

Learning Management System (LMS) using gRPC and LLM

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Raft Implementation Overview

1. Leader Election

Goal: Ensure that a single leader is elected among the Raft nodes.

Functionality:

Each node starts as a follower and can initiate an election if it doesn't receive a heartbeat from a leader within a specified ELECTION_TIMEOUT over a random period.

Nodes vote for candidates based on the term and log information.

A node becomes the leader if it receives a majority of votes(>50%)

2. Log Replication

Goal: Ensure consistency of logs across all nodes.

Functionality:

The leader appends new entries to its log and sends these entries to followers via heartbeat messages.

Followers can identify if they are out of sync and request additional log entries from the leader.

Logs are stored in a shared text file, enabling persistence and recovery.

These logs can be used to bring databases for each server node to a consistent state (eventually consistent)

3. Heartbeat Mechanism

Goal: Maintain the leadership and keep followers updated.

Functionality:

The leader periodically sends heartbeat messages to followers to assert its uptime and update them with any new log entries.

If followers fail to receive heartbeats, they will consider starting a new election.

The leader processes the request, appends the corresponding log entry, and replicates it to followers.

4. RPC Protocol

Goal: Facilitate communication between nodes in the cluster.

Functionality:

Implemented using gRPC for efficient and fast messaging.

Key RPCs:

RequestVote: For nodes to request votes during elections.

AppendEntries: For the leader to send log entries to followers, which also acts as the heartbeat.

GetLeader: To retrieve the current leader's address. In case a follower receives a request from a client, it will inform the client about the leader's address and a new request will be triggered.

RedirectWrite: To inform raft nodes about the write requests received (only for leader)

5. Error Handling and Resilience

Goal: Handle failures gracefully and ensure system robustness.

Functionality:

Nodes handle exceptions and can retry operations where necessary.

The system is designed to recover from network partitions and node failures.

7. Data Storage

Goal: Ensure logs are stored persistently.

Functionality:

Logs are written to a text file, enabling durability and facilitating recovery upon restart.

The log format includes timestamps, terms, and database queries.

Implementation Details

The system is built to run on the same machine, allowing for shared logs between the Raft service and the LMS service.

Future Enhancements

- In case of contesting logs, choose one and delete the other.
- Update database state when logs are replicated
- More robust raft. Current implementation needs to be tested more.