# 15-319 / 15-619 Cloud Computing

Recitation 3

Jan 26 & 28, 2016

# Overview

- **Administrative Issues**
- **Last Week's Reflection**
  - Project 1.1, OLI Unit 1, Quiz 1
- **This Week's Schedule**
  - Project1.2, OLI Unit 2, Module 3 and 4, Quiz 2
- **Demo**
- **Questions**

# Administrative

- TA office hours are posted
  - Piazza
  - Google calendar
- Suggestions for using Piazza
  - Discussion forum, contribute questions and answers
  - Read the Piazza Post Guidelines (@9) before asking
  - Read Piazza questions & answers carefully to avoid duplicate ones
  - Don’t ask a public question about a quiz question
  - Try to ask a public question if possible

# Keeping Your Account Secure

- Do not make your code available publically on the internet
- Do not share anywhere (Piazza, etc…)
- Remove any account identification information away before committing to a private repository
- Do NOT submit .pem files through the autograder.
- Remove account credentials before submitting code

# Reflecting on Last Week

- Reading:
  - Unit 1: Introduction to Cloud Computing
    - Modules 1 & 2
  - Quiz 1: Introduction to Cloud Computing
    - (Mean: 82%; Median:  83.5%; StdDev: 12%; 100s: 9)
- Project:
  - Project 1.1:
    - Wikipedia Dataset
    - Filtering one hour’s worth of data
    - 251 (of 264) students scored 80/80

# Looking back at Project 1.1

- Loading all the data to memory to filter and process is a bad idea!
  - Recurring theme in the course projects
  - But if you can fit everything in-memory, big win

- A better approach: work from disk, build a processing pipeline
  - Write programs that process the data line by line

# This Week's Schedule

- Complete Unit 2 (Modules 3 & 4)
- **Quiz 2**
  - Deadline, Friday, Jan 29, 11:59pm ET
- **Complete Project 1.2 (Using Elastic MapReduce)**
  - Deadline, Sunday, Jan 31, 11:59pm ET

# Why Study Data Centers in Unit 2?

- The cloud is the data centers
- Learn what influences
  - performance, failure, cost, …
- Make you a better cloud programmer
- Make sure to read and understand the content of Unit 2
  - Equipment in a data center
  - Power, cooling, networking
  - How to design data centers
  - What could break

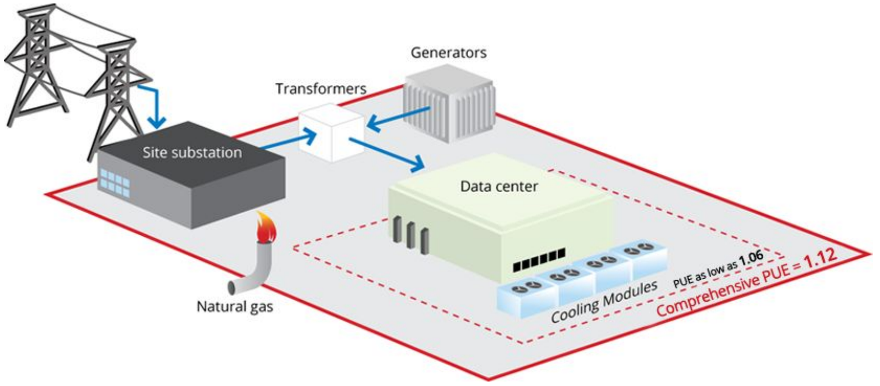
# Module 3: Data Center Trends

- Definition & Origins
  - Infrastructure dedicated to housing computer and networking equipment, including power, cooling, and networking.
- Growth
  - Size (No. of racks and cabinets)
  - Density
- Efficiency
  - Servers
  - Server Components
  - Power
  - Cooling

Facebook data center

# Module 4: Data Center Components

- IT Equipment
  - Servers : rack-mounted
    - Motherboard
    - Expansion cards
  - Type of Storage
    - Direct attached storage (DAS)
    - Storage area network (SAN)
    - Network attached storage (NAS)
  - Networking
    - Ethernet, protocols, etc.
- Facilities
  - Server room
  - Power (distribution)
  - Cooling
  - Safety




Source: http://www.google.com/about/datacenters/efficiency/internal/

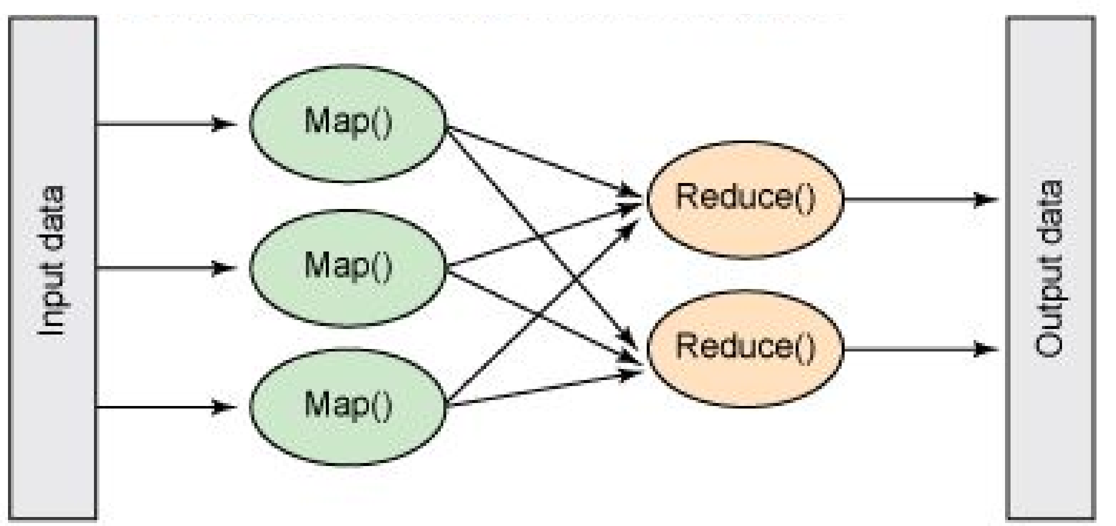
# Project 1.2

- In Project 1.1, we processed 1 hour of data on one single machine
- How do you filter and sort the data for one month?

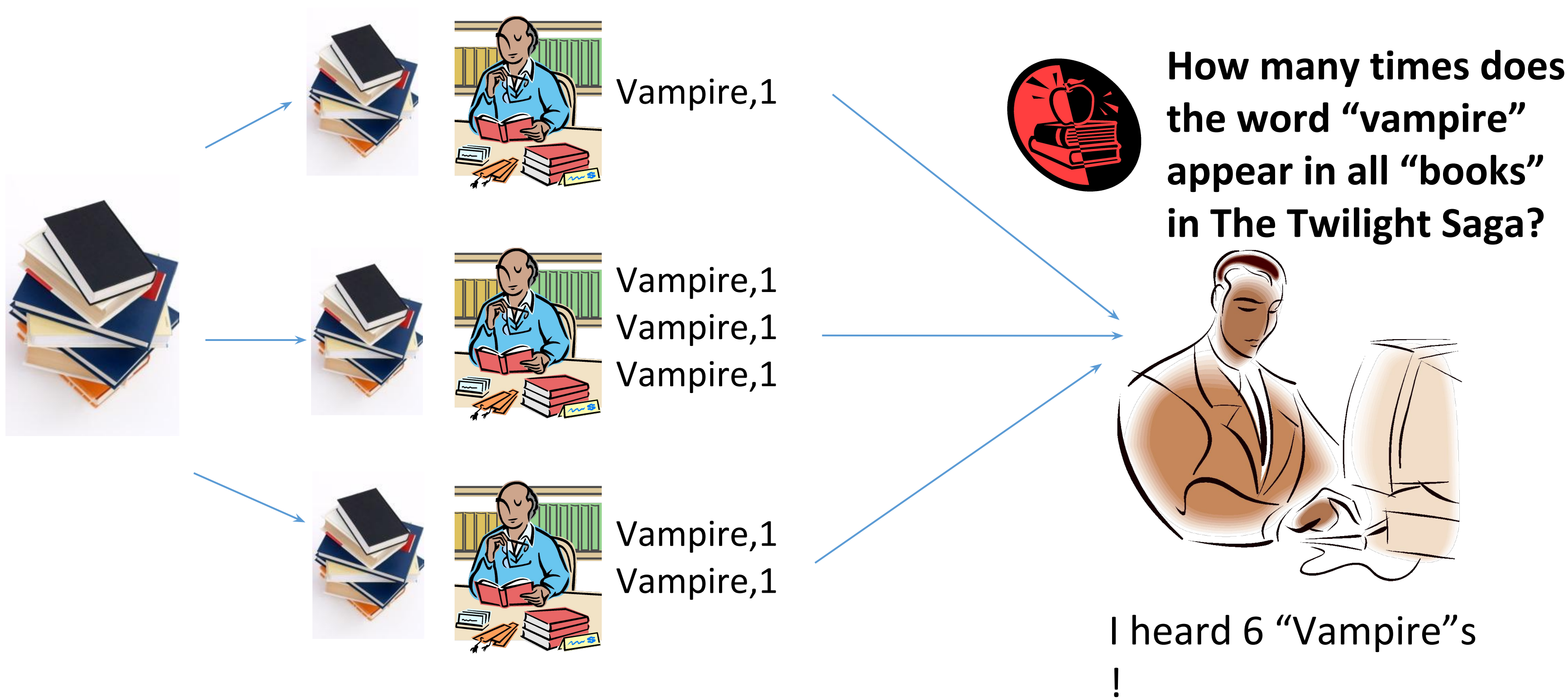
- Parallel & Distributed Processing
  - How about Pthreads/MPI/…?
    - How simple are these frameworks?
    - Need to design many elements from scratch:
      - File Handling
      - Task Management
      - Orchestration
    - Painful. Take 15440/15618 for a taste ☺

# Introduction to MapReduce

- **Definition**: Programming model for processing large data sets with a parallel, distributed algorithm on a cluster
- **Map**: Extract something you care about
- **Group by key**: Sort and Shuffle
- **Reduce**: Aggregate, summarize, filter or transform
- **Output** the result

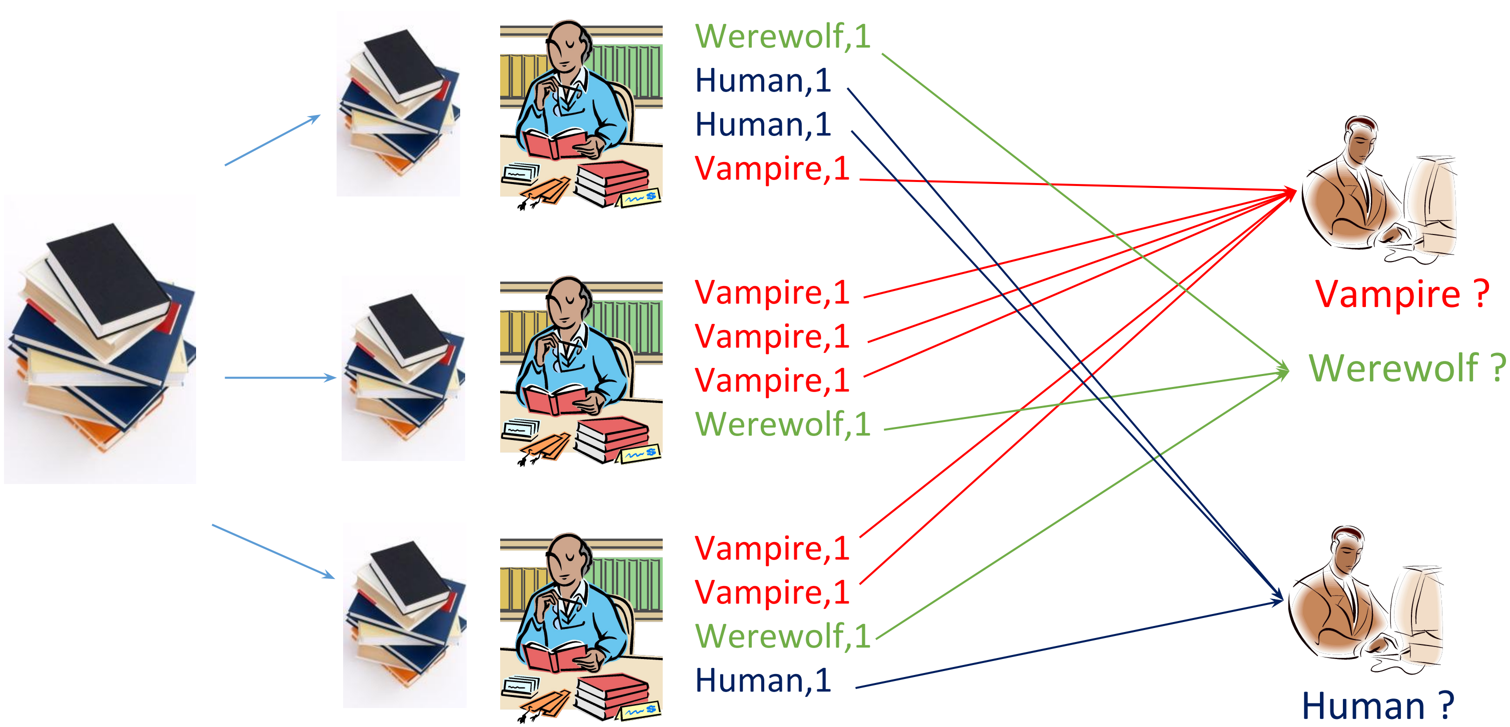


# MapReduce Example



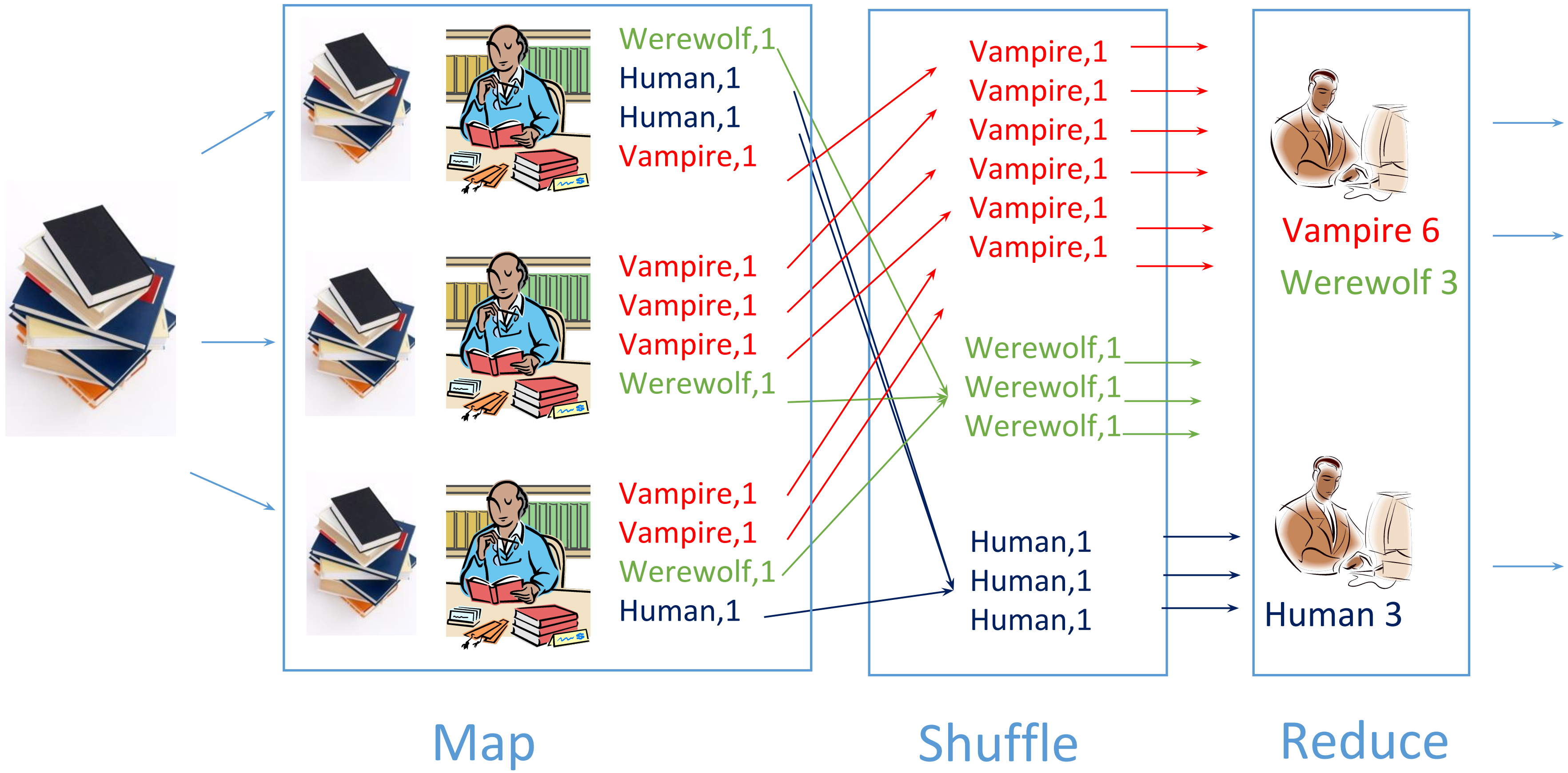
# MapReduce Example

What if we want to count the number of times all species appeared in these "books"?

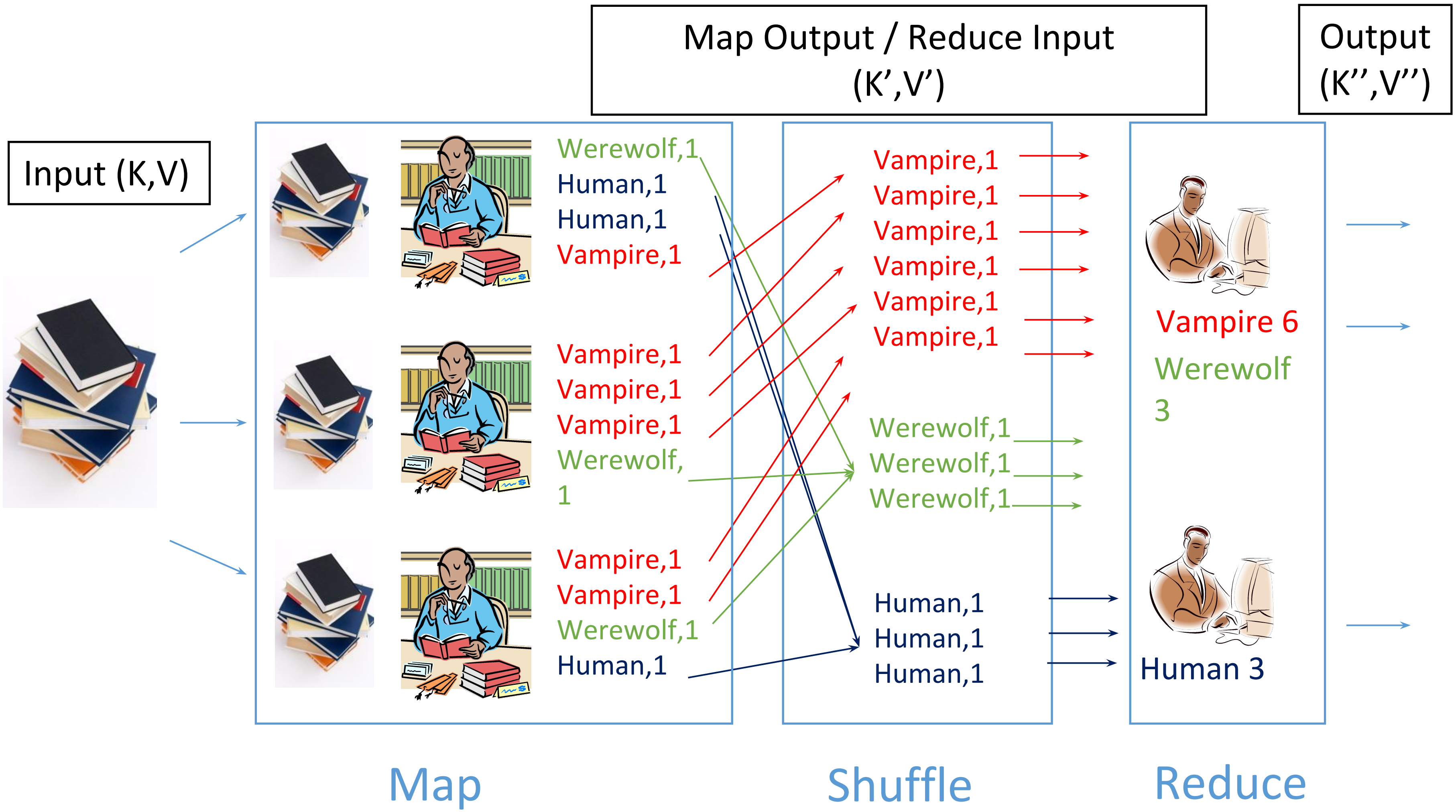



You can have multiple aggregators, each one working on a distinct set of species.

# MapReduce Example



# MapReduce Example



# Steps of MapReduce

- Map
- Shuffle
- Reduce
- Produce final output

# Steps of MapReduce

- Map
  - Prepare input for mappers
    - Split input into parts and assign them to mappers
  - Map Tasks
    - Each mapper will work on its portion of the data
    - Output: **key-value pairs**
      - Keys are used in Shuffling and Merge to find the Reducer that handles it
      - Values are messages sent from mapper to reducer
      - e.g. (Vampire, 1)

# Steps of MapReduce

- Shuffle
  - Sort and group by key:
    - Split keys and assign them to reducers (based on hashing)
    - Each key will be assigned to exactly one reducer
- Reduce
  - Input: mapper's output (key-value pairs)
  - Each reducer will work on one or more keys
  - Output: the result needed
- Produce final output
  - Collect all output from reducers
  - Sort them by key

# MapReduce: Framework

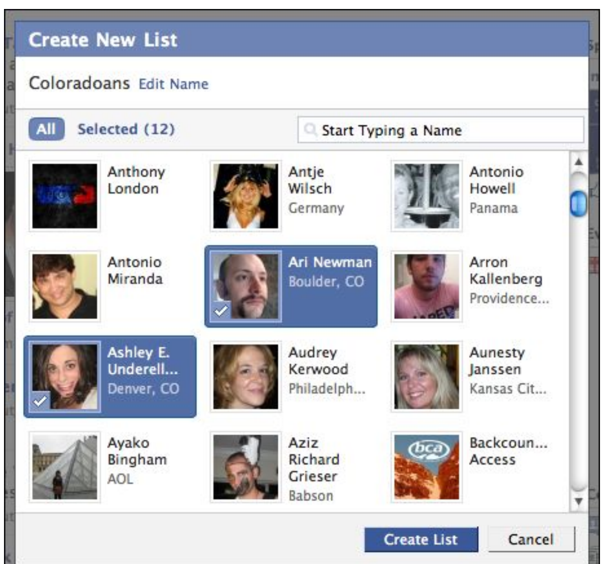
- The MapReduce framework takes care of:
  - Partitioning the input data
  - Scheduling the program’s execution across a set of machines
  - Perform the group by key (sort & shuffle) step
  - Handling machine failures
  - Manage required inter-machine communication

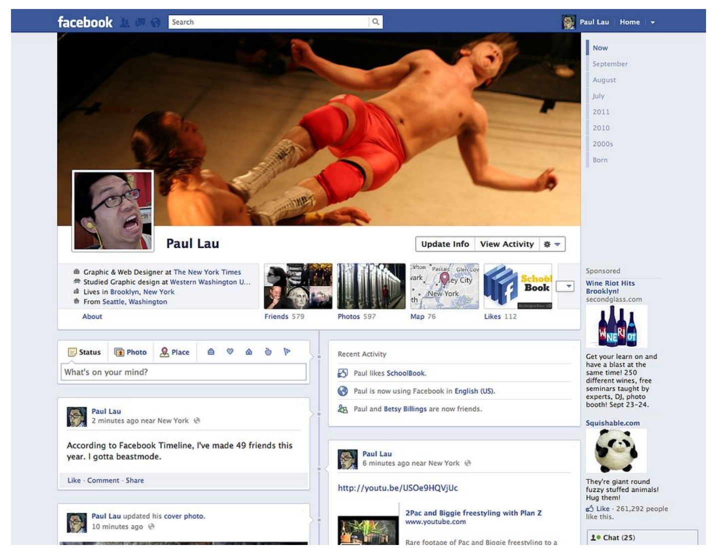
# Parallelism in MapReduce

- Mappers run in parallel, creating different intermediate values from input data
- Reducers also run in parallel, each working on different keys
- However, reducers cannot start until all mappers finish
  - The Shuffle can start early as soon as the intermediate data from the mappers is ready

# Example: Friend/Product Suggestion

- Facebook gathers information on your profile and timeline
  - e.g. contact list, messages, direct comments made, page visits, common friends, workplace/residence nearness
  - This info is dumped into a log or a database

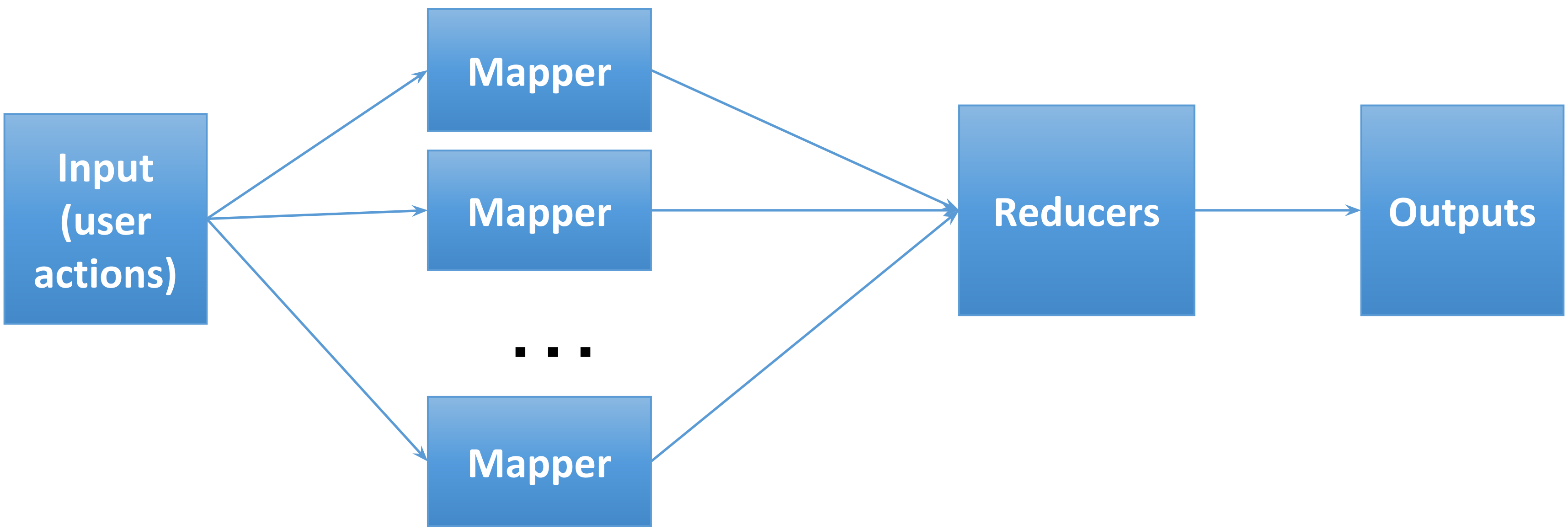


# Real Example: Friend/Product Suggestion

Generate key-value pairs:
Key: Friends pair
Value: Friends statistics (e.g. common friends)
e.g. (<u>Tom, Sara</u> statistics)

Aggregate the statistics value for the same key and output the friends pair if it's above the threshold
e.g. (Tom Sara)



# Project 1.2 Elastic MapReduce

- Setup a **Streaming Elastic MapReduce** job flow in AWS
- Write simple Mapper and Reducer in the language of your choice
- Example job flow: Wordcount provided in writeup

```java
public class wordcountMapper{

    public static void main (String args[]) {

    try{
        BufferedReader br =
                    new BufferedReader(new InputStreamReader(System.in));
        String input;
        //While we have input on stdin
        while((input=br.readLine())!=null){
            //Initialize Tokenizer on string input
            StringTokenizer tokenizer = new StringTokenizer(input);
            while(tokenizer.hasMoreTokens())
            {
                String word = tokenizer.nextToken();  //Get the next word
                System.out.println(word+"\t"+"1");    //Output word\t1
            }
        }

    }catch(IOException io){
        io.printStackTrace();
    }
  }
```

```java
public class wordcountReducer{

    public static void main (String args[]) {

    try{
        BufferedReader br =
                    new BufferedReader(new InputStreamReader(System.in));
        //Initialize Variables
        String input;
        String word = null;
        String currentWord = null;
        int currentCount = 0;

        //While we have input on stdin
        while((input=br.readLine())!=null){
            try{
                String[] parts = input.split("\t");
                word = parts[0];
                int count = Integer.parseInt(parts[1]);

                //We have sorted input, so check if we
                //are we on the same word?
                if(currentWord!=null && currentWord.equals(word))
```

# How to write the Mappers and Reducers?

- The programs must read input files through stdin
- They have to write output through stdout
- Mapper, reducer and input data should be in S3
- Test your program on a local machine before launching a cluster!

  **cat input | mapper | sort |reducer > output**

- Launch a cluster to process the data
  - Budget: $15

# How to Work on a Budget

- You will need to create an EMR cluster
  - EMR has additional hourly cost per instance.
  - Example: 10 x m1.large = 10 x (0.175 + 0.044) = **$2.19 per hour!**
  - Total time you have: ~ 6.84 hours in this configuration

- **Spot Instances are your friend**:
  - Same cluster @ spot pricing = 10 x (0.0161 + 0.044) = **$0.601 per hour!**

# P1.2 Logistics

- For this checkpoint, use tags with
  - Key: **Project** and Value: **1.2** for all resources
  - Tag before Launching! And check after launching!
  - No tags ➔ 10% grade penalty
- Budget
  - For P1.2, each student's budget is $15
  - Exceeding $15 ➔ 10% project penalty
  - Exceeding $30 ➔ 100% project penalty
- Plagiarism ➔ the lowest penalty is 200% & potential dismissal

# P1.2 Program Flow

- Specify given S3 location as input
- At the mapper:
    - Read all data as lines from stdin
    - Find the filename associated with each line in the mapper
        - Use mapreduce_map_input_file to get filename
        - Do not use the filename to open() the file
    - Extract the date and the title, view count
- At the reducer:
    - Aggregate daily counts and print the ones over the threshold

# Upcoming Deadlines

- **Quiz 2**
  - Deadline, Friday, Jan 29, 11:59pm ET
- **Complete Project 1.2 (Using Elastic MapReduce)**
  - Deadline, Sunday, Jan 31, 11:59pm ET

# Demo

- Viewing environment variables on EMR
- Walkthrough of EMR output and runner.sh questions
- Anything else you may be interested in?
  - Quick Tour of AWS
    - On-Demand and Spot Instances
    - EMR
    - Billing and Monitoring Costs

# Some hints

- Implement WordCount from the examples provided
- Most commonly missed edge cases:
  - Last date / hour / line in file
- Q2: Make sure you break ties
- Q5: Does every month have the same number of days?
- Q9: Needs two passes, find length and count sequences