

61A Lecture 36

Wednesday, November 30

Project 4 Contest Gallery

Prizes will be awarded for the winning entry in each of the following categories.

- **Featherweight.** At most 128 words of Logo, not including comments and delimiters.
- **Heavyweight.** At most 1024 words of Logo, not including comments and delimiters.

Winners will be selected by popular vote! (Homework 13)

- Static **images** of the output of your programs
- Tonight at midnight: I'll post your Logo **implementations!**
 - Run them to see these images evolve!
- I will also post a **solution** to the Logo project
 - It runs (almost) all of the contest entries
 - You can use it as a study guide for the final

(Demo)

MapReduce

Bonus
Material

MapReduce is a *framework* for batch processing of Big Data

What does that mean?

- **Framework:** A system used by programmers to build applications
- **Batch processing:** All the data is available at the outset and results aren't consumed until processing completes
- **Big Data:** A buzzword used to describe datasets so large that they reveal facts about the world via statistical analysis

(Demo)

The big ideas that underly MapReduce:

- Datasets are too big to be stored or analyzed on one machine
- When using multiple machines, systems issues abound
- Pure functions enable an abstraction barrier between data processing logic and distributed system administration

Systems

Systems research enables the development of applications by defining and implementing abstractions:

- **Operating systems** provide a stable, consistent interface to unreliable, inconsistent hardware
- **Networks** provide a simple, robust data transfer interface to constantly evolving communications infrastructure
- **Databases** provide a declarative interface to software that stores and retrieves information efficiently
- **Distributed systems** provide a single-entity-level interface to a cluster of multiple machines

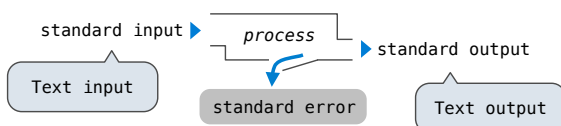
A unifying property of effective systems:

Hide *complexity*, but retain *flexibility*

The Unix Operating System

Essential features of the Unix operating system (and variants)

- **Portability:** The same operating system on different hardware
- **Multi-Tasking:** Many processes run concurrently on a machine
- **Plain Text:** Data is stored and shared in text format
- **Modularity:** Small tools are composed flexibly via pipes



The **standard streams** in a Unix-like operating system are conceptually similar to Python iterators

(Demo)

Python Programs in a Unix Environment

The built-in `input` function reads a line from *standard input*.

The built-in `print` function writes a line to *standard output*.

(Demo)

The values `sys.stdin` and `sys.stdout` also provide access to the Unix *standard streams* as "files."

A Python "file" is an interface that supports iteration, read, and write methods.

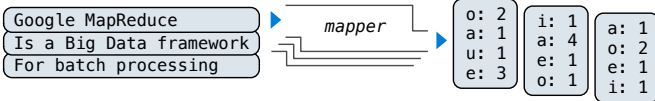
Using these "files" takes advantage of the operating system *standard stream* abstraction.

(Demo)

MapReduce Evaluation Model

Map phase: Apply a *mapper* function to inputs, emitting a set of **intermediate key-value pairs**

- The *mapper* takes an iterator over inputs, such as text lines.
- The *mapper* yields 0 or more **key-value pairs** per input.

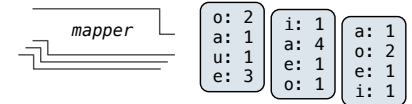


Reduce phase: For each **intermediate key**, apply a *reducer* function to accumulate all values associated with that key

- The *reducer* takes an iterator over **key-value pairs**.
- All pairs with a given key are consecutive
- The *reducer* yields 0 or more values for a key, each associated with that **intermediate key**.

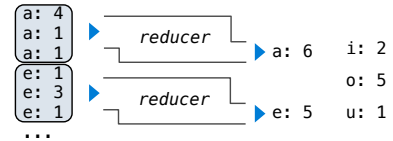
MapReduce Evaluation Model

Google MapReduce
Is a Big Data framework
For batch processing

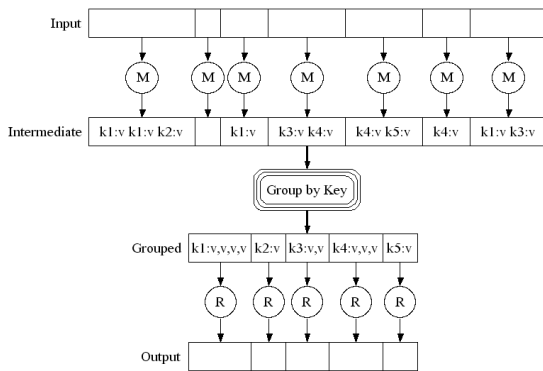


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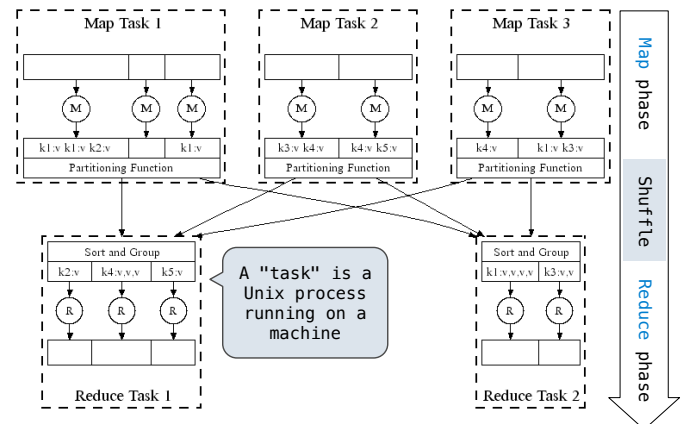


Above-the-Line: Execution model



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

Below-the-Line: Parallel Execution



<http://research.google.com/archive/mapreduce-osdi04-slides/index-auto-0008.html>

Python Examples of a MapReduce Application

The *mapper* and *reducer* are both self-contained Python programs

- Read from *standard input* and write to *standard output*!

Mapper

Tell Unix: this is Python

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

```
import sys
from ucb import main
from mr import emit

def emit_vowels(line):
    for vowel in 'aeiou':
        count = line.count(vowel)
        if count > 0:
            emit(vowel, count)
```

The emit function outputs a key and value as a line of text to standard output

```
@main
def run():
    for line in sys.stdin:
        emit_vowels(line)
```

Mapper inputs are lines of text provided to standard input

Python Examples of a MapReduce Application

The *mapper* and *reducer* are both self-contained Python programs

- Read from *standard input* and write to *standard output*!

Reducer

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

```
import sys
from ucb import main
from mr import emit, values_by_key
```

Takes and returns iterators

Input: lines of text representing key-value pairs, grouped by key
Output: Iterator over (key, value_iterator) pairs that give all values for each key

```
@main
def run():
    for key, value_iterator in values_by_key(sys.stdin):
        emit(key, sum(value_iterator))
```

What Does the MapReduce Framework Provide

Fault tolerance: A machine or hard drive might crash

- The MapReduce framework automatically re-runs failed tasks.

Speed: Some machine might be slow because it's overloaded

- The framework can run multiple copies of a task and keep the result of the one that finishes first.

Network Locality: Data transfer is expensive

- The framework tries to schedule map tasks on the machines that hold the data to be processed.

Monitoring: Will my job finish before dinner?!?

- The framework provides a web-based interface describing jobs.