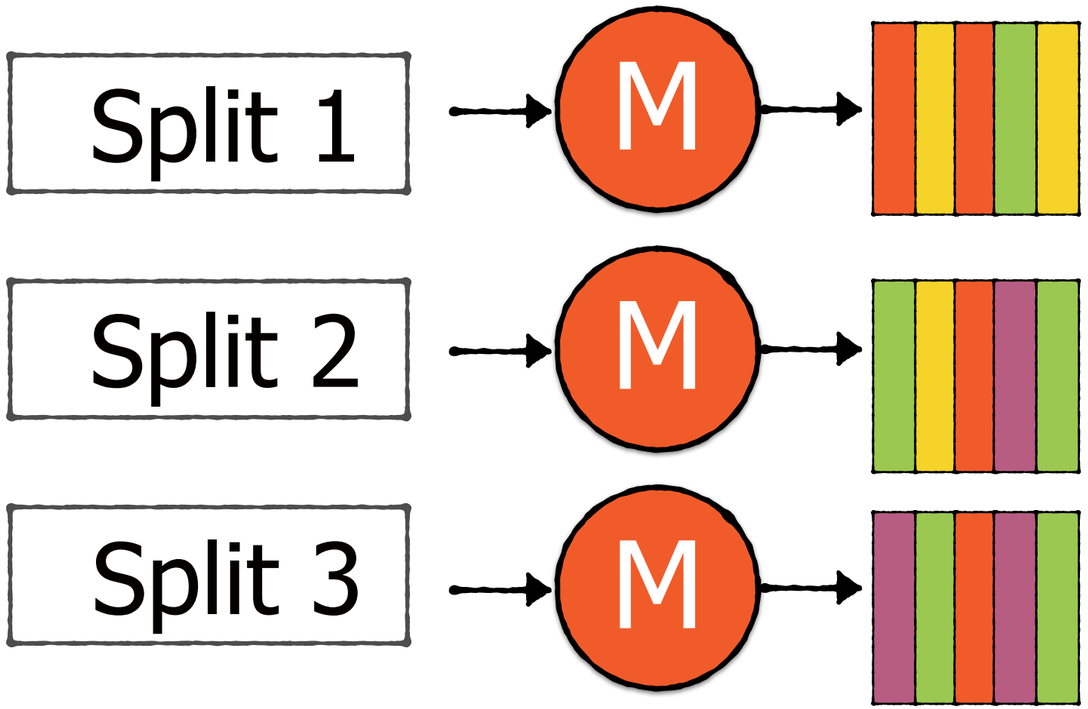
Combine values with the same key

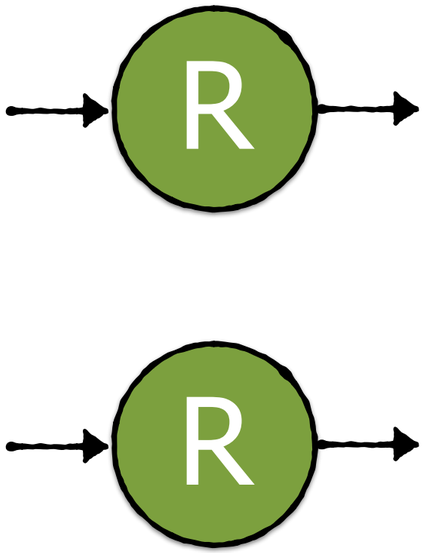
Behind the Scenes



Handled by the framework completely behind the scenes

Behind the Scenes





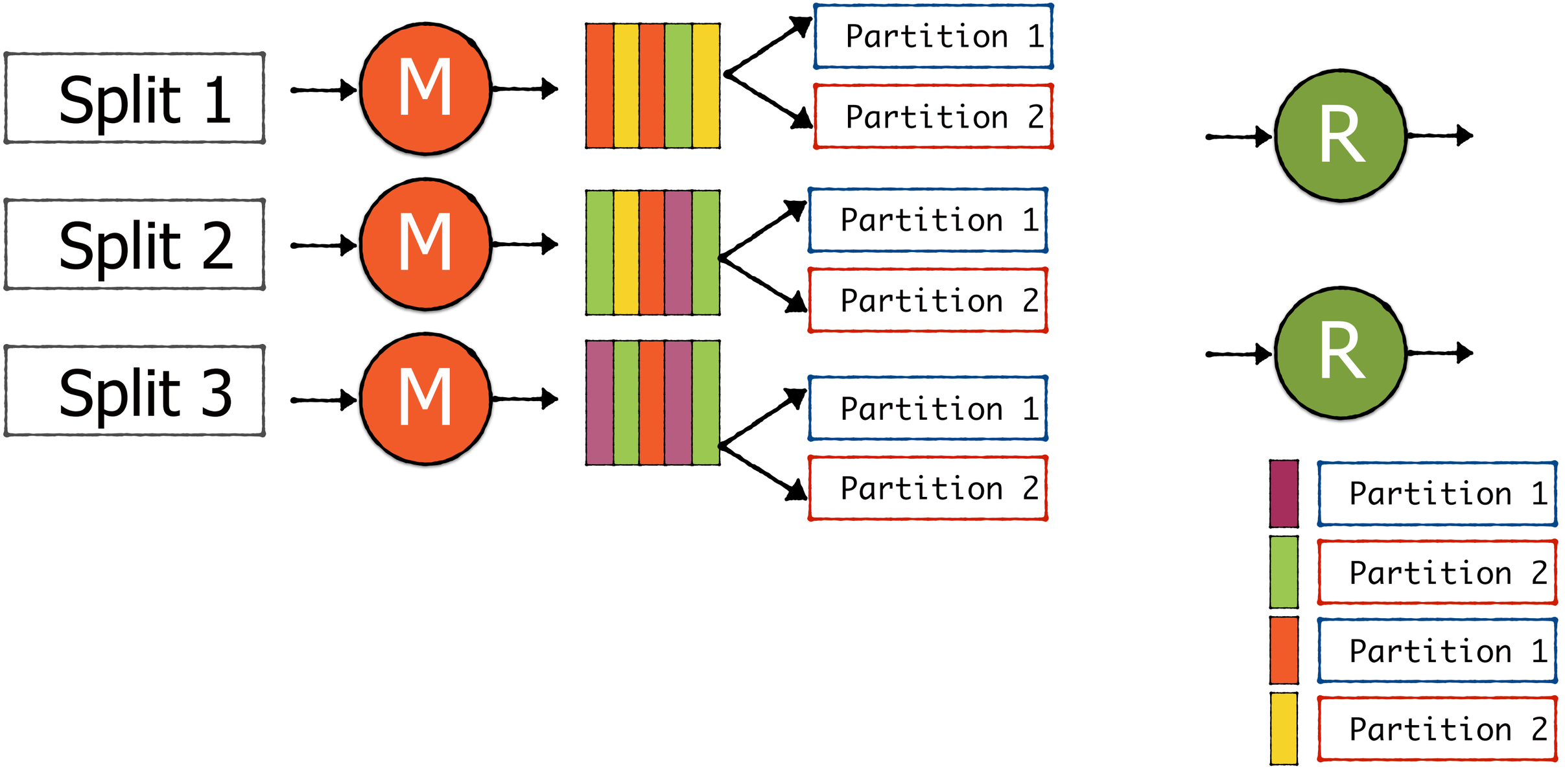
2 Reducers

Assigning Partitions

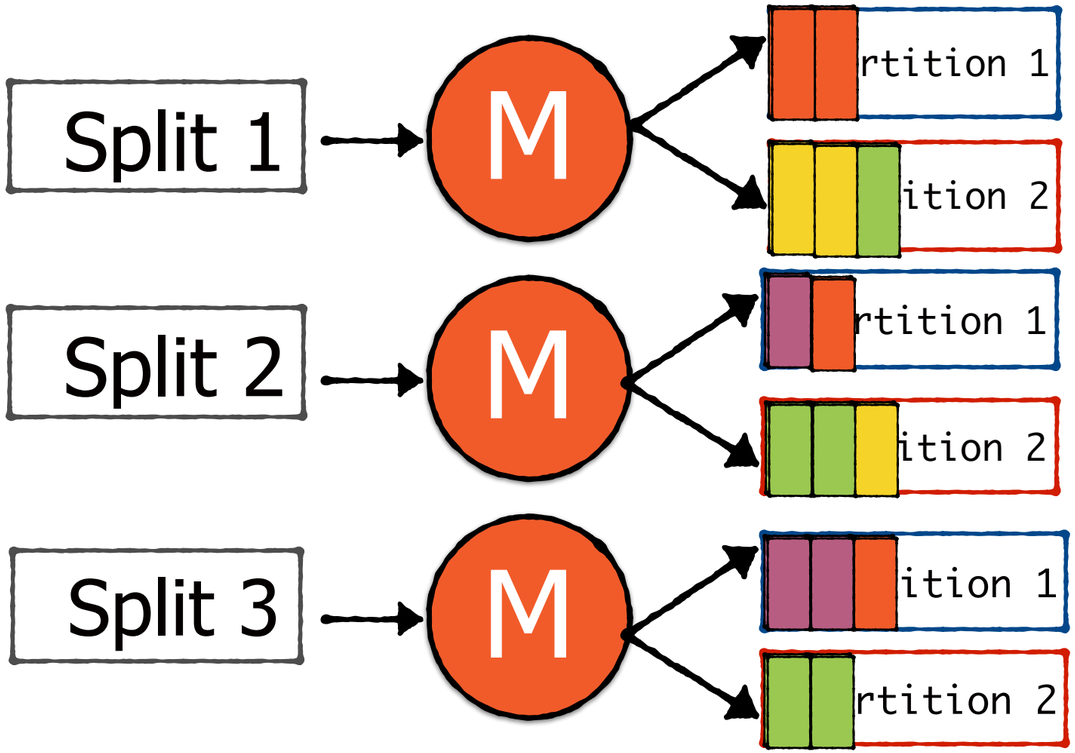
After the map step, each key is assigned to a partition

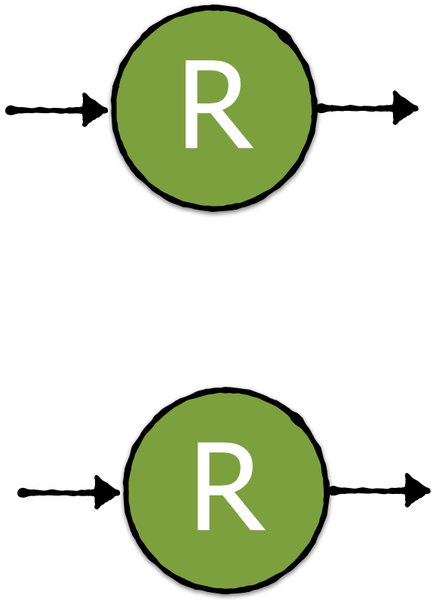
 # Partitions = # Reducers

Behind the Scenes



Behind the Scenes



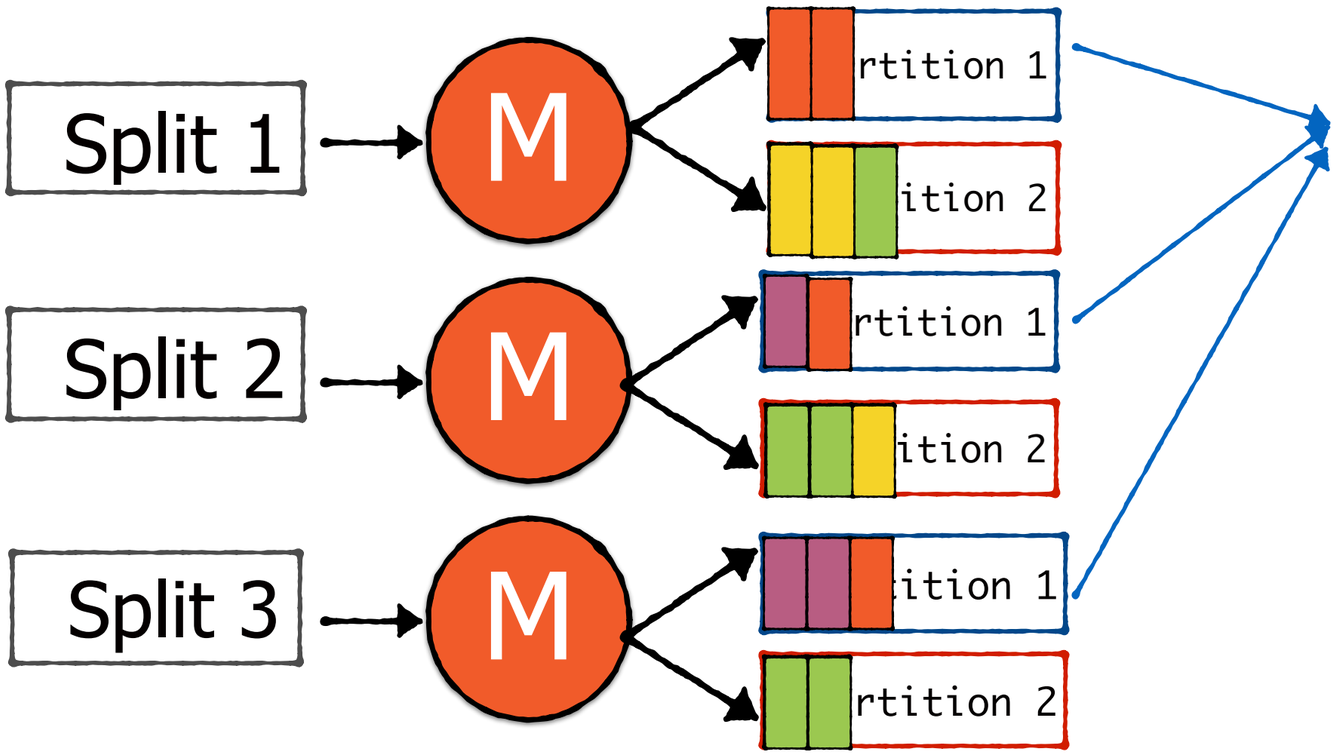


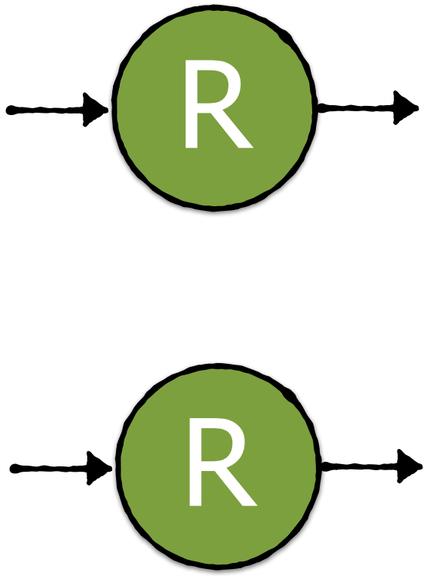
Assigning Partitions

 # Partitions = # Reducers

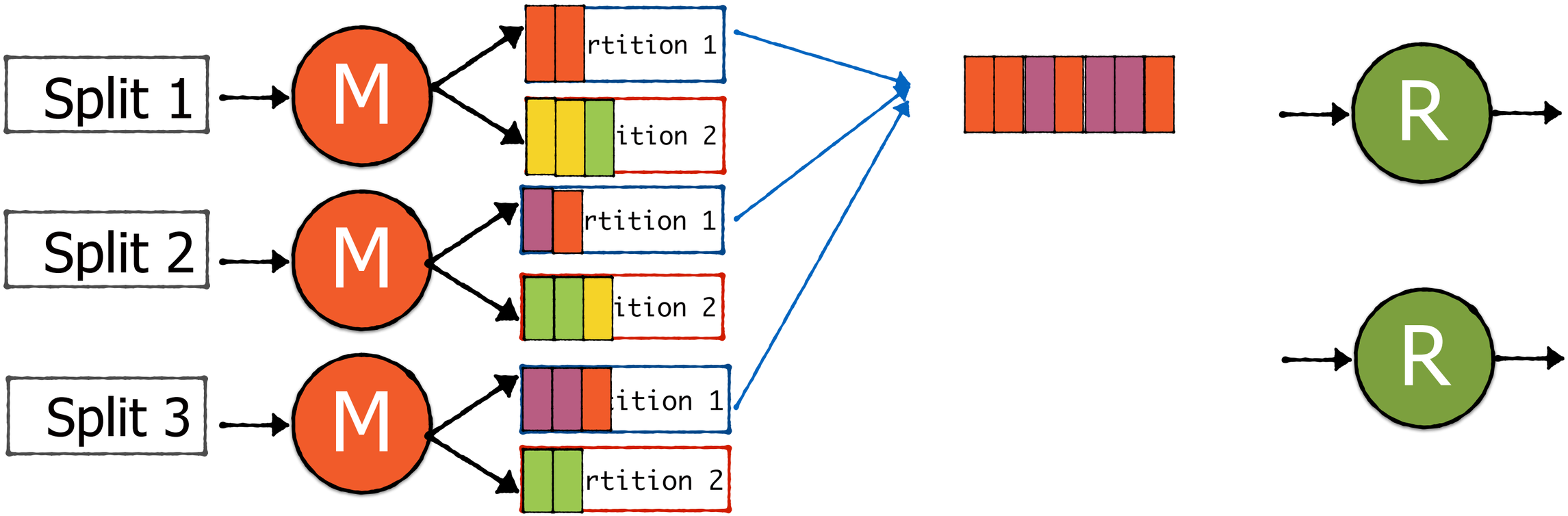
All the results in 1 partition will go to 1 reducer

Behind the Scenes



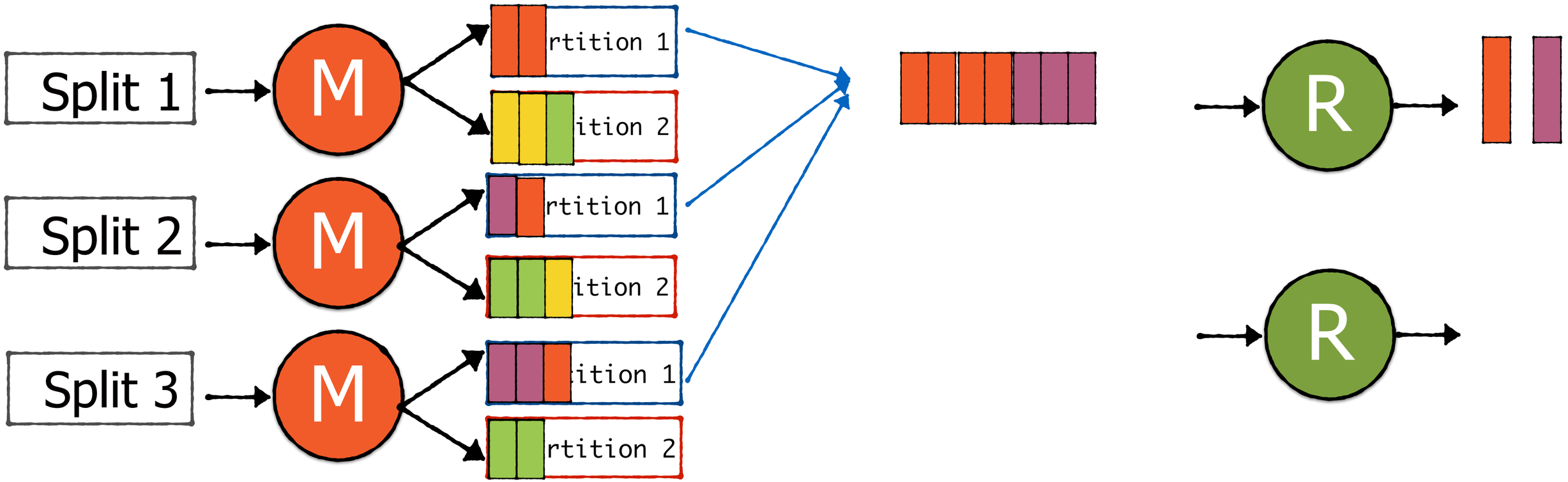


Behind the Scenes



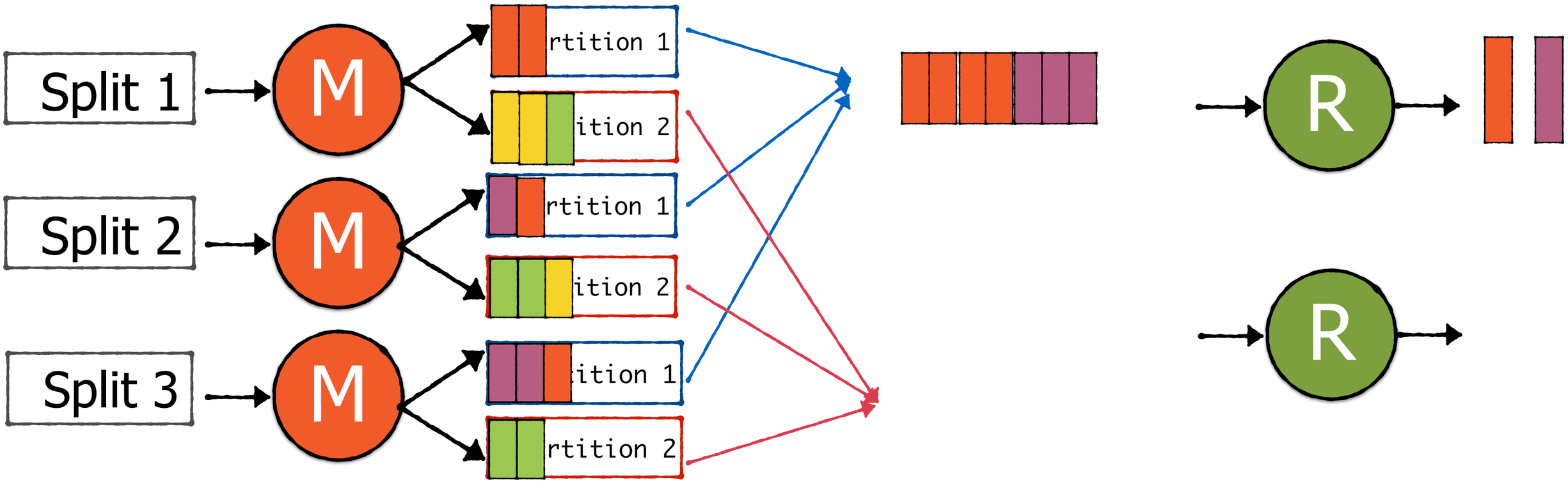
The pairs are also sorted by key

Behind the Scenes



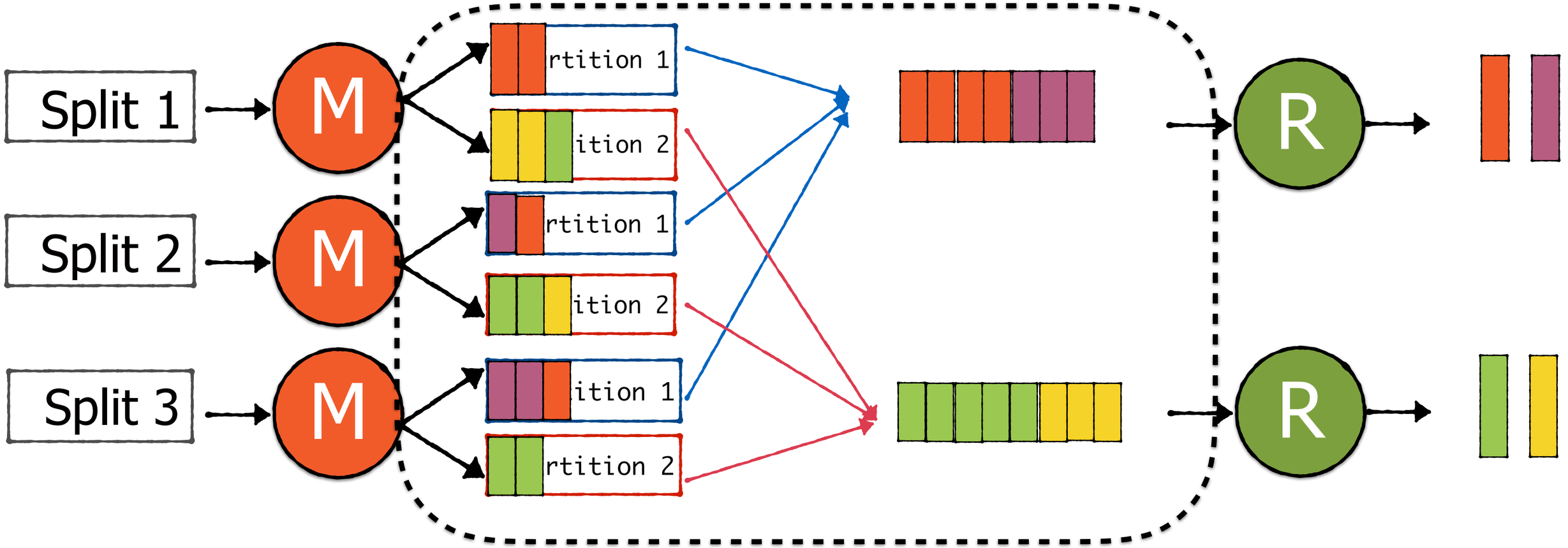
The reducer combines values based on the programmer supplied logic

Behind the Scenes



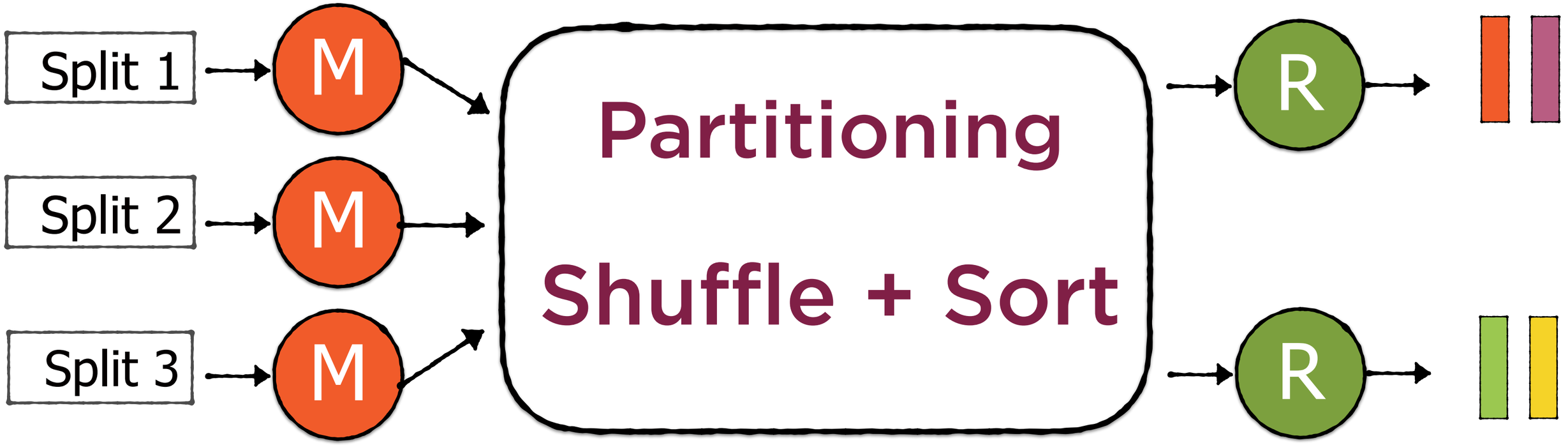
All of this occurs in parallel for each partition, reducer

Behind the Scenes



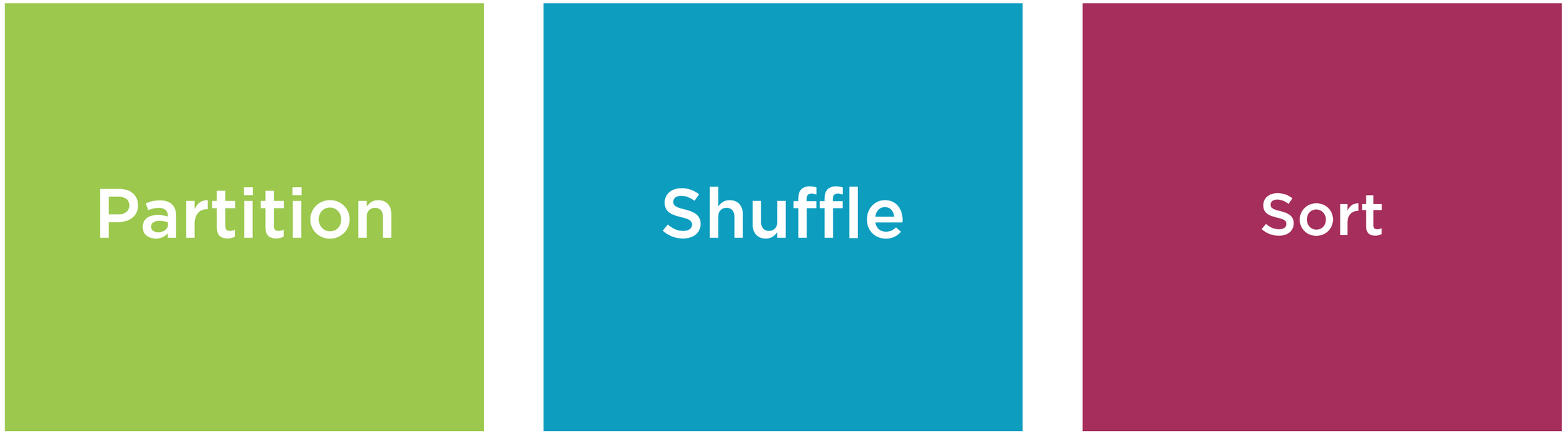
These 2 steps are managed completely behind the scenes

Behind the Scenes



These framework provided features which allow us to control parallelism

Between the Map and Reduce Phases



Three operations performed by the Hadoop MapReduce framework

Partition

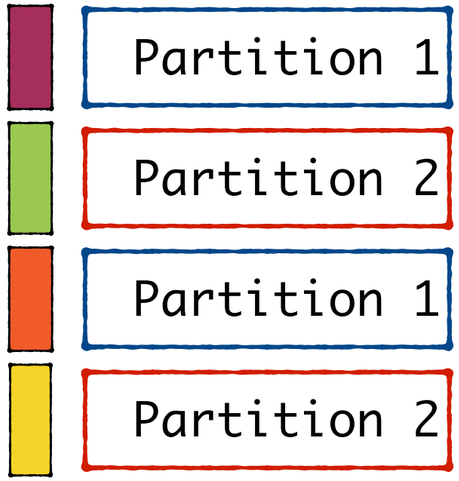
This refers to determining which map output key goes to which partition

Used with multiple reducers

Partition

By default Hadoop uses a hash function on the keys to split them across partitions

Partition



All the results in one partition go to one reducer

Partition

The hash function should be consistent, the same key is always assigned the same partition

How should we choose the number of reducers?

Partition

Choose reducers such that keys are evenly distributed across partitions

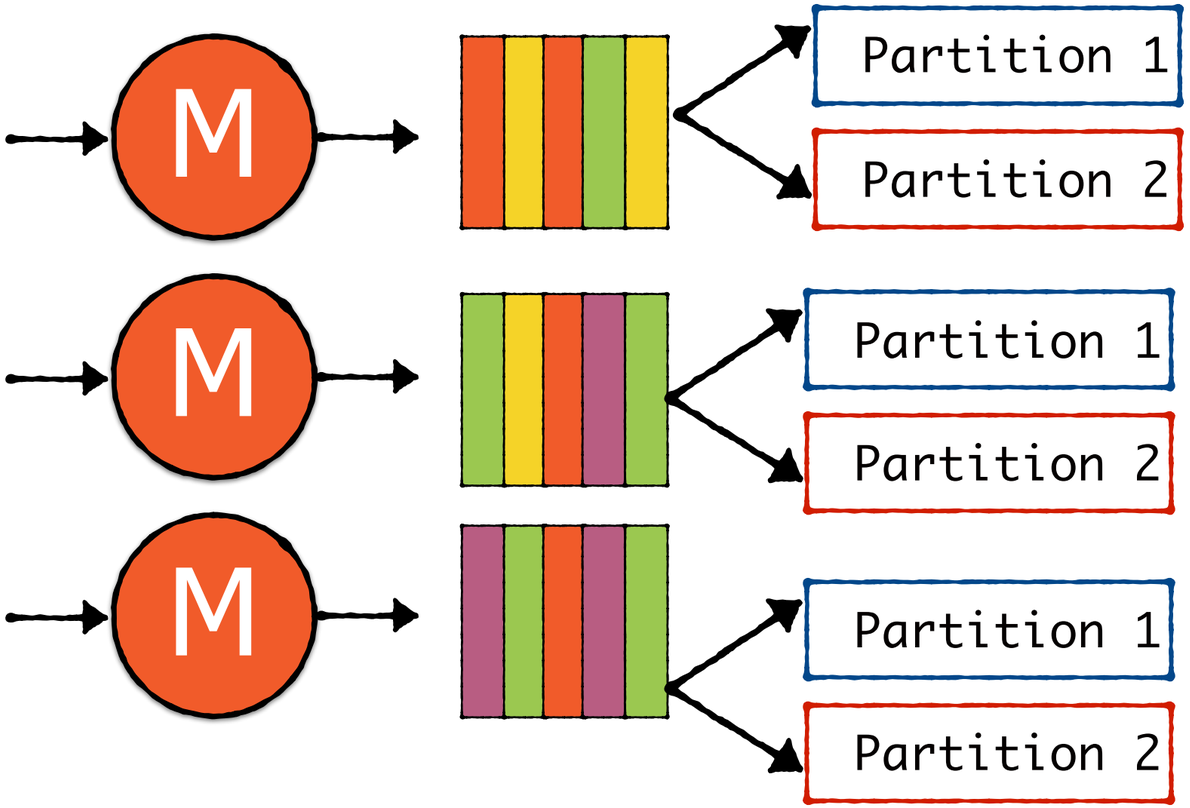
Partition

Hadoop allows you to customize how you partition the data as well

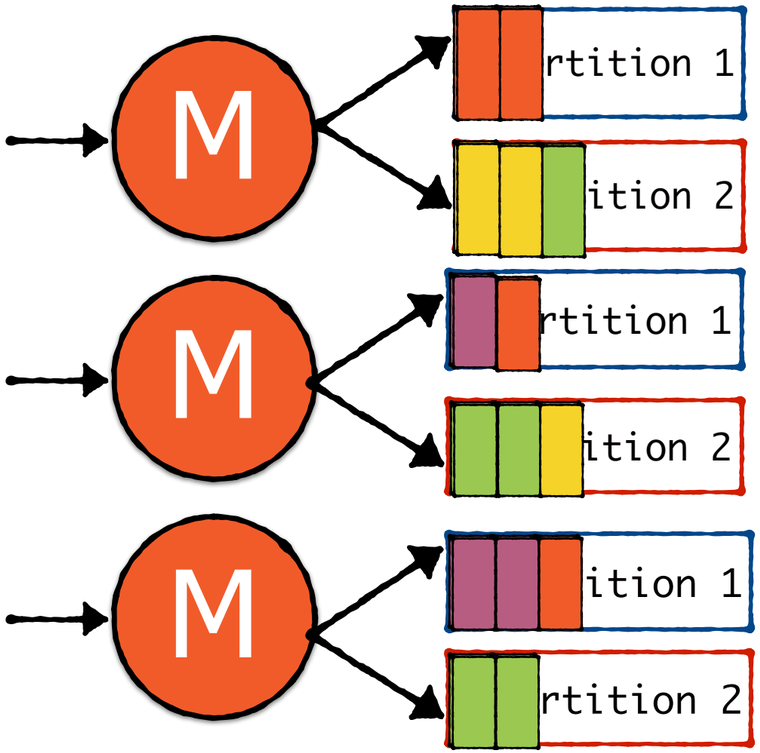
Shuffle

The process of moving data from the mappers to the reducers

Shuffle


M
M
M
Partition 1
Partition 2
Partition 1
Partition 2
Partition 1
Partition 2

Shuffle



Shuffle

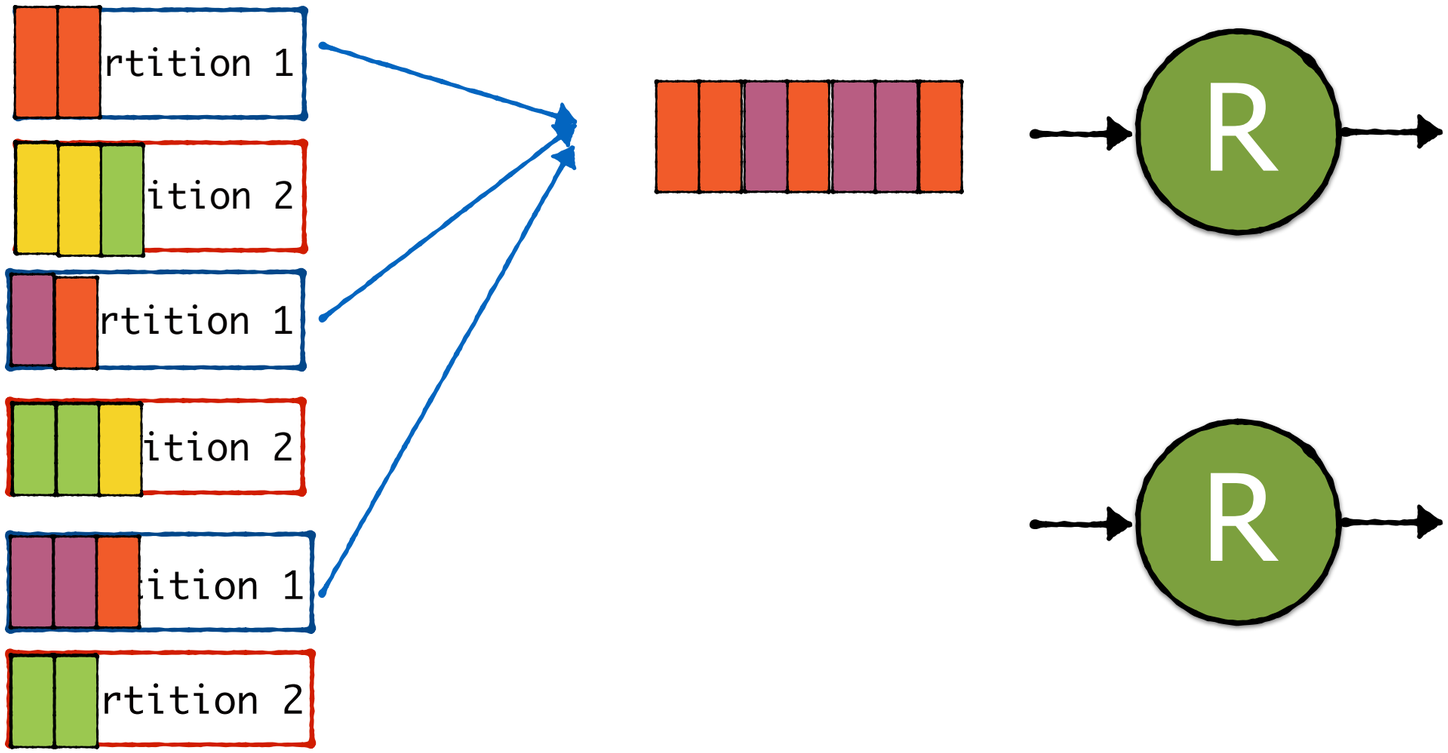
Required so reducers get the data to operate on

Sort

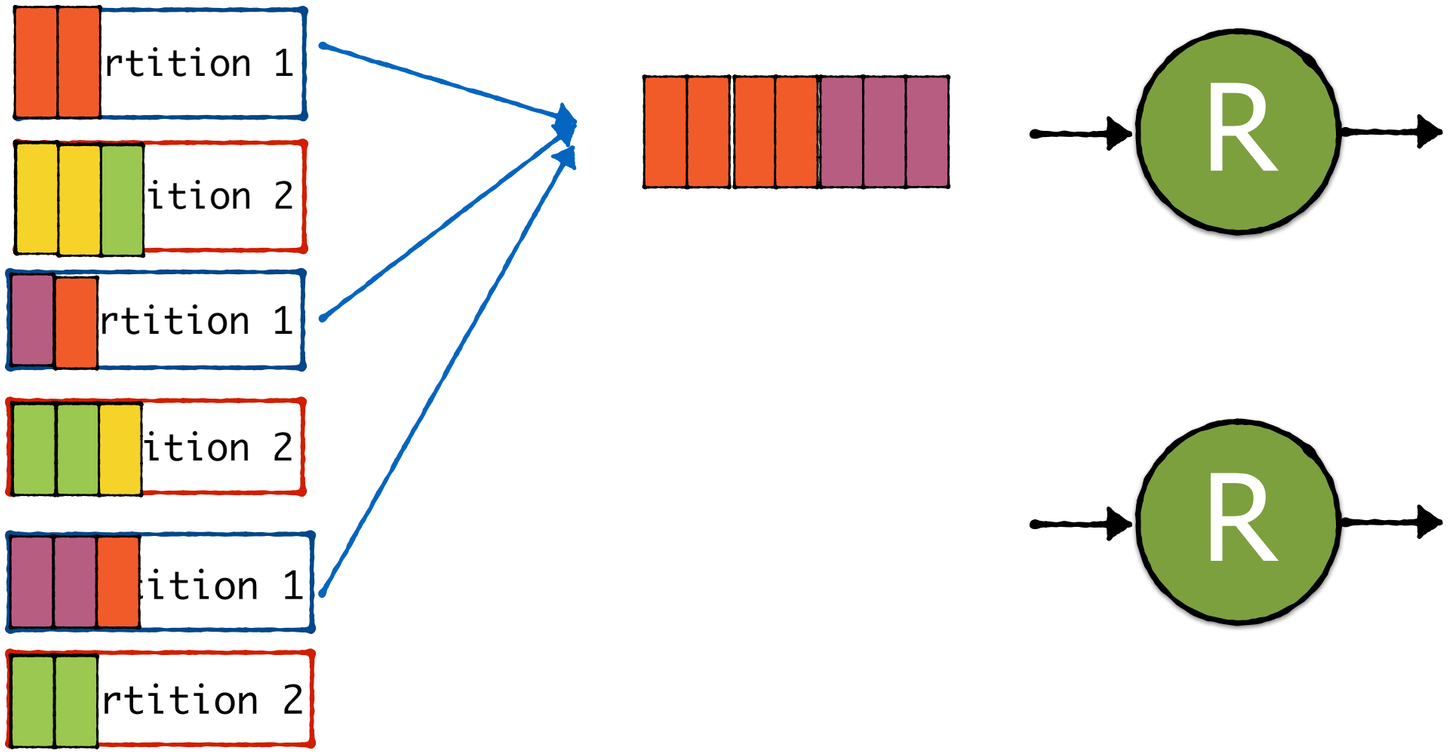
Operation done on the reducer to get all the same keys together in a group

Values with the same key appear as a collection to the reducer

Sort



Sort



Demo

Specify the number of Reducers to run on our MapReduce job

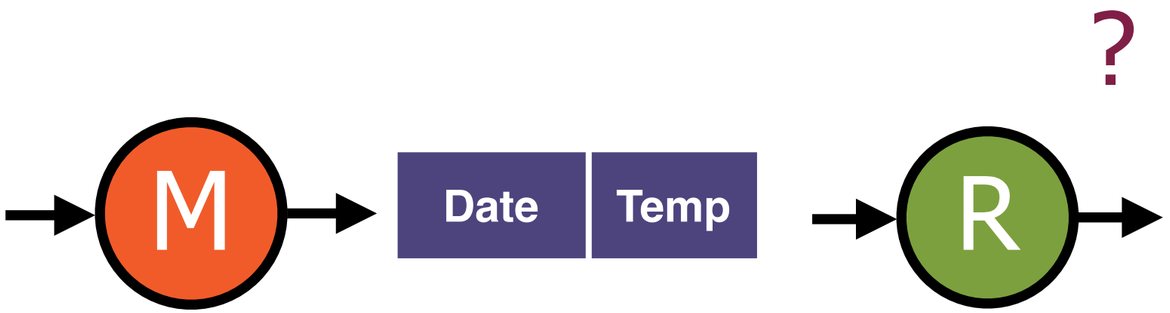
Max Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

What is the maximum recorded temperature on a given day?

Max Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

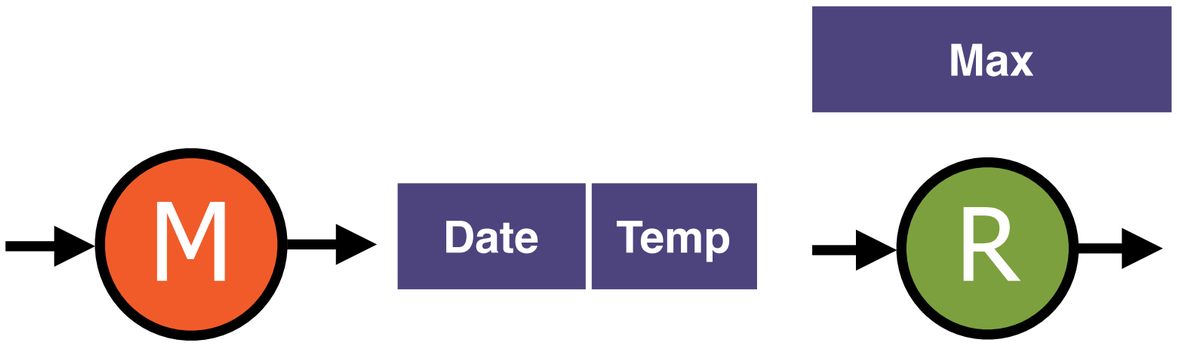


Date	Max Temp
12/12/2015	52
12/13/2015	55

From each record extract the date and the temperature

Max Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

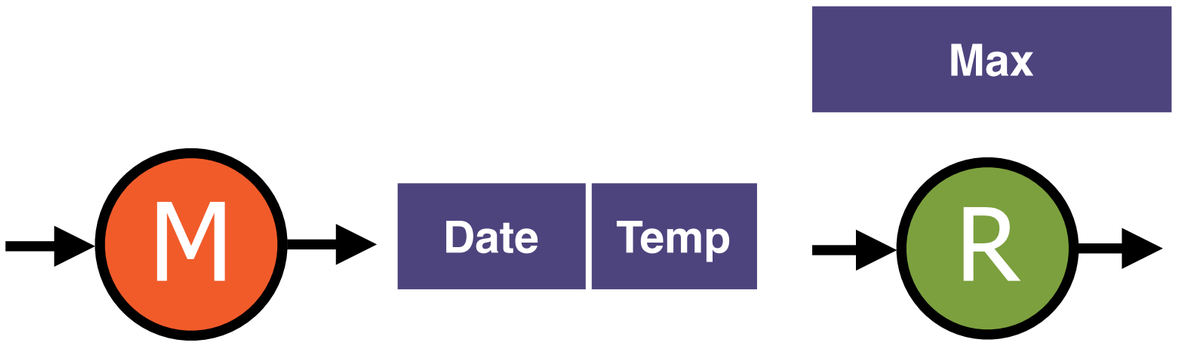


Date	Max Temp
12/12/2015	52
12/13/2015	55

The reduce phase finds the maximum temperature for a particular date

Max Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55



Date	Max Temp
12/12/2015	52
12/13/2015	55

The original data is likely to be split across multiple machines - the input splits

Max Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

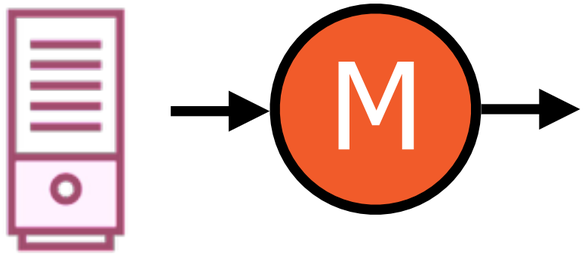
Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52

Date	Time	Temp
12/12/2015	02:00	49
12/13/2015	00:00	48

Date	Time	Temp
12/13/2015	01:00	54
12/13/2015	02:00	55

Max Temperature in a Day

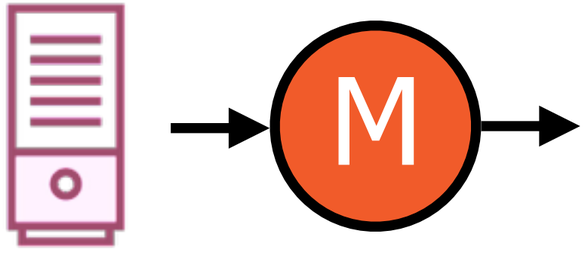
Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52



{“12/12/2015”, 50}

{“12/12/2015”, 52}

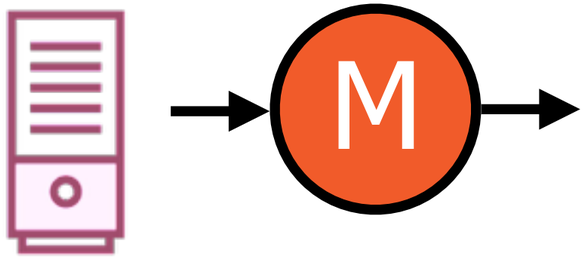
Date	Time	Temp
12/12/2015	02:00	49
12/13/2015	00:00	48



{“12/12/2015”, 49}

{“12/13/2015”, 48}

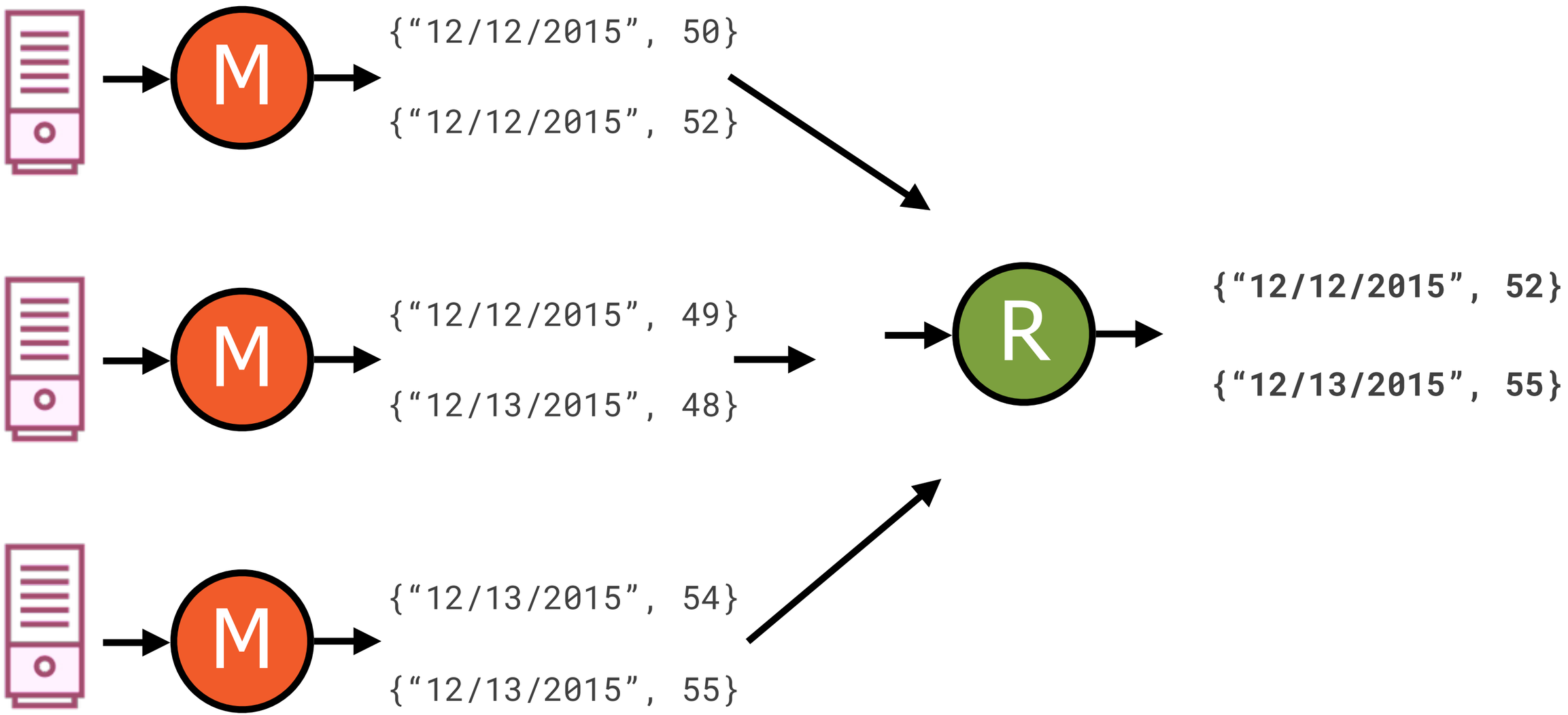
Date	Time	Temp
12/13/2015	01:00	54
12/13/2015	02:00	55



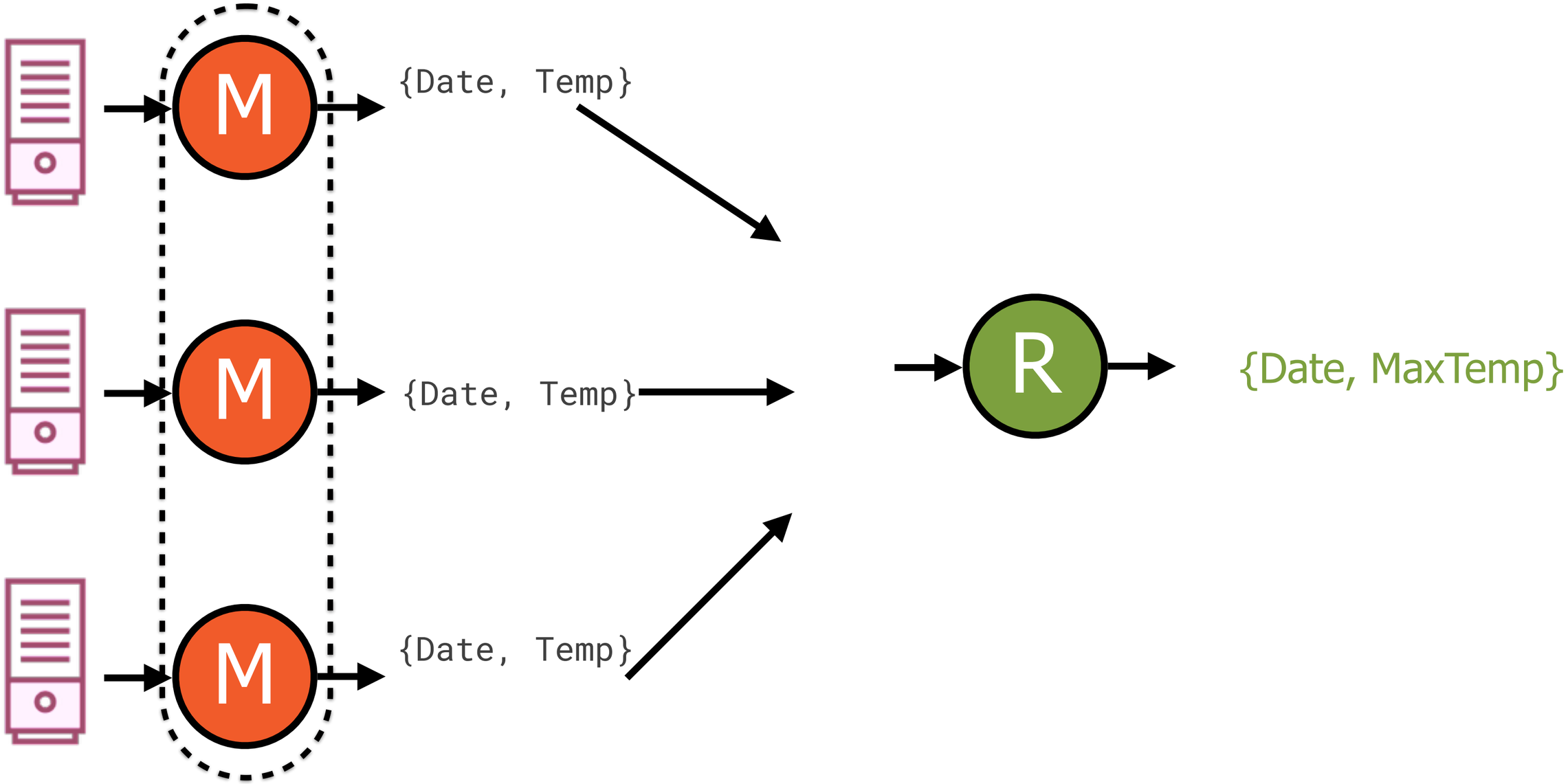
{“12/13/2015”, 54}

{“12/13/2015”, 55}

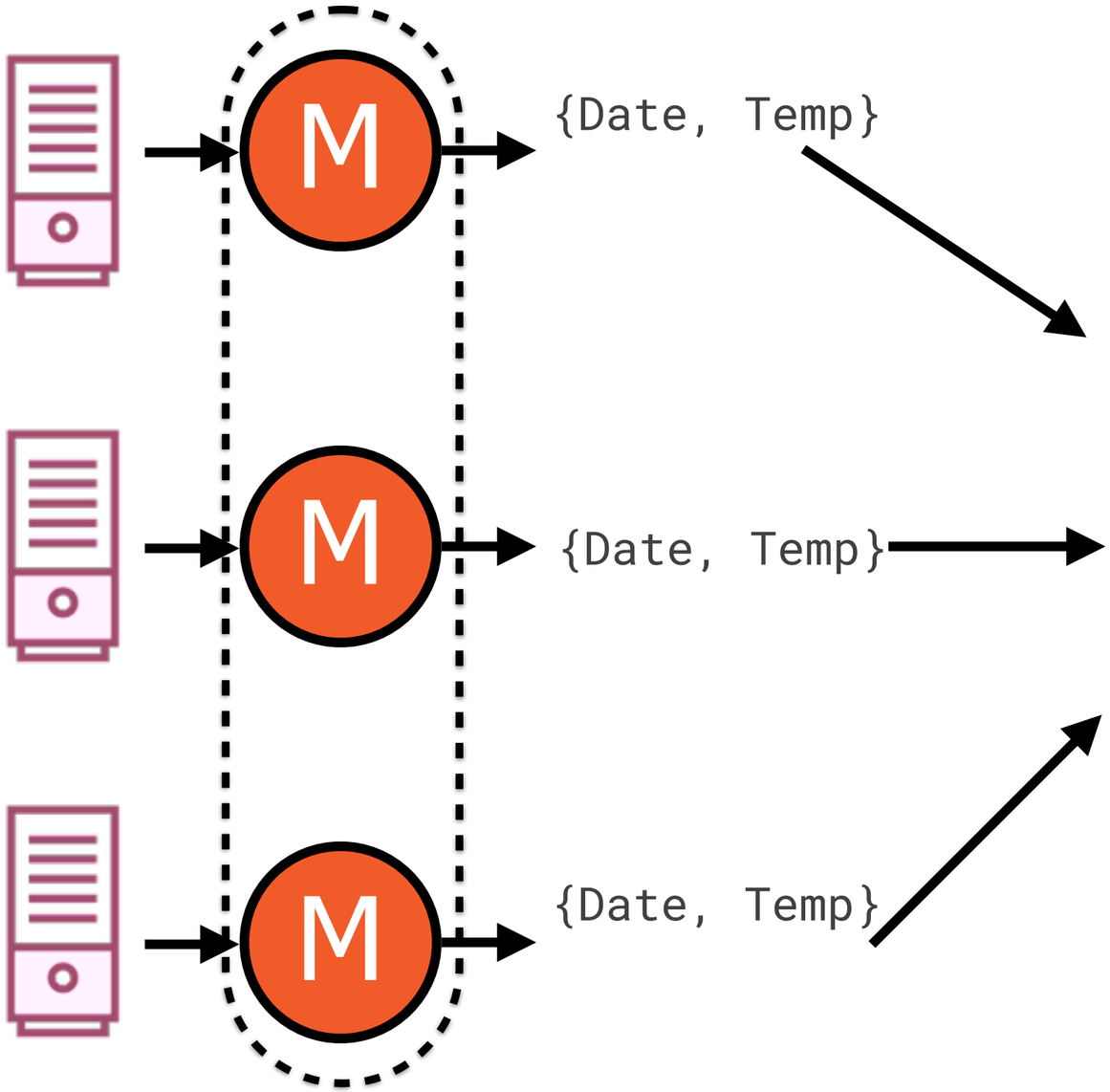
Max Temperature in a Day



Typical MapReduce Flow

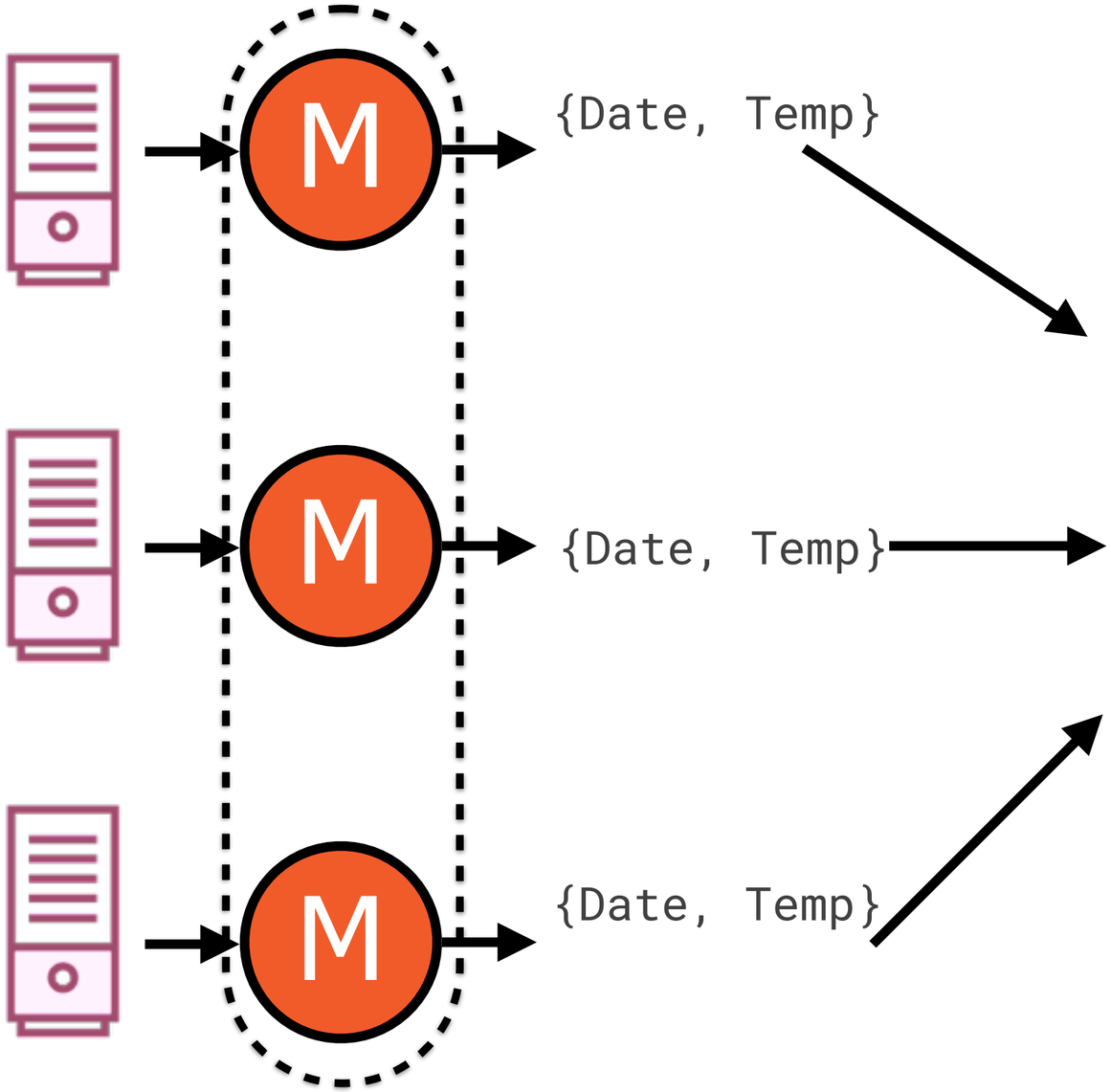


Typical MapReduce Flow



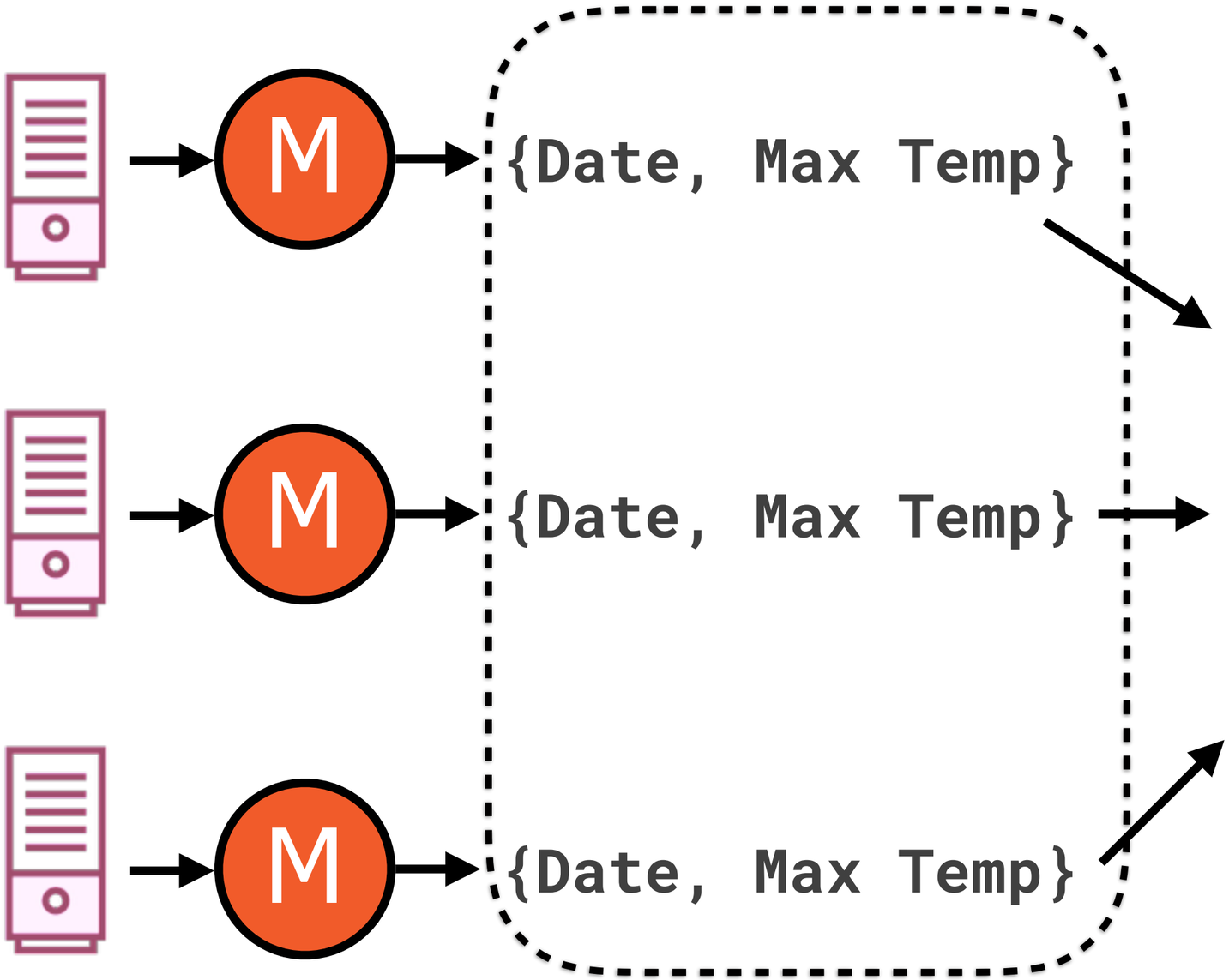
The map phase does the bare minimum needed to get the maximum temperature

Typical MapReduce Flow



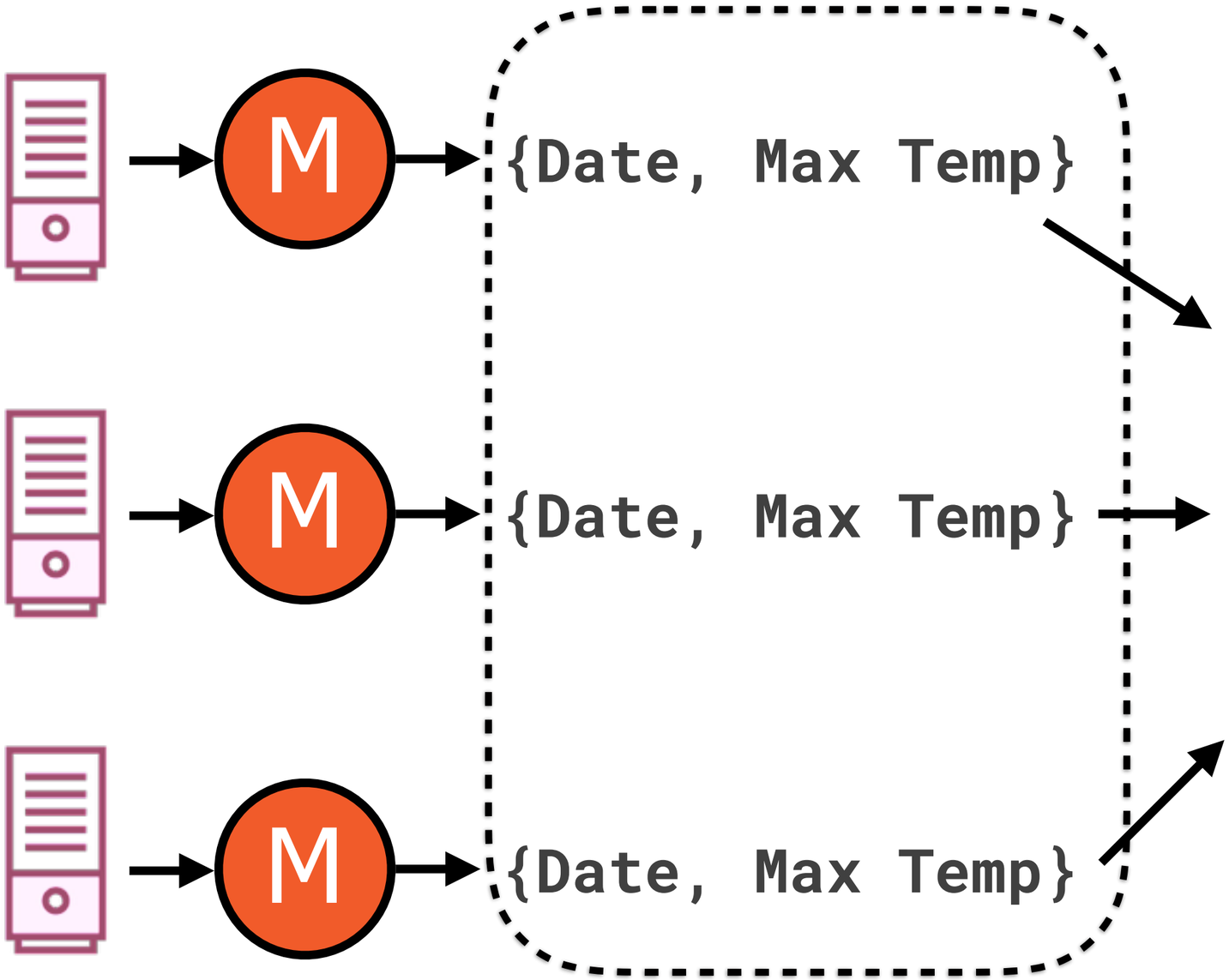
It could do more

Typical MapReduce Flow



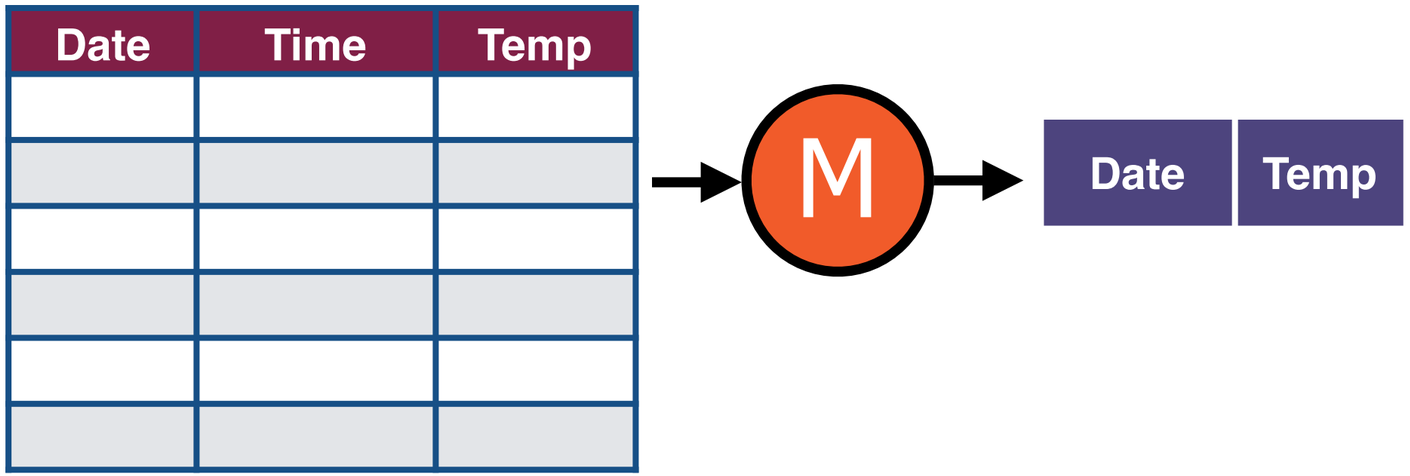
What if we could implement some combining logic at the map stage itself?

Typical MapReduce Flow



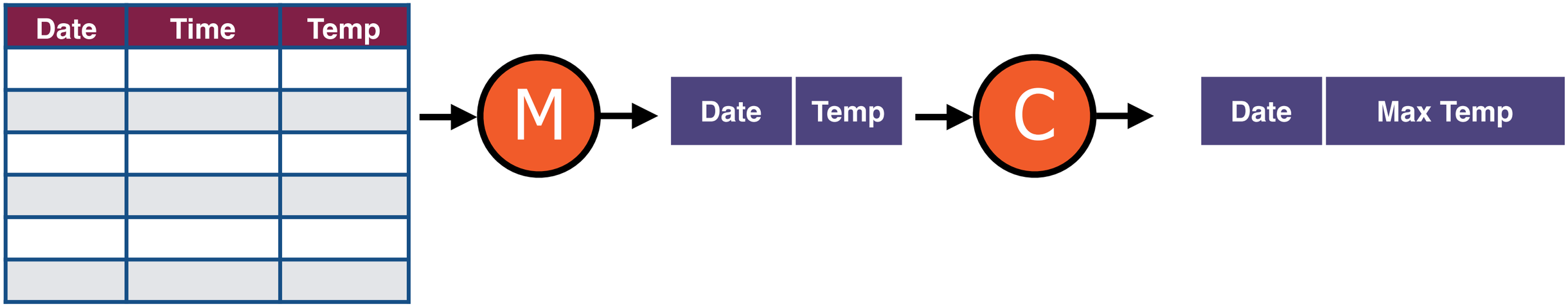
A combiner performs a part of the reduce step on the map node

Combiner Function



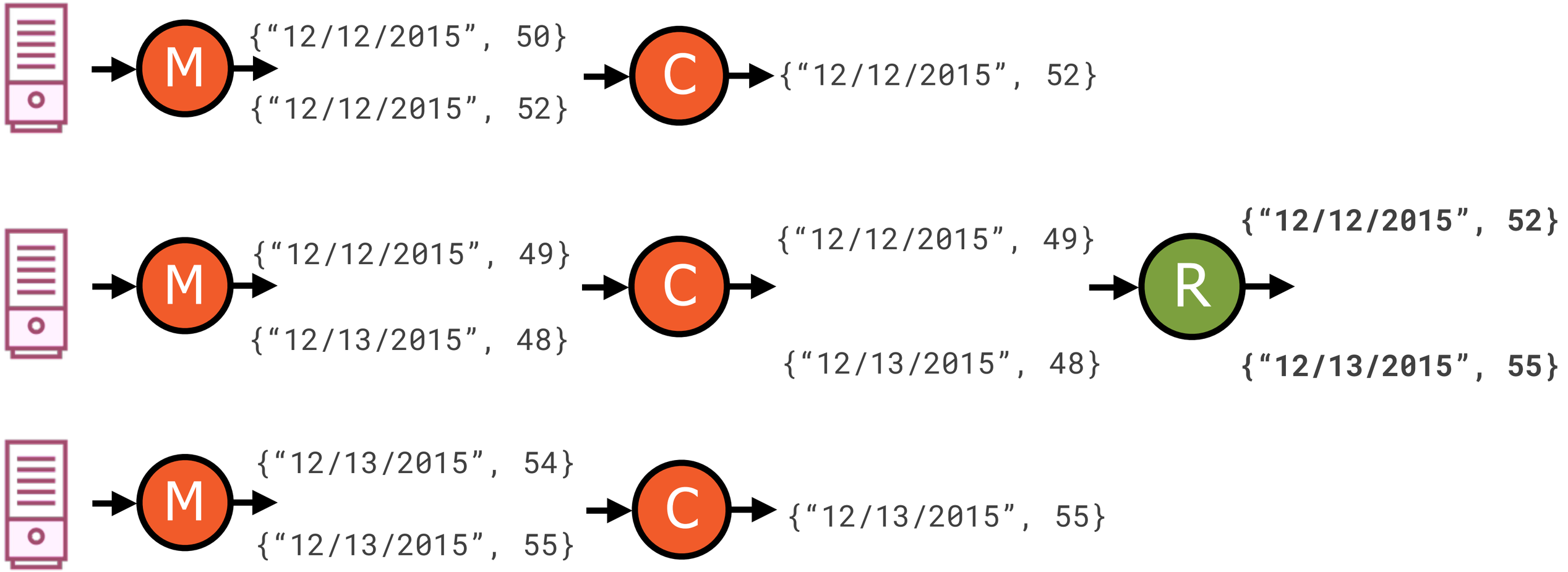
1 Mapper

Combiner Function

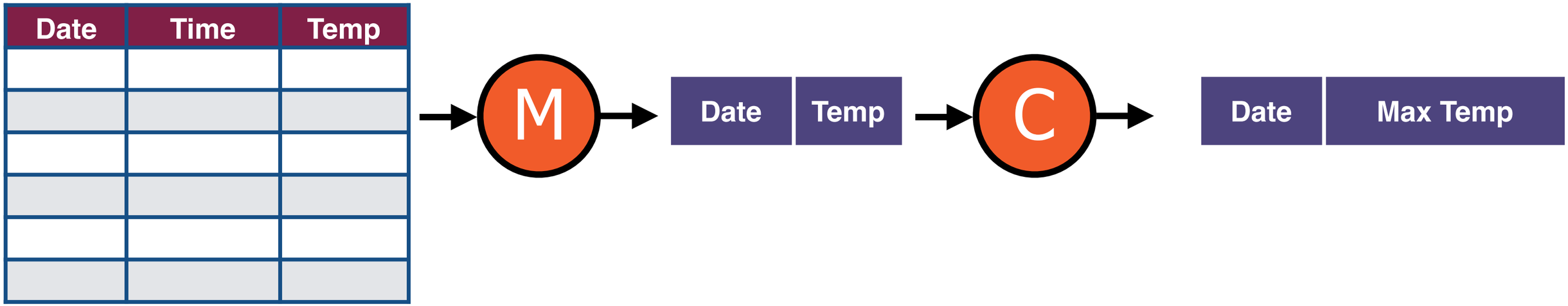


Combine values with the same key before they are copied over to the reducer

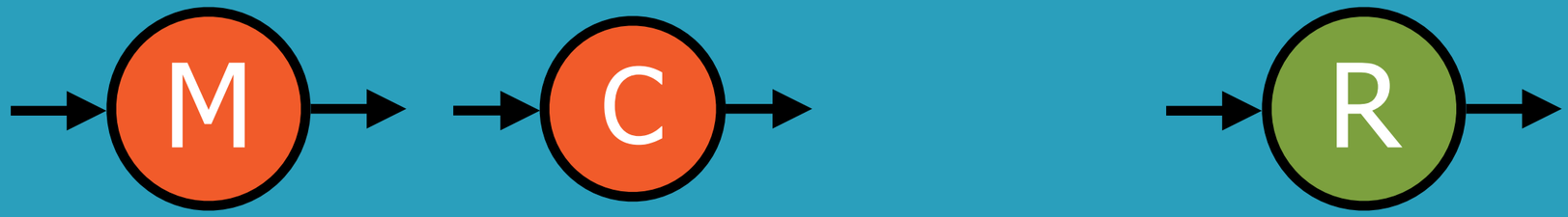
Combiner Function



Combiner Function



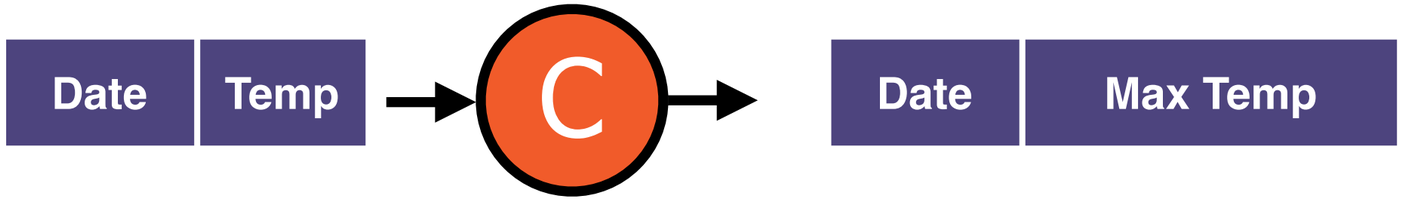
Combine values with the same key before they are copied over to the reducer



A combiner works on the mapper output before it is sent to the reducer

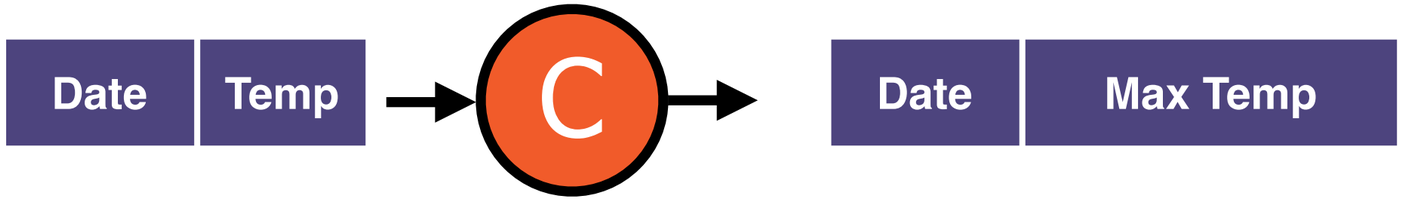
Combiner Function

This is the same logic that happens in the Reducer!



Combiner Function

We can use the Reducer class directly as the Combiner



Demo

Use the Reduce class as the combiner in our ViewCount MapReduce

What Are the Advantages of Combiners?

Improve parallelism

Reduce data transfer

Improve parallelism

More processing on the map node

Multiple map nodes means greater processing in parallel

Reduce data transfer

Results in fewer key, value pairs in the map output

Less data transfer to the reducer node

But...

Use combiners with caution

No impact on the final result

The result of the MapReduce with and without combiners should be the same

The combiners should not change the logic of the processing

Reducers as Combiners

Maximum

Minimum

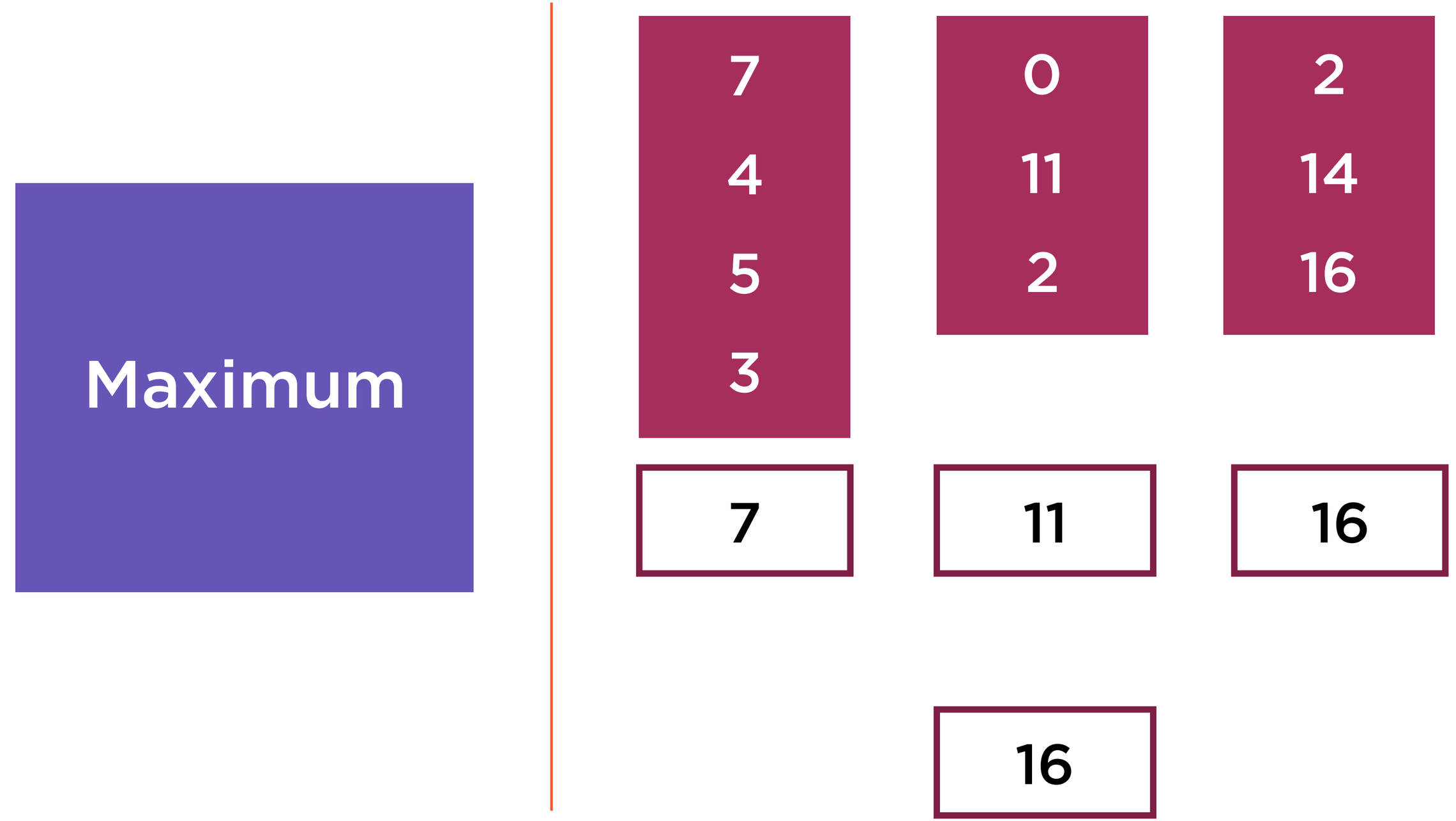
Sum

The combiner performs the same operation as the reducer

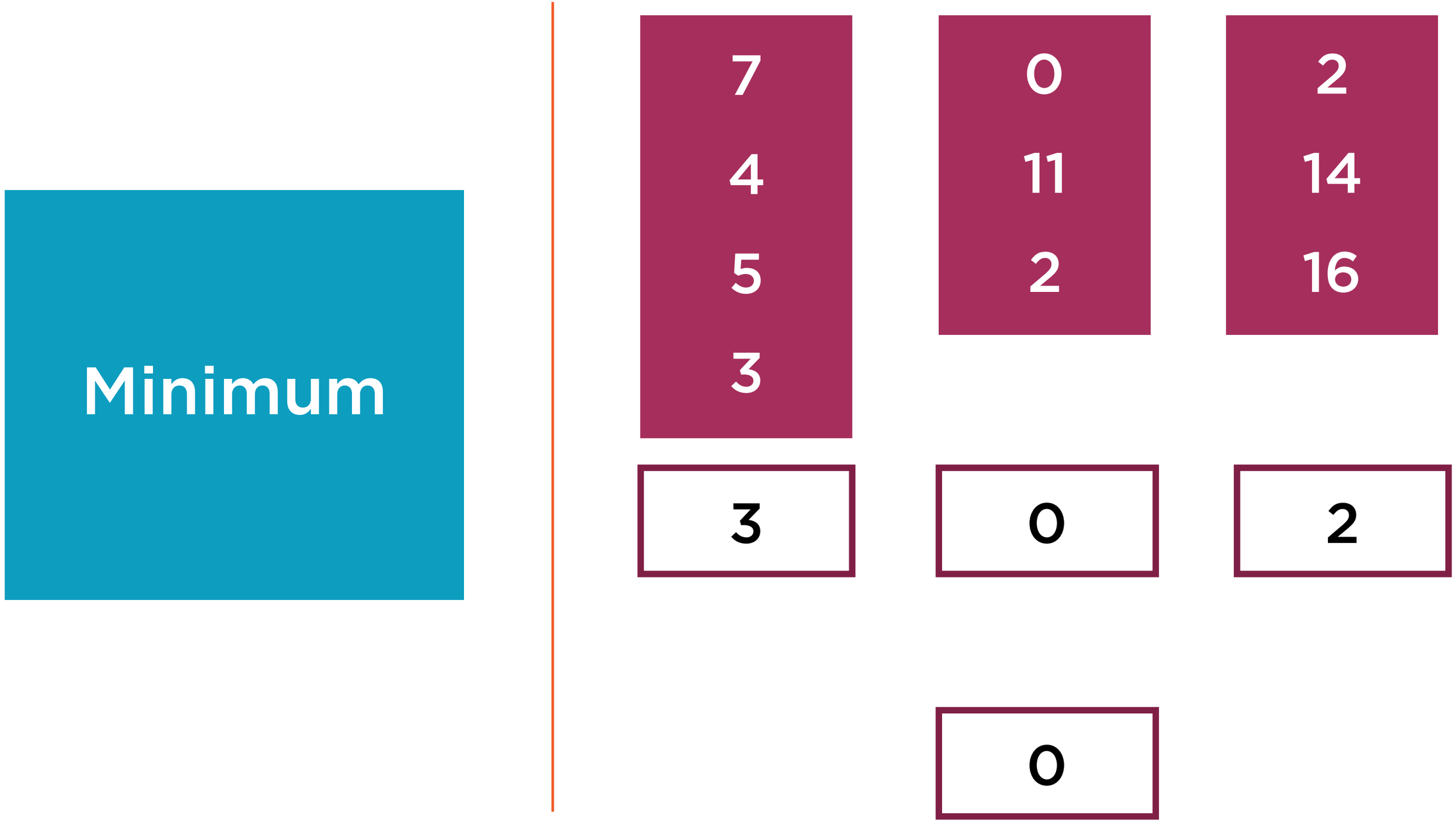
Maximum

We've seen a detailed example of how the Combiner process is exactly the same as the Reducer

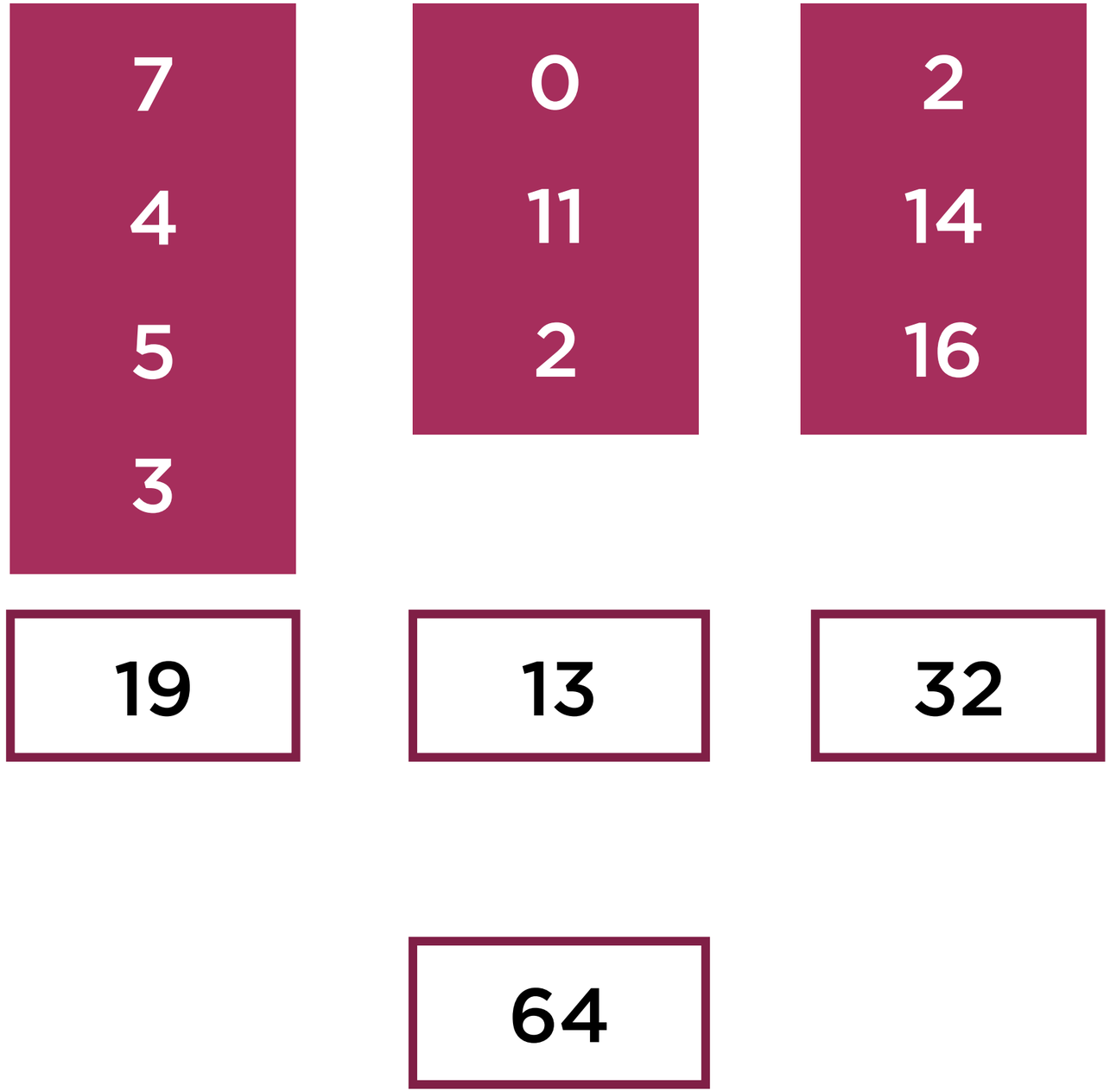
Maximum



Minimum



Sum



Reducers as Combiners

Maximum

Minimum

Sum

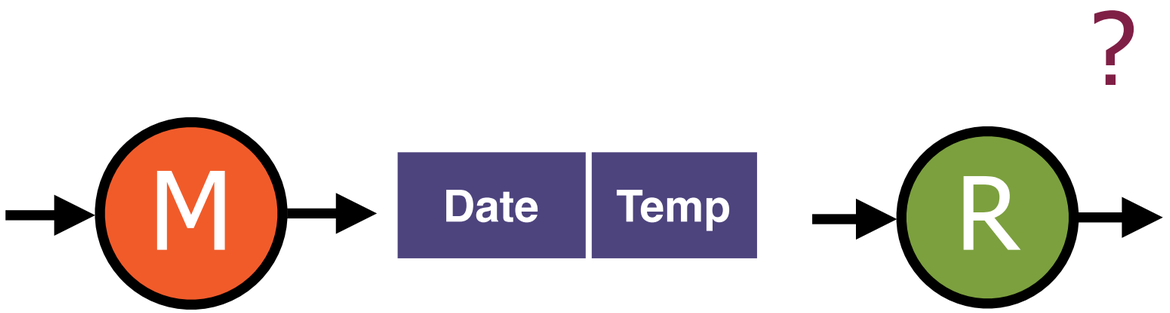
The combiner performs the same operation as the reducer

Reducers as Combiners

Combiner and reducer functions have to be different!

Average Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55



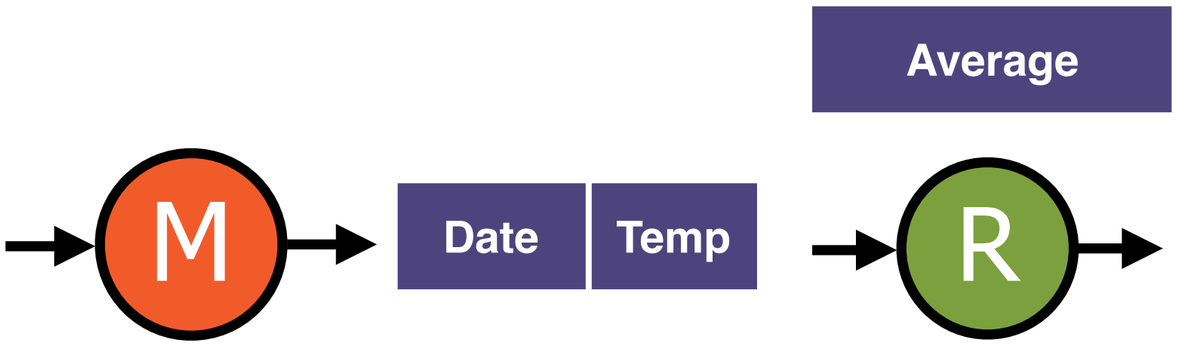
Date	Avg Temp
12/12/2015	50.3
12/13/2015	52.3

From each record
extract the date and
the temperature

Without a combiner

Average Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

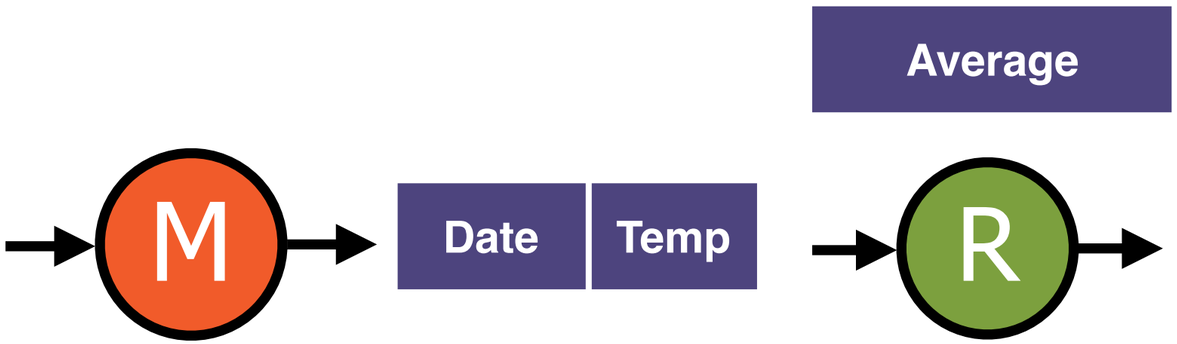


Date	Avg Temp
12/12/2015	52
12/13/2015	55

The reduce phase finds the average temperature for a particular date

Average Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

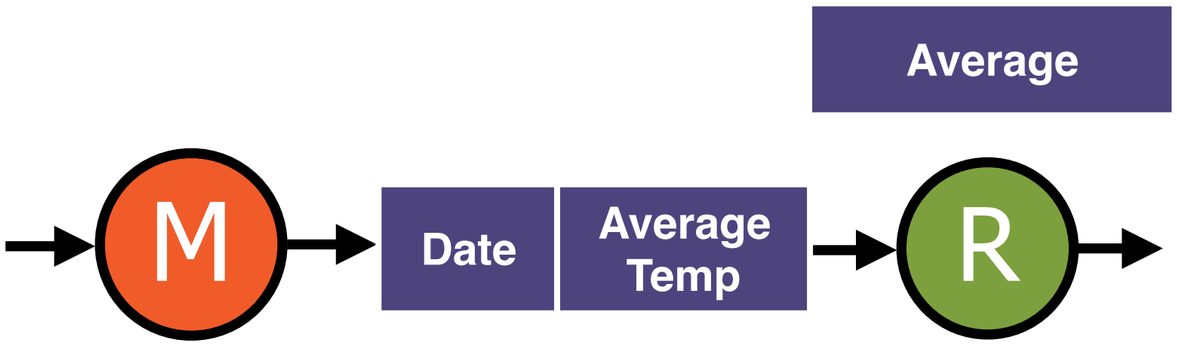


Date	Avg Temp
12/12/2015	52
12/13/2015	55

What if we used the Reducer as the combiner function?

Average Temperature in a Day

Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55

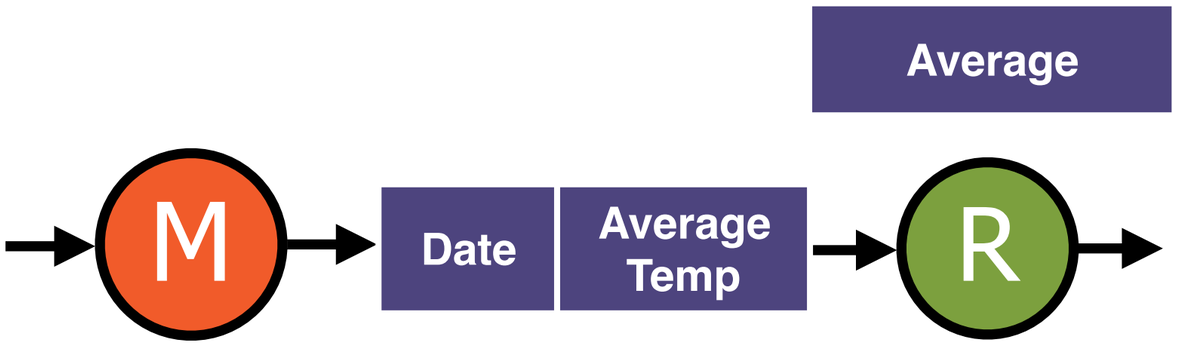


Date	Avg Temp
12/12/2015	52
12/13/2015	55

What if we used the Reducer as the combiner function?

Average Temperature in a Day

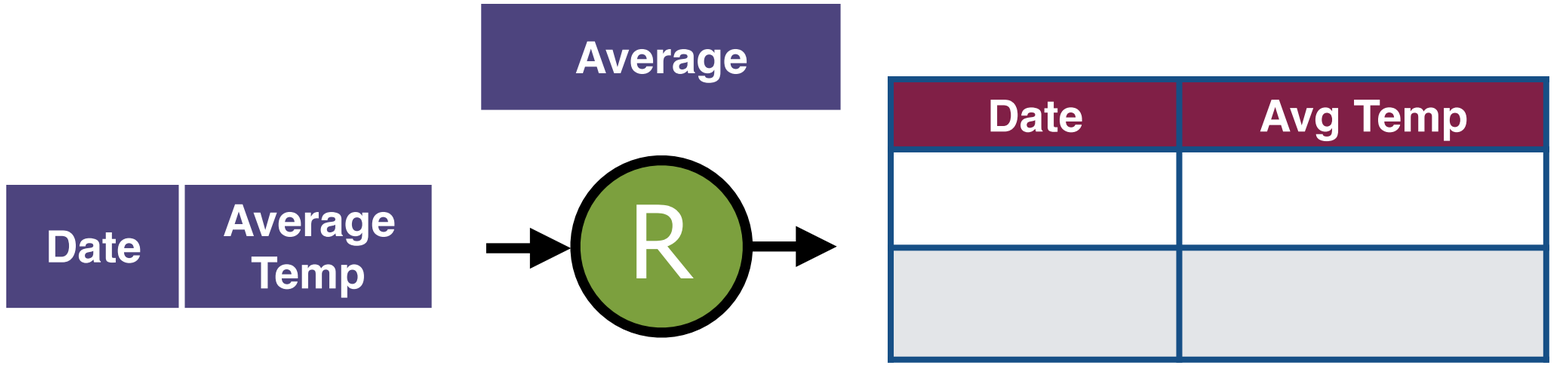
Date	Time	Temp
12/12/2015	00:00	50
12/12/2015	01:00	52
12/12/2015	02:00	49
12/13/2015	00:00	48
12/13/2015	01:00	54
12/13/2015	02:00	55



Date	Avg Temp
12/12/2015	52
12/13/2015	55

This is wrong!

Average Temperature in a Day

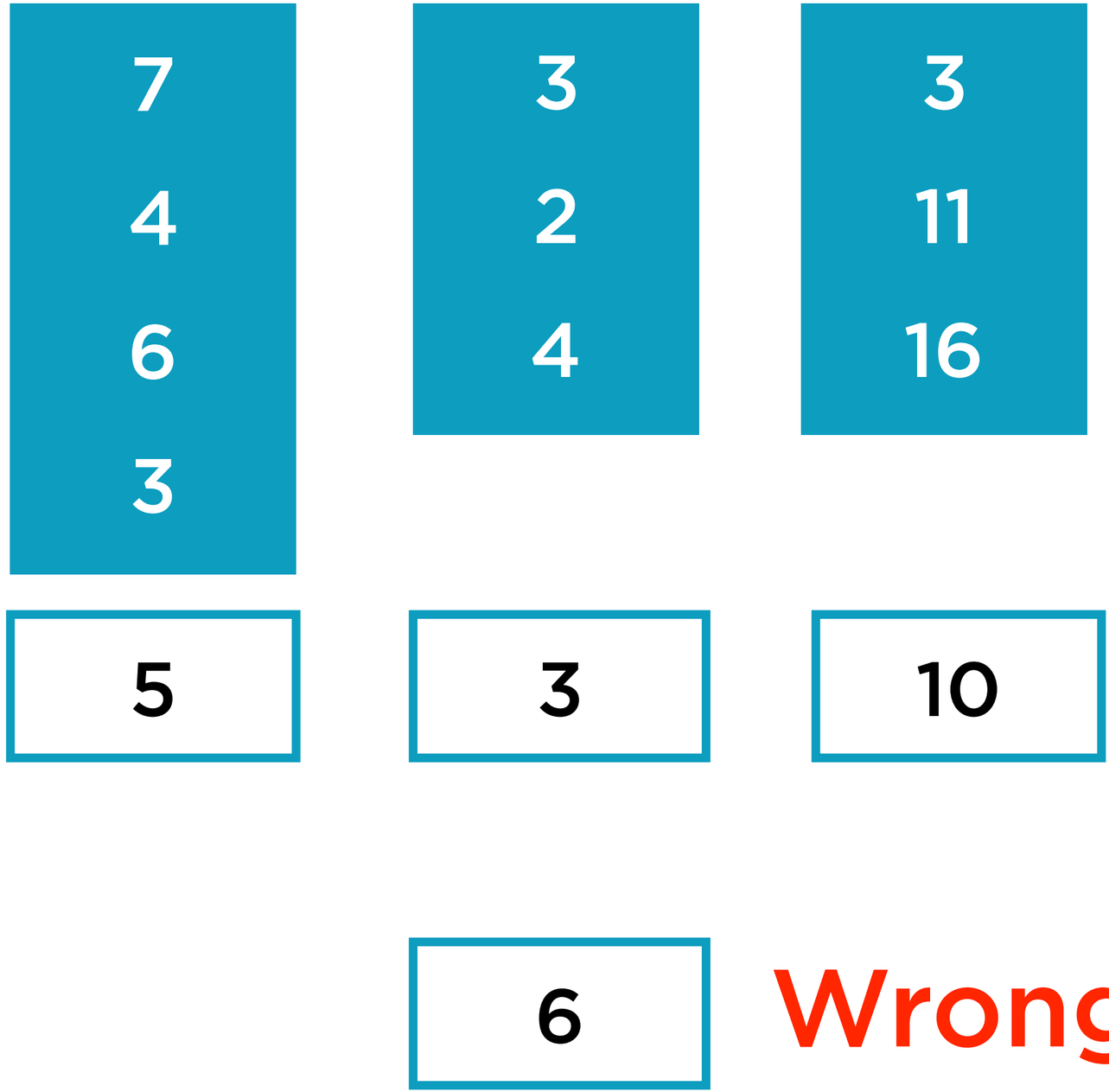


Average of a set of numbers <> Average (Averages of subsets)

Reducers as Combiners

Combiner and reducer functions have to be different!

Average



Average

7	3	3
4	2	11
6	4	16
3		

Correct answer is

5.9

Summary

Control parallelism by changing the number of reducers

Understand the role of partitioning, shuffle and sort in a MapReduce task

Add a combiner to improve parallelism and reduce data transfer

Ensure that the combiner does not change the final result