Quiz 1

Online (In-class) Quiz –

1. [1 point] In data mining, the discovered patterns and models are required to be:

   a. Valid

   b. Useful

   c. Expected

   d. Understandable

   Answer – A,B,D

2. [1 point] Consider a system with “m” mappers and “r” reducers. In the grouping stage, the master controller applies a hash function of the form “(a+b*x) % y”, where “a” and “b” are constants, “x” is the key that comes from the mapper. What should the ideal value of “y” be?
   A. m - 1
   B. m
   C. r
   D. r - 1

   Answer - The master controller typically applies a hash function to keys and produces a bucket number from 0 to r for this to happen, the value of “y” must be “r”

3. [1 point] In MapReduce, which of the following is **max of I/O cost along any path**?
   a. Elapsed Computation cost
   b. Communication cost
   c. Elapsed Communication cost
   d. Total Payable cost
4. [1 point] Briefly explain the advantages of a distributed file system.
   High Availability - stores data across multiple disks for availability and persistence
   Moves the computation closer to the data to minimize data movement.
5. [1.5 points] Design a MapReduce algorithm that takes a very large file of integers and produces as output all unique integers from the original file that are evenly divisible by 13. Just indicate the logic needed using pseudocode.

   ```
   Map (key, value list):
   for v in value list:
   if (v % 3) == 0:
   emit (v, 1)
   ```

Reduce (key, values):
(Eliminate duplicates)
emit (key, 1)

6. [1.5 points] Where does the MapReduce program store 1. Input data, 2. Intermediate files, and 3. Output data? Why do we care about where they store the data?

   1. Distributed File System

   2. Local File System of Mapper

   3. Distributed File System

   The location of stored data plays importance as the main goal is to reduce the communication cost and also it helps in dealing with node failures.

   (as if the node running map is failed, entire operation is repeat even if the process is complete, this is because the node running map stores intermediate files on its memory, While when node running reduce operation is failed after the process is completed, there is nothing to worry about as the result of reduce operation is stored in the DFS)

   Also, when the size of data is extremely large and cannot be placed in the local memory, the map reduce functions communicates, only chunks of data and it is processed generating intermediate files which are stored in the main memory while input and output still will be in DFS.

7. [1 point] Consider multiplying two matrices A (3X3) and B (3X2). Consider the **two-stage** approach to matrix multiplication (AXB) as discussed in class.

   A = [1 1 1]
   [2 1 2]
   [1 2 1]

   B= [1 0]
   [0 1]
   [1 2]

   If the Mapper in **stage 1** takes as the input the element B[3,2], which of the following key-value pairs will be in its output?

   a. (3,(B,2,B[3,2]))
   b. (2,(B,2,B[3,2]))
   c. (2,(B,3,B[3,2]))

d. (3,(B,3,B[3,2]))

Answer - emit(j , (B, k, B[j,k])

8. [1 point] Consider a Map-Reduce program that computes the **largest integer** in a large set of integers. Suppose one of its Mapper outputs a key-value pair : (8,1). Which of the following is/are **unlikely** to be the input of Mapper?
   a. (“8”, [3,5,1,8])
   b. (“1”, [1,8,5,9])
   c. (“8”, [10,9,8,11])
   d. (“1”,[7,8,8,6])

Offline (Take-home) Quiz –

9. [1 point] What is the advantage of using combiners?
   Reduce network traffic for data sent to the reduce tasks.

10. [2 points] Recall the “evil-doer” example when we talked about **Bonferroni's principle**. Suppose that we make the following assumptions. We track 3 million people for 100 days. Each person stays in a hotel 1% of the time. Each hotel holds 100 people and there are 100 hotels.What is the expected number of “suspicious” pairs of people (i.e., they went to the same hotel on some two days)?

    Expected number of suspicious people is 2500 * 4
    Let p be the probability of person p being in the hotel
    p = 1/100
    Let q be the probability of person q being in the hotel
    q = 1/100
    A = probability that p and q are in the same hotel on day d
    A = 1/100 * 1/100 * 1/100 = 10^-6
    B = probability that p and q are in the same hotel on day d1 and d2
    B = A * A = 10^-6 * 10^-6 = 10^(-12) [0.5 point]
    Choose 2 days = 100C2
    C = probability that p and q are in the same hotel on day d1 and d2 with two days selected
    C = 10^(-12) * 100*100/2 = 10^-8/2 [0.5 point]
    Choose pairs of people = 3*10^6C2 = 9*10^12/2 [0.5 point]
    D = the expected number of "suspicious" pairs of people
    D = (10^-8)/2 * (10^12)/2 = 10^4/4 = 2500*9 [0.5 point]
    the expected number of "suspicious" pairs of people = 22500

11. [1.5 points] What is Distributed File Systems (DFS)? Name two DFS.

    A distributed file system is a file system with data stored on multiple servers. In a distributed file system, one or more central servers store files that can be accessed by any number of remote clients in the network.
    It consists of:
    1) Chunk Server: The file is split into chunks (typically 64 MB). Each chunk is replicated usually 2x to 3x times and the replicas are kept in different racks.
    2) Master Node: Stores metadata about where files are stored
    3) Client library for file access: Talks to master to find chunk servers and connects directly to chunk servers to access data
    Two types of DFS -

Hadoop Distributed File System(HDFS), Google File System (GFS)

12. [1 point] Consider a Map-Reduce program that computes the **largest integer** in a large set of integers. Suppose one of its Mapper outputs a key-value pair : (8,1). Which of the following is/are **unlikely** to be the input of Mapper?
    a. (“8”, [3,5,1,8])
    b. (“1”, [1,8,5,9])
    c. (“8”, [10,9,8,11])
    d. (“1”,[7,8,8,6])
13. [1.5 points] Why is that when map workers fail, the tasks that are completed or in-progress at map workers are reset to idle and rescheduled but only in-progress tasks are reset to idle when reduce worker fails?

    Answer-

    If the node running map is failed, entire operation is repeat even if the process is complete, this is because the node running map stores intermediate files on its memory or local disk drives, While when node running reduce operation is failed after the process is completed, there is nothing to worry about as the result of reduce operation is stored in the DFS

14. [1.5 points] Write a MapReduce program that multiplies two matrices A and B in **two** stages. You can assume that the matrices are provided to you in a file in a sparse matrix format. Each line of the file represents an element in a matrix. For example, a line: [‘A’, 0, 0, 1] indicates that A[0, 0] = 1. You may assume that both matrices are 2 x 2. Pseudocode is fine.
    Answer- 0.5 points to each map and reduce
    1st Map Task-
    For each matrix element A[i,j] : emit(j , (‘A’, i, A[i,j]))
    For each matrix element B[j,k] : emit(j , (‘B’, k, B[j,k]))

    1st Reduce Task:
    For each key j, produce all possible products
    For each value of (i,k) which comes from A and B,
    i.e., (‘A’, i, A[i, j]) and (‘B’, k, B[j, k]): emit ((i,k), (A[i, j] * B[j, k]))

    2nd Map Task:
    The input would be the (key, value) from 1st Reduce task
    Let the pair of ((i,k), (A[i, j] * B[j, k])) pass through

    2nd Reduce Task:
    For each (i,k), add up the values, emit ((i,k), SUM(values))

15. [1.5 points] We know that we sometimes convert a one-stage MapReduce program to two or more stages so that the program can process a large input dataset on a given cluster. Use your solution in Q4 and Q5 to explain when we would need a two-stage MapReduce and give at least

one example of memory bottlenecks that makes one-stage program inefficient. Note that in Q4 and Q5, your input matrixes are not very large. For this question, consider the input matrixes can have billions of rows and columns.

Answer-

If a row of the matrix M or a column of the matrix N is so large that it will not fit in main memory, then the Reduce tasks will be forced to use an external sort to order the values associated with a given key (i, k) or for example, a reducer will need to handle the process of dot product and in one-stage programs, the input (matrixed of billions of rows and columns) to the reducer might be too large.