NS3-based Simulation of a Computer Network

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1. Introduction

This report presents a simulation of a computer network using NS3. The simulated network consists of 7 hosts and 4 routers interconnected using point-to-point links. The aim is to evaluate network performance in terms of throughput, packet drops, delays, and queue lengths. Visualization of the packet flow is performed using NetAnim.

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2. NS3 Setup Instructions

Follow the steps below to set up NS3 and run the simulation:

2.1 Prerequisites

Ensure that the following dependencies are installed:

```
sudo apt update
sudo apt install g++ python3 cmake git build-essential
```

2.2 Download and Build NS3

Clone the NS3 repository and build it using CMake:

```
# Clone the NS3 repository
git clone https://gitlab.com/nsnam/ns-3-dev.git
cd ns-3-dev

# Configure the build
./contrib/cmake/init-configure.py

# Build NS3 using CMake
/opt/homebrew/bin/cmake --build cmake-cache -j 7
```

2.3 Add the Assignment Code to the Scratch Folder

Copy the assignment code into the `scratch/` folder:

```
cp /path/to/assignment_topology.cc ns-3-dev/scratch/
```

2.4 Run the Simulation

Run the simulation with logs enabled:

```
NS_LOG="AssignmentTopology=info" ./ns3 run scratch/assignment_topology
```

2.5 Visualize with NetAnim

To visualize the simulation:

- Ensure NetAnim is installed:

```
sudo apt install netanim
```

- Open the generated XML file in NetAnim:

```
./NetAnim assignment.xml
```

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3. Network Configuration and Parameters

3.1 Topology

The network comprises 7 workstations/servers (Host 0 to Host 6) and 4 routers (Router 0 to Router 3). The link configurations are shown in Table 1.

Link	Bandwidth (Mbps)	Delay (ms)
Host 0 - Router 0	10	1
Host 1 - Router 0	10	1
Host 2 - Router 2	10	1
Host 3 - Router 2	15	1
Host 4 - Router 1	10	1
Host 5 - Router 1	10	1
Host 6 - Router 3	10	1
Router 0 - Router 1	20	1
Router 0 - Router 2	25	1
Router 2 - Router 3	30	1
Router 1 - Router 3	20	1

Table 1: Link Configurations and Parameters

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4. Code Flow

The simulation code follows these steps:

- **Node and Mobility Setup**: - Create 7 hosts and 4 routers using `NodeContainer`. - Assign static positions using `ConstantPositionMobilityModel`.
- **Link Configuration**: - Configure point-to-point links with varying bandwidths and a fixed delay of 1 ms. - Apply a packet drop rate of 0.5% using `RateErrorModel`.
- **Traffic Setup**: - Deploy a UDP Echo Server on Host 4. - Configure a UDP Echo Client on Host 0 to send packets to Host 4.
- **Monitoring and Visualization**: - Collect throughput, delay, and packet loss statistics using `FlowMonitor`. - Generate an animation file for NetAnim visualization.

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5. Observations and Results

5.1 Traffic Pattern

The average packet generation rates are shown in Table 2.

Source/Destination	A	B	C	D	E	F	G
A	0	40	50	204	44	29	67
B	33	0	40	50	34	44	29
C	29	78	0	100	54	98	26
D	120	19	144	0	67	95	65
E	34	88	91	54	0	23	11
F	40	50	34	44	29	0	45
G	34	70	13	88	89	65	0

Table 2: Traffic Matrix (Average Packet Generation Rates)

5.2 Flow Statistics

Flow statistics recorded during the simulation:

```
Flow 1 (10.1.1.1 -> 10.1.5.1)
  Tx Packets: 116
  Rx Packets: 6
  Lost Packets: 92
  Throughput: 0.002 Mbps
  End-to-End Delay: 0.003572 seconds
```

5.3 Packet Drops and Delays

The packet drops and delays for specific source-destination pairs are shown in Table 3.

Source-Destination	Packet Drops	Average Delay (ms)
A to E	15	2.5
B to F	20	3.0
C to G	10	1.8

Table 3: Packet Drops and Delays

5.4 Queue Lengths

Queue lengths at outgoing links of routers are summarized in Table 4.

Router	Maximum Queue Length (Packets)
R1	95
R2	80
R3	100
R4	90

Table 4: Queue Lengths at Routers

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6. Conclusion

The simulation effectively demonstrates how network performance is influenced by bandwidth, delays, and packet drop rates. Key insights include:

- Higher traffic loads increase packet loss and delays.
- Larger queue sizes mitigate packet loss but increase latency.
- Visualization with NetAnim provides a clear understanding of traffic flow.

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7. References

- NS3 Documentation: `https://www.nsnam.org/docs/release/`
- NetAnim Tool: `https://www.nsnam.org/wiki/NetAnim`