

Part –A

Experiment No: 1

Installation of NS3 and configuration of NetAnim software.

Program :

First, update the package list by executing this command:

```
sudo apt-get update
```

For ns-3:

1. gcc
2. g++
3. python
4. python-dev

Steps to install ns-3:

1. Download ns-allinone-3.26.tar.bz2 and unzip it.

Paste it on Desktop

2. Go to ns-allinone-3.26 and give the following command:

```
./build.py --enable-examples --enable-tests
```

This command will install ns-3, NetAnim and PyViz.

3. Once the installation completes, go to ns-allinone-3.26/ns-3.26 and give the following command:

```
./test.py
```

You are done with it!

Compiler:

```
./waf
```

```
ns-allinone-3.26/ns-3.26 $ cd examples
```

```
ns-allinone-3.26/ns-3.26/examples $ cd tutorial
```

```
copy the file (first.cc) program paste it in scratch folder which is present in  
ns-allinone-3.26/ns-3.26/scratch folder
```

to run the program

```
./waf --run scratch/first
```

NetAnim install

List of Prerequisite Packages to be installed:

1. gcc
2. g++

3. python**4. python-dev (Optional: If you want to use Python as the main language for network configuration)****5. mercurial (Optional: If you choose Method 2 (explained below) for downloading and installing *ns-3*)****6. qt4-dev-tools (Optional: If you want to install *NetAnim* (animator for *ns-3*) along with *ns-3*)****7. tcpdump (Optional: Required for analyzing packet capture files (.pcap) generated by *ns-3*)****8. wireshark (Optional: Alternative to tcpdump. You can use anyone of these)****9. gnuplot (Optional: Required for plotting high quality graphs through *.dat* files generated by *ns-3*)****NetAnim: to run the animation file****Step 1: Go to ns-allinone-3.26/netanim-3.107 and give the following command:**

```
ns-allinone-3.26/netanim-3.107 $ ./NetAnim  
open .xml file
```

run the simulation file.

Experiment No: 2

Implement two nodes point - to - point network with duplex links between them. Vary the data rate & delay to see the output on NetAnim.

Program :

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/netanim-module.h"
#include "ns3/mobility-module.h"

using namespace ns3;

NS_LOG_COMPONENT_DEFINE ("FirstScriptExample");

int
main (int argc, char *argv[])
{
    CommandLine cmd;
    cmd.Parse (argc, argv);

    Time::SetResolution (Time::NS);
    LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
    LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);

    NodeContainer nodes;
    nodes.Create (2);

    PointToPointHelper pointToPoint;
    pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
    pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));

    NetDeviceContainer devices;
```

```
devices = pointToPoint.Install (nodes);
```

```
InternetStackHelper stack;  
stack.Install (nodes);
```

```
Ipv4AddressHelper address;  
address.SetBase ("10.1.1.0", "255.255.255.0");
```

```
Ipv4InterfaceContainer interfaces = address.Assign (devices);
```

```
UdpEchoServerHelper echoServer (9);
```

```
ApplicationContainer serverApps = echoServer.Install (nodes.Get (1));  
serverApps.Start (Seconds (1.0));  
serverApps.Stop (Seconds (10.0));
```

```
UdpEchoClientHelper echoClient (interfaces.GetAddress (1), 9);  
echoClient.SetAttribute ("MaxPackets", UIntegerValue (1));  
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));  
echoClient.SetAttribute ("PacketSize", UIntegerValue (1024));
```

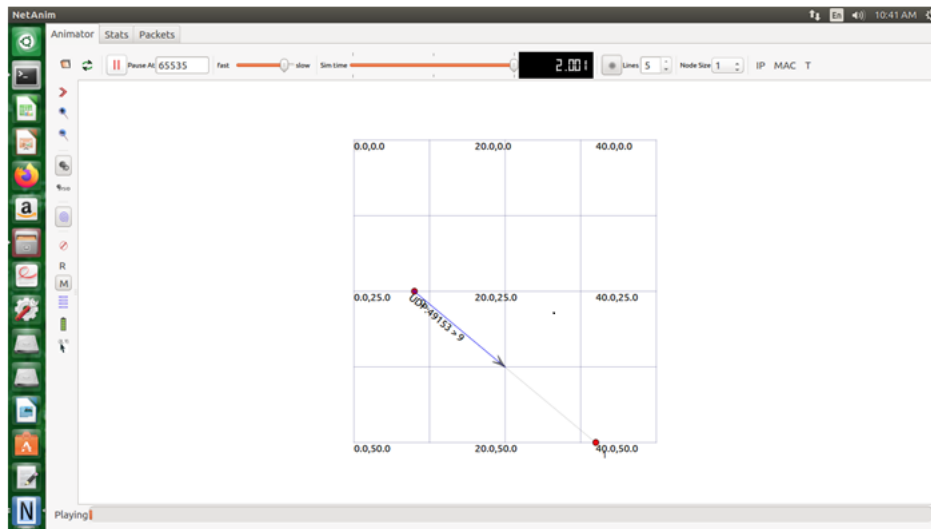
```
ApplicationContainer clientApps = echoClient.Install (nodes.Get (0));  
clientApps.Start (Seconds (2.0));  
clientApps.Stop (Seconds (10.0));
```

```
MobilityHelper mobility;  
mobility.SetMobilityModel ("ns3::ConstantPositionMobilityModel");  
mobility.Install (nodes);
```

```
AnimationInterface anim ("first.xml");  
AnimationInterface::SetConstantPosition (nodes.Get (0), 10, 25);  
AnimationInterface::SetConstantPosition (nodes.Get (1), 40, 50);  
anim.EnablePacketMetadata (true);
```

```
Simulator::Run ();  
Simulator::Destroy ();  
return 0;  
}
```

Output:



Experiment No: 3**Implement Bus Topology.****Program :**

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/csma-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/ipv4-global-routing-helper.h"
#include "ns3/netanim-module.h"

// Default Network Topology
// 10.1.1.0
// n0 ----- n1 n2 n3 n4
// point-to-point |||
// =====
// LAN 10.1.2.0

using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("SecondScriptExample");
int main (int argc, char *argv[])
{
  LogComponentEnable ("UdpEchoClientApplication", LOG_LEVEL_INFO);
  LogComponentEnable ("UdpEchoServerApplication", LOG_LEVEL_INFO);

  NodeContainer p2pNodes;
  p2pNodes.Create (2);

  NodeContainer csmaNodes;
  csmaNodes.Add (p2pNodes.Get (1));
  csmaNodes.Create (3);

  PointToPointHelper pointToPoint;
```

```
pointToPoint.SetDeviceAttribute ("DataRate",StringValue ("5Mbps"));  
pointToPoint.SetChannelAttribute ("Delay",StringValue ("2ms"));
```

```
NetDeviceContainer p2pDevices;  
p2pDevices = pointToPoint.Install (p2pNodes);
```

```
CsmaHelper csma;  
csma.SetChannelAttribute ("DataRate",StringValue ("100Mbps"));  
csma.SetChannelAttribute ("Delay",TimeValue (NanoSeconds (6560)));
```

```
NetDeviceContainer csmaDevices;  
csmaDevices = csma.Install (csmaNodes);
```

```
InternetStackHelper stack;  
stack.Install (p2pNodes.Get (0));  
stack.Install (csmaNodes);
```

```
Ipv4AddressHelper address;  
address.SetBase ("10.1.1.0", "255.255.255.0");  
Ipv4InterfaceContainer p2pInterfaces;  
p2pInterfaces = address.Assign (p2pDevices);
```

```
address.SetBase ("10.2.1.0", "255.255.255.0");  
Ipv4InterfaceContainer csmaInterfaces;  
csmaInterfaces = address.Assign (csmaDevices);
```

```
UdpEchoServerHelper echoServer (9);
```

```
ApplicationContainer serverApps = echoServer.Install(csmaNodes.Get (3));  
serverApps.Start (Seconds (1.0));  
serverApps.Stop (Seconds (10.0));
```

```
UdpEchoClientHelper echoClient (csmaInterfaces.GetAddress (3), 9);  
echoClient.SetAttribute ("MaxPackets",UIntegerValue (1));
```

```
echoClient.SetAttribute ("Interval", TimeValue (Seconds (1.0)));  
echoClient.SetAttribute ("PacketSize", UIntegerValue (1024));
```

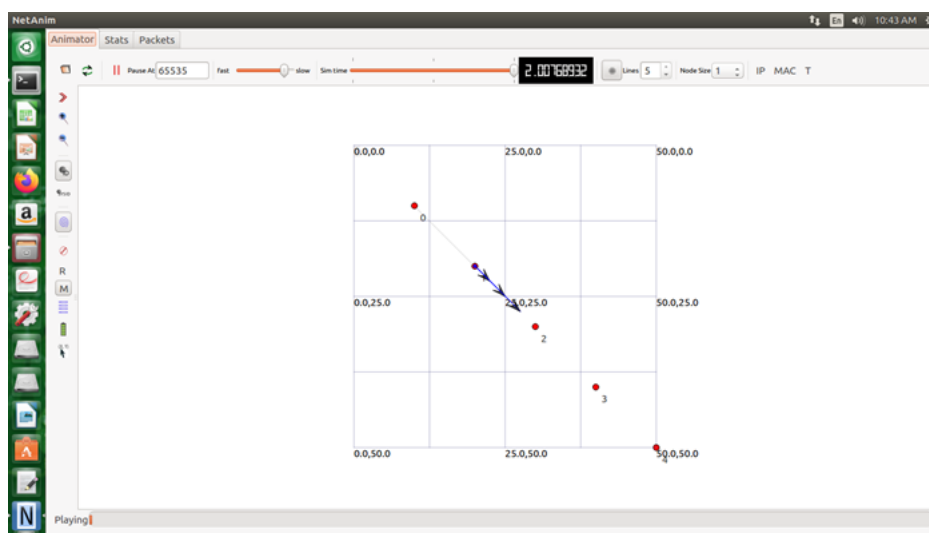
```
ApplicationContainer clientApps = echoClient.Install (p2pNodes.Get (0));  
clientApps.Start (Seconds (2.0));  
clientApps.Stop (Seconds (10.0));
```

```
Ipv4GlobalRoutingHelper::PopulateRoutingTables ();
```

```
pointToPoint.EnablePcapAll ("p2p");  
csma.EnablePcapAll ("csma");
```

```
AnimationInterface anim("bus.xml");  
anim.SetConstantPosition(p2pNodes.Get(0),10.0,10.0);  
anim.SetConstantPosition(csmaNodes.Get(0),20.0,20.0);  
anim.SetConstantPosition(csmaNodes.Get(1),30.0,30.0);  
anim.SetConstantPosition(csmaNodes.Get(2),40.0,40.0);  
anim.SetConstantPosition(csmaNodes.Get(3),50.0,50.0);  
Simulator::Run ();  
Simulator::Destroy ();  
return 0;  
}
```

Output:

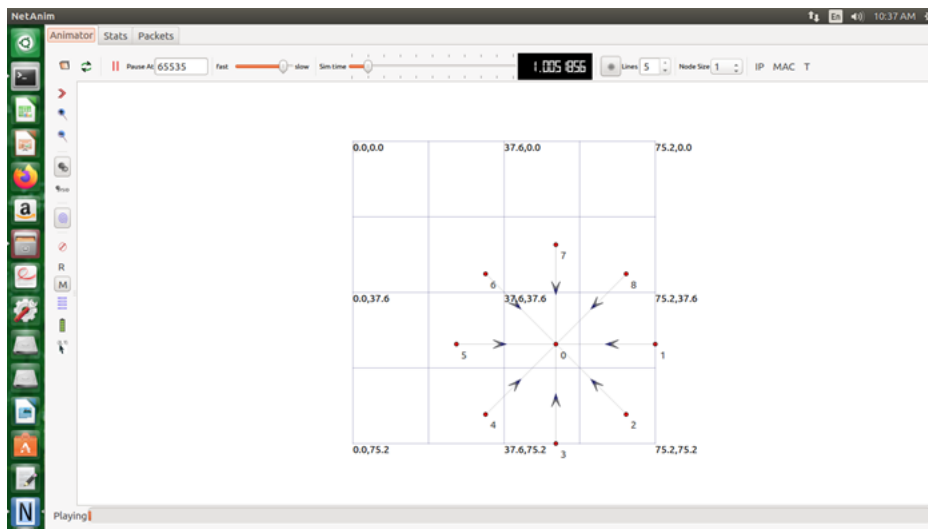


Experiment No: 4**Implement Star Topology.****Program :**

```
#include "ns3/core-module.h"
#include "ns3/network-module.h"
#include "ns3/netanim-module.h"
#include "ns3/internet-module.h"
#include "ns3/point-to-point-module.h"
#include "ns3/applications-module.h"
#include "ns3/point-to-point-layout-module.h"
using namespace ns3;
NS_LOG_COMPONENT_DEFINE ("Star");
int main (int argc, char *argv[])
{
    // Set up some default values for the simulation.
    Config::SetDefault ("ns3::OnOffApplication::PacketSize", UIntegerValue (137));
    // ??? try and stick 15kb/s into the data rate
    Config::SetDefault ("ns3::OnOffApplication::DataRate", StringValue ("14kb/s"));
    // Default number of nodes in the star. Overridable by command line argument.
    uint32_t nSpokes = 8;

    PointToPointHelper pointToPoint;
    pointToPoint.SetDeviceAttribute ("DataRate", StringValue ("5Mbps"));
    pointToPoint.SetChannelAttribute ("Delay", StringValue ("2ms"));
    PointToPointStarHelper star (nSpokes, pointToPoint);
    NS_LOG_INFO ("Install internet stack on all nodes.");
    InternetStackHelper internet;
    star.InstallStack (internet);
    NS_LOG_INFO ("Assign IP Addresses.");
    star.AssignIpv4Addresses (Ipv4AddressHelper ("10.1.1.0", "255.255.255.0"));
    NS_LOG_INFO ("Create applications.");
    //
    // Create a packet sink on the star "hub" to receive packets.
    //
    uint16_t port = 50000;
    Address hubLocalAddress (InetSocketAddress (Ipv4Address::GetAny (), port));
    PacketSinkHelper packetSinkHelper ("ns3::TcpSocketFactory", hubLocalAddress);
```

```
ApplicationContainer hubApp = packetSinkHelper.Install (star.GetHub ());
hubApp.Start (Seconds (1.0));
hubApp.Stop (Seconds (10.0));
//
// Create OnOff applications to send TCP to the hub, one on each spoke node.
//
OnOffHelper onOffHelper ("ns3::TcpSocketFactory", Address ());
onOffHelper.SetAttribute ("OnTime", StringValue
("ns3::ConstantRandomVariable[Constant=1]"));
onOffHelper.SetAttribute ("OffTime", StringValue
("ns3::ConstantRandomVariable[Constant=0]"));
ApplicationContainer spokeApps;
for (uint32_t i = 0; i < star.SpokeCount (); ++i)
{
    AddressValue remoteAddress (InetSocketAddress (star.GetHubIpv4Address (i), port));
    onOffHelper.SetAttribute ("Remote", remoteAddress);
    spokeApps.Add (onOffHelper.Install (star.GetSpokeNode (i)));
}
spokeApps.Start (Seconds (1.0));
spokeApps.Stop (Seconds (10.0));
NS_LOG_INFO ("Enable static global routing.");
//
// Turn on global static routing so we can actually be routed across the star.
//
Ipv4GlobalRoutingHelper::PopulateRoutingTables ();
NS_LOG_INFO ("Enable pcap tracing.");
//
// Do pcap tracing on all point-to-point devices on all nodes.
//
pointToPoint.EnablePcapAll ("star");
star.BoundingBox (1,1,100,100);
AnimationInterface anim("star.xml");
NS_LOG_INFO ("Run Simulation.");
Simulator::Run ();
Simulator::Destroy ();
NS_LOG_INFO ("Done.");
return 0;
}
```

Output:

Experiment No: 5

Implement LAN using n nodes and set multiple traffic nodes and plot congestion window for different source/destination.

Program :

```
set ns [new Simulator]
set tf [open lab3.tr w]
$ns trace-all $tf
set nf [open lab3.nam w]
$ns namtrace-all $nf
set n0 [$ns node]
$n0 color "magenta"
$n0 label "src1"
set n1 [$ns node]
set n2 [$ns node]
$n2 color "magenta"
$n2 label "src2"
set n3 [$ns node]
$n3 color "blue"
$n3 label "dest2"
set n4 [$ns node]
set n5 [$ns node]
$n5 color "blue"
$n5 label "dest1"
$ns make-lan "$n0 $n1 $n2 $n3 $n4" 100Mb 100ms LL Queue/DropTail
Mac/802_3

$ns duplex-link $n4 $n5 1Mb 1ms DropTail
set tcp0 [new Agent/TCP]
$ns attach-agent $n0 $tcp0
set ftp0 [new Application/FTP]
$ftp0 attach-agent $tcp0
$ftp0 set packetSize_ 500
$ftp0 set interval_ 0.0001
```

```
set sink5 [new Agent/TCPSink]
$ns attach-agent $n5 $sink5
$ns connect $tcp0 $sink5
set tcp2 [new Agent/TCP]
$ns attach-agent $n2 $tcp2
set ftp2 [new Application/FTP]
$ftp2 attach-agent $tcp2
$ftp2 set packetSize_ 600
$ftp2 set interval_ 0.001
set sink3 [new Agent/TCPSink]
$ns attach-agent $n3 $sink3
$ns connect $tcp2 $sink3
```

```
set file1 [open file1.tr w]
$tcp0 attach $file1
set file2 [open file2.tr w]
$tcp2 attach $file2
$tcp0 trace cwnd_
$tcp2 trace cwnd_
proc finish { } {
    global ns nf tf
    $ns flush-trace
    close $tf
    close $nf
    exec nam lab3.nam &
    exit 0
}
$ns at 0.1 "$ftp0 start"
$ns at 5 "$ftp0 stop"
$ns at 7 "$ftp0 start"
$ns at 0.2 "$ftp2 start"
$ns at 8 "$ftp2 stop"
$ns at 14 "$ftp0 stop"
$ns at 10 "$ftp2 start"
```

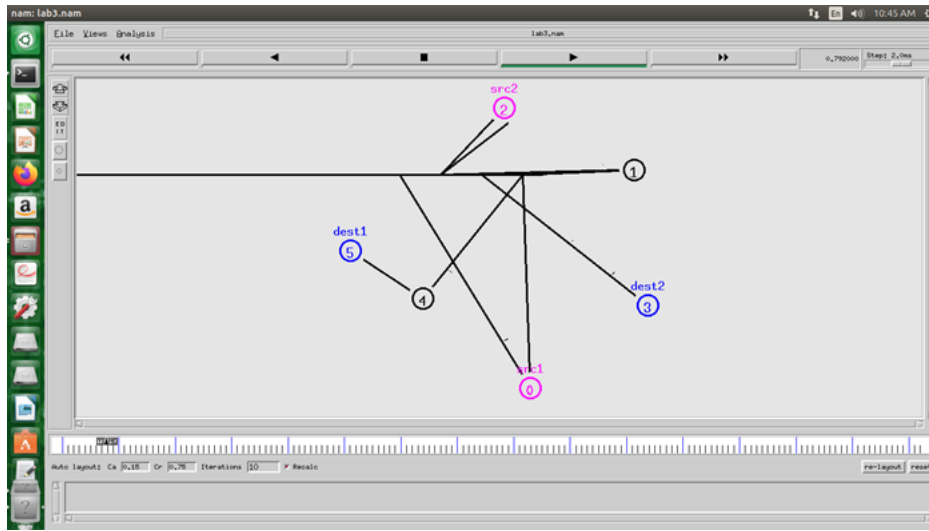
\$ns at 15 "\$ftp2 stop"

\$ns at 16 "finish"

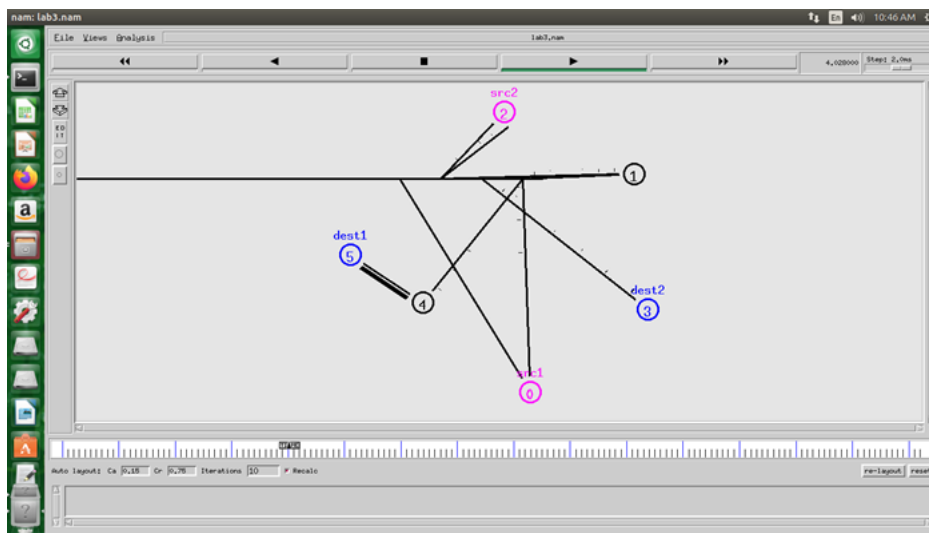
\$ns run

Output:

Case1



Case 2



PART-B**Introduction to JAVA**

Java is a general-purpose computer programming language that is simple, concurrent, class-based, object-oriented language. The compiled Java code can run on all platforms that support Java without the need for recompilation hence Java is called as "write once, run anywhere" (WORA). The Java compiled intermediate output called "byte-code" that can run on any Java virtual machine (JVM) regardless of computer architecture. The language derives much of its syntax from C and C++, but it has fewer low-level facilities than either of them.

Java is defined by a specification and consists of a programming language, a compiler, core libraries and a runtime (Java virtual machine). The Java runtime allows software developers to write program code in other languages than the Java programming language which still runs on the Java virtual machine. The *Java platform* is usually associated with the *Java virtual machine* and the *Java core libraries*.

In Linux operating system Java libraries are preinstalled. It's very easy and convenient to compile and run Java programs in Linux environment. To compile and run Java Program is a two-step process:

1. Compile Java Program from Command Prompt

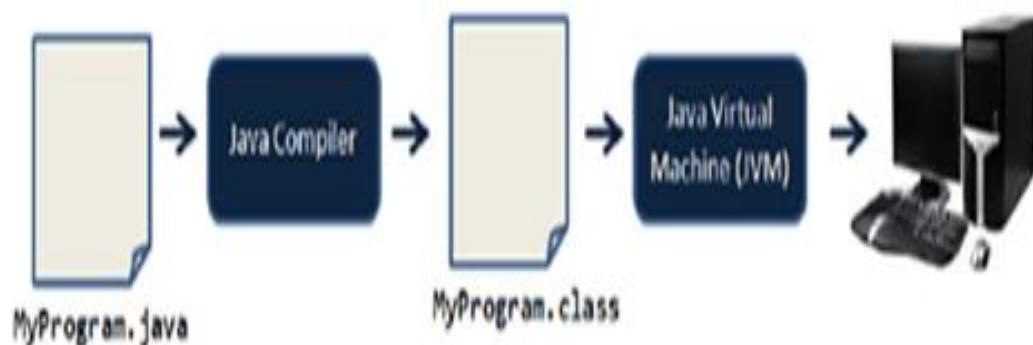
[root@host ~]# javac MyProgram.java

The Java compiler (Javac) compiles java program and generates a byte-code with the same file name and .class extension.

2. Run Java program from Command Prompt

[root@host ~]# java MyProgram

The java interpreter (Java) runs the byte-code and gives the respective output. It is important to note that in above command we have omitted the .class suffix of the byte-code (Filename.class).



Experiment No: 7**Error Detecting Code Using CRC-CCITT (16-bit)**

Objective : Write a program for error detecting code using CRC-CCITT (16- bits).

Theory :

Whenever digital data is stored or interfaced, data corruption might occur. Since the beginning of computer science, developers have been thinking of ways to deal with this type of problem. For serial data they came up with the solution to attach a parity bit to each sent byte. This simple detection mechanism works if an odd number of bits in a byte changes, but an even number of false bits in one byte will not be detected by the parity check. To overcome this problem developers have searched for mathematical sound mechanisms to detect multiple false bits. The **CRC** calculation or *cyclic redundancy check* was the result of this. Nowadays CRC calculations are used in all types of communications. All packets sent over a network connection are checked with a CRC. Also each data block on your hard disk has a CRC value attached to it. Modern computer world cannot do without these CRC calculations. So let's see why they are so widely used. The answer is simple; they are powerful, detect many types of errors and are extremely fast to calculate especially when dedicated hardware chips are used.

The idea behind CRC calculation is to look at the data as one large binary number. This number is divided by a certain value and the remainder of the calculation is called the CRC. Dividing in the CRC calculation at first looks to cost a lot of computing power, but it can be performed very quickly if we use a method similar to the one learned at school. We will as an example calculate the remainder for the character 'm'—which is 1101101 in binary notation— by dividing it by 19 or 10011. Please note that 19 is an odd number. This is necessary as we will see further on. Please refer to your schoolbooks as the binary calculation method here is not very different from the decimal method you learned when you were young. It might only look a little bit strange. Also notations differ between countries, but the method is similar.

$$\begin{array}{r}
 101 = 5 \\
 \hline
 10011 / 1101101 \\
 \underline{10011} \\
 00000 \\
 \underline{00000} \\
 00000 \\
 \underline{00000} \\
 00000 \\
 \underline{00000} \\
 00000 \\
 \underline{00000} \\
 00000 \\
 \underline{00000} \\
 00000 \\
 \hline
 1110 = 14 = \text{remainder}
 \end{array}$$

With decimal calculations you can quickly check that 109 divided by 19 gives a quotient of 5 with 14 as the remainder. But what we also see in the scheme is that every bit extra to check only costs one binary comparison and in 50% of the cases one binary subtraction. You can easily increase the number of bits of the test data string—for example to 56 bits if we use our example value "Lammert"—and the result can be calculated with 56 binary comparisons and an average of 28 binary subtractions. This can be implemented in hardware directly with only very few transistors involved. Also software algorithms can be very efficient.

All of the CRC formulas you will encounter are simply checksum algorithms based on modulo-2 binary division where we ignore carry bits and in effect the subtraction will be equal to an *exclusive or* operation. Though some differences exist in the specifics across different CRC formulas, the basic mathematical process is always the same:

- The message bits are appended with c zero bits; this *augmented message* is the dividend
- A predetermined $c+1$ -bit binary sequence, called the *generator polynomial*, is the divisor
- The checksum is the c -bit remainder that results from the division operation

Table 1 lists some of the most commonly used generator polynomials for 16- and 32-bit CRCs. Remember that the width of the divisor is always one bit wider than the remainder. So, for example, you'd use a 17-bit generator polynomial whenever a 16-bit checksum is required.

	CRC-CCITT	CRC-16	CRC-32
Checksum Width	16 bits	16 bits	32 bits
Generator Polynomial	10001000000100001	11000000000000101	100000100110000010001110110110111

International Standard CRC Polynomials

Algorithm :

Input: Frame data.

Output: Data with or without errors.

1. Start
2. Given a bit string, append $(n-1)$ 0's at the end where n is the size of some agreed on Polynomial $G(x)$.
3. Divide $B(x)$ by polynomial $G(x)$ and determine the remainder $R(x)$.
4. Define $T(x) = B(x) - R(x)$
 $(T(x)/G(x) \Rightarrow \text{remainder } 0)$
5. Transmit T , the bit string corresponding to $T(x)$.

Step 6: Let T' represent the bit stream the receiver gets and $T'(x)$ the associated polynomial. The receiver divides $T'(x)$ by $G(x)$. If there is a 0 remainder, the receiver concludes $T = T'$ and no error occurred otherwise, the receiver concludes an error occurred and requires a retransmission.

Step 7: stop

Program:

```
import java.io.*;
class Crc
{
    public static void main(String args[]) throws
    IOException {
        BufferedReader br=new BufferedReader(new
        InputStreamReader(System.in));
        int[ ] data;
        int[ ]div;
        int[ ]divisor;
        int[ ]rem;
        int[ ] crc;
        int data_bits, divisor_bits, tot_length;
        System.out.println("Enter number of data bits : ");
        data_bits=Integer.parseInt(br.readLine());
        data=new int[data_bits];
        System.out.println("Enter data bits : ");
        for(int i=0; i<data_bits; i++)
            data[i]=Integer.parseInt(br.readLine());
        System.out.println("Enter number of bits in
        divisor : ");
        divisor_bits=Integer.parseInt(br.readLine());
        divisor=new int[divisor_bits];
        System.out.println("Enter Divisor bits : ");
        for(int i=0; i<divisor_bits; i++)
            divisor[i]=Integer.parseInt(br.readLine());
        System.out.print("Data bits are : ");
        for(int i=0; i< data_bits; i++)
            System.out.print(data[i]);
        System.out.println();
        System.out.print("divisor bits are : ");
        for(int i=0; i< divisor_bits; i++)
            System.out.print(divisor[i]);
        System.out.println();
        tot_length=data_bits+divisor_bits-1;
        div=new int[tot_length];
        rem=new int[tot_length];
```

```
crc=new int[tot_length];

/*----- CRC GENERATION-----*/

for(int i=0;i<data.length;i++)
    div[i]=data[i];

System.out.print("Dividend (after appending 0's) are : ");
for(int i=0; i< div.length; i++) System.out.print(div[i]);

System.out.println();
for(int j=0; j<div.length; j++){
    rem[j] = div[j];
}
rem=divide(div, divisor, rem);
for(int i=0;i<div.length;i++)    //append dividend and remainder
{
    crc[i]=(div[i]^rem[i]);
}

System.out.println();
System.out.println("CRC code : ");
for(int i=0;i<crc.length;i++)
    System.out.print(crc[i]);

/*-----ERROR DETECTION-----*/

System.out.println();
System.out.println("Enter CRC code of "+tot_length+" bits : ");
for(int i=0; i<crc.length; i++)
    crc[i]=Integer.parseInt(br.readLine());

System.out.print("crc bits are : ");
for(int i=0; i< crc.length; i++)
    System.out.print(crc[i]);

System.out.println();
for(int j=0; j<crc.length; j++){
    rem[j] = crc[j];
}
rem=divide(crc, divisor, rem);
for(int i=0; i< rem.length; i++)
{
    if(rem[i]!=0)
```

```
        {
            System.out.println("Error");
            break;
        }
        if(i==rem.length-1)
            System.out.println("No Error");
    }
    System.out.println("THANK YOU.... :)");
}
static int[] divide(int div[],int divisor[], int rem[])
{
    int cur=0;
    while(true)
    {
        for(int i=0;i<divisor.length;i++)
            rem[cur+i]=(rem[cur+i]^divisor[i]);
        while(rem[cur]==0 && cur!=rem.length-1)
            cur++;
        if((rem.length-cur)<divisor.length))
            break;
    }
    return rem;
}
}
```

Output:

```
[root@localhost ~]# gedit Crc.java
```

OUTPUT 1:

```
$ javac Crc.java
```

```
$ java Crc
```

```
Enter number of data bits :
```

```
5
```

```
Enter data bits :
```

```
1
```

```
1
```

```
0
```

```
1
```

```
1
```

```
Enter number of bits in divisor :
```

```
3
```

```
Enter Divisor bits :
```

```
1
```

```
0
```

```
1
```

```
Dividend (after appending 0's) are : 1101100
```

```
CRC code :
```

```
1101100
```

```
Enter CRC code of 7 bits :
```

```
1
```

```
1
```

```
0
```

```
1
```

```
1
```

```
0
```

```
0
```

```
No Error
```

```
THANK YOU.... :)
```

OUTPUT 2:

```
Enter number of data bits :
```

```
5
```

```
Enter data bits :
```

```
1
```

```
1
```

```
0
```

1

1

Enter number of bits in divisor :

3

Enter Divisor bits :

1

0

1

Dividend (after appending 0's) are : 1101100

CRC code :

1101100

Enter CRC code of 7 bits :

1

0

0

1

1

0

0

Error

THANK YOU.... :)

Experiment No: 8

Bellman-Ford Algorithm

Objective : Write a program to find the shortest path between vertices using bellman-ford algorithm

Theory :

Distance Vector Algorithm is a decentralized routing algorithm that requires that each router simply inform its neighbors of its routing table. For each network path, the receiving routers pick the neighbor advertising the lowest cost, then add this entry into its routing table for re-advertisement. To find the shortest path, Distance Vector Algorithm is based on one of two basic algorithms: the Bellman-Ford and the Dijkstra algorithms.

Routers that use this algorithm have to maintain the distance tables (which is a one-dimension array -- "a vector"), which tell the distances and shortest path to sending packets to each node in the network. The information in the distance table is always up date by exchanging information with the neighboring nodes. The number of data in the table equals to that of all nodes in networks (excluded itself). The columns of table represent the directly attached neighbors whereas the rows represent all destinations in the network. Each data contains the path for sending packets to each destination in the network and distance/or time to transmit on that path (we call this as "cost"). The measurements in this algorithm are the number of hops, latency, the number of outgoing packets, etc.

The Bellman-Ford algorithm is an algorithm that computes shortest paths from a single source vertex to all of the other vertices in a weighted digraph. It is slower than Dijkstra's algorithm for the same problem, but more versatile, as it is capable of handling graphs in which some of the edge weights are negative numbers. Negative edge weights are found in various applications of graphs, hence the usefulness of this algorithm. If a graph contains a "negative cycle" (i.e. a cycle whose edges sum to a negative value) that is reachable from the source, then there is no cheapest path: any path that has a point on the negative cycle can be made cheaper by one more walk around the negative cycle. In such a case, the Bellman-Ford algorithm can detect negative cycles and report their existence.

Algorithm:

```
function BellmanFord(list vertices, list edges, vertex source)
    ::distance[],predecessor[]
// Step 1: initialize graph
for each vertex v in vertices:
    distance[v] := inf
    predecessor[v] := null
distance[source] := 0
// Step 2: relax edges repeatedly
for i from 1 to size(vertices)-1:
    for each edge (u, v) with weight w in edges:
        if distance[u] + w < distance[v]:
            distance[v] := distance[u] + w
            predecessor[v] := u
// Step 3: check for negative-weight cycles
for each edge (u, v) with weight w in edges:
    if distance[u] + w < distance[v]:
        error "Graph contains a negative-weight cycle"
return distance[], predecessor[]
```

Program:

```
import java.util.Scanner;

public class BellmanFord
{
    private int D[];
    private int num_ver;
    public static final int MAX_VALUE = 999;
    public BellmanFord(int num_ver)
    {
        this.num_ver = num_ver;
        D = new int[num_ver + 1];
    }

    public void BellmanFordEvaluation(int source, int A[][])
    {
        for (int node = 1; node <= num_ver; node++)
        {
            D[node] = MAX_VALUE;
        }
        D[source] = 0;
        for (int node = 1; node <= num_ver - 1; node++)
        {
            for (int sn = 1; sn <= num_ver; sn++)
            {
                for (int dn = 1; dn <= num_ver; dn++)
                {
                    if (A[sn][dn] != MAX_VALUE)
                    {
                        if (D[dn] > D[sn] + A[sn][dn])
                            D[dn] = D[sn] + A[sn][dn];
                    }
                }
            }
        }
        for (int sn = 1; sn <= num_ver; sn++)
        {
            for (int dn = 1; dn <= num_ver; dn++)
```



```
        {
            if (A[sn][dn] != MAX_VALUE)
            {
                if (D[dn] > D[sn] + A[sn][dn])

                System.out.println("The Graph contains negative egde
                cycle");
            }
        }
    }
    for (int vertex = 1; vertex <= num_ver; vertex++)
    {
        System.out.println("distance of source " + source + " to " + vertex + "
        is " + D[vertex]);
    }
}

public static void main(String[ ] args)
{
    int num_ver = 0;
    int source;
    Scanner scanner = new
    Scanner(System.in);
    System.out.println("Enter the number of
    vertices"); num_ver = scanner.nextInt();
    int A[][] = new int[num_ver + 1][num_ver + 1];
    System.out.println("Enter the adjacency matrix");
    for (int sn = 1; sn <= num_ver; sn++)
    {
        for (int dn = 1; dn <= num_ver; dn++)
        {

            A[sn][dn] = scanner.nextInt();
            if (sn == dn)
            {
                A[sn][dn] = 0;
                continue;
            }
            if (A[sn][dn] == 0)
```

```

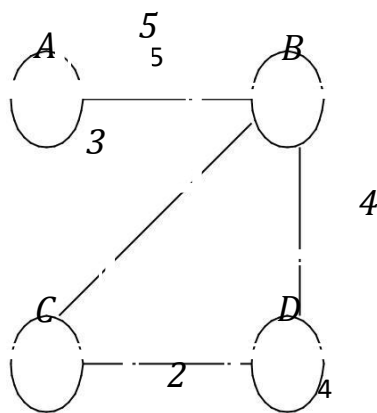
        {
            A[sn][dn] = MAX_VALUE;
        }
    }

}

System.out.println("Enter the source vertex");
source = scanner.nextInt();

BellmanFord b = new BellmanFord
(num_ver); b.BellmanFordEvaluation(source,
A); scanner.close();
}
}

```

Input graph:**Output:**

```

$ javac BellmanFord.java
$ java BellmanFord
Enter the number of vertices
4
Enter the adjacency matrix
0 5 0 0
5 0 3 4
0 3 0 2
0 4 2 0
Enter the source vertex
2
distance of source 2 to 1 is 5
distance of source 2 to 2 is 0
distance of source 2 to 3 is 3
distance of source 2 to 4 is 4

```

Experiment No: 9**Client –Server Using TCP/IP Sockets**

Objective : Using TCP/IP sockets, write a client – server program to make the client send the file name and to make the server send back the contents of the requested file if present. Implement the above program using as message queues or FIFOs as IPC channels.

Theory :

Socket is an interface which enables the client and the server to communicate and pass on information from one another. Sockets provide the communication mechanism between two computers using TCP. A client program creates a socket on its end of the communication and attempts to connect that socket to a server. When the connection is made, the server creates a socket object on its end of the communication. The client and the server can now communicate by writing to and reading from the socket.

Algorithm :**Server Side :**

1. Create socket, port = x for incoming request
serverSocket = socket()
2. Wait for incoming connection request
connectionSocket = serverSocket.accept()
3. Read request from **connectionSocket**
4. Write reply to **connectionSocket**
5. Close **connectionSocket**

Client Side :

1. create socket, connect to **hostid**, port = x
clientSocket = socket()
2. send request using **clientSocket**
3. read reply from **clientSocket**
4. close **clientSocket**

Program:**TCP Client**

```
import java.io.BufferedReader;
import java.io.DataInputStream;
import java.io.DataOutputStream;
import java.io.EOFException;
import java.io.File;
import java.io.FileOutputStream;
import java.io.InputStreamReader;
import java.net.Socket;
import java.util.Scanner;

class Client
{
    public static void main(String args[])throws Exception
    {
        String address = "";
        Scanner sc=new Scanner(System.in);
        System.out.println("Enter Server Address: ");
        address=sc.nextLine();
        //create the socket on port 5000
        Socket s=new Socket(address,5000);

        DataInputStream din=new DataInputStream(s.getInputStream());
        DataOutputStream dout=new DataOutputStream(s.getOutputStream());
        BufferedReader br=new BufferedReader(new InputStreamReader(System.in));
        System.out.println("Send Get to start...");
        String str="",filename="";
        try
        {
            while(!str.equals("start"))
            str=br.readLine();
            dout.writeUTF(str);
            dout.flush();
            filename=din.readUTF();
            System.out.println("Receiving file: "+filename);
            filename="client"+filename;

            System.out.println("Saving as file: "+filename);
```

```
        long sz=Long.parseLong(din.readUTF()); System.out.println
        ("File Size: "+(sz/(1024*1024))+ " MB");

        byte b[]=new byte [1024];

        System.out.println("Receiving file..");

        FileOutputStream fos=new FileOutputStream(new File(filename),true);

        long bytesRead;

        do

        {

                bytesRead = din.read(b, 0, b.length);

                fos.write(b,0,b.length);


        }while(!(bytesRead<1024));

        System.out.println("Completed");

        fos.close();

        dout.close();

        s.close();

    }

    catch(EOFException e)

    {

        //do nothing

    }

}

}

}

}
```

TCP Server

```
import java.io.DataInputStream;
import java.io.DataOutputStream;
import java.io.File;
import java.io.FileInputStream;
import java.net.ServerSocket;
import java.net.Socket;
import java.util.Scanner;

class Server

{

    public static void main(String args[])throws Exception
    {
```

```
String filename;
System.out.println("Enter File Name: ");
Scanner sc=new Scanner(System.in);
filename=sc.nextLine();
sc.close();
while(true)
{
    //create server socket on port 5000
    ServerSocket ss=new ServerSocket(5000);
    System.out.println ("Waiting for request");
    Socket s=ss.accept();
    System.out.println ("Connected With "+s.getInetAddress().toString());
    DataInputStream din=new DataInputStream(s.getInputStream());
    DataOutputStream dout=new DataOutputStream(s.getOutputStream());
    try
    {
        String str="";
        str=din.readUTF();
        System.out.println("SendGet....Ok");
        if(!str.equals("stop")){
            System.out.println("Sending File: "+filename);
            dout.writeUTF(filename);
            dout.flush();
            File f=new File(filename);
            FileInputStream fin=new FileInputStream(f);
            long sz=(int) f.length();
            byte b[]=new byte [1024];
            int read;
            dout.writeUTF(Long.toString(sz));
            dout.flush();
            System.out.println ("Size: "+sz);
            System.out.println ("Buf size:
            "+ss.getReceiveBufferSize()); while((read = fin.read(b)) !=
            -1) {

                dout.write(b, 0, read);
                dout.flush();
            }
        }
    }
}
```

```
        fin.close();
        System.out.println("..ok");
        dout.flush();
    }
    dout.writeUTF("stop");
    System.out.println("Send Complete");
    dout.flush();
}
catch(Exception e)
{
    e.printStackTrace();
    System.out.println("An error occured");
}
    din.close();
    s.close();
    ss.close();
}
}
```

Note: Create two different files Client.java and Server.java. Follow the steps given:

1. Open a terminal run the server program and provide the filename to send
2. Open one more terminal run the client program and provide the IP address of the server. We can give localhost address "127.0.0.1" as it is running on same machine or give the IP address of the machine.
3. Send any start bit to start sending file.

Output:

Server end

```
$ javac TCPServer.java
```

```
$ java TCPServer
```

Sever ready for Connection

Waiting for filename

File Contents sent Successfully

Client end

```
$javac TCPClient.java
```

```
$ java TCPClient
```

Connection Successfull

Enter the File Name

```
test.java
```

```
System.out.println(hello);
```

Experiment No: 10**Client –Server Communication using UDP**

Objective : Write a program on datagram socket for client/server to display the messages on client side, typed at the server side.

Theory :

A datagram socket is the one for sending or receiving point for a packet delivery service. Each packet sent or received on a datagram socket is individually addressed and routed. Multiple packets sent from one machine to another may be routed differently, and may arrive in any order.

Algorithm :**Server Side :**

1. Create socket, port= x
serverSocket =socket(AF_INET,SOCK_DGRAM)
2. read datagram from **serverSocket**
3. write reply to **serverSocket** specifying client address,port number

Client Side :

1. create socket:
clientSocket =socket(AF_INET,SOCK_DGRAM)
2. Create datagram with server IP and port=x; send datagram **via clientSocket**
3. read datagram from **clientSocket**
4. close **clientSocket**

Program :**UDP Client**

```
import java.io.*;
import java.net.*;

public class UDPC
{
    public static void main(String[] args)
    {
        DatagramSocket skt;
        try
```



```
        {  
            skt=new DatagramSocket();  
            String msg= "text message ";  
            byte[] b = msg.getBytes();  
  
            InetAddress host=InetAddress.getByName("127.0.0.1");  
            int serverSocket=6788;  
  
            DatagramPacket request =new DatagramPacket  
                (b,b.length,host,serverSocket); skt.send(request);  
  
            byte[] buffer =new byte[1000];  
  
            DatagramPacket reply= new  
                DatagramPacket(buffer,buffer.length); skt.receive(reply);  
  
            System.out.println("client received:" +new  
                String(reply.getData())); skt.close();  
  
        }  
        catch(Exception ex)  
        {  
        }  
    }  
}
```

UDP Server

```
import java.io.*;  
import java.net.*;  
public class UDPS  
{  
    public static void main(String[] args)  
    {  
        DatagramSocket skt=null;  
        try  
        {  
            skt=new DatagramSocket(6788);  
            byte[] buffer = new byte[1000];  
            while(true)  
            {
```

```
DatagramPacket request = new
    DatagramPacket(buffer,buffer.length); skt.receive(request);

    String[] message = (new String(request.getData())).split(" ");
    byte[] sendMsg= (message[1]+ " server processed").getBytes();
    DatagramPacket      reply      =      new
    DatagramPacket(sendMsg,sendMsg.length,request.getAddress

    (),request.getPort());
    skt.send(reply);
    }
}
catch(Exception ex)
{
}
}
}
```

Note: Create two different files UDPC.java and UDPS.java. Follow the following steps:

1. Open a terminal run the server program.
2. Open one more terminal run the client program, the sent message will be received.

OUTPUT:

Server end

```
$ javac UDPS.java
$ java UDPS
```

```
clientmsgHI
Server
```

Client end

```
$javac UDPC.java
$ java UDPC
Client
```

```
HI
```

Experiment No: 11

RSA Algorithm to Encrypt and Decrypt the Data

Objective : Write a program for simple RSA algorithm to encrypt and decrypt the data.

Theory

RSA is an example of public key cryptography. It was developed by Rivest, Shamir and Adelman. The RSA algorithm can be used for both public key encryption and digital signatures. Its security is based on the difficulty of factoring large integers.

The RSA algorithm's efficiency requires a fast method for performing the modular exponentiation operation. A less efficient, conventional method includes raising a number (the input) to a power (the secret or public key of the algorithm, denoted e and d , respectively) and taking the remainder of the division with N . A straight-forward implementation performs these two steps of the operation sequentially: first, raise it to the power and second, apply modulo. The RSA algorithm comprises of three steps, which are depicted below:

Algorithm

Key Generation Algorithm

1. Generate two large random primes, p and q , of approximately equal size such that their product $n = p \cdot q$
2. Compute $n = p \cdot q$ and Euler's totient function (ϕ) $\phi(n) = (p-1)(q-1)$.
3. Choose an integer e , $1 < e < \phi$, such that $\gcd(e, \phi) = 1$.
4. Compute the secret exponent d , $1 < d < \phi$, such that $e \cdot d \equiv 1 \pmod{\phi}$.
5. The public key is (e, n) and the private key is (d, n) . The values of p , q , and ϕ should also be kept secret.

Encryption

Sender A does the following:-

1. Using the public key (e, n)
2. Represents the plaintext message as a positive integer M
3. Computes the cipher text $C = M^e \bmod n$.
4. Sends the cipher text C to B (Receiver).

Decryption

Recipient B does the following:-

1. Uses his private key (d, n) to compute $M = C^d \bmod n$.
2. Extracts the plaintext from the integer representative m.

Program

```
import java.io.DataInputStream;
import java.io.IOException;
import java.math.BigInteger;
import java.util.Random;

public class RSA
{
    private BigInteger p,q,N,phi,e,d;
    private int bitlength=1024;
    private Random r;
    public RSA()
    {
        r=new Random();
        p=BigInteger.probablePrime(bitlength,r);
        q=BigInteger.probablePrime(bitlength,r);
        System.out.println("Prime number p is"+p);
        System.out.println("prime number q is"+q);
        N=p.multiply(q);
        phi=p.subtract(BigInteger.ONE).multiply(q.subtract(BigInteger.ONE));
        e=BigInteger.probablePrime(bitlength/2,r);
        while(phi.gcd(e).compareTo(BigInteger.ONE)>0&&e.compareTo(phi)<0)
        {
            e.add(BigInteger.ONE);
        }
        System.out.println("Public key is"+e);
        d=e.modInverse(phi);
        System.out.println("Private key is"+d);
    }
    public RSA(BigInteger e,BigInteger d,BigInteger N)
    {
        this.e=e;
```

```
this.d=d;
this.N=N;
}
public static void main(String[] args)throws IOException
{
RSA rsa=new RSA();
DataInputStream in=new DataInputStream(System.in);
String testString;
System.out.println("Enter the plain text:");
testString=in.readLine();
System.out.println("Encrypting string:"+testString);
System.out.println("string in bytes:"+bytesToString(testString.getBytes()));
byte[] encrypted=rsa.encrypt(testString.getBytes());
byte[] decrypted=rsa.decrypt(encrypted);
System.out.println("Dcrypting Bytes:"+bytesToString(decrypted));
System.out.println("Dcrypted string:"+new String(decrypted));
}
private static String bytesToString(byte[] encrypted)
{
String test=" ";
for(byte b:encrypted)
{
test+=Byte.toString(b);
}
return test;
}
public byte[]encrypt(byte[]message)
{
return(new BigInteger(message)).modPow(e,N).toByteArray();
}
public byte[]decrypt(byte[]message)
{
return(new BigInteger(message)).modPow(d,N).toByteArray();
}
}
```

Output:

```
$javac RSA.java
```

```
$ java RSA
```

```
Enter the plain text:
```

```
HELLO
```

```
Encrypting string: HELLO
```

```
string in bytes: 7269767679
```

```
Dcrypting Bytes: 7269767679
```

```
Dcryptd string :HELLO
```

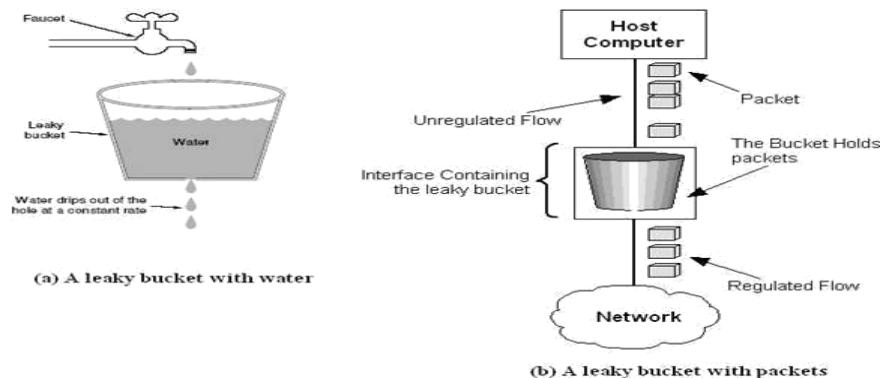
Experiment No: 12

Congestion Control Using Leaky Bucket Algorithm

Objective : Write a program for congestion control using leaky bucket algorithm.

Theory

The main concept of the leaky bucket algorithm is that the output data flow remains constant despite the variant input traffic, such as the water flow in a bucket with a small hole at the bottom. In case the bucket contains water (or packets) then the output flow follows a constant rate, while if the bucket is full any additional load will be lost because of spillover. In a similar way if the bucket is empty the output will be zero. From network perspective, leaky bucket consists of a finite queue (bucket) where all the incoming packets are stored in case there is space in the queue, otherwise the packets are discarded. In order to regulate the output flow, leaky bucket transmits one packet from the queue in a fixed time (e.g. at every clock tick). In the following figure we can notice the main rationale of leaky bucket algorithm, for both the two approaches (e.g. leaky bucket with water (a) and with packets (b)).



While leaky bucket eliminates completely bursty traffic by regulating the incoming data flow its main drawback is that it drops packets if the bucket is full. Also, it doesn't take into

account the idle process of the sender which means that if the host doesn't transmit data for some time the bucket becomes empty without permitting the transmission of any packet.

Algorithm

1. Start
2. Set the bucket size or the buffer size.
3. Set the output rate.
4. Transmit the packets such that there is no overflow.
5. Repeat the process of transmission until all packets are transmitted. (Reject packets where its size is greater than the bucket size)
6. Stop

Program

```
import java.util.Scanner;
import java.lang.*;
public class lb {
public static void main(String[] args)
{
int i;
int a[]=new int[20];
int buck_rem=0,buck_cap=4,rate=3,sent,recv;
Scanner in = new Scanner(System.in);
System.out.println("Enter the number of packets");
int n = in.nextInt();
System.out.println("Enter the packets");
for(i=1;i<=n;i++)
a[i]= in.nextInt();
System.out.println("Clock \t packet size \t accept \t sent \t remaining");
for(i=1;i<=n;i++)
{
if(a[i]!=0)
{
if(buck_rem+a[i]>buck_cap)
recv=-1;
else
{
recv=a[i];
buck_rem+=a[i];
}
}
else
recv=0;
if(buck_rem!=0)
{
if(buck_rem<rate)
{sent=buck_rem;
buck_rem=0;
}
```



```

else
{
sent=rate;
buck_rem=buck_rem-rate;
}
}
else
sent=0;
if(recv==-1)
System.out.println(+i+ "\t\t" +a[i]+ "\t dropped \t" + sent +"\t" +buck_rem);
else
System.out.println(+i+ "\t\t" +a[i] + "\t\t" +recv +"\t" +sent + "\t" +buck_rem);
}
}
}

```

Output:

```
$javac lb.java
```

```
$ java lb
```

```
distance of Enter the number of packets
```

```
5
```

```
Enter the packets
```

```
2
```

```
3
```

```
4
```

```
1
```

```
6
```

Clock	packet size	accept	sent	remaining
1	2	2	2	0
2	3	3	3	0
3	4	4	3	1
4	1	1	2	0
5	6	dropped	0	0