

Assignment 1
Software Architecture for Learning Management System

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Chapter 1

Software Architecture for Learning Management System

1.1 Project Description :

With the increase in remote learning it has become mandatory for a highly available and easy to use Learning Management System with abilities for taking class and conducting examinations for High Schools as well as large Educational Institutions across the world. This project tends to suggest an architecture for the same.

1.2 High Level Requirements :

High level requirements to the project are as follows :

1. Ability to take Video classes
2. Ability to track the attendance of students
3. Ability to provide assignments and seminars
4. Ability to conduct Mid Semester and End Semester Exams with ease and stringency similar to the on campus exams.
5. Ability to summarize the marks and provide the grade sheets to the students and parents with ease.

1.3 Diagrammatic Representation of High Level Use Cases

The diagrammatic representations of the high level use cases can be found below :

1. Video Classes
2. Track Attendance of the Students
3. Provide Assignments and Seminars
4. Conduct Mid Semester and End Semester Exams
5. Examination Grading and Reporting

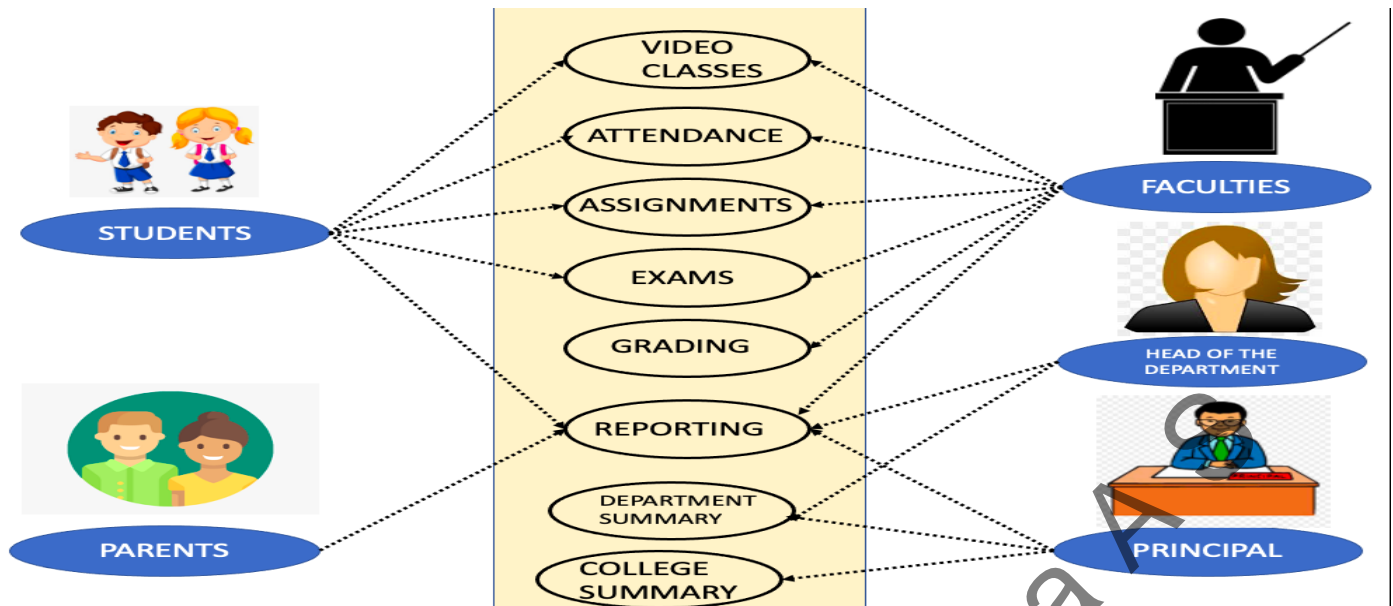


Figure 1.1: High Level Cases - View

As shown in the Figure 1.1 at the high level following users need access to the following modules.

1. Students should be able to attend Video Classes, provide attendance , submit assignments, write exams and view their grades.
2. Faculties should be able to take Online Classes, view at the attendance, provide assignments , conduct exams, grade the exams and view at the final report.
3. Head of the Department should be able to look at the reports for a particular students in his / her department as well as the Summary for the entire department
4. The Principal should be able to see the report for each student, summary of the department and summary of the college as the whole.
5. Parents should be able to look at the Reports of their children.

1.4 Stakeholders and their requirements

The various stake holders and their requirements are as follows

1. Principal of the Education Institution
 - Data stored should be safe and secure
 - Only the faculty should be able to provide the marks
 - Should be able to get the summary of each of the department with ease
 - There should be very less downtime
 - None of the course contents or Marks should be deleted
2. Head of the Department
 - Should be able to see the summary of the students and various courses offered at ease.
3. Faculties
 - Should be easy to organize Video classes for students
 - Should be easy to provide assignments
 - Should be easy to conduct Examinations

- Should be easy to provide grading
- Students should not be able to copy from the web or using their phones

4. Students

- Should be easy to attend the classes and submit the assignments
- Ability to view Classroom recordings

5. Parents

- Should be able to monitor the child's grades with ease.

1.5 Project Requirements

1.5.1 Business Requirements :

The Business Requirement is to build the architecture for a learning management system.

1.5.2 Motivation :

Due to Covid 19 Pandemic schools and colleges are closed. Students and Faculties are finding it very difficult to use multiple platforms for conducting classes, providing assignments and conducting examinations. We have to provide architecture a single platform that has all these capabilities.

1.5.3 Users :

The users for the particular platform are as follows :

1. Principal of Educational Institution
2. Head of the Departments of various departments
3. Faculties
4. Students
5. Parents

1.5.4 Functional Requirements :

The Functional Requirements are as follows :

1. Ability to take Online classes
2. Ability to take Attendance Automatically during the online class
3. Ability to provide assignments
4. Ability to conduct examinations
5. Ability to prevent students from copying either using online and offline methods during the exam.
6. Ability to grade the subjects very easily
7. Ability for grading to be provided only to faculties
8. Ability to view Classroom Recordings
9. Ability to send grades to the parents

1.5.5 Non Functional Requirements :

1. Security
2. Very Less Downtime
3. No unnecessary deletion
4. Logging

1.5.6 Quality Attribute Requirements :

Based on the above mentioned requirements the following Quality Attributes are required

1. Security
2. High Availability
3. Usability
4. Performance
5. Interoperability

1.6 Architecturally Significant Requirements (ASR) Table:

Table 1.1: ASR table

Scenario	Quality Attribute	Business Value	Architecture Impact
Ability to take Online classes	Usability	High	High
Ability to take Attendance Automatically during the online class	Usability	High	Low
Ability to provide assignments	Usability	High	Medium
Ability to conduct examinations	Usability	High	Medium
Ability to prevent students from copying either using online and offline methods during the exam.	Security	High	High
Ability to grade the subjects very easily	Usability	High	Medium
Ability for grading to be provided only to faculties	Security	High	Medium
Ability to view Classroom Recordings	Usability	Medium	High
Ability to send grades to the parents	Interoperability	Medium	High
No student should be able to delete the data	Security	High	High
The Video Call should be able to include all the students	Scalability	High	Medium
There should not be any delay in Audio / Video during the class, loading of questions during assignments and Exams	Performance	Medium	Medium
There should be very less downtime	Availability	High	Medium

1.7 Design Architecture :

1.7.1 Views:

1.7.1.1 Module View :

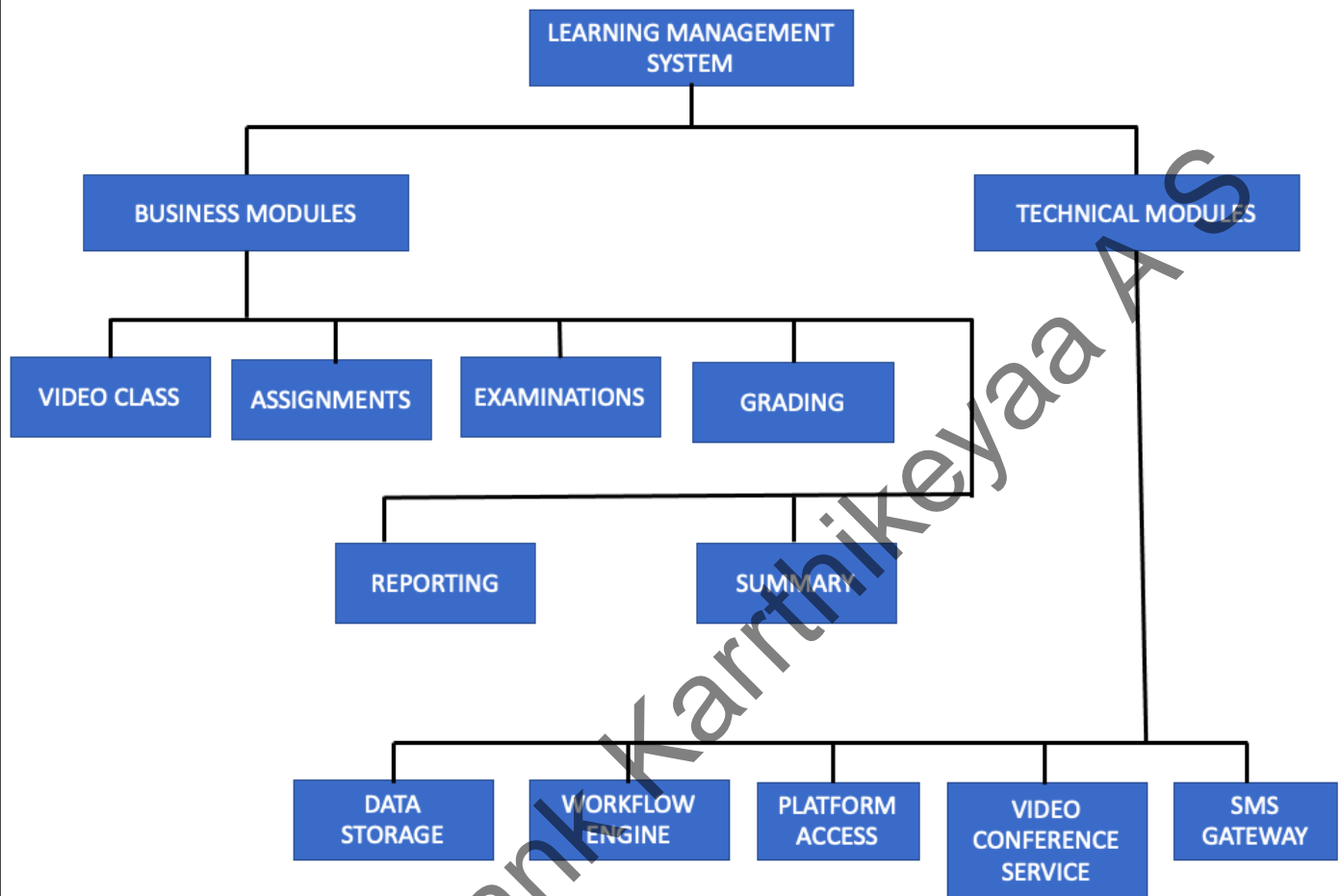


Figure 1.2: Module Decomposition View

1.7.1.2 Deployment View :

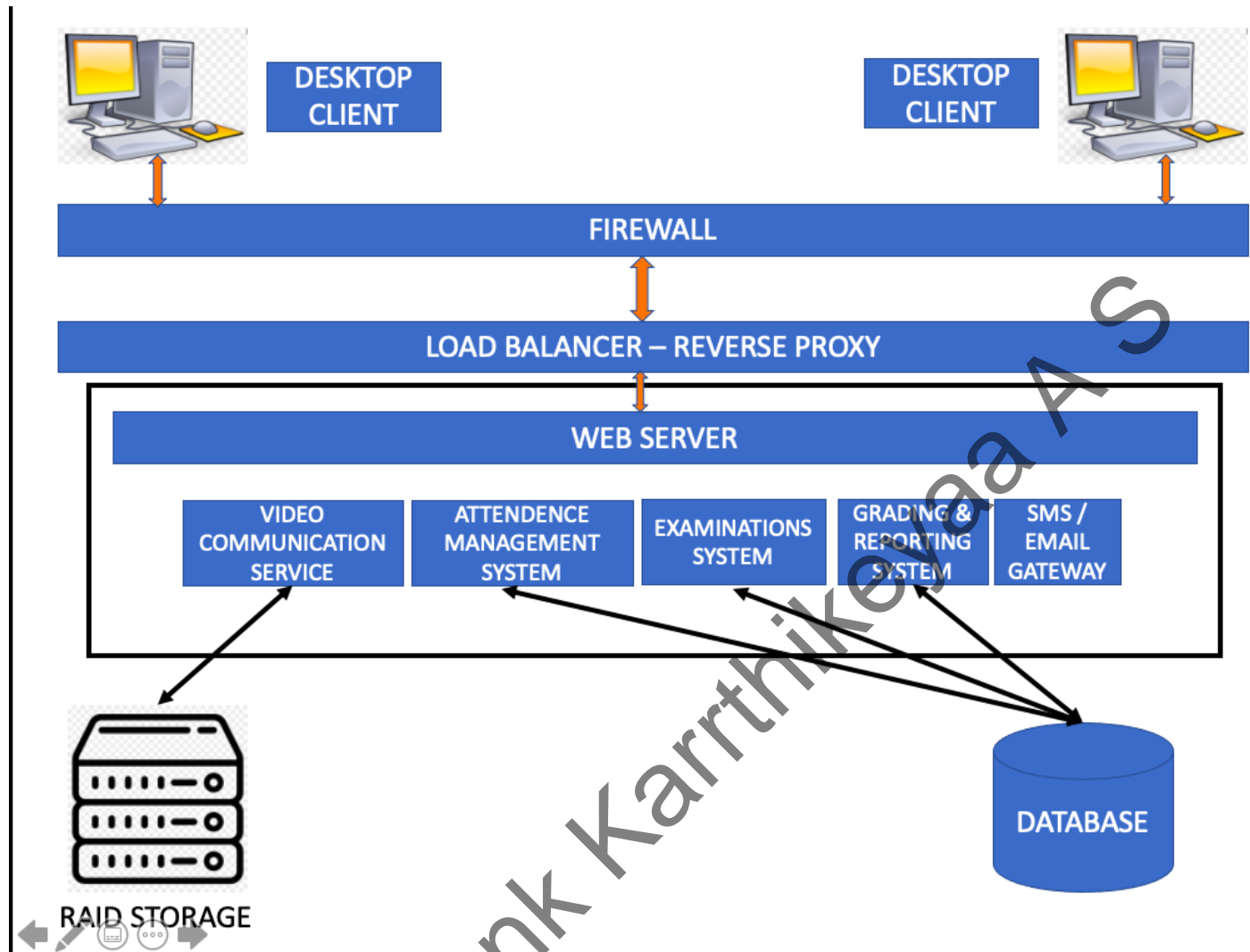


Figure 1.3: Deployment View

1.7.2 Identification of Tactics :

The various Tactics are shown in the Table 1.7.2

Table 1.2: Identification of Tactics

Scenario	Quality Attribute	Tactics
Ability to take Online classes	Usability	Integrating a Video Communication Service into the LMS
Ability to take Attendance Automatically during the online class	Usability	Write to the Database the Timestamp each time a student Logs In or Logs Out of the class
Ability to provide assignments	Usability	Build a UI that would be intuitive for both the students and faculties
Ability to conduct examinations	Usability	Build a UI along with Video Communication Service that would enable the student to write the exam and proctors to monitor the exam
Ability to prevent students from copying either using online and offline methods during the exam.	Security	<ol style="list-style-type: none"> 1. To prevent students from copying using Offline Mode Proctors can be appointed to monitor the students. 2. To prevent the students from copying using Online Mode an desktop app can be built so that any other window/process other than the exam cannot be opened.
Ability to grade the subjects very easily	Usability	<ol style="list-style-type: none"> 1. Build a UI in such a way that the Answers written by the student and the Key are displayed without any clutter 2. Automate the process of calculating the grades so that the faculty should be providing marks only for the questions.
Ability for grading to be provided only to faculties	Security	<ol style="list-style-type: none"> 1. In the LMS provide different access privileges for Students and Faculties 2. Require a 2FA to confirm the identity of the faculty
Ability to view Classroom Recordings	Usability	<ol style="list-style-type: none"> 1. Record the classrooms as they are happening and store it in a BLOB Storage 2. Provide the functionality to review the recordings easily 3. Disable this functionality when Examinations are being conducted .
Ability to send grades to the parents	Interoperability	<ol style="list-style-type: none"> 1. Configure an SMS Gateway to send the score cards as an SMS 2. Configure an E-Mail Gateway to send automatic E - Mails
No student should be able to delete the data	Security	Limit the access privileges to the students
The Video Call should be able to include all the students	Scalability	Increase the Number of Clusters processing the Video Call Request
There should not be any delay in Audio / Video during the class, loading of questions during assignments and Exams	Performance	<ol style="list-style-type: none"> 1. Use the best available broadband connection , 2. Increase the processing capabilities by increasing the nodes in the cluster.
There should be very less downtime	Availability	<ol style="list-style-type: none"> 1. Use Internet Connections from Multiple Providers. 2. Run two as separate instances 3. Use replication in Cloud Providers to increase the Availability.

1.8 Architectural Patterns:

The following Architectural Patterns are used :

1. Layered Pattern :

We will be following a Multi Layered Approach for better Security and Modifiability The following are the layers :

(a) Data Access Layer :

In this layer we will be having processes that would read and write data into databases and RAID/BLOB Storage

(b) Services Layer :

In this layer we will be having various services like Video Calling, Grading , etc...

(c) API Services Layer :

In this layer the API's for Clients Apps are exposed

2. Client Server Pattern :

We will be having a Client Server Pattern between the Client Application and the Server using REST APPs. For the given scenario where a desktop app has to communicate with the server based on the operation performed Client Server Pattern is better when compared to pipeline and publish subscribe patterns

3. Multi Tier Architecture :

The Databases and Storage will be in a separate tier while the web server would be in the separate tier. This provides security and Modifiability. The Database or Data Storage can be changed without disturbing the Web Server.

1.9 Architecture :

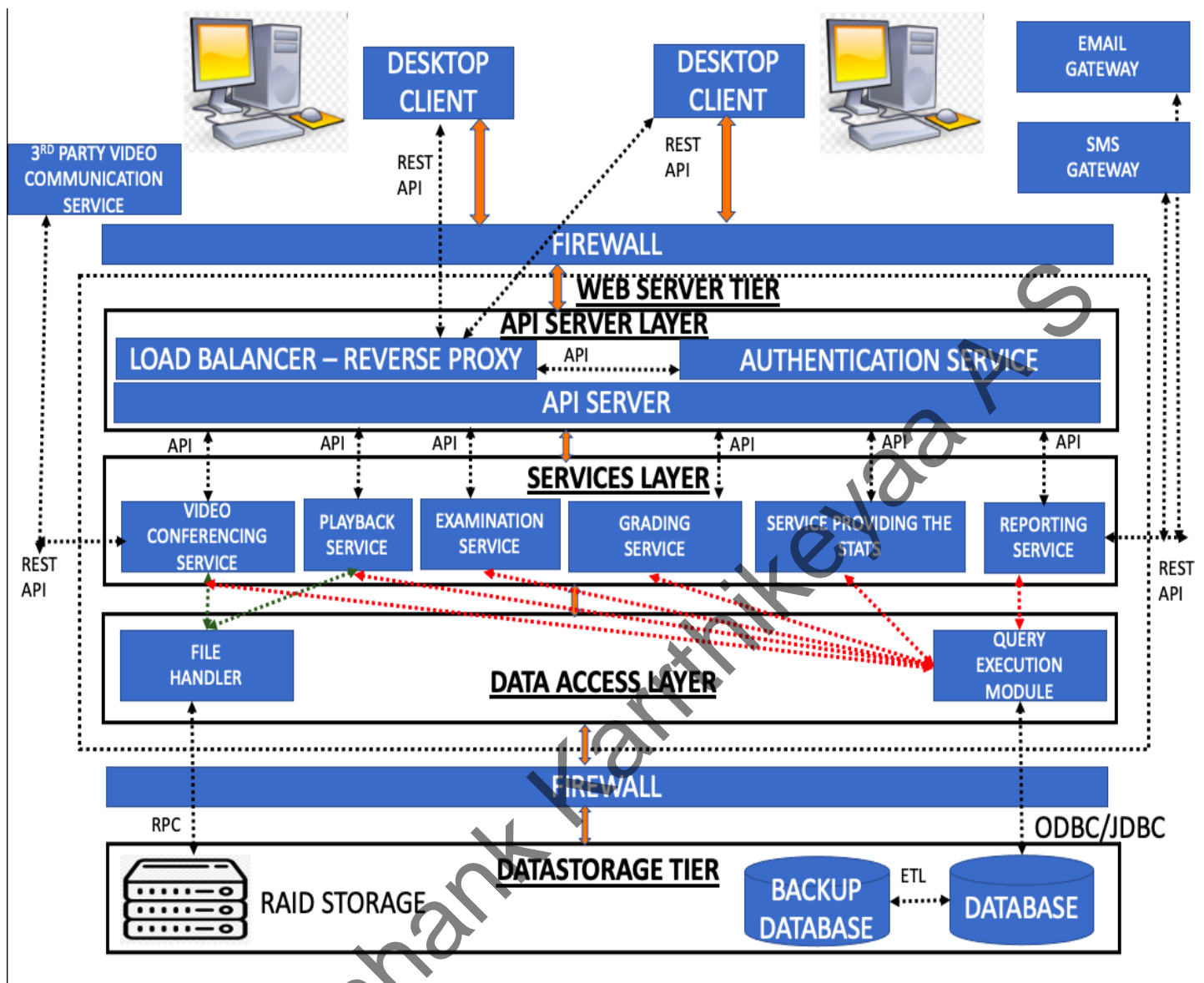


Figure 1.4: Proposed Architecture

Table 1.3: Legend - Architecture

Orange Double Headed Arrows	Actual Path of Communication between layers/tiers/clients
Black Dotted Arrows	Communication between Modules
Green Dotted Arrows	Communication with the File Handler
Red Dotted Arrows	Communication with the Query Execution Module
RPC	Remote Procedure Call
API	Application Programming Interface
REST	Representational State Transfer
RAID	Redundant Array of Independent Disks
ETL	Extract Transform Load
ODBC	Open Database Connectivity
JDBC	Java Database Connectivity

1.10 Architecture Evaluation

The detailed Architecture is shown in the Figure 1.4 and the respective legends in the Table 1.3

1. Desktop Client The Desktop Client is built for all the available platforms and the installers are provided to the students and faculties for installation. The Desktop App Communicated by means of REST API to the WEB Server

2. Web Server Tier

- (a) API Server Layer

- i. Load Balancer : The Load Balancer is a Reverse Proxy Server. It is used to manage the requests sent to the server. Example : Nginx
 - ii. Authentication Service The Authentication Service is used to authenticate each and every user before they have access to the entire platform. The Desktop App can be designed to follow OAuth 2.0 Authorization and can use Access Token every time it makes request to the server.
 - iii. API Server The API Server has the exposed End Points by means of which the Desktop Client can actually interact with the services. Usually .NET or Java is used to power the API Server. The API Server interacts with the modules in the Services Layer by means of API.

- (b) Services Layer The services Layer has independent modules that provide the required functionality. The services can be built using Java, Python or .NET

- i. Video Conferencing Service : The Video Conferencing Service can be used to take classes and record the same. We can integrate the Video Conferencing Services with 3rd Party Providers like Zoom and gotomeeting so that our server need not handle all the load. The recorded classroom session are sent to the File Handler for storage and Metadata is sent to the Query Execution Module to store in the Database.
 - ii. Playback Service : The Playback service makes sure that the students can actually play the required classroom sessions based on their need. The Service first reaches the Query Execution Module to load the metadata from the Database and then reaches the File Handler to retrieve the file from RAID Storage and provide to the user.
 - iii. Examination Service : The Examination service can be used by the faculties to conduct the Exam. The Service stores the Questions and the respective answer provided by each student in the Database for grading by the Faculty.
 - iv. Grading Service : The faculty could use the grading service to read the answers provided by the students from the database and grade each question. The automated script can calculate the total and Cumulative Grade Point of the Student.
 - v. Service Providing the stats : The Service providing the stats can be used to provide the course level summary to the instructor, department level summary to the HOD and institutional level summary to the Principal
 - vi. Reporting Service : The Reporting Service could be used to provide reporting facilities to both the student and parents. It can be configured with external SMS gateways or E-Mail gateways for send the grades for each semester automatically by fetching the student and parent contact details stored in the Database.

- (c) Data Access layer

The Data Access Layer contains modules that can communicate with the Data Storage Tier

- i. File Handler : The File Handler could be used to read and write data to the RAID Storage as and when needed. The recording of each classroom session is stored in the RAID Storage. It communicates with the RAID Cluster by means of RPC.
 - ii. Query Execution Module : The Query execution module can be used to run the required queries on the data stored in the database. It communicates with the Database by means of ODBC/JDBC Drivers.

- (d) Data storage Tier : The Data storage Tier consists of the RAID Storage and Database Storage

- i. RAID Storage : Redundant Array of Independent Disks is used to store and retrieve unstructured data with ease. It has inherent capabilities for fault tolerance and failure handling capability.
 - ii. Database : Any SQL Database can be used to stored the necessary data and retrieve it with ease. We can have a backup database that periodically copies the data from the Primary Database in regular intervals for backup in case of Database failure. The tables are indexed for faster access.

The data is stored encrypted in both RAID and SQL Databases for security and compliance.

- (e) Firewall The firewalls are used to make sure only allowed communications are allowed between the Server and External Applications. They have been configured to allow only the required 443 HTTPS Port for external communication. All other ports are blocked both inbound and outbound for security reasons. In case of the Firewall for Data Storage it is made sure that only communication from the File Handler and Query Execution Module are allowed and any other form of access is not allowed.