Computer Network Laboratory

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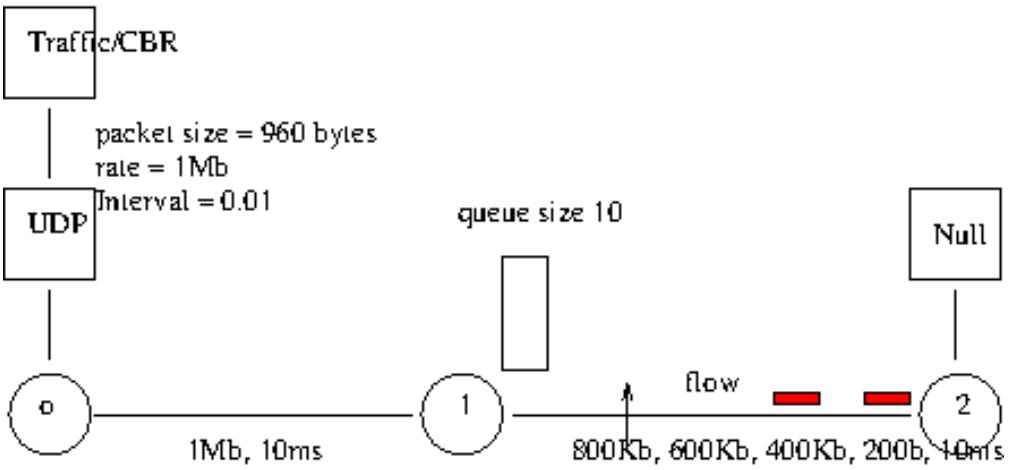
1 PART A - Simulation

2 Network of three nodes

Implement three nodes point - to - point network with duplex links between them. Set the queue size, vary the bandwidth and find the number of packets dropped.

DESIGN:



Simulation time = 10 seconds

CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 1.tcl
```

```
# Three nodes network & measure packets dropped

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]

$ns trace-all $tf
$ns namtrace-all $nf

# Create nodes
set num 3
for {set i 0} {$i < $num} {incr i} {
    set node($i) [$ns node]
}

# Create links
$ns duplex-link $node(0) $node(1) 1Mb 10ms DropTail
$ns duplex-link $node(1) $node(2) 800Kb 10ms DropTail ;#800, 600, 400, 200

# Create queues
$ns duplex-link-op $node(1) $node(2) queuePos 0.5
$ns queue-limit $node(1) $node(2) 10

# Label nodes
$node(0) label "UDP"
$node(2) label "Null"

# Label flows
$ns color 0 Red

# Create connections
set udp [$ns create-connection UDP $node(0) Null $node(2) 0]
set cbr [$udp attach-app Traffic/CBR]

# Traffic
$cbr set packetSize_ 960
$cbr set rate_ 1Mb
$cbr set interval_ 0.001 ;# choose 0.01 only; 0.001, 0.01, 0.1

$ns at 0.0 "$cbr start"
$ns at 10 "finish"

proc finish {} {
    global ns tf nf
    $ns flush-trace
    close $tf
    close $nf
    exit 0
}
```

```
# Start simulation
$ns run


# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 1.awk
# Count dropped packets

BEGIN {
    count=0;
}
{
    if($1=="d") count++;
}
END {
    printf("Number of packets dropped is %d\n", count);
}
```

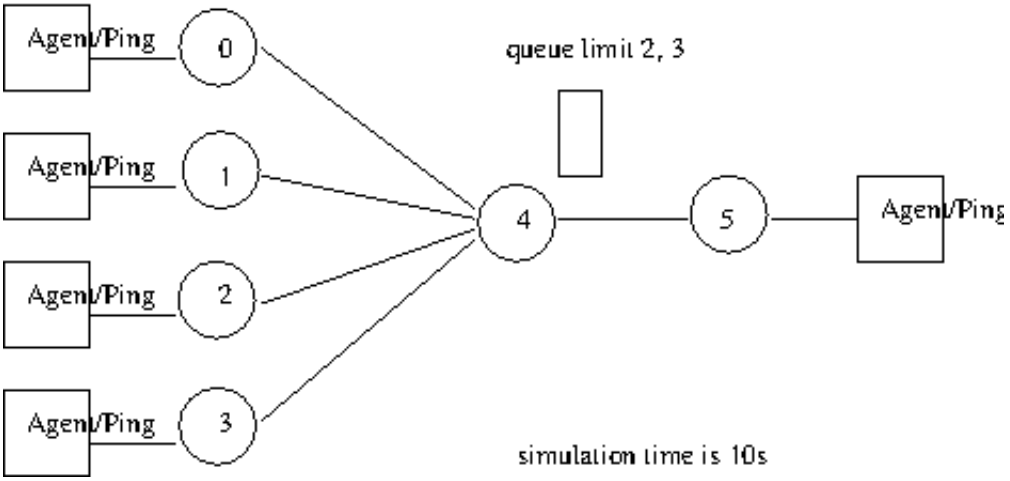
RUN:

```
ns 1.tcl
nam out.nam
awk -f 1.awk out.tr
BW(Kb/s) 800 600 400 200
Dropped  0   210 470 730
```

3 Ping traffic

Implement transmission of ping messages/trace route over a network topology consisting of 6 nodes and find the number of packets dropped due to congestion.

DESIGN:



CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 2.tcl
# Simulate Ping & count dropped packets due to congestion

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]

$ns trace-all $tf
$ns namtrace-all $nf

# Create nodes
set num 6
for {set i 0} {$i < $num} {incr i} {
    set node($i) [$ns node]
}

# Create links
$ns duplex-link $node(0) $node(4) 1Mb 10ms DropTail
$ns duplex-link $node(1) $node(4) 1Mb 10ms DropTail
$ns duplex-link $node(2) $node(4) 1Mb 10ms DropTail
```

```
$ns duplex-link $node(3) $node(4) 1Mb 10ms DropTail
$ns duplex-link $node(4) $node(5) 1Mb 10ms DropTail

# Create queue
$ns duplex-link-op $node(4) $node(5) queuePos 0.5
$ns queue-limit $node(4) $node(5) 2 ;# different from normal 3, 2

# Label flows
$ns color 1 "red"
$ns color 2 "blue"
$ns color 3 "green"
$ns color 4 "yellow"
$ns color 5 "orange"

# Define a 'recv' function for the class 'Agent/Ping'
Agent/Ping instproc recv {from rtt} {
    $self instvar node_
    puts "node [$node_ id] received ping answer from $from with round-trip-time $rtt ms."
}

# Create connections
set p0 [$ns create-connection Ping $node(0) Ping $node(5) 1]
set p1 [$ns create-connection Ping $node(1) Ping $node(5) 2]
set p2 [$ns create-connection Ping $node(2) Ping $node(5) 3]
set p3 [$ns create-connection Ping $node(3) Ping $node(5) 4]
set p5 [$ns create-connection Ping $node(5) Ping $node(4) 5]

# Schedule events
for { set i 0} {$i < 10} {incr i} {
    for {set j 0} {$j < 10} {incr j} {
        $ns at [expr $i+.1+$j/10] "$p0 send"
        $ns at [expr $i+.1+$j/10] "$p5 send"
        $ns at [expr $i+.2+$j/10] "$p1 send"
        $ns at [expr $i+.3+$j/10] "$p2 send"
        $ns at [expr $i+.4+$j/10] "$p3 send"
        $ns at [expr $i+.5+$j/10] "$p5 send"
    }
}
$ns at 10 "finish"

proc finish {} {
    global ns tf nf
    $ns flush-trace
    close $tf
    close $nf
    exit 0
}

# Start simulation
```

```
$ns run


# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 2.awk
# Count dropped packets due to congestion

BEGIN {
    count=0;
}

{
    if($1=="d") count++;
}
END {
    printf("total no of packets dropped due to cngestion : %d\n", count);
}
```

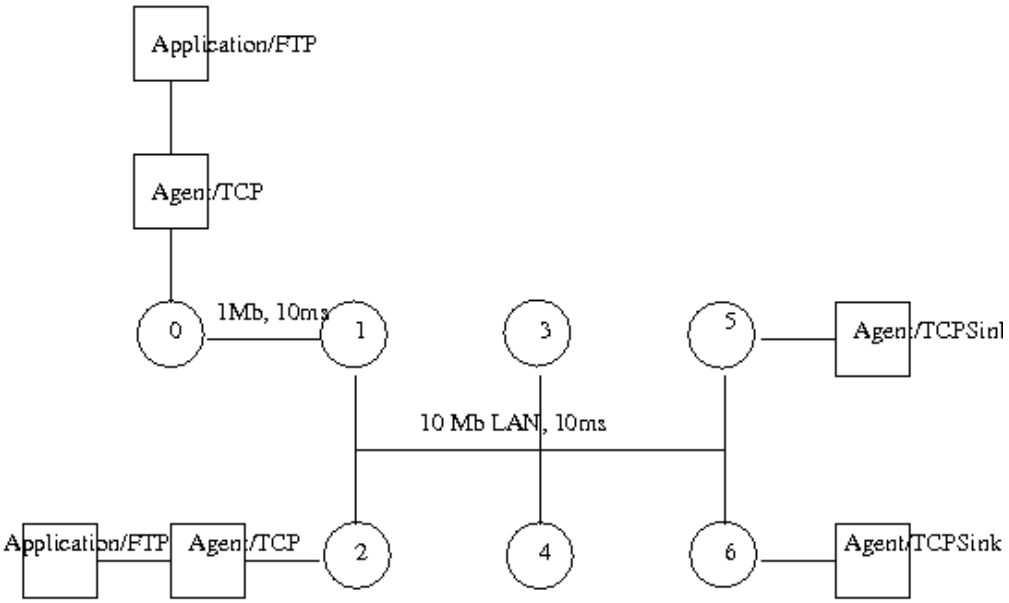
RUN:

```
ns 2.tcl
nam out.nam
awk -f 2.awk out.tr
1. qsize(n4,n5) = 2, 30 packets dropped due to congestion
2. qsize(n4,n5) = 3, 20 packets dropped
```

4 LAN

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

DESIGN



Connections: 1–5, 2–6 Simulation time is 10s

CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 3.tcl
# LAN simulation (congestion window size with time)

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]

$ns trace-all $tf
$ns namtrace-all $nf

# Create nodes
set node(0) [$ns node]

set num 6
```

```
for {set i 1} {$i <= $num} {incr i} {
    set node($i) [$ns node]
    lappend nodelist $node($i)
}

# create LAN and links
$ns make-lan $nodelist 10Mb 10ms LL Queue/DropTail

$ns duplex-link $node(0) $node(1) 1Mb 10ms DropTail
$ns duplex-link-op $node(0) $node(1) queuePos 0.5
$ns duplex-link-op $node(0) $node(1) orient right

# Create connections
set tcp0 [$ns create-connection TCP $node(0) TCPSink $node(5) 0]
set tcp1 [$ns create-connection TCP $node(2) TCPSink $node(6) 0]

set ftp0 [$tcp0 attach-app FTP]
set ftp1 [$tcp1 attach-app FTP]

$tcp0 attach $tf
$tcp0 trace cwnd_

$tcp1 attach $tf
$tcp1 trace cwnd_

$ns at 0.1 "$ftp0 start"
$ns at 0.2 "$ftp1 start"

$ns at 10 "finish"

proc finish {} {
    global ns tf nf
    $ns flush-trace
    close $tf
    close $nf
    exit 0
}

# Start simulator
$ns run


# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 3.awk
# Plot conestion window X time

BEGIN{
}
```

```
{
    if($6=="cwnd_")
    {
        if ($2 == 0 && $4 == 5) printf("%4.2f\t%4.2f\t\n",$1,$7); # $1=time, $7=cwnd size
#       if ($2 == 2 && $4 == 6) printf("%4.2f\t%4.2f\t\n",$1,$7);
    }
}
END{
    puts "DONE";
}
```

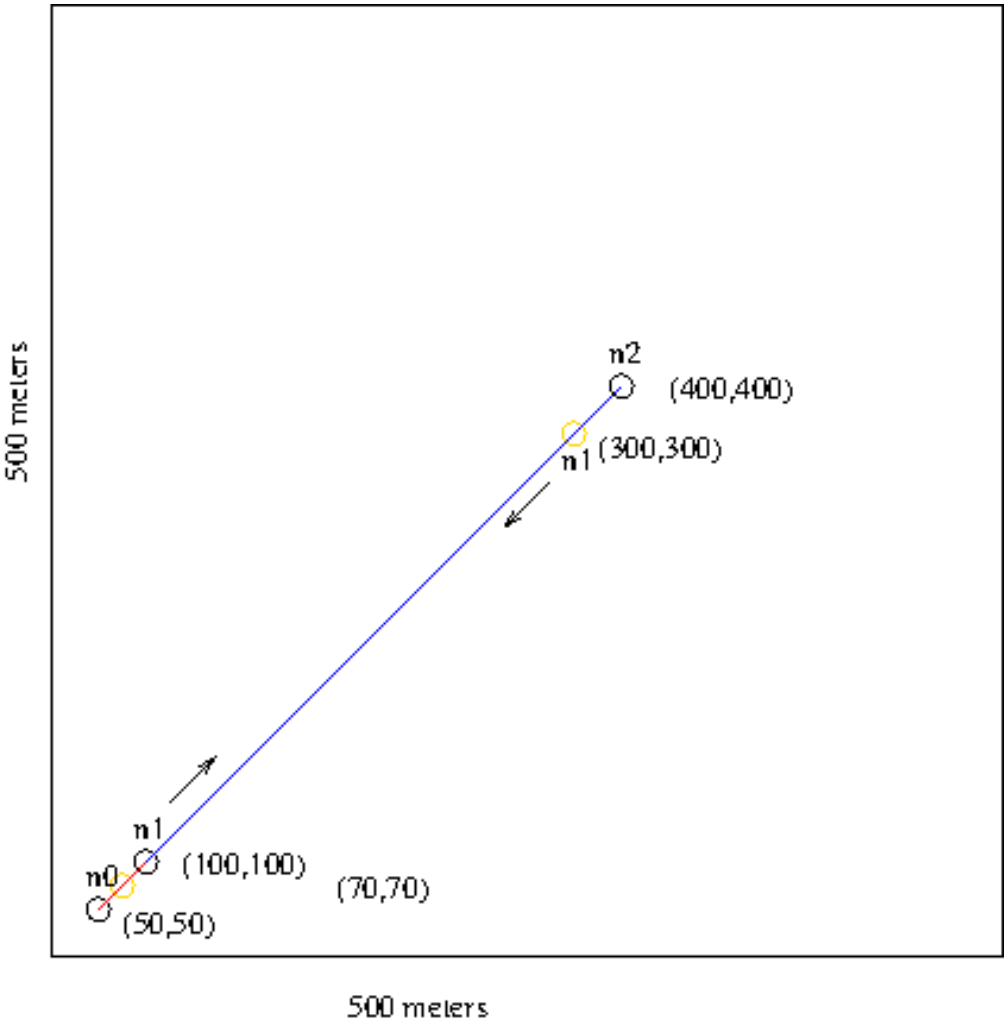
RUN:

```
ns 3.tcl
nam out.nam
awk -f 3.awk out.tr > out.txt
xgraph out.txt
modify awk script to use another tcp connection
```

5 Simple ESS

Simulate simple ESS and with transmitting nodes in wire-less LAN by simulation and determine the performance with respect to transmission of packets.

DESIGN:



Simulation time 25 s; n1 moves towards n2 at 10s; retracts back at 20 s.

CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
```

```
# File 4.tcl
# Wireless LAN simulation

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]

$ns trace-all $tf
$ns namtrace-all-wireless $nf 500 500

set topo [new Topography]
$topo load_flatgrid 500 500

$ns node-config \
    -adhocRouting DSDV \
    -llType       LL \
    -macType      Mac/802_11 \
    -ifqType      Queue/DropTail \
    -ifqLen       10 \
    -phyType      Phy/WirelessPhy \
    -propType     Propagation/TwoRayGround \
    -antType      Antenna/OmniAntenna \
    -topoInstance $topo \
    -agentTrace   ON \
    -routerTrace  ON \
    -macTrace     ON \
    -channel      [new Channel/WirelessChannel]

create-god 3 ;# General Operations Director

set num 3
for {set i 0} {$i < $num} {incr i} {
    set node($i) [$ns node]
}

$node(0) label "TCP"
$node(1) label "TCPSink, TCP"
$node(2) label "TCPSink"

$node(0) set X_ 50
$node(0) set Y_ 50
$node(0) set Z_ 0

$node(1) set X_ 100
$node(1) set Y_ 100
$node(1) set Z_ 0

$node(2) set X_ 400
$node(2) set Y_ 400
```

```
$node(2) set Z_ 0

# Create connections
set tcp0 [$ns create-connection TCP $node(0) TCPSink $node(1) 1]
set tcp1 [$ns create-connection TCP $node(1) TCPSink $node(2) 2]

$ns color 1 "red"
$ns color 2 "blue"

set ftp0 [$tcp0 attach-app FTP]
set ftp1 [$tcp1 attach-app FTP]

$ns at 0 "$node(0) setdest 50 50 100"
$ns at 0 "$node(1) setdest 100 100 100"
$ns at 0 "$node(2) setdest 400 400 100"

$ns at 1 "$ftp0 start"
$ns at 1 "$ftp1 start"

$ns at 10 "$node(1) setdest 300 300 100"
$ns at 15 "$node(1) setdest 100 100 100"

$ns at 20 "finish"

proc finish {} {
    global ns tf nf
    $ns flush-trace
    close $tf
    close $nf
    exit 0
}

# Start simulation
$ns run


# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 4.awk
# Wireless LAN link performance

BEGIN{
    count1=0;
    count2=0;
    pack1=0;
    pack2=0;
    time1=0;
    time2=0;
}
```

```
{
    if($1=="r" && $3=="_1_" && $4=="AGT")
    {
        count1++;
        pack1=pack1+$8
        time1=$2;
    }
    if($1=="r" && $3=="_2_" && $4=="AGT")
    {
        count2++;
        pack2=pack2+$8;
        time2=$2;
    }
}
END{
    printf("node(0) to node(1) link performance : %6.2f Mbps\n",((count1*pack1*8)/(time1*1000000)
    printf("node(0) to node(1) link performance : %6.2f Mbps\n",((count2*pack2*8)/(time2*1000000)
}
```

RUN:

```
ns 4.tcl
nam out.nam
awk -f 4.awk out.tr
The throughput from node(0) to node(1): 415.40 Mb/s
The throughput from node(1) to node(2): 184.56 Mb/s
```

6 GSM

Implement and study the performance of GSM on NS2/NS3 (Using MAC layer) or equivalent environment.

CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 5.tcl
# Wireless LAN simulation

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]
$ns trace-all $tf
$ns namtrace-all $nf
set node(ms1) [$ns node]
set node(bs1) [$ns node]
set node(msc) [$ns node]
set node(bs2) [$ns node]
set node(ms2) [$ns node]

$ns duplex-link $node(ms1) $node(bs1) 1Mb 1ms DropTail
$ns duplex-link $node(bs1) $node(msc) 1Mb 10ms DropTail
$ns duplex-link $node(msc) $node(bs2) 1Mb 10ms DropTail
$ns duplex-link $node(bs2) $node(ms2) 1Mb 1ms DropTail

puts "Cell Topology"

$ns bandwidth $node(ms1) $node(bs1) 9.6Kb simplex
$ns bandwidth $node(bs1) $node(ms1) 9.6Kb simplex

$ns insert-delayer $node(ms1) $node(bs1) [new Delayer]


set tcp1 [$ns create-connection TCP $node(ms1) TCPSink $node(ms2) 0]
set ftp1 [$tcp1 attach-app FTP]
$ns at 0.1 "$ftp1 start"


proc stop {} {
    global node opt nf
    set sid [$node(ms1) id]
    set did [$node(bs1) id]

    puts $sid
```

```
    puts $did

    exec getrc -s $sid -d $did -f 0 out.tr | \
         raw2xg -s 0.01  -m 100 -r > plot.xgr
    exec getrc -s $did -d $sid -f 0 out.tr | \
         raw2xg -a -s 0.01 -m 100  >> plot.xgr

    exec ./xg2gp.awk plot.xgr
    exec xgraph -bb -tk -nl -m -x time -y packets plot.xgr &
    exit 0
}
$ns at 20 "stop"
$ns run
```

7 CDMA

Implement and study the performance of CDMA on NS2/NS3 (Using stack called Call net) or equivalent environment.

CODE:

```
# Author: G. Srinivasachar
# Date:   3/6/16
#
# File 6.tcl
# Wireless LAN simulation

set ns [new Simulator]
set tf [open out.tr w]
set nf [open out.nam w]
$ns trace-all $tf
$ns namtrace-all $nf
set node(ms1) [$ns node]
set node(bs1) [$ns node]
set node(msc) [$ns node]
set node(bs2) [$ns node]
set node(ms2) [$ns node]

$ns duplex-link $node(ms1) $node(bs1) 1Mb 1ms DropTail
$ns duplex-link $node(bs1) $node(msc) 1Mb 10ms DropTail
$ns duplex-link $node(msc) $node(bs2) 1Mb 10ms DropTail
$ns duplex-link $node(bs2) $node(ms2) 1Mb 1ms DropTail

puts "Cell Topology"

$ns bandwidth $node(ms1) $node(bs1) 64Kb simplex
$ns bandwidth $node(bs1) $node(ms1) 384Kb simplex

$ns insert-delayer $node(ms1) $node(bs1) [new Delayer]


set tcp1 [$ns create-connection TCP $node(ms1) TCPSink $node(ms2) 0]
set ftp1 [$tcp1 attach-app FTP]
$ns at 0.1 "$ftp1 start"


proc stop {} {
    global node opt nf
    set sid [$node(ms1) id]
    set did [$node(bs1) id]

    puts $sid
```

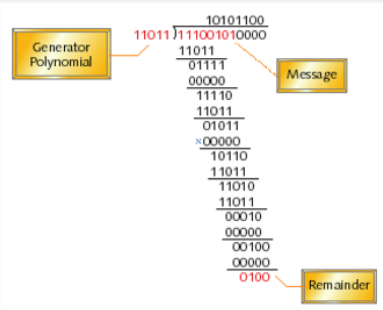
```
    puts $did

    exec getrc -s $sid -d $did -f 0 out.tr | \
         raw2xg -s 0.01  -m 100 -r > plot.xgr
    exec getrc -s $did -d $sid -f 0 out.tr | \
         raw2xg -a -s 0.01 -m 100  >> plot.xgr

    exec ./xg2gp.awk plot.xgr
    exec xgraph -bb -tk -nl -m -x time -y packets plot.xgr &
    exec exit 0
}
$ns at 20 "stop"
$ns run
```

8 PART B - JAVA

9 CRC

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

DESIGN:




```
              3   2   1   0   Bits
             +---+---+---+---+
     Pop! <- |   |   |   |   | <----- Augmented message
             +---+---+---+---+
           1   0   1   1   1   = The Poly
Load the register with zero bits.
Augment the message by appending W zero bits to the end of it.
While (more message bits)
   Begin
   Shift the register left by one bit, reading the next bit of the
      augmented message into register bit position 0.
```

```
   If (a 1 bit popped out of the register during shifting)
      Register = Register XOR Poly.
   End
The register now contains the remainder.
```

CODE:

```
import java.util.Scanner;

public class CRC {
    int W;
    char[] P;
    String checksum;
    String message;

    CRC()
      {
        W = 16;
        P = "10001000000100001".toCharArray(); // (16,12,5,0) ["CRC-16"]
      }

    void crc()
    {
        String crc = "0000000000000000"; // W zeros
        char[] msg = (message + crc).toCharArray(); // augmented message
        char[] rem = (crc+'0').toCharArray();

        int n = 0;
        while (n < msg.length)
        {
            rem[W] = msg[n++];
            boolean xorcopy = rem[0] == '1';
            for (int i=1; i <= W; i++)
              {
                rem[i-1] = xorcopy ? (rem[i]==P[i]?'0':'1') : rem[i];
              }

        }
        checksum = String.valueOf(rem).substring(0, W);
    }

    void input()
    {
        Scanner scanner = new Scanner(System.in);

        System.out.print("MESSAGE:");
        message = scanner.next();
```

```
        scanner.close();
     }

    void output()
    {
        System.out.println("Checksum:"+checksum);
    }


    public static void main(String[] args)
    {
        CRC crc = new CRC();

        crc.input();
        crc.crc();
        crc.output();
    }
}
```

RUN:

```
javac CRC.java
java  CRC

MESSAGE: 0101
Checksum: 0101000010100101

MESSAGE: 1011101
Checksum: 1000101101011000

MESSAGE: MESSAGE + Checksum.
Checksum: 0000000000000000

MESSAGE: (MESSAGE + CHecksum) error bits
Checksum: NOT Zero
```

10 Bellman Ford

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

DESIGN

```
BELLMAN-FORD(G, w, s)

// Initialization
for each vertex v ∈ G.V
     v.d = ∞
     v.π = NIL
s.d = 0

// Relaxation
for i = 1 to |G.V|-1
   for each edge(u,v) ∈ G.E
        if v.d > u.d + w(u,v)
              v.d = u.d + w(u,v)
              v.π = u

for each edge(u,v) ∈ G.E
     if v.d > u.d + w(u,v)
           return FALSE

return TRUE;
```

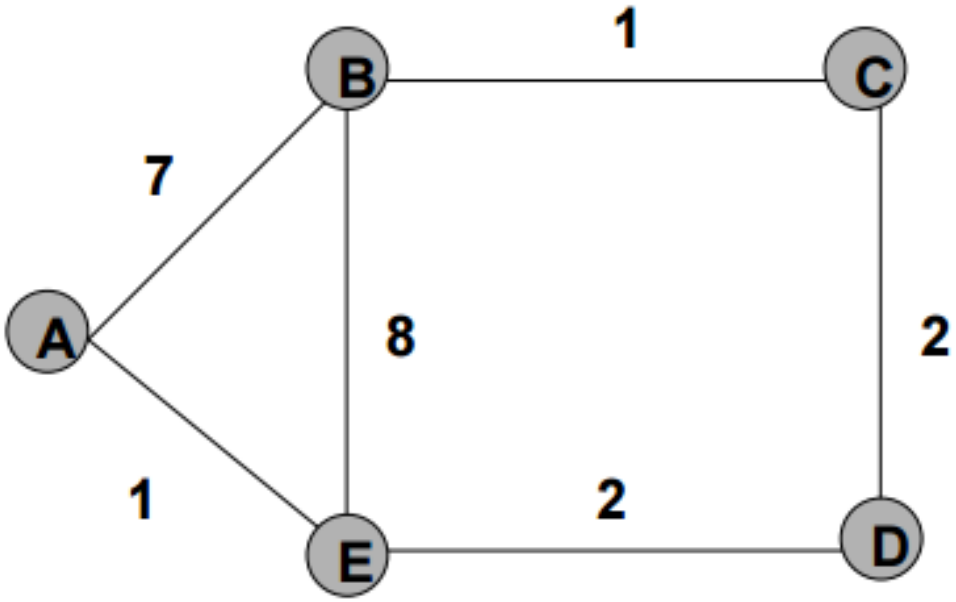
CODE:

```
import java.util.Scanner;

public class BellmanFord {
    int n;
    int[][] a;
    int[]   d;
    int[]   p;
    int s;
    public final static int INFTY=999;

    BellmanFord(int n)
    {
        this.n = n;

        a = new int[n][n];
        d = new int[n];
        p = new int[n];
    }
```

```
void bellmanFord()
{
    // Initialization
    for(int i=0; i < n; i++)
    {
        d[i] = a[s][i];
        p[i] = a[s][i] == INFTY ? -1 : s;
    }
    p[s] = -1;

    for(int i=0; i < n-1; i++)
    {
        // Relax all edges iteratively (n-1) times
        for(int u=0; u < n; u++)
        {
            for(int v=0; v < n; v++)
            {
                if(d[v] > d[u]+a[u][v])
                {
                    d[v] = d[u]+a[u][v];
                    p[v] = u;
                }
            }
        }
    }
}

void input(Scanner scanner)
{
    System.out.println("Enter G: ");

    for(int i=0; i<n; i++)
    {
        for(int j=0; j<n; j++)
        {
            a[i][j] = scanner.nextInt();
            if (i != j && a[i][j] == 0) a[i][j] = INFTY;
        }
    }

    System.out.print("Enter the source vertex: ");
    s = scanner.nextInt();

    scanner.close();
}

void path(int v)
{
```

```
        if (v == -1) return;

        path(p[v]);
        System.out.print("."+v);
    }

    void output()
    {
        int i;

        for(i=0; i < n; i++)
        {
            System.out.print("d(" + s + "," + i + ")=" + d[i]+" :p");
            path(i);
            System.out.println();
        }
    }

    public static void main(String[] args) {
        int         n;
        Scanner scanner = new Scanner(System.in);

        System.out.print("Enter n: ");
        n = scanner.nextInt();

        BellmanFord bf = new BellmanFord(n);

        bf.input(scanner);
        bf.bellmanFord();
        bf.output();
    }
}
```

RUN:




```
javac BellmanFord.java
java  BellmanFord

INPUT:

Enter n: 5
Enter a:
0  7  0  0  1
7  0  1  0  8
0  1  0  2  0
0  0  2  0  2
1  8  0  2  0

Dest Dist path...
1    6    4.3.2.1.
2    5    4.3.2.
3    3    4.3.
4    1    4.
```

11 File transfer using TCP

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.

DESIGN:

SERVER

- Create a server socket and bind to a specific address
- Wait for client connection
- Create input and output stream for the client socket
- Read file name from the input stream
- Read all lines from the file
- Write the lines to output stream

CLIENT

- Create a socket with the server address
- Create input and output stream for the socket
- Read file name from the console
- Write file name to the socket
- Read, in a loop, the lines from server until the line is "stop"

CODE: TcpServer.java, TcpClient.java, f.txt

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

import java.nio.file.*;
import java.nio.charset.*;
import java.util.*;

public class TcpServer {

    void server() throws Exception
    {
        ServerSocket ss=new ServerSocket(3333);
```

```
        System.out.println("Server waiting for connection from client");

        Socket cs=ss.accept();

        DataInputStream din=new DataInputStream(cs.getInputStream());
        DataOutputStream dout=new DataOutputStream(cs.getOutputStream());

        String fileName = din.readUTF();
        List<String> lines = Files.readAllLines(Paths.get(fileName), Charset.defaultCharset());

        for (int i=0; i < lines.size(); i++)
        {
            System.out.println("server: "+lines.get(i));
            dout.writeUTF(lines.get(i));
        }

        din.close();

        cs.close();
        ss.close();
    }

    public static void main(String[] args) throws Exception {
        TcpServer ts = new TcpServer();
        ts.server();
    }

}


import java.io.*;
import java.net.*;
import java.util.*;

public class TcpClient {
    void client() throws Exception {
        Socket s=new Socket("localhost",3333);

        DataInputStream din=new DataInputStream(s.getInputStream());
        DataOutputStream dout=new DataOutputStream(s.getOutputStream());

        Scanner scanner = new Scanner(System.in);

        System.out.print("Enter filename:");
        String fileName = scanner.next();

        dout.writeUTF(fileName);

        String message;
        do
```

```
        {
            message = din.readUTF();
            System.out.println("Client: " + message);
        }
        while(!message.equals("stop"));

        scanner.close();

        dout.close();
        s.close();
    }

    public static void main(String[] args) throws Exception {
        TcpClient tc = new TcpClient();
        tc.client();
    }
}


1
2
3
4
stop
```

RUN:

```
javac TcpServer.java TcpClient.java
java TcpServer
java TcpClient

Enter Filename: f.txt
```

12 Data transfer using UDP

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

DESIGN:

SERVER

- Create a datagram socket and bind to a specific address
- Create a datagram packet for given message buffer
- Receive datagram packet and extract the message and client address
- Read line from the console and write to the socket until "stop"

CLIENT

- Create a datagram socket
- Create a datagram packet with message, server address
- Send the packet
- Receive, in a loop, packet and display the message until the "stop"

CODE

```
import java.net.*;
import java.util.Scanner;

class UdpServer
{
    public void server() throws Exception
    {
        DatagramSocket socket = new DatagramSocket(3333);
        DatagramPacket packet;

        System.out.println("UDP Server Listening in " + 3333);

        byte[] msgBuffer = new byte[1024];
        packet = new DatagramPacket(msgBuffer, msgBuffer.length);
        socket.receive(packet);

        String message = new String(msgBuffer, 0, packet.getLength());
```

```
        System.out.println("Client: Message received = " + message);

        InetAddress address = packet.getAddress();
        int port = packet.getPort();

        Scanner scanner = new Scanner(System.in);
        System.out.println("Server: type lines of text; type 'stop' to terminate");

        do
            {
                message = scanner.nextLine();
                packet = new DatagramPacket(message.getBytes(), message.length(), address, port);

                socket.send(packet);
            }
        while (message.compareTo("stop") != 0);

        scanner.close();
        socket.close();
    }

    public static void main(String args[]) throws Exception
    {
        UdpServer us = new UdpServer();
        us.server();
    }
}


import java.net.*;

class UdpClient
{
    public void client() throws Exception
    {
        DatagramSocket socket = new DatagramSocket();
        DatagramPacket packet;

        String message = "Start";
        packet = new DatagramPacket(message.getBytes(), message.length(), InetAddress.getByName("

        socket.send(packet);
        System.out.println("Client: Sent data to Server ; Message = " + message);
        byte[] msgBuffer = new byte[1024];
        packet = new DatagramPacket(msgBuffer, msgBuffer.length);

        do
            {
                socket.receive(packet);
```

```
                message = new String(msgBuffer, 0, packet.getLength());
                System.out.println(message);
            }
        while (!message.equals("stop"));
        socket.close();
    }

    public static void main(String args[]) throws Exception
    {
        UdpClient uc = new UdpClient();
        uc.client();
    }
}
```

RUN

```
javac UdpServer.java UdpClient.java
java  UdpServer
java  UdpClient
```

13 RSA

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

DESIGN

1. Compute two large primes p and q such tha p $\neq$ q
2. Compute the modulus n=p.q
3. Compute totient ϕ(n) = (p-1).(q-1)
4. Choose an integer e, smaller than and relatively prime to ϕ(n), such that gcd(e, ϕ(n))=1. e is called the public key exponent.
5. Compute an integer d such that d.e=1 mod ϕ(n). d is called the private key exponent.
6. Public key pair is (e,n); Private key pair is (d,n)
7. Encryption: C = P(M) = M^e (mod n); Decryption: M = S(C) = C^d (mod n)

CODE

```
import java.util.Scanner;

public class RSA {
    int d;
    int e;
    int n;

    String  M;

    int gcd(int m, int n)
    {
        int rv = n == 0 ? m : gcd(n, m % n);

        return rv;
    }

    int pow(int a, int m, int n)
    {
        int r = 1;
        while (m-- != 0)
            r = (r*a) % n;

        return r ;
    }
```

```
void rsa()
{
    int p;
    int q;
    int z;

    //odd prime numbers 3, 5 (3, 11?)
    p = 11;
    q = 13;

    n = p*q;
    z = (p-1)*(q-1);

    // choose e
    for (e=2; gcd(e, z) != 1; e++);

    // choose d as inverse of e
    for (d=2; (d*e) % z != 1; d++);
}

void input()
{
    Scanner scanner = new Scanner(System.in);

    System.out.print("Enter M:");
    M = scanner.next();

    scanner.close();
}

void output()
{
    System.out.println("S=(d,n)=(" + d + "," + n + ")");
    System.out.println("P=(e,n)=(" + e + "," + n + ")");

    System.out.println("T: " + M);

    char[] T = M.toCharArray();
    for (int i=0; i < M.length(); i++)
        {
            T[i] = (char)pow((int)T[i], e, n);
        }
    System.out.println("C: " + String.valueOf(T));

    for (int i=0; i < M.length(); i++)
        {
            T[i] = (char)pow((int)T[i], d, n); //convert(a, d, n);
        }
    System.out.println("T: " + String.valueOf(T));
```

```
    }


    public static void main(String[] args) {
        RSA r = new RSA();

        r.input();
        r.rsa();
        r.output();
    }
}
```

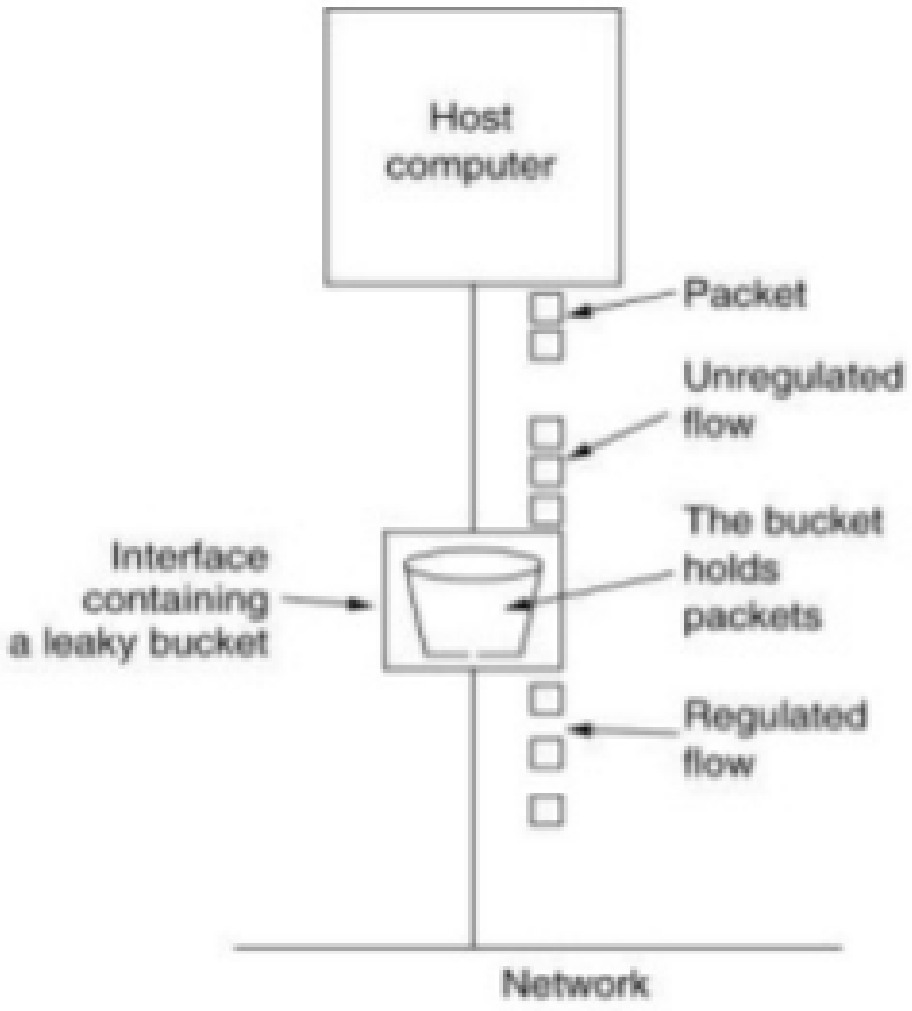
RUN:

```
javac RSA.java
java  RSA

Enter M:ABCabc123

S=(d,n)=(103,143)
P=(e,n)=(7,143)
T: ABCabc123
C: ABY; ,$)t
T: ABCabc123
```

14 Leaky Bucket

Write a program for congestion control using leaky bucket algorithm.

DESIGN



1. The leaky bucket algorithm used to control rate in a network
2. In this algorithm the input rate can vary but the output rate remains constant
3. This algorithm saves bursty traffic into fixed rate traffic by averaaging the data rate
4. If the bucket (buffer) overflows then packets are discarded
5. It is implemented as a single-server queue with constant service rate

ALGORITHM

Step 1. Initialise the counter to 'n' at every tick of clock

Step 2. If n is greater than the size of packet in the front of queue send the packet into the network and decrement the counter by sze of packet. Repeat the step until 'n' is less than the size of packet.

Step 3. Reset the counter and goto step 1.

n = 1000, buffer size of 6 packets. incoming packets –> [200,700,500,450,400,200] -> sent packets

packets 200, 400 are sent and n=400. Next packet will not be sent as its size is > n. Wait for the next clock tick before reseting n.

CODE

```
import java.util.*;

public class LeakyBucket {

    int n;
    int burst;
    int outgoingRate;
    int bucketSize;

    int incoming;
    int outgoing;
    int pending;
    int overflow;

    int duration;
    int interval;

    LeakyBucket()
    {
        pending = 0;
        incoming = 0;
        overflow = 0;
        outgoing = 0;
    }


    void leakyBucket()
    {
        System.out.println("Time    Incoming Pending Overflow Outgoing");

        Random rand = new Random();
        int time=0;
```

```
        while (time < duration)
        {
            incoming = rand.nextInt(burst);
            if ((pending + incoming) > bucketSize)
            {
                overflow = (pending + incoming) - bucketSize;
                pending = bucketSize;
            }
            else pending += incoming;

            //interval = rand()%10; // Next packet will come at time
            interval = 1;

            for(int clk = 0; clk < interval; ++clk)
            {
                output(time, incoming, pending, overflow, outgoing);
                //sleep(1);
                outgoing = Math.min(outgoingRate, pending);
                pending -= outgoing;

                incoming = 0;
                ++time;
            }
        }
    }

    void input()
    {
        Scanner scanner = new Scanner(System.in);
        System.out.println("Enter burst size: ");
        burst = scanner.nextInt();

        System.out.println("Enter bucket size: ");
        bucketSize = scanner.nextInt();

        System.out.println("Enter outgoing rate: ");
        outgoingRate = scanner.nextInt();

        System.out.println("Enter duration: ");
        duration = scanner.nextInt();

        scanner.close();
    }

    void output(int time, int incoming, int pending, int overflow, int outgoing)
    {
        System.out.printf("%d\t%d\t%d\t%d\t%d\n",time,incoming,pending,overflow,outgoing);
    }
```

```
    public static void main(String[] args) {
        LeakyBucket lb = new LeakyBucket();

        lb.input();
        lb.leakyBucket();
    }

}
```

RUN

```
javac LeakyBucket.java
java  LeakyBucket

Enter burst size: 8
Enter bucket size: 8
Enter outgoing rate: 2
Enter duration: 8

Time    Incoming Pending Overflow Outgoing
0        2        2        0        0
1        4        4        0        2
2        5        7        0        2
3        4        8        1        2
4        5        8        3        2
5        6        8        4        2
6        5        8        3        2
7        0        6        3        2
```