	Course Name:	Parallel and Distributing Computing	Course Code:	CS3006
	Degree Program:	BS (CS)	Semester:	Spring 2023
	Exam Duration:	180 Minutes	Total Marks:	80
	Paper Date:	24/05/23	Weight	45
	Exam Type:	Final	Page(s):	10

Student : Name:_____ Roll No._____ Section:_____

Instruction: Attempt all questions on the question paper. Rough sheets can be used but it should not be attached. If you think some information is missing then assume it and mention it clearly.

Question # 1: **[15 marks, CLO # 1]**

From the given options, select the best answer.

i. **Which of the following combination is used by Hadoop for storage and processing?**
   a. AFS and MapReduce
   b. HDFS and MapReduce
   c. AFS and UFIDs
   d. HDFS and UFIDs

ii. **The mechanism of packing function parameters into a message packet is called _____.**
   a. Marshalling
   b. RPC paradigm
   c. Stubbing
   d. None of the above

iii. **_____ is a meta language to describe the services offered by a service provider.**
   a. SOAP
   b. XML
   c. WSDL
   d. UDDI

iv. **_____ redundancy technique does not provide error masking.**
   a. Active
   b. Passive
   c. Hybrid
   d. TMR

v. **'Google App Engine' is an example of**
   a. Infrastructure as a service
   b. Platform as a service
   c. Software as a service
   d. None of the above

vi. **An f-resilient algorithm needs _____ rounds to solve consensus for f failed processors**
   a. f
   b. f + 2
   c. f + 1
   d. 2f

vii. **_____ is a consensus algorithm for replicated logs.**

a. Logical clocks
b. Byzantine
c. YARN
d. RAFT

viii. **In RPC, _____ arises when no fault-tolerance measures are applied.**

a. Maybe Semantics
b. At-least-once Semantics
c. At-most-once Semantics
d. None of the given options

ix. **_____ is the ability to view a distributed system as if it were a single computer.**

a. Openness
b. Transparency
c. Extensibility
d. Resource Sharing

x. **In _____ service model, only application and data is managed by the end-user.**

a. IaaS
b. PaaS
c. SaaS
d. All of the above

True/False

i. **In HDFS, DataNode is used to maintain and manage the file system metadata.**

a. True
b. False

ii. **In permanently evicted strategy of Fault Tolerance for spare nodes, the spares remain constant over time.**

a. True
b. False

iii. **A NodeManager is a master daemon that communicates with the client, tracks resources on the cluster, and orchestrates work by assigning tasks.**

a. True
b. False

iv. **Cloud is an infrastructure that involves the integrated and collaborative use of Computers, networks, databases and scientific instruments owned and managed by multiple organizations.**

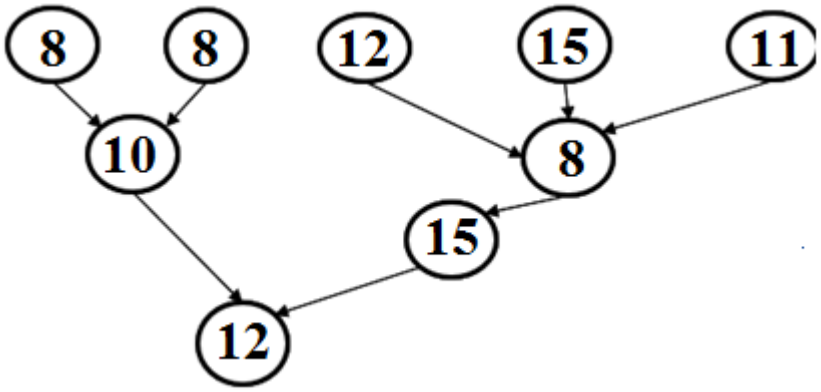
a. True
b. False

v. **In Karp-Flatt metric, if e increases as p increases, it means that parallelization overhead is affecting the speedup.**

a. True
b. False

Question # 2: **[3 + 4 + 3 marks, CLO # 1]**

(a) Analyze the following graph and calculate:



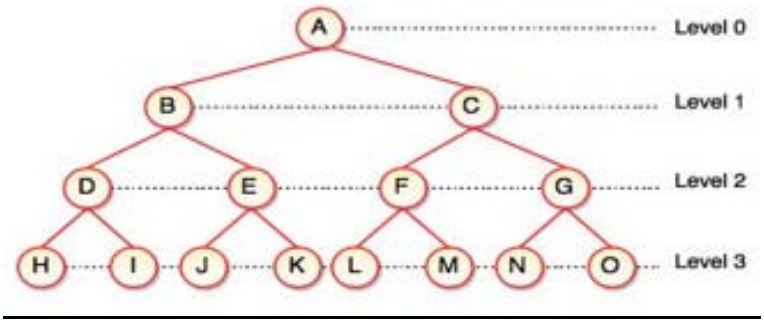
(i) Critical Path Length

(ii) The average degree of concurrency

(iii) Maximum speed up if the number of processes are 2

(b) Draw a 4 x 4 Omega network (4 processes and 4 mem modules) and explain how P3 will access M2.

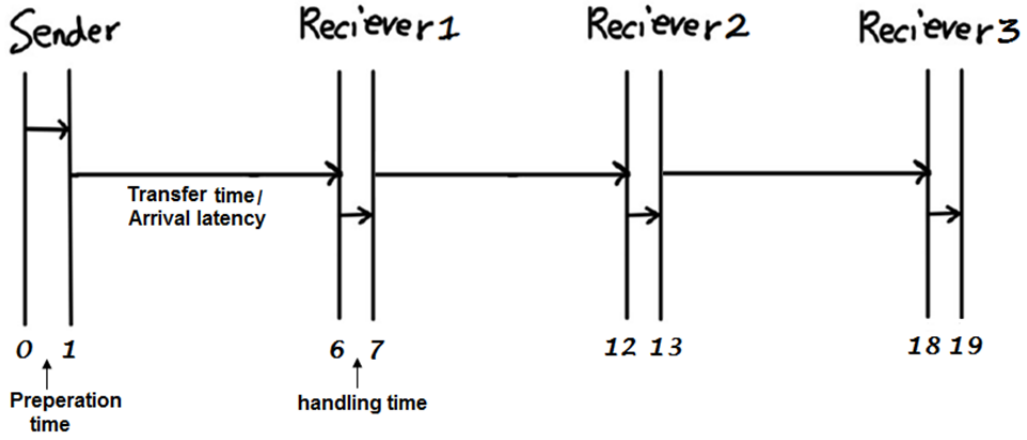
(c) Calculate diameter, total cost and bisection width for a complete binary tree of 3 levels as shown in the image below:



<u>Question # 3:</u> **[4+6 marks, CLO # 1]**

a) What is Amdahl's law? According to this law if we want to double the overall speed of a system having 60% parallelizable code then how many processors would be required?

b) Calculate the time required to transfer 500 mbits of data from Sender to Receiver3. Bandwidth of the links is 5 mbits/s.



Question # 4: **[10 marks, CLO # 3]**

Suppose you have to design a reliable fault-tolerant system that has the capability to tolerate 4 hardware faults and provide 100% availability without any down-time. There is no constraint on area and cost. However, if power could be reduced then that would be a plus. What would be the best hardware redundancy technique in this case? Draw a figure and explain the working of the system. You should provide complete details.

Solution:

Strategy with required number of nodes and their type:

Figure:

Explanation:

Question # 5: **[1+3+3 marks, CLO # 3]**

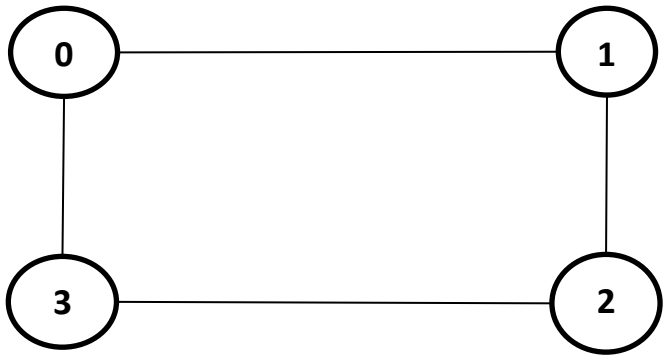
Assume we have a 4*4 matrix with the following values:

1 3 5 7
2 4 6 8
11 13 15 17
10 12 14 16

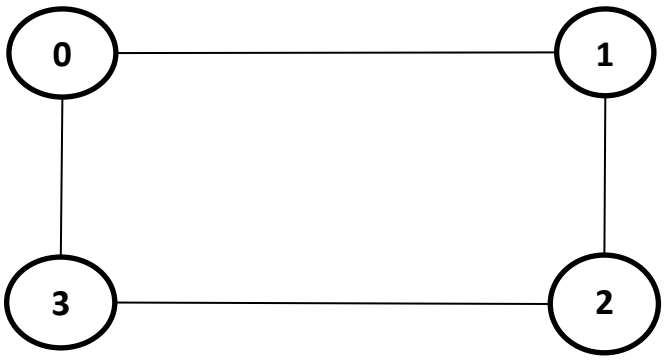
Assume each row is stored at different processes, row 1 (1, 3, 5, 7) is stored at process P0, row 2 at P1, row 3 at P2, and row 4 (10, 12, 14, 16) at P3. We want to apply a matrix transpose. Describe:

(i) **The operation that needs to take place**

(ii) **Draw the message originating from process P0 and show what happens at each step with this message**

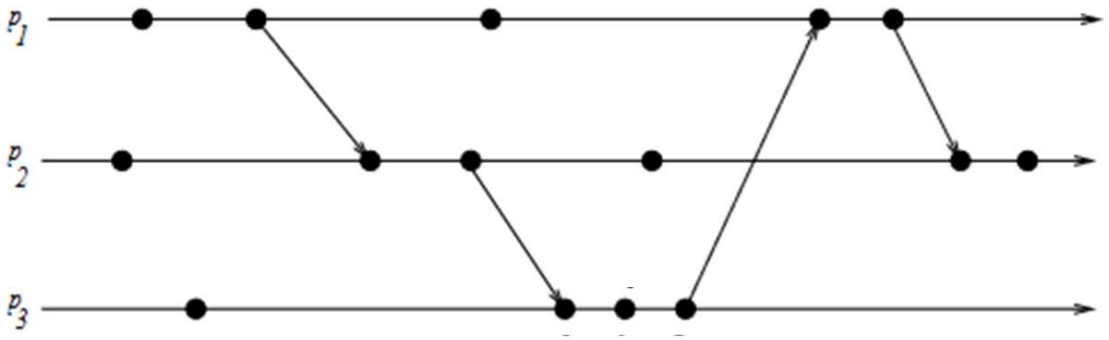


(iii) **Draw the message originating from process P3 and show what happens at each step with this message**



Question # 6: **[8 + 2 marks, CLO # 3]**

a) Show the value of the logical clock on each of the three processes after every event. This includes after each local event and message. Also show the value of the timestamp on each message.



b) Assume three processes, P_A, P_B and P_C. Assume P_A sends a message to P_C. P_A has a vector clock of (4, 1, 0), whereas before receiving this message, P_C has a vector clock of (0, 0, 2). What will the vector clock of P_C be after receiving this message from P_A?

Question # 7: [6 + 2 marks, CLO # 2]

a) Write the output for the following piece of OpenMP code assuming that there are no errors.

```
#include <iostream>
#include <omp.h>
using namespace std;

int main() {
  int nums[20], total = 0;
  bool p;
  for (int i = 0; i < 20; i++) nums[i] = i + 1;

#pragma omp parallel for num_threads(4) schedule(static, 3) private(p)
  for (int j = 0; j < 20; j++) {
    int n = nums[j];
    p = true;
    for (int k = 2; k <= (n / 2); ++k) {
      if (n % k == 0) {
        p = false;
        break;
      }
    }
    if (p) {
      cout << "At " << omp_get_thread_num() << ": n=" << n << endl;
#pragma omp critical
      total++;
    }
  }
  cout << "\nTotal = " << total << endl;
  return 0;
}
```

b) Would you agree that setting `OMP_NESTED` to `TRUE` in the code above would have no impact on the code above?

Question # 8: **[8 + 2 marks, CLO # 2]**

a) Write the output for the following piece of code assuming that there are 8 MPI processes & no errors.

```
#include <mpi.h>
#include <stdio.h>
#include <cmath>

int main(int argc, char** argv) {
MPI_Init(NULL, NULL);
MPI_Status status;
  int p, recVal, my_rank, neighbor;
MPI_Comm_size(MPI_COMM_WORLD, &p);
MPI_Comm_rank(MPI_COMM_WORLD, &my_rank);

  int* d_val = new int[p];
  int myVal = pow(2, my_rank+1); // 2^(my_rank+1)
  int sTag = my_rank;
  if (my_rank % 2 == 0) neighbor = (my_rank + 1) % p;
  else neighbor = (my_rank - 1) % p;
MPI_Sendrecv(&myVal, 1, MPI_INT, neighbor, sTag, &recVal, 1, MPI_INT, neighbor, neighbor,
MPI_COMM_WORLD, &status);
  int diff = abs(myVal - recVal); // absolute value
  if (my_rank> 0 &&my_rank< (p - 1)) {
    if (my_rank % 2 == 1) neighbor = (my_rank + 1) % p;
    else neighbor = (my_rank - 1) % p;
MPI_Sendrecv(&myVal, 1, MPI_INT, neighbor, sTag, &recVal, 1, MPI_INT, neighbor, neighbor,
MPI_COMM_WORLD, &status);
    if (abs(myVal - recVal) > diff) diff = abs(myVal - recVal);
  }
MPI_Gather(&diff, 1, MPI_INT, d_val, 1, MPI_INT, 0, MPI_COMM_WORLD);
  if (my_rank == 0) {
    int dmax = d_val[0];
    for (int i = 1; i< p; i++) {
      printf("d_val[%d] = %d \n", i, d_val[i]);
      if (d_val[i] >dmax) dmax = d_val[i];
    }
    printf("\n Max = %d\n", dmax);
  }
MPI_Finalize(); // Finalize the MPI environment.
}
```

b) Can you interpret the meaning of the value of the variable `dmax` **in the code above?**