SI 330: DATA MANIPULATION

# LARGE-SCALE DISTRIBUTED COMPUTING

# COURSE TRAJECTORY

- Concepts
  - Big Data
  - Distributed Computing
- Technologies
  - Hadoop: MapReduce, Hive, Pig, Spark
  - MRJob, pyspark
  - local, virtual machine, Advanced Research Computing

# BIG DATA

- The Three Vs:
  - Volume
    - not just sampling
  - Velocity
    - real-time
  - Variety
    - text, audio, images, video

# DISTRIBUTED COMPUTING

- vertical vs. horizontal scaling
- what’s your limit?
- computing time (weeks vs. days vs. hours vs. minutes)

# KEY REQUIREMENTS OF DISTRIBUTED COMPUTING

- Fault tolerance
- Recoverability
- Consistency
- Scalability

## HADOOP

- “The Apache™ Hadoop® project develops open-source software for reliable, scalable, distributed computing”

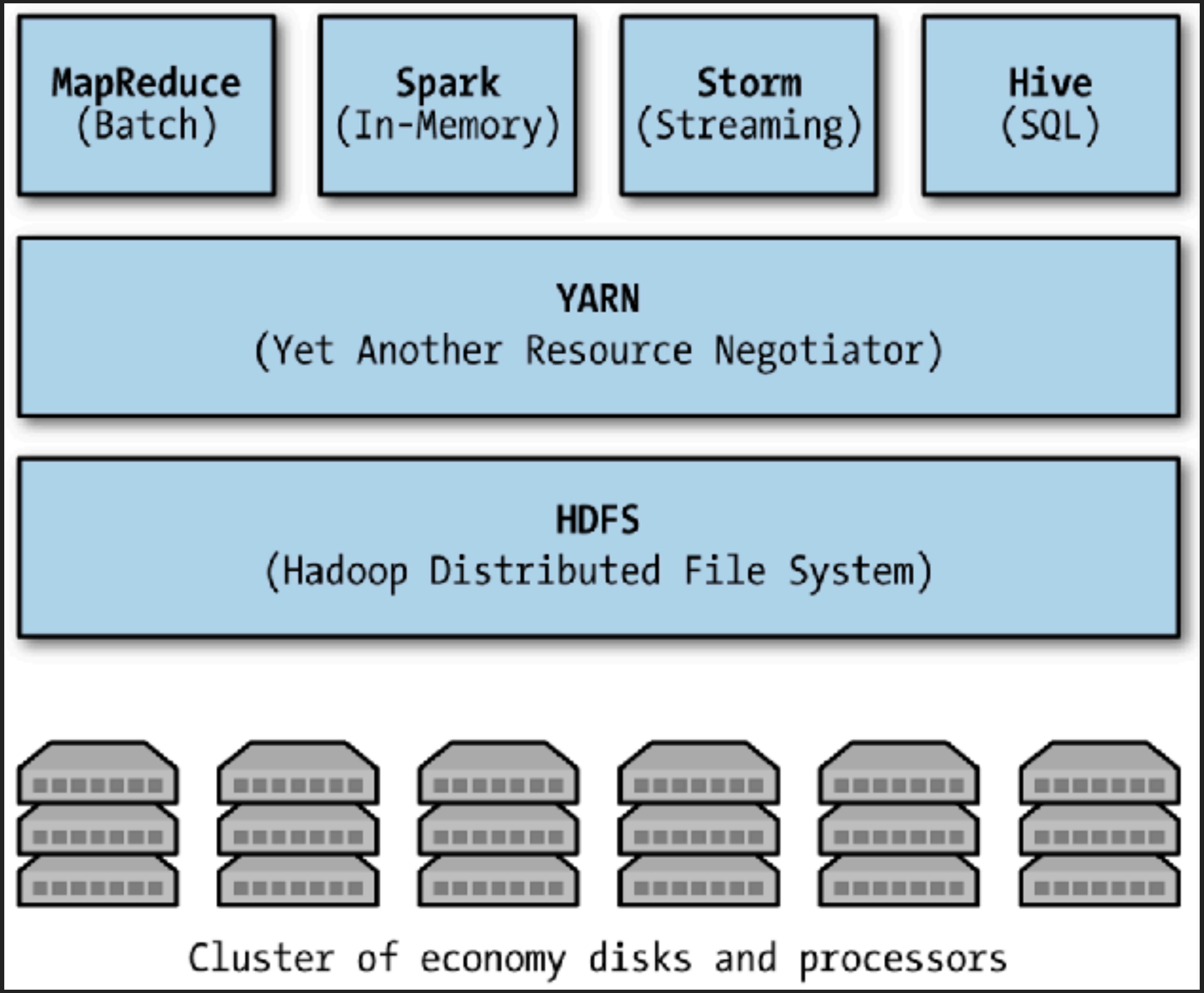
# HADOOP

- HDFS
- YARN
- MapReduce
- Ambari
- Hive
- Pig
- Spark

# HADOOP'S ANSWER TO KEY REQUIREMENTS

- data distribution
- fixed data block size and replication
- jobs and tasks
- high-level programming
- minimizing network traffic
- redundant jobs
- master-worker paradigm

# HADOOP ARCHITECTURAL STACK



MapReduce
(Batch)

Spark
(In-Memory)

Storm
(Streaming)

Hive
(SQL)

YARN
(Yet Another Resource Negotiator)

HDFS
(Hadoop Distributed File System)

Cluster of economy disks and processors

# HDFS: HADOOP DISTRIBUTED FILE SYSTEM

- getting the data where it needs to be
  - (i.e. close to where the computing is going to happen)
- typically 64MB, 128MB or 256MB blocks
- access is provided by NameNode and Secondary NameNode (think pilot and co-pilot)

# YARN: YET ANOTHER RESOURCE NAVIGATOR

- decouples job and workload management from cluster and resource management
- YARN is to computing resources as HDFS is to storage

# HDFS: A PRIMER

- getting your data onto a Hadoop machine isn't enough: you need to make it available to computations
- How?  Put it into HDFS!
- HDFS looks like a plain old file system (but it's not)
- hadoop fs provides an interface to the filesystem that uses familiar syntax

# HADOOP FS

- hadoop fs -ls
  - lists the files in your HDFS directory
- hadoop fs -copyFromLocal <filename>
  - copies <filename> from your file system to HDFS
- hadoop fs -rm <filename>
  - deletes <filename> from your HDFS directory
- hadoop fs -cat <filename>
  - shows contents of <filename>

# ABOUT THE CONCEPT OF 'LOCAL'

- we are going to be using hadoop in three modes:
  - local (e.g. MRJob): no real hadoop infrastructure required
  - local virtual machine (e.g. Hortonworks): single-node hadoop infrastructure
  - Advanced Research Computing (ARC) Flux Cluster

# WHY USE LOCAL?

- Local
  - Pros: easy to set up (almost none required), good for teaching concepts about MapReduce
  - Cons: not really Hadoop, can’t go beyond MapReduce

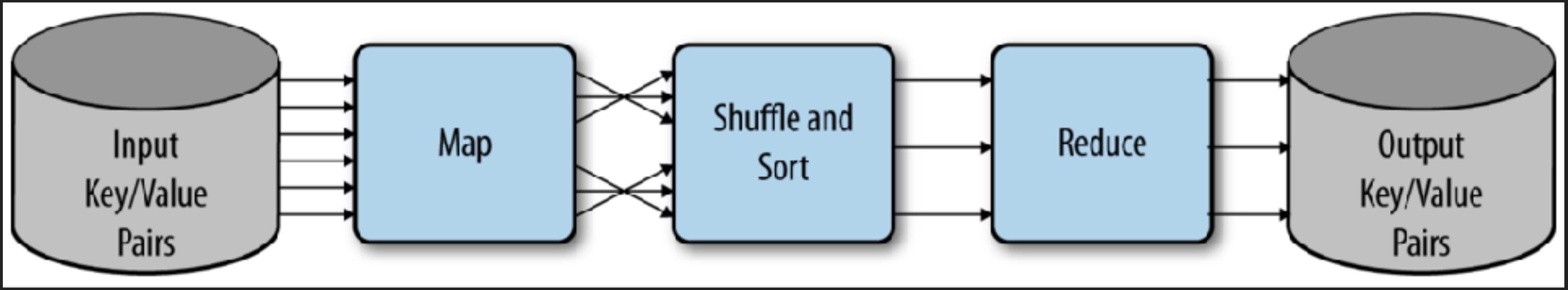
# WHY USE LOCAL VIRTUAL MACHINE?

- Pros:
  - Complete Hadoop ecosystem on your laptop
- Cons:
  - 11GB required for image, plus more for storage
  - only provides single-node functionality

# WHY USE FLUX (ARC)?

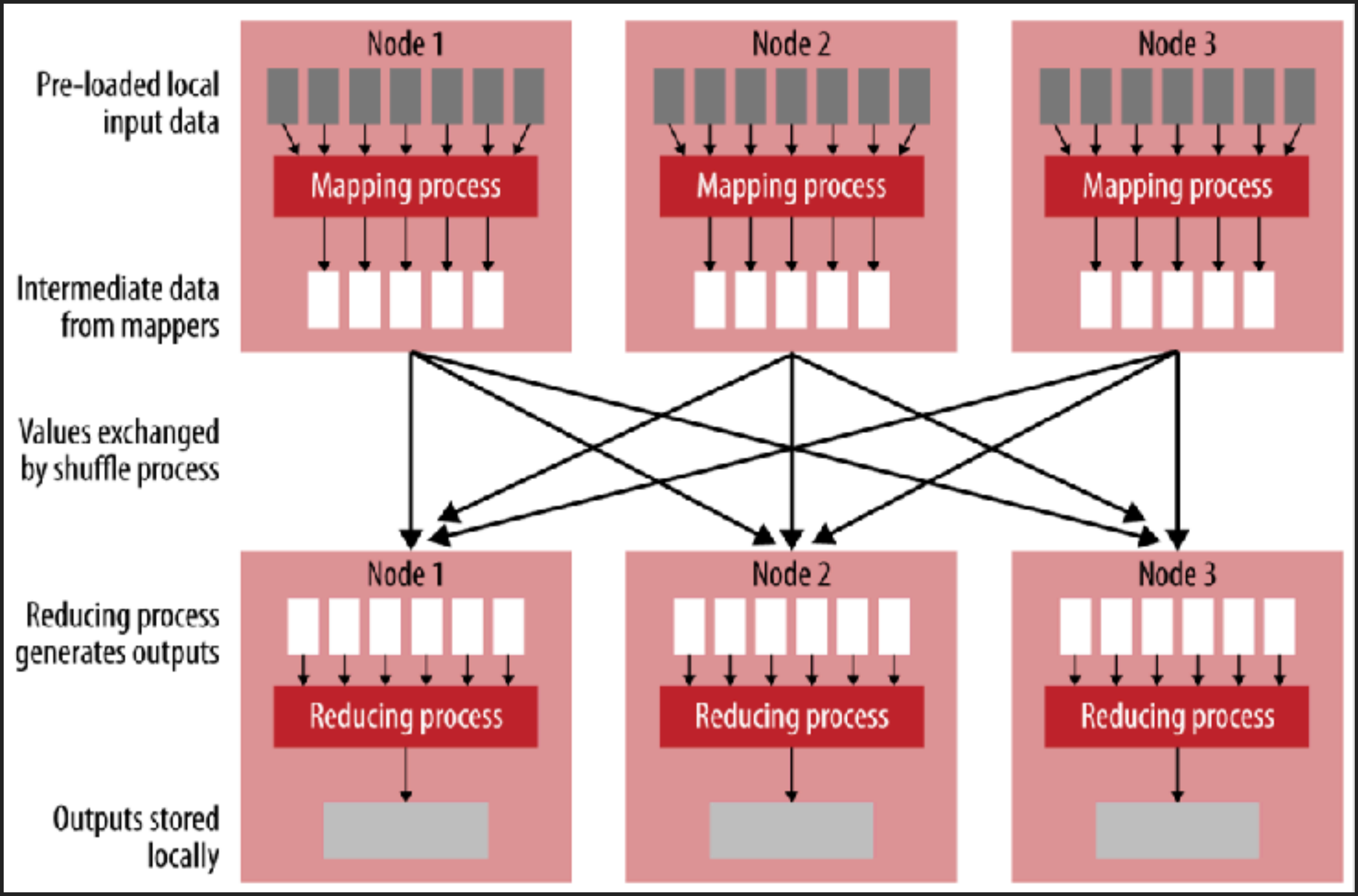
- Pros:
  - Provides complete Hadoop experience
- Cons:
  - Provides complete Hadoop experience

# LET'S LOOK AT MAPREDUCE

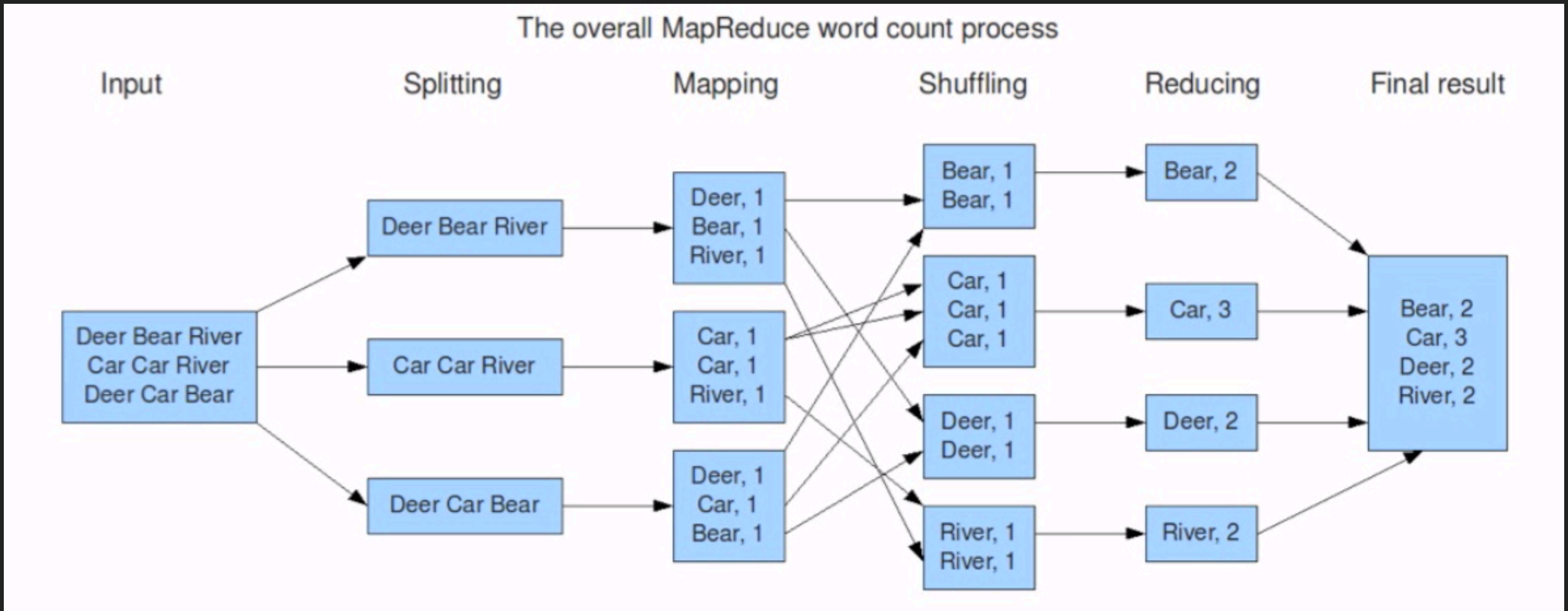


- (book_id, rating) -> count ratings -> (book_id, #ratings)

# MAPREDUCE: MAP, SORT & SHUFFLE, REDUCE



# MAPREDUCE: WORD-COUNT EXAMPLE



## CLASS QUESTION:

- What are the necessary conditions to be able to use MapReduce?

# TWO WAYS TO TACKLE MAPREDUCE

- Step-by-step:
  - You provide the mapper, the reducer, optionally more
  - mrjob
- Table-level:
  - Load, transform, dump (saaaaay….)
  - High-level SQL-like manipulation of data
  - Hive, Pig, Spark

# LET'S START WITH THE DIY APPROACH: MRJOB

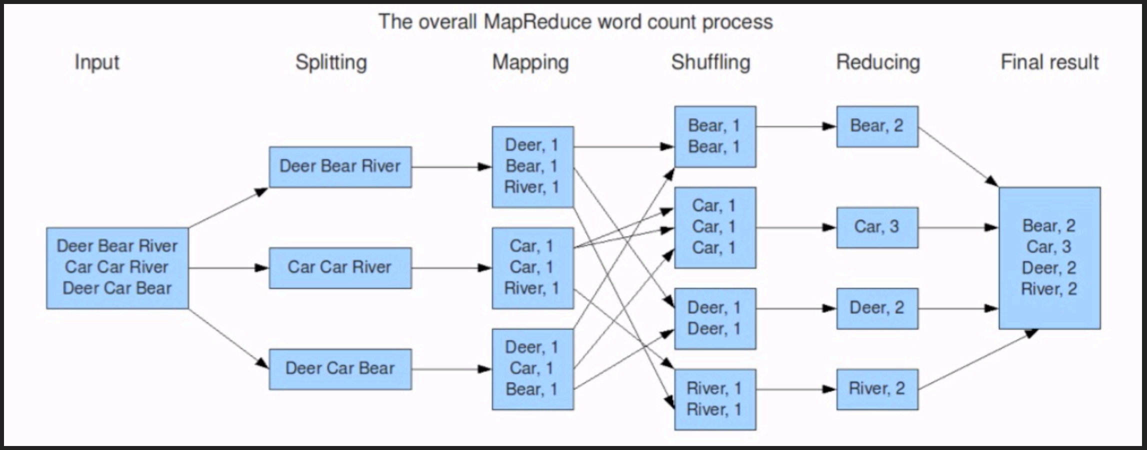
- conda install mrjob
- stand-alone: can use entirely locally or hook up to more powerful back-end (like Amazon's Elastic MapReduce)

Text

- see http://pythonhosted.org/mrjob for documentation
- must define at least one of: mapper, reducer, combiner

# MRJOB FRAMEWORK AND WORD COUNTS

- Mapper:
  - break input line into key, value pairs



- Reducer:
  - take all (key, value) pairs with same key and compute aggregate function (e.g. sum, count)
- MRJob takes care of:
  Sorting mapper output, invoking reduce tasks, assembling final output, scheduling and monitoring tasks

# A BASIC MRJOB MAPREDUCE EXAMPLE

```
#!/usr/bin/python

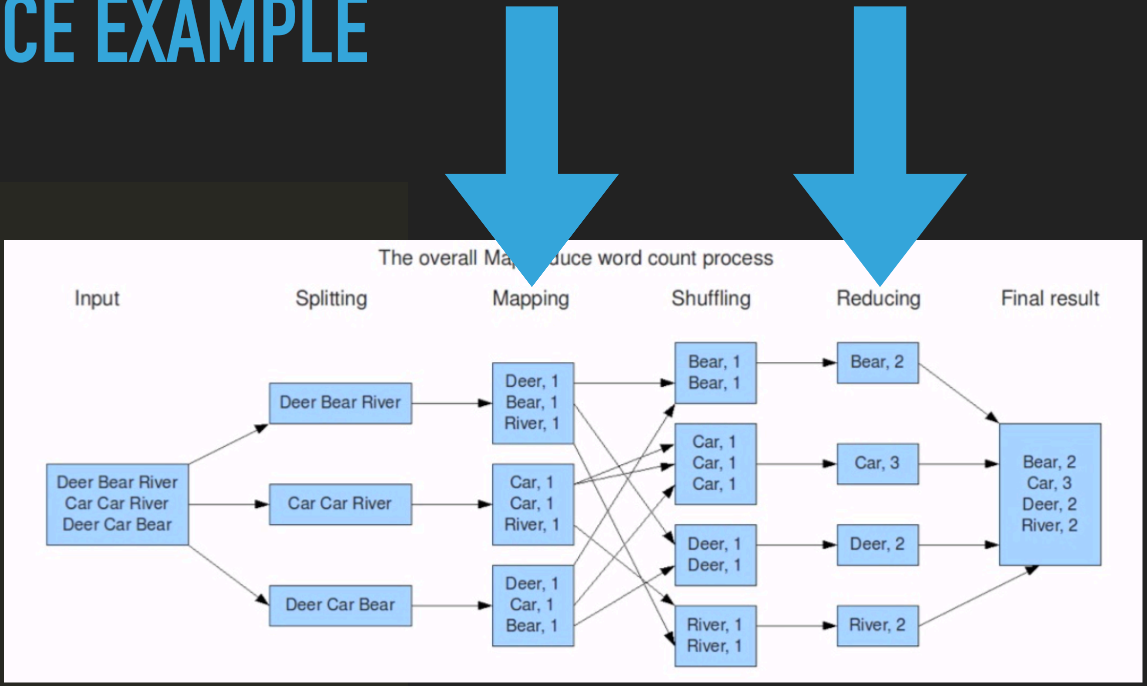
from mrjob.job import MRJob
import re

class MRWordFrequencyCount(MRJob):

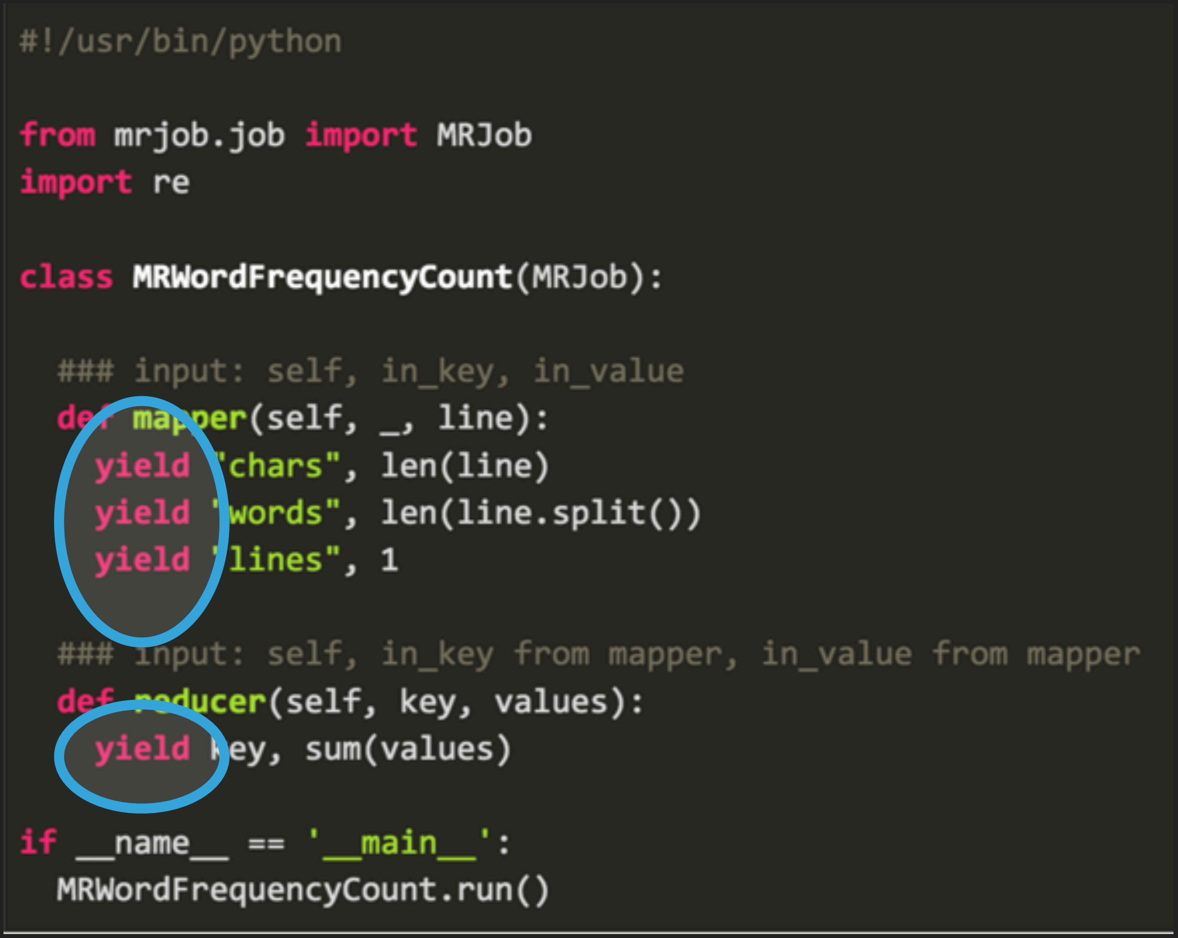
  ### input: self, in_key, in_value
  def mapper(self, _, line):
    yield "chars", len(line)
    yield "words", len(line.split())
    yield "lines", 1

  ### input: self, in_key from mapper, in_value from mapper
  def reducer(self, key, values):
    yield key, sum(values)

if __name__ == '__main__':
  MRWordFrequencyCount.run()
```



# WHOA, WHOA, WHOA!



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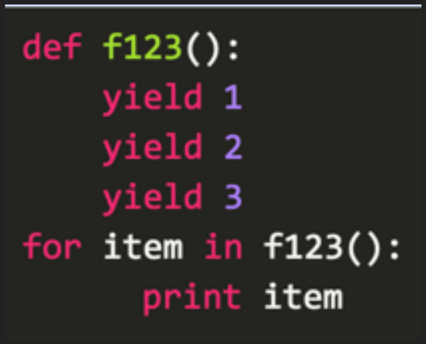
- yield?
- it’s a generator thing
- what?

# GENERATORS



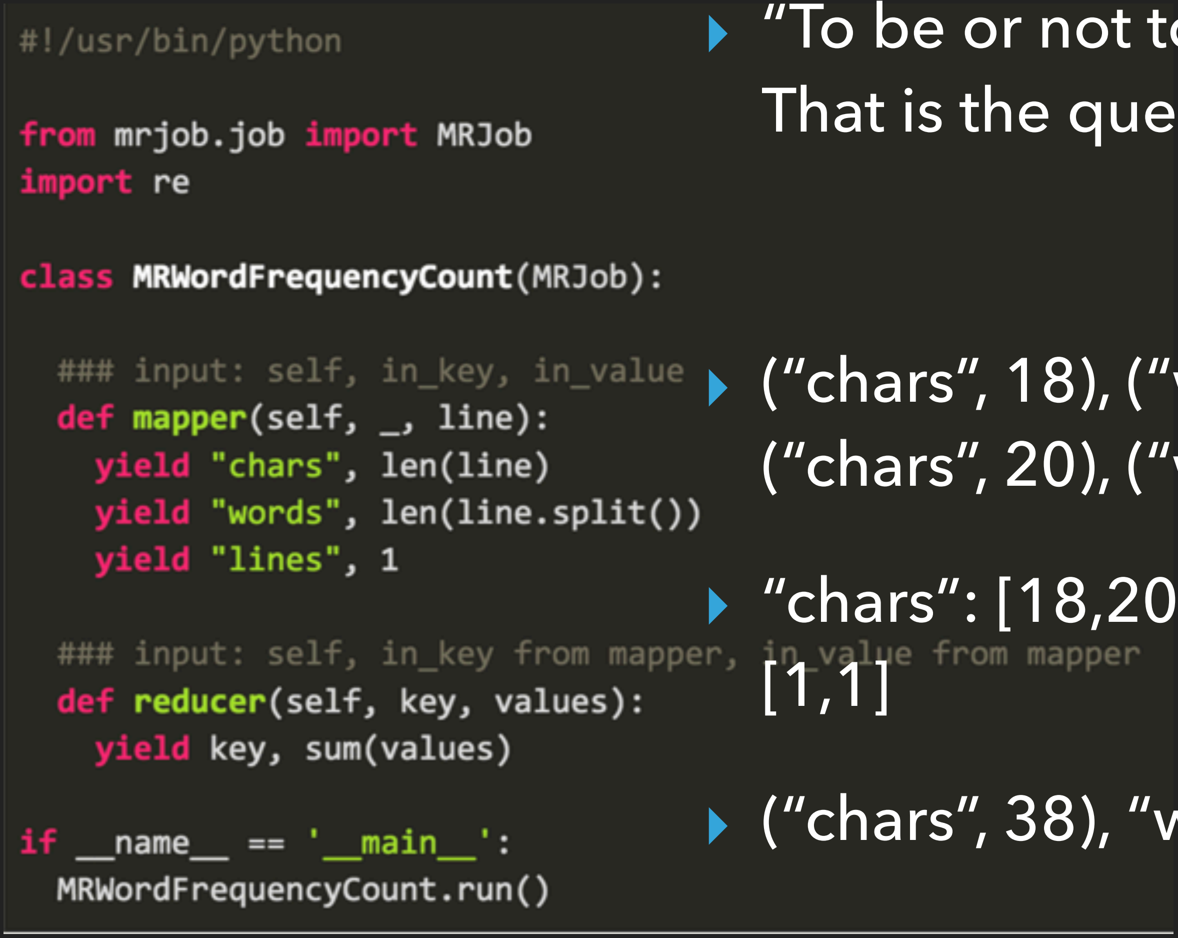
```
def f123():
    yield 1
    yield 2
    yield 3
for item in f123():
      print item
```

- A GENERATOR is a lazy iterable object: lazy objects wait to produce results only when they absolutely have to.
- When f123() is called, it does not return any of the values in the yield statements.
- It returns a generator object. Also, the function does not really exit - it goes into a suspended state.
- When the for loop tries to loop over the generator object, the function:
  - Resumes from its suspended state
  - Runs until the next yield statement
  - Returns that yield result as the next item.
- This happens until the function exits, at which point the generator raises StopIteration, and the loop exits.

# MAPPERS AND REDUCERS

- mappers and reducers are generators supplied by YOU!
- too weird?
  - basically, yield means return and then pick up here next time through

# WORDCOUNT BY MAPPING AND REDUCING



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if __name__ == '__main__':
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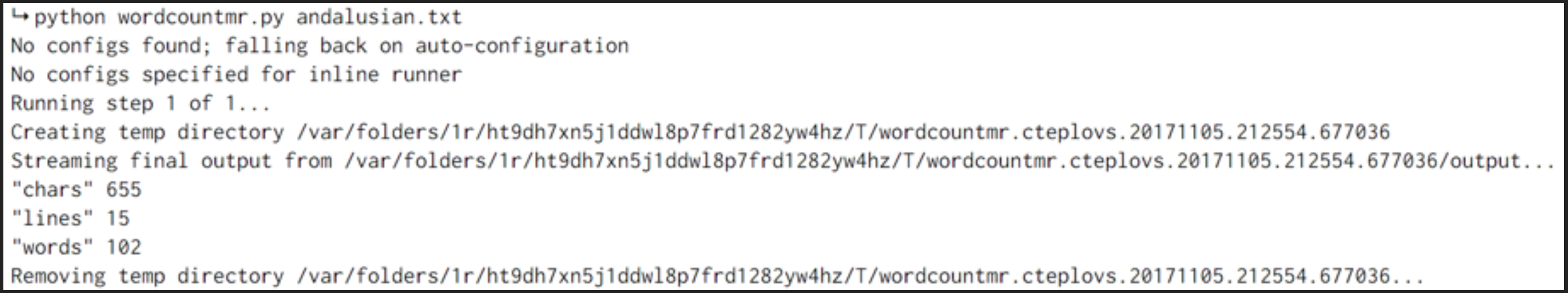
```

- “To be or not to be,
  That is the question.”
- (“chars”, 18), (“words”,  6), (“lines”, 1)
  (“chars”, 20), (“words”,  4), (“lines”, 1)
- “chars”: [18,20], “words”: [6,4], “lines”: [1,1]
- (“chars”, 38), “words”, 10), (“lines”, 2)

# LET'S RUN THAT MRJOB WORDCOUNT PROGRAM



```
↳python wordcountmr.py andalusian.txt
No configs found; falling back on auto-configuration
No configs specified for inline runner
Running step 1 of 1...
Creating temp directory /var/folders/1r/ht9dh7xn5j1ddwl8p7frd1282yw4hz/T/wordcountmr.cteplovs.20171105.212554.677036
Streaming final output from /var/folders/1r/ht9dh7xn5j1ddwl8p7frd1282yw4hz/T/wordcountmr.cteplovs.20171105.212554.677036/output...
"chars" 655
"lines" 15
"words" 102
Removing temp directory /var/folders/1r/ht9dh7xn5j1ddwl8p7frd1282yw4hz/T/wordcountmr.cteplovs.20171105.212554.677036...
```

# WHAT JUST HAPPENED?

- we ran our wordcount MapReduce python script on our local machine