Labs Next Week

Does this work for you?

```
ssh student.ssh.inf.ed.ac.uk
```

then from there

```
ssh scutter0$((RANDOM%7+1))
```

If that didn't work, ask for access to the Hadoop Cluster:

`http://www.inf.ed.ac.uk/systems/support/form/`

Lab Allocation

Go to the lab you picked on Doodle.
Ignore the official assignments.

Everybody have a non-clashing lab?

Extreme Computing
Let's implement MapReduce!

On the exam

- Understand how MapReduce works
- Pseudocode for mappers/reducers
- Performance considerations

Not on the exam (but generally useful)

- Command line programs
- This implementation
- Python
- C++

Goal: Word Count

We'll take a text file and collect the count of each word.

./map.py <toy.txt

```python
#!/usr/bin/python
import sys
for line in sys.stdin:
  for word in line.split():
    print(word + "\t1")
```

Text → Mapped

```
this is toy
toy is small
```

```
this     1
is       1
toy      1
toy      1
is       1
small    1
```

./map.py <toy.txt |sort

```python
#!/usr/bin/python
import sys
for line in sys.stdin:
  for word in line.split():
    print(word + "\t1")
```

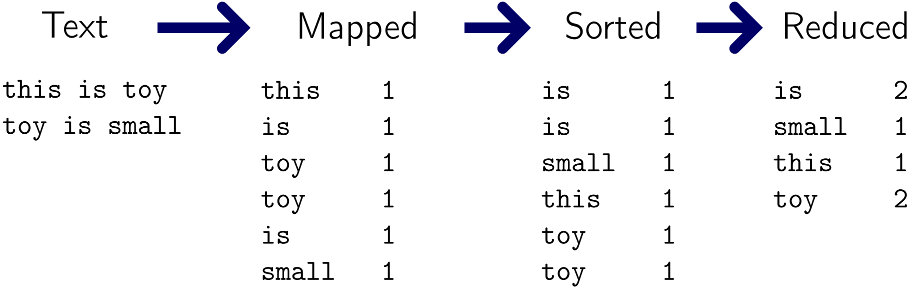
Text → Mapped → Sorted

```
this is toy      this    1        is      1
toy is small     is      1        is      1
                 toy     1        small   1
                 toy     1        this    1
                 is      1        toy     1
                 small   1        toy     1
```

reduce.py

```
#!/usr/bin/python3
import fileinput
key, count = None, 0
for line in fileinput.input():
    key2, count2 = line.strip().split(’\t’)
    count2 = int(count2)
    if key2!=key:
        if key:
            print(key, count, sep=’\t’)
        key, count = key2, count2
    else:
        count += count2
if key:
    print(key, count, sep=’\t’)
```

```
./map.py <toy.txt |sort |./reduce.py
```



Text

```
this is toy
toy is small
```

Mapped

```
this    1
is      1
toy     1
toy     1
is      1
small   1
```

Sorted

```
is      1
is      1
small   1
this    1
toy     1
toy     1
```

Reduced

```
is      2
small   1
this    1
toy     2
```

Measuring Performance

```
pv big.txt >/dev/null
```

```
9.09MiB 0:00:02 [2.94MiB/s] [>               ]  0% ETA 0:06:40
```

pv	Print a file with a progress bar.
big.txt	A text file I made for you.
>/dev/null	Discard the output

Let's Watch

```
pv -c -N map medium.txt |./map.py |sort | \
  pv -c -N reduce |./reduce.py >/dev/null
```

`pv`	Make a progress bar.
`-c`	Do not mess up the terminal, please.
`-N map`	Name the progress bar.
`\`	Continue on the next line.
`>/dev/null`	Discard the output.

What we have now

- One mapper
- One sort
- One reducer

Faster?

GNU Parallel

```
pv big.txt |./map.py >/dev/null
 95.5MiB 0:00:06 [15.7MiB/s] [>           ]  5% ETA 0:01:48
```

```
pv big.txt |parallel --pipe ./map.py >/dev/null
  639MiB 0:00:15 [38.1MiB/s] [===>        ] 34% ETA 0:00:27
```

`parallel`	Powerful parallelization tool
`--pipe`	Split stdin, run jobs on multiple cores

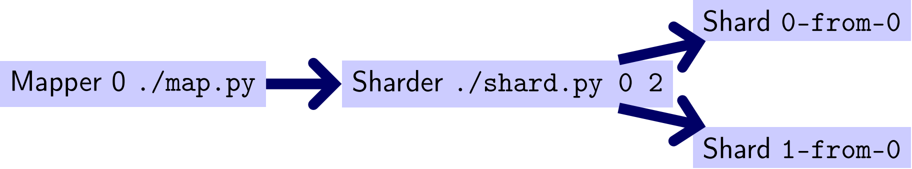
Sorting is a bottleneck

```
pv big.txt |parallel --pipe ./map.py |sort >/dev/null
81.1MiB 0:00:27 [3.26MiB/s] [>             ]  4% ETA 0:09:41
```

Way slower ☹
Can we parallelize this?

Sharding: Split by Key

```
#!/usr/bin/python
#Usage: ./shard.py mapper shards
import sys
shards = [open(str(p) + "-from-" + sys.argv[1], "w")
  for p in range(int(sys.argv[2]))]
for l in sys.stdin:
    key = l.split('\t')[0]
    shard = hash(key) % len(shards)
    shards[shard].write(l)
```



Toy Sharding

```
./map.py <toy.txt |./shard.py 0 2
pv 0-from-* |sort |./reduce.py
pv 1-from-* |sort |./reduce.py
```

Toy Sharding

```
./map.py <toy.txt |./shard.py 0 2
pv 0-from-* |sort |./reduce.py
pv 1-from-* |sort |./reduce.py
```

Parallel Mapping and Sharding

```
pv medium.txt |parallel --pipe ./map.py \| ./shard.py {#} 2
pv 0-from-* |sort |./reduce.py
pv 1-from-* |sort |./reduce.py
```

`\|` Escape the | character so sharding is part of the parallel command

`{#}` Mapper number

Parallel Map and Reduce

```
pv medium.txt |parallel --pipe ./map.py \| ./shard.py {#} 2
parallel cat {}-from-* \| sort \| ./reduce.py ::: 0 1
```

`{}` Substitute argument (reducer number) here.

`::: 0 1` Arguments to substitute are 0 and 1 (for two reducers).

Command Line MapReduce

- Parallel map and reduce
- Single machine[1]
- Limited fault tolerance

[1] GNU parallel can SSH (awesome!), but data still passes though one machine