

SWENG 837: Software Design Course Project

Object-Oriented Software System Design for Cloud-Based File Storage and Collaboration
by David Luo

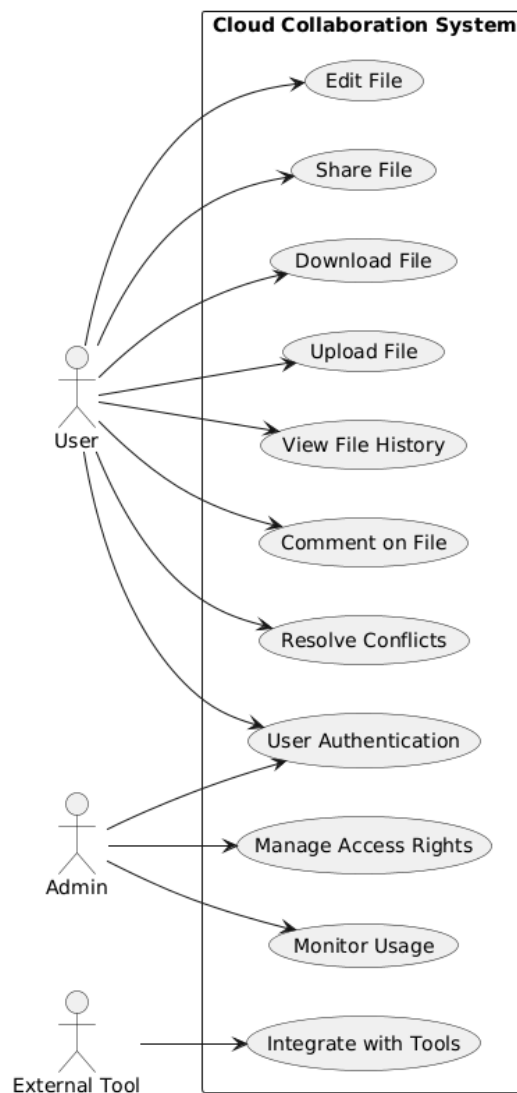
Problem Statement

In the current workplace environment, teams and individuals commonly face difficulties in work caused by inefficient collaboration and disorganized file management. Tools that attempt to workaround these problems typically rely on a combination of local storage, email attachments, and third-party cloud services. These tools are widely used and effective to a limited extent. However, issues are still experienced by users such as version conflicts and connectivity issues which can result in decreased productivity and workflow disruptions.

The primary challenge in designing the system is creating a scalable, intuitive, and secure cloud-based storage system that enables seamless file organization, controlled access management, and real-time collaboration. Central elements will especially need to be addressed, including data structure optimization, role-based access control, file editing conflict resolution, and integration with external tools. By focusing on these design elements, the access of data can be enhanced, along with document consistency and the creation of a unified workspace for efficient team collaboration.

System Design using Domain Modeling

1. UML Use Case Diagram

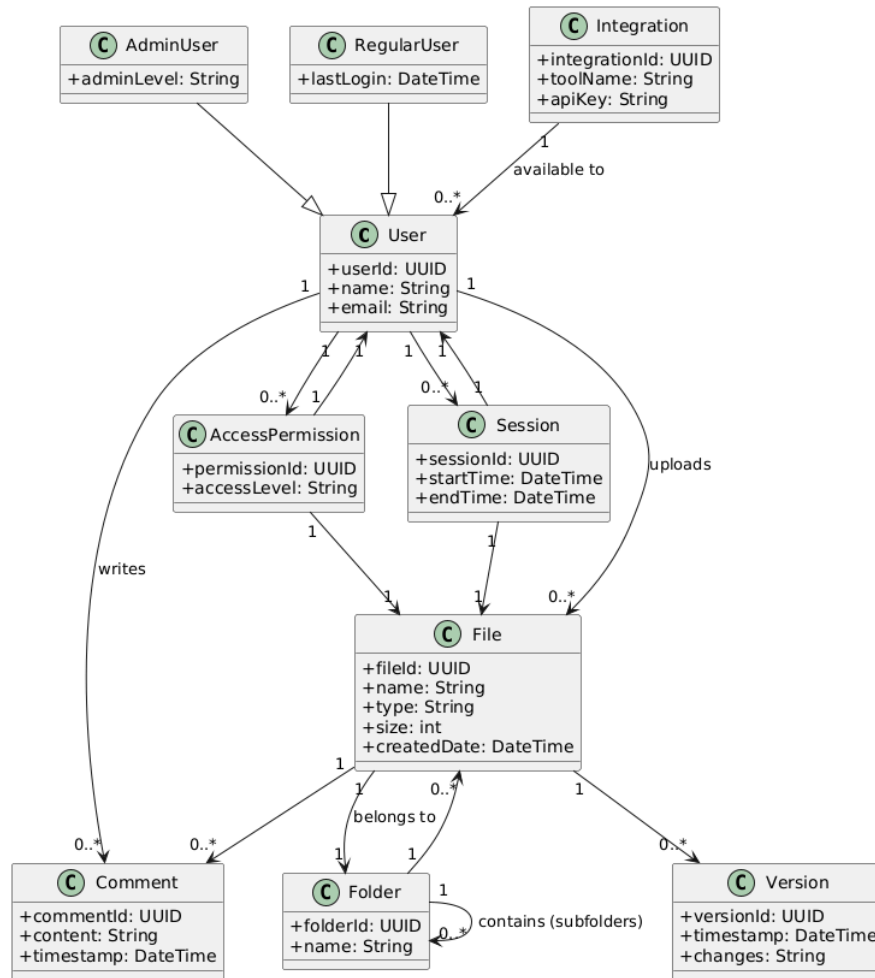


The above Use Case Diagram illustrates the interactions between actors (e.g. users and external systems) and the Cloud-Based File Storage and Collaboration Tool. It also identifies the functional requirements of the system by depicting what it should do from the point of view of its users/actors.

Actors:

- A User interacts with the system to edit or access a file
- An Admin is a user with extended privileges responsible for monitoring system activity and managing permissions
- External Tools are third-party applications that are integrated into the system, providing additional functionality

2. UML Domain Model

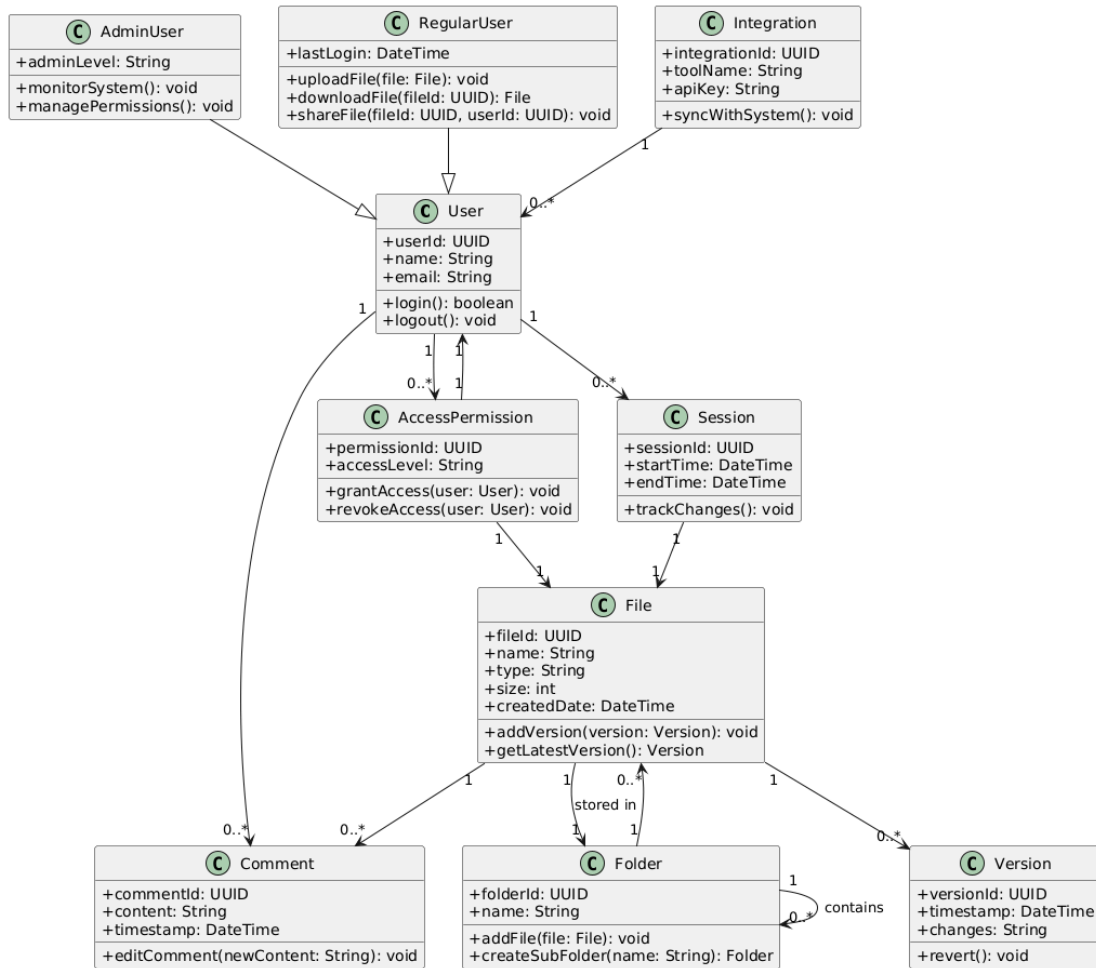


The above Domain Model illustration depicts the key interconnected concepts and relationships within the Cloud-Based File Storage and Collaboration Tool. Acting as the foundation of the system's object-oriented design, it ensures that the system maintains consistency and clarity.

Relationships:

- A User can own/access Files/Folders containing AccessPermissions
- A File belongs to a Folder and can contain Comments and Versions
- Integrations connect the system with external tools, providing additional functionality
- Sessions track user interactions/changes

3. UML Class Diagram

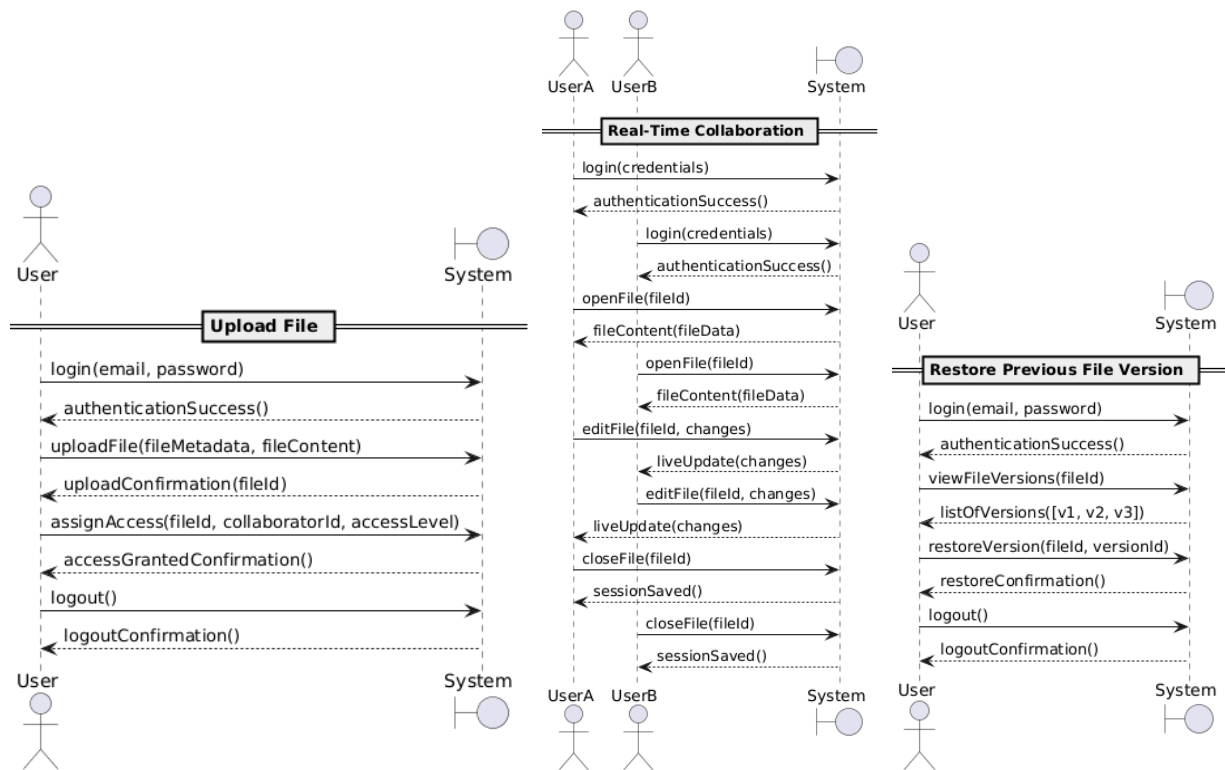


The above Class Diagram represents the overall structure of the Cloud-Based File Storage and Collaboration Tool in terms of its classes, attributes, operations, and relationships. It builds upon the Domain Model by incorporating additional depictions of the system's functionality.

Structure:

- AdminUser extends User with additional permissions to monitor and manage the system
- AccessPermission defines access control (e.g. read/write) while linking User to File

4. UML Sequence Diagrams



The above Sequence Diagrams illustrate the interaction flows between processes and objects in the events of three separate use cases--uploading a file, facilitating real-time collaboration, and restoring a version of a previous file.

Upload File

- User is authenticated and sends a request to upload a file, which is processed and confirmed with a unique fileId
- User assigns access permissions to a collaborator before logging out

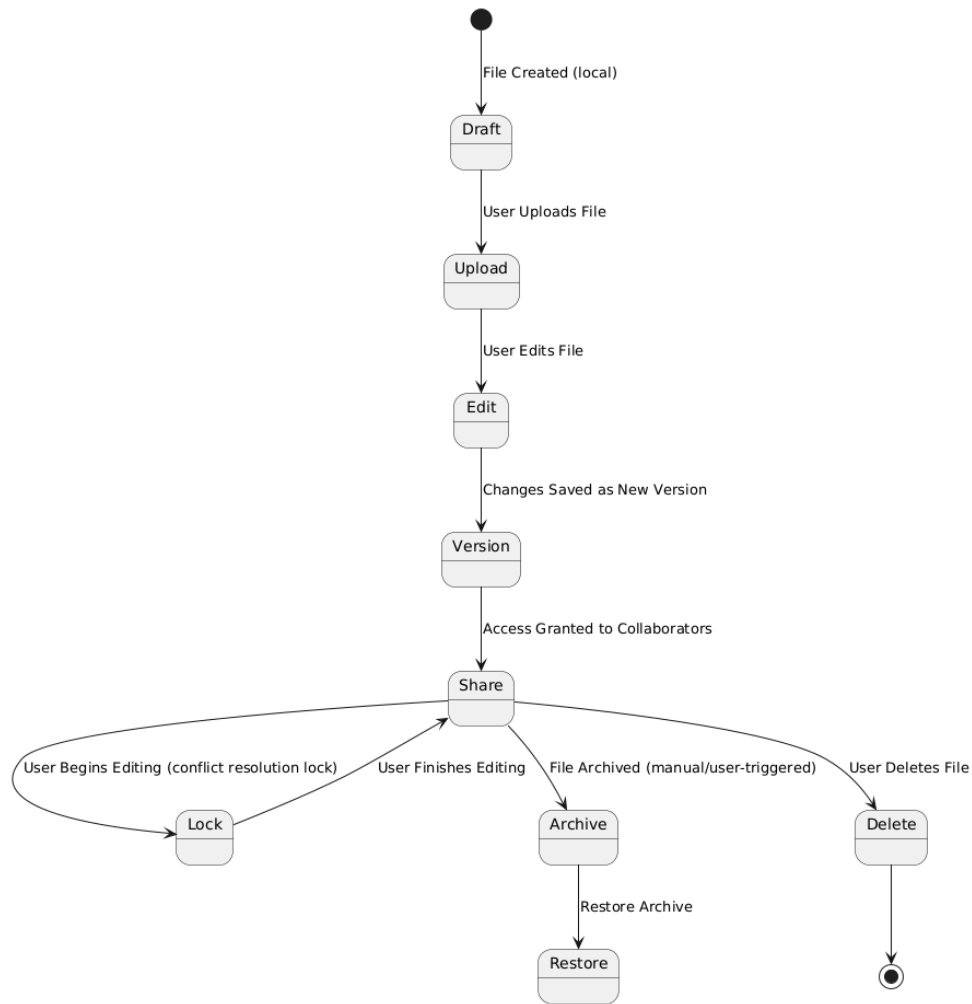
Real-Time Collaboration

- Two users are authenticated; they send requests to open & edit a file, which are processed and confirmed with unique fileIds--these changes are updated live
- When the file is closed, the session is saved for future use

Restore Previous File Version

- User is authenticated and sends a request to view a file version; a list of previous versions is provided for the user
- User then sends a request to revert a file to a selected file version, which is processed and confirmed with a unique fileId

5. UML State Diagram

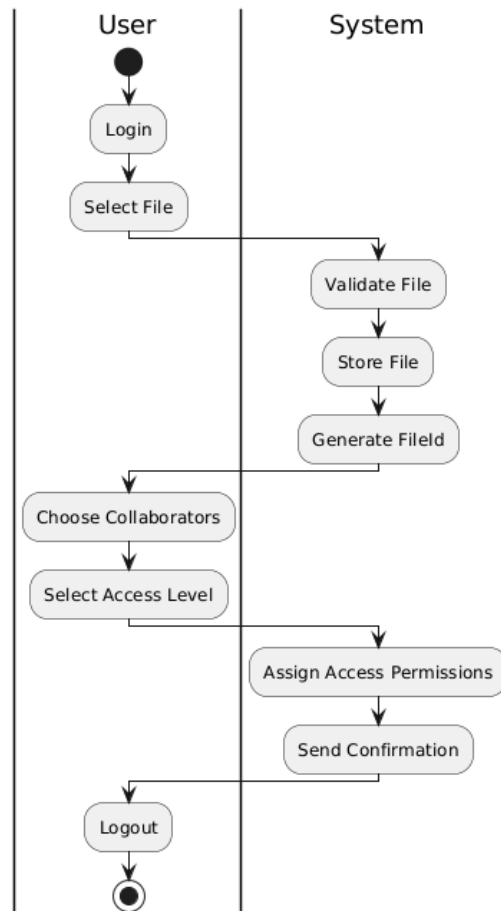


The above State Diagram follows the workflow of states that a file can encounter during its time in the Cloud-Based File Storage and Collaboration Tool.

Key States:

- Draft: File is created locally by the user before being uploaded
- Upload: File is saved by the user within the system
- Edit & Version: User creates an edit to the file, resulting in a new file version
- Share: File is made accessible to other collaborators
- Lock: File is locked for editing temporarily to avoid conflicts
- Archive & Restore: File is marked as inactive but can be restored at a later point
- Delete: Final state of the file after being removed from the system

6. UML Activity Diagram (Swimlane Diagram)



The above Activity Diagram depicts a workflow of activities that typically occurs within the Cloud-Based File Storage and Collaboration Tool. The diagram additionally represents swimlanes that determine the responsibilities of objects.

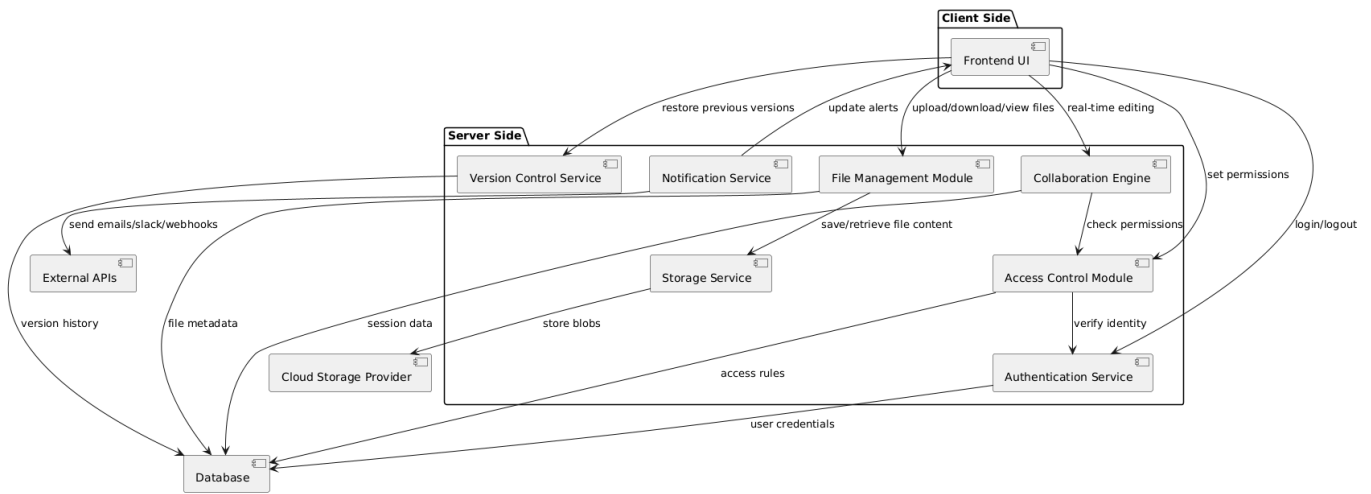
Swimlanes:

- User Lane: includes actions triggered by UI (e.g. login, file select, access level selection)
- System Lane: includes background tasks (e.g. file validation & storage, access control)

Workflow:

- User logs in authenticates before selecting a file to manage
- System validates and stores file with a unique Fileid
- User chooses file collaborators and selects their access levels
- System confirms the user's selection and assigns permissions for collaborators
- User logs out

7. UML Component Diagram

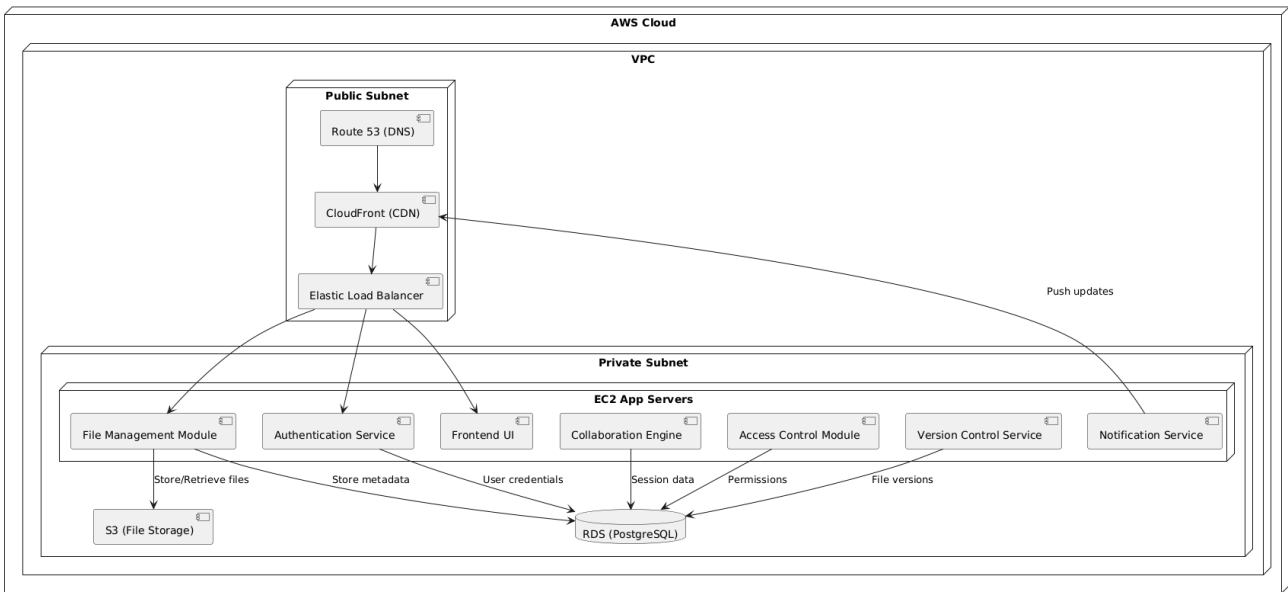


The above Component Diagram represents an overview of the major parts of the Cloud-Based File Storage and Collaboration Tool and their interactions with other objects. Dependency arrows between objects are shown within the diagram and reflect component communications and responsibilities.

Components:

- Frontend UI: User interface for system interaction
- Access Control Module: Handles role-based access management
- File Management Module: Handles file uploading/downloading
- Authentication Service: Handles user sessions
- Notification Service: Sends alerts to users
- Storage Service: Handles file storage logic
- Version Control Service: Handles file versioning and rollbacking
- Collaboration Engine: Handles session synchronization and real-time editing
- Database: Stores file metadata/history and access controls, among other objects
- External Integration APIs: Integrated with the system for application hooks, etc.

8. Cloud Deployment Diagram



The above Cloud Deployment Diagram illustrates how the Cloud-Based File Storage and Collaboration Tool is deployed in a cloud environment--in this case, Amazon Web Services (AWS). The diagram additionally depicts how software components are assigned to cloud infrastructure nodes.

AWS Resources:

- Amazon Route 53: handles DNS resolution
- Amazon CloudFront: distributes static content
- Amazon RDS: handles database management
- Amazon S3: stores file content
- Elastic Load Balancer: distributes incoming traffic
- EC2 App Servers: hosts UI frontend and backend

9. Skeleton Class and Tables Definition

| | | |
|--|--|--|
| <u>User.java</u> <pre>class User { String userId; String name; String email; String passwordHash; Role role; void login(String email, String password); void logout(); void updateProfile(String name, String email); }</pre> | <u>File.java</u> <pre>class File { String fileId; String fileName; String ownerId; Date uploadDate; String currentVersionId; void upload(byte[] content); void delete(); void share(String userId, PermissionLevel level); void restoreVersion(String versionId); }</pre> | <u>FileVersion.java</u> <pre>class FileVersion { String versionId; String fileId; Date modifiedDate; String modifiedBy; byte[] content; void createNewVersion(byte[] newContent); }</pre> |
| <u>Permission.java</u> <pre>class Permission { String permissionId; String fileId; String userId; PermissionLevel level; boolean hasAccess(PermissionLevel requiredLevel); }</pre> | <u>EditSession.java</u> <pre>class EditSession { String sessionId; String fileId; List<String> participantIds; Date startedAt; Date endedAt; void start(); void syncChanges(String userId, String delta); void end(); }</pre> | <u>Notification.java</u> <pre>class Notification { String notificationId; String userId; String message; Date createdAt; boolean isRead; void markAsRead(); }</pre> |

Table for User

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|--------------|-------------|-------------------------------|
| userId | UUID-PK | User unique identifier |
| name | Varchar | User display name |
| email | Varchar | User unique email |
| passwordHash | Varchar | User encrypted password |
| role | Varchar | Viewer, editor, administrator |

Table for File

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|------------------|-------------|------------------------|
| fileId | UUID-PK | File unique identifier |
| fileName | Varchar | File name |
| ownerId | UUID-FK | File owner |
| uploadDate | Varchar | File upload date |
| currentVersionId | UUID-FK | File latest version |

Table for FileVersion

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|---------------------|--------------------|-----------------------------------|
| versionId | UUID-PK | File version ID |
| fileId | UUID-FK | File unique identifier |
| modifiedDate | Timestamp | File version creation date |
| modifiedBy | UUID-FK | User who created the file version |
| content | Blob | File binary content |

Table for Permission

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|---------------------|--------------------|---------------------------|
| permissionId | UUID-PK | User unique identifier |
| fileId | UUID-FK | User display name |
| userId | UUID-FK | User unique email |
| level | Varchar | User encrypted password |

Table for EditSession

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|---------------------|--------------------|---------------------------------|
| sessionId | UUID-PK | Session unique identifier |
| fileId | UUID-FK | File that session is created on |
| startedAt | Timestamp | Start time of session |
| endedAt | Timestamp | End time of session |

Table for Notification

| <u>Field</u> | <u>Type</u> | <u>Information</u> |
|---------------------|--------------------|--|
| notificationId | UUID-PK | Notification unique identifier |
| userId | UUID-FK | User who receives the notification |
| message | Text | Notification message content |
| createdAt | Timestamp | Notification creation time |
| isRead | Boolean | Flag that denotes whether the user read the notification |

The skeleton classes above (each containing attributes and corresponding to a table) reflect central behaviors of the system. Object relationships are mirrored both in class definitions and schema, with the skeleton classes being created for easy extension whenever needed.

10. Design Patterns

A number of software design patterns and principles were utilized when planning the Cloud-Based File Storage and Collaboration Tool.

GRASP Patterns

- Controller: system-level operations (e.g. file uploading & sharing) are handled by controller components (e.g. FileManager) for more efficient organization of system behavior by assigning responsibilities to lower-level components

SOLID Principles

- Single Responsibility: Classes are focused on specific tasks (e.g. the User class handles authentication and profile management while the File class manages versioning and metadata)

GOF Patterns

- Observer: Edit sessions and notifications are updated in real-time, as the system is enabled to notify users of events without a high degree of coupling

Microservices Patterns

- Service Decomposition: The system is broken down into more loosely coupled services (e.g. for authentication and file management) to allow for easier scaling and independent deployment