Exercise 1 (2.5 points). Answer the following short questions:

a) Given the following SOAP message: qhat protocol application uses? Identify the main fields of the message and briefly describe the content.

```
POST / engelen/calcserver.cgi HTTP/1.1
Host: websrv.cs.fsu.edu
User-Agent: gSOAP/2.7
Content-Type: text/xml; charset=utf-8
Content-Length: 464
Connection: close
SOAPAction: ""

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:SOAP-ENC="http://schemas.xmlsoap.org/soap/encoding/"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:c="urn:calc">
  <SOAP-ENV:Body SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encoding/">
    <c:add>
      <a>1</a>
      <b>2</b>
    </c:add>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

b) Given the following distributed system comprising nodes N = 7. Apply the method of voting (quorum) for:

- Determine the combination of R nodes (read replica) and W node (write replica) that form a valid quorum.
- If the cost of reading is half the cost of writing and reading probability p=0.35, what combination of R and W nodes of the above would be the most efficient? Justify your answer.

c) Given the following distributed system comprises N nodes, N = 6, which uses dynamic voting to maintain consistency of the replicas. Nodes have the following NV and SC values for a given configuration:

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
NV	5	5	5	6	6	6
SC	6	6	6	3	3	3

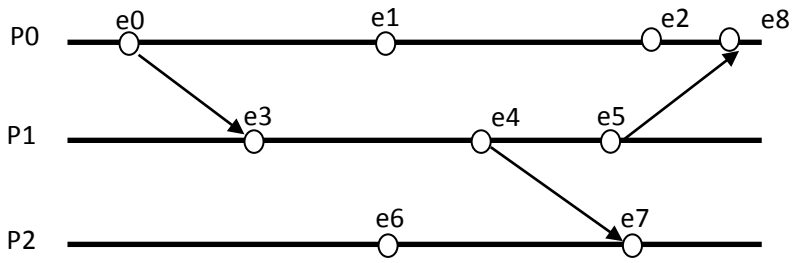
- Can you update the replicas in the {4,5,6} partition? Fill in the following table properly and justify the answer.

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
NV						
SC						

- A power failure fragments the partition {4,5,6} into two: {4} and {5,6}. In this situation can you update the replica in partition {4}?

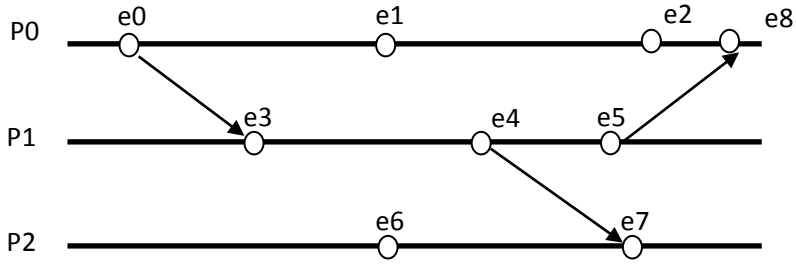
d) What is volunteer computing? Cite some examples of applications..

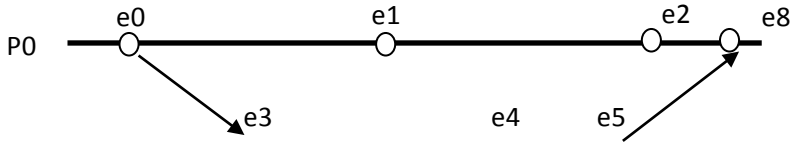
Exercise 2 (1.5 points). Given the following P1, P2 and P3 processes that are running on a distributed system, and which produce the events shown in the following figure.

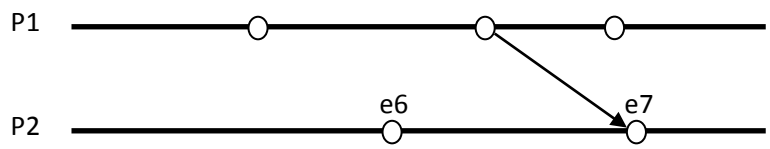


State:

a) Define the Lamport causal relationships between events that appear in Figure.
b) Define what events is not possible to establish a Lamport causality relationships. Justify your answer.
c) Using Lamport logical clocks, indicate the time stamps for the events of the previous processes.







d) If RL1(e0)<RL2(e3), Would it be possible to say that e0 precedes e3? Justify your answer.

Exercise 3 (2.5 points). They want to implement distributed mutual exclusion algorithm based on message passing using a coordinator. In this algorithm, one node acts as coordinator. When *i* process wants to enter the critical section, it sends a message to the coordinator:

send_lock (i) :

The role of the coordinator is to decide whether the applicant process that may or may not enter the critical section. If at the time of receiving the message no other process is running the critical section, the coordinator will allow the applicant to enter and it will send the message :

send_ok (i)

If there is some other process running in the critical section, the coordinator does not respond to the requesting process until the critical section is free. When a process i leaves the critical section ,it sends the message to the coordinator indicating that leaves the critical section:

send_unlock (i)

Required:

a) Design a set of primitives for the messages exchanged between the coordinator and process i.

b) Implement the pseudocode of the coordinating process using the primitive specified in this statement.

Exercise 4 (3.5 points). A gaming company intends to implement on-line a basic version of the game "Angry Words". In this game, users compose words by users and a series of random letters. To allow users to start playing you must first register and then start a game with another user already registered. Once the game started, users compose words and sent to the server for validation. If the word is correct, the server will calculate your score and return the user that score. The goal is to get more points than the opponent. The game ends when the user decides or when all letters are finished.

They want to implement a distributed system that provides the "Angry Words" service. The basic services that should be offered are:

1) Loging: go into the system with your personal data.
2) Start the game: a user starts a new game with another user.
3) Send a word: an user sends a word in a started game.
4) Finish the game: an user decides to leave the game previously initiated.

State:

a) Design the previous client-server application using sockets, indicating and specifying all aspects necessary for your design. As part of the design, describe in detail the service protocol.

b) According to the previous design, specify what calls are needed in the socket library on the client and on the server side, and in what order.
NOTE: Indicate the most relevant arguments of the socket functions.

c) Set the necessary interface to implement client-server application for Sun RPC.