PARALLEL COMPUTING WITH DASK

Using Dask DataFrames

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Reading CSV

```
In [1]: import dask.dataframe as dd
```

- **`dd.read_csv()`** function
  - Accepts single filename or *glob* pattern (using wildcard `*`)
  - Does not read file immediately (*lazy evaluation*)
  - File(s) need not fit in memory

Reading Multiple CSV Files

```
In [2]: %ls
quarter1.csv  quarter2.csv  quarter3.csv  quarter4.csv

In [3]: transactions = dd.read_csv('*.csv')

In [4]: transactions.head()
Out[4]:
    id    names  amount        date
0  131  Norbert   -1159  2016-01-01
1  342    Jerry    1149  2016-01-01
2  485      Dan    1380  2016-01-01
3  513   Xavier    1555  2016-01-02
4  849  Michael     363  2016-01-02

In [5]: transactions.tail()
Out[5]:
      id     names  amount        date
195  838     Wendy      87  2016-12-28
196  915       Bob     852  2016-12-30
197  749  Patricia    1741  2016-12-31
198  743   Michael    1191  2016-12-31
199  889     Wendy     336  2016-12-31
```

Building Delayed Pipelines

```
In [6]: is_wendy = (transactions['names'] == 'Wendy')

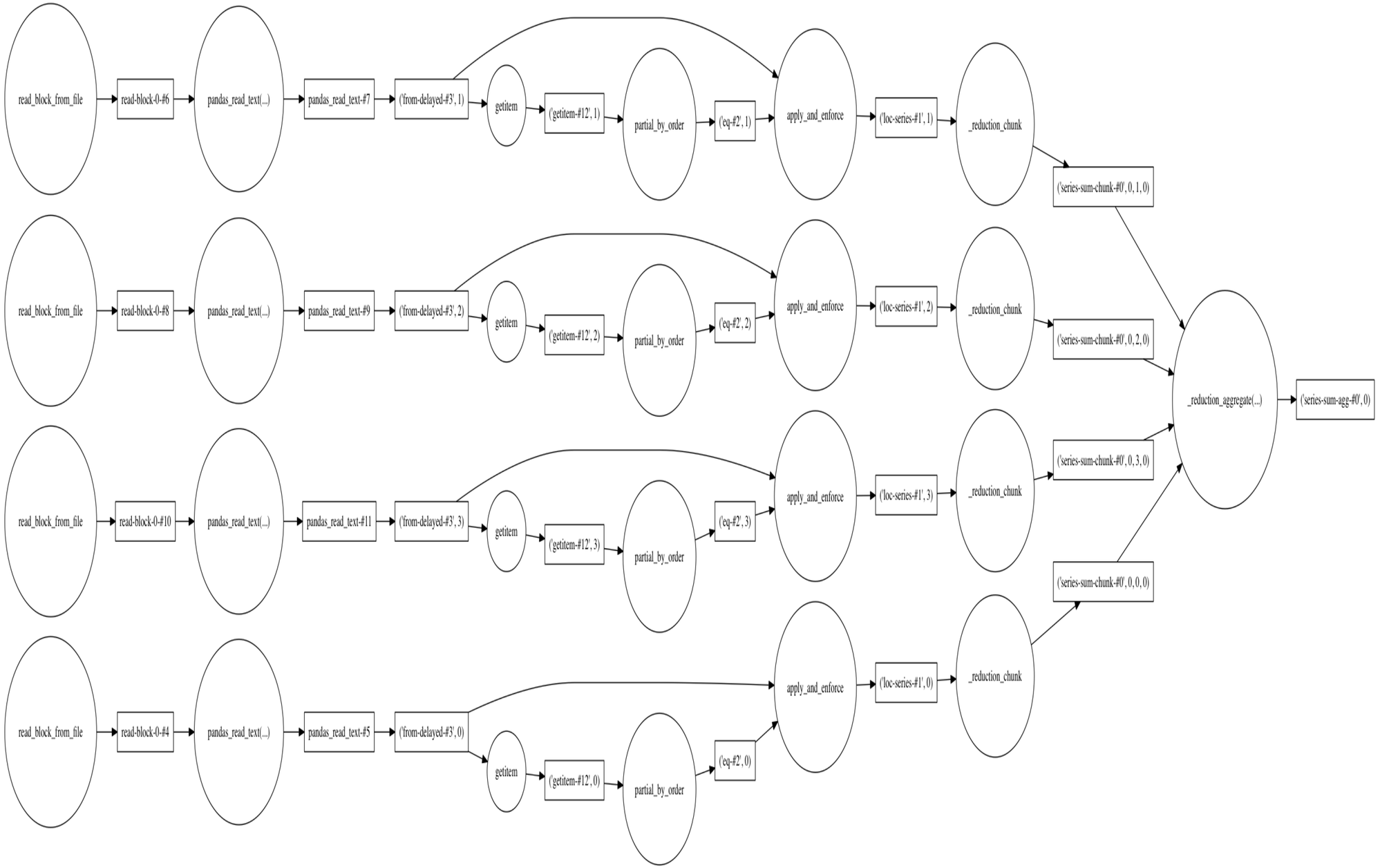
In [7]: wendy_amounts = transactions.loc[is_wendy, 'amount']

In [8]: wendy_amounts
Out[8]:
Dask Series Structure:
npartitions=4
None    int64
None      ...
None      ...
None      ...
None      ...
Name: amount, dtype: int64
Dask Name: loc-series, 24 tasks

In [9]: wendy_diff = wendy_amounts.sum()

In [10]: wendy_diff
Out[10]: dd.Scalar<series-..., dtype=int64>

In [11]: wendy_diff.visualize(rankdir='LR')
```


read_block_from_file
read-block-0-#6
pandas_read_text(...)
pandas_read_text-#7
('from-delayed-#3', 1)
getitem
('getitem-#12', 1)
partial_by_order
('eq-#2', 1)
apply_and_enforce
('loc-series-#1', 1)
_reduction_chunk
('series-sum-chunk-#0', 0, 1, 0)
read_block_from_file
read-block-0-#8
pandas_read_text(...)
pandas_read_text-#9
('from-delayed-#3', 2)
getitem
('getitem-#12', 2)
partial_by_order
('eq-#2', 2)
apply_and_enforce
('loc-series-#1', 2)
_reduction_chunk
('series-sum-chunk-#0', 0, 2, 0)
read_block_from_file
read-block-0-#10
pandas_read_text(...)
pandas_read_text-#11
('from-delayed-#3', 3)
getitem
('getitem-#12', 3)
partial_by_order
('eq-#2', 3)
apply_and_enforce
('loc-series-#1', 3)
_reduction_chunk
('series-sum-chunk-#0', 0, 3, 0)
read_block_from_file
read-block-0-#4
pandas_read_text(...)
pandas_read_text-#5
('from-delayed-#3', 0)
getitem
('getitem-#12', 0)
partial_by_order
('eq-#2', 0)
apply_and_enforce
('loc-series-#1', 0)
_reduction_chunk
('series-sum-chunk-#0', 0, 0, 0)
_reduction_aggregate(...)
('series-sum-agg-#0', 0)

Compatibility with Pandas API

Unavailable in `dask.dataframe`:

- some unsupported file formats (e.g., `.xls`, `.zip`, `.gz`)
- sorting

Available in `dask.dataframe`:

- indexing, selection, & reindexing
- aggregations: `.sum()`, `.mean()`, `.std()`, `.min()`, `.max()` etc.
- grouping with `.groupby()`
- datetime conversion with `dd.to_datetime()`

PARALLEL COMPUTING WITH DASK

Let's practice!

PARALLEL COMPUTING WITH DASK

Timing DataFrame Operations

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How Big is Big Data?

Data size M	Required hardware
$M < 8\,\mathrm{GB}$	RAM (single machine)
$8\,\mathrm{GB} < M < 10\,\mathrm{TB}$	hard disk (single machine)
$M > 10\,\mathrm{TB}$:	*specialized hardware*

Two key questions:

- Data fits in RAM (random access memory)?
- Data fits on hard disk?

Taxi CSV Files

```
In [1]: %ll -h yellow_tripdata_2015-*.csv
-rw-r--r--  1 user  staff   1.8G 31 Jul 16:43 yellow_tripdata_2015-01.csv
-rw-r--r--  1 user  staff   1.8G 31 Jul 16:43 yellow_tripdata_2015-02.csv
-rw-r--r--  1 user  staff   1.9G 31 Jul 16:43 yellow_tripdata_2015-03.csv
-rw-r--r--  1 user  staff   1.9G 31 Jul 16:43 yellow_tripdata_2015-04.csv
-rw-r--r--  1 user  staff   1.9G 31 Jul 16:43 yellow_tripdata_2015-05.csv
-rw-r--r--  1 user  staff   1.8G 31 Jul 16:43 yellow_tripdata_2015-06.csv
-rw-r--r--  1 user  staff   1.7G 31 Jul 16:43 yellow_tripdata_2015-07.csv
-rw-r--r--  1 user  staff   1.6G 31 Jul 16:43 yellow_tripdata_2015-08.csv
-rw-r--r--  1 user  staff   1.6G 31 Jul 16:43 yellow_tripdata_2015-09.csv
-rw-r--r--  1 user  staff   1.8G 31 Jul 16:43 yellow_tripdata_2015-10.csv
-rw-r--r--  1 user  staff   1.7G 31 Jul 16:43 yellow_tripdata_2015-11.csv
-rw-r--r--  1 user  staff   1.7G 31 Jul 16:43 yellow_tripdata_2015-12.csv
```

Timing I/O & Computation: Pandas

```
In [2]: import time, pandas as pd

In [3]: t_start = time.time(); \
   ...: df = pd.read_csv('yellow_tripdata_2015-01.csv'); \
   ...: t_end = time.time(); \
   ...: print('pd.read_csv(): {} s'.format(t_end-t_start)) # time [s]
Out[3]:
pd.read_csv: 43.820565938949585 s

In [4]: t_start = time.time(); \
   ...: m = df['trip_distance'].mean(); \
   ...: t_end = time.time(); \
   ...: print('.mean(): {} ms'.format((t_end-t_start)*1000)) # time [ms]
Out[4]:
.mean(): 17.752885818481445 ms
```

Timing I/O & Computation: Dask

```
In [5]: import dask.dataframe as dd, time

In [6]: t_start = time.time();\
   ...: df = dd.read_csv('yellow_tripdata_2015-*.csv');\
   ...: t_end = time.time();\
   ...: print('dd.read_csv: {} ms'.format((t_end-t_start)*1000))  # time [ms]
Out[6]:
dd.read_csv: 404.7999382019043 ms

In [7]: t_start = time.time();\
   ...: m = df['trip_distance'].mean();\
   ...: t_end = time.time();\
   ...: print('.mean(): {} ms'.format((t_end-t_start)*1000))  # time [ms]
Out[7]:
.mean(): 2.289295196533203 ms

In [8]: t_start = time.time(); \
   ...: result = m.compute(); \
   ...: t_end = time.time(); \
   ...: print('.compute(): {} min'.format((t_end-t_start)/60))  # time [min]
Out[8]:
.compute(): 3.4004417498906454 min
```

Timing in the IPython Shell

```
In [9]: m = df['trip_distance'].mean()

In [10]: %time result = m.compute()
CPU times: user 9min 50s, sys: 1min 16s, total: 11min 7s
Wall time: 3min 1s
```

Is Dask or Pandas Appropriate?

- How big is dataset?
- How much RAM available?
- How many threads/cores/CPUs available?
- Are Pandas computations/formats supported in Dask API?
- Is computation *I/O-bound* (disk-intensive) or *CPU-bound* (processor intensive)?

Best use case for Dask

- Computations from Pandas API available in Dask
- Problem size close to limits of RAM, fits on disk

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Analyzing NYC Taxi Rides

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The New York Taxi Dataset

Taxi CSV Files

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-rw-r--r--  1 user  staff   1.7G 31 Jul 16:43 yellow_tripdata_2015-12.csv
```

- Exercises use smaller files...

Taxi Data Features

```
In [2]: import pandas as pd

In [3]: df = pd.read_csv('yellow_tripdata_2015-01.csv')

In [4]: df.shape
Out[4]: (12748986, 19)

In [5]: df.columns
Out[5]:
Index(['VendorID', 'tpep_pickup_datetime', 'tpep_dropoff_datetime',
       'passenger_count', 'trip_distance', 'pickup_longitude',
       'pickup_latitude', 'RateCodeID', 'store_and_fwd_flag',
       'dropoff_longitude', 'dropoff_latitude', 'payment_type', 'fare_amount',
       'extra', 'mta_tax', 'tip_amount', 'tolls_amount',
       'improvement_surcharge', 'total_amount'],
      dtype='object')
```

Amount Paid

- How much was each ride?
  - `fare_amount`: cost of ride
  - `tolls_amount`: charges for toll roads
  - `extra`: additional charges
  - `tip_amount`: amount tipped (credit cards only)
  - `total_amount`: total amount paid by passenger

Payment type

```
In [6]: df['payment_type'].value_counts()
Out[6]:
1    7881388
2    4816992
3      38632
4      11972
5          2
Name: payment_type, dtype: int64
```

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