Distributed Computing

(CACSC15)

PRACTICAL EXAMINATION FILE

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CSAI - 1

Semester V

INDEX

Practical - 1

AIM: Write a Program to implement Lamport's Logical Clock

Code:

```
#include <bits/stdc++.h>
using namespace std;

int d = 1;

class process
{
   int n;                  // No. of events
   vector<int> timestamps; // timestamp for each event
public:

   process(int n)
   {
      this->n = n;
      for (int i = 0; i < n; i += d) // Implementation Rule 1
         timestamps.push_back(i + 1);
   }

   int get_events()
   {
      return n;
   }

   int get_timestamp(int event_no)
   {
      return timestamps[event_no];
   }

   void adjust_timestamp(int Ci, int recieve_event) // Implementation Rule 2
   {
      int &Cj = timestamps[recieve_event];
      Cj = max(Cj, Ci + d);
      for (int i = recieve_event + 1; i < timestamps.size(); i++)
      {
         if (timestamps[i - 1] < timestamps[i])
            break;
         timestamps[i] = timestamps[i - 1] + d;
      }
   }

   void print_timestamps()
   {
      for (int i = 0; i < n; i++)
         cout << timestamps[i] << " ";
      cout << endl;
   }
};
```

```
int main()
{
    int n;
    cout << "Enter the no. of processes: " << endl;
    cin >> n; // No. of processes
    vector<process> processes;
    for (int i = 0; i < n; i++)
    {
        int events;
        cout << "Enter the no. of events in process " << i + 1 << endl;
        cin >> events;
        process p(events);
        processes.push_back(p);
    }

    int m;
    cout << "Enter the no. of messages sent: " << endl;
    cin >> m;

    for (int i = 0; i < m; i++)
    {
        int send_process, send_event, recieve_process, recieve_event;
        cout << "Enter the process no. and event no. of sender for message " << i + 1 << endl;
        cin >> send_process >> send_event;
        cout << "Enter the process no. and event no. of reciever for message " << i + 1 << endl;
        cin >> recieve_process >> recieve_event;
        process sender = processes[send_process - 1];
        process &reciever = processes[recieve_process - 1];
        // to adjust causal dependencies
        reciever.adjust_timestamp(sender.get_timestamp(send_event - 1), recieve_event - 1);
    }

    for (int i = 0; i < n; i++)
    {
        cout << "The timestamps of events in Process " << i + 1 << " are :" << endl;
        processes[i].print_timestamps();
    }
    return 0;
}
```

```
D:\3rd Year\DC\Practicals>g++ lamport_logical_clock.cpp -o out && out
Enter the no. of processes:
3
Enter the no. of events in process 1
5
Enter the no. of events in process 2
3
Enter the no. of events in process 3
3
Enter the no. of messages sent:
4
Enter the process no. and event no. of sender for message 1
3 1
Enter the process no. and event no. of reciever for message 1
1 2
Enter the process no. and event no. of sender for message 2
2 1
Enter the process no. and event no. of reciever for message 2
1 3
Enter the process no. and event no. of sender for message 3
1 3
Enter the process no. and event no. of reciever for message 3
2 2
Enter the process no. and event no. of sender for message 4
1 5
Enter the process no. and event no. of reciever for message 4
3 3
The timestamps of events in Process 1 are :
1 2 3 4 5
The timestamps of events in Process 2 are :
1 4 5
The timestamps of events in Process 3 are :
1 2 6

D:\3rd Year\DC\Practicals>
```

Practical - 2

AIM: Write a Program to implement non-token based algorithm for Mutual Exclusion.

Code:

```
#include <bits/stdc++.h>

using namespace std;

int main()
{
   int n;
   int process_id;
   int count = 0;
   bool flag = true;
   cout << "Lamport's Distributed Mutual Exclusion Algorithm: " << endl;
   cout << "Enter no of processes:" << endl;
   cin >> n;
   vector<int> waiting_queue;

   do
   {
      int choice;
      cout << "Enter the process which wants to execute Critical Section:" << endl;
      cin >> process_id;
      waiting_queue.push_back(process_id);
      cout << "Any other process wants to execute Critical Section?:" << endl;
      cout << "1. Yes" << endl;
      cout << "2. No" << endl;
      cin >> choice;
      if (choice == 2)
         flag = false;
   } while (flag);

   for (int j = 0; j < waiting_queue.size(); j++)
   {
      printf("\nCritical Section executing for the Process %d .....",
            waiting_queue[j]);
      printf("\nCritical Section is finished for the Process %d",
            waiting_queue[j]);
      printf("\nRelease Message has been sent by the Process %d\n",
            waiting_queue[j]);
   }
   return 0;

}
```

```
D:\3rd Year\DC\Practicals>g++ mutual_exclusion.cpp -o out && out
Lamport's Distributed Mutual Exclusion Algorithm:
Enter no of processes:
3
Enter the process which wants to execute Critical Section:
2
Any other process wants to execute Critical Section?:
1. Yes
2. No
1
Enter the process which wants to execute Critical Section:
1
Any other process wants to execute Critical Section?:
1. Yes
2. No
1
Enter the process which wants to execute Critical Section:
3
Any other process wants to execute Critical Section?:
1. Yes
2. No
2

Critical Section executing for the Process 2 .....
Critical Section is finished for the Process 2
Release Message has been sent by the Process 2

Critical Section executing for the Process 1 .....
Critical Section is finished for the Process 1
Release Message has been sent by the Process 1

Critical Section executing for the Process 3 .....
Critical Section is finished for the Process 3
Release Message has been sent by the Process 3

D:\3rd Year\DC\Practicals>
```

Practical - 3

AIM: Write a Program to implement edge chasing distributed deadlock detection algorithm.

Code:

```
#include <bits/stdc++.h>

using namespace std;

bool deadlock(int start, int current, vector<vector<bool>> &depends, vector<bool> &visited, vector<int>
&site_of_event)
{
    if (visited[current])
        return true; // deadlock detected
    visited[current] = true;
    for (int i = 0; i < depends[current].size(); i++)
    {
        if (!depends[current][i])
            continue;
        if (i == current) // self dependency
            return true;
        if (site_of_event[current] != site_of_event[i]) // sending a probe from one site to other
            cout << "Probe is sent: (" << start + 1 << "," << current + 1 << "," << i + 1 << ")" << endl;
        return deadlock(start, i, depends, visited, site_of_event);
    }
    return false;
}

int main()
{
    int sites;
    vector<int> site_of_event;
    cout << "Enter number of sites: " << endl;
    cin >> sites;
    int total_no_of_events = 0;

    for (int i = 0; i < sites; i++)
    {
        int events;
        cout << "Enter number of events in site " << i + 1 << ": " << endl;
        cin >> events;
        for (int j = 0; j < events; j++)
            site_of_event.push_back(i);
        total_no_of_events += events;
    }
    cout << "So, we have " << sites << " sites and " << total_no_of_events << " events numbered " << endl;

    for (int i = 1; i <= total_no_of_events; i++)
        cout << i << " ";
    cout << endl;

    vector<vector<bool>> depends(total_no_of_events, vector<bool>(total_no_of_events, false));
```

```
    int m;
    cout << "Enter the no. of dependencies: " << endl;
    cin >> m;

    for (int i = 0; i < m; i++)
    {
        int a, b;
        cout << "Enter the Dependencies (If event 1 depends on event 2, enter 1 2):"
             << endl;
        cin >> a >> b;
        depends[a - 1][b - 1] = true;
    }

    cout << "Enter the Node to Start Probe: " << endl;

    int start;
    cin >> start;
    start--;
    vector<bool> visited(total_no_of_events, false);
    if (deadlock(start, start, depends, visited, site_of_event))
        cout << "A Deadlock exists" << endl;
    else
        cout << "No Deadlock doesn't exist" << endl;
    return 0;
}
```

```
D:\3rd Year\DC\Practicals>g++ edgeChasing.cpp -o out && out
Enter number of sites:
2
Enter number of events in site 1:
3
Enter number of events in site 2:
2
So, we have 2 sites and 5 events numbered
1 2 3 4 5
Enter the no. of dependencies:
6
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
1 2
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
2 3
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
3 4
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
2 4
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
4 5
Enter the Dependencies (If event 1 depends on event 2, enter 1 2):
5 1
Enter the Node to Start Probe:
1
Probe is sent: (1,3,4)
Probe is sent: (1,5,1)
A Deadlock exists

D:\3rd Year\DC\Practicals>
```

Practical - 4

AIM: Write a Program to implement locking algorithm.

Code:

```
#include <bits/stdc++.h>

using namespace std;

int main()
{
   int lock = 0;
   bool locked_by_T1 = false, locked_by_T2 = false;

   while (1)
   {
      int choice;
      if (!locked_by_T1)
      {
         cout << "Transaction T1 wants to Lock Data Object ?" << endl;
         cout << "1. Yes" << endl;
         cout << "2. No" << endl;
         cin >> choice;
         if (!lock && choice == 1)
         {
            lock = 1;
            locked_by_T1 = true;
            cout << "T1 has been given the Lock for the Data Object" << endl;
         }
         else if (lock)
            cout << "\nData Object is Already Locked by " << (locked_by_T1 ? "T1" : "T2") << endl << endl;
      }
      if (!locked_by_T2)
      {
         cout << "Transaction T2 wants to Lock Data Object ?" << endl;
         cout << "1. Yes" << endl;
         cout << "2. No" << endl;
         cin >> choice;
         if (!lock && choice == 1)
         {
            lock = 1;
            locked_by_T2 = true;
            cout << "T2 has been given the Lock for the Data Object" << endl;
         }
         else if (lock)
            cout << "\nData Object is Already Locked by " << (locked_by_T1 ? "T1" : "T2") << endl << endl;
      }
      if (lock)
      {
         if (locked_by_T1)
         {
```

```
            cout << "Transaction T1 wants to Release the Lock on Data Object?" << endl;
            cout << "1. Yes" << endl;
            cout << "2. No" << endl;
            cin >> choice;
            if (choice == 1)
            {
                lock = 0, locked_by_T1 = false;
                cout << "The Lock on Data Object has been released by T1 !" << endl;
            }
        }
        else
        {
            cout << "Transaction T2 wants to Release the Lock on Data Object?" << endl;
            cout << "1. Yes" << endl;
            cout << "2. No" << endl;
            cin >> choice;
            if (choice == 1)
            {
                lock = 0, locked_by_T2 = false;
                cout << "The Lock on Data Object has been released by T2 !" << endl;
            }
        }
    }
  }
  return 0;
}
```

```
D:\3rd Year\DC\Practicals>g++ locking.cpp -o out && out
Transaction T1 wants to Lock Data Object ?
1. Yes
2. No
1
T1 has been given the Lock for the Data Object
Data Object is Already Locked by T1

Transaction T1 wants to Release the Lock on Data Object?
1. Yes
2. No
2
Transaction T2 wants to Lock Data Object ?
1. Yes
2. No
1

Data Object is Already Locked by T1

Transaction T1 wants to Release the Lock on Data Object?
1. Yes
2. No
1
The Lock on Data Object has been released by T1 !
Transaction T1 wants to Lock Data Object ?
1. Yes
2. No
2
Transaction T2 wants to Lock Data Object ?
1. Yes
2. No
1
T2 has been given the Lock for the Data Object
Transaction T2 wants to Release the Lock on Data Object?
1. Yes
2. No
1
The Lock on Data Object has been released by T2 !
Transaction T1 wants to Lock Data Object ?
1. Yes
2. No
T1 has been given the Lock for the Data Object^C
D:\3rd Year\DC\Practicals>
```

Practical - 5

AIM: Write a Program to implement Remote Method Invocation.

Code: We have implemented a Calculator using RMI. The implementation of this program consists of four Java files, namely CalculatorImpl.java, CalculatorServer.java, Calculator.java and CalculatorClient.java.

Calculator.java: // This is an interface

```
import java.rmi.*;

public interface Calculator extends Remote {
   public long add(long a, long b) throws RemoteException;

   public long sub(long a, long b) throws RemoteException;

   public long mul(long a, long b) throws RemoteException;

   public long div(long a, long b) throws RemoteException;
}
```

CalculatorImpl.java // This is the implementation file of calculator methods

```
public class CalculatorImpl extends java.rmi.server.UnicastRemoteObject implements
      Calculator {
   public CalculatorImpl() throws java.rmi.RemoteException {
      super();
   }

   public long add(long a, long b) {
      return a + b;
   }

   public long sub(long a, long b) {
      return a - b;
   }

   public long mul(long a, long b) {
      return a * b;
   }

   public long div(long a, long b) {
      return a / b;
   }
}
```

CalculatorServer.java // This is the server implementing the calculator

```
import java.rmi.Naming;

public class CalculatorServer {
   public CalculatorServer() {
      try {
         Calculator c = new CalculatorImpl();
         Naming.rebind("rmi://localhost:1099/CalculatorService", c);
```

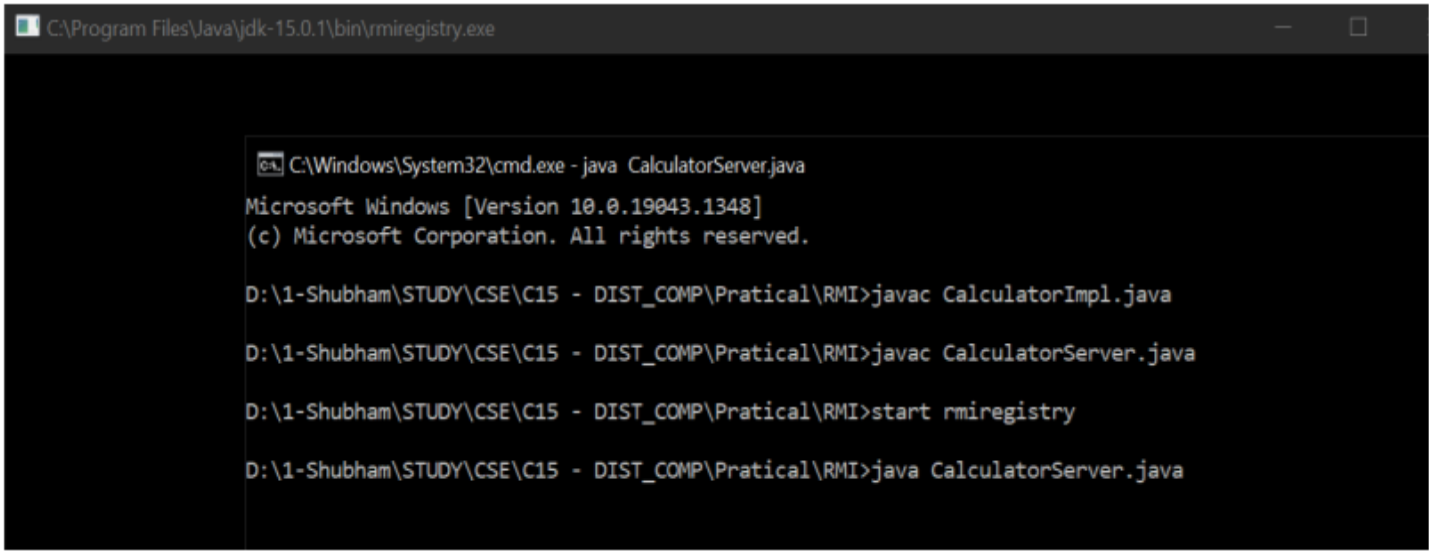
```
        } catch (Exception e) {
            System.out.println("Trouble: " + e);
        }
    }
    public static void main(String args[]) {
        new CalculatorServer();
    }
}
```

CalculatorClient.java // This is the actual client program using Calculator interface

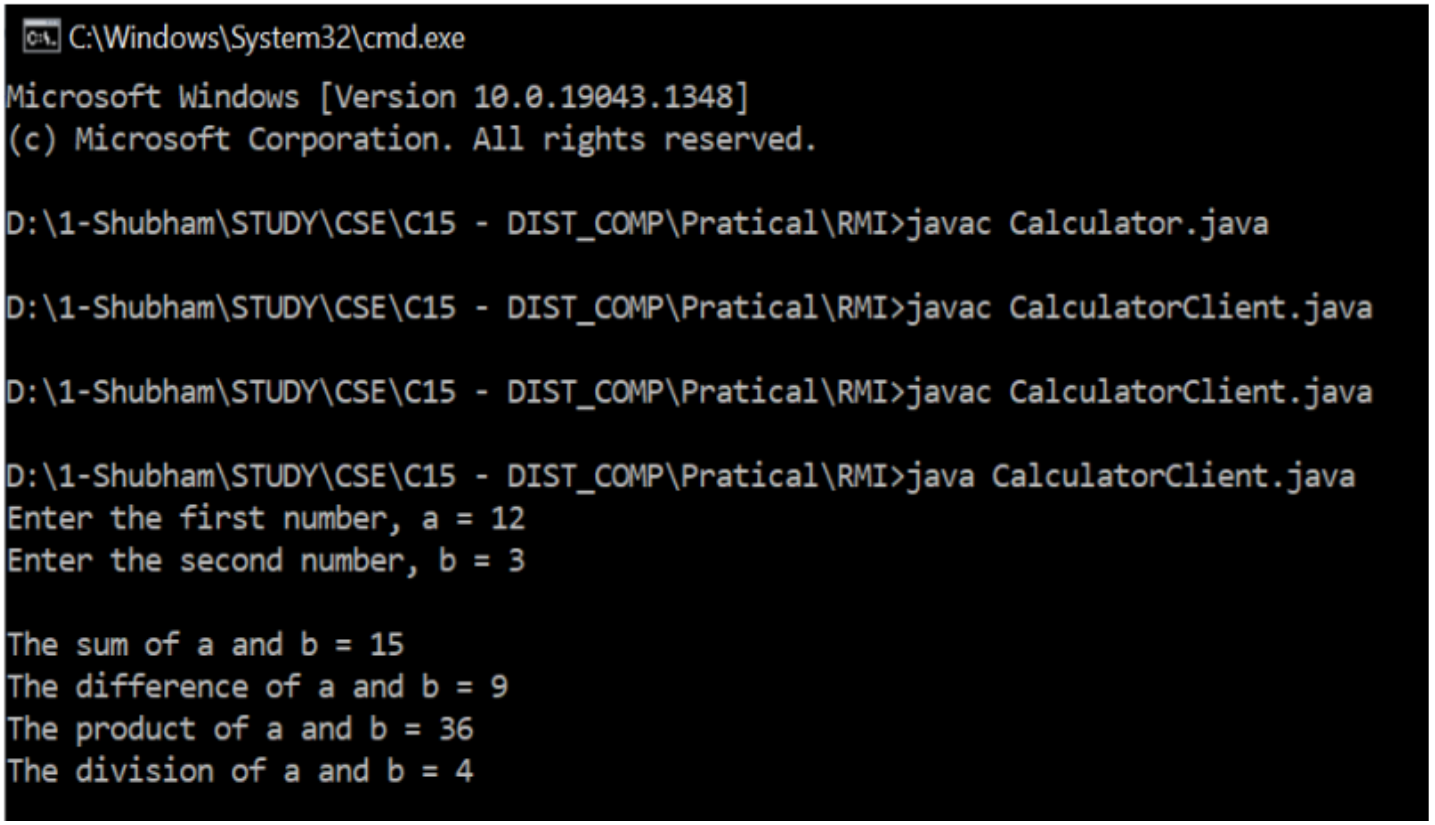
```
import java.rmi.Naming;
import java.rmi.RemoteException;
import java.net.MalformedURLException;
import java.rmi.NotBoundException;
import java.util.*;

public class CalculatorClient {
    public static void main(String[] args) {
        try {
            Calculator c = (Calculator) Naming.lookup("rmi://localhost/CalculatorService");
            Scanner sc = new Scanner(System.in);
            System.out.print("Enter the first number, a = ");
            int a = sc.nextInt();
            System.out.print("Enter the second number, b = ");
            int b = sc.nextInt();
            sc.close();
            System.out.println();
            System.out.print("The sum of a and b = ");
            System.out.println(c.add(a, b));
            System.out.print("The difference of a and b = ");
            System.out.println(c.sub(a, b));
            System.out.print("The product of a and b = ");
            System.out.println(c.mul(a, b));
            System.out.print("The division of a and b = ");
            System.out.println(c.div(a, b));
        } catch (MalformedURLException murle) {
            System.out.println();
            System.out.println("MalformedURLException");
            System.out.println(murle);
        } catch (RemoteException re) {
            System.out.println();
            System.out.println("Remote Exception");
            System.out.println(re);
        } catch (NotBoundException nbe) {
            System.out.println();
            System.out.println("NotBoundException");
            System.out.println(nbe);
        } catch (java.lang.ArithmeticException ae) {
            System.out.println();
            System.out.println("java.lang.ArithmeticException");
            System.out.println(ae);
        }
```

```
    }
}
```

Server and RMI registry:



Client:



Practical - 6

AIM: Write a Program to implement Remote Procedure Call.

Code:

Client -

```
#include "IDL.h"
#include <stdio.h>
float compute_6(char *host, float a, float b, char op)
{
   CLIENT *client_object;
   float *result;
   values oper_6_arg;
   oper_6_arg.num1 = a;
   oper_6_arg.num2 = b;
   oper_6_arg.operation = op;
   client_object = client_object_create(host, COMPUTE, COMPUTE_VERS,
                                "udp");
   if (client_object == NULL)
   {
      client_object_pcreateerror(host);
      exit(1);
   }
   if (op == '+')
      result = add_6(&oper_6_arg, client_object);
   else if (op == '-')
      result = sub_6(&oper_6_arg, client_object);
   else if (op == '*')
      result = mul_6(&oper_6_arg, client_object);
   else if (op == '/')
   {
      if (b == 0)
      {
         printf("Division by Zero is Invalid !!!\n");
         exit(1);
      }
      result = div_6(&oper_6_arg, client_object);
   }
   if (result == (float *)NULL)
   {
      client_object_perror(client_object, "call failed");
   }
   client_object_destroy(client_object);
   return (*result);
}
int main(int argc, char *argv[])
{
   char *host;
   float number1, number2;
   char oper;
   printf("Enter the first number:\n");
```

```
    scanf("%f", &number1);
    printf("Enter the operator (+, -, *, /):\n");
    scanf("%s", &oper);
    printf("Enter the second number:\n");
    scanf("%f", &number2);
    host = argv[1];
    printf("%f %s %f = %f\n", number1, oper, number2, compute_6(host, number1, number2, oper));
    exit(0);
}
```

Server -

```
#include "IDL.h"
#include <stdio.h>
float *add_6_svc(values *argp, struct svc_req *rqstp)
{
    static float result;
    result = argp->num1 + argp->num2;
    return &result;
}

float *sub_6_svc(values *argp, struct svc_req *rqstp)
{
    static float result;
    result = argp->num1 - argp->num2;
    return &result;
}

float *mul_6_svc(values *argp, struct svc_req *rqstp)
{
    static float result;
    result = argp->num1 * argp->num2;
    return &result;
}

float *div_6_svc(values *argp, struct svc_req *rqstp)
{
    static float result;
    result = argp->num1 / argp->num2;
    return &result;
}
```

```
shubham@SHUBHAM:~/DSA$ ./a.out
Enter the first number:
23
Enter the operator (+, -, *, /):
+
Enter the second number:
7
23 + 7 = 30
shubham@SHUBHAM:~/DSA$ ./a.out
Enter the first number:
45
Enter the operator (+, -, *, /):
-
Enter the second number:
3
45 - 3 = 42
shubham@SHUBHAM:~/DSA$ ./a.out
Enter the first number:
3
Enter the operator (+, -, *, /):
*
Enter the second number:
2
3 * 2 = 6
shubham@SHUBHAM:~/DSA$ ./a.out
Enter the first number:
12
Enter the operator (+, -, *, /):
/
Enter the second number:
4
12 / 4 = 3
shubham@SHUBHAM:~/DSA$ ./a.out
Enter the first number:
23
Enter the operator (+, -, *, /):
/
Enter the second number:
0
Division by Zero is Invalid !!!
```

Practical - 7

AIM: Write a Program to implement chat server.

Code:

Client -

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <netdb.h>

void error(const char *msg)
{
    perror(msg);
    exit(1);
}

int main(int argc, char *argv[])
{
    int sockfd, port_no, n;
    struct sockaddr_in server_address;
    struct hostent *server;
    char buffer[255];
    if (argc < 3)
    {
        fprintf(stderr, "ERROR: Less no. of arguments !!!\n");
        exit(1);
    }
    port_no = atoi(argv[2]);
    sockfd = socket(AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0)
    {
        error("ERROR: Socket Open Error !!!");
    }
    server = gethostbyname(argv[1]);
    if (server == NULL)
    {
        fprintf(stderr, "ERROR: No Such Host !!!");
        exit(1);
    }
    bzero((char *)&server_address, sizeof(server_address));
    server_address.sin_family = AF_INET;
    bcopy((char *)server->h_addr, (char *)&server_address.sin_addr.s_addr, server - > h_length);
    server_address.sin_port = htons(port_no);
    if (connect(sockfd, (struct sockaddr *)&server_address, sizeof(server_address)) <
        0)
        error("Connection Failed !!!");
```

```
    while (1)
    {
        bzero(buffer, 255);
        fgets(buffer, 255, stdin);
        n = write(sockfd, buffer, strlen(buffer));
        if (n < 0)
        {
            error("ERROR: Writing Error !!!");
        }
        bzero(buffer, 255);
        n = read(sockfd, buffer, 255);
        if (n < 0)
        {
            error("ERROR: Reading Error !!!");
        }
        printf("Server :%s\n", buffer);
        int i = strncmp("Bye", buffer, 3);
        if (i == 0)
            break;
    }
    close(sockfd);
    return 0;
}
```

Server -

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>

void error(const char *msg)
{
    perror(msg);
    exit(1);
}
int main(int argc, char *argv[])
{
    if (argc < 2)
    {
        fprintf(stderr, "ERROR: Port not provided !!!/n");
        exit(1);
    }
    int sockfd, newsockfd, portno, n;
    char buffer[255];
    struct sockaddr_in server_address, client_address;
    socklen_t clilen;
    sockfd = socket(AF_INET, SOCK_STREAM, 0);
    if (sockfd < 0)
```

```
    {
        error("ERROR: Socket Open Error !!!\n");
    }
    bzero((char *)&server_address, sizeof(server_address)); // Clearing server address
    portno = atoi(argv[1]);
    server_address.sin_family = AF_INET;
    server_address.sin_addr.s_addr = INADDR_ANY;

    server_address.sin_port = htons(portno);
    if (bind(sockfd, (struct sockaddr *)&server_address, sizeof(server_address)) < 0)
        error("Binding Failed !!!");

    listen(sockfd, 5);
    clilen = sizeof(client_address);
    newsockfd = accept(sockfd, (struct sockaddr *)&client_address, &clilen);
    if (newsockfd < 0)
    {
        error("ERROR: Accept Error !!!");
    }
    while (1)
    {
        bzero(buffer, 255);
        n = read(newsockfd, buffer, 255);
        if (n < 0)
            error("ERROR: Reading Error !!!");
        printf("\nClient: %s\n", buffer);
        bzero(buffer, 255);
        fgets(buffer, 255, stdin);
        n = write(newsockfd, buffer, strlen(buffer));
        if (n < 0)
            error("ERROR: Writing Error !!!");
        int i = strncmp("Bye", buffer, 3);
        if (i == 0)
            break;
    }
    close(newsockfd);
    close(sockfd);
    return 0;
}
```

Server

```
shubham@SHUBHAM:~/DSA$ ./server 9898

Client: Hi! I am a Client. My Name is Shubham.

Hello Shubham! I am the Server.

Client: The Chat Server is working nicely.

That's great.

Client: It was nice talking to you.

Same here.

Client: Bye

Bye
```

Client

```
shubham@SHUBHAM:~/DSA$ ./client 127.0.0.1 9898
Hi! I am a Client. My Name is Shubham.

Server: Hello Shubham! I am the Server.

The Chat Server is working nicely.

Server: That's great.

It was nice talking to you.

Server: Same here.

Bye

Server: Bye
```

Practical - 8

AIM: Write a Program to implement termination detection.

Code:

```
#include <bits/stdc++.h>

using namespace std;

int main()
{
    int n;
    cout << "Enter the no. of processes: " << endl;
    cin >> n;

    int controlling_process;
    cout << "Enter the controlling process: " << endl;
    cin >> controlling_process;

    unordered_map<int, float> weight;
    for (int i = 1; i <= n; i++)
    {
        if (i == controlling_process)
            weight[i] = 1;
        else
            weight[i] = 0;
    }

    while (1)
    {
        int sender, reciever;
        float w;
        cout << "For a message, Enter the sender process, reciever process and weight associated : " << endl;
        cin >> sender >> reciever >> w;
        if (weight[sender] == 0)
            cout << "Process " << sender << " is inactive ! Cannot send message !!!" << endl;
        else
        {
            weight[sender] = (weight[sender] <= w ? 0 : weight[sender] - w);
            weight[reciever] += w;
            if (weight[controlling_process] == 1)
            {
                cout << "Termination Detected !" << endl;
                break;
            }
            else
                cout << "Process not terminated yet ..." << endl;
        }
    }
    return 0;
}
```

```
D:\3rd Year\DC\Practicals>g++ terminal_detection.cpp -o out && out
Enter the no. of processes:
3
Enter the controlling process:
1
For a message, Enter the sender process, reciever process and weight associated :
1 2 0.3
Process not terminated yet ...
For a message, Enter the sender process, reciever process and weight associated :
1 3 0.5
Process not terminated yet ...
For a message, Enter the sender process, reciever process and weight associated :
2 3 0.2
Process not terminated yet ...
For a message, Enter the sender process, reciever process and weight associated :
2 1 0.1
Process not terminated yet ...
For a message, Enter the sender process, reciever process and weight associated :
3 1 0.7
Termination Detected !

D:\3rd Year\DC\Practicals>
```

Practical - 9

AIM: Write a Program to implement RSA Algorithm.

Code:

```
#include <bits/stdc++.h>
using namespace std;

typedef long long ll;

ll inverse(ll e, ll phi)
{
    ll r1 = e, r2 = phi;
    ll s1 = 1, s2 = 0;

    while (r2 > 0)
    {
        ll q = r1 / r2;
        ll r = r1 - q * r2;
        r1 = r2;
        r2 = r;

        ll s = s1 - q * s2;
        s1 = s2;
        s2 = s;
    }

    if (s1 < 0)
        s1 += (((-1 * s1) / phi) + 1) * phi;

    return s1;
}

ll Power(ll a, ll b, ll n)
{
    if (a == 0)
        return 0;

    if (b == 0)
        return 1;

    ll val = Power(a, b / 2, n);
    val = (val * val) % n;

    if (b & 1)
        val = (val * a) % n;

    return val;
}

int main(int args, char **argv)
```

```
{
    ll a, b, n, e, phi, d, m, c;
    cout << "Enter the value of prime numbers a and b: " << endl;
    cin >> a >> b;
    n = a * b;
    phi = (a - 1) * (b - 1);
    cout << "Enter the value of the public key (e, where 0 < e < " << phi << " and e is coprime to " << phi << "): "
<< endl;
    cin >> e;
    d = inverse(e, phi);

    while (1)
    {
        int choice;
        cout << "##### Implementing RSA. Enter between 1-3 #####" << endl;
        cout << "1. Encryption" << endl;
        cout << "2. Decryption" << endl;
        cout << "3. Quit" << endl;
        cout << "Enter your choice: " << endl;
        cin >> choice;
        switch (choice)
        {
        case 1:
            cout << "Enter the value of plaintext (less than " << n << ") :" << endl;
            cin >> m;

            c = Power(m, e, n);
            cout << "The ciphertext is: " << c << endl;
            break;

        case 2:
            cout << "Enter the value of ciphertext (less than " << n << ") :" << endl;
            cin >> c;

            m = Power(c, d, n);
            cout << "The plaintext is: " << m << endl;
            break;

        case 3:
            exit(0);
            break;

        default:
            cout << "Wrong input !!!" << endl;
            break;
        }
    }
}
```

```
D:\3rd Year\DC>g++ rsa.cpp -o out && out
Enter the value of prime numbers a and b:
7 5
Enter the value of the public key (e, where 0 < e < 24 and e is coprime to 24):
23
##### Implementing RSA. Enter between 1-3 #####
1. Encryption
2. Decryption
3. Quit
Enter your choice:
1
Enter the value of plaintext (less than 35) :
23
The ciphertext is: 32
##### Implementing RSA. Enter between 1-3 #####
1. Encryption
2. Decryption
3. Quit
Enter your choice:
2
Enter the value of ciphertext (less than 35) :
32
The plaintext is: 23
##### Implementing RSA. Enter between 1-3 #####
1. Encryption
2. Decryption
3. Quit
Enter your choice:
3

D:\3rd Year\DC>
```

Practical - 10

AIM: Write a Program to implement Diffie Hellman Key Exchange Algorithm

Code:

```
#include <bits/stdc++.h>
using namespace std;

typedef long long ll;

ll power(ll a, ll b, ll n)
{
    if (a == 0)
        return 0;

    if (b == 0)
        return 1;

    ll val = power(a, b / 2, n);
    val = (val * val) % n;

    if (b & 1)
        val = (val * a) % n;

    return val;
}

int main(int args, char **argv)
{
    ll p, q, x_a, x_b, y_a, y_b;
    cout << "Enter the value of prime number p: " << endl;
    cin >> p;
    cout << "Enter the value of q where q < p and q is a primitive root of p: " << endl;
    cin >> q;
    cout << "Enter the value of the private key of person A : " << endl;
    cin >> x_a;
    y_a = power(q, x_a, p);

    cout << "Enter the value of the private key of person B : " << endl;
    cin >> x_b;
    y_b = power(q, x_b, p);

    cout << "The public key of A is: " << y_a << endl;
    cout << "The public key of B is: " << y_b << endl;

    ll k1 = power(y_b, x_a, p), k2 = power(y_a, x_b, p);

    cout << "The key calculated by A is: " << k1 << endl;
    cout << "The key calculated by B is: " << k2 << endl;

    if (k1 == k2)
```

```
        cout << "The key has been exchanged successfully !!!" << endl;

    else
        cout << "Key exchange failed !!!" << endl;

    return 0;
}
```

```
D:\3rd Year\DC>g++ diffie_hellman.cpp -o out && out
Enter the value of prime number p:
5
Enter the value of q where q < p and q is a primitive root of p:
2
Enter the value of the private key of person A :
7
Enter the value of the private key of person B :
3
The public key of A is: 3
The public key of B is: 3
The key calculated by A is: 2
The key calculated by B is: 2
The key has been exchanged successfully !!!

D:\3rd Year\DC>
```