Sri Sivasubramaniya Nadar College of Engineering, Kalavakkam
(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

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<tr><td>Course Code</td><td colspan="2">UCS3511</td><td>Course Name</td><td colspan="6">Networks Lab</td></tr>
<tr><td rowspan="2">Course Type</td><td rowspan="2" colspan="2">Lab</td><td rowspan="2">Course Category</td><td rowspan="2">Professional Core (PC)</td><td>L</td><td>T</td><td>P</td><td>TW & SL</td><td>TH</td><td>C</td></tr>
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<tr><td>Regulation</td><td colspan="3">2024</td><td>Academic Year & Batch</td><td colspan="5">2026-27 & 2024-28</td></tr>
<tr><td colspan="4">Degree and Branch</td><td colspan="6">B.E. Computer Science & Engineering</td></tr>
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<tr><td>Assignment No.</td><td colspan="2">7</td><td>Assigned Date</td><td colspan="2">18-08-2026</td><td colspan="2">Due Date</td><td colspan="2">25-08-2026</td></tr>
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Assignment: Simulation of TCP Flow Control Using SimPy

Application: Cloud-Based File Transfer System

A cloud service transfers large files from a **TCP client** to a centralized **TCP server** over a communication network. Since the sender may transmit data faster than the receiver can process it, the receiver may become overloaded, resulting in buffer overflow and packet loss. To prevent this situation, TCP uses **flow control** based on the **receiver's advertised window (rwnd)**.

As a network engineer, develop a **SimPy-based simulation** of TCP flow control in which the client generates and transmits data segments, while the server receives and processes the segments according to its available receive-buffer capacity. The simulation should model **segment generation, transmission, acknowledgement, receiver buffer occupancy, advertised window, and sender window adjustment**, and analyze the effect of different receiver buffer sizes and transmission rates.

1a. TCP Client Simulation Using SimPy

Develop a **TCP Client module using SimPy** with the following functionalities:

1. Accept the following inputs:
    - Total amount of data to be transmitted.
    - TCP segment size.
    - Initial sending window size.
    - Data generation/transmission rate.
    - Transmission delay.
2. Generate TCP data segments periodically using a SimPy process.

3. Assign a unique **sequence number** to each segment.
4. Maintain the sender's transmission window.
5. Transmit segments only when space is available in the receiver's advertised window.
6. Maintain the number of unacknowledged bytes/segments.
7. Receive ACKs and update the sender's window.
8. Adjust the transmission rate according to the advertised receiver window.
9. Record:
    - Segments generated
    - Segments transmitted
    - ACKs received
    - Current sending window
    - Receiver advertised window
    - Number of outstanding segments
    - Total transmission time

1b. TCP Server Simulation Using SimPy

Develop a **TCP Server module using SimPy** with the following functionalities:

1. Accept the receiver buffer size as input.
2. Maintain a simulated TCP receive buffer.
3. Receive data segments from the client.
4. Update the buffer occupancy when a segment is received.
5. Generate cumulative ACKs for successfully received segments.
6. Calculate and advertise the **available receive window (rwnd)** to the client.
7. Process/remove data from the receive buffer at a specified processing rate.
8. Update the advertised window whenever buffer space becomes available.
9. Prevent buffer overflow by controlling the advertised window.
10. Record:

- Segments received
- Segments processed
- ACKs generated
- Buffer occupancy
- Advertised window
- Number of rejected/delayed segments

1c. Simulation and Analysis

Run the simulation under different flow-control conditions:

Scenario 1 – Receiver Faster Than Sender

The receiver processes data faster than the sender generates it.

Scenario 2 – Sender Faster Than Receiver

The sender generates data faster than the receiver can process it.

Scenario 3 – Small Receiver Buffer

Use a small receive buffer and analyze how the advertised window limits the sender.

Scenario 4 – Large Receiver Buffer

Increase the receiver buffer and compare the transmission performance.

Scenario 5 – Different Segment Sizes

Compare the effect of different TCP segment sizes on buffer utilization and transmission efficiency.

For each scenario, calculate and compare:

- Total segments generated
- Total segments transmitted
- Total segments received
- Total ACKs generated
- Average receiver buffer occupancy
- Maximum buffer occupancy
- Average advertised window
- Total transmission time
- Throughput
- Number of delayed transmissions

Sample Data for Laboratory Verification

Test Case	Data	Segment Size	Initial Window	Receiver Buffer	Sender Rate	Receiver Rate
TC1	10 KB	1 KB	4 KB	8 KB	2 KB/s	4 KB/s
TC2	20 KB	1 KB	8 KB	4 KB	8 KB/s	4 KB/s
TC3	20 KB	1 KB	8 KB	2 KB	8 KB/s	2 KB/s
TC4	20 KB	1 KB	8 KB	8 KB	8 KB/s	4 KB/s
TC5	20 KB	2 KB	8 KB	8 KB	8 KB/s	4 KB/s

Sample Client Output

```
TCP CLIENT SIMULATION

Total Data        : 20 KB
Segment Size      : 1 KB
Initial Window    : 8 KB

Segment S1 Transmitted
Segment S2 Transmitted
Segment S3 Transmitted
```

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Segment S4 Transmitted

ACK Received : S1
Advertised Window : 4 KB

ACK Received : S2
Advertised Window : 3 KB

Sender Waiting - Receiver Window Full

ACK Received : S3
Advertised Window : 4 KB

Segment S5 Transmitted
...

Transmission Completed

Total Segments Sent : 20
Total ACKs Received : 20
Total Waiting Events: 5
```

Sample Server Output

```
TCP SERVER SIMULATION

Receive Buffer Size : 4 KB

Segment S1 Received
Buffer Occupancy : 1 KB
Advertised Window : 3 KB
ACK S1 Sent

Segment S2 Received
Buffer Occupancy : 2 KB
Advertised Window : 2 KB
ACK S2 Sent

Segment S3 Received
Buffer Occupancy : 3 KB
Advertised Window : 1 KB
ACK S3 Sent

Segment S4 Received
Buffer Occupancy : 4 KB
Advertised Window : 0 KB
ACK S4 Sent

Receive Buffer Full
Sender Transmission Temporarily Restricted

Processing Data...

Buffer Occupancy : 3 KB
Advertised Window : 1 KB

Buffer Space Available
Sender Can Continue Transmission
```

Performance Observation Table

Test Case	Receiver Buffer	Sender Rate	Receiver Rate	Avg. Buffer Occupancy	Waiting Events	Throughput	Observation
TC1	8 KB	2 KB/s	4 KB/s	Varies	Low	Varies	Receiver keeps pace
TC2	4 KB	8 KB/s	4 KB/s	High	High	Varies	Flow control activated
TC3	2 KB	8 KB/s	2 KB/s	Very High	High	Varies	Small buffer restricts sender
TC4	8 KB	8 KB/s	4 KB/s	High	Moderate	Varies	Larger buffer improves transmission
TC5	8 KB	8 KB/s	4 KB/s	Varies	Varies	Varies	Effect of segment size

Analysis

Based on the simulation results, analyze:

1. How the **advertised receiver window (rwnd)** controls the sender's transmission.
2. How receiver buffer size affects the sender's waiting time.
3. The effect of sender and receiver processing rates on throughput.
4. How TCP flow control prevents receiver buffer overflow.
5. The relationship between **window size, buffer occupancy, and throughput**.

Note: Students should record the **aim, problem analysis, SimPy-based client algorithm, SimPy-based server algorithm, source code, sample input/output, screenshots, test cases, performance observations, analysis, and conclusion** in the laboratory record.

Expected Learning Outcome – K4

Students will **analyze TCP flow-control behavior** by modelling sender transmission, receiver buffering, acknowledgements, and advertised-window mechanisms using SimPy, and evaluate the impact of receiver capacity and transmission rates on network performance.