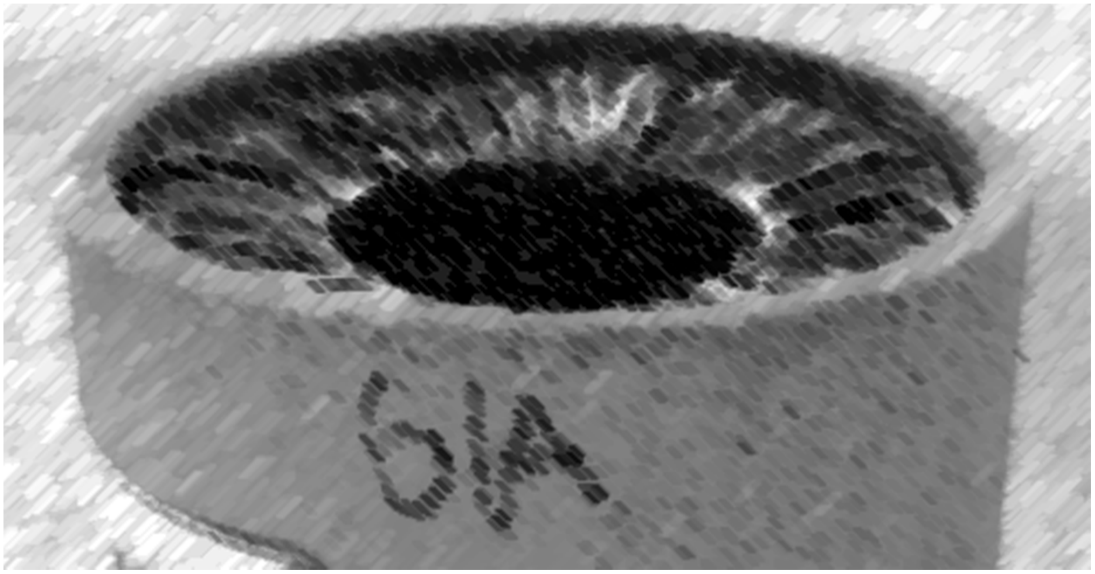


CS61A Lecture 42

Amir Kamil

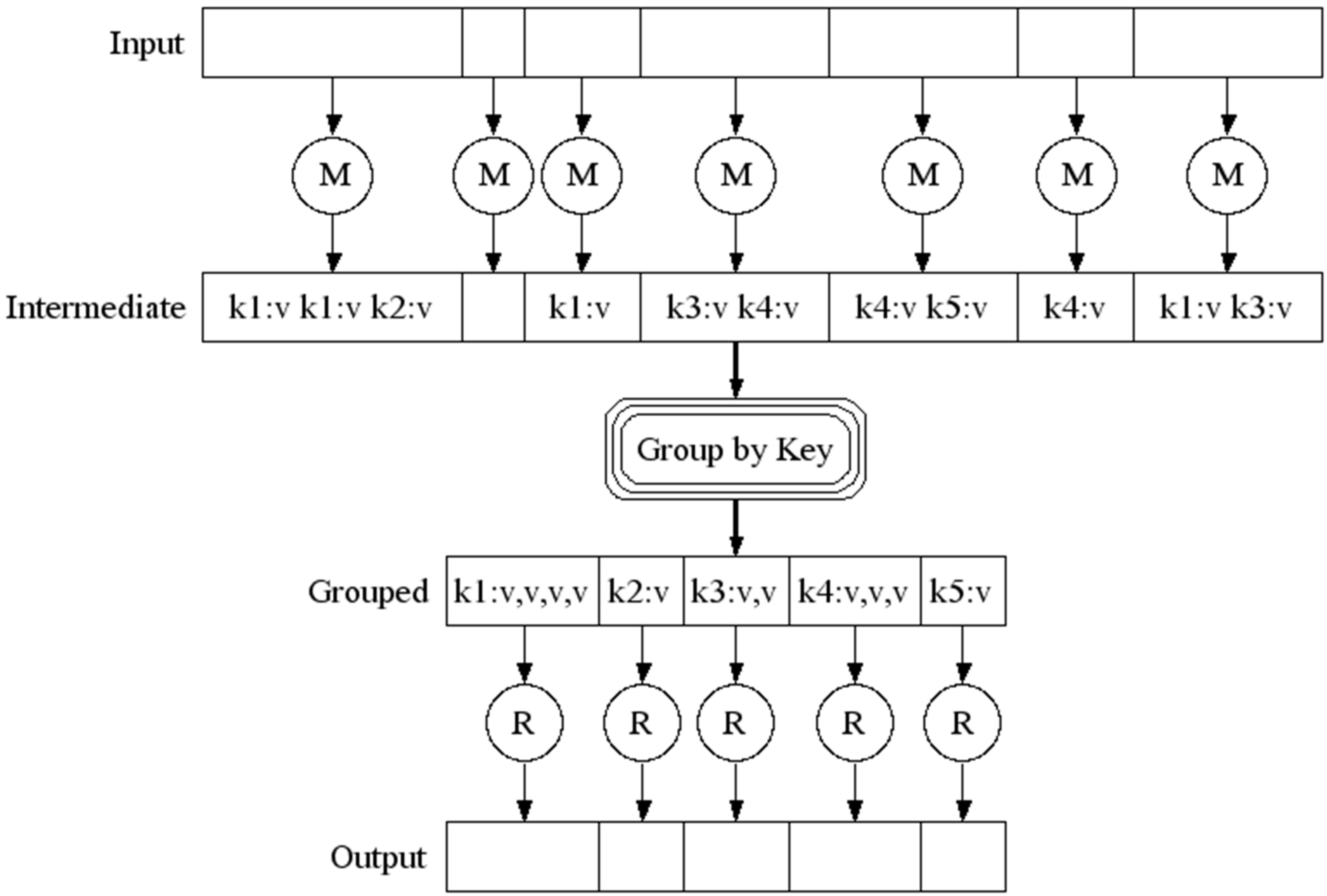
UC Berkeley

April 29, 2013

Announcements

- HW13 due Wednesday
- Scheme project due tonight!!!
- Scheme contest deadline extended to Friday

MapReduce Execution Model



http://research.google.com/archive/mapreduce-osdi04-slides/index-auto-0007.html

Python Example of a MapReduce Application

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Mapper

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def emit_vowels(line):
    for vowel in 'aeiou':
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for line in sys.stdin:
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Reducer

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Reducer

```
#!/usr/bin/env python3

import sys
from ucb import main
from mapreduce import emit, group_values_by_key
```

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Takes and returns iterators

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```
for key, value_iterator in group_values_by_key(sys.stdin):
    emit(key, sum(value_iterator))
```

Parallel Computation Patterns

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1. Dense Linear Algebra
2. Sparse Linear Algebra
3. Spectral Methods
4. N-Body Methods
5. Sructured Grids
6. Unstructured Grids
7. MapReduce
8. Combinational Logic
9. Graph Traversal
10. Dynamic Programming
11. Backtrack and Branch-and-Bound
12. Graphical Models
13. Finite State Machines

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MapReduce is only one of these patterns

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MapReduce is only one of these patterns

The rest require shared mutable state

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Processes execute in separate interpreters, generally not sharing data

- Shared state can be communicated explicitly between processes
- Since processes run in separate interpreters, they can be executed in parallel as the underlying hardware and software allow

The concepts of threads and processes exist in other systems as well

Threads

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Start the other thread

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def thread_say_hello():
    print('hello from', current_thread().name)
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>>> thread_hello()
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Function that the new thread should run

Start the other thread

Arguments to that function

```
>>> thread_hello()
hello from Thread-1
```

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    other.start()
    thread_say_hello()

def thread_say_hello():
    print('hello from', current_thread().name)

>>> thread_hello()
hello from Thread-1
hello from MainThread
```

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Print output is not synchronized, so can appear in any order

Processes

The **multiprocessing** module contains classes that enable processes to be created and synchronized

Here is a "hello world" example with two processes:

```
from multiprocessing import Process, current_process

def process_hello():
    other = Process(target=process_say_hello, args=())
    other.start()
    process_say_hello()

def process_say_hello():
    print('hello from', current_process().name)
```

Function that the new process should run

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```
>>> process_hello()
hello from MainProcess
>>> hello from Process-1
```

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What is the value of **`counter[0]`** at the end?

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What is the value of **`counter[0]`** at the end?

Only the most basic operations in CPython are *atomic*, meaning that they have the effect of occurring instantaneously

The counter increment is three basic operations: read the old value, add 1 to it, write the new value

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We can see what happens if a switch occurs at the wrong time by trying to force one in CPython:

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from threading import Thread
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counter = [0]

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May cause the interpreter to switch threads

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Given a switch at the **`sleep`** call, here is a possible sequence of operations on each thread:

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`Thread 0` `Thread 1`

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Thread 0	Thread 1
read counter[0]: 0	

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write 1 -> counter[0]
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calculate 0 + 1: 1
write 1 -> counter[0]
                                   calculate 0 + 1: 1
                                   write 1 -> counter[0]
```

The counter ends up with a value of 1, even though it was incremented twice!

Race Conditions

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We will see some basic tools for managing shared state

Synchronized Data Structures

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Some data structures guarantee synchronization, so that their operations are atomic

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```
from queue import Queue

queue = Queue()

def increment():
    count = queue.get()
    sleep(0)
    queue.put(count + 1)

other = Thread(target=increment, args=())
other.start()

queue.put(0)

increment()
other.join()

print('count is now', queue.get())
```

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Synchronized FIFO queue

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Synchronized FIFO queue

Waits until an item is available

Add initial value of 0