Automation of Design Process of Aircraft Systems as per DO-254
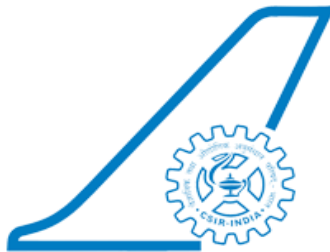
Submitted by,

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Carried out at

AEROSPACE ELECTRONICS AND SYSTEMS DIVISION

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL AEROSPACE LABORATORIES

BANGALORE – 560017

Under the Guidance of

Dr. C M Ananda

Senior Principal Scientist

Head of Aerospace Electronics and Systems Division

CSIR-NAL Bangalore

Manipal Institute of Technology, Manipal

Date: 21/07/2017

CERTIFICATE

This is to certify that **Ms. Kritika M,** student of **Manipal Institute of Technology (Manipal Campus), Bachelor of Technology in Information Technology,** carried out an Internship at **Aerospace Electronics and Systems Division of CSIR-National Aerospace Laboratories, Bengaluru** during 5th June 2017 and 21st July 2017 under my Supervision and Guidance.

C. M. Ananda   21/7/17

डॉ सी.एम. आनंदा/ Dr. C.M. ANANDA
प्रधान / Head
वांतरिक इलेक्ट्रानिकी तथा प्रणाली प्रभाग
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Contents

ACKNOWLEDGEMENT

As an Intern I found the academic/lab and education environment very conducive for deep learning. It was an honor and privilege to be a part of this prestigious organization of national repute and be afforded an opportunity to educate myself on important contemporary topics of multi-disciplinary engineering.

I express my sincere thanks to **Mr. Jitendra J Jadhav**, Director CSIR- NAL, Bengaluru, **Dr. J.S. Mathu**r, Head KTMD, **Mrs. Sasikala GR Murthy**, Principal Technical Officer, KTMD, NAL, Bengaluru.

I was fortunate to have **Dr. C M Ananda PhD**, Senior Principal Scientist and Head of Department, Aerospace Electronics and System Division (ALD), CSIR-NAL, Bengaluru as my guide and mentor under whose able guidance, support and motivation I could apply my knowledge and perform. To him and his team in the various laboratories who assisted me, I will always be indebted.

I hope I get another opportunity to work on a larger independent project in future in NAL and contribute to Aerospace engineering especially in the field of Computer Science.

I would also like to thank the administrative and security Officer/staff of NAL who have helped me in this journey.

With deepest Gratitude.

KRITIKA M

DECLARATION

I hereby declare that entire work embodied in this Internship report has been carried out by me and no part of it has been submitted for any degree or diploma of any institute previously.

Place: BANGALORE   Signature of Student

Date: 20/7/2017

Introduction

National Aerospace Laboratories (NAL), a constituent of the Council of Scientific and Industrial Research (CSIR), India, is the only civilian aerospace Research and Development laboratory in India. CSIR-NAL is a high-tech oriented institution focusing on advanced topics in aerospace and related disciplines and has a mandate to develop aerospace technologies with strong science content, design and build small and medium-size civil aircraft and support all national aerospace programs.

At the Aerospace Electronics and System Division of CSIR-NAL, research along with product design and development is carried out in 5 major disciplines namely

- Avionics and embedded systems for Civil Aircrafts
- Systems Engineering
- Software engineering
- Micro Air Vehicles
- Active noise control

The current Project deals with the automation of airborne electronic hardware reviews. The avionic systems used on aircraft, artificial satellites, and spacecraft which include communication system, navigation system, the display and management systems, contain both hardware and software components. Any hardware or software developed for the Avionic systems must follow a set of standards such as DO-254, DO-176 A/B/C etc. The purpose of the hardware review during design & development is to assess whether or not the airborne

electronic hardware complies with airworthiness requirements and the proposed means of compliances.

To assess compliance, there are typically four Stages of FAA Involvement throughout the hardware life cycle of a project. These are:

STAGE OF INVOLVEMENT #1 - Planning review

- Assure plans meet DO-254 objectives.
- Assure that the processes described in the applicant's plans meet the objectives of DO-254.
- Obtain agreement between FAA and applicant on the plans.

STAGE OF INVOLVEMENT #2 - Design review

- Assess implementation of plans and standards in the hardware life cycle data.
- Assess and agree to plan changes.
- Assure lifecycle data meets DO-254 objectives.

STAGE OF INVOLVEMENT #3 - Validation and Verification review

- Assess implementation of verification and test plans and procedures.
- Check completion of all associated CM and Process Assurance tasks.
- Ensure hardware requirement are verified.
- Ensure validation and verification activity satisfied requirements in DO-254.

STAGE OF INVOLVEMENT #4 - Final review

- Assures final hardware product meets DO-254 objectives and is ready for certification.
- Address any open items.

Project

Overview

The proposed project is a tool that aids in the documentation of the SOI#1 which is the Planning Phase (STAGE OF INVOLVEMENT #1 – PLANNING REVIEW). Hardware certification is performed by a review team. The review team will typically divide responsibilities and are assigned various roles based on the project needs. Team members focus on different areas like design, validation/verification data, process assurance and configuration management. In addition to the hardware engineers, there may be one or more non-hardware engineers as part of the team to oversee the system, safety, and application aspects of the project. Each team has one or more project leader who is responsible for coordination, scheduling and other review activities. One or more of the following documents are created as part of the STAGE OF INVOLVEMENT #1 – PLANNING REVIEW

1. Plan for Hardware Aspects of Certification (PHAC)
2. Hardware Design Plan (HDP)
3. Hardware Validation/Verification Plan (HVP)
4. Hardware Configuration Management Plan (HCMP)
5. Hardware Process Assurance Plan (HPAP)

The above documents are as per DO-254 requirements and are required in order to get clearance to use the hardware in an aircraft.

The tool is a web application that aids in creating a project and required documentation for a hardware review.

User can perform following actions:

- Create a project and Input details pertaining to the project
- Assign team leaders and member
- Assign roles to various team members
- Select documentation relevant to the project
- Create Microsoft Word templates of the selected documents along with project details

The database has been designed in such a way that it can be easily extended to support different

- stages of involvements
- revisions of the project
- versions of the documents

Software

Language   :   Java – JDK 1.8

Web Technologies   :   HTML, CSS, Java script, Java Server Pages

Database   :   mySQL

Web Server   :   Apache Tomcat 8.0.15

Tomcat Server Architecture

Tomcat Server is an open-source Java Servlet Container developed by the Apache Software Foundation (ASF). Tomcat employs a hierarchical and modular architecture as illustrated:
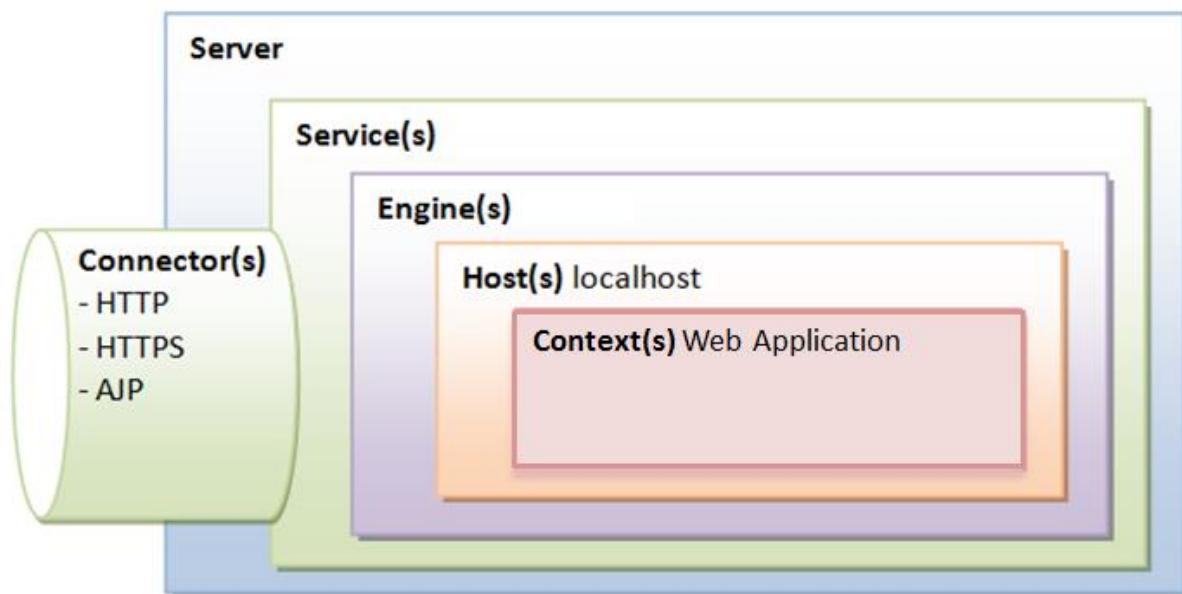
Server is the whole container, representing an instance of Tomcat. It owns a port. Multiple servers can be setup on one node provided they use different ports.

A **Service** is an intermediate component which lives inside a Server and ties one or more Connectors to exactly one Engine.

An **Engine** represents request processing pipeline for a specific Service. As a Service may have multiple Connectors, the Engine receives and processes all

requests from these connectors, handing the response back to the appropriate connector for transmission to the client.

A **Host** is an association of a network name, e.g. www.yourcompany.com, to the Tomcat server. It contains a name and an IP address. The default configuration defines one host called localhost.

A **Context** represents a web application. A Host may contain multiple contexts, each with a unique path.

A **Connector** handles communications with the client. There are multiple connectors available with Tomcat. These include the HTTP connector which is used for most HTTP traffic, especially when running Tomcat as a standalone server, and the AJP connector which implements the AJP (Apache JServ Protoco) protocol used when connecting Tomcat to a web server such as Apache HTTPD server.

MySQL Server Architecture

MySQL, the most popular Open Source SQL database management system, is developed, distributed, and supported by Oracle Corporation. The architecture is illustrated below:
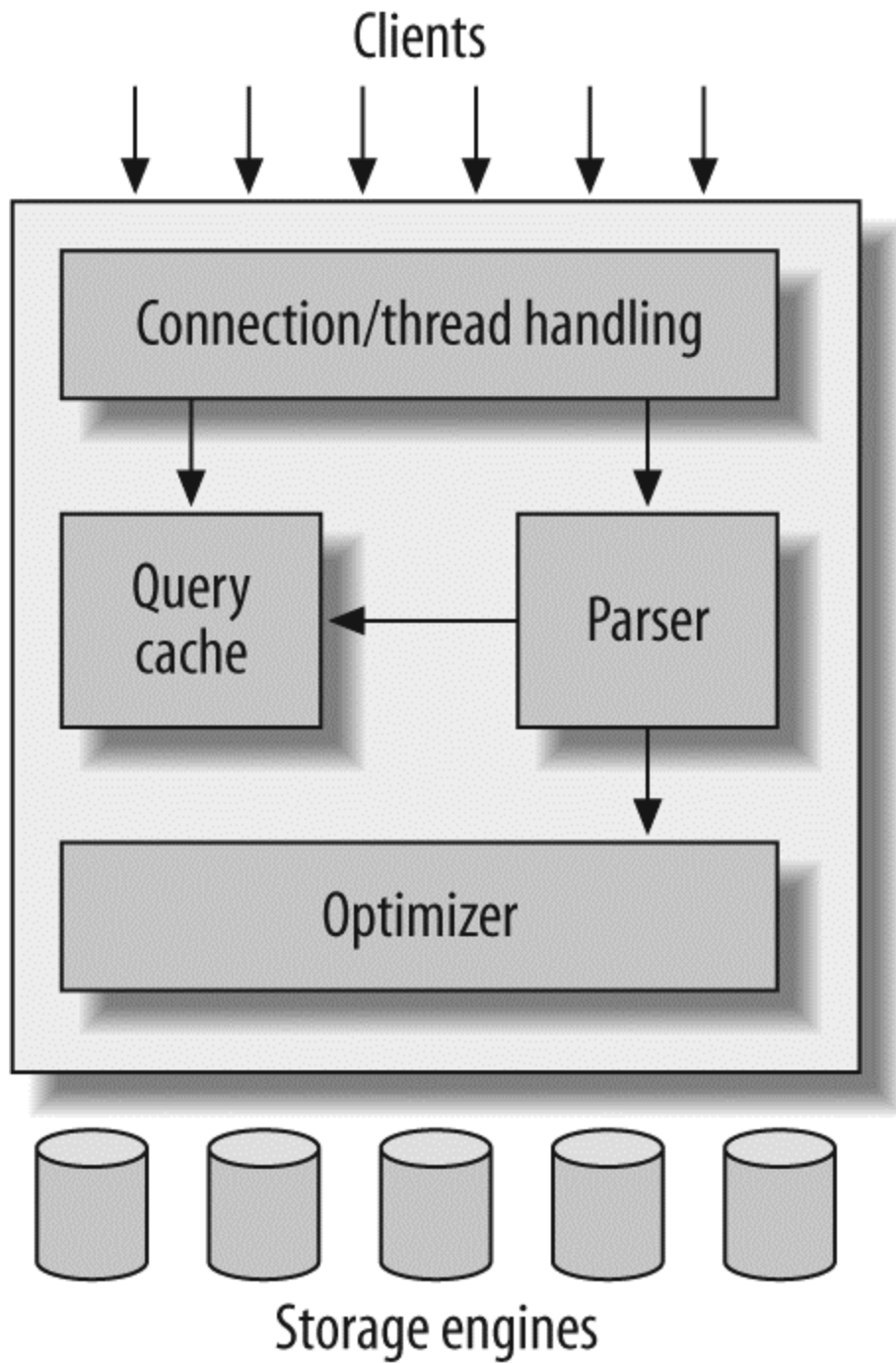
The topmost layer contains the services like connection handling, authentication, security, and so forth.

Much of MySQL's brains are in the second layer, including the code for query parsing, analysis, optimization, caching, and all the built-in functions (e.g., dates, times, math, and encryption). Any functionality provided across storage engines lives at this level for example stored procedures, triggers, and views.

The third layer contains the storage engines. They are responsible for storing and retrieving all data stored "in" MySQL database. The server communicates with them through the *storage engine API*. This interface hides differences between storage engines and makes them largely transparent at the query layer. The API contains low-level functions that perform operations such as "begin a transaction" or "fetch the row that has this primary key." The storage engines don't communicate with each other; they simply respond to requests from the server.

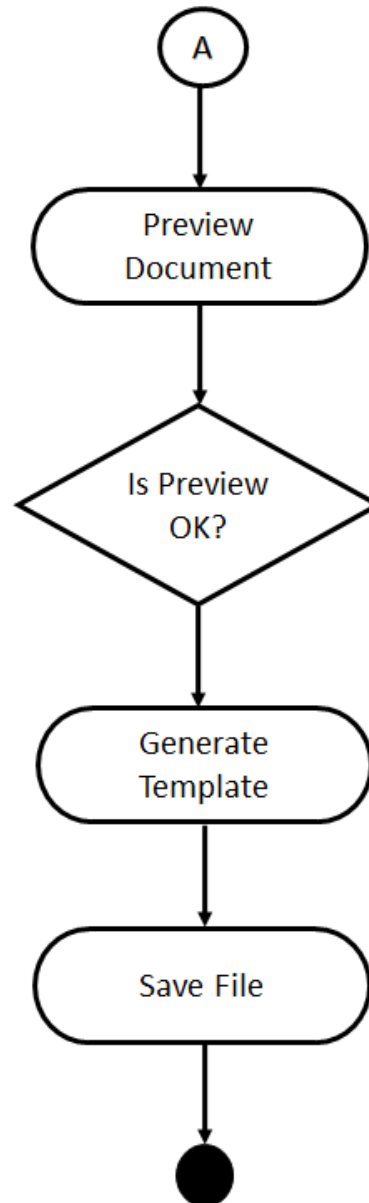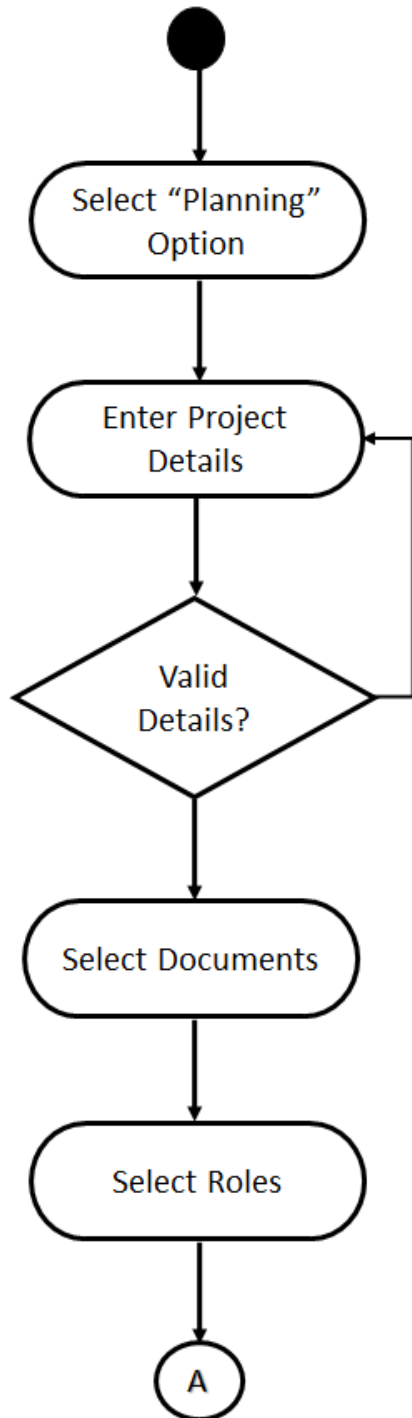# Diagrams

Use Case Diagram
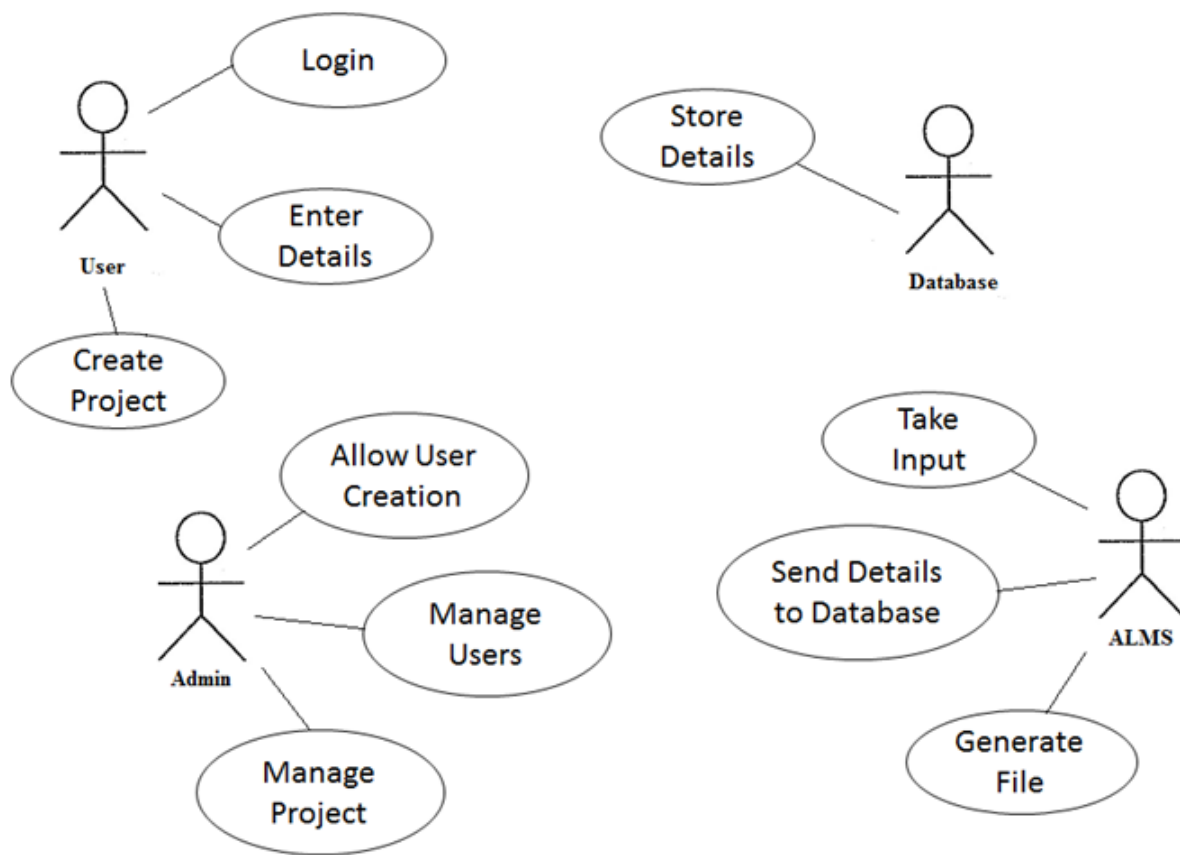
Sequence Diagram
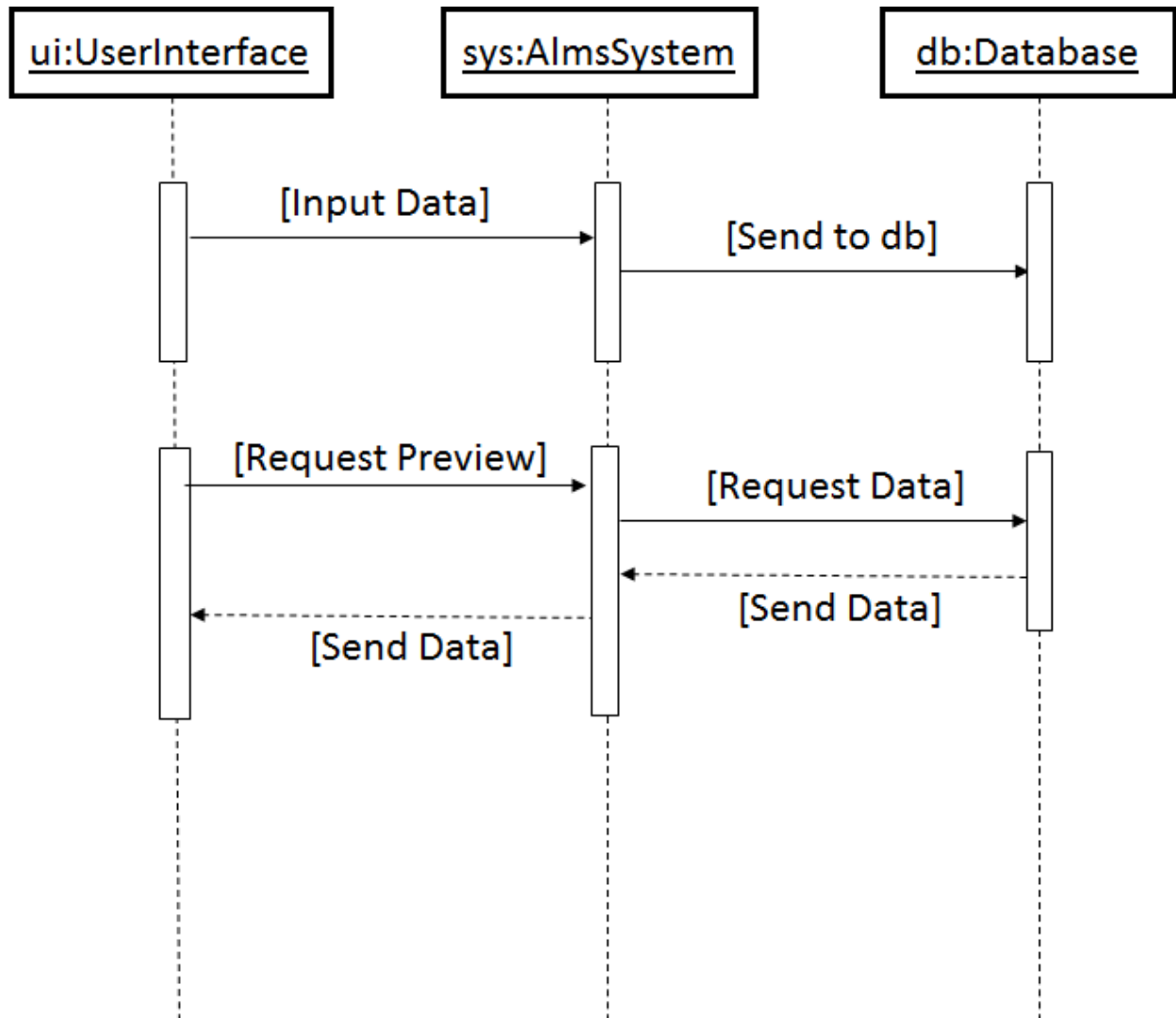
Explanation:

The User inputs the details through the Interface. The ALMS then sends the data to be stored in the MySql Database. When user requests for a preview, the ALMS sends a request to the database. Select queries are executed and the data is retrieved from the database to displayed in the user interface

Activity Diagram

```
                ●
                │
                ▼
      ┌──────────────────┐
      │ Select "Planning" │
      │     Option        │
      └──────────────────┘
                │
                ▼
      ┌──────────────────┐◄─────────┐
      │  Enter Project    │          │
      │    Details        │          │
      └──────────────────┘          │
                │                    │
                ▼                    │
              ◇ Valid ──────────────┘
                Details?
                │
                ▼
      ┌──────────────────┐
      │ Select Documents  │
      └──────────────────┘
                │
                ▼
      ┌──────────────────┐
      │   Select Roles    │
      └──────────────────┘
                │
                ▼
               ( A )
```

```
               ( A )
                │
                ▼
      ┌──────────────────┐
      │     Preview       │
      │    Document       │
      └──────────────────┘
                │
                ▼
              ◇ Is Preview
                 OK?
                │
                ▼
      ┌──────────────────┐
      │     Generate      │
      │    Template       │
      └──────────────────┘
                │
                ▼
      ┌──────────────────┐
      │     Save File     │
      └──────────────────┘
                │
                ▼
                ●
```

Step-1: The user logs in

Step-2: User navigates to the planning option and clicks it

Step-3: The ALMS-Planning Page opens

Step-4: The user enters the project details

Step-5: If the details are correct, proceed to next page else error message is displayed.

Step-6: User can select documents and clicks on "next".

Step-7: Now, the user chooses roles for each member of the project and clicks on next.

Step-8: The preview page opens. If the user is satisfied, he can click on generate word document button to download it in the form of a word document. If not he can click the back button and edit the contents

Step-9: Once the document has been generated, the user can make final changes and save the file

ER Diagram
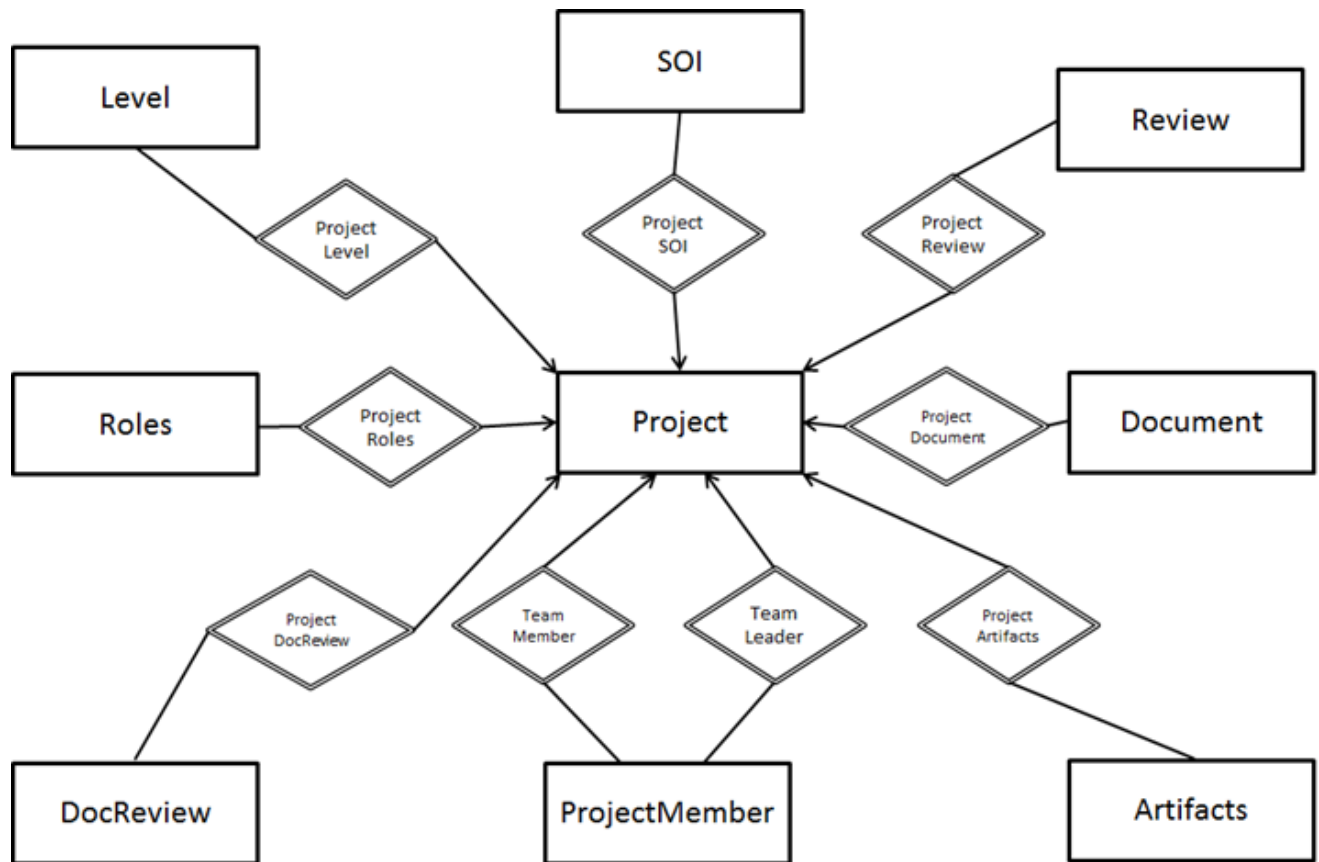
Database Structure

Project		
Column Name	**Datatype**	**Constraint**
ProjectId	Integer	Primary key; not null; auto_increment
Title	Varchar(300)	
ProjectNo	Varchar(30)	Unique
ProjectCode	Varchar(30)	
Division	Varchar(30)	
PartNo	Varchar(15)	
PubNo	Varchar(15)	
Volume	Integer	
ReportNo	Integer	
IssueNo	Integer	
RevNo	Integer	
IssueDate	Date	
RevDate	Date	
StartDate	Date	
CurrentPdc	Date	
Objective	Varchar(1000)	
Deliverables	Varchar(1000)	
Checklist	Varchar(10)	

ProjectLevel		
Column Name	**Datatype**	**Constraint**
ProjectId	Integer	Foreign key(projectid) references project(projectid)
LevelId	Integer	

ProjectMember		
Column Name	**Datatype**	**Constraint**
MemberId	Integer	Primary key not null auto_increment
Name	Varchar(30)	

ProjectSoi

Column Name	Datatype	Constraint
ProjectId	Integer	Foreign key(projectid) references project(projectid)
SoiId	Integer	Foreign key(soiid) references soi(soiid)

TeamLeader

Column Name	Datatype	Constraint
ProjectId	Integer	Foreign key(projectid) references project(projectid)
MemberId	Integer	Foreign key(memberid) references projectmember(memberid)

TeamMember

Column Name	Datatype	Constraint
ProjectId	Integer	Foreign key(projectid) references project(projectid)
MemberId	Integer	Foreign key(memberid) references projectmember(memberid)

ProjectDocument

Column Name	Datatype	Constraint
ProjectId	Integer	Foreign key(projectid) references project(projectid)
DocId	Integer	Foreign key(docid) references document(docid)

ProjectReview

Column Name	Datatype	Constraint
ProjectId	Integer	Foreign key(projectid) references project(projectid)
ReviewId	Integer	Foreign key(reviewid) references review(reviewid)

ProjectDocReview		
Column Name	**Datatype**	**Constraint**
ProjectId	Integer	Foreign key(projectid) references project(projectid)
DocReviewId	Integer	Foreign key(docreviewid) references docreview(docreviewid)

ProjectArtifacts		
Column Name	**Datatype**	**Constraint**
ProjectId	Integer	Foreign key(projectid) references project(projectid)
ArtifactsId	Integer	Foreign key(artifactsid) references artifacts(artifactsid)

CoordinationSheet		
Column Name	**Datatype**	**Constraint**
ProjectId	Integer	Foreign key(projectid) references project(projectid)
DocId	Integer	Foreign key(docid) references document(docid)
RoleId	Integer	Foreign key(roleid) references roles(roleid)
MemberId	Integer	Foreign key(memberid) references projectmember(memberid)

Test Cases

Test case	Test Scenario	Test Step	Expected result
01	Create Project	Enter all Project details with a unique Project Number	Project should be created successfully
02	Create Project	Enter all Project details with a Project Number that already exists in the system	User should be prompted to enter a unique project number
03	Create Project	Ensure user has input all required data	If any data is incorrect or not of the appropriate format, error message should be displayed.
04	Create team members	User should be able to create upto 10 team members.	If input is properly provided team members should be added to the project successfully
05	Create team members	User should be able to create upto 10 team members	System should not allow to add team members beyond 10
06	Create project leaders	User should be able to create upto 3 project leaders.	If input is properly provided project leaders should be added to the project successfully
07	Create project leaders	User should be able to create upto 3 project leaders	System should not allow to add project leaders beyond 3

Test case	Test Scenario	Test Step	Expected result
08	Create Project	Select different levels, artifacts and reviews	Selected options should be updated to the project
09	Create Project	Select documents relevant to the project	Based on the documents selected, option to assign roles to team members should be provided
10	Assign Roles	Check Team members displayed on the UI	Team members who are part of the project should be displayed
11	Assign Roles	Select and assign roles to team members	Ensure Team members are assigned the role that was selected in the UI

User Interface Screen Shots

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ISO 9001:2008 Certified

DAL Level	☑ Level-1 ☐ Level-2 ☐ Level-3
SOI	☑ #1 ☑ #2 ☐ #3 ☐ #4 ☐ #5
Document(s)	☑ PHAC ☐ HVP ☐ HDP ☐ HCMP ☐ HPAP
Review(s)	☐ Planning ☑ Design ☐ Verification and Validation ☐ Final
Checklist	◯ NAL ◉ FAA
Artifacts(s)	☑ Review All Plans ☐ Addition ☐ Consideration ☐ Review

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Coordination Sheet for PHAC

Assign Roles to Team Members:

Author:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Verification:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Process Assurance:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Configuration Managemnt:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Certification Liason:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Approval:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

Certification Authority:
- Kritika Murugan
- Dhruv Sharma
- Sneha Bharti

| Back | Submit |

Challenges faced

- Transferring data between Java Server Pages and Javascript: There was a need in the code to fetch data from the database and display it in the user interface. The data fetched by the JSP had to be used in javascript. Since JavaScript works on the front end and JSP works on the back-end it is not possible to directly transfer data between them. So, the values were first inserted into a hidden input type via JavaScript and when the form was submitted to the next page, the values were sent to the next page and from there, JSP could access it as usual and the values could easily be stored in the database.

- Creating Dynamic checkboxes: When creating dynamic checkboxes for assigning roles to the team members, the name of the team members is fetched from the database. The same set of team members are to be displayed for all the roles available. Hence the check boxes that are dynamically created have the same names. This causes loss of data if the same team member plays multiple roles. To overcome this problem, the selected team members for each role are stored in hidden fields using javascript. On submit, the hidden fields are read using JSP and saved in the database.

- Using filesaver.js class to generate a Microsoft word document: FileSaver.js is the class that can be used to save files or sensitive information on the client side that shouldn't be sent to an external server.

Acronyms

CSIR	Council of Scientific & Industrial Research
CSS	Cascading Style Sheet
DB	Database
FAA	Federal Aviation Administration
HCMP	Hardware Configuration Management Plan
HDP	Hardware Design Plan
HPAP	Hardware Process Assurance Plan
HTML	Hyper Text Markup Language
HVP	Hardware Validation/Verification Plan
JDK	Java Development Kit
JS	Java Script
JSP	Java Server Page
NAL	National Aerospace Laboratories
PHAC	Plan for Hardware Aspects of Certification
SOI	Stage of Involvement