



## **MINI PROJECT REPORT ON**

### **Raft3D - 3D Prints Management using Raft Consensus Algorithm**

*Submitted in partial fulfilment of the requirements for the award of degree of*

**Bachelor of Technology**

**in**

**Computer Science & Engineering**

**UE22CS351B – CLOUD COMPUTING PROJECT**

*Submitted by:*

<b>NIKITHA THAMMAIAH</b>	<b>PES2UG22CS362</b>
<b>NIKITA ANUP</b>	<b>PES2UG22CS361</b>
<b>NEHA MS</b>	<b>PES2UG22CS347</b>
<b>NIKHITA SATISH</b>	<b>PES2UG22CS360</b>

Under the guidance of

**Dr. Sudeepa Roy**

Associate Professor

PES University

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**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING  
PES UNIVERSITY**

(Established under Karnataka Act No. 16 of 2013)

Electronic City, Hosur Road, Bengaluru – 560 100, Karnataka, India

# PROJECT OVERVIEW

**Raft3D** is a distributed system designed to manage 3D printers, filaments, and print jobs across multiple nodes in a reliable and fault-tolerant manner. The system ensures that all operations are consistent and resilient to node failures using the **Raft Consensus Algorithm**.

In a real-world scenario, managing 3D printing infrastructure at scale requires a system that can maintain accuracy, availability, and durability—even in the face of network or hardware issues. Raft3D addresses this challenge by distributing the state across multiple nodes, where one node acts as the leader to handle client requests, and the rest act as followers that replicate and maintain the same state.

The **purpose** of the project is to:

- Provide APIs to register and manage 3D printers and filaments.
- Handle the scheduling and tracking of print jobs.
- Ensure **strong consistency** using Raft, even in the event of node failures.
- Eliminate the need for an external database by persisting state within the Raft Finite State Machine (FSM).

By using Raft, Raft3D guarantees:

- **Leader Election:** A leader is automatically elected among the nodes to handle client operations.
- **State Replication:** Every update to the system's state (e.g., adding a printer or print job) is logged and replicated across all nodes.
- **Fault Tolerance:** If the current leader fails, a new leader is elected without data loss, and the system continues to function seamlessly.

This ensures that Raft3D is not just a simple backend system, but a resilient and production-ready distributed management platform.

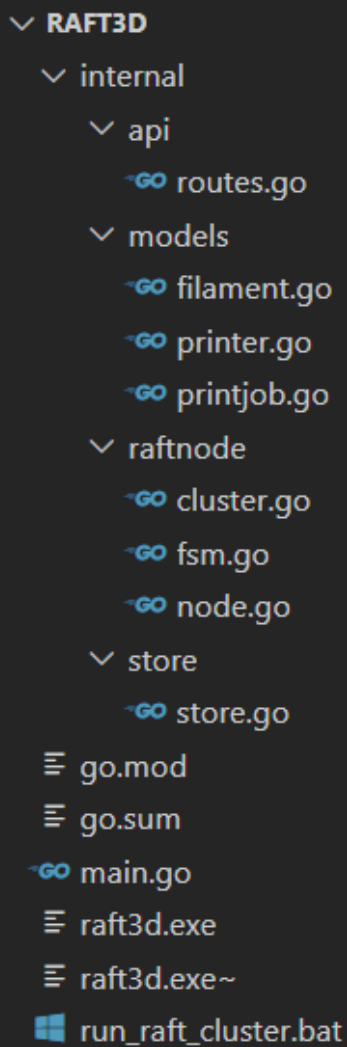
# TECHNOLOGIES USED

- **Language:** Go (Golang)
- **Library:** Hashicorp Raft
- **API Testing:** Postman / cURL
- **No external DB:** Uses in-memory FSM with Raft snapshot persistence

# DESIGN PATTERNS

- **FSM (Finite State Machine)** – handles state persistence
- **Leader Election** – automatic via Raft
- **State Replication** – all state changes go through the leader, replicated to followers

# PROJECT STRUCTURE



```

▼ RAFT3D
  ▼ internal
    ▼ api
      routes.go
    ▼ models
      filament.go
      printer.go
      printjob.go
    ▼ raftnode
      cluster.go
      fsm.go
      node.go
    ▼ store
      store.go
  go.mod
  go.sum
  main.go
  raft3d.exe
  raft3d.exe~
  run_raft_cluster.bat

```

The image shows a file explorer view of a project named RAFT3D. The project structure is as follows:

- RAFT3D
  - internal
    - api
      - routes.go
    - models
      - filament.go
      - printer.go
      - printjob.go
    - raftnode
      - cluster.go
      - fsm.go
      - node.go
    - store
      - store.go
  - go.mod
  - go.sum
  - main.go
  - raft3d.exe
  - raft3d.exe~
  - run\_raft\_cluster.bat

# EXECUTION STEPS

1. Clone repo
2. Run go mod tidy
3. Double-click run\_raft\_cluster.bat

## OUTPUT SCREENSHOTS

### 1) NODE1 (leader)

```
Raft Node 1 - raft3d.exe --id 1
2025/04/17 15:47:45 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025-04-17T15:47:46.175+0530 [INFO] raft: Initial configuration (index=0): []
2025/04/17 15:47:46 Bootstrapping cluster...
2025-04-17T15:47:46.176+0530 [INFO] raft: Node at 127.0.0.1:9000 [Follower] entering Follower state (Leader: "")
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:46 Server running on port 127.0.0.1:8000
2025-04-17T15:47:46.717+0530 [WARN] raft: Heartbeat timeout from "" reached, starting election
2025-04-17T15:47:46.718+0530 [INFO] raft: Node at 127.0.0.1:9000 [Candidate] entering Candidate state in term 2
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025-04-17T15:47:46.930+0530 [DEBUG] raft: Votes needed: 2
2025-04-17T15:47:46.931+0530 [DEBUG] raft: Vote granted from node1 in term 2. Tally: 1
2025-04-17T15:47:47.087+0530 [DEBUG] raft: Vote granted from node2 in term 2. Tally: 2
2025-04-17T15:47:47.087+0530 [INFO] raft: Election won. Tally: 2
2025-04-17T15:47:47.088+0530 [INFO] raft: Node at 127.0.0.1:9000 [Leader] entering Leader state
2025-04-17T15:47:47.089+0530 [INFO] raft: Added peer node2, starting replication
2025-04-17T15:47:47.089+0530 [INFO] raft: Added peer node3, starting replication
2025-04-17T15:47:47.091+0530 [WARN] raft: AppendEntries to {Voter node2 127.0.0.1:9001} rejected, sending older logs (next: 1)
2025-04-17T15:47:47.092+0530 [WARN] raft: AppendEntries to {Voter node3 127.0.0.1:9002} rejected, sending older logs (next: 1)
2025-04-17T15:47:47.093+0530 [INFO] raft: pipelining replication to peer {Voter node2 127.0.0.1:9001}
2025-04-17T15:47:47.093+0530 [INFO] raft: pipelining replication to peer {Voter node3 127.0.0.1:9002}
```

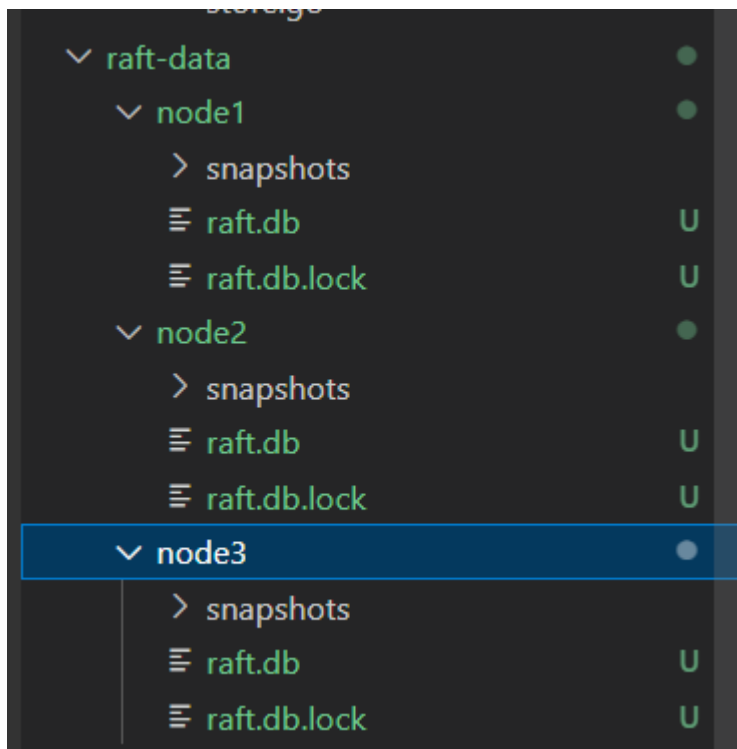
### 2) NODE2 (follower)

```
Raft Node 2 - raft3d.exe --id 2
2025/04/17 15:47:45 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025-04-17T15:47:46.160+0530 [INFO] raft: Initial configuration (index=0): []
2025/04/17 15:47:46 Server running on port 127.0.0.1:8001
2025-04-17T15:47:46.162+0530 [INFO] raft: Node at 127.0.0.1:9001 [Follower] entering Follower state (Leader: "")
2025/04/17 15:47:46 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62069
2025-04-17T15:47:46.943+0530 [DEBUG] raft: lost leadership because received a requestvote with newer term
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025-04-17T15:47:47.091+0530 [WARN] raft: Failed to get previous log: 1 log not found (last: 0)
2025/04/17 15:47:47 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62072
```

### 3) NODE3 (follower)

```
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025-04-17T15:47:46.251+0530 [INFO] raft: Initial configuration (index=0): []
2025/04/17 15:47:46 Server running on port 127.0.0.1:8002
2025-04-17T15:47:46.255+0530 [INFO] raft: Node at 127.0.0.1:9002 [Follower] entering Follower state (Leader: "")
2025/04/17 15:47:46 [DEBUG] raft-net: 127.0.0.1:9002 accepted connection from: 127.0.0.1:62070
2025-04-17T15:47:46.943+0530 [DEBUG] raft: lost leadership because received a requestvote with newer term
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025-04-17T15:47:47.091+0530 [WARN] raft: Failed to get previous log: 1 log not found (last: 0)
2025/04/17 15:47:47 [DEBUG] raft-net: 127.0.0.1:9002 accepted connection from: 127.0.0.1:62071
```

## AUTOMATICALLY CREATED FOLDER TO STORE SNAPSHOTS AND LOGS



# IMPLEMENTING 7API

```
C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST http://127.0.0.1:8000/printers -H "Content-Type: application/json" -d '{"id":"p1","company":"HP","model":"DeskJet 123"}'

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8001/printers
{"id":"","company":"","model":"","p1":{"id":"p1","company":"HP","model":"DeskJet 123"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8000/printers
{"id":"","company":"","model":"","p1":{"id":"p1","company":"HP","model":"DeskJet 123"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8002/printers
{"id":"","company":"","model":"","p1":{"id":"p1","company":"HP","model":"DeskJet 123"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8001/filaments
{}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST http://localhost:8000/filaments -H "Content-Type: application/json" -d '{"id":"f1","type":"PLA","color":"Red","total_weight_in_grams":1000,"remaining_weight_in_grams":800}'

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8000/filaments
{"f1":{"id":"f1","type":"PLA","color":"Red","total_weight_in_grams":1000,"remaining_weight_in_grams":800}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8001/filaments
{"f1":{"id":"f1","type":"PLA","color":"Red","total_weight_in_grams":1000,"remaining_weight_in_grams":800}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8002/filaments
{"f1":{"id":"f1","type":"PLA","color":"Red","total_weight_in_grams":1000,"remaining_weight_in_grams":800}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST http://127.0.0.1:8000/printjobs -H "Content-Type: application/json" -d '{"id":"job1","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"}'

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8001/printjobs
{"job1":{"id":"job1","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8002/printjobs
{"job1":{"id":"job1","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST "http://localhost:8000/printjobs/job1/status?status=running"
Can only move to 'running' from 'queued'

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST http://127.0.0.1:8000/printjobs -H "Content-Type: application/json" -d '{"id":"job2","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"}'

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8002/printjobs
{"job1":{"id":"job1","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"},"job2":{"id":"job2","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"}}

C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl -X POST "http://localhost:8000/printjobs/job2/status?status=running"
Print job status updated successfully
C:\Users\NIMITHA THARMAIAH\Documents\NIMI_PES\SEM_6\CC\WINIPROJECT\demo1\Raft3D>curl http://127.0.0.1:8002/printjobs
{"job1":{"id":"job1","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"Queued"},"job2":{"id":"job2","printer_id":"p1","filament_id":"f1","filepath":"/models/sample.stl","print_weight_in_grams":120,"status":"running"}}
```

## LEADER ELECTION

After killing leader (node1)

Re-election on node 2

```
Raft Node 2 - raft3d.exe --id 2
2025/04/17 15:47:45 Rollback failed: tx closed
2025/04/17 15:47:46 Rollback failed: tx closed
2025-04-17T15:47:46.160+0530 [INFO] raft: Initial configuration (index=0): []
2025/04/17 15:47:46 Server running on port 127.0.0.1:8001
2025-04-17T15:47:46.162+0530 [INFO] raft: Node at 127.0.0.1:9001 [Follower] entering Follower state (Leader: "")
2025/04/17 15:47:46 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62069
2025-04-17T15:47:46.903+0530 [DEBUG] raft: lost leadership because received a requestvote with newer term
2025/04/17 15:47:46 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025/04/17 15:47:47 Rollback failed: tx closed
2025-04-17T15:47:47.091+0530 [WARN] raft: Failed to get previous log: 1 log not found (last: 0)
2025/04/17 15:47:47 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62072
2025/04/17 15:57:41 [ERR] raft-net: Failed to decode incoming command: read tcp 127.0.0.1:9001->127.0.0.1:62069: wsarecv: An existing connection was forcibly closed by the remote host.
2025/04/17 15:57:41 [ERR] raft-net: Failed to decode incoming command: read tcp 127.0.0.1:9001->127.0.0.1:62072: wsarecv: An existing connection was forcibly closed by the remote host.
2025-04-17T15:57:42.875+0530 [WARN] raft: Heartbeat timeout from "127.0.0.1:9000" reached, starting election
2025-04-17T15:57:42.876+0530 [INFO] raft: Node at 127.0.0.1:9001 [Candidate] entering Candidate state in term 3
2025/04/17 15:57:42 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62129
2025/04/17 15:57:42 Rollback failed: tx closed
2025-04-17T15:57:42.935+0530 [ERROR] raft: Failed to make RequestVote RPC to {Voter node1 127.0.0.1:9000}: dial tcp 127.0.0.1:9000: connect: No connection could be made because the target machine actively refused it.
2025/04/17 15:57:42 Rollback failed: tx closed
2025/04/17 15:57:43 Rollback failed: tx closed
2025-04-17T15:57:43.046+0530 [DEBUG] raft: Votes needed: 2
2025-04-17T15:57:43.046+0530 [DEBUG] raft: Vote granted from node2 in term 3. Tally: 1
2025-04-17T15:57:43.047+0530 [INFO] raft: Duplicate RequestVote for same term: 3
2025-04-17T15:57:44.138+0530 [DEBUG] raft: lost leadership because received a requestvote with newer term
2025/04/17 15:57:44 Rollback failed: tx closed
2025/04/17 15:57:44 Rollback failed: tx closed
2025/04/17 15:57:44 Rollback failed: tx closed
2025-04-17T15:57:44.315+0530 [INFO] raft: Node at 127.0.0.1:9001 [Follower] entering Follower state (Leader: "")
2025/04/17 15:57:44 [DEBUG] raft-net: 127.0.0.1:9001 accepted connection from: 127.0.0.1:62136
```

[GITHUB LINK](#) (currently private- will make it public after sem end)