Documentation: Distributed LMS with LLM-based Tutoring and Raft-based Data Consistency

Overview

In this milestone, the LMS integrates the Raft consensus algorithm to ensure data consistency across distributed nodes, enhancing reliability and fault tolerance. Building on the Phi-3 LLM integration, Raft maintains consensus among servers, improving data storage and management.

Technologies Used

- **Python**: Primary development language.
- **gRPC**: For Remote Procedure Calls (RPC) between client and server.
- **SQLite**: For storing user data and file paths.
- **Raft Protocol**: For ensuring data consistency across distributed nodes.
- **SHA-256**: For securely hashing passwords.
- **AES-256**: For session token management.
- **Phi-3 Fine-tuned LLM**: To provide intelligent, context-aware responses to student queries.

System Components and Functions

1. Auth Service

Handles user authentication and session management for both students and instructors.

- **studentLogin**: Authenticates students with SHA-256 hashed passwords, generating an AES-256 encrypted session token.
  Returns: A session token, course details, and an error code if applicable.
- **facultyLogin**: Authenticates instructors, issuing a session token and course details.
  Returns: A session token and error code if authentication fails.

2. Materials Service

Manages course material uploads and retrieval for students and instructors.

- **courseMaterialUpload**: Uploads course materials in chunks, supporting large files.
  Returns: File size and any errors encountered.
- **getCourseContents**: Retrieves available materials for a specified course and term.
  Returns: Course material details and error messages if applicable.
- **getCourseMaterial**: Streams specific course material by name for a course and term.
  Returns: The course material data streamed to the client.

3. Assignments Service

Handles assignment submissions by students and retrieval by instructors.

- **submitAssignment**: Allows students to submit assignment data in bytes for a specific course.
  Returns: Success status or error message.
- **getSubmittedAssignment**: Enables instructors to retrieve all submissions for an assignment.
  Returns: Submitted assignment data mapped to student IDs.

4. Queries Service

Manages the posting, retrieval, and answering of student queries.

- **createQuery**: Enables students to post queries for a specific course and term.
  Returns: Error message if creation fails.
- **getQueries**: Retrieves all queries for a specified course and term.
  Returns: List of queries and any error messages.
- **answerQuery**: Allows instructors to answer student queries.
  Returns: Confirmation or error message on query answer status.

5. LLM Service

Uses the fine-tuned Phi-3 model to deliver intelligent, context-aware responses to student queries.

- **askLlm**: Allows students to ask course-related questions to the LLM. The model processes and provides a detailed, contextually relevant response.
  Returns: Streamed response from the LLM, along with any error messages.

6. Raft Service

Oversees leader election, log replication, and data consistency among distributed LMS nodes.

- **requestVote**: Manages voting requests for leader election.
  Returns: Indicates if the vote was granted and the current term.
- **appendEntries**: Receives and replicates log entries from the leader to followers, ensuring consistency.
  Returns: Confirmation of successful log replication.
- **getLeader**: Provides nodes with the current leader's ID within the Raft cluster.
  Returns: ID of the current leader.

Database Design (SQLite)

SQLite continues to serve as the database for managing user data, course materials, assignments, and queries. The tables are designed to work seamlessly with the Raft protocol, ensuring that data changes are replicated and consistent across all nodes.

- **Users**: Stores user credentials, session tokens, and roles (student or instructor).
- **Courses**: Stores information about courses, including file paths for uploaded materials.
- **Assignments**: Stores file paths for student-submitted assignments.
- **Queries**: Tracks queries and answers related to courses and terms.

Conclusion

Enhances the LMS with the Raft protocol, ensuring reliable, fault-tolerant data consistency across distributed nodes. Together with the Phi-3 LLM, Raft creates a more interactive, robust platform for students and instructors, optimising the learning experience.