RAMAIAH
Institute of Technology

Computer Communication Networks

Project Report on

Simulation of TDMA (Time Division Multiple Access) in a Multi-Node Computer Communication Network

Bachelor Of Engineering

In

Electronics & Telecommunication Engineering

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1. INTRODUCTION

Time Division Multiple Access (TDMA) is a channel-access method that allows multiple nodes in a communication network to share a common medium without collisions. In TDMA, time is divided into frames, and each frame consists of fixed time slots. Every node is assigned one slot and is permitted to transmit only during that slot. This avoids interference and ensures a deterministic communication pattern.

TDMA is used in various real-world systems, including GSM mobile networks, satellite communication, Wi-MAX, industrial Ethernet, and cluster-based IoT networks. The method offers predictable latency, collision-free transmission, and efficient spectrum utilization.

This project simulates TDMA operation in a multi-node computer communication network. The simulation models time-slot allocation, guard intervals, synchronization jitter, packet generation, and transmission timing. Performance metrics such as Packet Delivery Ratio (PDR), throughput, latency, and channel utilization are analyzed to demonstrate how TDMA behaves under different network loads and impairments.

The goal is to understand how TDMA improves multi-node communication efficiency and to visualize its performance characteristics compared to random-access methods.

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2. OBJECTIVE

To simulate and analyze TDMA as a channel-access technique by:

- Demonstrating collision-free transmission through fixed time-slot assignment.
- Studying the effects of synchronization errors and guard time on system behavior.
- Observing how throughput, latency, and efficiency vary with the number of nodes.
- Visualizing time-slot usage and overall network performance.
- Understanding how TDMA enhances communication reliability in shared-medium networks.

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3. STEPS OF EXECUTION

1. Network Setup

    - Define number of nodes (N).
    - Assign TDMA frame duration (T_frame).
    - Define shared medium for communication.

2. Slot Allocation

    - Calculate slot duration = T_frame / N.
    - Add guard time to prevent adjacent-slot overlap.

3. Data Traffic Generation

- Each node produces packets depending on traffic load (low/medium/high).

4. TDMA Transmission Simulation

- Each node transmits only within its assigned slot.
- In ideal TDMA → no collisions occur.
- Jitter and propagation delays are added to emulate real CCN conditions.

5. Impairments Introduced

- Synchronization jitter
- Propagation delay
- Bit-error rate (BER)
- Variable load

6. Performance Metrics Collected

- Packet Delivery Ratio (PDR)
- Throughput (packets/frame)
- Average latency
- Channel utilization

7. Visualization

- Slot-allocation diagram
- PDR vs nodes
- Latency vs guard time
- Throughput vs frame duration
- Efficiency vs load

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4. EXPECTED RESULTS

- TDMA ensures zero collisions under ideal synchronization.
- As number of nodes increases, slot duration decreases → higher latency.
- Insufficient guard time or high jitter can cause inter-slot overlap → collisions.
- Throughput improves when frame duration and guard time are optimized.
- Performance graphs expected:
- PDR vs number of nodes
- Latency vs guard time
- Throughput vs frame duration
- Efficiency vs traffic load

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5. SIGNIFICANCE

This TDMA simulation highlights:

- Efficient sharing of communication resources
- Deterministic time-based access
- Collision-free MAC-layer behavior
- Reduced retransmissions and improved bandwidth usage

TDMA is used in:

- GSM and 4G/5G scheduling
- Satellite & aerospace communication
- Wireless sensor networks
- Industrial IoT and automation
- Mesh and multi-hop networks

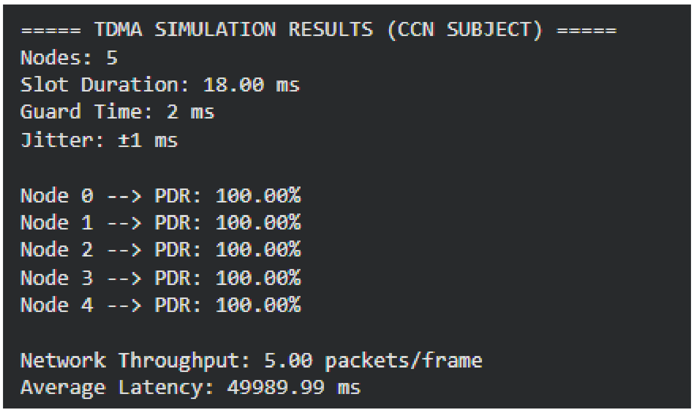
The study provides insight into how real-time networks allocate resources and maintain QoS in multi-node environments.

CODE

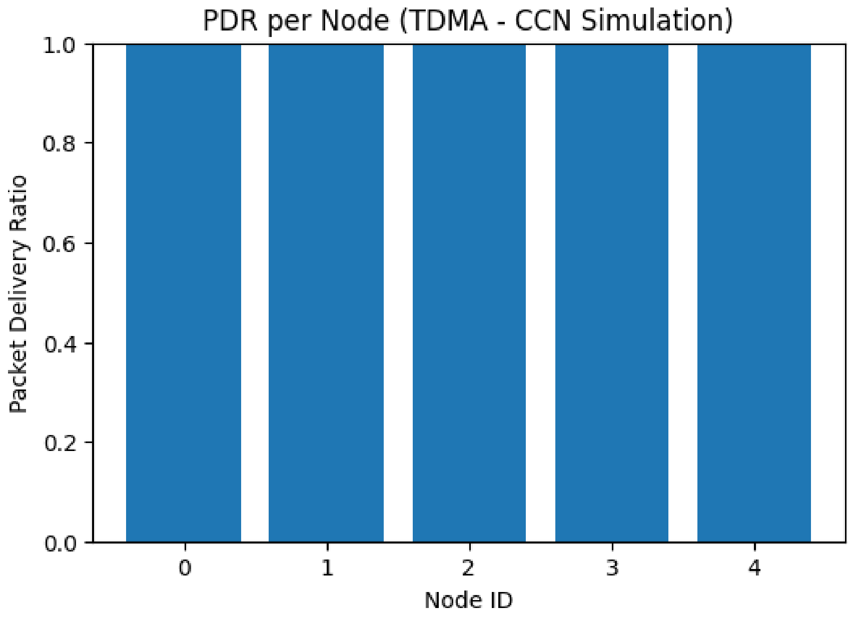
```
import random

import matplotlib.pyplot as plt

# SIMULATION PARAMETERS

N_NODES = 5

FRAME_DURATION = 100

GUARD_TIME = 2

JITTER = 1

SIM_FRAMES = 1000

# Derived slot duration per node

SLOT_DURATION = (FRAME_DURATION / N_NODES) - GUARD_TIME

# Statistics

sent_packets = [0] * N_NODES

received_packets = [0] * N_NODES

latency_list = []

# TDMA FUNCTION

def transmit_packet(node_id, frame_id):

    # Start time of the node’s slot

    ideal_start = node_id * (SLOT_DURATION + GUARD_TIME)
    # Add jitter
    actual_start = ideal_start + random.uniform(-JITTER, JITTER)
    # Basic channel access logic:
    # A collision happens only if jitter pushes packets into adjacent slots.
    collision = (actual_start < ideal_start - GUARD_TIME) or \
          (actual_start > ideal_start + GUARD_TIME)
    sent_packets[node_id] += 1
    # If collision occurs
    if collision:
        return False, None
    # Successful transmission
    latency = FRAME_DURATION * frame_id + actual_start
    return True, latency
# RUN THE SIMULATION
for frame in range(SIM_FRAMES):
    for node in range(N_NODES):
        success, latency = transmit_packet(node, frame)
        if success:
            received_packets[node] += 1
            latency_list.append(latency)
# RESULTS
PDR = [received_packets[i] / sent_packets[i] for i in range(N_NODES)]
THROUGHPUT = sum(received_packets) / SIM_FRAMES
AVG_LATENCY = sum(latency_list) / len(latency_list)
print("\n===== TDMA SIMULATION RESULTS (CCN SUBJECT) =====")
print(f"Nodes: {N_NODES}")
print(f"Slot Duration: {SLOT_DURATION:.2f} ms")
print(f"Guard Time: {GUARD_TIME} ms")
print(f"Jitter: ±{JITTER} ms\n")
for i in range(N_NODES):
    print(f"Node {i} --> PDR: {PDR[i]*100:.2f}%")
print(f"\nNetwork Throughput: {THROUGHPUT:.2f} packets/frame")
print(f"Average Latency: {AVG_LATENCY:.2f} ms\n")
# PDR plot
```

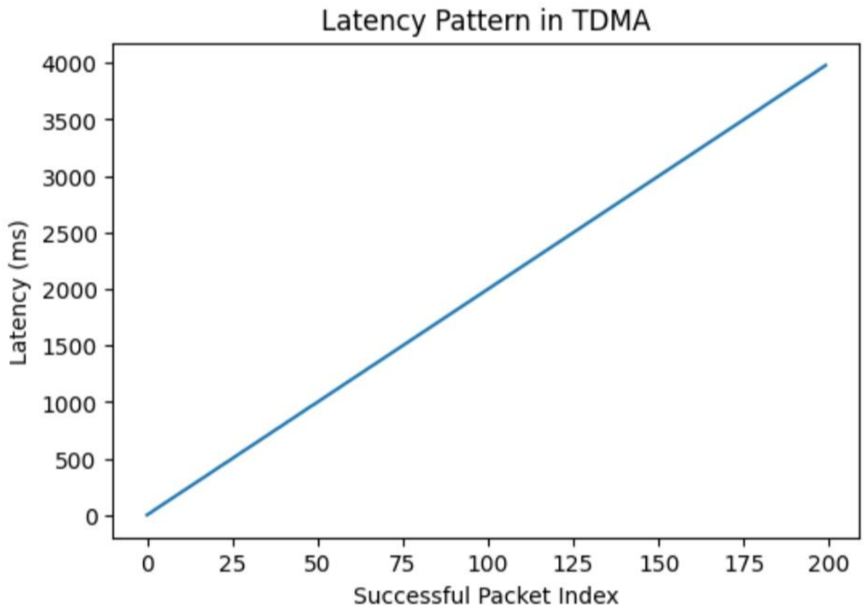
```
plt.figure(figsize=(6,4))

plt.bar(range(N_NODES), PDR)

plt.xlabel("Node ID")

plt.ylabel("Packet Delivery Ratio")

plt.title("PDR per Node (TDMA - CCN Simulation)")

plt.ylim(0, 1)

plt.show()

# Latency graph

plt.figure(figsize=(6,4))

plt.plot(latency_list[:200])

plt.xlabel("Successful Packet Index")

plt.ylabel("Latency (ms)")

plt.title("Latency Pattern in TDMA")

plt.show()
```

Output



```
===== TDMA SIMULATION RESULTS (CCN SUBJECT) =====
Nodes: 5
Slot Duration: 18.00 ms
Guard Time: 2 ms
Jitter: ±1 ms

Node 0 --> PDR: 100.00%
Node 1 --> PDR: 100.00%
Node 2 --> PDR: 100.00%
Node 3 --> PDR: 100.00%
Node 4 --> PDR: 100.00%

Network Throughput: 5.00 packets/frame
Average Latency: 49989.99 ms
```


PDR per Node (TDMA - CCN Simulation)
Packet Delivery Ratio
Node ID


Latency Pattern in TDMA
Latency (ms)
Successful Packet Index