Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First Semester 2021-2022

Mid-Semester Test
(EC-2 Makeup)

Course No.	: DSECLZG522
Course Title	: Big Data Systems
Nature of Exam	: Open Book
Weightage	: 30%
Duration	: 2 Hours
Date of Exam	: 23/01/2022 (FN)

No. of Pages = 3
No. of Questions = 6

Note to Students:
1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

1. Figures 1(a) and 1(b) show sequences of reads and writes for data items in a distributed DB across nodes P1, P2, P3, P4 on a timeline. "R: X=V" at P1 means read operation on data item X returns value V at P1 and "W: Y=V" at P2 means data item Y is written with value V by P2. In each case (a) and (b), explain with adequate reasons whether it is a case of strict consistency, causal consistency or eventual consistency. [Marks:5]

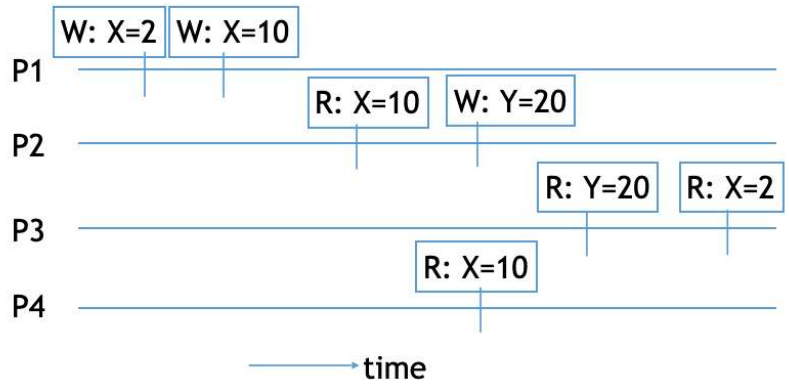

Figure 1(a)

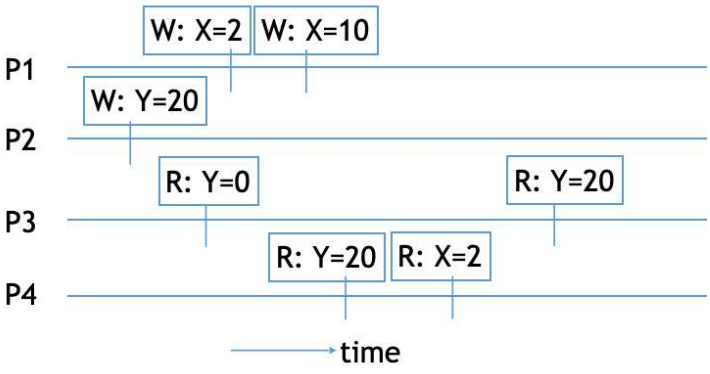

Figure 1(b)

2. A data analysis program can achieve maximum 65% parallelism in its computation because certain operations are inherently sequential. You wish to explore performance improvement using various systems techniques, such as adding compute nodes, caches to reduce storage access latency etc. Answer the following questions :

(a) What will be the speedup of the program with a fixed data set size when the number of processors is 4 and 16 ?
(b) What is the theoretical speed-up if you had unlimited processors at your disposal but unchanged data set size?
(c) If you could increase the problem size and work with larger data sets, what is the theoretical speed-up you could achieve with 64 processors ?
(d) The parallel program on the Compute cluster uses a Storage cluster that has an access latency of 100ms for every data request. You can improve storage access performance using a cache between the Compute and the Storage clusters. You want to reduce the access latency for each request to be 50ms. The cache technology has 25ms access latency. If the program always accesses data via cache, what is the target storage cache hit rate you have to achieve for the workload ?

[Marks:5]

3. An IoT sensor network is deployed in a manufacturing facility to monitor errors in various machines. Each minute every machine sends the count of errors in the last minute for severity levels LOW and HIGH. The data collected is moved to an HDFS file in a Hadoop cluster every day around midnight. Each line in the file has a CSV format with following details: <timeid><machineid><error severity><count of errors>, e.g.
1342, MID6754, LOW, 2
1342, MID6754, HIGH, 0
…
The 2 records in the example capture that machine MID6754 had 2 LOW severity errors and 0 HIGH severity errors in the same minute with timeid 1342. Each minute has a different timeid. Everyday after mid-night, this file is analyzed to check for machines at a risk of failure. A machine is 'at-risk 'if the total count of HIGH severity errors in the entire day is > 10 OR LOW severity errors is > 50. Write a Map-Reduce program (with one or two iterations) to create the list of such 'at-risk 'machines. Write the map and the reduce function logic and clearly comment your pseudo-code to explain the logical steps.

[Marks:5]

4. In the following scenarios, refer to CAP theorem to briefly justify which type of database configuration is preferred among AP, CP, and CA.

(a) A large scale highly distributed event reservation system has less than 50% seats booked.
(b) MyChange.org is an online forum running in a distributed Cloud environment to collect user feedback on a new government policy.
(c) An IPL cricket game is selling some last minute tickets across multiple counters at the venue and all remote counters / online portals are now closed.
(d) A Bank runs its money transaction system and DB within a centralized data center.
(e) A large e-retailer running its backend systems across multiple data centers is giving a limited set of coupons to purchase an item on promotion.

[Marks:5]

5. An enterprise application consists of a 2 node application server cluster connected to a 3 node DB cluster. Over a long period of time it has been observed that an application server node fails every 100 days and a DB server node fails every 50 days.

(a) What is the overall MTTF of the 2-tier system ?
(b) The availability of an app server node is 98%. What is the availability of the app server cluster ?
(c) If the end to end availability of the 2-tier system is 96.5% and the cost of downtime is USD 20000 per hour, what is the yearly downtime cost ?

[Marks:5]

6. A data set is given in a file PERSONS.CSV and each record contains : <name>,<age>,<ward>,<education level>. A MapReduce program executes the following query on a data set : SELECT DISTINCT(person.name) where person.age > 21. The database contains a list of 800 million people. Out of these entries, 200 million people have age <= 21. However, only 10 million distinct names are there. Assume, the mapper creates a key-value pair of size 1KB.

(a) Suppose there are 2 mappers and 1 reducer that run on 2 slave nodes. What is the average and the maximum communication cost in terms of total data flow as the map output is sent to reducers ? Assume age filter is done on map side and distinct is applied during reduction.

(b) Education level is a number between 1-5 and ward is an alphanumeric code for the municipality ward. Write syntactically accurate PIG queries to first import the data from a HDFS file and find out average education level for people with age>21 by ward and sort the output in descending order.

[Marks:5]

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