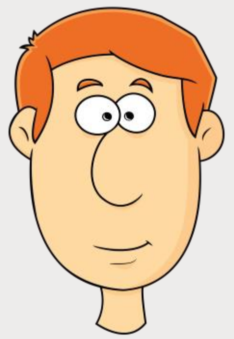
MAPREDUCE FUNDAMENTAL CONCEPTS

Why MapReduce?

- Distributes the processing of data on your cluster
- Divides your data up into partitions that are MAPPED (transformed) and REDUCED (aggregated) by mapper and reducer functions you define
- Resilient to failure – an application master monitors your mappers and reducers on each partition

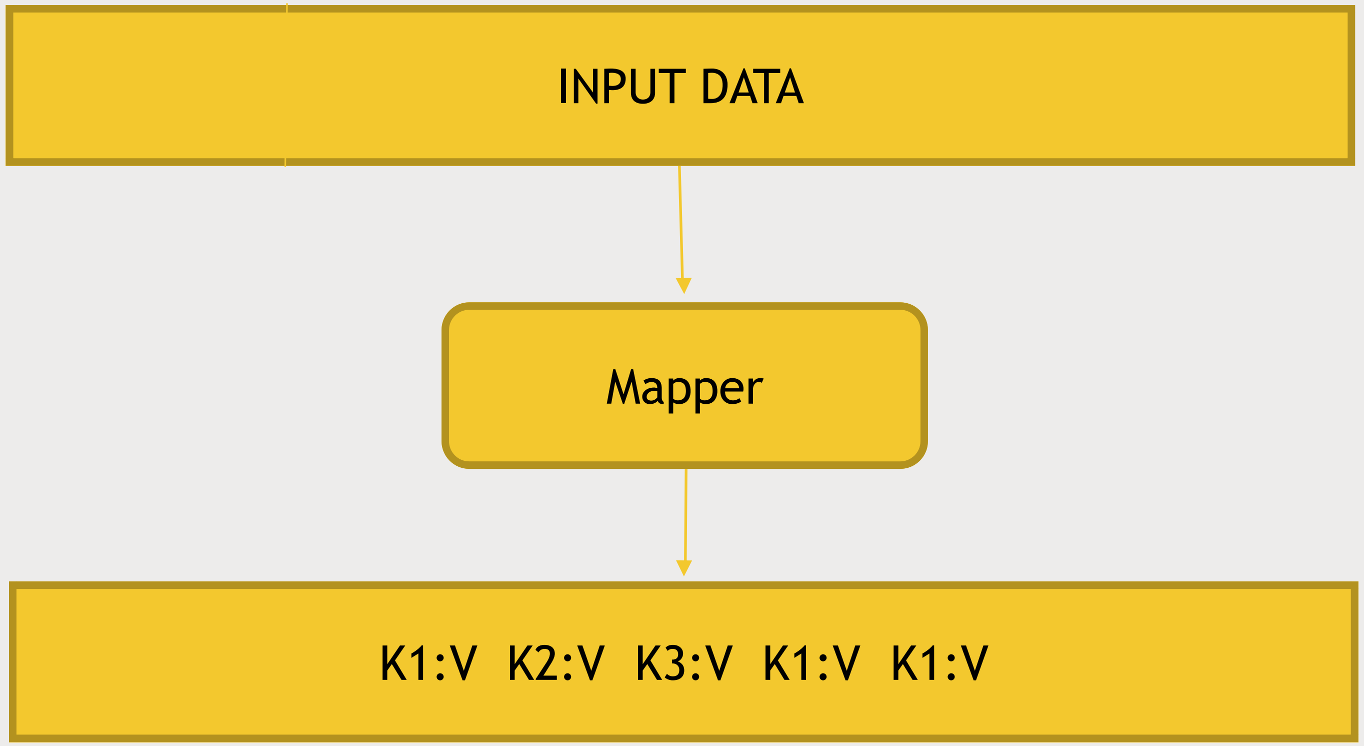
Let’s illustrate with an example

- How many movies did each user rate in the MovieLens data set?



How MapReduce Works: Mapping

- The MAPPER converts raw source data into **key/value** pairs



Example: MovieLens Data (u.data file)

USER ID	MOVIE ID	RATING	TIMESTAMP
196	242	3	881250949
186	302	3	891717742
196	377	1	878887116
244	51	2	880606923
166	346	1	886397596
186	474	4	884182806
186	265	2	881171488

Map users to movies they watched

USER ID	MOVIE ID	RATING	TIMESTAMP
196	242	3	881250949
186	302	3	891717742
196	377	1	878887116
244	51	2	880606923
166	346	1	886397596
186	474	4	884182806
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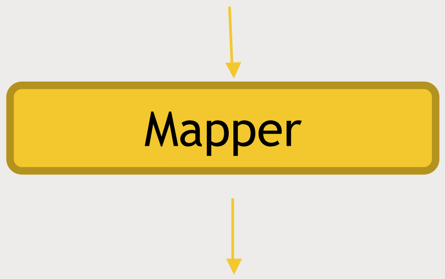

196:242 186:302 196:377 244:51 166:346 186:274 186:265

Extract and Organize What We Care About

196:242 186:302 196:377 244:51 166:346 186:274 186:265

MapReduce Sorts and Groups the Mapped Data (“Shuffle and Sort”)

196:242 186:302 196:377 244:51 166:346 186:274 186:265

$\downarrow$

166:346   186:302,274,265   196:242,377   244:51

The REDUCER Processes Each Key’s Values

$$\begin{tikzcd}
\text{166:346 \quad 186:302,274,265 \quad 196:242,377 \quad 244:51} \arrow[d] \\
\text{len(movies)} \arrow[d] \\
\text{166:1 \quad 186:3 \quad 196:2 \quad 244:1}
\end{tikzcd}$$

Putting it All Together

USER ID	MOVIE ID	RATING	TIMESTAMP
196	242	3	881250949
186	302	3	891717742
196	377	1	878887116
244	51	2	880606923
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$\downarrow$

MAPPER

$\downarrow$

196:242 186:302 196:377 244:51 166:346 186:274 186:265

$\downarrow$

SHUFFLE AND SORT

$\downarrow$

166:346   186:302,274,265   196:242,377   244:51

$\downarrow$

REDUCER

$\downarrow$

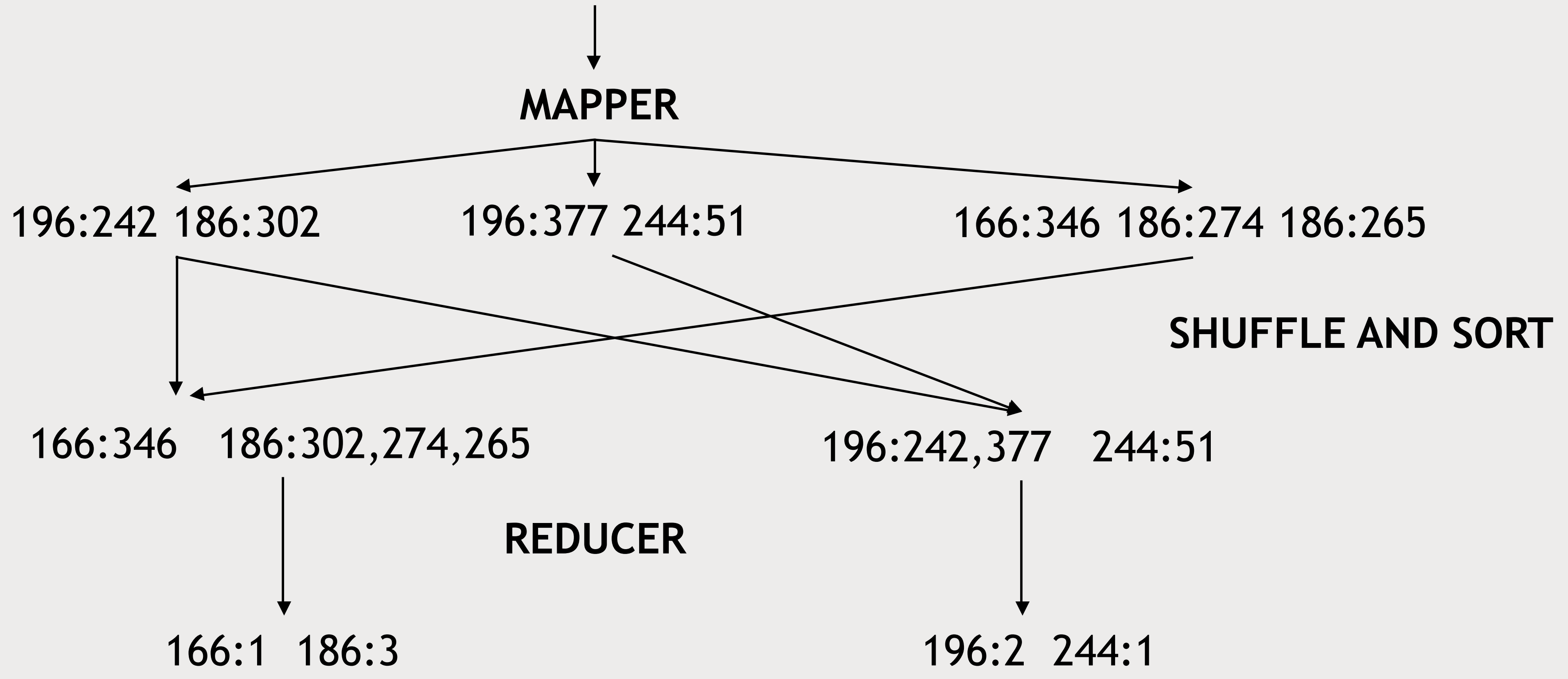
166:1   186:3   196:2   244:1

MAPREDUCE ON A CLUSTER

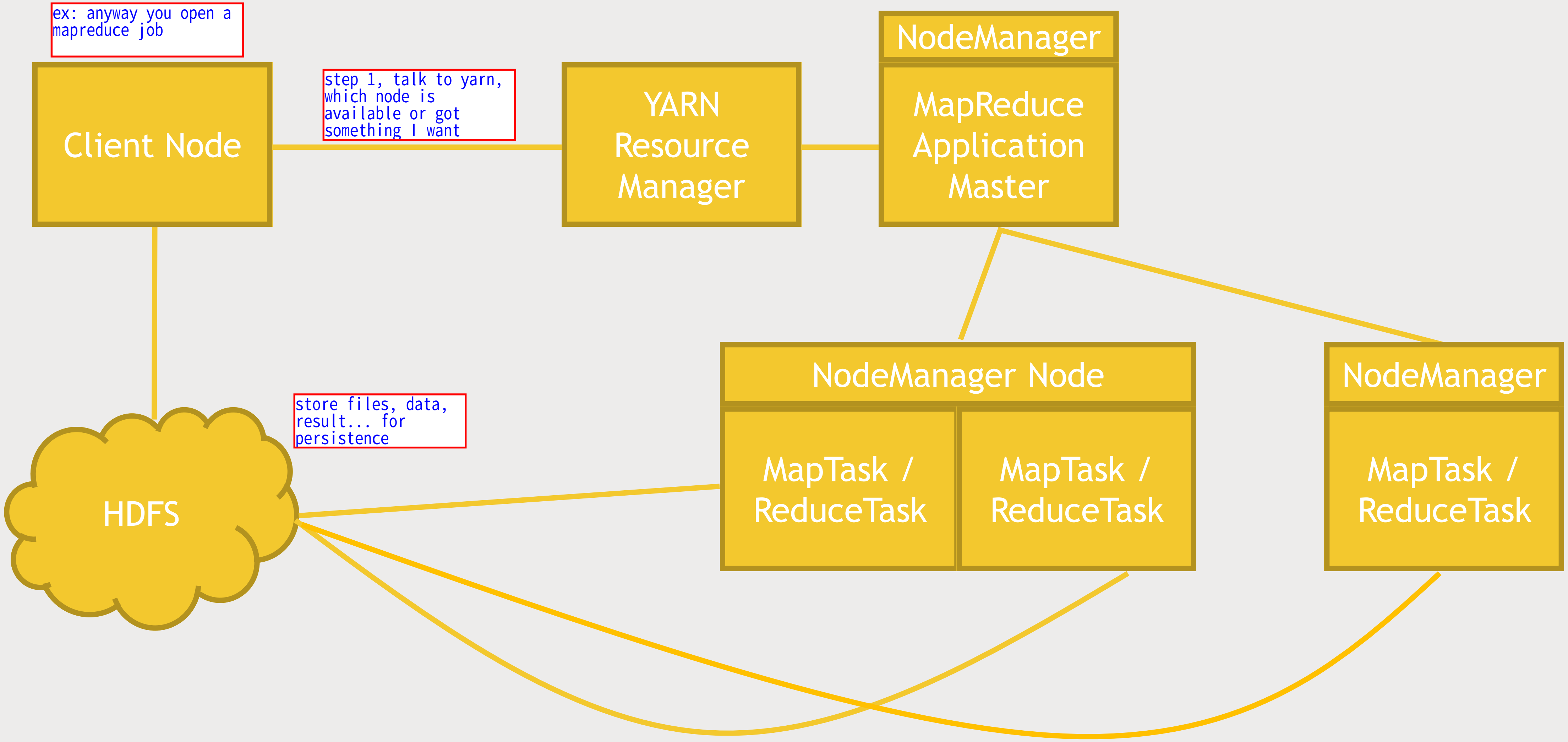
How MapReduce Scales

Putting it All Together

USER ID	MOVIE ID	RATING	TIMESTAMP
196	242	3	881250949
186	302	3	891717742
196	377	1	878887116
244	51	2	880606923
166	346	1	886397596
186	474	4	884182806
186	265	2	881171488

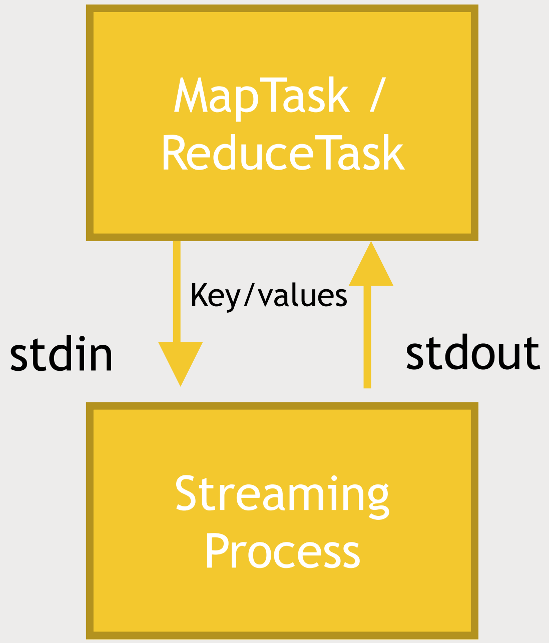


What's Happening


ex: anyway you open a mapreduce job
Client Node
step 1, talk to yarn, which node is available or got something I want
YARN Resource Manager
NodeManager
MapReduce Application Master
store files, data, result... for persistence
HDFS
NodeManager Node
MapTask / ReduceTask
MapTask / ReduceTask
NodeManager
MapTask / ReduceTask

How are mappers and reducers written?

- MapReduce is natively Java
- STREAMING allows interfacing to other languages (ie Python)



Handling Failure

- Application master monitors worker tasks for errors or hanging
  - *Restarts as needed*
  - *Preferably on a different node*
- What if the application master goes down?
  - *YARN can try to restart it*
- What if an entire Node goes down?
  - *This could be the application master*
  - *The resource manager will try to restart it*
- What if the resource manager goes down?
  - *Can set up "high availability" (HA) using Zookeeper to have a hot standby*

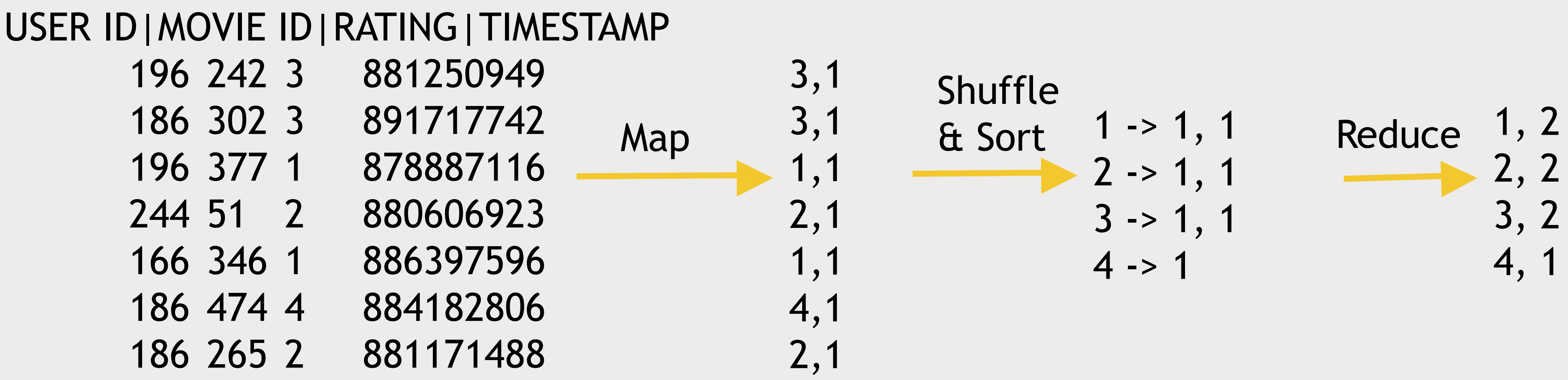
MAPREDUCE: A REAL EXAMPLE

How many of each rating type exist?

How many of each movie rating exist?

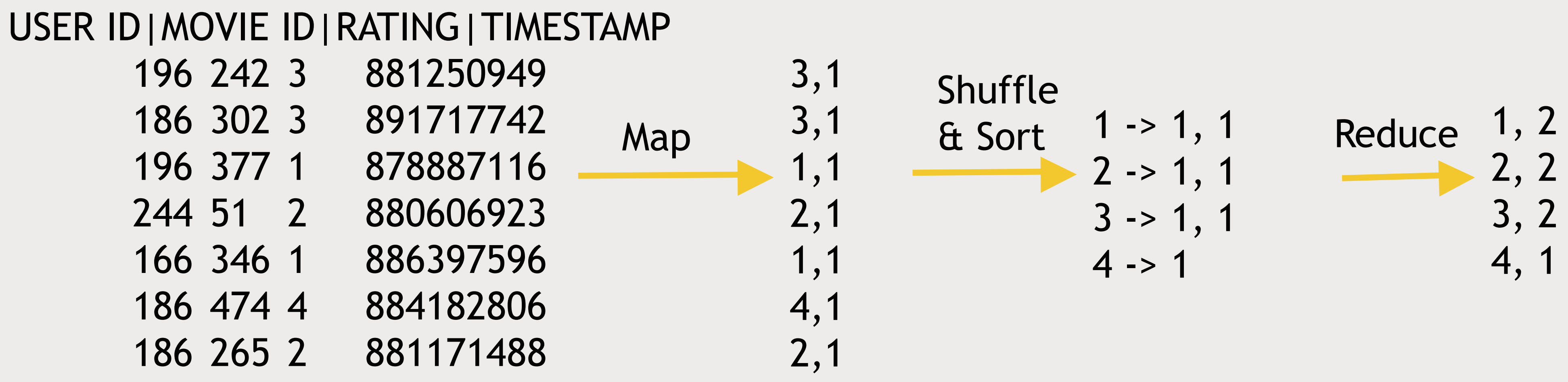
Making it a MapReduce problem

- MAP each input line to (rating, 1)
- REDUCE each rating with the sum of all the 1’s



```
USER ID|MOVIE ID|RATING|TIMESTAMP
        196  242  3     881250949              3,1      Shuffle
        186  302  3     891717742     Map      3,1      & Sort    1 -> 1, 1          Reduce    1, 2
        196  377  1     878887116   ------->   1,1     -------->  2 -> 1, 1        -------->   2, 2
        244  51   2     880606923              2,1                3 -> 1, 1                    3, 2
        166  346  1     886397596              1,1                4 -> 1                       4, 1
        186  474  4     884182806              4,1
        186  265  2     881171488              2,1
```

Writing the Mapper

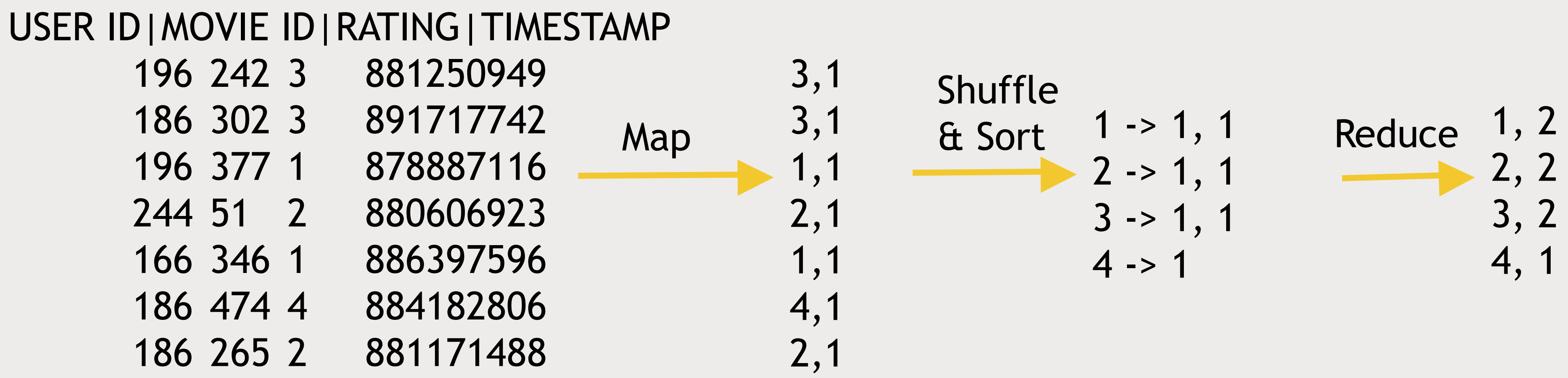


USER ID|MOVIE ID|RATING|TIMESTAMP

```
196 242 3    881250949                3,1
186 302 3    891717742     Map        3,1    Shuffle
196 377 1    878887116   -------->    1,1    & Sort    1 -> 1, 1     Reduce     1, 2
244 51  2    880606923                2,1  -------->   2 -> 1, 1   -------->   2, 2
166 346 1    886397596                1,1              3 -> 1, 1               3, 2
186 474 4    884182806                4,1              4 -> 1                  4, 1
186 265 2    881171488                2,1
```

```python
def mapper_get_ratings(self, _, line):
    (userID, movieID, rating, timestamp) = line.split('\t')
    yield rating, 1
```

Writing the Reducer



```
USER ID|MOVIE ID|RATING|TIMESTAMP
        196 242 3     881250949                3,1
        186 302 3     891717742                3,1     Shuffle
        196 377 1     878887116      Map       1,1     & Sort    1 -> 1, 1      Reduce    1, 2
        244 51  2     880606923    ------->    2,1    ------->   2 -> 1, 1     ------->   2, 2
        166 346 1     886397596                1,1               3 -> 1, 1                3, 2
        186 474 4     884182806                4,1               4 -> 1                   4, 1
        186 265 2     881171488                2,1
```

```python
def reducer_count_ratings(self, key, values):
    yield key, sum(values)
```

Putting it all together

```python
from mrjob.job import MRJob
from mrjob.step import MRStep

class RatingsBreakdown(MRJob):
    def steps(self):
        return [
            MRStep(mapper=self.mapper_get_ratings,
                   reducer=self.reducer_count_ratings)
        ]

    def mapper_get_ratings(self, _, line):
        (userID, movieID, rating, timestamp) = line.split('\t')
        yield rating, 1

    def reducer_count_ratings(self, key, values):
        yield key, sum(values)

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

RUNNING MAPREDUCE WITH MRJOB

Run our MapReduce job in our Hadoop installation

Installing what we need

- PIP
  - *Utility for installing Python packages*

  -
    ```
    su root
    yum install python-pip
    ```
- Nano
  - `yum install nano`
- MRJob

  -
    ```
    pip install mrjob
    exit
    ```
    `downgrade the PyYAML package to 5.4.1 --> sudo pip install PyYAML==5.4.1`
- Data files and the script
  - `wget http://media.sundog-soft.com/hadoop/ml-100k/u.data`
  - `wget http://media.sundog-soft.com/hadoop/RatingsBreakdown.py`

Running with mrjob

- Run locally
  - *python RatingsBreakdown.py u.item*
- Run with Hadoop
  - *python MostPopularMovie.py -r hadoop --hadoop-streaming-jar /usr/hdp/current/hadoop-mapreduce-client/hadoop-streaming.jar u.data*

YOUR CHALLENGE

Sort movies by popularity with Hadoop

Challenge exercise

- Count up ratings given for each movie
  - *All you need is to change one thing in the mapper – we don’t care about ratings now, we care about movie ID’s!*
  - *Start with this and make sure you can do it.*
  - *You can use nano to just edit the existing RatingsBreakdown.py script*

Stretch goal

- Sort the movies by their numbers of ratings
- Strategy:
  - *Map to (movieID, 1) key/value pairs*
  - *Reduce with output of (rating count, movieID)*
  - *Send this to a second reducer so we end up with things sorted by rating count!*
- Gotchas:
  - *How do we set up more than one MapReduce step?*
  - *How do we ensure the rating counts are sorted properly?*

Multi-stage jobs

- You can chain map/reduce stages together like this:

```
def steps(self):
        return [
            MRStep(mapper=self.mapper_get_ratings,
                    reducer=self.reducer_count_ratings),
            MRStep(reducer=self.reducer_sorted_output)
        ]
```

Ensuring proper sorting

- By default, streaming treats all input and output as strings. So things get sorted as strings, not numerically.
- There are different formats you can specify. But for now let’s just zero-pad our numbers so they’ll sort properly.
- The second reducer will look like this:

```
def reducer_count_ratings(self, key, values):
        yield str(sum(values)).zfill(5), key
```

Iterating through the results

- Spoiler alert!

```
def reducer_sorted_output(self, count, movies):
    for movie in movies:
        yield movie, count
```

CHECK YOUR RESULTS

Did it work?

My solution

```python
from mrjob.job import MRJob
from mrjob.step import MRStep

class RatingsBreakdown(MRJob):
    def steps(self):
        return [
            MRStep(mapper=self.mapper_get_ratings,
                   reducer=self.reducer_count_ratings),
            MRStep(reducer=self.reducer_sorted_output)
        ]

    def mapper_get_ratings(self, _, line):
        (userID, movieID, rating, timestamp) = line.split('\t')
        yield movieID, 1

    def reducer_count_ratings(self, key, values):
        yield str(sum(values)).zfill(5), key

    def reducer_sorted_output(self, count, movies):
        for movie in movies:
            yield movie, count


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