BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
WORK INTEGRATED LEARNING PROGRAMMES
COURSE HANDSON LAB ASSIGNMENT

M.Tech

Course Title:	**Database Systems and Applications**
Course No:	**SESAP ZC337**
Lab Session:	**Nov-Dec 25**

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WORK INTEGRATED
LEARNING PROGRAMMES

SOFTWARE REQUIREMENTS SPECIFICATION (SRS) DOCUMENT

For EMPLOYEE MANAGEMENT Database System PROJECT ASSIGNMENT - DBSA

Version: 1.0
Prepared by: Divyansh, Student ID: 2024SL70022
Date: November 19, 2025

Contents

SRS Document 1: Employee Management Database System

Formalization of Term I Prototype

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1. Introduction

1.1 Purpose

This Software Requirements Specification (SRS) defines the requirements for the Employee Management Database System, designed to manage employee, department, project, and dependent information with advanced normalization (up to BCNF) and optimized join operations. The document specifies all functional and non-functional requirements, database schema constraints, and user interactions. It serves as a reference for database developers and system evaluators. The system supports efficient data access, analytical queries, and integrity enforcement across interconnected entities such as employees, departments, projects, and dependents.

1.2 Scope

The Employee Management Database System automates data management for a company's core operations.

Functions include:

- Maintaining employee personal and employment details
- Tracking departmental structure and managers
- Recording projects and their associated departments
- Tracking employee participation in projects and dependents

Database is a normalized relational system supporting:

- Employee, department, project, and dependent management
- Recursive relationships (supervision)
- Multi-entity joins and derived reporting
- The system ensures data integrity, referential consistency, and normalization (3NF/BCNF)
- Data models optimized through BCNF to ensure minimal redundancy and fast join performance
- **Future provisions for multimodal extensions (Image/Spatial data)**

1.3 Definitions, Acronyms, and Abbreviations

Term	Meaning
DBMS	Database Management System
SRS	Software Requirements Specification
DDL	Data Definition Language
DML	Data Manipulation Language
PK	Primary Key
FK	Foreign Key
SQL	Structured Query Language
BCNF	Boyce-Codd Normal Form - Advanced database normalization eliminating all functional dependency anomalies
CRUD	Create, Read, Update, Delete operations
SQLite3	Lightweight relational database management system
BLOB	Binary Large Object for storing multimodal data

1.4 References

- **Term I Assignment Implementation Report** (DivyanshDBSA.pdf)
- **IEEE 830–1998, ISO/IEC/IEEE 29148:2018** - Systems and Software Engineering Requirements
- **Elmasri & Navathe, Fundamentals of Database Systems, 7th Ed.**
- **Database System Concepts** - Silberschatz, Korth, Sudarshan
- **SQLite Documentation** - Official SQLite3 Reference

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2. Overall Description

2.1 Product Perspective

The Employee Management Database System is a relational database developed using SQL and runs under SQLite3 RDBMS, with full-stack implementation using React.js and Node.js.

It is a central data store for all company divisions and will be integrated with future applications such as payroll or project tracking tools. The system is designed with **provisions for multimodal extensions** including Image/Document storage (BLOB) and Spatial data capabilities.

2.2 Product Functions

- Manage employees and departments
- Assign managers to departments
- Record projects and link them to departments
- Track which employees work on which projects
- Record employee dependents
- Generate summary and analytical queries
- **Future capability:** Store and manage employee profile photos (Image Extension)
- **Future capability:** Geographic location tracking for departments and projects (Spatial Extension)

2.3 User Characteristics

User Role	Description
Database Administrator	Defines database schema, manages users, backups, system maintenance
HR Manager	Maintains employee, department, dependent data with full CRUD access
Project Manager	Manages project details and employee assignments
Employee	Read-only access to personal data and project assignments

2.4 Constraints

- The database must be in **Boyce-Codd Normal Form (BCNF)** or higher
- All referential integrity constraints must be enforced through FKs
- Access control must restrict schema modification to the Administrator
- Must use standard SQL DDL/DML commands
- Web-based interface for cross-platform accessibility
- SQLite3 for lightweight deployment

2.5 Assumptions and Dependencies

- Each employee belongs to one department
- Each department has exactly one manager
- Each project belongs to one department
- The system depends on an underlying SQL RDBMS environment
- Single organizational unit deployment
- English language interface
- Standard web browser compatibility required

2.6 Database Normalization Strategy

The database uses progressive normalization up to **BCNF** to:

- Ensure atomic attribute dependencies
- Eliminate redundancy and update anomalies
- Improve consistency in join-based queries (especially analytical joins)
- Maintain **future extensibility** for multimodal data types (BLOB for images, Spatial for geographic data)

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3. Specific Requirements

3.1 Functional Requirements

ID	Requirement Description	Priority
FR1	The system shall allow creation of new Employee records, including SSN, Name, Birth Date, Address, Sex, Salary, Department No, and Supervisor SSN.	High
FR2	The system shall allow retrieval and listing of all Employees with their related Department, Supervisor, and Project Assignments.	High
FR3	The system shall allow updating Employee attributes except the primary key (SSN).	High
FR4	The system shall allow deletion of an Employee only if referential constraints (e.g., dependents, assignments) permit.	High
FR5	The system shall allow creation of new Departments with Department Number, Name, Manager SSN, and Start Date.	High
FR6	The system shall allow updating Department details, including Manager assignment.	Medium
FR7	The system shall allow deletion of Departments with proper restriction checks.	Medium
FR8	The system shall allow creation of Project records with Project Number, Name, Location, and owning Department Number.	High
FR9	The system shall allow updating Project details and Department assignment.	Medium
FR10	The system shall allow deleting Projects and automatically remove related Work Assignments.	Medium
FR11	The system shall allow assigning an Employee to a Project with recorded weekly Hours (0–80).	High
FR12	The system shall allow updating the Hours in a Work Assignment.	Medium
FR13	The system shall allow removing an Employee–Project assignment.	Medium
FR14	The system shall allow creation of Dependent records linked to Employees.	Medium
FR15	The system shall allow updating and deleting Dependent records.	Medium
FR16	The system shall enforce referential integrity between Employees–Departments, Employees–Supervisors, Projects–Departments, and Dependents–Employees.	High
FR17	The system shall allow execution of join queries combining Employees, Departments, Projects, Supervisors, and Dependents.	High
FR18	The system shall allow displaying Employee supervisory hierarchy (recursive self-join).	Medium
FR19	The system shall allow searching/filtering across all entity categories.	Medium
FR20	The system shall allow consistent CRUD operations through the React front-end with backend validation.	High

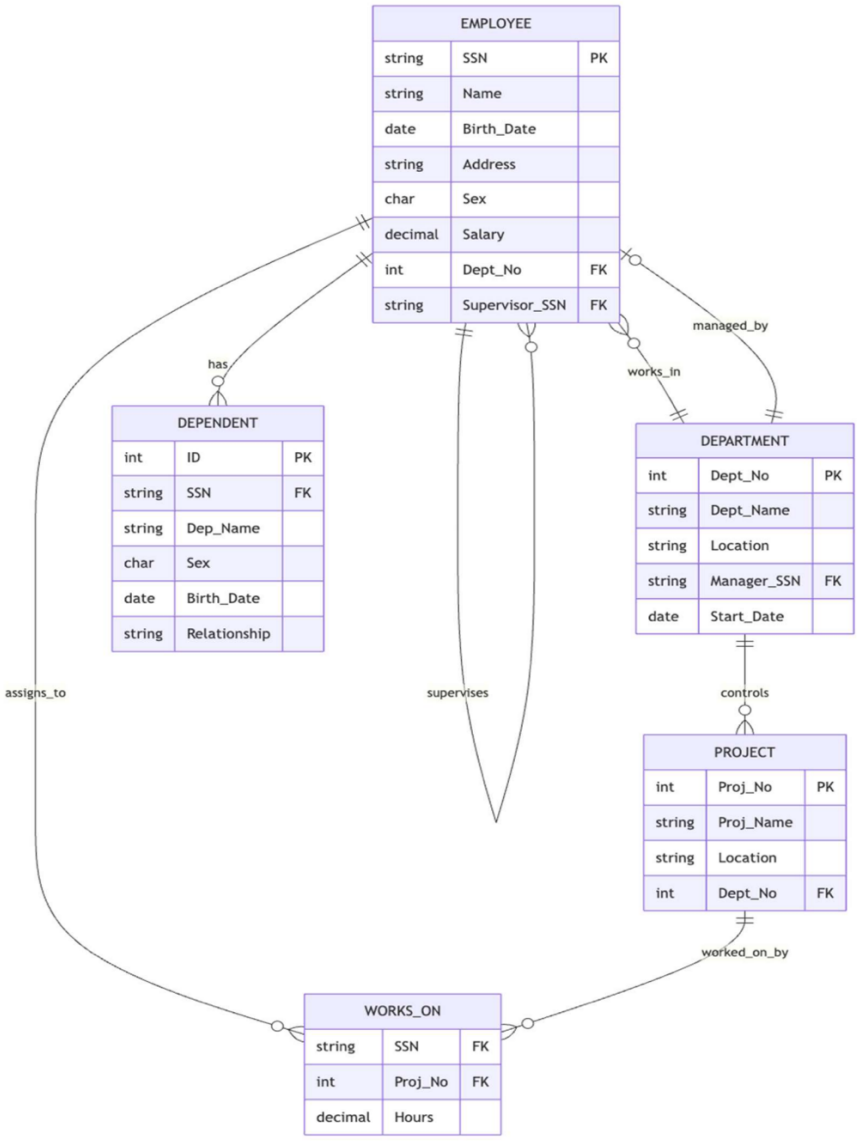
3.2 Non-Functional Requirements

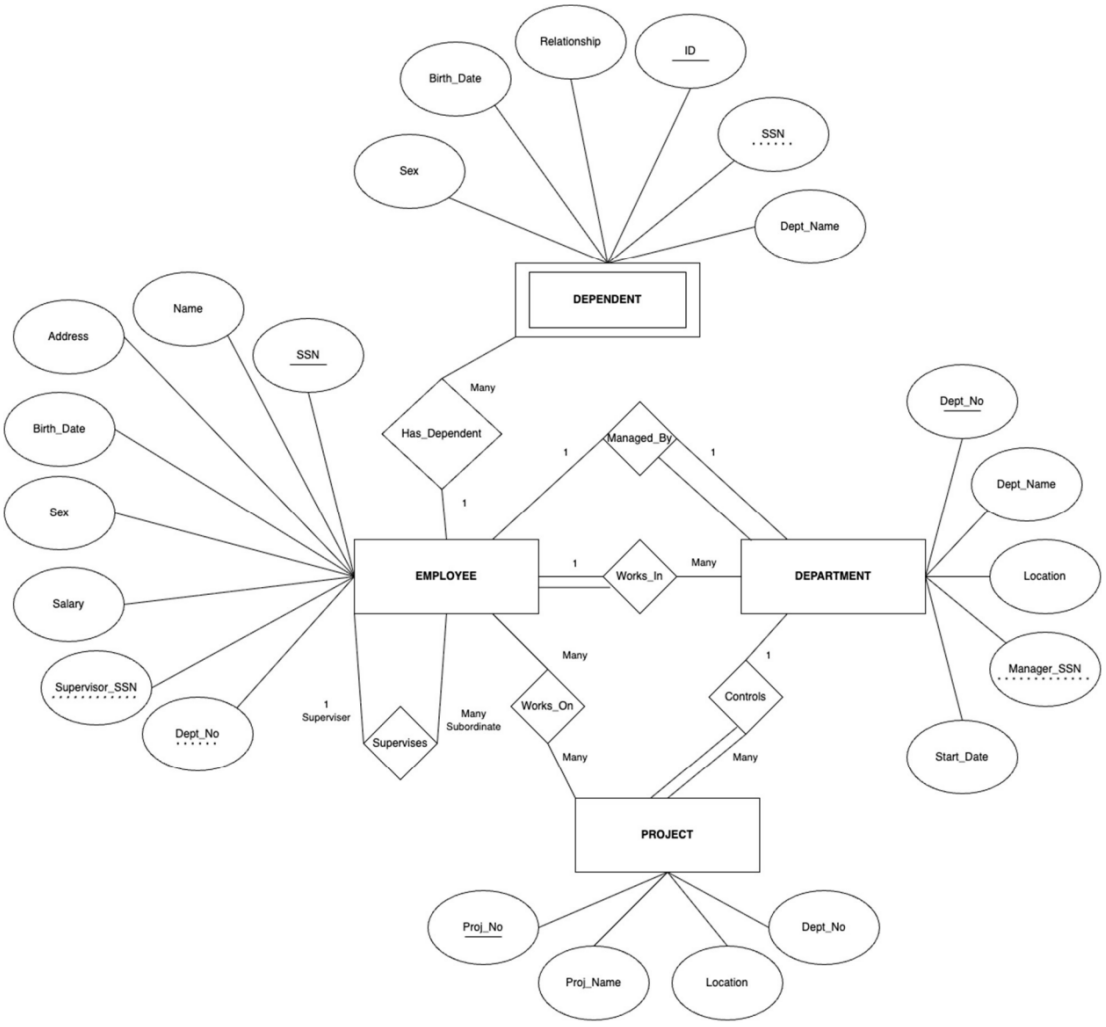
ID	Category	Requirement Description	Priority
NFR1	Performance	Query execution for up to 1,000 rows shall complete within 2 seconds.	High
NFR2	Performance	Joins involving up to 4 tables (Employee–Works_On–Project–Department) shall execute under 3 seconds.	High
NFR3	Reliability	The system shall enforce PK, FK, CHECK, and NOT NULL constraints to prevent invalid data insertion.	High
NFR4	Reliability	Delete operations shall follow cascade/restrict rules to ensure no orphan records.	High
NFR5	Security	User input to the backend shall be validated to prevent SQL injection.	High
NFR6	Security	Only authorized backend endpoints may modify database records.	High
NFR7	Maintainability	The schema shall be structured in BCNF to reduce anomalies and ease schema evolution.	Medium
NFR8	Scalability	The system architecture (React + Node + SQLite) shall support migration to PostgreSQL/MySQL without redesign.	Medium
NFR9	Usability	UI forms shall validate all inputs client-side before sending to backend.	Medium
NFR10	Availability	The system shall ensure ACID-compliant commits via SQLite transaction support.	Medium

4. Database Design

4.1 Entity and Attribute Definitions

1. **EMPLOYEE**(SSN, Name, Birth_Date, Address, Sex, Salary, Supervisor_SSN, Dept_No)
2. **DEPARTMENT**(Dnumber, Dname, Location, Manager_SSN, Mgr_start_date)
3. **PROJECT**(Pnumber, Pname, Plocation, Dnum)
4. **WORKS_ON**(Essn, Pno, Hours)
5. **DEPENDENT**(ID, Essn, Dependent_name, Sex, Bdate, Relationship)




Relationship
ID
Birth_Date
SSN
Sex
Dept_Name
DEPENDENT
Name
Address
SSN
Birth_Date
Sex
Salary
Supervisor_SSN
Dept_No
Many
Has_Dependent
1
1
Managed_By
1
Dept_No
Dept_Name
Location
Manager_SSN
Start_Date
EMPLOYEE
1
Works_In
Many
DEPARTMENT
1
Superviser
Supervises
Many
Subordinate
Many
Works_On
Many
1
Controls
Many
PROJECT
Proj_No
Proj_Name
Location
Dept_No

4.2 Relational Schema (DDL)

```sql
-- Department Entity (Created first due to FK dependencies)
CREATE TABLE DEPARTMENT (
    Dnumber INTEGER PRIMARY KEY,
    Dname VARCHAR(50) UNIQUE NOT NULL,
    Location VARCHAR(100),
    Manager_SSN VARCHAR(11) UNIQUE,
    Mgr_start_date DATE NOT NULL
);

-- Employee Entity
CREATE TABLE EMPLOYEE (
    SSN VARCHAR(11) PRIMARY KEY,
    Name VARCHAR(100) NOT NULL,
    Birth_Date DATE,
    Address VARCHAR(200),
    Sex CHAR(1) CHECK(Sex IN ('M','F')),
    Salary DECIMAL(10,2) CHECK(Salary > 0),
    Supervisor_SSN VARCHAR(11),
    Dept_No INTEGER,
    FOREIGN KEY (Supervisor_SSN) REFERENCES EMPLOYEE(SSN),
    FOREIGN KEY (Dept_No) REFERENCES DEPARTMENT(Dnumber)
);

-- Add Manager FK constraint after EMPLOYEE table exists
ALTER TABLE DEPARTMENT
ADD FOREIGN KEY (Manager_SSN) REFERENCES EMPLOYEE(SSN);

-- Project Entity
CREATE TABLE PROJECT (
    Pnumber INTEGER PRIMARY KEY,
    Pname VARCHAR(100) UNIQUE NOT NULL,
    Plocation VARCHAR(50),
    Dnum INTEGER,
    FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber)
);

-- Works_On/Assignment Entity
CREATE TABLE WORKS_ON (
    Essn VARCHAR(11),
    Pno INTEGER,
    Hours DECIMAL(4,1) CHECK(Hours BETWEEN 0 AND 80),
    PRIMARY KEY (Essn, Pno),
    FOREIGN KEY (Essn) REFERENCES EMPLOYEE(SSN),
    FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber)
);

-- Dependent Entity
CREATE TABLE DEPENDENT (
    ID INTEGER PRIMARY KEY AUTOINCREMENT,
    Essn VARCHAR(11),
    Dependent_name VARCHAR(50),
    Sex CHAR(1) CHECK(Sex IN ('M','F')),
    Bdate DATE,
    Relationship VARCHAR(20) CHECK(Relationship IN ('Spouse','Son','Daughter','Parent','Other')),
    FOREIGN KEY (Essn) REFERENCES EMPLOYEE(SSN) ON DELETE CASCADE
);
```

4.3 Normalization Process

Normal Form	Description	Achieved Purpose
1NF	Atomic attribute values; repeating groups removed	Each column contains indivisible data
2NF	Non-key attributes depend on full PK	Partial dependencies removed
3NF	Transitive dependencies removed	No non-key attribute depends on another non-key
BCNF	Every determinant is a candidate key	Functional dependencies refined

Result: Each table in Employee Management DB is in **BCNF**, allowing optimal join-based query decomposition. The EMPLOYEE–WORKS_ON–PROJECT join is lossless, maintaining full consistency.

4.4 Advanced Joins and Analytical Views (Level 7 Optimization)

Example Derived Views:

```sql
-- Comprehensive Employee-Project View
CREATE VIEW EMP_PROJECT_VIEW AS
SELECT E.SSN, E.Name, D.Dname AS Department, P.Pname AS Project, W.Hours
FROM EMPLOYEE E
JOIN WORKS_ON W ON E.SSN = W.Essn
JOIN PROJECT P ON P.Pnumber = W.Pno
JOIN DEPARTMENT D ON D.Dnumber = E.Dept_No;

-- Management Hierarchy View
CREATE VIEW MANAGEMENT_HIERARCHY AS
SELECT E.SSN, E.Name AS Employee, S.Name AS Supervisor, D.Dname AS Department
FROM EMPLOYEE E
LEFT JOIN EMPLOYEE S ON E.Supervisor_SSN = S.SSN
JOIN DEPARTMENT D ON E.Dept_No = D.Dnumber;
```

Example Analytical Queries:

- Q1: List total hours each employee worked per project
- Q2: Find employees supervised by a manager working on the same project
- Q3: Aggregate average salary per department
- Q4: Identify departments managing projects at multiple locations

Performance Optimization:

- Create indexes on all FK columns (e.g., Essn, Pno, Dept_No)
- Use materialized views for complex analytical joins
- Employ query rewriting for automatic join optimization

4.5 Table Definitions (Core Schema with Indexes)

```
-- Performance Indexes for Join Optimization
CREATE INDEX idx_employee_dept_no ON EMPLOYEE(Dept_No);
CREATE INDEX idx_employee_supervisor ON EMPLOYEE(Supervisor_SSN);
CREATE INDEX idx_works_on_essn ON WORKS_ON(Essn);
CREATE INDEX idx_works_on_pno ON WORKS_ON(Pno);
CREATE INDEX idx_project_dnum ON PROJECT(Dnum);
CREATE INDEX idx_dependent_essn ON DEPENDENT(Essn);
```

These indexes support high-performance joins in analytical workloads and ensure optimal query execution times.

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5. System Features

5.1 Data Integrity Features

Feature	Implementation	Benefit
Normalization	BCNF schema design	Eliminates update anomalies and data redundancy
Constraint Enforcement	CHECK, UNIQUE, NOT NULL constraints	Ensures data quality and business rule compliance
Referential Integrity	Foreign key constraints with CASCADE options	Maintains relationship consistency
Transaction Support	ACID-compliant operations	Ensures data consistency during concurrent access

5.2 Reporting and Query Capabilities

Supported Query Types

- **Employee-Department Joins**: Manager and departmental reporting
- **Project-Assignment Analysis**: Resource allocation and workload distribution
- **Hierarchical Queries**: Supervisory relationship traversal
- **Aggregate Reporting**: Salary statistics, project hours summation
- **Cross-Entity Analytics**: Multi-table complex reporting

5.3 Advanced Features

- **Recursive Relationships**: Employee supervisory hierarchy management
- **Composite Keys**: Multi-attribute primary keys for dependent and assignment entities
- **Temporal Data**: Manager start dates and dependent birthdates
- **Gender Constraints**: Validated enumeration values

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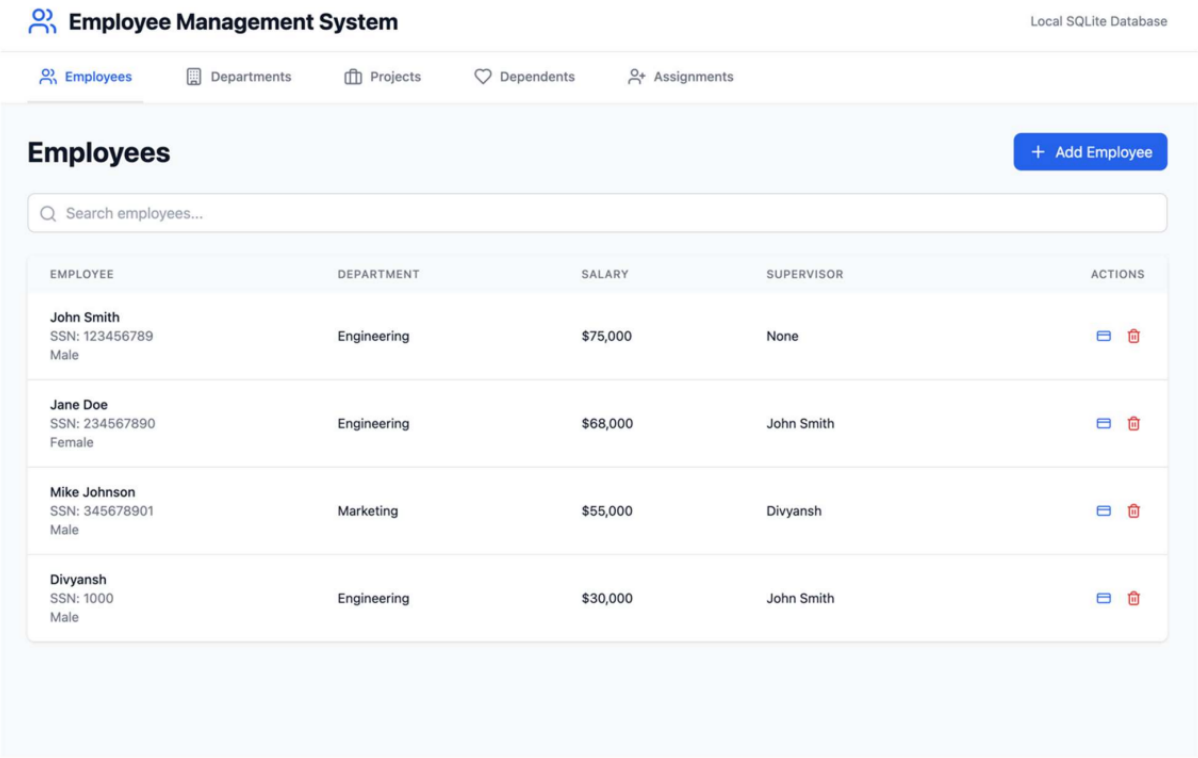
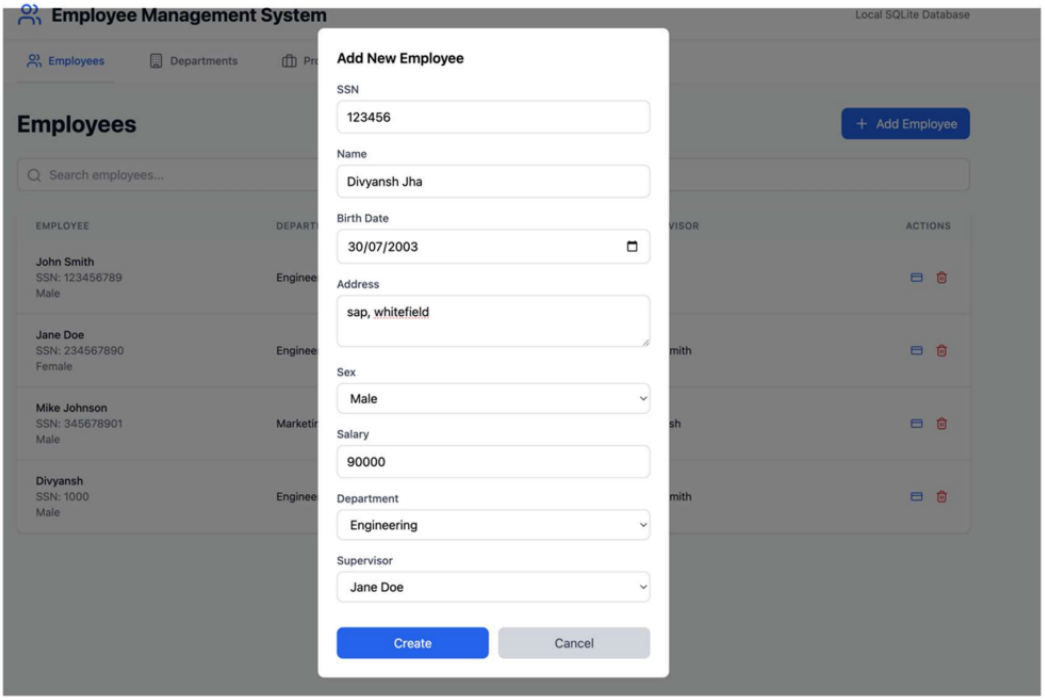
6. External Interface Requirements

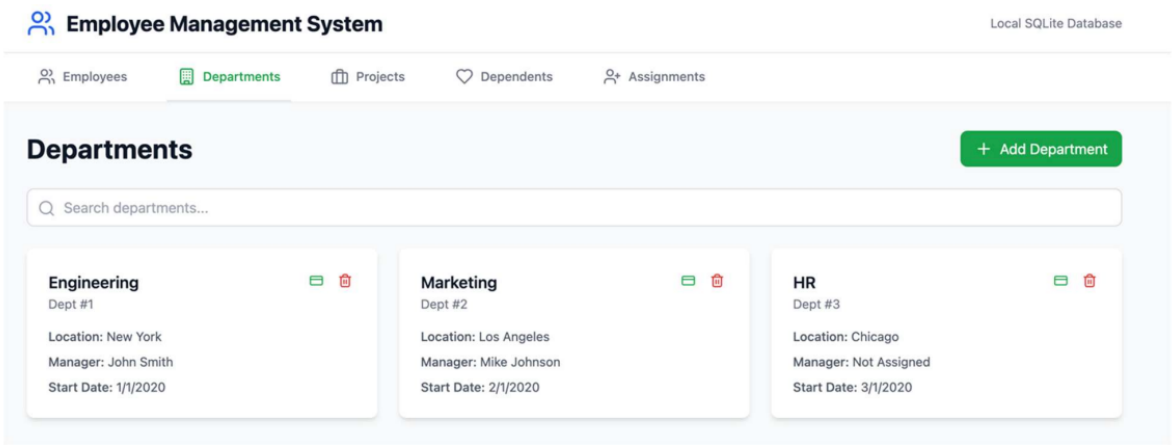
Interface Type	Description
User Interface	React.js web application with responsive design; SQL console/DBMS GUI compatibility
Hardware	Standard server/workstation: 4GB RAM, Dual-core 2.0 GHz, 500MB storage, Broadband network
Software	SQLite3 RDBMS, Node.js runtime (16.x+), Modern web browsers (Chrome 90+, Firefox 88+, Safari 14+, Edge 90+)
Communication	RESTful APIs for client-server communication; Local DB connection (JDBC/ODBC compatible)

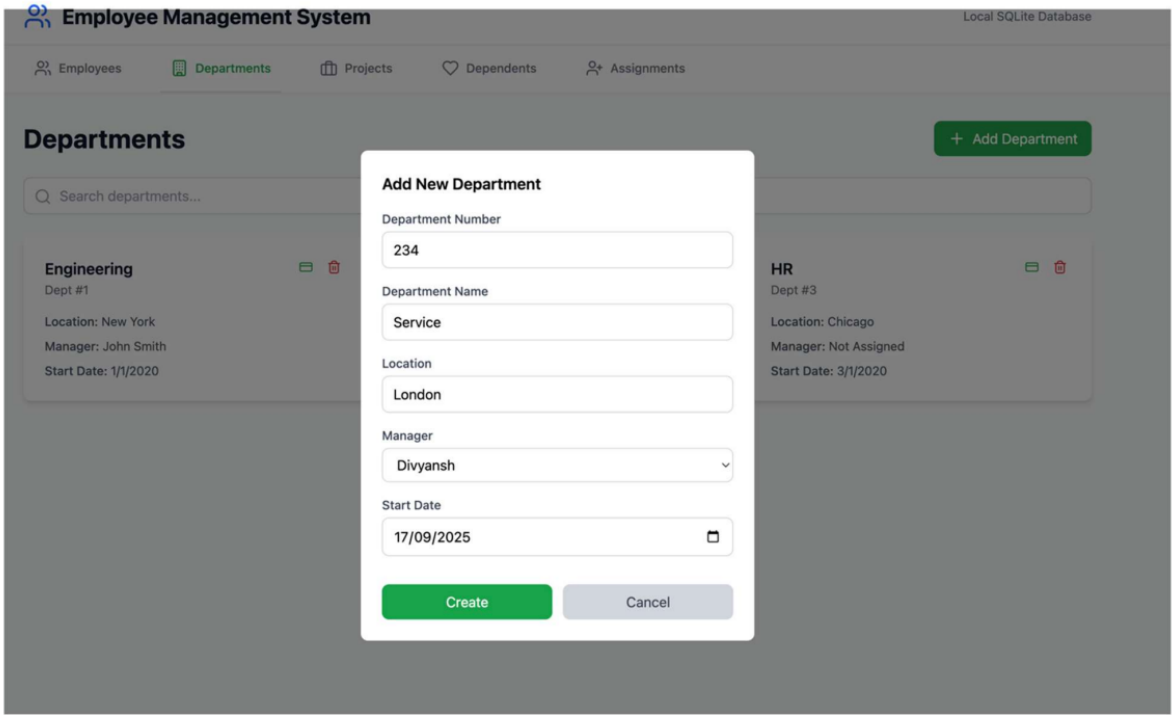
Integration Capability:
Supports integration with data analytics tools (e.g., Power BI, Tableau, or SQL-based dashboards) for join-based queries and reporting.

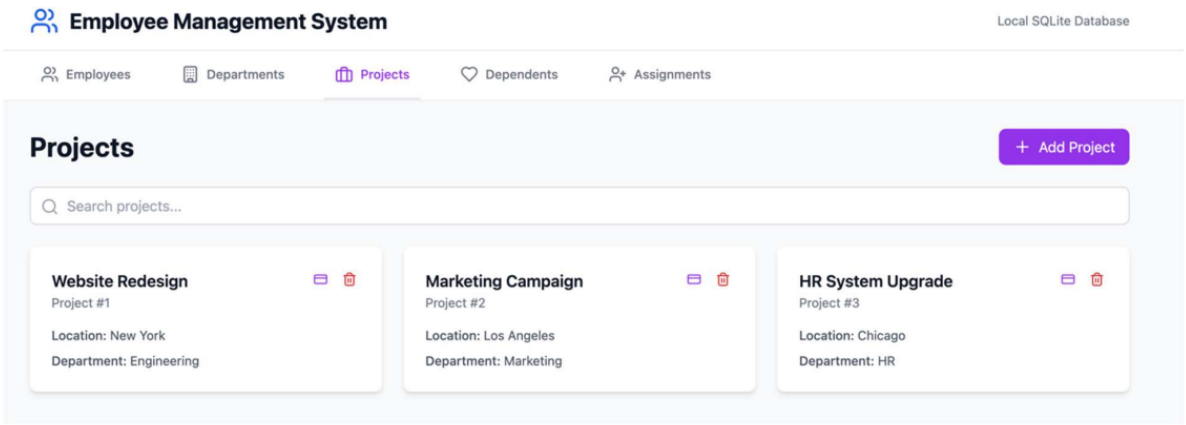
6.1 Screenshots of working CRUD

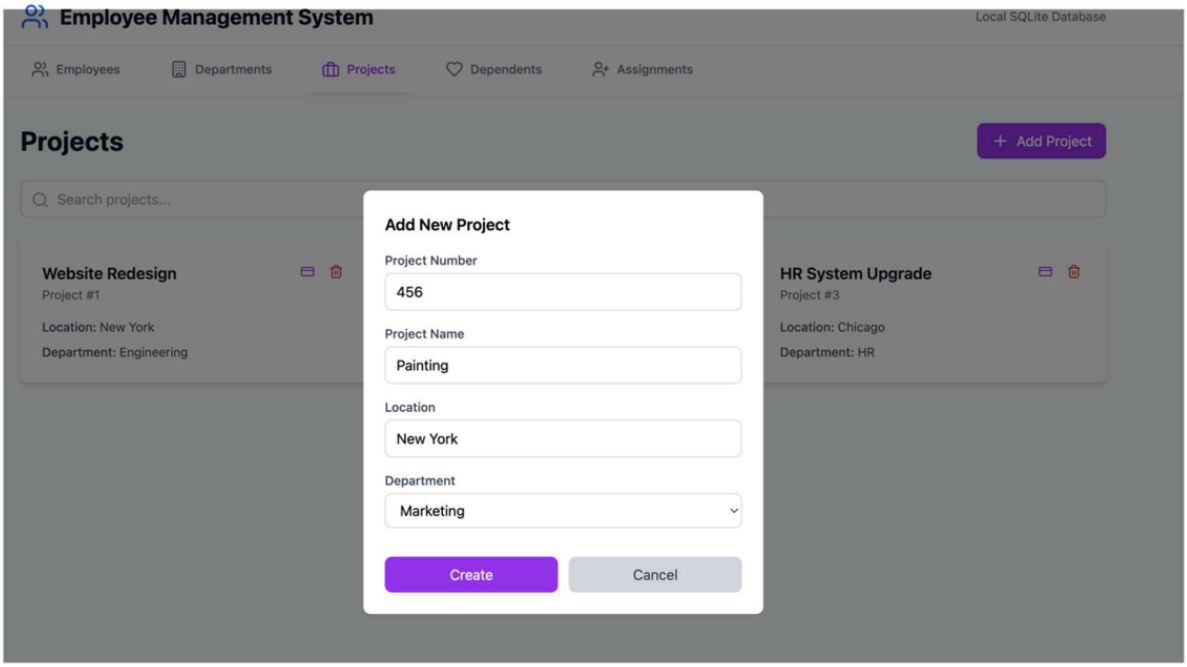


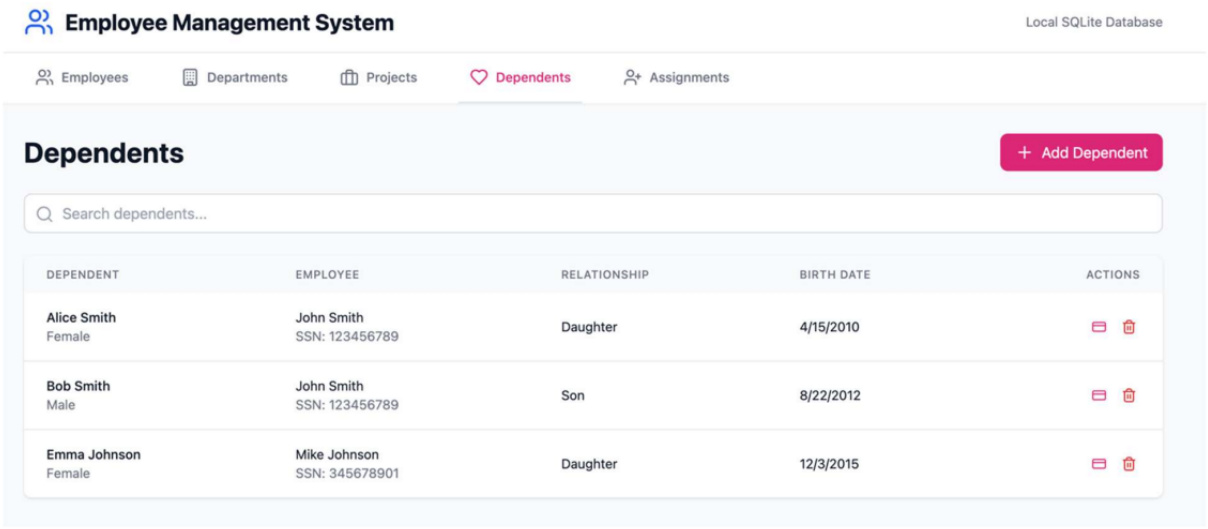


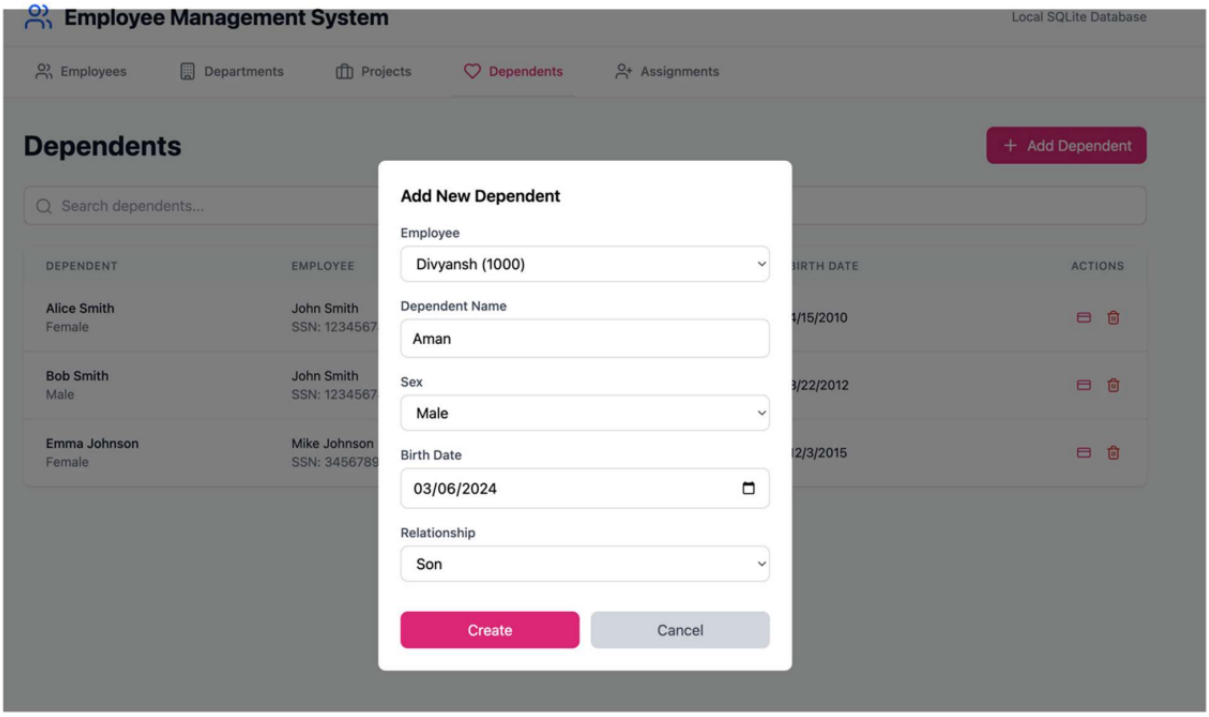

Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Departments
+ Add Department
Search departments...
Engineering
Dept #1
Location: New York
Manager: John Smith
Start Date: 1/1/2020
Marketing
Dept #2
Location: Los Angeles
Manager: Mike Johnson
Start Date: 2/1/2020
HR
Dept #3
Location: Chicago
Manager: Not Assigned
Start Date: 3/1/2020

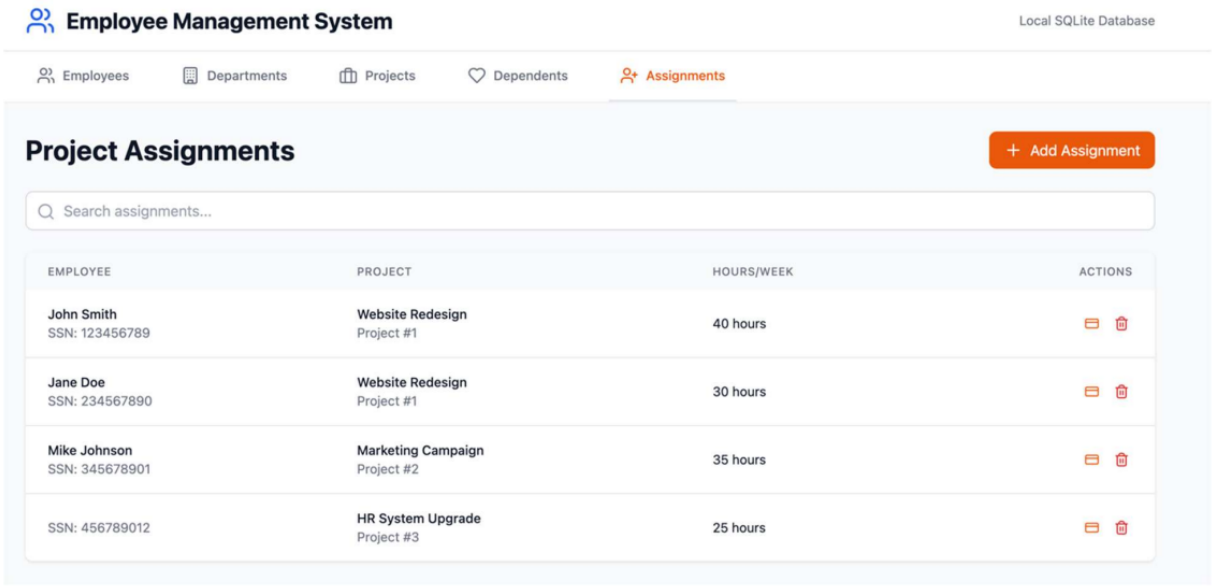

Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Departments
+ Add Department
Search departments...
Engineering
Dept #1
Location: New York
Manager: John Smith
Start Date: 1/1/2020
HR
Dept #3
Location: Chicago
Manager: Not Assigned
Start Date: 3/1/2020
Add New Department
Department Number
234
Department Name
Service
Location
London
Manager
Divyansh
Start Date
17/09/2025
Create
Cancel

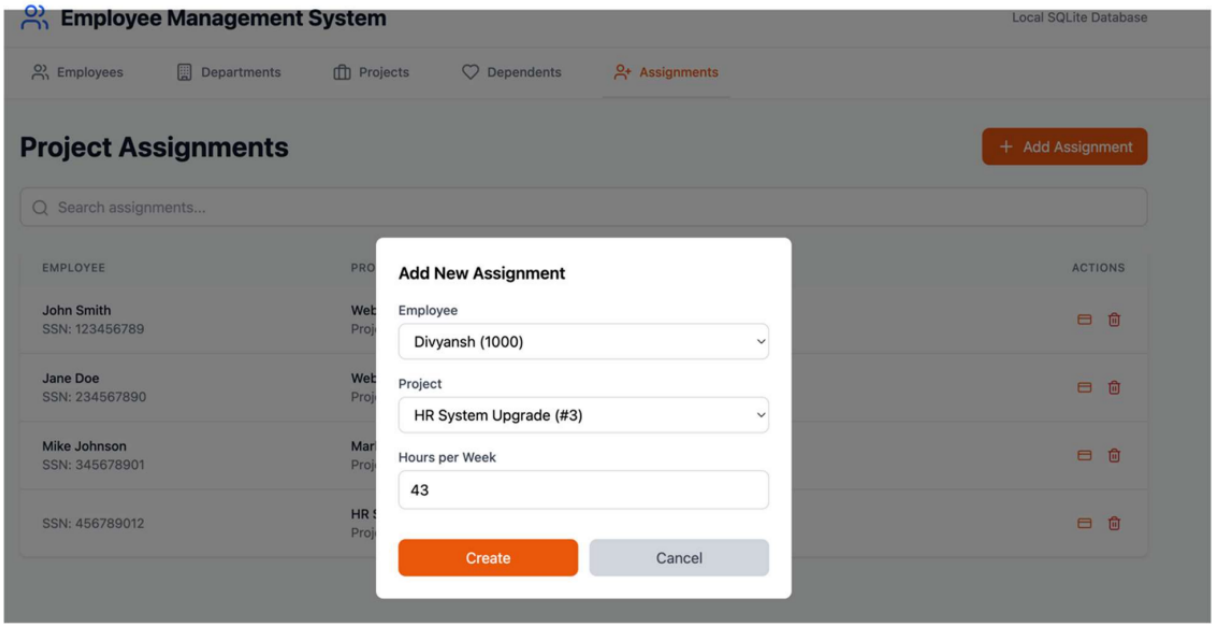

Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Projects
+ Add Project
Search projects...
Website Redesign
Project #1
Location: New York
Department: Engineering
Marketing Campaign
Project #2
Location: Los Angeles
Department: Marketing
HR System Upgrade
Project #3
Location: Chicago
Department: HR


Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Projects
+ Add Project
Search projects...
Website Redesign
Project #1
Location: New York
Department: Engineering
HR System Upgrade
Project #3
Location: Chicago
Department: HR
Add New Project
Project Number
456
Project Name
Painting
Location
New York
Department
Marketing
Create
Cancel


Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Dependents
+ Add Dependent
Search dependents...
DEPENDENT
EMPLOYEE
RELATIONSHIP
BIRTH DATE
ACTIONS
Alice Smith
Female
John Smith
SSN: 123456789
Daughter
4/15/2010
Bob Smith
Male
John Smith
SSN: 123456789
Son
8/22/2012
Emma Johnson
Female
Mike Johnson
SSN: 345678901
Daughter
12/3/2015


Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Dependents
+ Add Dependent
Search dependents...
Add New Dependent
Employee
Divyansh (1000)
Dependent Name
Aman
Sex
Male
Birth Date
03/06/2024
Relationship
Son
Create
Cancel


Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Project Assignments
+ Add Assignment
Search assignments...
EMPLOYEE
PROJECT
HOURS/WEEK
ACTIONS
John Smith
SSN: 123456789
Website Redesign
Project #1
40 hours
Jane Doe
SSN: 234567890
Website Redesign
Project #1
30 hours
Mike Johnson
SSN: 345678901
Marketing Campaign
Project #2
35 hours
SSN: 456789012
HR System Upgrade
Project #3
25 hours


Employee Management System
Local SQLite Database
Employees
Departments
Projects
Dependents
Assignments
Project Assignments
+ Add Assignment
Search assignments...
EMPLOYEE
ACTIONS
John Smith
SSN: 123456789
Jane Doe
SSN: 234567890
Mike Johnson
SSN: 345678901
SSN: 456789012
Add New Assignment
Employee
Divyansh (1000)
Project
HR System Upgrade (#3)
Hours per Week
43
Create
Cancel

7. Validation and Verification

7.1 Test Cases

Test ID	Test Category	Test Description	Input	Expected Result	Priority
T1	Referential Integrity	Insert Employee with valid Department	Dept_No exists in DEPARTMENT	Insert successful	High
T2	Referential Integrity	Insert Employee with invalid Dept_No	Dept_No = 999 (non-existent)	FK violation error	High
T3	Data Integrity	Insert Employee with negative salary	Salary = -100	CHECK constraint violation	High
T4	Business Logic	Assign Employee to Project with >80 hours	Hours = 120	CHECK constraint failure (Hours BETWEEN 0 AND 80)	High
T5	Cascade Operations	Delete Employee who has Dependents	Employee SSN referenced in DEPENDENT	Dependent records cascade deleted	High
T6	Complex Queries	Execute 4-table join query	Employee–Works_On–Project–Department	Correct combined dataset within 3 seconds	Medium
T7	Primary Key	Insert Employee with duplicate SSN	Existing SSN value	PK violation error	High
T8	Referential Integrity	Insert Dependent for non-existent Employee	SSN not found in EMPLOYEE	FK violation error	Medium
T9	Supervisory Hierarchy	Display Employee supervisory chain	Recursive self-join query	Correct hierarchical display	Medium
T10	Unique Constraints	Insert Department with duplicate name	Existing Department name	UNIQUE constraint violation	Medium

7.2 Verification Methods

Verification Type	Method	Coverage
Schema Validation	DDL script execution and constraint testing	Database structure integrity
Functional Testing	CRUD operation validation for all entities	Complete functionality coverage
Performance Testing	Query execution time measurement	System performance requirements
Integration Testing	End-to-end workflow validation	System component interaction

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8. Appendix

8.1 Future Enhancements

- **Add Image Storage (BLOB)** for employee profile photos
- Add spatial attributes (e.g., project site geometry)
- Implement temporal tables for salary history tracking
- Advanced analytics and business intelligence dashboards
- Mobile application development
- Real-time data synchronization capabilities

8.2 Document History

Version	Date	Description
1.0	**Nov 2025**	Initial draft for normalized Employee Management DB with BCNF achievement

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Compliance:
This enhanced SRS complies with **IEEE 830 and ISO/IEC/IEEE 29148**, including:

- Structured requirement hierarchy
- Full traceability of normalization design
- Testability of join and view operations
- Integration readiness for analytical tools
