Tushar Deshmukh
Final Year CSE PE27
1032201698

TITLE:

Bully election and ring election algorithm

AIM:

To study and implement Bully Election Algorithm

OBJECTIVES:

1. To understand the working of election algorithms

2. To simulate bully algorithm

THEORY:

Elections

Election in distributed computing refers to the process of selecting a leader or coordinator node among a group of distributed nodes. This leader is responsible for coordinating activities, making decisions, and ensuring the integrity and consistency of the distributed system. Elections are crucial for fault tolerance, load balancing, and maintaining system stability in distributed environments. Various algorithms, such as the Bully Algorithm and the Ring Algorithm, are used to facilitate the election process, ensuring that a new leader is elected promptly in the event of failures or changes in the system topology.

Bully Algorithm

The Bully Algorithm is a leader election algorithm used in distributed systems. It allows nodes within a network to elect a coordinator or leader in a decentralized manner. The Bully Algorithm operates on the principle of higher priority.

Messages:

There can be three types of messages that processes exchange with each other in the bully algorithm-

1. Election message: Sent to announce election.

2. OK (Alive) message: Responds to the Election message.

3. Coordinator (Victory) message: Sent by winner of the election to announce the new coordinator.

Steps:

1. Assume there are 6 Processes P0, P1, P2, P3, P4, P5 written in ascending order of their Process ID.
2. Suppose Process P2 sends a message to coordinator P5 and P5 does not respond in a desired time T (possible reason could be crash, down, etc.)
3. Then process P2, sends an election message to all processes with Process ID greater than P2 (i.e. P3, P4 & P5) and awaits a response from the processes.
4. If no one responds, P2 wins the election and become the coordinator.
5. If any of the processes with Process ID higher than 2 responds with OK, P2’s job is done and this Process will take over.

Tushar Deshmukh
Final Year CSE PE27
1032201698

6. It then restarts and initiates an election message.
7. Process P4 responds to P3 with an OK message to confirm its alive state and Process P4 figures out that process 5 has crashed, and the new process with the highest ID is process 4.
8. The process that receives an election message sends a coordinator message if it is the Process with the highest ID (in this case it is P4).
9. If a Process which was previously down (i.e. P5) comes back, it holds an election and if it has the highest Process Id then it will become the new coordinator and sends message to all other processes.

CODE:

```
#include <iostream>
#include <list>

using namespace std;

// class to represent a single node
class Node
{
private:
    // Static variable for ID
    static int nextId;

public:
    int id;
    bool isAlive;
    bool hasStartedElection;
    int coordinator;
    bool response;

    // constructor makes nodes alive, sets ID and sets no coordinator
    Node() : id(nextId++), isAlive(true), hasStartedElection(false),
coordinator(-1), response(false) {}

    void disableNode()
    {
        this->isAlive = false;
        cout << "Node " << this->id << " disabled." << endl;
    }

    void enableNode()
    {
        this->isAlive = true;
        cout << "Node " << this->id << " enabled." << endl;
    }

    void displayNode() const
    {
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

```
        cout << "Node ID: " << this->id << ", Alive: " << this->isAlive << ",
Election Started: " << this->hasStartedElection << ", Coordinator: " << this-
>coordinator << endl;
    }
};

// init static variable
int Node::nextId = 1;

// bully algo
void startBullyElection(list<Node> &nodes, int startingNodeId)
{
    // Find the starting node
    auto startingNode = nodes.end();

    for (auto it = nodes.begin(); it != nodes.end(); ++it)
    {
        if (it->id == startingNodeId)
        {
            startingNode = it;
            break;
        }
    }

    // if ahead of last node, return
    if (startingNode == nodes.end())
    {
        return;
    }

    // is node alive and not started election
    if (startingNode->isAlive && startingNode->hasStartedElection == false)
    {
        // cout<<startingNode->id<<endl;
        auto temp = startingNode;
        ++temp;
        for (auto it = temp; it != nodes.end(); it++)
        {
            cout << startingNode->id << " sends election to " << it->id <<
endl;
            if (it->isAlive)
            {
                cout << it->id << " sends OK." << endl;
                startingNode->response = true;
            }
        }

        // if no response, the sender is the coordinator
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

```
        if (startingNode->response == false)
        {
            cout << "No response, " << startingNode->id << " is coordinator."
<< endl;
            for (auto it = nodes.begin(); it != nodes.end(); ++it)
            {
                it->coordinator = startingNode->id;
            }
            return;
        }
    }

    // recursive call to next node
    startBullyElection(nodes, startingNodeId + 1);
}

// ring algo
void startRingElection(list<Node> &nodes, int startingNodeId)
{

    // Find the starting node
    auto startingNode = nodes.end();

    for (auto it = nodes.begin(); it != nodes.end(); ++it)
    {
        if (it->id == startingNodeId)
        {
            startingNode = it;
            break;
        }
    }

    // if ahead of last node, return
    if (startingNode == nodes.end())
    {
        return;
    }

    int maxId = startingNodeId;
    bool foundHigher = false;
    auto currentIt = startingNode;

    do
    {
        // move to the next node, wrap to the beginning if at the end
        do
        {
            currentIt++;
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

```
            if (currentIt == nodes.end())
            {
                currentIt = nodes.begin();
            }
        } while (!currentIt->isAlive && currentIt->id != startingNodeId); //
Skip dead nodes

        if (currentIt->id == startingNodeId && foundHigher)
        {
            // if made a full loop and found a higher ID, break
            break;
        }

        if (currentIt->id > maxId)
        {
            maxId = currentIt->id;
            foundHigher = true;
        }

        cout << "Node " << startingNode->id << " passes election to Node " <<
currentIt->id << endl;

        startingNode = currentIt; // move to next node

    } while (currentIt->id != startingNodeId); // loop back to the start

    // after completing the loop, maxId is the ID of the elected coordinator
    cout << "Node " << maxId << " is elected as coordinator." << endl;
    for (auto &node : nodes)
    {
        node.coordinator = maxId;
    }
}

int main()
{
    list<Node> nodes;

    int choice;
    do
    {
        // menu
        cout << "\nMenu:\n"
             << "1. Add nodes\n"
             << "2. Disable node\n"
             << "3. Enable node\n"
             << "4. Display nodes\n"
             << "5. Start election\n"
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

```
             << "6. Exit\n"
             << "Enter your choice: ";
        cin >> choice;

        switch (choice)
        {
        case 1:
        {
            // add nodes
            int n;
            cout << "Enter the number of nodes to add: ";
            cin >> n;
            for (int i = 0; i < n; ++i)
            {
                nodes.push_back(Node());
                cout << "Node " << nodes.back().id << " added successfully."
<< endl;
            }
            break;
        }
        case 2:
        {
            // disable a node
            int nodeId;
            cout << "Enter ID of the node to disable: ";
            cin >> nodeId;
            bool found = false;
            for (auto &node : nodes)
            {
                if (node.id == nodeId)
                {
                    node.disableNode();
                    found = true;
                    break;
                }
            }
            if (!found)
            {
                cout << "Node not found." << endl;
            }
            break;
        }
        case 3:
        {
            // enable a node
            int nodeId;
            cout << "Enter ID of the node to enable: ";
            cin >> nodeId;
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

```
            bool found = false;
            for (auto &node : nodes)
            {
                if (node.id == nodeId)
                {
                    node.enableNode();
                    found = true;
                    break;
                }
            }
            if (!found)
            {
                cout << "Node not found." << endl;
            }
            break;
        }
        case 4:

            // display all nodes
            if (nodes.empty())
            {
                cout << "No nodes added yet." << endl;
            }
            else
            {
                cout << "Nodes:\n";
                for (const auto &node : nodes)
                {
                    node.displayNode();
                }
            }
            break;

        case 5:
        {
            // start election
            cout << "Choose election algorithm:\n"
                 << "1. Bully election algorithm\n"
                 << "2. Ring election algorithm\n"
                 << "Enter your choice: ";
            int algoChoice;
            cin >> algoChoice;
            switch (algoChoice)
            {
            case 1:
            {
                // bully algo
                int startingNode;
```

Tushar Deshmukh
Final Year CSE PE27
1032201698

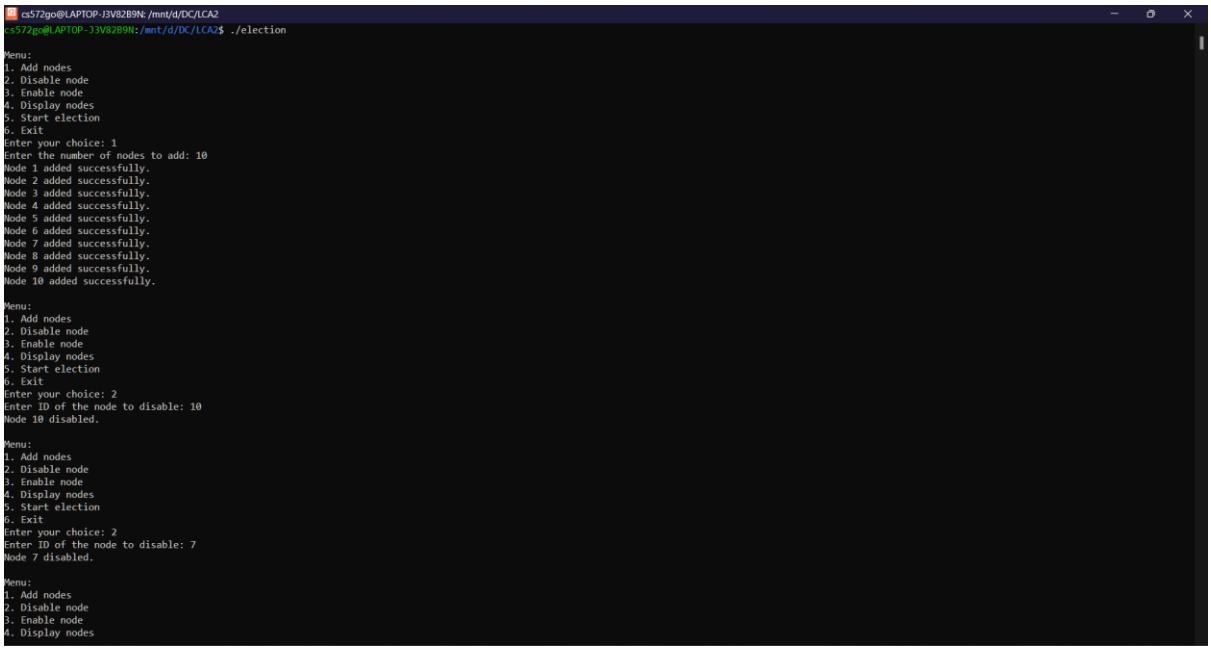
```
                cout << "Enter the starting node ID for the election: ";
                cin >> startingNode;
                startBullyElection(nodes, startingNode);

                // reset the election flags after election is over
                for (auto &node : nodes)
                {
                    node.hasStartedElection = false;
                    node.response = false;
                }
                break;
            }
            case 2:
                // ring algo
                int startingNode;
                cout << "Enter the starting node ID for the election: ";
                cin >> startingNode;
                startRingElection(nodes, startingNode);

                // reset the election flags after election is over
                for (auto &node : nodes)
                {
                    node.hasStartedElection = false;
                    node.response = false;
                }
                break;

            default:
                cout << "Invalid choice." << endl;
                break;
            }
            break;
        }

        case 6:
            // Exit
            cout << "Exiting program." << endl;
            break;
        default:
            cout << "Invalid choice." << endl;
            break;
        }
    } while (choice != 6);

    return 0;
}
```

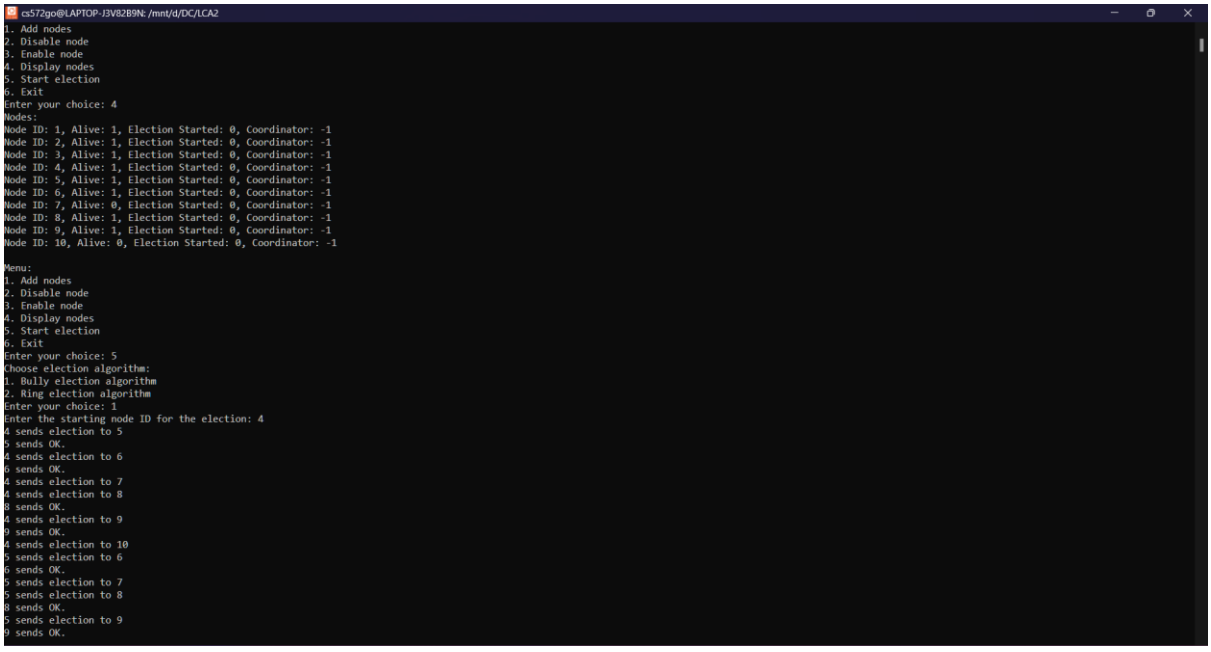
Tushar Deshmukh
Final Year CSE PE27
1032201698

INPUT: 10 processes with IDs from 1 to 10. Fail node 10 and 7. Start election from node 4.

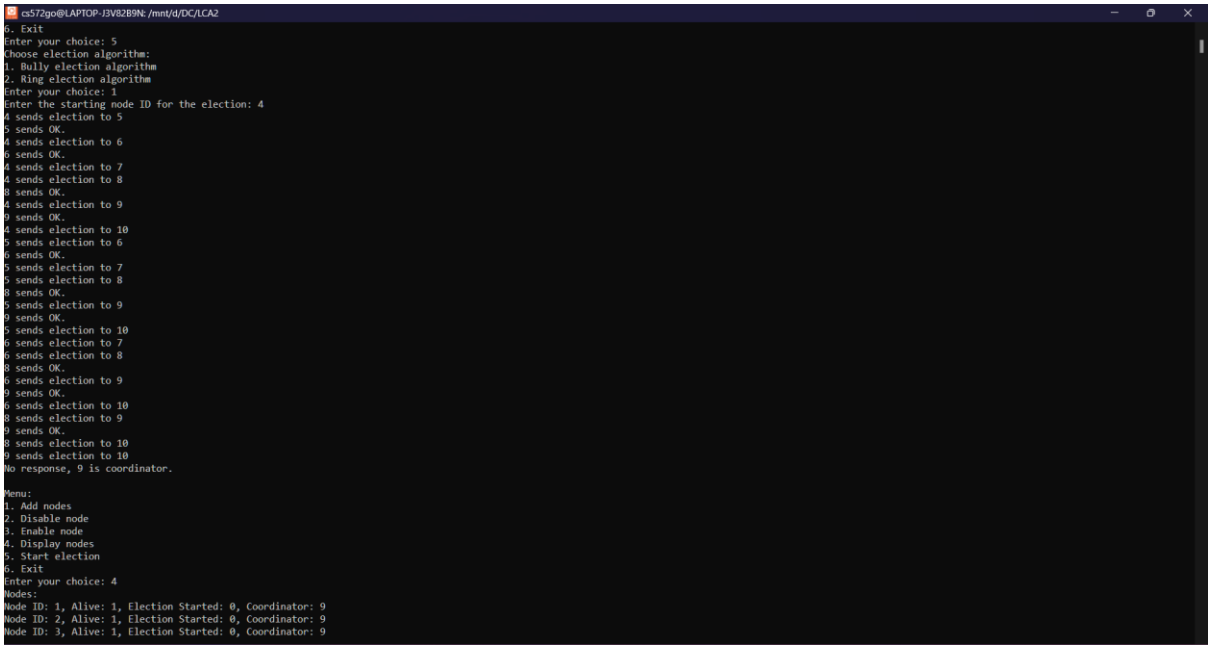
OUTPUT:

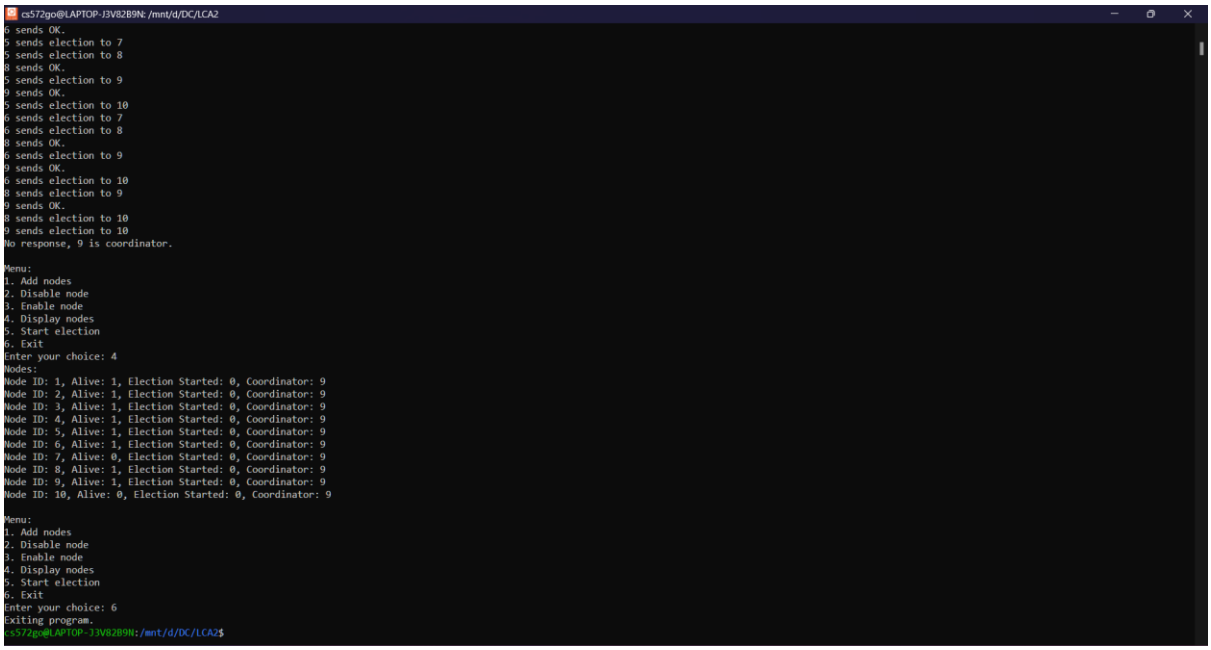
1. **Bully Algorithm**





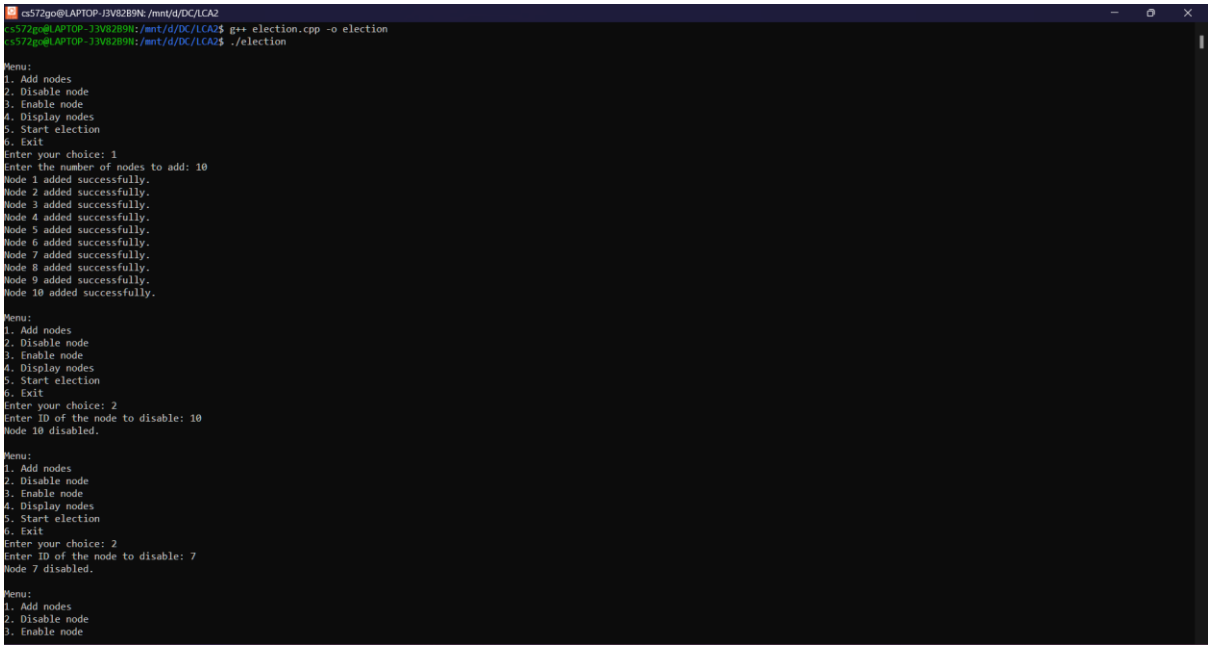
Tushar Deshmukh
Final Year CSE PE27
1032201698

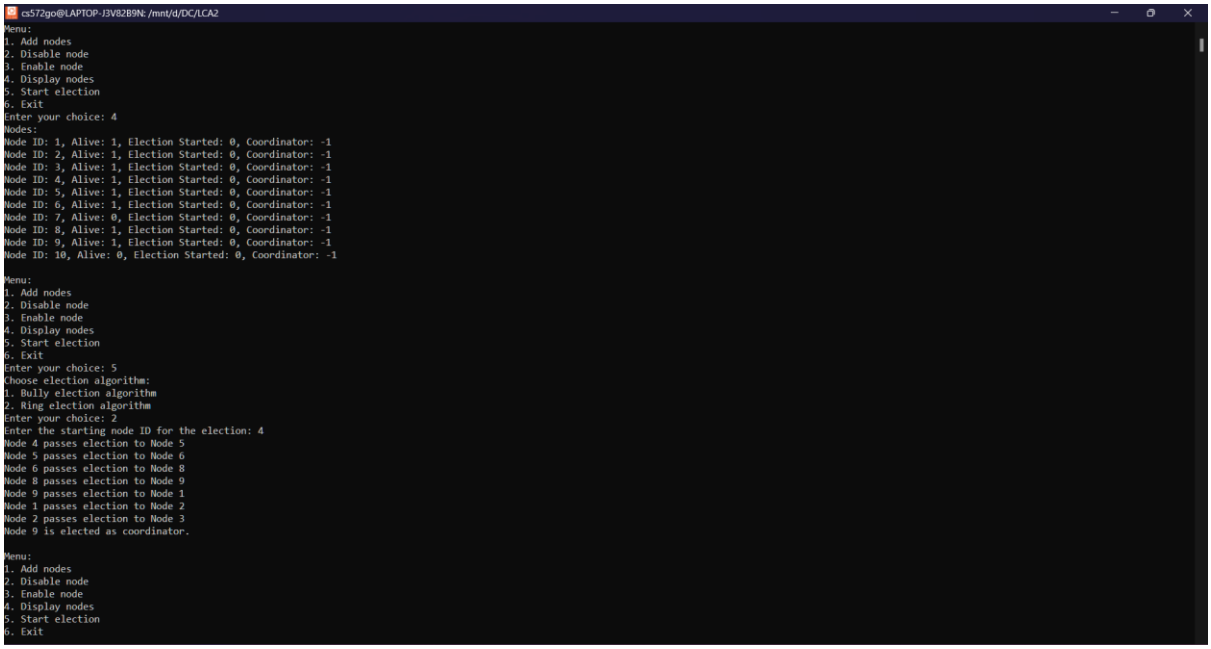




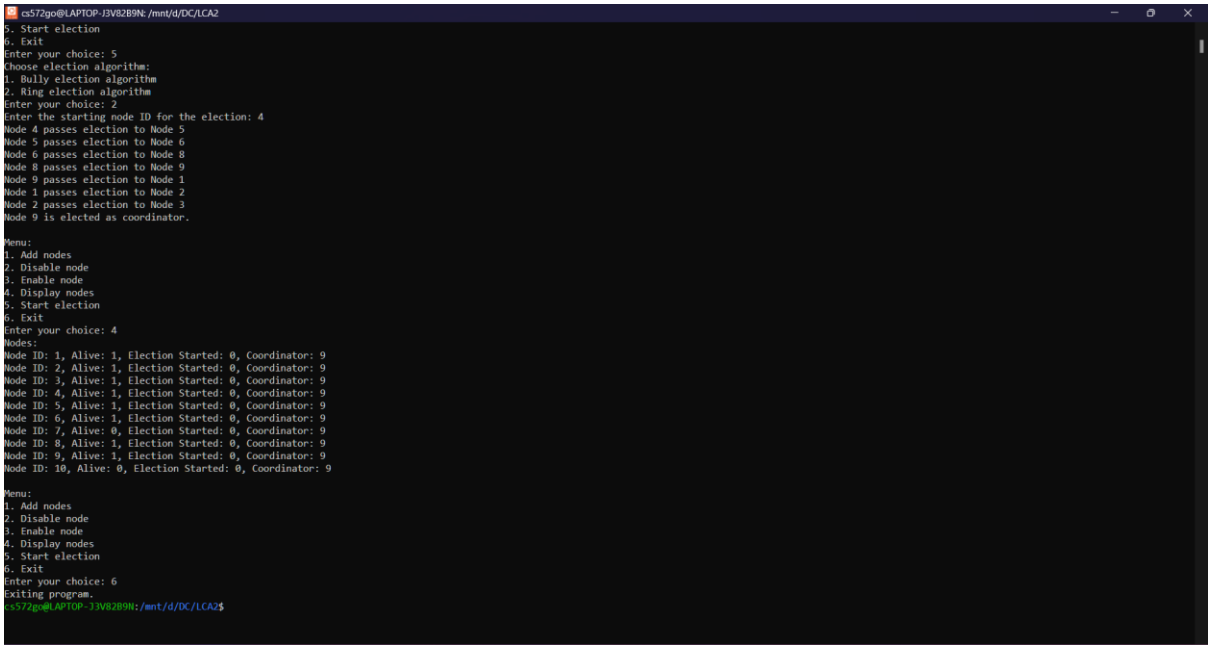
Tushar Deshmukh
Final Year CSE PE27
1032201698

2. Ring algorithm





Tushar Deshmukh
Final Year CSE PE27
1032201698



PLATFORM:

Windows:

- VSCode
- Windows Subsystem for Linux (Ubuntu 22.04 LTS)

LANGUAGE:

C++.

CONCLUSION:

Thus, bully algorithm is successfully implemented.

Tushar Deshmukh
Final Year CSE PE27
1032201698

FAQS

1. What is the time complexity (best, average, worst) of bully algorithm?

Answer:

Best Case: O(1), when the highest process ID is the coordinator initially, requiring no election.

Average Case: O(n), considering a random distribution of processes across the network.

Worst Case: O(n^2), when the lowest process ID initiates an election, leading to a complete exchange of messages among all processes.

2. Why do we have to elect the coordinator process?

Answer:

Electing a coordinator process ensures system resilience and efficient task management in distributed systems. It establishes a single point of contact for coordinating actions, such as resource allocation, task scheduling, and fault management. By electing a coordinator, the system can maintain order and consistency, even in the presence of failures or network partitions. This process helps prevent conflicts, reduces message overhead, and facilitates efficient communication and decision-making within the system.

3. How did the name of "Bully" approach come up?

Answer:

The name "Bully" in the Bully Algorithm reflects the behaviour of nodes in a distributed system. When a lower-ranked node detects that the current coordinator has failed, it “bullies” higher-ranked nodes by initiating an election process. This aggressive behaviour is like a subordinate challenging higher-ranking node for leadership in the system. The term “bully” serves as a metaphor for this hierarchical interaction, where lower-ranked nodes assert themselves to take control in the absence of a coordinator.