

ISRT Library Management System

Software Requirement and Specification Analysis

Course Code: SE 2206

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1. Inception

1.1 Identify All Stakeholders:

Stakeholder	Role
Librarian	Handles day-to-day tasks like issuing, returning, and cataloging.
Typist	Inputs Data
Cataloger	Creates and maintains catalog
Gatekeeper	Manages entry/exit of users, checks library cards, prevents unauthorized access, and monitors borrowed items at the gate.
Teacher	Uses the library for teaching resources, recommends materials, and may request references for students.
Technical Officers	Maintain IT infrastructure, digital library systems, OPAC (Online Public Access Catalog), and resolve technical issues.
Student	Primary user of the library—borrows books, accesses study materials, uses digital resources, and participates in research.

1.2 Understanding the Existing System

This section summarizes how the current manual or semi-manual system works and highlights pain points or areas for improvement.

1.2.1 Existing System

The ISRT Library currently operates using a combination of manual processes and physical record-keeping systems. The primary components of the existing system are as follows:

- ◊ Book Acquisition
 - A Book Purchase Committee oversees the procurement process.
 - More than 40 books are acquired at a time.
 - Bills are manually verified.
 - Books are categorized using subject-based codes.

- ◊ Registration and Inventory
 - Information for ~12,000 books is maintained in a Registration Ledger, including:
 - Title, Author, Classification No, Page No, Publisher, Price, etc.
 - If a book is lost, the fine imposed is double its original price.
- ◊ Storage and Identification
 - Books are stored in cabinets based on classification numbers and subject categories.
 - Retrieval relies on the physical identification of books by ID or code.
- ◊ Book Issue Process
 - ISRT students are issued two library cards each.
 - The student must manually fill out the card with:
 - Name, Roll, Department, Book Issue Date, and Due Date.
 - A book card is also maintained for each book to track availability and borrower information.
- ◊ Budget and Journals
 - ISRT uses its own budget to purchase books.
 - The library maintains its own research journal, supporting publications by ISRT faculty and researchers.
- ◊ Teacher and Staff Rules
 - Teachers must notify the library via official letter before borrowing books.
 - Teachers/staff must receive library clearance before going abroad or retiring.
 - All users (students and staff) must get library clearance before obtaining any certificates/documents.

1.2.2 Observations & Problems in the Existing System:

- Manual tracking via cards and ledgers is time-consuming and error-prone.
- No digital search system—users rely on IDs and physical location.
- No notification/reminder system for due dates or fines.
- Fine calculation for lost books is handled manually.
- Data redundancy (both a user card and a book card).

- Reports and analytics are not automated.
- Lack of role-based access control for various users (admin, librarian, member).

2. Elicitation

2.1 Quality Function Deployment (QFD)

This maps user needs to system functions, helping you prioritize features in the upcoming digital system.

2.1.1 Normal Requirements

- A predefined account will be given to the librarian/admin. The administrative account will have access to the central database containing all book records, user data, and borrowing history.
- The login module will have special accounts for librarians/admins with a separate interface to handle cataloging, issuing/returning books, managing fines, and generating reports.
- Students, teachers, and staff will provide their personal information to create a user account.
- The system will show all the currently available books, e-books, and digital resources to the users.
- The user can borrow, return, or renew physical/digital books based on availability.
- The user can also request specific resources or customized study material packages (e.g., journals, research papers).
- The system will allow fines to be paid via MFS. A receipt/invoice will be provided via email after payment.
- The librarian/admin can manage book inventory, add/remove books, and merge duplicate catalog records.
- The system must provide insights into student/teacher preferences, borrowing patterns, and most-read subjects.

2.2.2 Expected Requirements

- Users should be able to navigate the system effortlessly, without requiring extensive training.
- The interface should be responsive across various devices (desktop, laptop, tablet, smartphone).
- The system should provide secure password storage.
- The system should ensure proper data security and protect sensitive user/book information.
- A search bar will allow users to search by keywords such as title, author, or subject.
- Users will have a dashboard showing their borrowing history, fines, due dates, and recommendations.
- The system should send due date reminders via SMS/email/app notifications.
- The system should support holiday-aware due dates so that no fines are charged on library holidays.
- A blacklist mechanism should exist for users who violate library rules or consistently fail to return books.

2.2.3 Exciting Requirements

- The librarian/admin can perform advanced search and filtering (e.g., by author, subject, classification number, or user borrowing history).
- The system can generate AI-based book summaries to help users quickly understand content before borrowing/reading.
- A review & rating system allows students and teachers to rate and recommend books, creating a community-driven knowledge hub.

3. User Story:

[The ISRT Library Management System (LMS) is a comprehensive digital platform designed to automate and streamline all library operations at ISRT]

Users begin by selecting their user type—student, teacher, or staff—and registering by providing their full name and phone number. After submitting these, an OTP is sent to their mobile for verification. Once verified, users enter additional role-specific details: students provide roll number, registration number, session, hall name, institutional email, and address; teachers and staff provide designation, official email, and address. After successful validation, users create a unique User ID and Password. Access to a personalized dashboard is granted only after completing all these steps.

Users log in using their user ID and password. First, they must enter a valid user ID. Once the user ID is recognized, they are prompted to enter the corresponding password. If the password is correct, the user successfully logs in.

In case the user forgets their password, a recovery option is available. The system sends a one-time password (OTP) to the phone number associated with the account. Upon verifying the OTP, the user is allowed to reset their password and a confirmation email will be sent to the user.

Upon login, users access their role-specific dashboards. Students and teachers can view their borrowed books, due dates, fines, clearance status, and other personal library activities. They receive notifications via SMS or email regarding upcoming due dates and outstanding fines to ensure timely action. From the dashboard, users can also submit clearance requests whenever needed.

The E-Library subsystem provides a dedicated digital space where all available book PDFs are systematically organized and easily accessible. Users can browse or search for books, and upon selecting a specific title, they are presented with several interactive options. These include downloading the full book PDF, accessing a system-generated summary in PDF format, and participating in the Review & Ratings section. This section features a star-based rating system and allows users to leave written feedback. By offering multiple ways to engage with digital resources, the E-Library subsystem promotes self-paced learning and encourages active user interaction with library content.

The system features a smart search function, enabling users to find books by any detail—such as title, author, or subject—using text or voice input, along with filtering options for refined results.

Users can initiate a book borrowing request directly from their personalized dashboard. The system offers two methods to begin the process. In the first method, users can manually fill out a borrowing form by entering key book details such as the title, author, and classification number. In the second method, users can browse or search for a book through the integrated library catalog. When a book is found, its detail page displays a “Borrow This Book” button. Clicking

this button auto-fills the borrowing form with the book's information. In both cases—manual entry or catalog selection—the user then submits the completed request form. Once submitted, the system forwards the request to the librarian's admin panel for further processing.

When a borrowing request enters the Pending Approval module, the system follows a step-by-step process. First, the librarian checks the book's availability through the Availability subsystem. If no copies are available, the request is redirected to the Waitlist subsystem. If copies are available, the librarian then checks the user's eligibility using the Eligibility subsystem. If the user is eligible, the request is forwarded to the Approval subsystem for final approval. If the user is not eligible, the request is rejected, and a cancellation email is sent automatically with the reason.

When a borrowing request is received, the Availability subsystem automatically checks the real-time stock of the requested book. It verifies how many copies are currently available and whether the book is already reserved or on hold. If copies are available, the request proceeds to the Eligibility check. If no copies are available or the book is on hold, the system redirects the request to the Waitlist subsystem. This process ensures that the librarian always works with accurate availability data before moving forward with any decision.

The Eligibility subsystem automatically checks the user's borrowing status when a request is received. It verifies if the user has unpaid fines, demerit points, or blacklist status. The system then shows a clear pass or fail result next to the request. If the user is eligible, the request moves to the Approval subsystem. If not, the system rejects the request and sends a cancellation notice with the reason.

When a book is unavailable or all copies are borrowed, the Waitlist automatically adds new requests to a digital queue. Each user is placed in the queue based on their role and application time. Teachers are given the highest priority and are always placed at the front, regardless of when they applied. All other users are organized on a first-come, first-served basis within their category. The system continuously monitors book availability. When a copy becomes available, it notifies the librarian and highlights the next eligible user based on the queue.

If the user is eligible and copies are available, the librarian reviews the request and can approve it by setting a custom return deadline aligned with library policy or specific user needs. Once approved, the system generates a confirmation PDF that includes the book and user details, the set return deadline, the fine policy, and an official library seal marked "Permission Granted." This PDF is then emailed to the user and simultaneously saved in their dashboard for easy access and future reference.

If the user is blacklisted or does not meet the eligibility criteria, the system automatically rejects the request. It then generates a cancellation notice clearly explaining the reason for rejection and sends this notice to the user promptly.

The system comprehensively manages fines by automatically calculating charges for delayed returns and lost books, with lost items incurring double fees. Users are notified via mail of their fines and can pay through Mobile Financial Services such as bKash or Nagad. Upon payment confirmation, the system updates the user's fine status accordingly. If fines remain unpaid and the user accumulates three demerit points, they are automatically blacklisted, causing all borrowing requests to be rejected until dues are settled. To regain borrowing privileges, blacklisted users must clear all outstanding fines, return any overdue books, and submit a "Reactivation Request" via their dashboard. After the librarian verifies all conditions are met, they can approve the reactivation, restoring the user's normal borrowing rights.

One day before the return deadline, the system sends the user a reminder email that includes an option to request a renewal if needed. If the user submits a renewal request, the librarian reviews and approves or denies it. On the due date, if the book is not returned and no renewal has been approved, the system adds a demerit point to the user's dashboard. Upon return, the librarian clicks a "Book Received" button linked to the borrowing record, which updates the system in real time by marking the book as returned, increasing its available copies, and closing the transaction. The user then receives a confirmation and thank-you email.

The system handles extension requests by forwarding each renewal application to the librarian for approval. The librarian may approve a user's renewal request up to two consecutive times; after that, any further renewal request is automatically denied. When approved, the system updates the return deadline, generates a new confirmation PDF with the revised due date, and emails it to the user. If the renewal is denied—either automatically after two consecutive approvals or by librarian decision—the user is promptly notified to return the book on time.

A book purchase committee, composed of 6 to 7 faculty members, is responsible for making book selection and purchase decisions. Each year, the BPC manually analyzes borrowing patterns and student demand to suggest specific books or categories for purchase. The number of books purchased can vary depending on priorities and budget availability. All purchases are funded by ISRT's annual budget, and bills are manually verified after the purchase to ensure financial transparency and accountability. Once new books are purchased, the BPC updates the book list in the system. Outdated or damaged books may be removed from the active catalog and archived instead of deleted. This helps retain metadata and borrowing history for internal reference and audit purposes.

The library maintains its own research journal to support academic publishing by ISRT faculty and researchers. Accepted works are formally published either digitally or in print. This initiative not only encourages scholarly contributions but also provides a dedicated platform for showcasing the research output of the institution.

In the ISRT Library Management System, users can request clearance through a dedicated button on their dashboard. Students may apply for certificate or marksheets clearance, while teachers and staff can apply for pension-related clearance. After selecting the clearance type, users fill out a detailed form—students provide their name, roll number, registration number, session, hall name, institutional email, phone number, address, and reason; teachers and staff provide their name, designation, working duration, official email, phone number, address, and reason. Once submitted, the request appears on the admin's dashboard under the clearance section. Before taking action, the system or admin checks the user's eligibility by verifying whether the user has any pending books, unpaid fines, or is blacklisted. If the user is eligible, the admin approves the request, and a PDF clearance certificate is automatically generated containing the user's submitted details, a statement confirming that no books or fines are pending, and an auto-generated library seal. The certificate is emailed to the user and made available for download. If the user is not eligible, the admin cancels the request and must provide a reason, which is included in a cancellation email sent to the user.

4. Use Case Diagram

A use case is a list of actions or event steps typically defining the interactions between a role (actor) and a system to achieve a goal. The actor can be a human or other external system. In this modeling, use case diagram is a graphical depiction of a user's possible interactions with a system. A use case diagram shows various use cases and different types of users the system has and will often be accompanied by other types of diagrams as well. Use case diagrams are a blueprint for the system. Due to their simplistic nature, use case diagrams can be a good communication tool for stakeholders. The drawings attempt to mimic the real world and provide a view for the stakeholder to understand how the system is going to be designed. Use case diagrams consist of actors, use cases and their relationships. The diagram is used to model the system/subsystem of an application. A single use case diagram captures a particular functionality of a system.

Primary Actor: Primary actors interact to achieve required system function and derive the intended benefit from the system. They work directly and frequently with the software.

Secondary Actor: Secondary actors support the system so that primary actors can do their work. They either produce or consume information.

Level 0:

Name: ISRT Library Management System (LMS)

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actors: OTP Generator, Summary Generator, MFS (Mobile Financial Service), Email Generator, Book Purchase Committee (BPC)

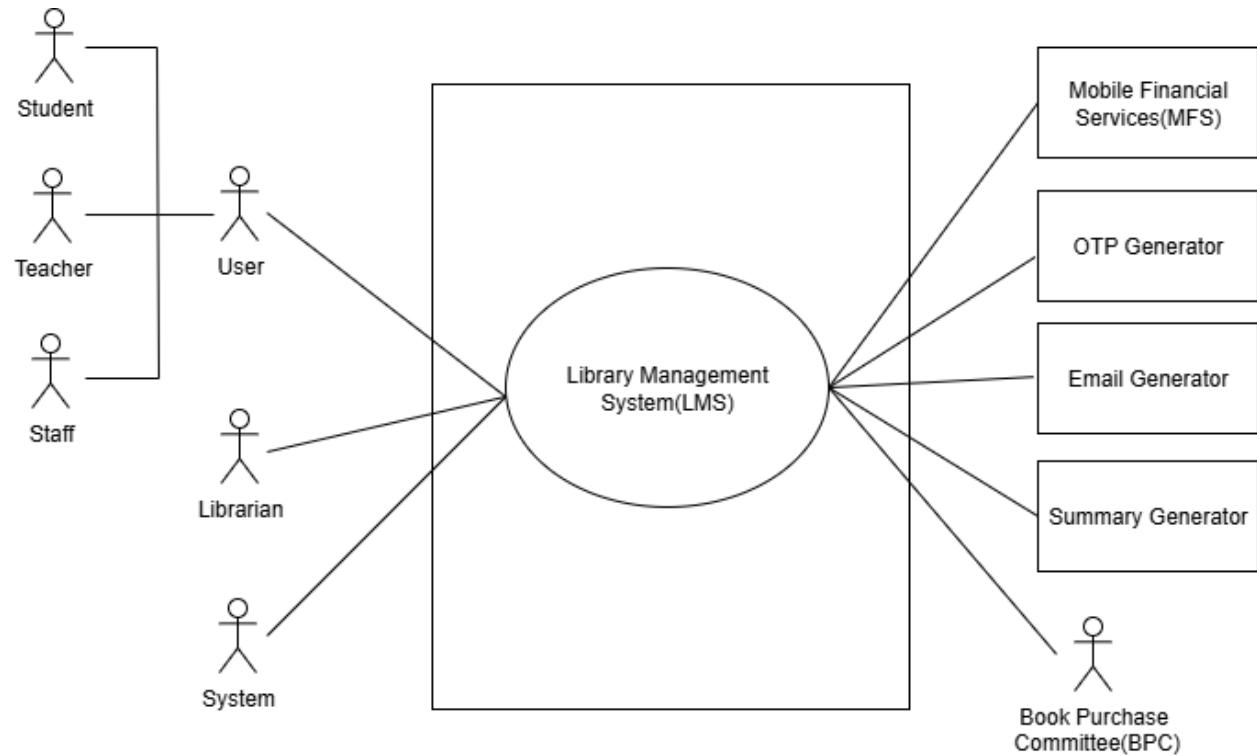


Figure 1: ISRT Library Management System (LMS) Use Case Diagram

Level 1:

Name: ISRT Library Management System (LMS)

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actors: OTP Generator, Summary Generator, MFS (Mobile Financial Service), Email Generator, Book Purchase Committee (BPC)

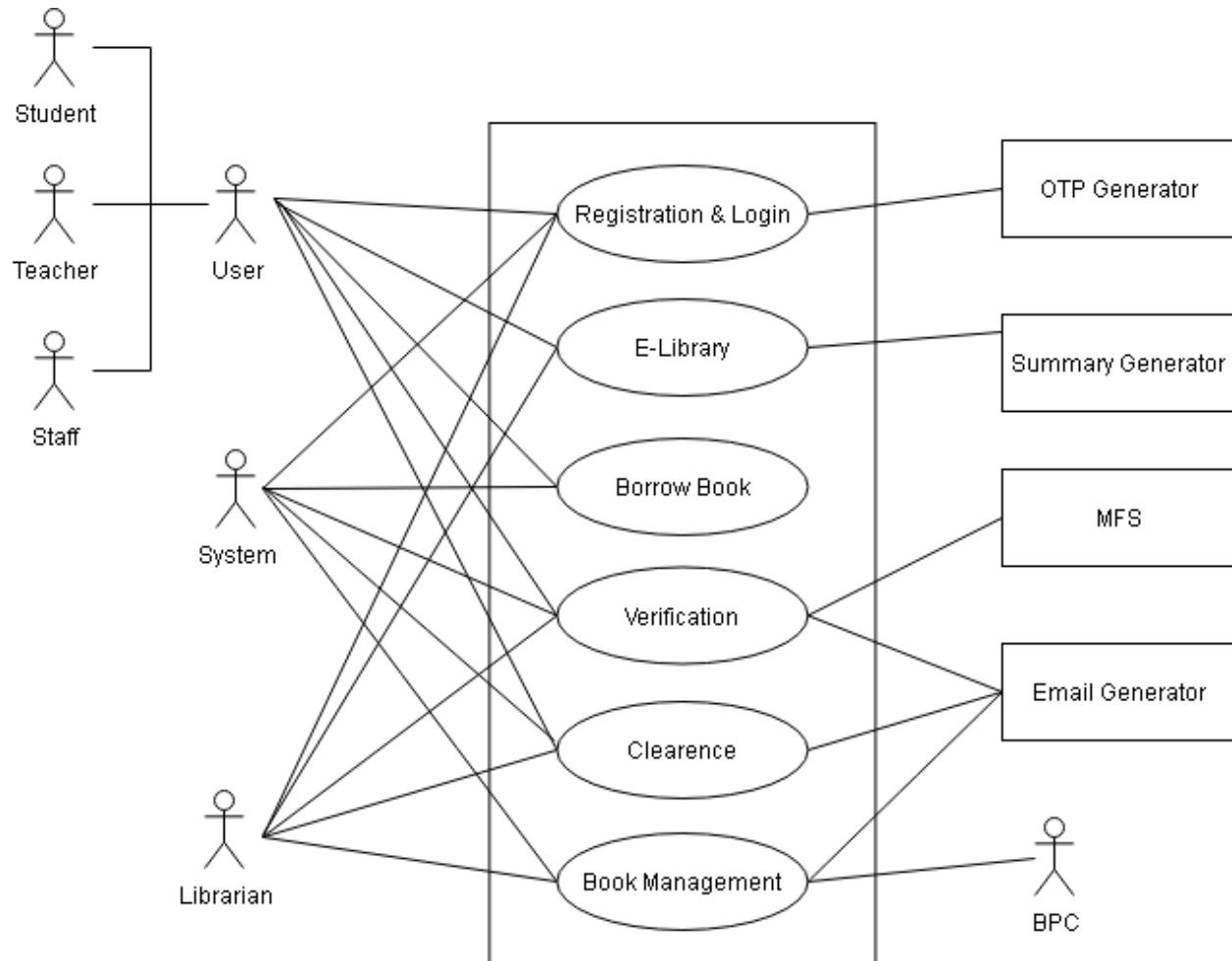


Figure 2: ISRT Library Management System (Detailed) Use Case Diagram

Description:

- 1. Registration and Login:** Manages the creation and secure access of user accounts. Users register by selecting their role (Student, Teacher, or Staff), providing personal and role-specific details, and verifying their identity via OTP. After validation, they create a

unique User ID and Password. The subsystem also handles login and password recovery via OTP.

2. **E-Library:** Offers a digital space where book PDFs, research journals, and academic resources are stored and accessible. Users can search for or browse books, download full PDFs, generate summaries, read research publications, and leave reviews and ratings, all while supporting self-paced learning and research engagement.
3. **Borrow Book:** Allows users to request physical books via two methods: manually filling out a form or selecting a book from the catalog. The subsystem forwards requests to the librarian for processing while capturing essential book and user details for tracking.
4. **Verification:** Handles librarian-side operations for borrowing requests. It checks book availability and user eligibility (including unpaid fines, blacklist status, and demerit points) before granting approval. Upon approval, the system generates a confirmation PDF with due dates, fine policy, and an official seal, sending it to the user via email.
5. **Clearance:** Enables users to request clearance certificates when needed (e.g., certificate, marksheets, or pension-related). The system verifies that there are no pending books, fines, or blacklist issues before generating and emailing a PDF clearance certificate. If requirements are not met, a cancellation notice is sent.
6. **Book Management:** Supports the management and growth of the library collection. The system analyzes borrowing trends and user demand to suggest books for purchase. A book purchase committee reviews these suggestions, makes final decisions, and manually verifies bills. The librarian then updates the system's records to keep the catalog accurate and up to date.

Level 1.1:

Name: Registration & Login

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actors: OTP Generator, Email Generator

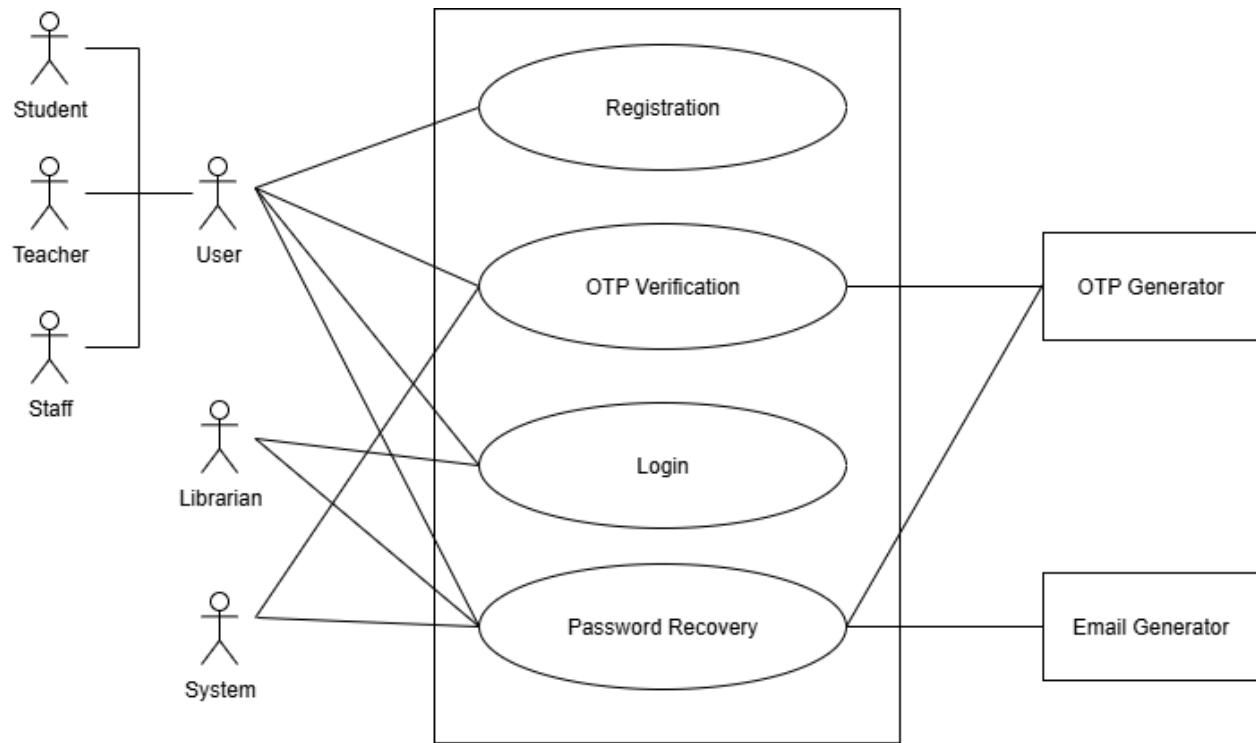


Figure 3: Registration & Login Use Case Diagram

Description:

1. **Registration:** New users, including students, teachers, and staff, begin by selecting their user type and providing their phone number along with required role-specific details, such as roll number, registration number, session, hall name, institutional email, and address for students, or designation, official email, and address for teachers and staff.
2. **OTP Verification:** An OTP is sent via the OTP Generator to the user's registered phone number to confirm their identity; this process is used both during initial registration and for password recovery to ensure that only authorized users can access or modify their accounts. Successful verification allows the process to continue.

- 3. Login:** After successful registration, users log in using their User ID and password. The system validates credentials and grants access to the role-specific dashboard.
- 4. Password Recovery:** If a user forgets their password, they can enter their username and registered phone number to receive an OTP for identity verification. After verifying the OTP, they can set a new password, and the Email Generator sends a confirmation email to ensure account security.

Level 1.2:

Name: E-library

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actor: Summary Generator

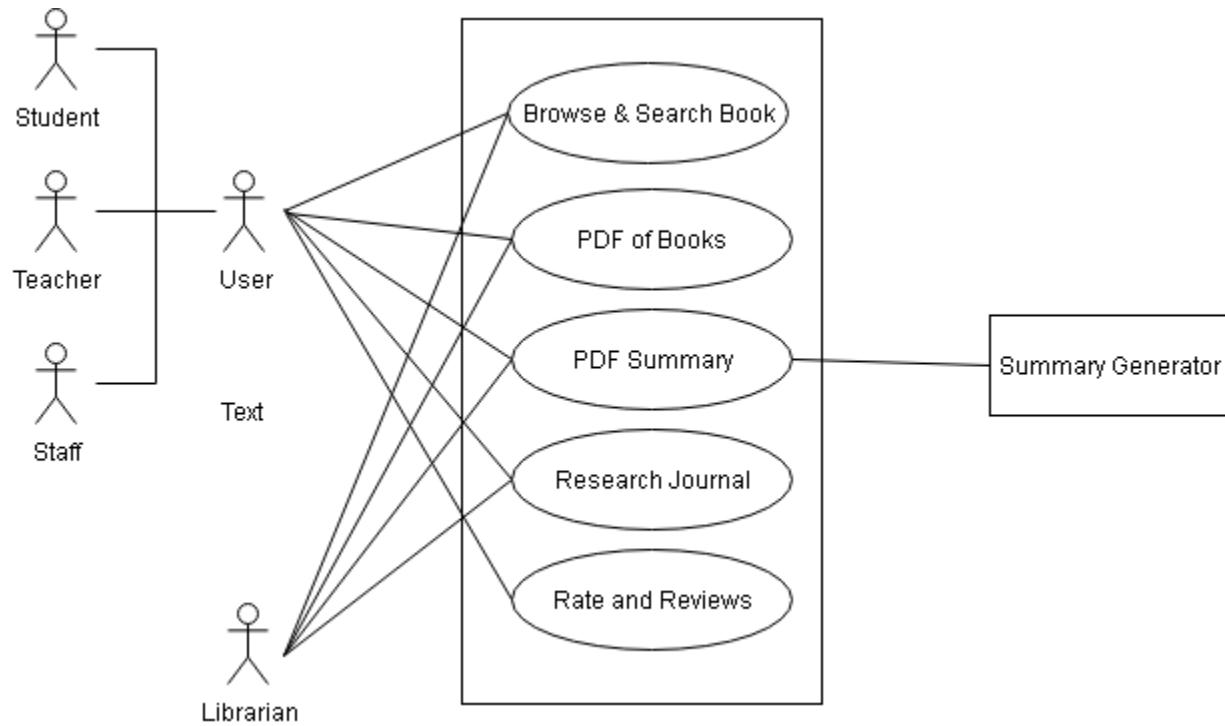


Figure 4: E-library Use Case Diagram

Description:

1. **Browse & Search Book:** Users and librarians can browse the library catalog or use smart search to find books by title, author, subject, etc., with filtering options.
2. **PDF of Books:** Users and librarians can access and download full digital copies of available books in PDF format from the E-Library.
3. **PDF Summary:** Allows users and librarians to download AI-generated summaries of books. The Summary Generator component powers this process.
4. **Research Journal:** It enables students, teachers, staff, and librarians to access published research journals authored by ISRT faculty and researchers. The librarian is responsible for

uploading research journal PDFs to the system, ensuring that new publications are regularly added and made accessible to all authorized users for reading and reference

5. **Rate and Reviews:** Users (students, teachers, staff) can provide star ratings and write reviews on books they've read. Librarians may view these for quality assurance.

Level 1.3:

Name: Borrow Book

Primary Actor: User (Student, Teacher, Staff), System

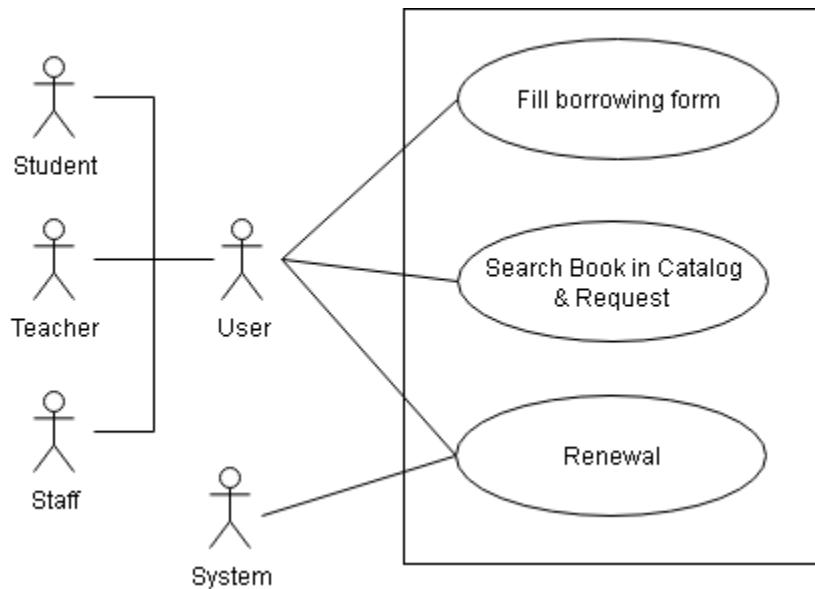


Figure 5: Borrow Book Use Case Diagram

Description:

1. **Fill Borrowing Form:** Users (students, teachers, staff) can manually fill out a borrowing request form by entering key book details such as title, author, and classification number. Alternatively, if a user selects a book from the catalog, the system auto-fills this form with the relevant data.
2. **Search Book in Catalog & Request:** Users can search for books using the library catalog, including a smart search feature that allows queries by title, author, classification number, or subject through text or voice input. The system also suggests books if the user enters nearly correct or partial information, helping to refine the search. Results can be further filtered for more precise browsing. Once users find a desired book, they can proceed to borrow it directly from its detail page. After completing the borrowing form either manually or via catalog auto-fill, users submit the request for processing. The system forwards the request to the librarian's admin panel.

3. **Renewal:** Users can request to extend the return deadline of a borrowed book from their dashboard. The request is sent to the librarian for review. If approved, the system updates the due date and sends a new confirmation PDF to the user. Each user may renew a book up to two consecutive times. If no renewal is granted and the due date passes, the system automatically adds a demerit point.

Level 1.4:

Name: Verification

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actor: Email Generator, MFS

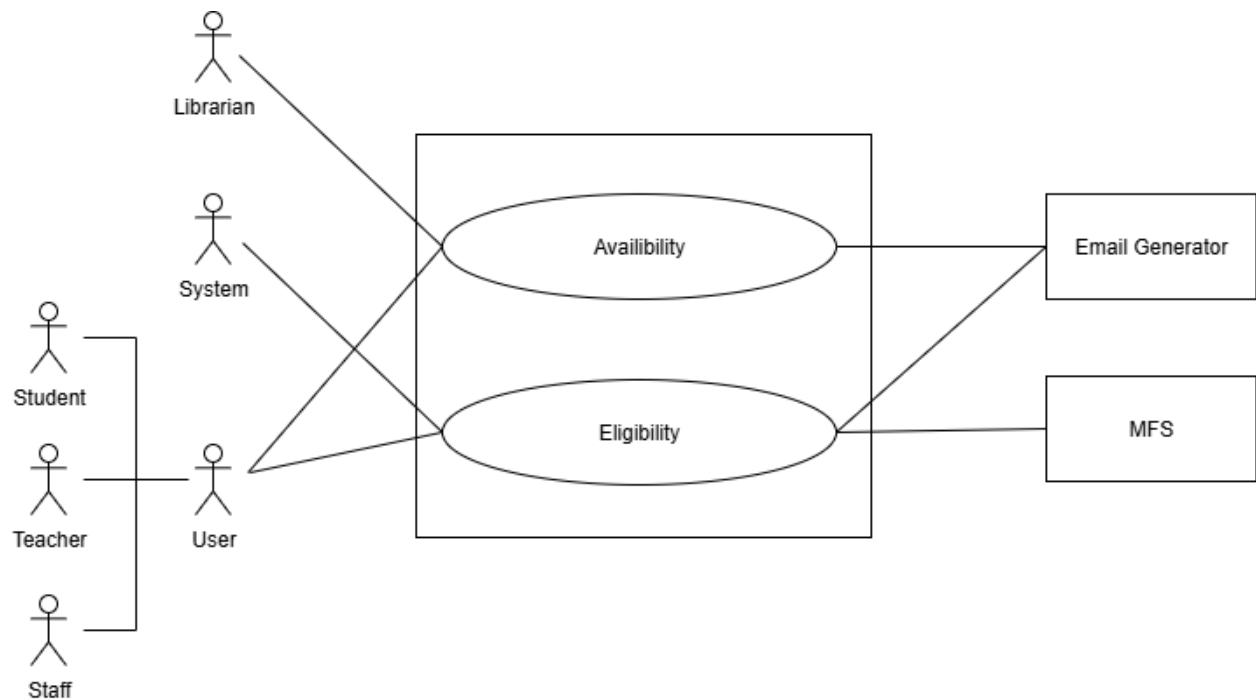


Figure 6: Verification Use Case Diagram

Description:

This use case manages the approval process for book borrowing. After a user submits a borrow request, the librarian initiates checks through the Availability and Eligibility subsystems. If books are available and the user meets all criteria (no fines, not blacklisted), the librarian approves the request and sets a custom return date. A confirmation PDF is generated and sent via email. If the request is denied, a cancellation notice is sent with the reason. Fines and penalties are handled through MFS integration.

Level 1.4.1:

Name: Availability

Primary Actor: Librarian, System

Secondary Actor: Email Generator

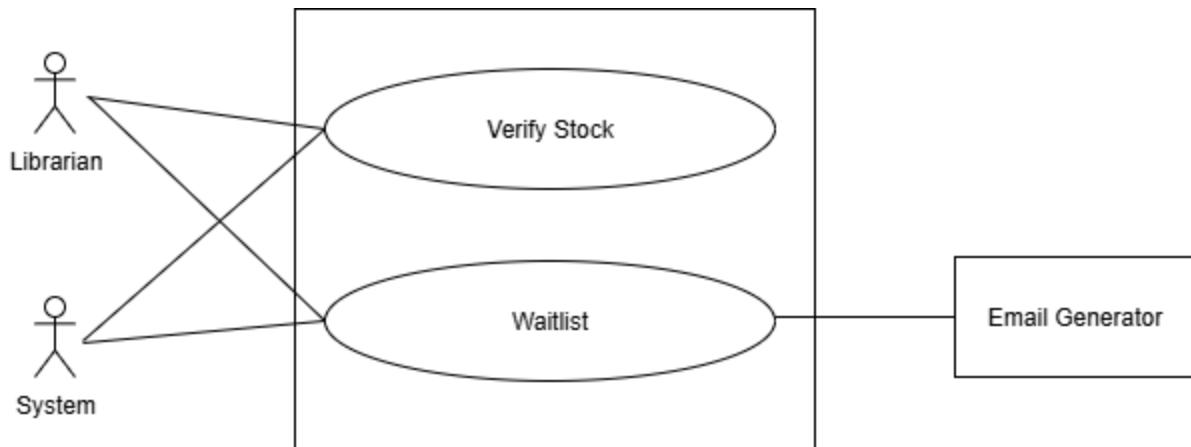


Figure 7: Availability Use Case Diagram

Description:

This subsystem verifies the real-time stock of requested books. The librarian can check whether copies are available or if the book is already on hold. If unavailable, the system adds the user to a waitlist queue, prioritizing teachers first, then others by request time. The Email Generator notifies users about status updates or waitlist placement.

Level 1.4.2:

Name: Eligibility

Primary Actor: User (Student, Teacher, Staff), System

Secondary Actor: Email Generator, MFS

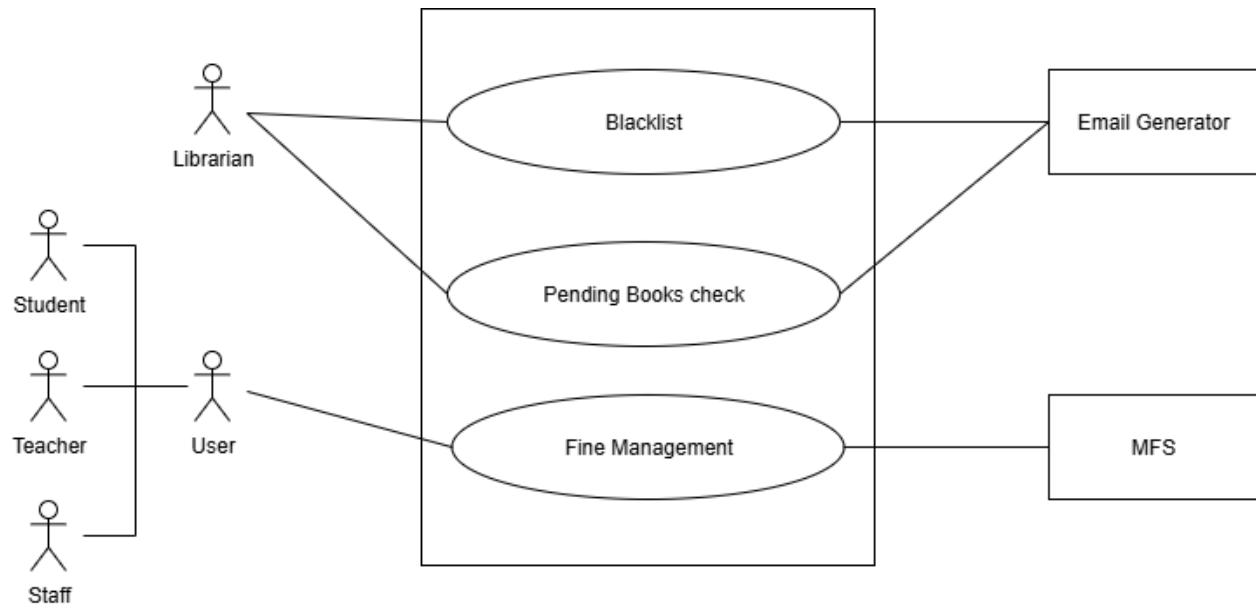


Figure 8: Eligibility Use Case Diagram

Description:

This use case verifies whether a user is eligible to borrow a book. It checks for unpaid fines, demerit points, or blacklist status. If the user fails any of these checks, the request is automatically rejected and a cancellation email is sent. Fine calculations and status updates are handled through MFS. Eligible users proceed to the final approval step.

Level 1.5:

Name: Clearance

Primary Actor: User (Student, Teacher, Staff), Librarian, System

Secondary Actor: Email Generator

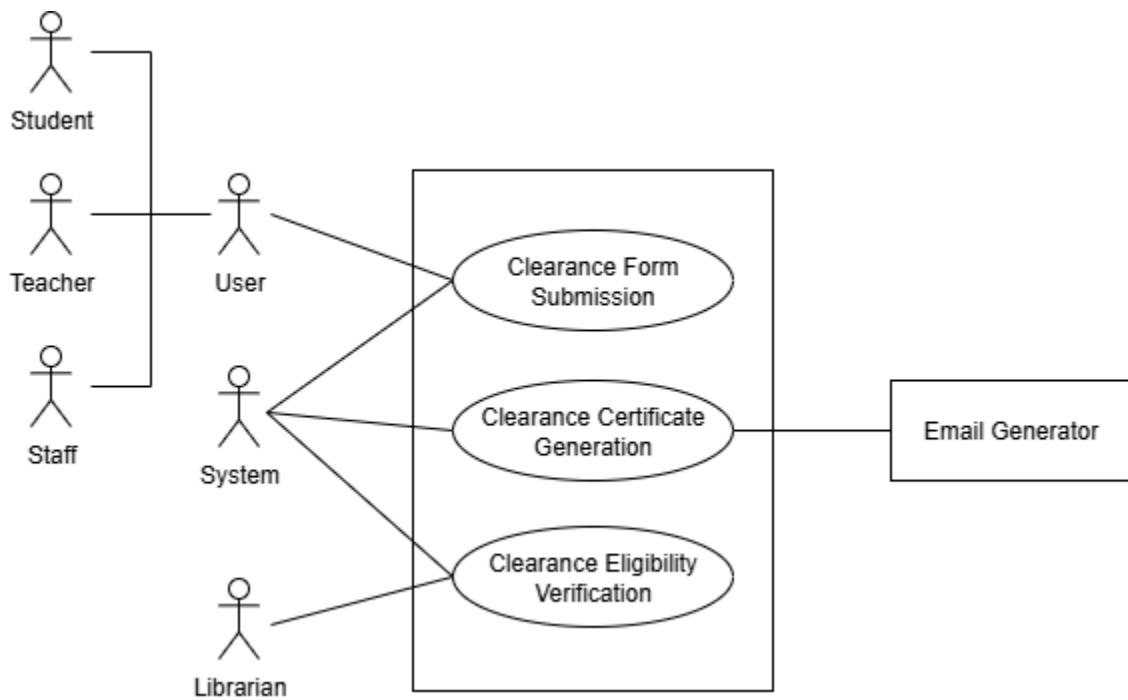


Figure 9: Clearance Use Case Diagram

Description:

1. **Clearance Form Submission:** Users (students, teachers, staff) submit a role-specific clearance form via their dashboard, providing necessary personal and institutional details. The request is forwarded for verification.
2. **Clearance Eligibility Verification:** The librarian checks if the user has pending books, unpaid fines, or blacklist status. Eligible users proceed; ineligible ones receive a rejection with reasons.
3. **Clearance Certificate Generation:** For eligible users, the system generates a PDF clearance certificate with user details and a library seal. It is emailed to the user via the Email Generator and added to their dashboard.

Level 1.6:

Name: Book Management

Primary Actor: Librarian

Secondary Actor: BPC(Book Purchase Committee)

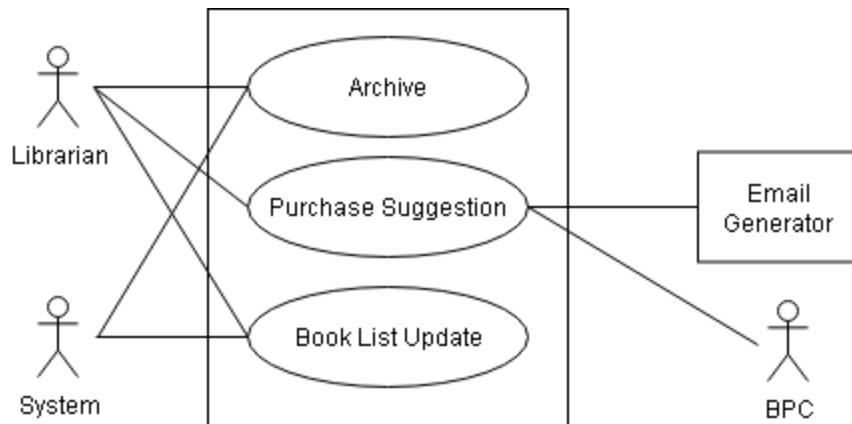


Figure 10: Update Book Record Use Case Diagram

Description:

1. **Purchase Suggestion:** Matches the data-driven recommendation system that supports the faculty book purchase committee.
2. **Book List Update:** The admin manually adds newly purchased books to the book list, entering all relevant details to make them available for users in the catalog. Similarly, any books that are damaged or no longer usable are deleted from the list to prevent future borrowing requests. This process maintains the reliability and quality of the library's available resources.
3. **Archive:** Allows librarians to store records of removed or outdated books for internal reference and auditing, without displaying them in the active catalog.

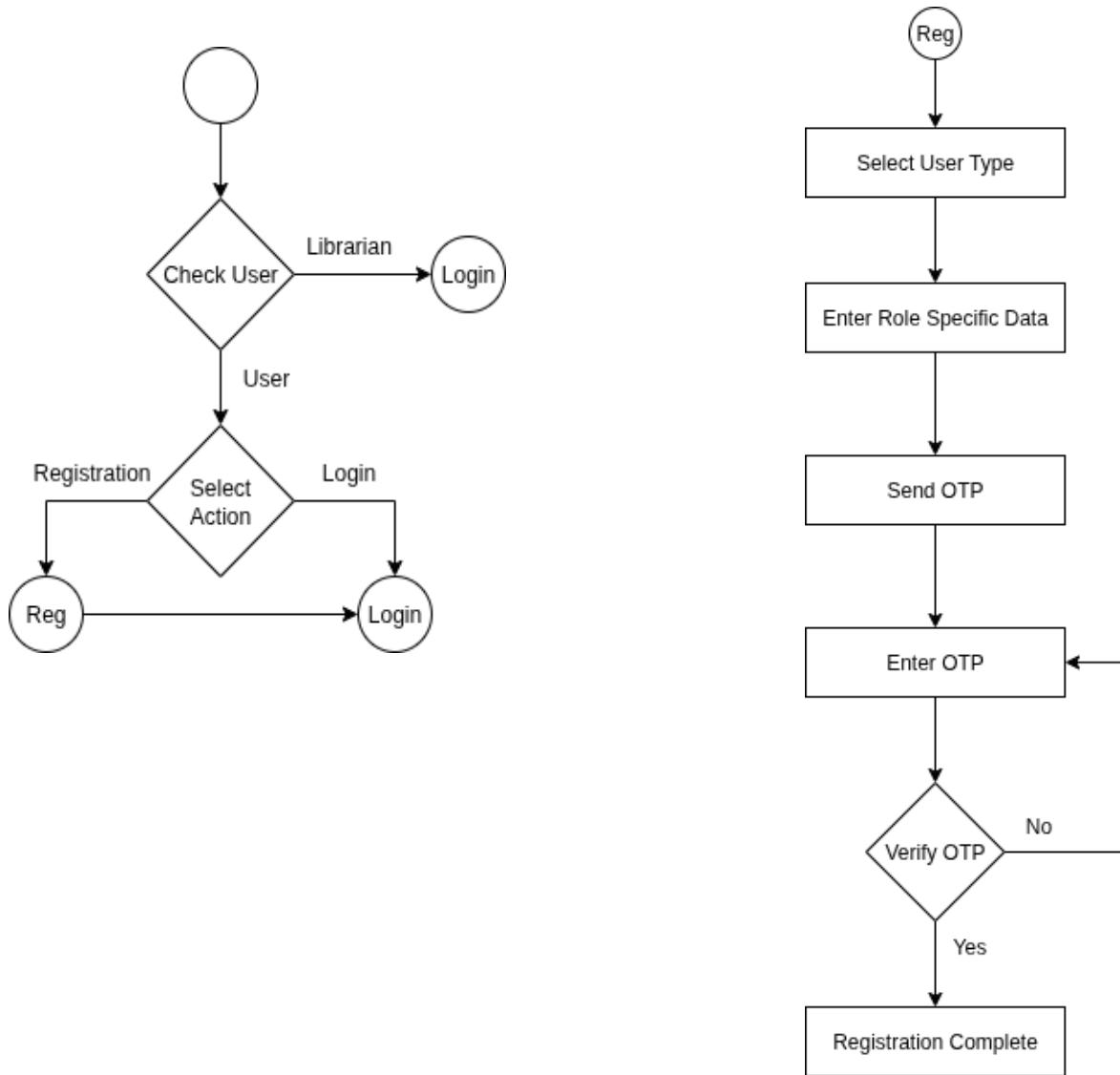
5. Activity Diagram

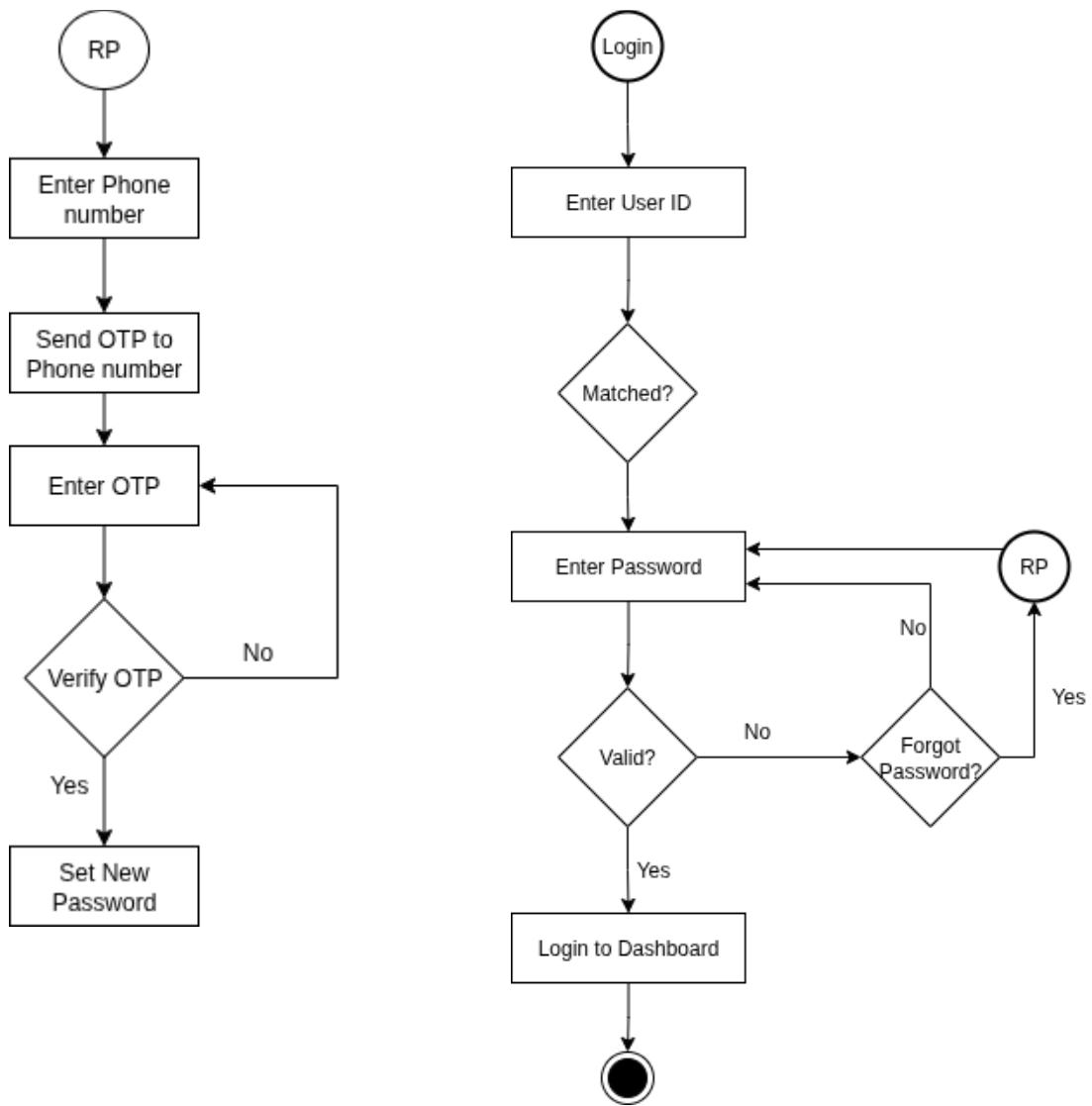
Activity diagram is an important behavioral diagram in UML diagram to describe dynamic aspects of the system. Activity diagram is essentially an advanced version of flowchart that models the flow from one activity to another activity.

Level 1.1:

Name: Registration & Login

Reference: Use Case Diagram Level 1.1

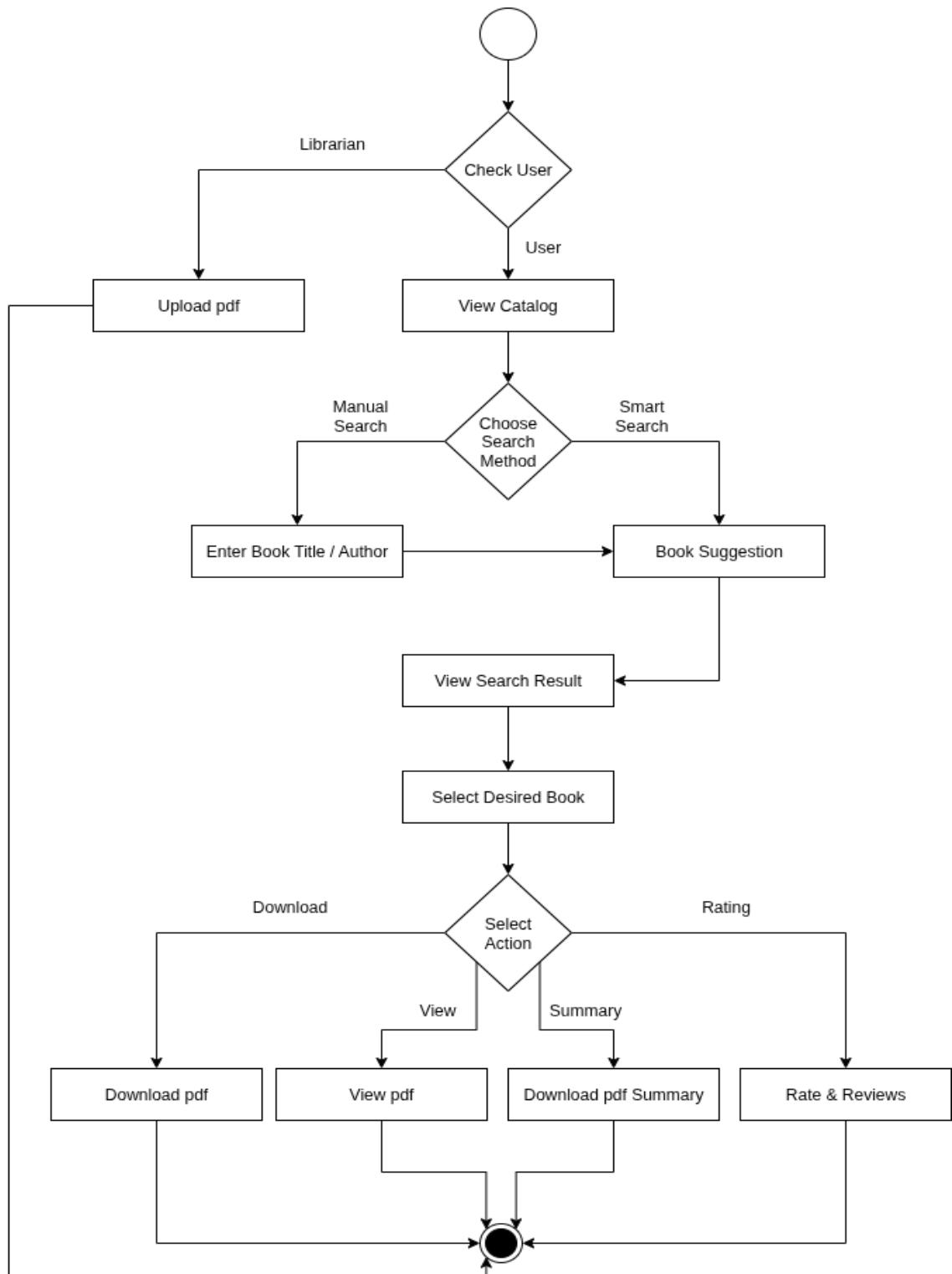




Level 1.2:

Name: E-library

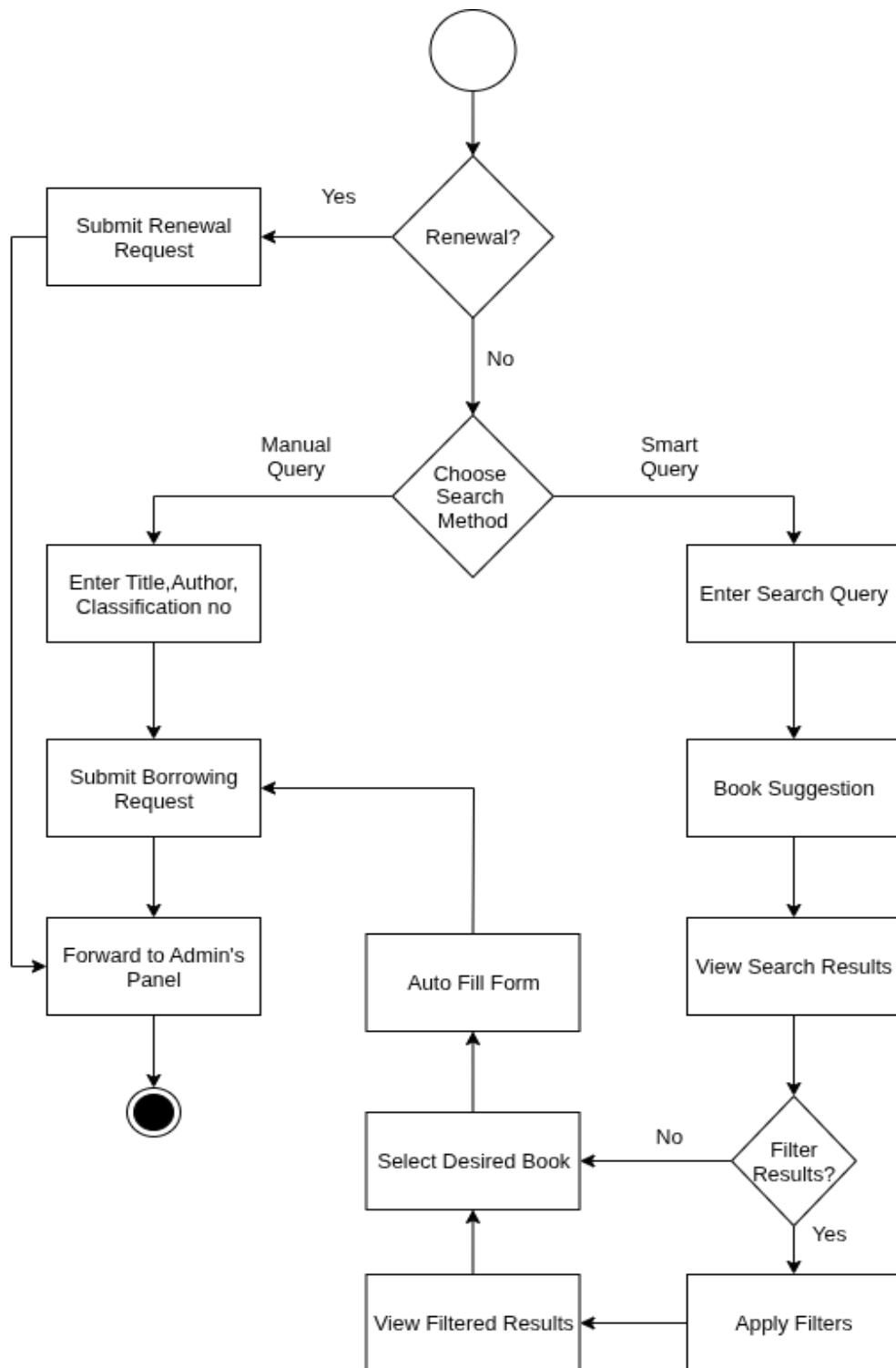
Reference: Use Case Diagram Level 1.2



Level 1.3:

Name: Borrow Book

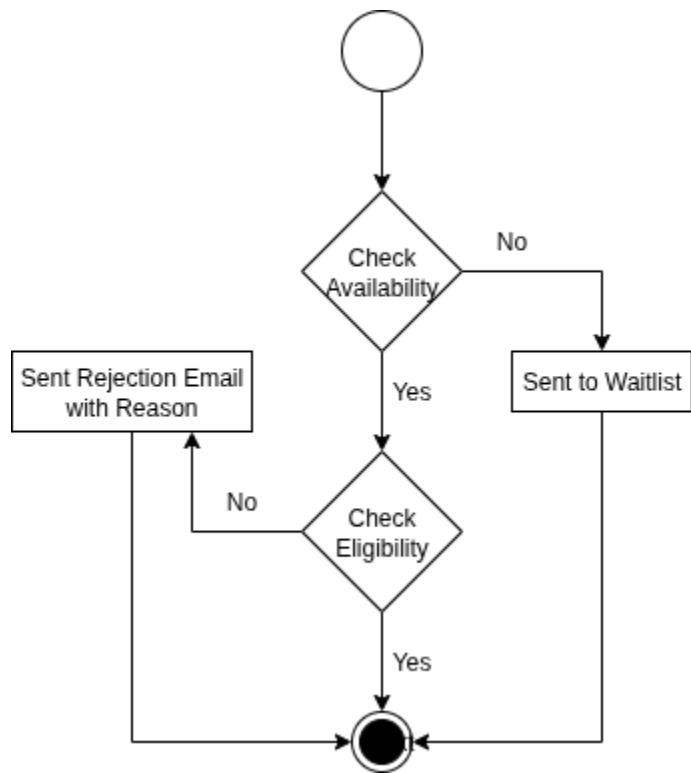
Reference: Use Case Diagram Level 1.3



Level 1.4:

Name: Verification

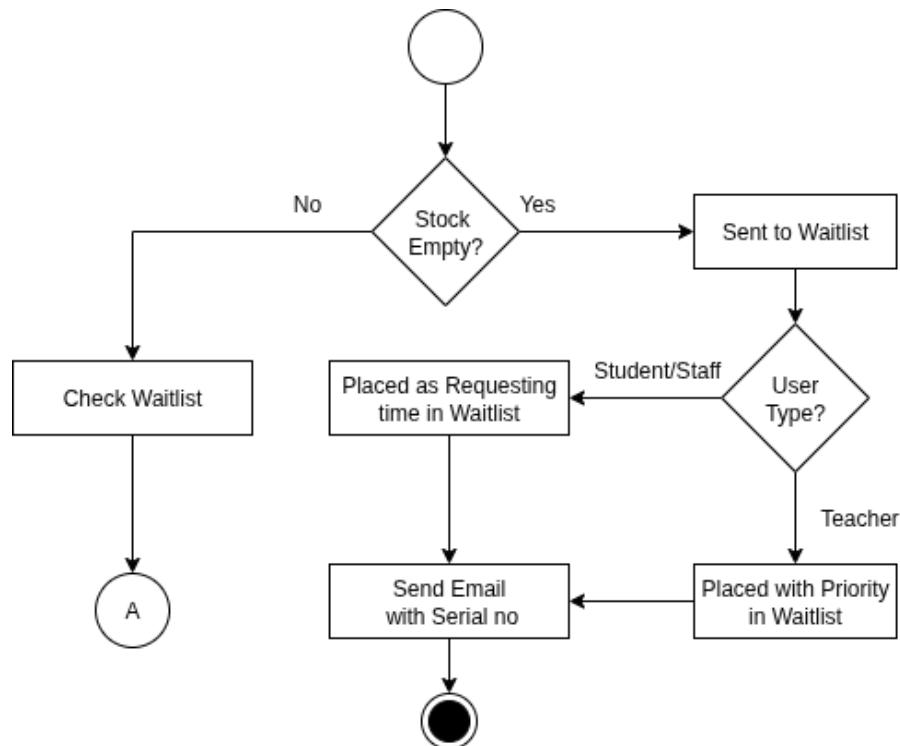
Reference: Use Case Diagram Level 1.4



Level 1.4.1:

Name: Availability

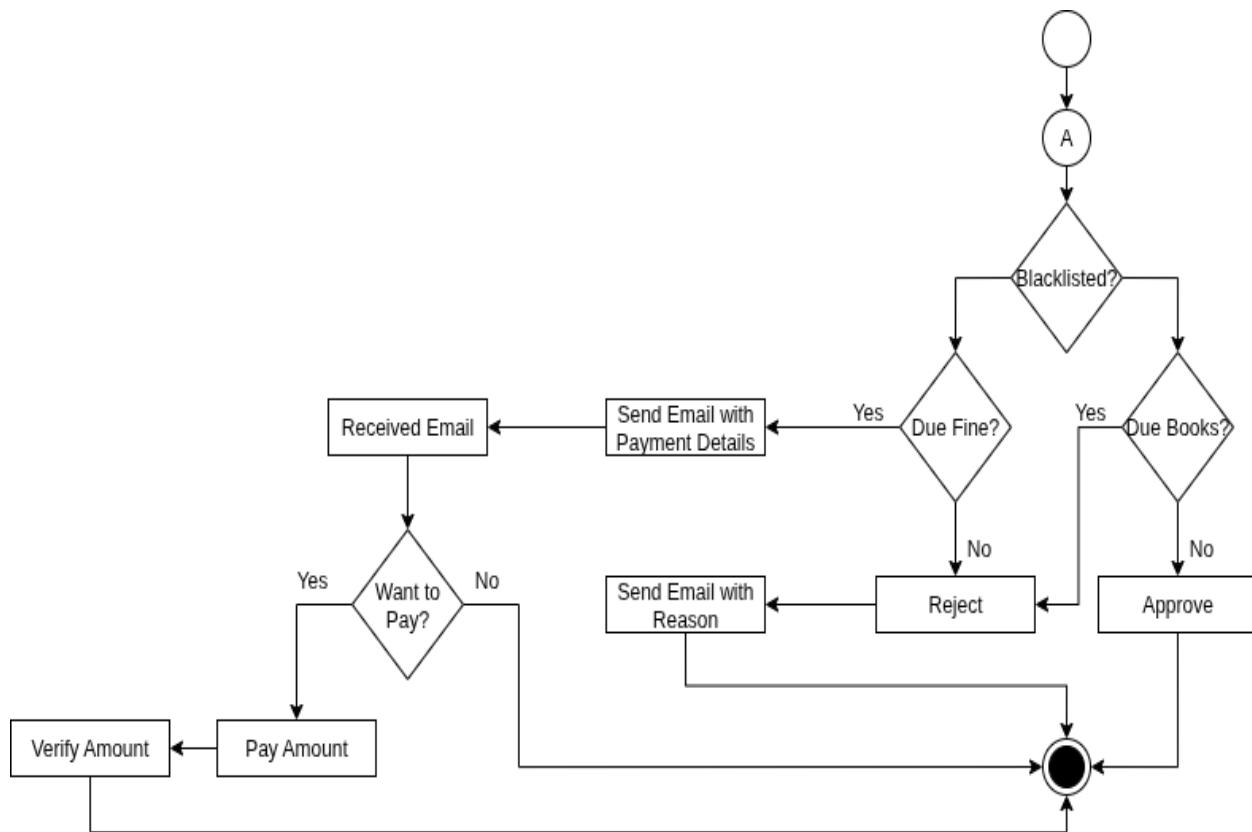
Reference: Use Case Diagram Level 1.4.1



Level 1.4.2:

Name: Eligibility

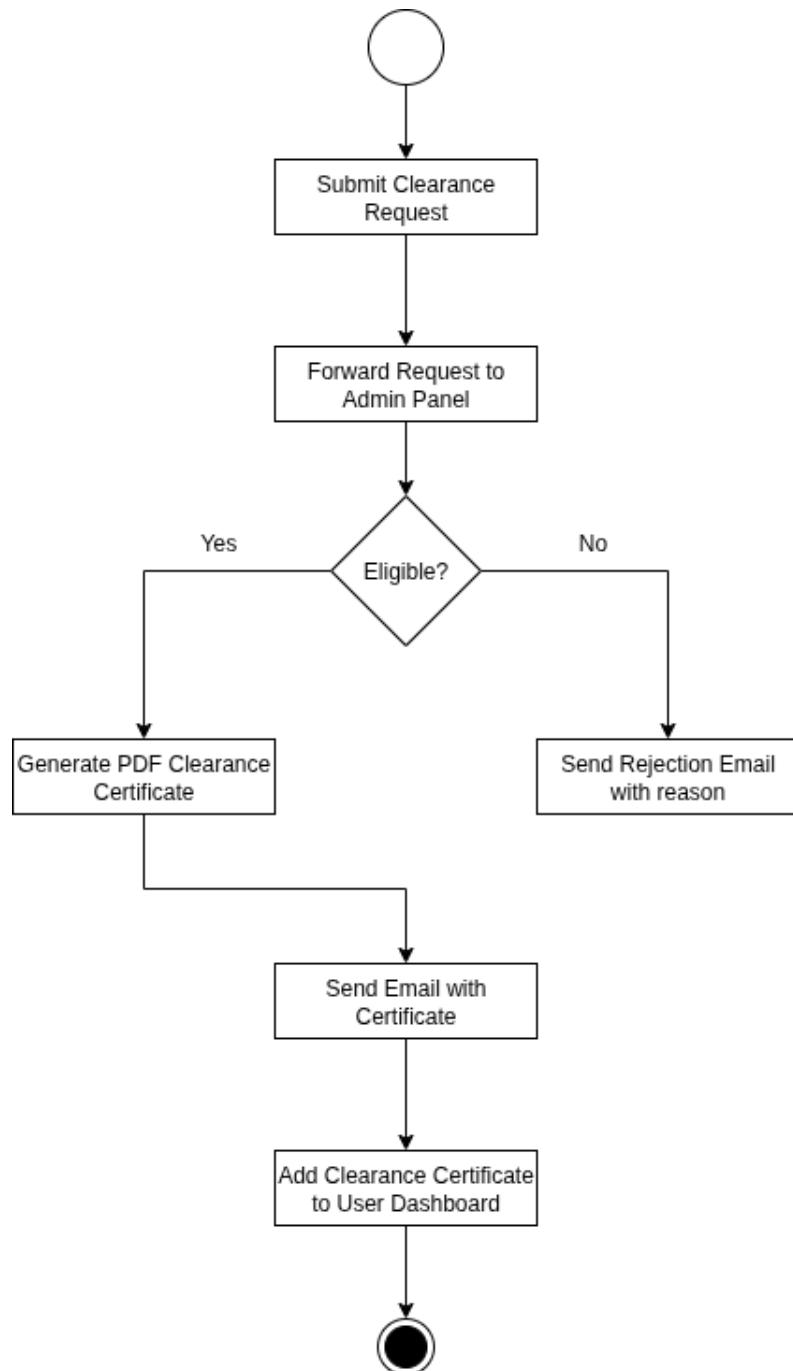
Reference: Use Case Diagram Level 1.4.2



Level 1.5:

Name: Clearance

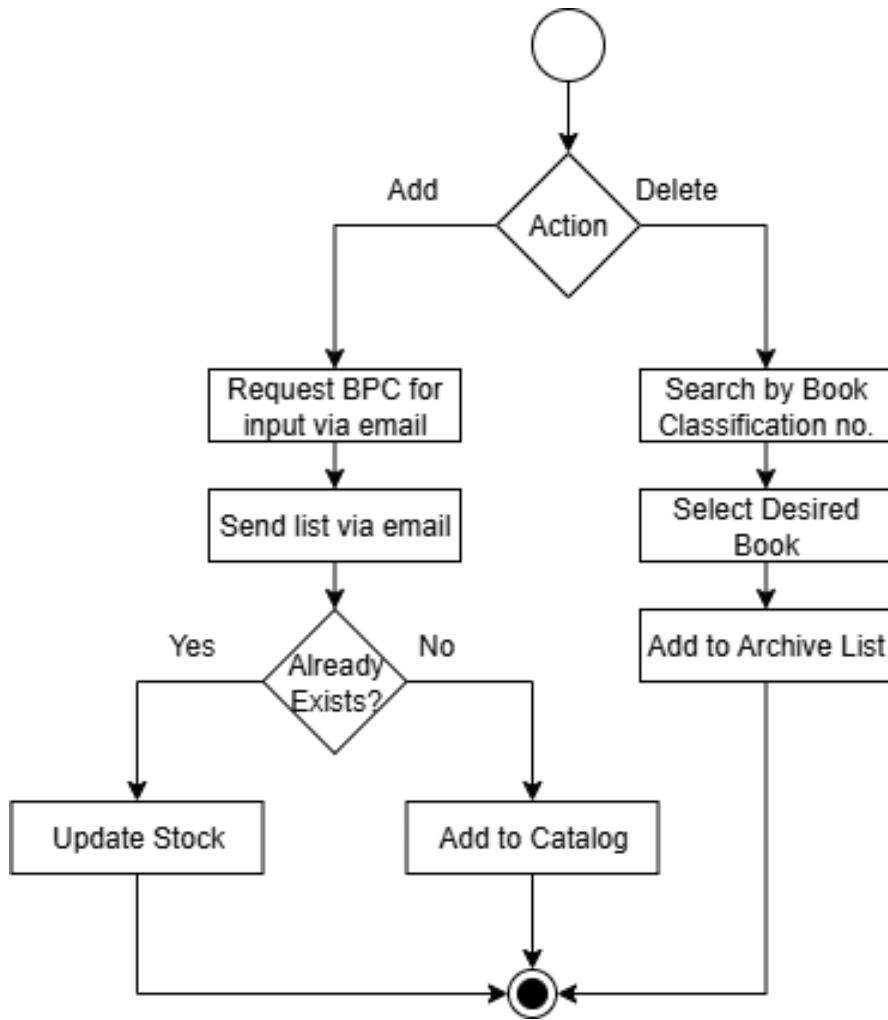
Reference: Use Case Diagram Level 1.5



Level 1.6:

Name: Book Management

Reference: Use Case Diagram Level 1.6



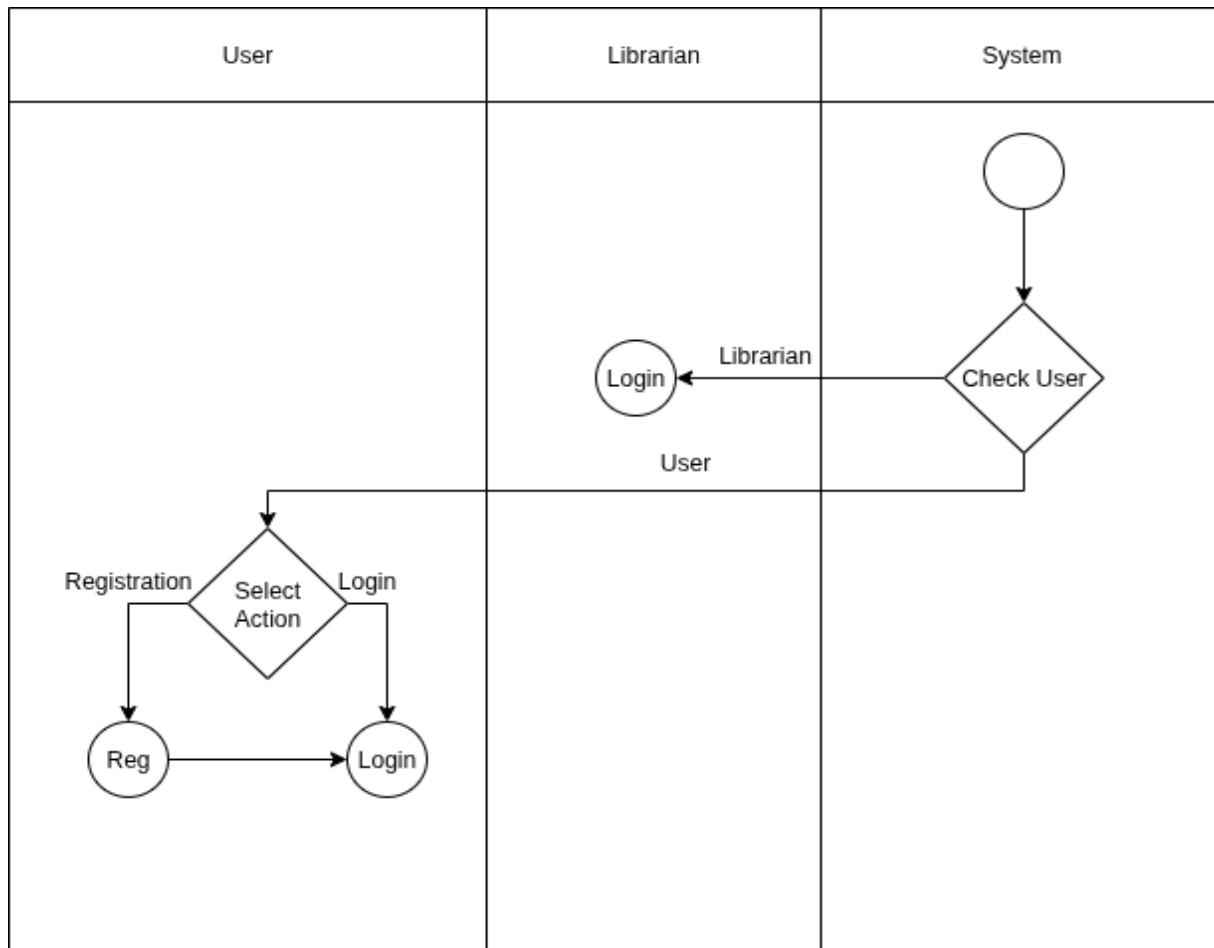
6. Swimplane Diagram

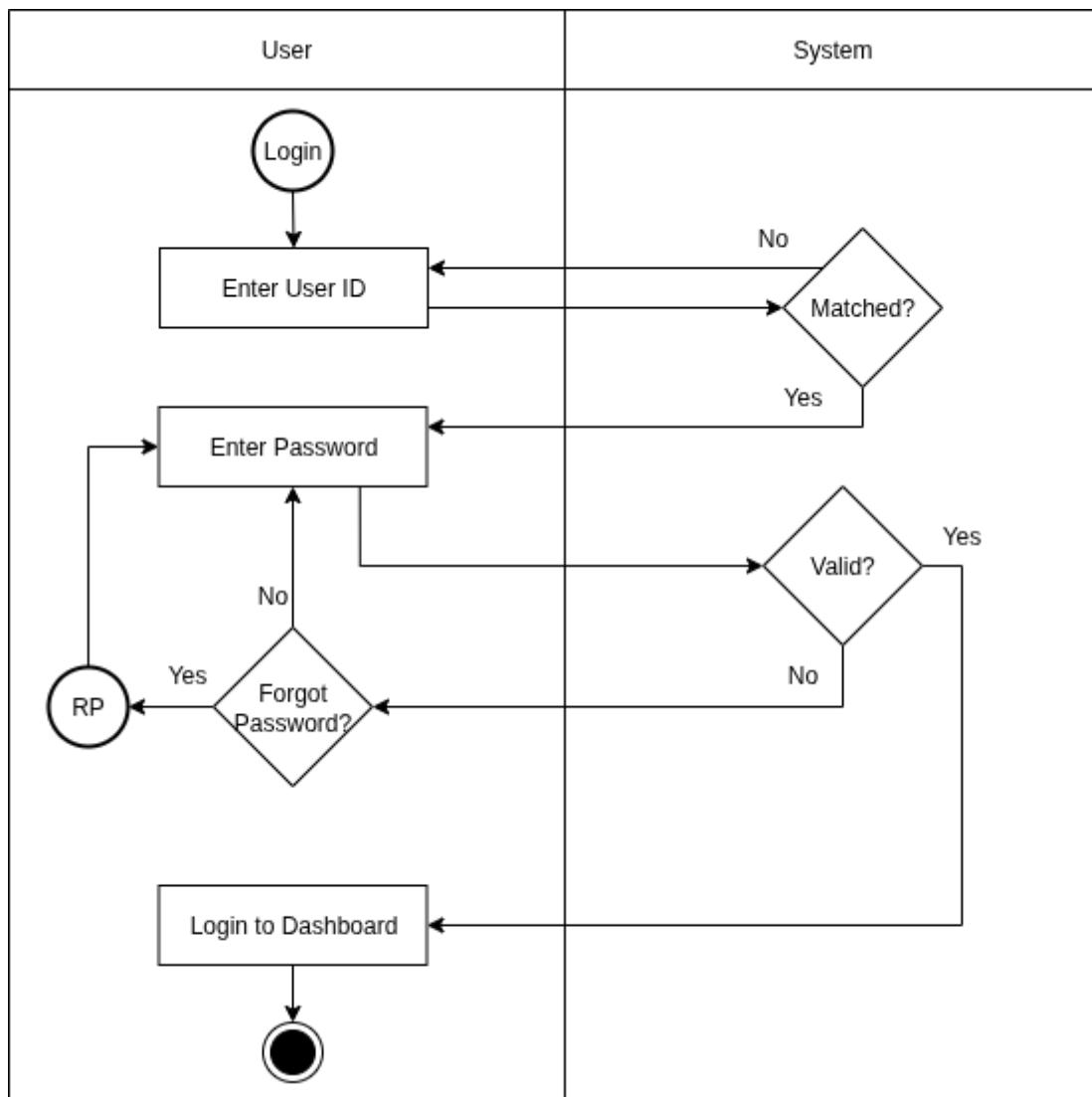
A Swimplane diagram is a type of flowchart, which diagrams a process from start to finish, but it also divides these steps into categories to help distinguish which departments or employees are responsible for each set of actions. It is based on the analogy of lanes in a pool, as it places process steps within the horizontal or vertical “Swimlanes” of a particular department, work group or employee, thus ensuring clarity and accountability.

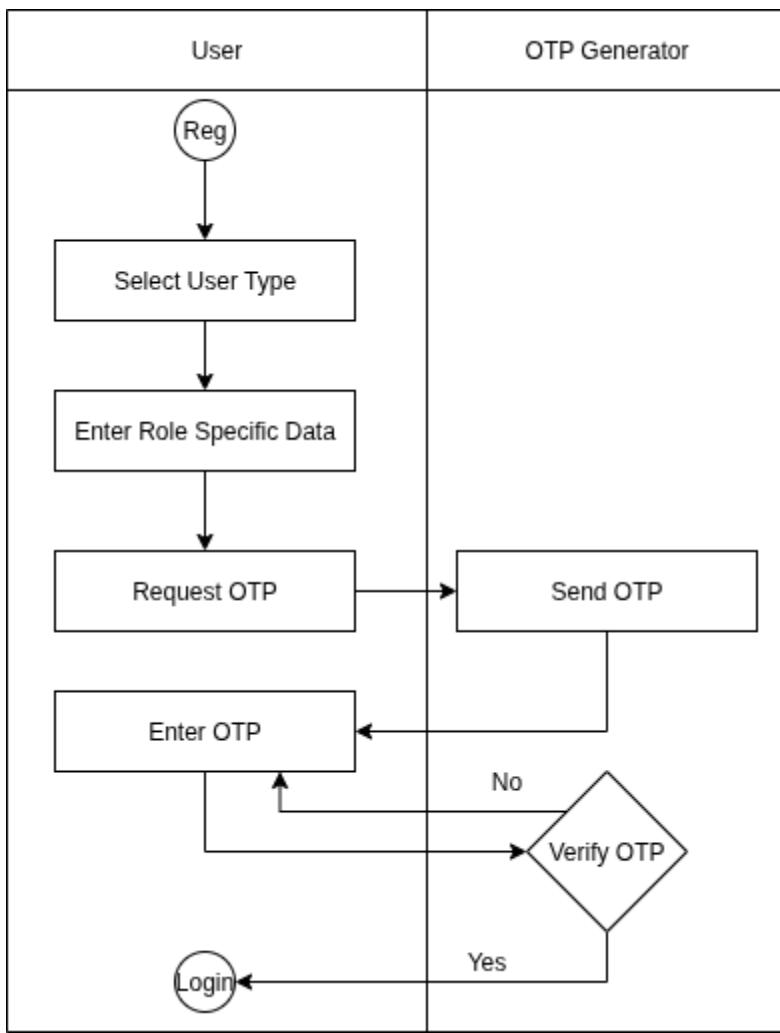
Level 1.1:

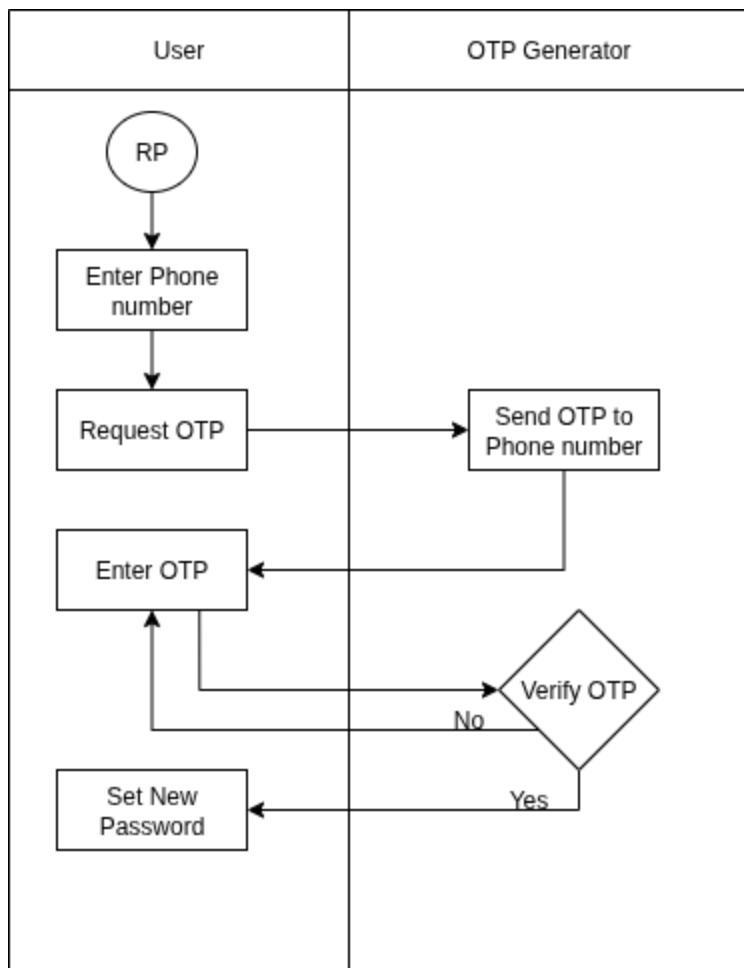
Name: Registration & Login

Reference: Activity Diagram Level 1.1





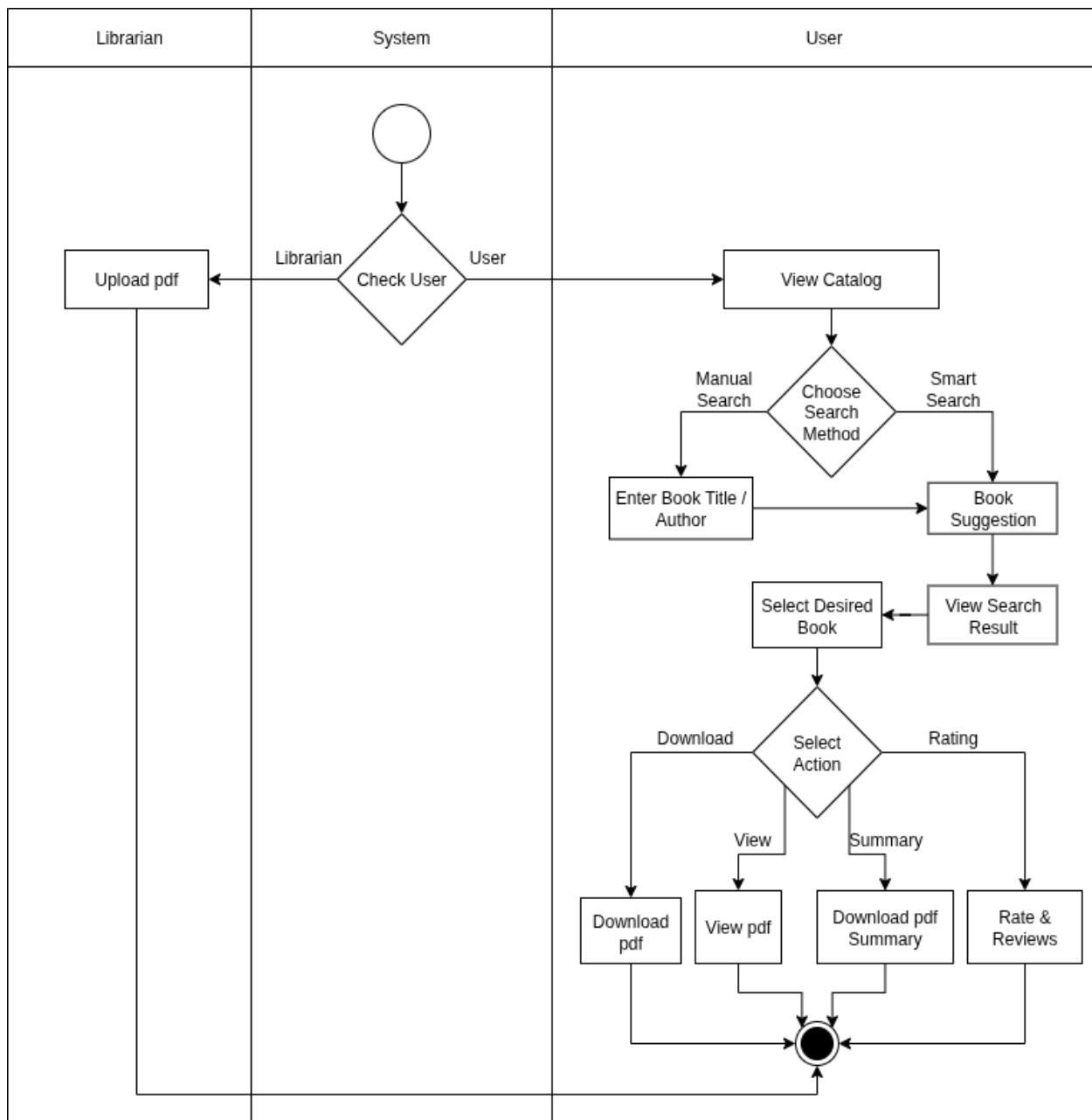




Level 1.2:

Name: E-library

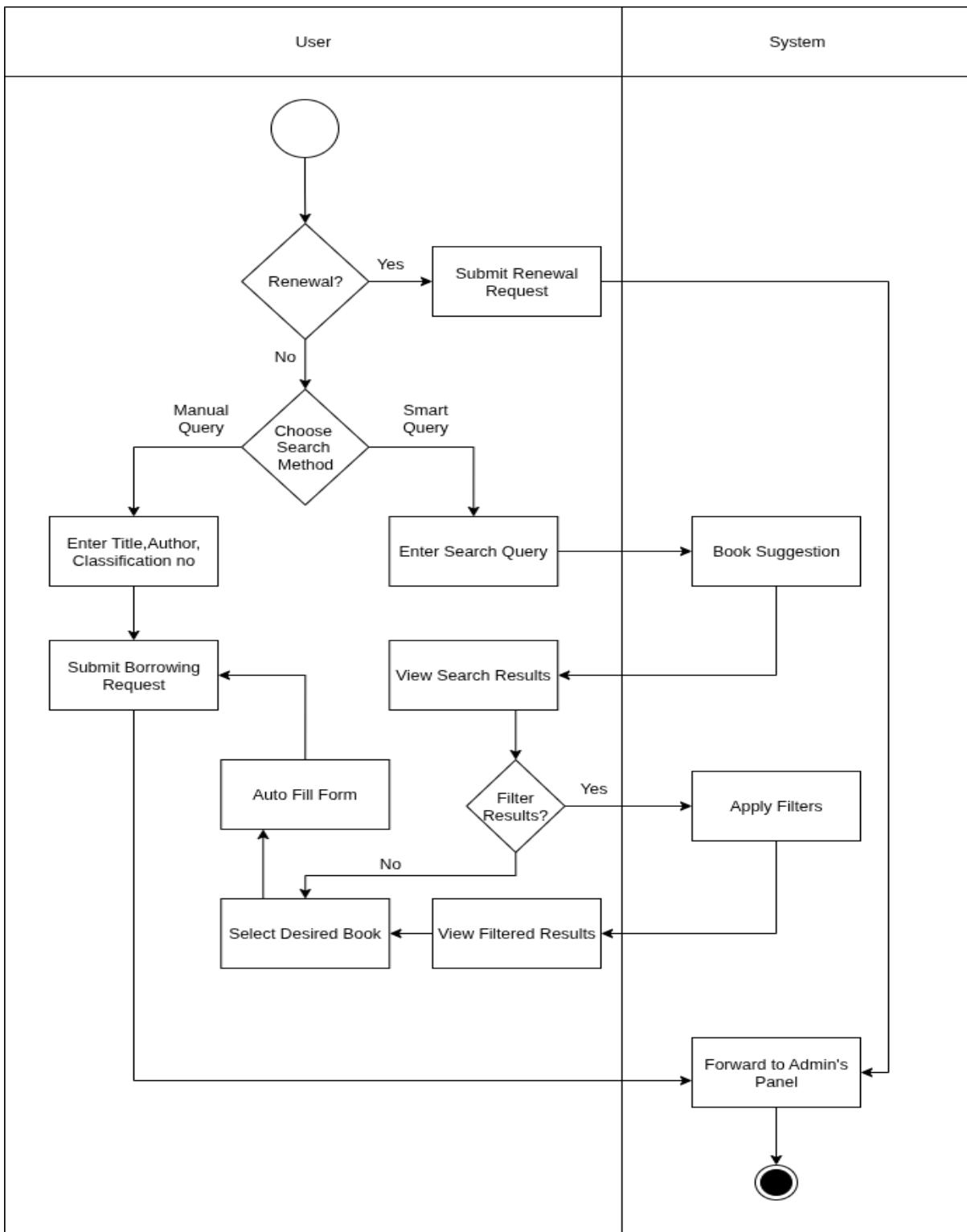
Reference: Activity Diagram Level 1.2



Level 1.3:

Name: Borrow Book

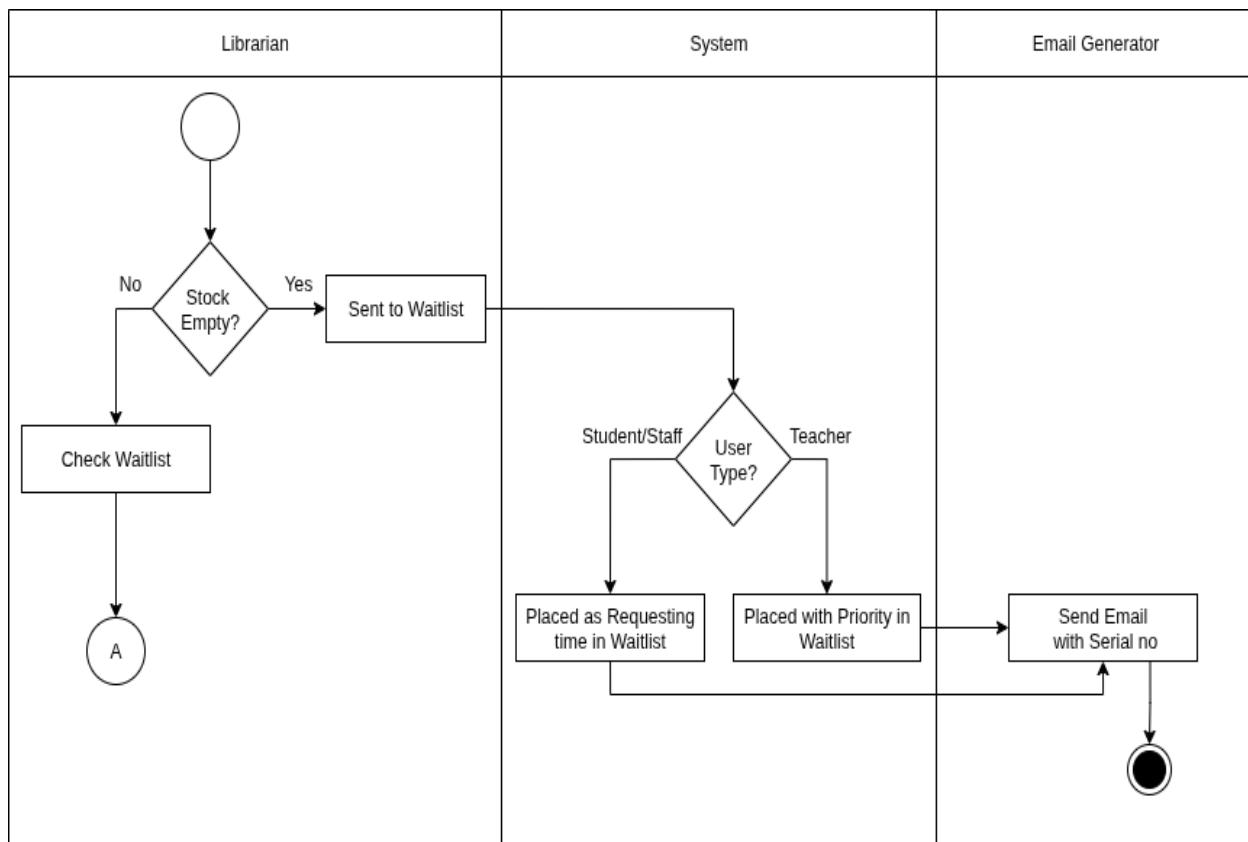
Reference: Activity Diagram Level 1.3



Level 1.4.1:

Name: Availability

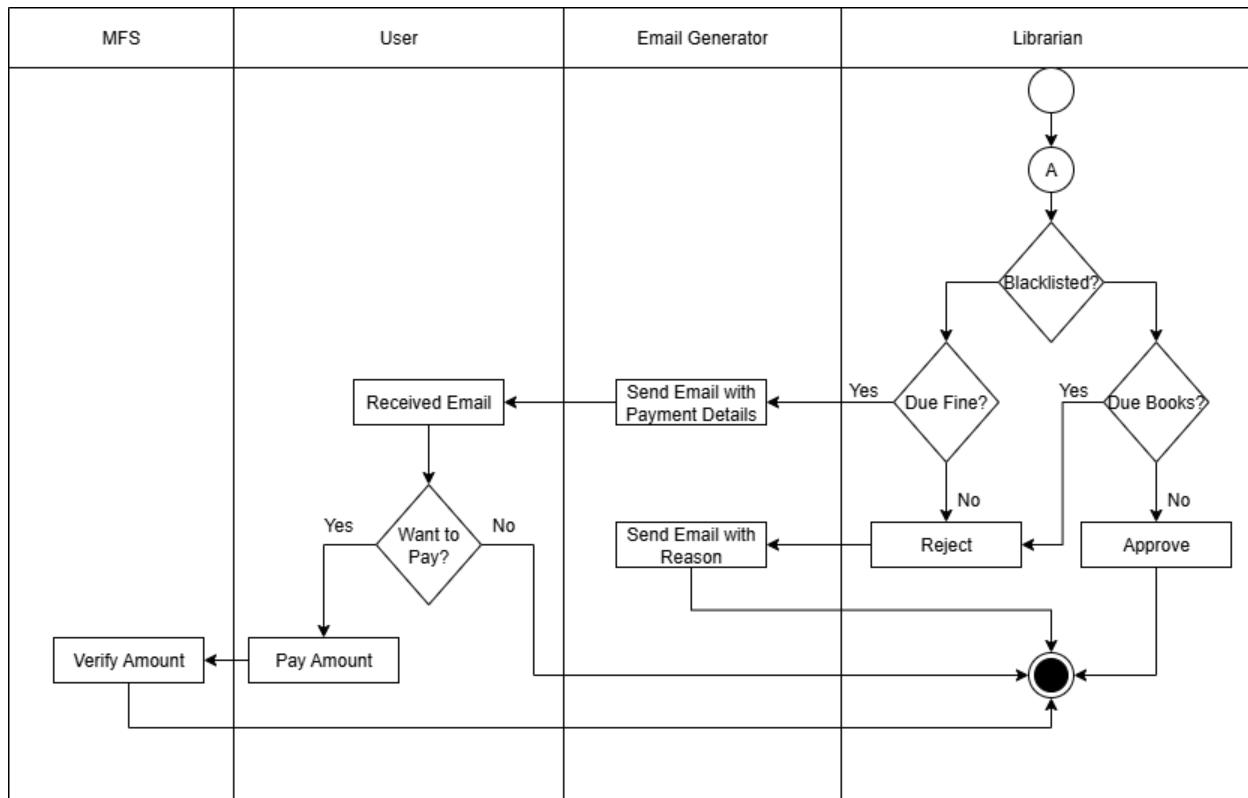
Reference: Activity Diagram Level 1.4.1



Level 1.4.2:

Name: Eligibility

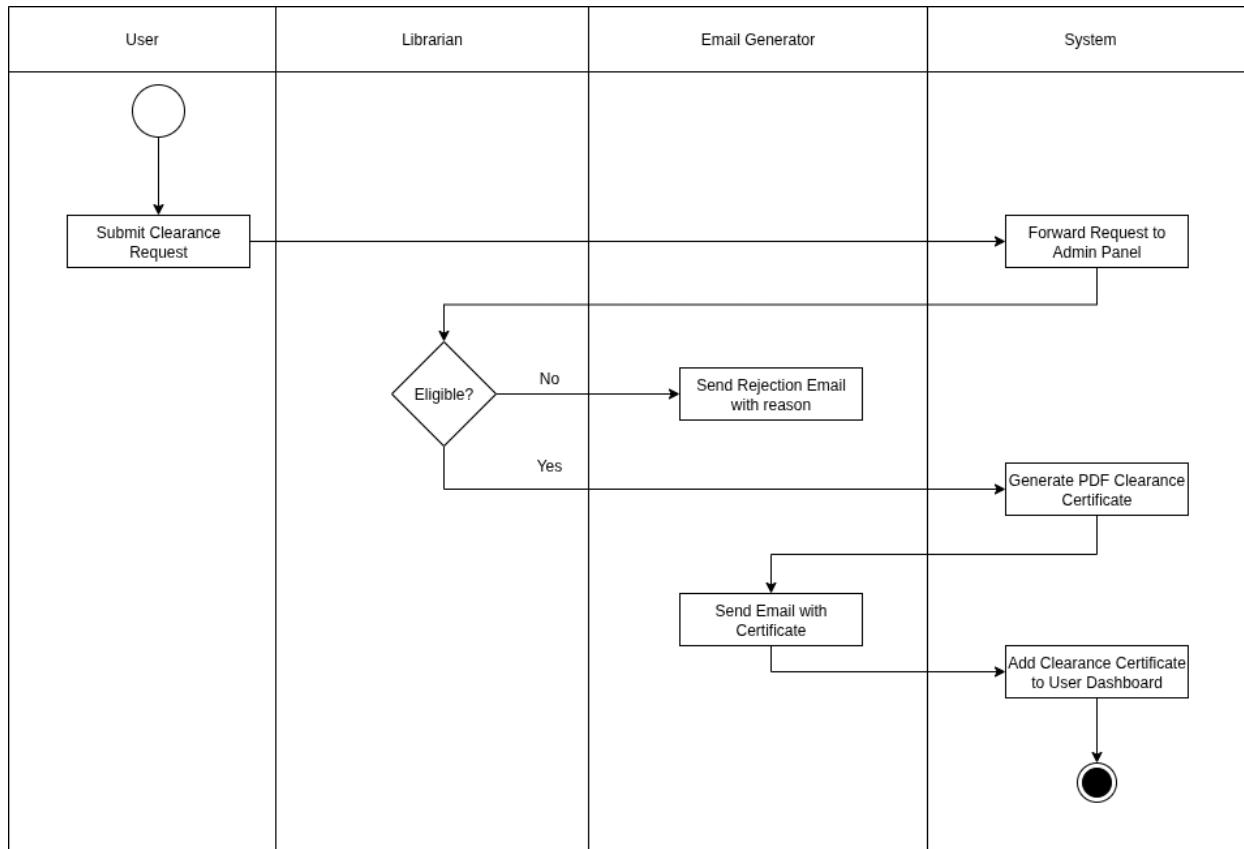
Reference: Activity Diagram Level 1.4.2



Level 1.5:

Name: Clearance

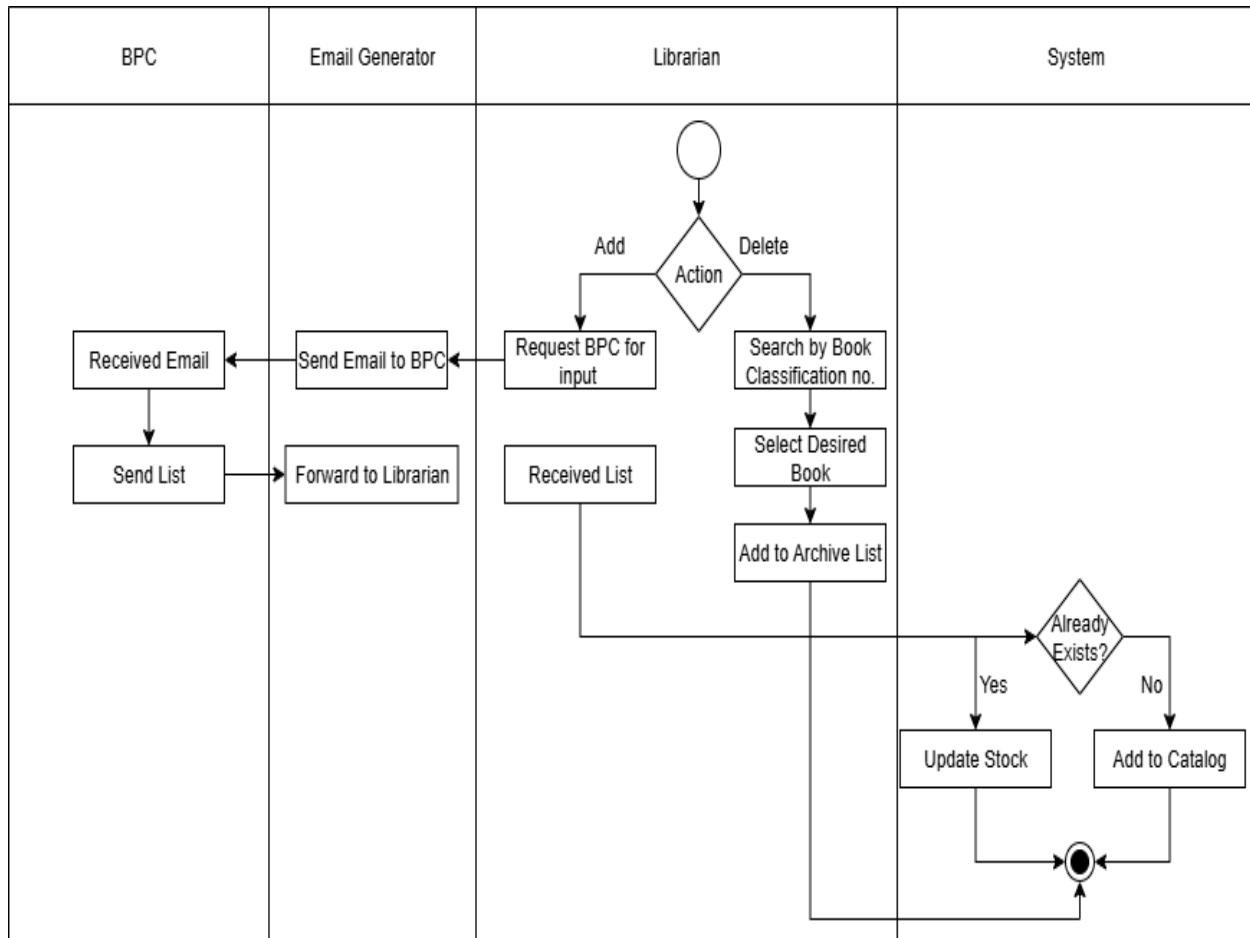
Reference: Activity Diagram Level 1.5



Level 1.6:

Name: Book Management

Reference: Activity Diagram Level 1.6



7. Data Based Modeling

7.1 Data Object Identification

No.	Noun	P / S	Attributes
1	ISRT	P	
2	Research Journal	P	
3	Demand	P	
4	Suggestion	P	
5	Category	S	
6	Annual budget	P	
7	Bill	P	
8	Accountability	P	
9	Borrowing	S	87, 45, 48, 15
10	Internal reference	P	
11	Researcher	P	
12	Research	P	
13	Output	P	
14	Certificate	P	
15	Date	S	
16	Marksheet	P	
17	Pension	P	
18	Pending book	P	
19	Statement	P	
20	Mobile	P	
21	Working duration	P	
22	Metadata	P	

23	Audit	P	
24	Academic publishing	P	
25	Account	P	
26	Library Management System (LMS)	P	
27	User	S	32, 33, 40, 41, 44, 70, 80, 91
28	Student	S	36, 37, 38, 39
29	Teacher	S	42, 89
30	Staff	S	42, 89
31	Faculty	P	
32	Name	S	
33	Phone number	S	
34	OTP	S	33, 71, 15
35	Verification	P	
36	Roll number	S	
37	Registration number	S	
38	Session	S	
39	Hall name	S	
40	Email	S	
41	Address	S	
42	Designation	S	
43	User ID	S	
44	Password	S	
45	Return date	S	
46	Fine	S	87, 103

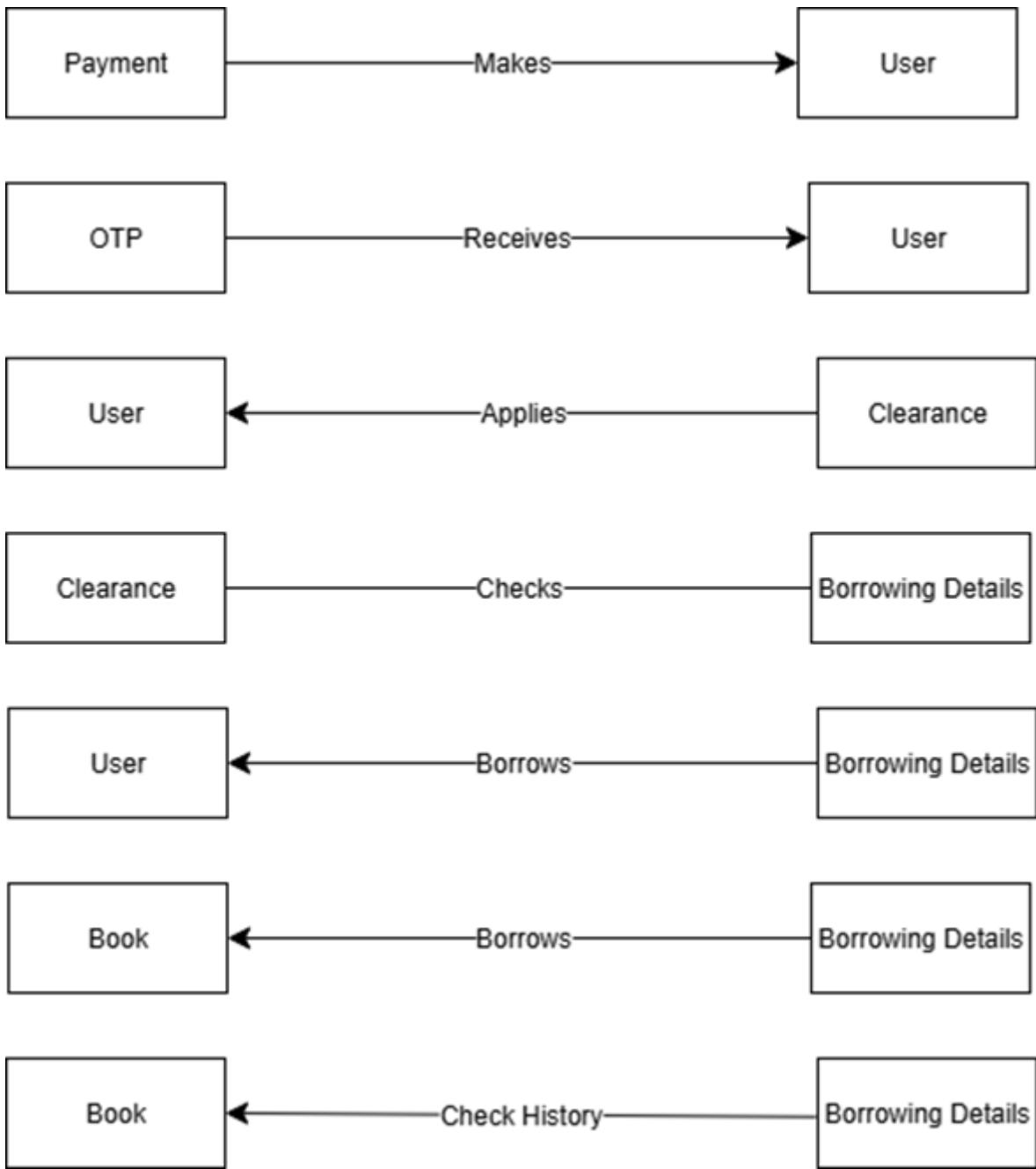
47	Payment	S	33, 78,92
48	Status	S	
49	Notification	P	
50	SMS	P	
51	E-Library	P	
52	Book PDF	S	
53	Title	S	
54	Author	S	
55	Subject	S	
56	Summary PDF	S	
57	Review	S	
58	Rating	S	
59	Feedback	P	
60	Smart search function	P	
61	Filtering option	P	
62	Borrowing request	P	
63	Borrowing form	S	
64	Classification number	S	
65	Integrated library catalog	P	
66	Availability	P	
67	Waitlist	P	
68	Eligibility	P	
69	Queue	P	
70	Role	S	
71	Application time	S	

72	Teacher priority	P	
73	Return deadline	S	
74	Fine policy	P	
75	Library seal	P	
76	Blacklist status	S	
77	Cancellation notice	P	
78	Mobile Financial Services (bKash, Nagad)	S	
79	Transaction confirmation	P	
80	Demerit point	S	
81	Renewal	P	
82	Borrowing record	P	
83	Book purchase committee	P	
84	Clearance	S	48,76, 85, 86, 87, 14
85	Request	P	
86	Type	S	
87	Form	S	
88	Pending book	S	
89	Department	S	
90	Book	S	52, 53, 54, 93, 94, 55, 64, 5, 58, 94
91	Amount	S	
92	Transaction ID	S	
93	Price	S	
94	Number of pages	S	
95	Archive		

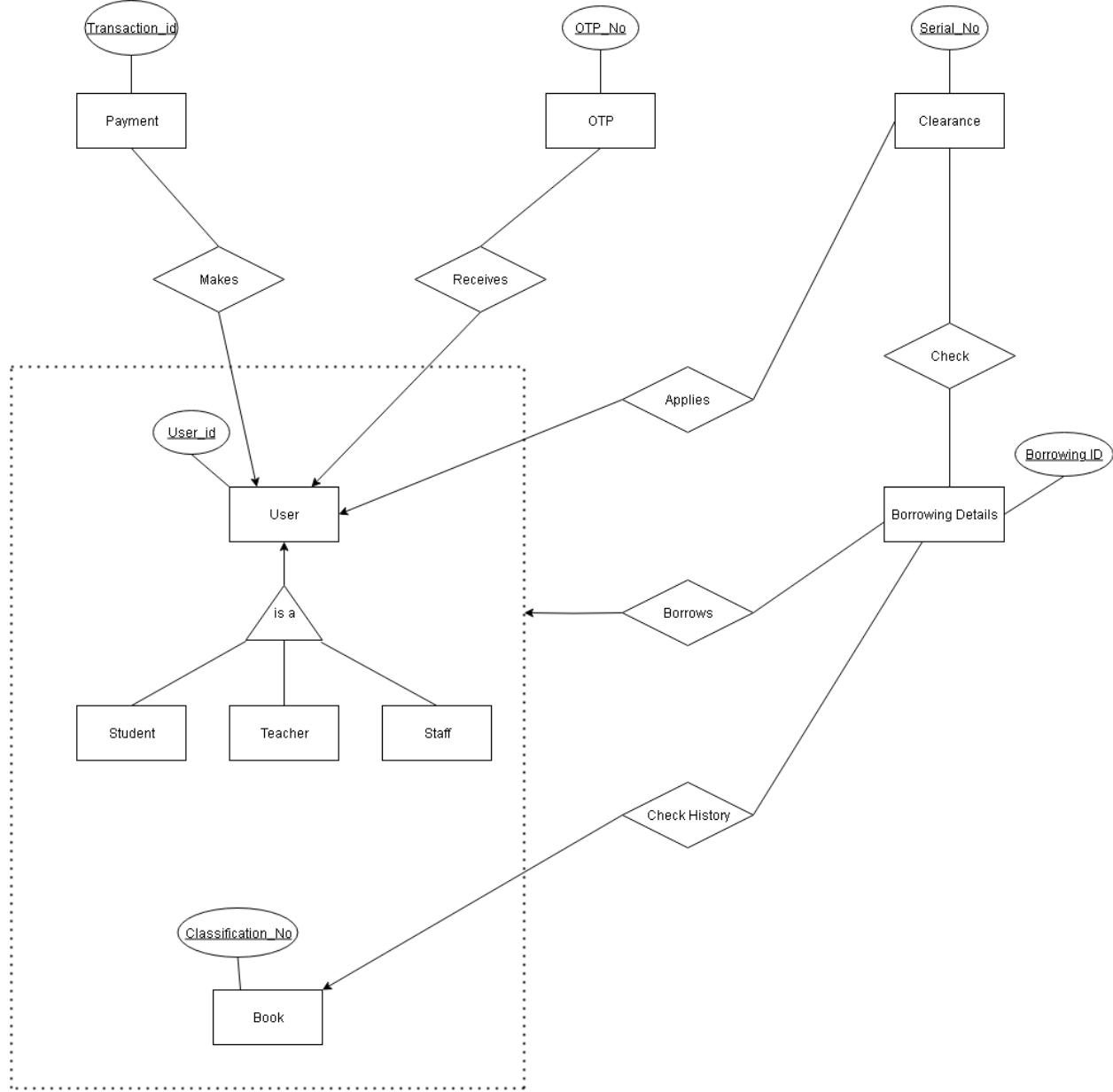
7.2 Data Objects:

No.	Data Objects	Attributes
1	User	Name, Phone no, Email, Address, User Id, Password, Role, Demerit Point, Amount
2	Student	Roll no, Registration no, Session, Hall
3	Teacher	Designation, Department
4	Staff	Designation, Department
5	Clearance	Status, Blacklist Status, Request, Type, Form, Certificate
6	Book	Book pdf, Title, Author, Number of Page, Price, Subject, Classification no, Category, Rating, Archive
7	Payment	Phone no, MFS, Transaction ID
8	OTP	OTP no, Phone no, Time, Date
9	Borrowing_Details	Borrow Id, Borrow Date, Form, Return date, Status

7.3 Relations:



7.4 ERD:



7.5 Schema:

No.	Entity Name	Attribute	Type	Description
1.	User	User_Id (PK)	INT	Unique identifier for each user
		Name	VARCHAR	Full name of the user
		Phone_No	VARCHAR	User's phone number
		Email	VARCHAR	User's email address
		Address	VARCHAR	Residential address
		Password	VARCHAR	Login password
		Role	VARCHAR	Defines user type (Student, Teacher, Staff)
		Demerit_Point	INT	Points deducted for violations
		Amount	INT	Balance amount or dues
2.	Student	User_Id (PK, FK)	INT	References User
		Roll_No	VARCHAR	Student roll number
		Registration_No	VARCHAR	Student registration number
		Session	VARCHAR	Academic session
		Hall	VARCHAR	Hall or dormitory name
3	Teacher	User_Id (PK, FK)	INT	References User
		Designation	VARCHAR	Teacher's designation
		Department	VARCHAR	Department of the teacher
4	Staff	User_Id (PK, FK)	INT	References User
		Designation	VARCHAR	Staff designation
		Department	VARCHAR	Staff department
5	Clearance	Serial_No (PK)	INT	Unique clearance number
		User_Id (FK)	INT	References User

		Status	VARCHAR	Clearance status
		Blacklist_Status	BOOLEAN	Whether the user is blacklisted
		Request	VARCHAR	Clearance request type
		Type	VARCHAR	Type of clearance
		Form	VARCHAR	Clearance form
		Certificate	VARCHAR	Related certificate
6	Book	Classification_No (PK)	INT	Unique classification number
		Title	VARCHAR	Book title
		Author	VARCHAR	Book author
		Subject	VARCHAR	Subject area
		Book_PDF	VARCHAR	PDF file path or link
		Category	VARCHAR	Book category
		Rating	INT	Book rating
		Price	DECIMAL	Price of a Book
		Number_of_page	INT	Number of pages of a book
		Archive	BOOLEAN	Whether book is archived
7	Payment	Transaction_Id (PK)	INT	Unique transaction identifier
		User_Id (FK)	INT	References User
		Phone_No	VARCHAR	Payment phone number
		MFS	VARCHAR	Mobile financial service used
8	OTP	OTP_No (PK)	INT	One-time password identifier
		User_Id (FK)	INT	References User
		Phone_No	VARCHAR	User's phone number
		Time	VARCHAR	OTP generation time

		Date	DATE	OTP generation date
9	Borrowing_Details	Borrow_Id (PK)	INT	Unique borrow identifier
		User_Id (FK)	INT	References User
		Classification_No (FK)	INT	References Book
		Borrow_Date	DATE	Borrowing date
		Return_Date	DATE	Book return date
		Status	VARCHAR	Status of Borrowing
10	Check	Serial_No (PK, FK)	INT	References Clearance
		Borrow_Id (PK, FK)	INT	References Borrowing_Details

8. Class Based Modeling

Class-based modeling defines the structure of the entire system by identifying the static structure of objects in that system. A class model defines attributes and operations for the objects of each class and also the relationship between the objects, and the collaborations that occur between the classes of the systems. The elements of a class-based model include classes and objects, attributes, operations, Class- Responsibility- Collaborator (CRC) models, collaboration diagrams, and packages.

8.1 General Characteristics

Candidate classes are categorized based on the seven general classification. The analysis classes manifest themselves in one of the following ways:

1. External Entities
2. Things
3. Occurrence/Events
4. Organizational Unit
5. Role
6. Places
7. Structures

A candidate class is selected for special classification if it fulfills three or more characteristics.

List of Nouns:

Sl. No.	Noun	P / S	General Classification
1.	Library Management System (LMS)	S	4
0.	User	S	4,5,7
0.	Student	S	4,5,7
0.	Teacher	S	4,5,7
0.	Staff	S	4,5,7
0.	Name	S	2
0.	Phone number	S	2
0.	OTP	S	1
0.	Verification	S	3
0.	Roll number	S	2
0.	Registration number	S	2
0.	Session	S	2
0.	Hall	S	6
0.	Email	S	1
0.	Address	S	6
0.	Designation	S	2
0.	User ID	S	2
0.	Password	S	2
0.	Account	S	2
0.	Due date	S	
0.	Fine	S	
0.	Payment	S	3
0.	Status	S	

0.	Notification	S	
0.	SMS	S	
0.	E-Library	S	
0.	Book PDF	S	
0.	Title	S	
0.	Author	S	5
0.	Subject	S	
0.	Summary PDF	S	
0.	Review	S	
0.	Rating	S	
0.	Feedback	S	
0.	Smart search function	S	
0.	Filtering option	S	
0.	Borrowing request	S	
0.	Borrowing form	S	
0.	Classification number	S	2
0.	Integrated library catalog	S	2
0.	Book information	S	
0.	Availability	S	
0.	Waitlist	S	
0.	Eligibility	S	
0.	Approval	S	
0.	Real-time stock	S	
0.	Queue	S	
0.	Role	S	
0.	Application time	S	

0.	Teacher priority	S	
0.	Category	S	
0.	Return deadline	S	
0.	Fine policy	S	
0.	Library seal	S	
0.	Blacklist status	S	
0.	Cancellation notice	S	
0.	Mobile Financial Services (bKash, Nagad)	S	1
0.	Transaction confirmation	S	
0.	Demerit point	S	2
0.	Outstanding fine	S	2
0.	Reactivation	S	3
0.	Renewal	S	3
0.	Borrowing record	S	
0.	Book purchase committee	S	4
0.	Clearance	S	3, 7
0.	Request	S	
0.	Type	S	
0.	Form	S	
0.	Certificate	S	
0.	Marksheet	S	
0.	Pension	S	
0.	Pending book	S	
0.	Department	S	
0.	Book	S	2, 4, 7
0.	Amount	S	

0.	Transaction ID	S	
0.	Payment	S	3,7
0.	OTP	S	1, 2, 3, 7
0.	Admin	S	4, 5, 7
1.	BPC	S	1

Possible Classes:

1. User
2. Student
3. Teacher
4. Staff
5. MFS
6. OTP
7. Book
8. Admin
9. EmailGenerator
10. SummaryGenerator
11. BPC

8.2 Selection Criteria:

1. Retained Information
2. Needed Service
3. Multiple Attributes
4. Common Operation
5. Common Attributes
6. Essential Requirements

No	Classes	Selection Criteria
1.	User	1, 3, 5, 6
2.	Student	1, 3, 5, 6
3.	Teacher	1, 3, 5, 6
4.	Staff	1, 3, 5, 6
5.	MFS	6
6.	OTP	6
7.	Book	1, 2, 3, 6
8.	Admin	1, 3, 6
9.	EmailGenerator	6
10.	SummaryGenerator	6
11.	BPC	6

Analysis:

We can remove “Student, Teacher, Staff” class because all attributes and responsibilities can be found in “User” class.

8.3 List of Verbs:

No	Verbs	No	Verbs
1.	Begin	41.	View
2.	Select	42.	Borrow
3.	Register	43.	Activity
4.	Provide	44.	Ensure
5.	Submit	45.	Request
6.	Sent	46.	Need
7.	Verify	47.	Browse
8.	Enter	48.	Search
9.	Create	49.	Download
10.	Access	50.	Participate
11.	Grant	51.	Review
12.	Complete	52.	Leave
13.	Login	53.	Offer
14.	Recognize	54.	Engage
15.	Forget	55.	Promote
16.	Recover	56.	Encourage
17.	Allow	57.	Enable
18.	Reset	58.	Find
19.	Confirm	59.	Filter
20.	Initiate	60.	Fill out
21.	Find	61.	Display
22.	Click	62.	Forward
23.	Process	63.	Check
24.	Redirect	64.	Reject

25.	Cancel	65.	Receive
26.	Reserve	66.	Hold
27.	Ensure	67.	Move
28.	Add	68.	Place
29.	Give	69.	Organize
30.	Monitor	70.	Notify
31.	Return	71.	Align
32.	Include	72.	Save
33.	Meet	73.	Pay
34.	Update	74.	Settle
35.	Clear	75.	Approve
36.	Renewal	76.	Handle
37.	Analyze	77.	Depend
38.	Remove	78.	Publish
39.	Apply	79.	Appear
40.	Contain		

Selected Classes:

1. User

a. Attributes:

- Name
- Phone No
- Email
- Address
- User Id
- Password
- Role

- Demerit Point
- Amount

b. Methods:

- register()
- login()
- recoverPassword()
- updateProfile()
- submitClearanceRequest()
- borrowBook()
- payFine()
- receiveNotification()

2. Admin

a. Attributes:

- Name
- Phone No
- Email
- adminId
- Password

b. Methods:

- approveBorrowRequest()
- rejectBorrowRequest()
- approveClearance()
- rejectClearance()
- setReturnDeadline()
- uploadResearchJournal()
- addBook()

- updateBook()
- deleteBook()
- verifyPurchaseBills()

3. Book

a. Attributes:

- bookId
- title
- author
- subject
- classificationNo
- category
- rating
- bookPDF
- archived

b. Methods:

- searchBook()
- viewDetails()
- downloadPDF()
- updateAvailability()
- archiveBook()
- addRating()

4. MFS (Mobile Financial Service)

a. Attributes:

- transactionId
- phoneNo
- serviceName

b. Methods:

- processPayment()
- verifyTransaction()
- notifyUser()

5. OTP

a. Attributes:

- otpNo
- phoneNo
- time
- date

b. Methods:

- generateOTP()
- sendOTP()
- verifyOTP()
- expireOTP()

6. EmailGenerator

a. Attributes:

- email
- date

b. Methods:

- sendAccountEmail()
- sendBorrowingEmail()
- sendClearanceEmail()
- sendNotificationEmail()

7. SummaryGenerator

a. Attributes:

- pdf
- bookTitle

b. Methods:

- generateSummary()
- exportSummaryPDF()
- saveSummary()

8. BPC

a. Attributes:

- members
- budget
- committeeId
- bookList

b. Methods

- reviewSuggestion()
- updateCommittee()
- updateBookList()

8.4 CRC:

1. User

Attributes	Methods
Name	register()
Phone No	login()
Email	recoverPassword()
Address	updateProfile()
User Id	submitClearanceRequest()
Password	borrowBook()
Role	payFine()
Demerit Point	rateBook()
Amount	
Responsibilities	Collaborator
Register and log in with role-specific details	Admin
Recover password using OTP	OTP
Pay fines via MFS	MFS
Request clearance (certificate, marksheets, pension)	Admin

2. Admin

Attributes	Methods
name	approveBorrowRequest()
phoneNo	rejectBorrowRequest()
email	approveClearance()
adminId	rejectClearance()
password	setReturnDeadline() uploadResearchJournal() addBook() updateBook() deleteBook() verifyPurchaseBills()
Responsibilities	Collaborator
Approve/reject borrow requests	User
Add, update, or delete book records	Book
Verify bills for purchased books	MFS, OTP

3. Book

Attributes	Methods
bookId	searchBook()
title	viewDetails()
author	downloadPDF()
subject	updateAvailability()
classificationNo	archiveBook()
category	addRating()
rating	
bookPDF	
archived	
Responsibilities	Collaborator
Maintain book metadata	Admin
Provide PDF downloads	SummaryGenerator

4. MFS

Attributes	Methods
transactionId	processPayment()
phoneNo	verifyTransaction()
serviceName	notifyUser()
Responsibilities	Collaborator
Process payments (fines, fees)	User
Verify transaction IDs	Admin
Notify users of successful or failed payments	User

5. OTP

Attributes	Methods
otpNo	generateOTP()
phoneNo	sendOTP()
time	verifyOTP()
date	
Responsibilities	Collaborators
Generate & send OTP for registration and password recovery	User
Verify OTP for authentication	Admin

6. EmailGenerator:

Attributes	Methods
Email Date	sendAccountEmail() sendBorrowingEmail() sendClearanceEmail() sendNotificationEmail()
Responsibilities	Collaborators
Send account-related emails	User
Send borrowing approval/rejection	Admin
Send clearance approval/rejection	User, Admin
Send due/fine notifications	User
Log email with date	OTP, MFS, SummaryGenerator

7. BPC

Attributes	Methods
members budget committeeId bookList	reviewSuggestion() updateCommittee() updateBookList()
Responsibility	Collaborator
verifies bills	Admin
Give book list	Admin

8. Summary Generator

Attributes	Methods
pdf bookTitle	generateSummary() exportSummaryPDF() saveSummary()
Responsibility	Collaborator
Generates summary of book or journal	User

8.5 CRC Diagram:

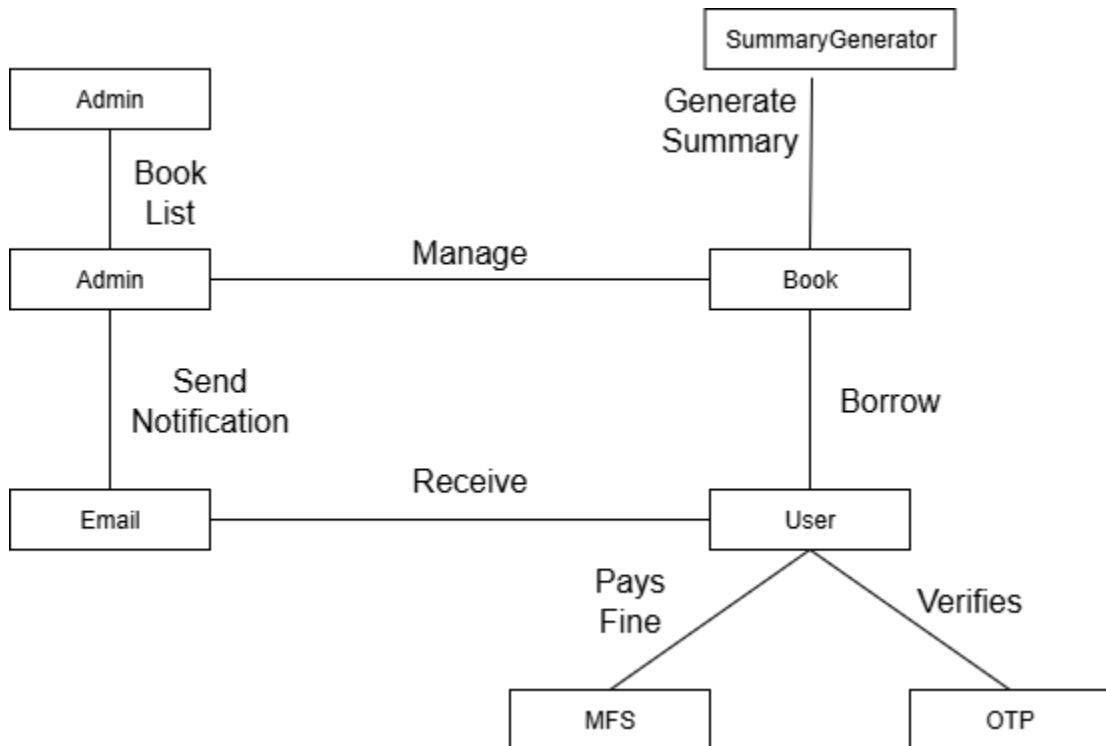


Figure 42: Class Responsibility Collaborator Diagram

9. Behavioral Modeling

9.1 Introduction

The behavioral model predicts how the software will react to events or stimuli outside its control. Two distinct characterizations of states must be taken into account while modeling behavior: (1) the state of each class as the system executes its function, and (2) the state of the system as seen from the outside as the system executes its function.

9.2 State Transition

List of Events:

No	Initiator	Event	Event Name	Collaborator
01	Admin	Enter classification no, title, author	Add Book to Catalog	Book
02	Admin	Enter classification no to search	Check Book Availability	Book
03	User	Provide registration details	User Registration	OTP
04	User	Enter user id, password	User Login	Admin
05	User	Enter classification no/title	Search Book	Book
06	User	Submit clearance application	Clearance Request Submitted	Admin
07	User	Pay fine via MFS	Fine Payment	MFS
08	User	Enter book title for PDF	Request PDF Download	Book
09	MFS	Complete transaction	Payment Confirmed	User
10	OTP	Generate and send OTP	OTP Sent	User
11	EmailGenerator	Send confirmation/fine/clearance email	Notification Sent	User
12	Admin	Enter admin id, password	Admin Login	Admin

No	Initiator	Event	Event Name	Collaborator
13	Admin	Upload book PDF/journal	E-Library Update	Book
14	BPC	Send approved book list	Book List Submitted	Admin
15	Admin	Approve clearance request	Clearance Approved	EmailGenerator
16	Admin	Reject clearance request	Clearance Rejected	User
17	Admin	Approve borrow request, set deadline	Borrow Approved	User
18	Admin	Reject borrow request	Borrow Rejected	User
19	User	Return borrowed book	Book Returned	Admin
20	Admin	Update book status after return	Availability Updated	Book
21	User	Submit rating/review	Book Rated	Book
22	SummaryGenerator	Generate summary PDF	Summary Created	User
23	User	Request renewal	Renewal Requested	Admin
24	Admin	Approve renewal (within limit)	Renewal Approved	EmailGenerator
25	Admin	Reject renewal	Renewal Rejected	User
26	System	Trigger before deadline	Reminder Sent	EmailGenerator
27	Admin	Archive old/damaged book	Book Archived	Book
28	Admin	Verify purchase bills	Bills Verified	BPC
29	User	Update personal profile	Profile Updated	Admin
30	Admin	Assign budget for book purchase	Budget Allocated	BPC
31	BPC	Review borrowing trends and demand	Suggest Books	Admin
32	Admin	Delete a book record	Book Deleted	Book
33	User	Request account reactivation	Reactivation Requested	Admin

No	Initiator	Event	Event Name	Collaborator
34	Admin	Verify fines and overdue books	Reactivation Verified User	
35	Admin	Approve reactivation	Reactivation Approved	User
36	Admin	Reject reactivation	Reactivation Rejected	User
37	User	Forget password and enter phone no	Password Recovery Started	OTP
38	OTP	Verify OTP for password reset	OTP Verified	User
39	User	Set new password	Password Reset	Admin
40	EmailGenerator	Send password reset confirmation	Password Reset Email Sent	User
41	System	Add demerit point after missed deadline	Demerit Assigned	User
42	User	View borrowed book list	Borrowed List Viewed	Admin
43	Admin	Upload research journal	Research Journal Added	Book
44	User	View research journal	Journal Accessed	Book
45	User	Log out	User Logged Out	Admin
46	Admin	Log out	Admin Logged Out	Admin

9.2.1 User

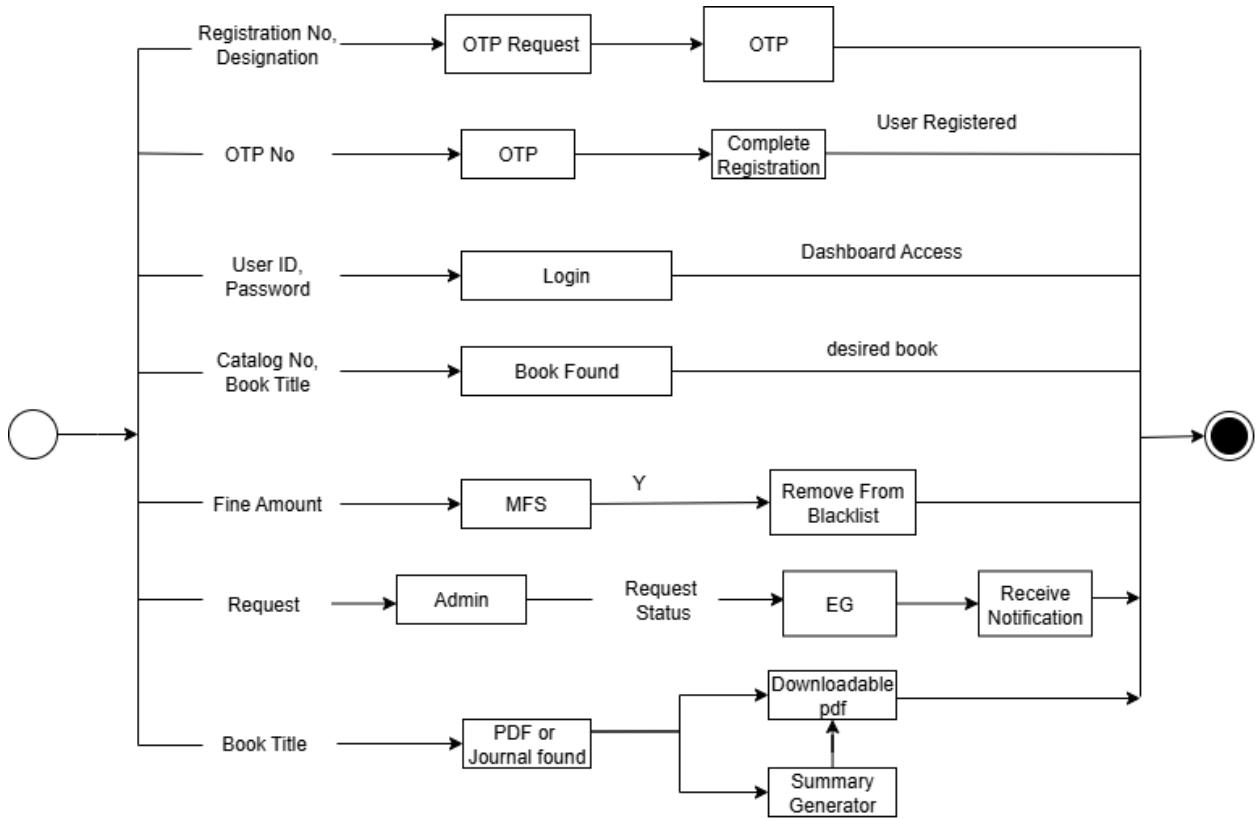


Figure 43: State Transition of User Class

9.2.2 OTP

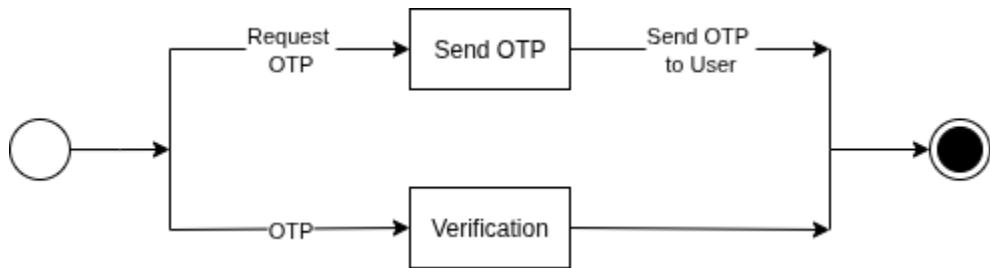


Figure 44: State Transition of OTP Class

9.2.3 MFS

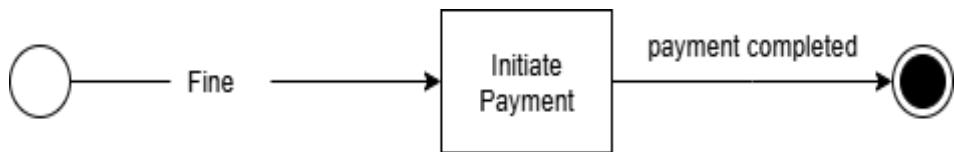


Figure 45: State Transition of MFS Class

9.2.4 EmailGenerator

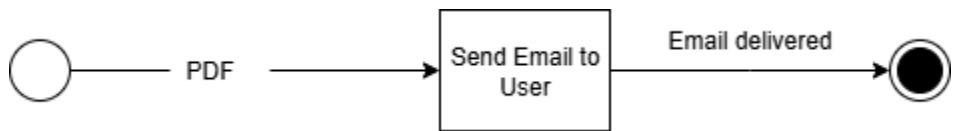


Figure 46: State Transition of EmailGenerator Class

9.2.5 Admin

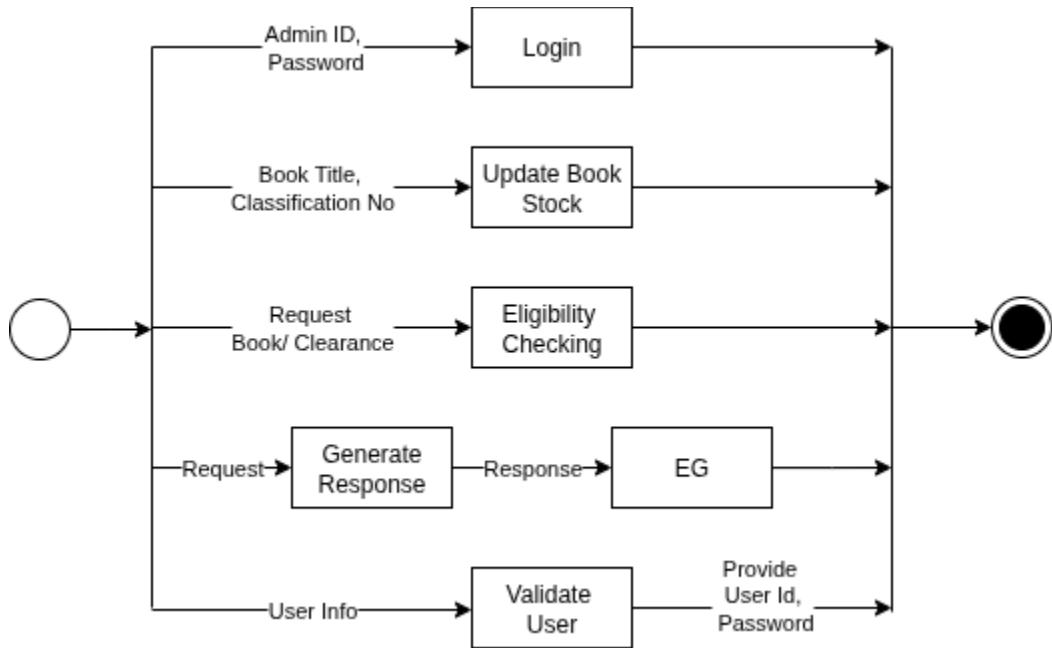


Figure 47: State Transition of Admin Class

9.2.6 Book

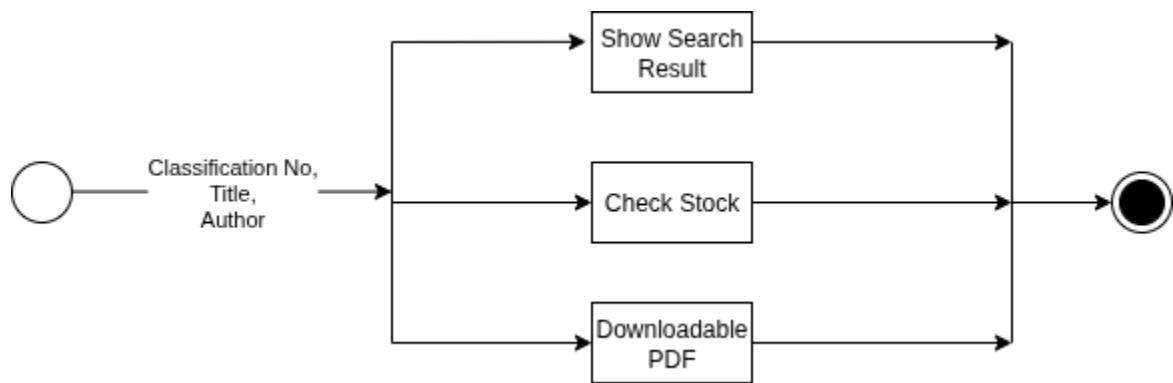


Figure 48: State Transition of Book Class

9.2.7 BPC

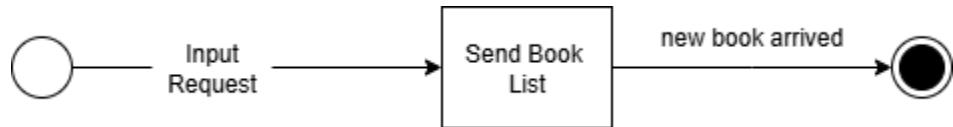


Figure 49: State Transition of BPC Class

9.2.8 SummaryGenerator

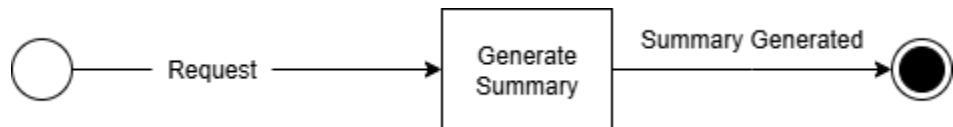


Figure 50: State Transition of SummaryGenerator Class

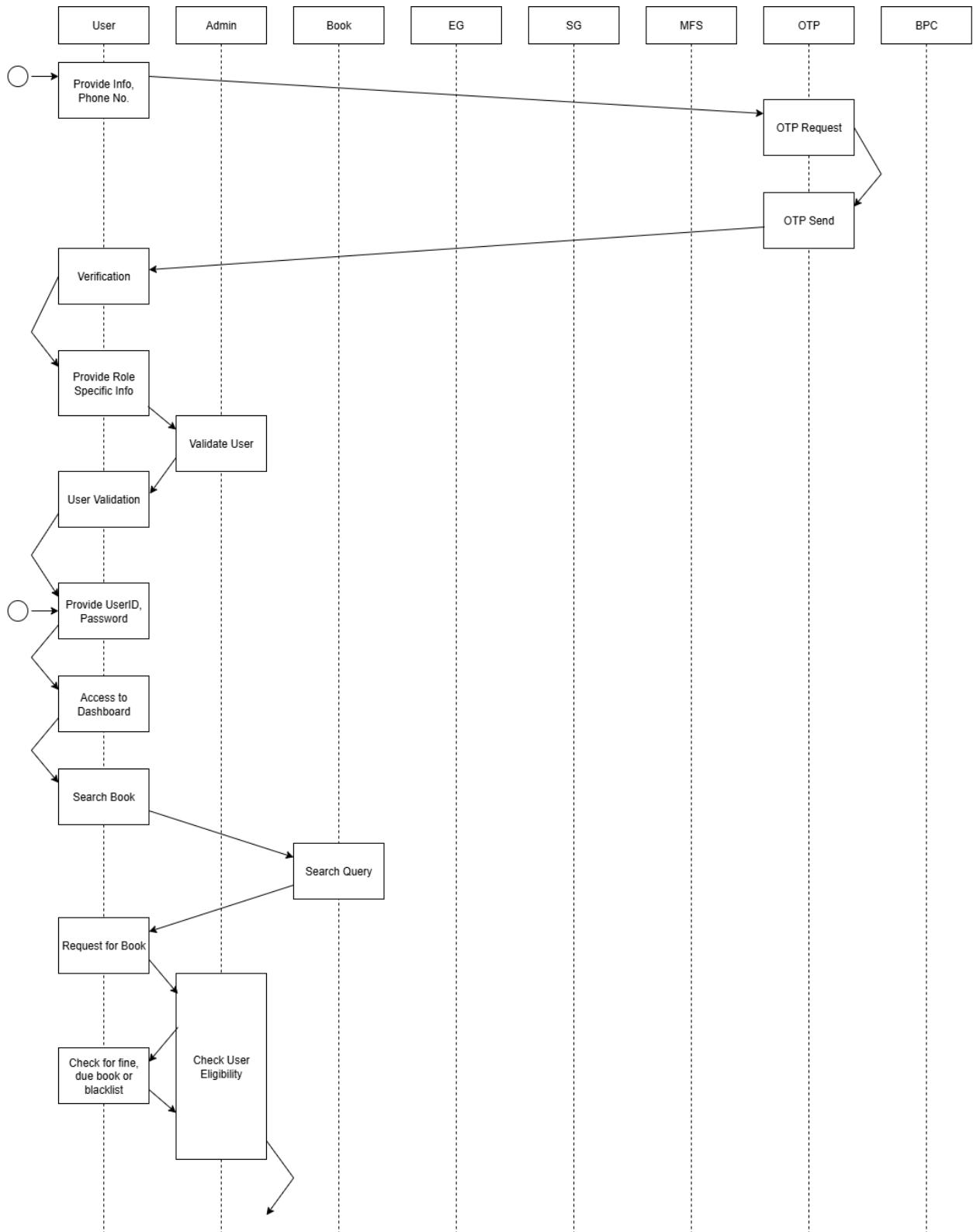
9.3 Sequence Diagram

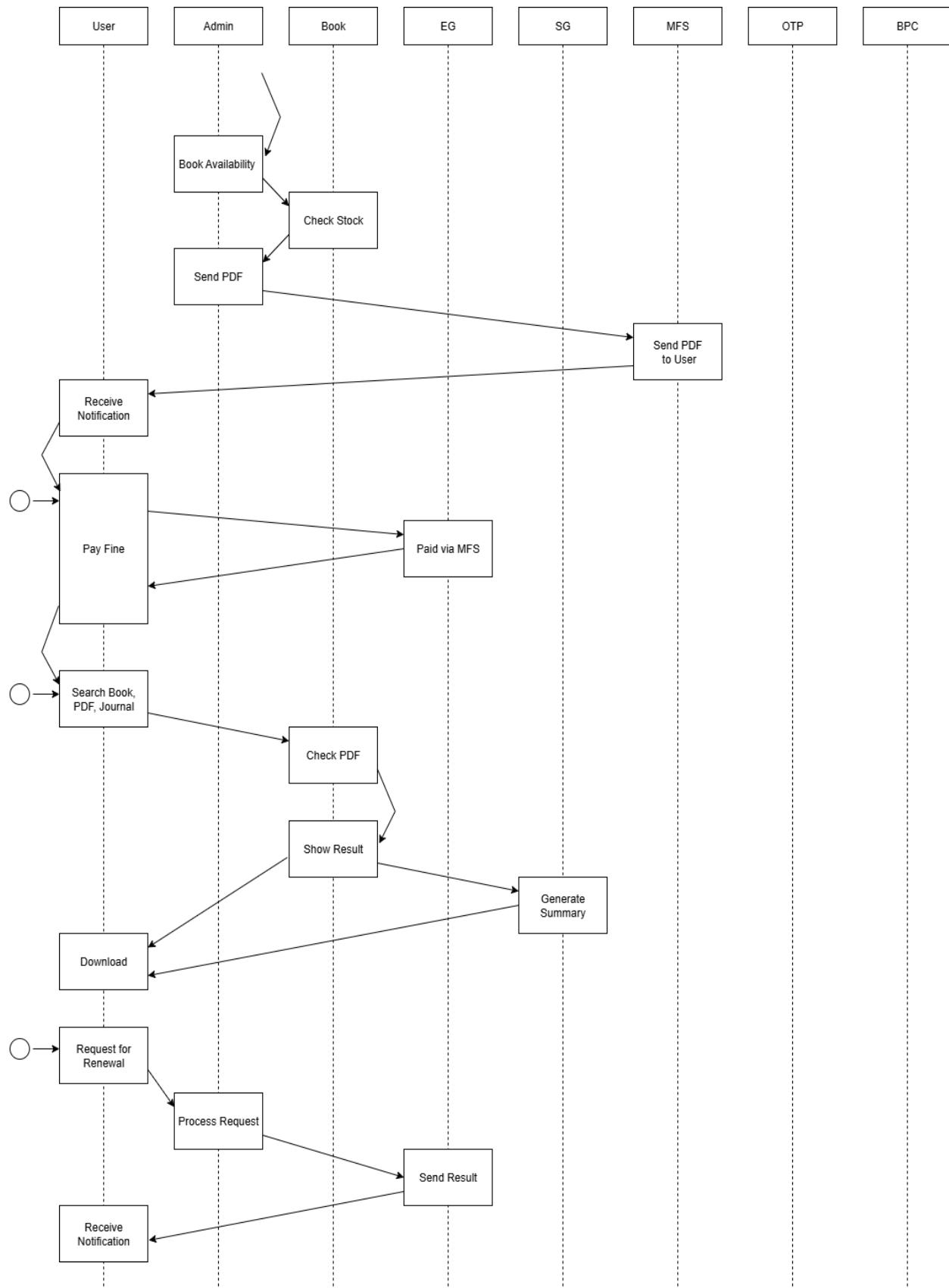
The second type of behavioral representation, called a sequence diagram in UML, represents how events cause flow from one object to another as a function of time. The sequence diagram is a shorthand version of the use case. It represents vital classes and the events that cause behavior to flow from class to class.

9.3.1 Purpose of Sequence Diagram

- High-level interaction between active objects in a system
- The interaction between object instances within a collaboration that realizes a use case
- The interaction between objects within a collaboration that realizes an operation
- Either model generic interactions (showing all possible paths through the interaction) or specific instances of an interaction (showing just one path through the interaction)

9.3.2 Sequence Diagram of LMS





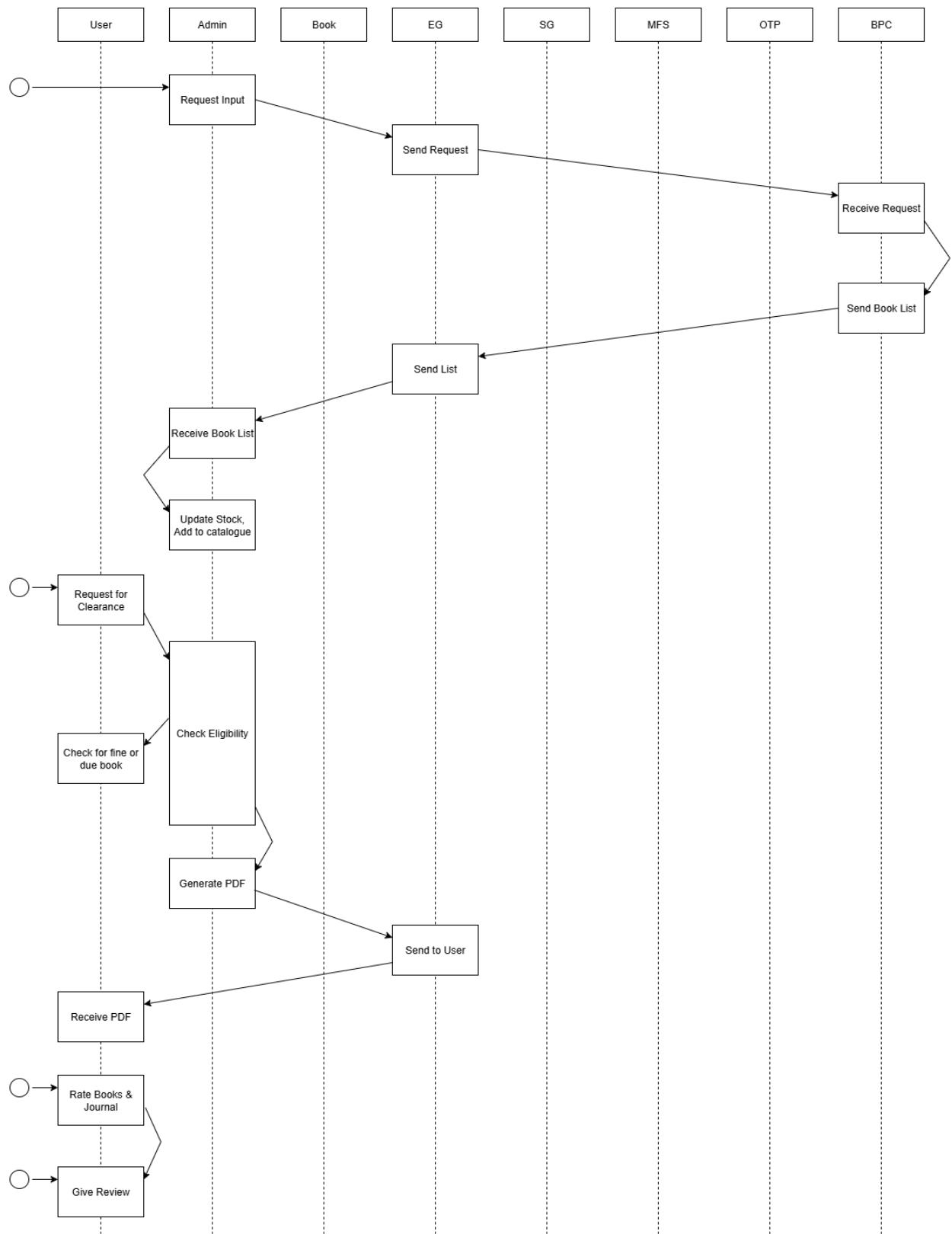


Figure 51: Sequence Diagram

10. Data Flow Diagram

A data flow diagram (DFD) is a graphical representation of the "flow" of data through an information system, modeling its process aspects. A DFD is often used as a preliminary step to create an overview of the system without going into great detail, which can later be elaborated.

Level 0:

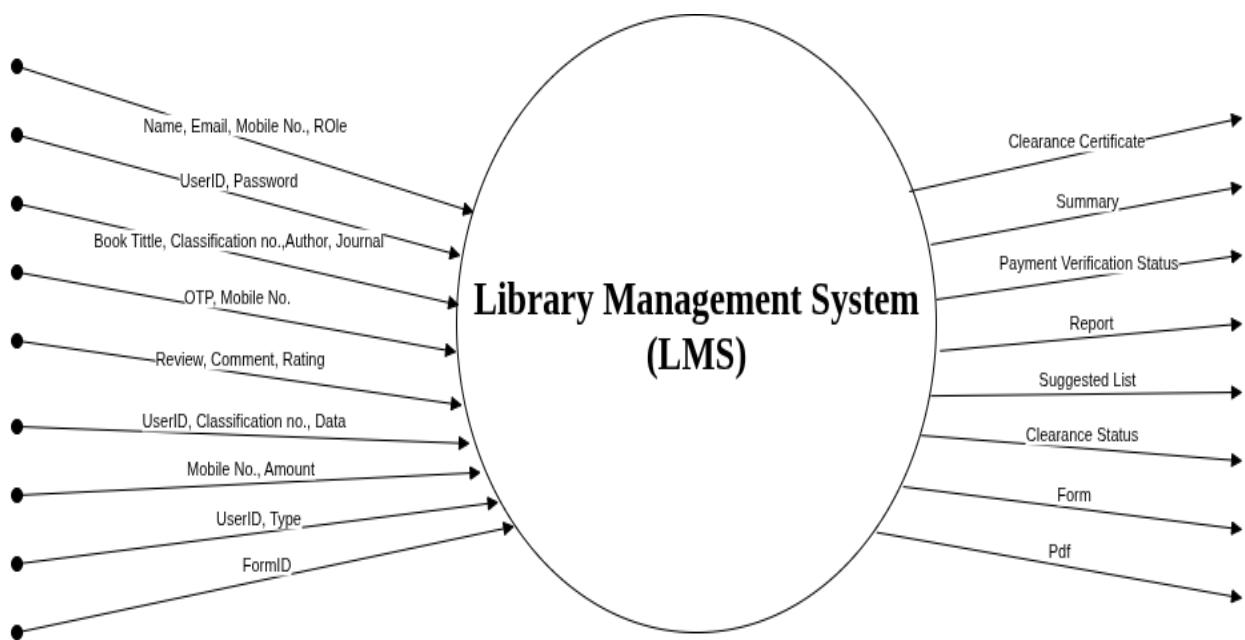


Figure 52: DFD of Level 0

Level 1:

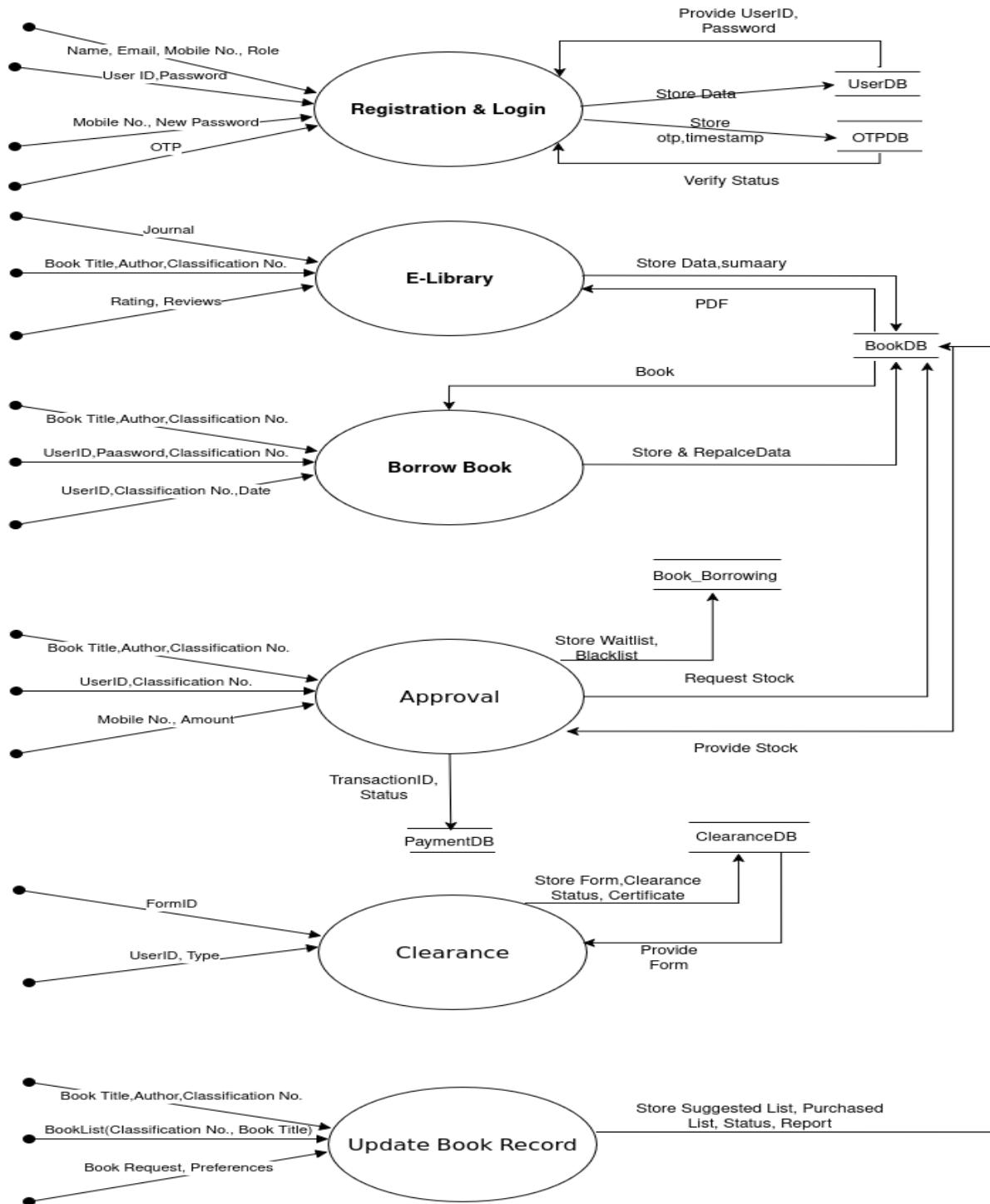


Figure 53: DFD of Level 1

Level 1.1:

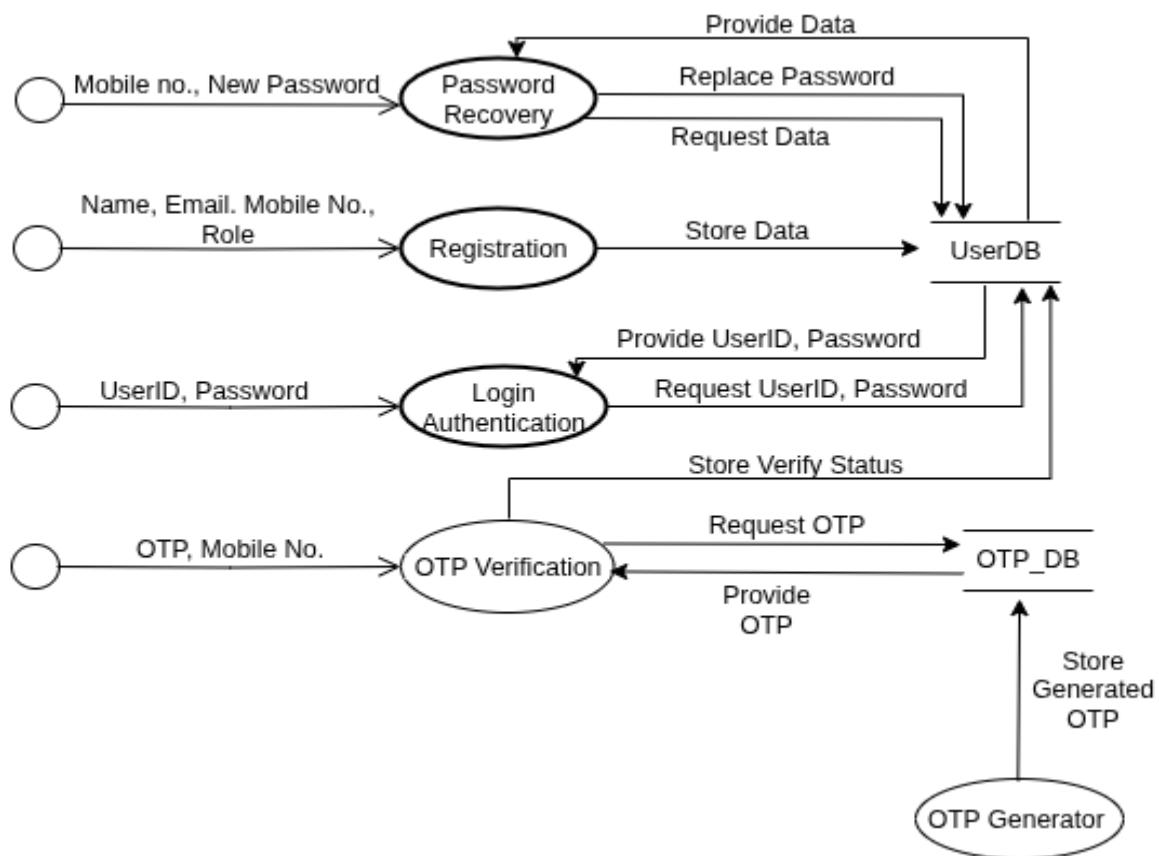


Figure 54: DFD of Level 1.1

Level 1.2:

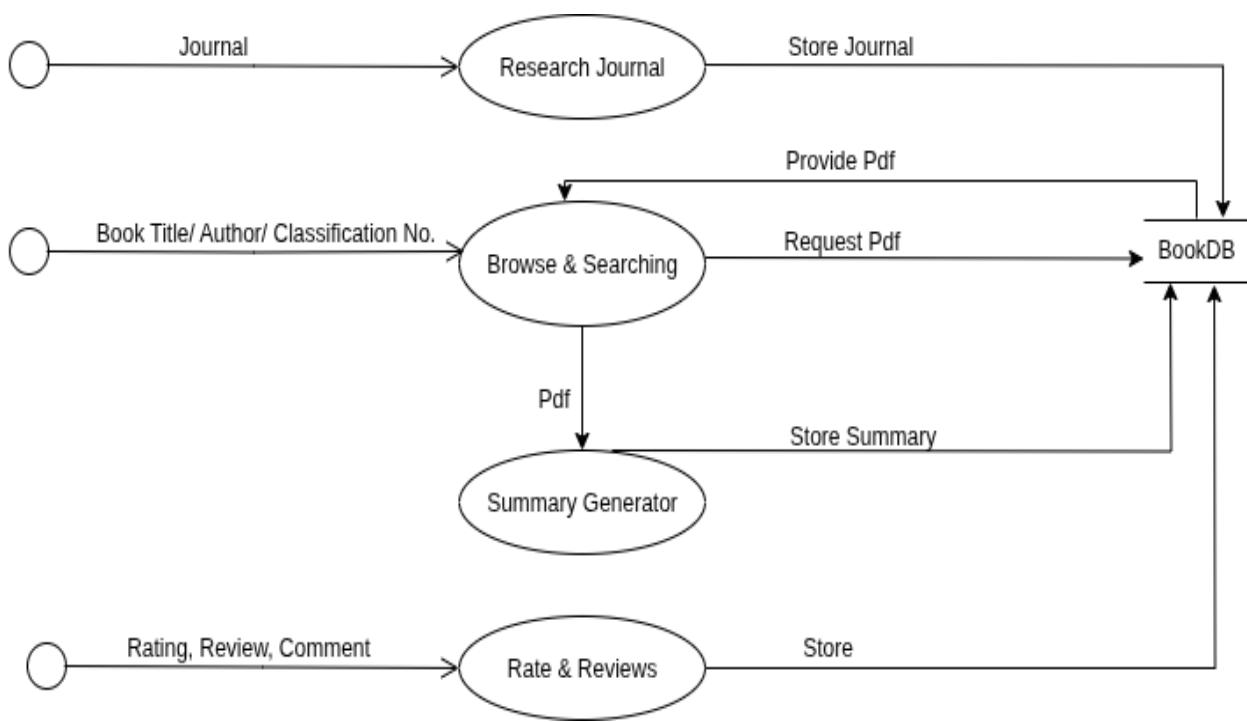


Figure 55: DFD of Level 1.2

Level 1.3:

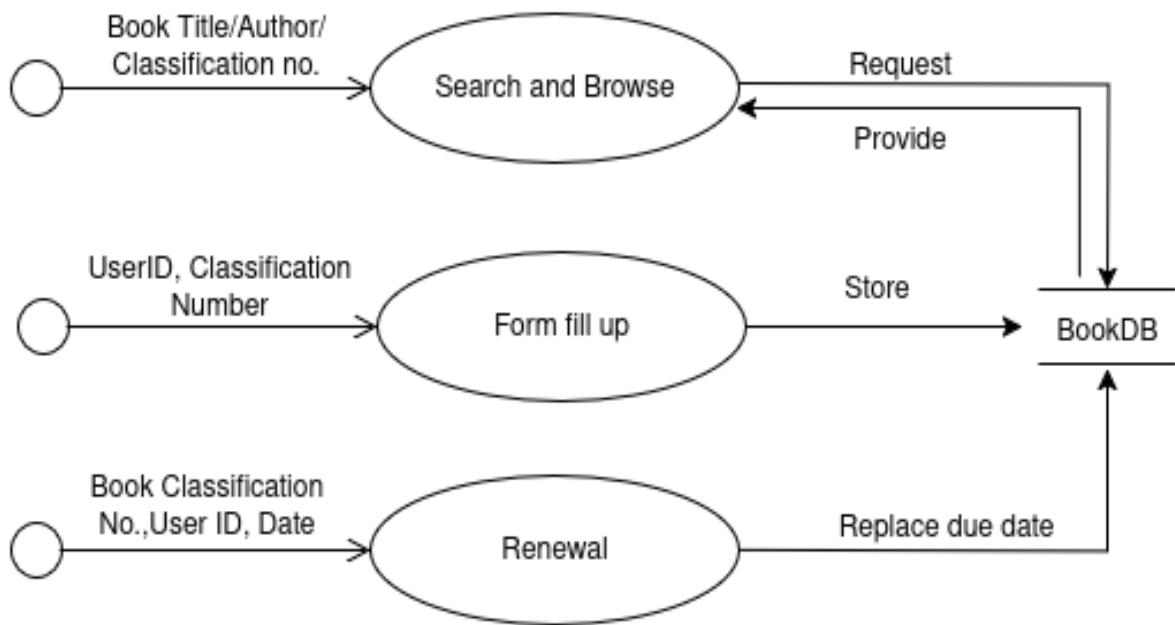


Figure 56: DFD of Level 1.3

Level 1.4:

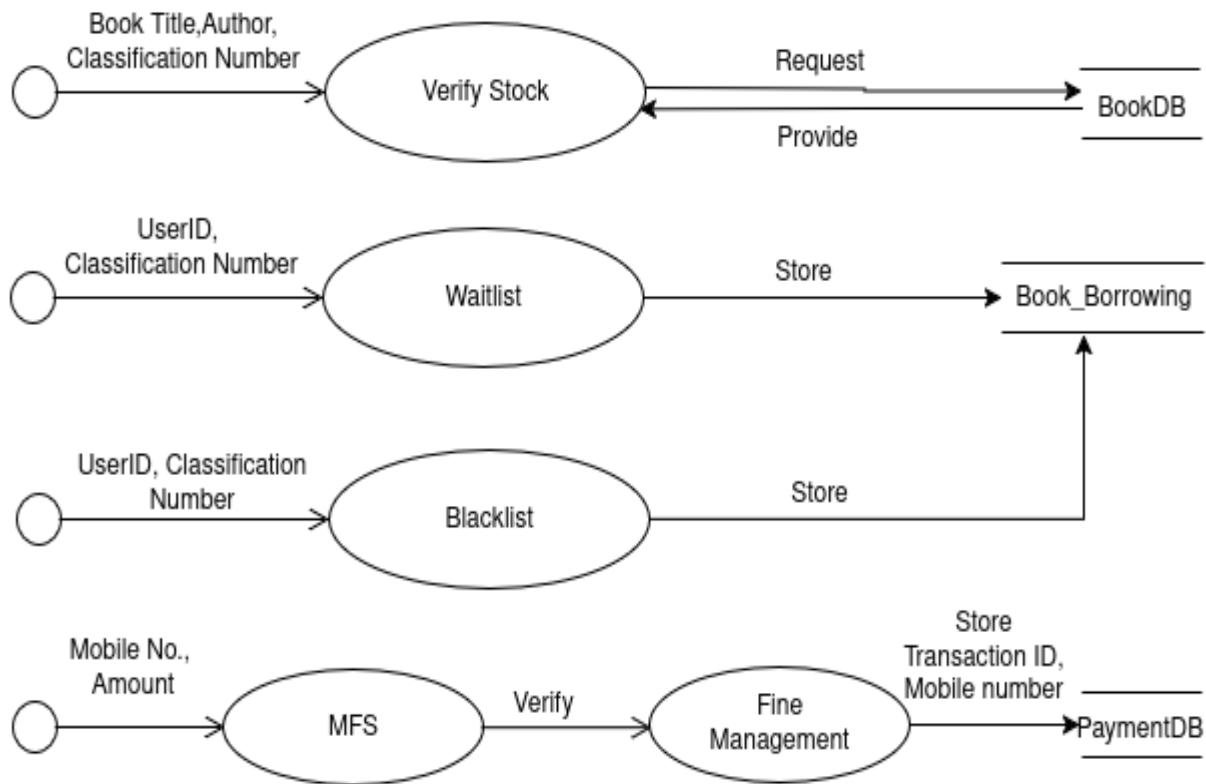


Figure 57: DFD of Level 1.4

Level 1.5:

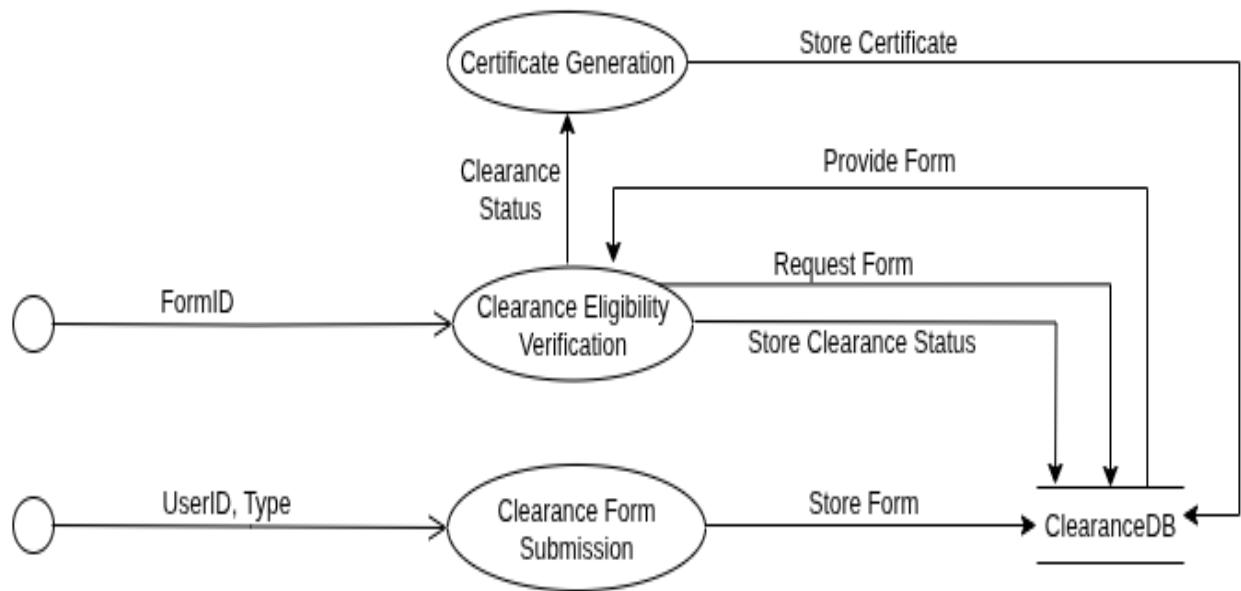


Figure 58: DFD of Level 1.5

Level 1.6:

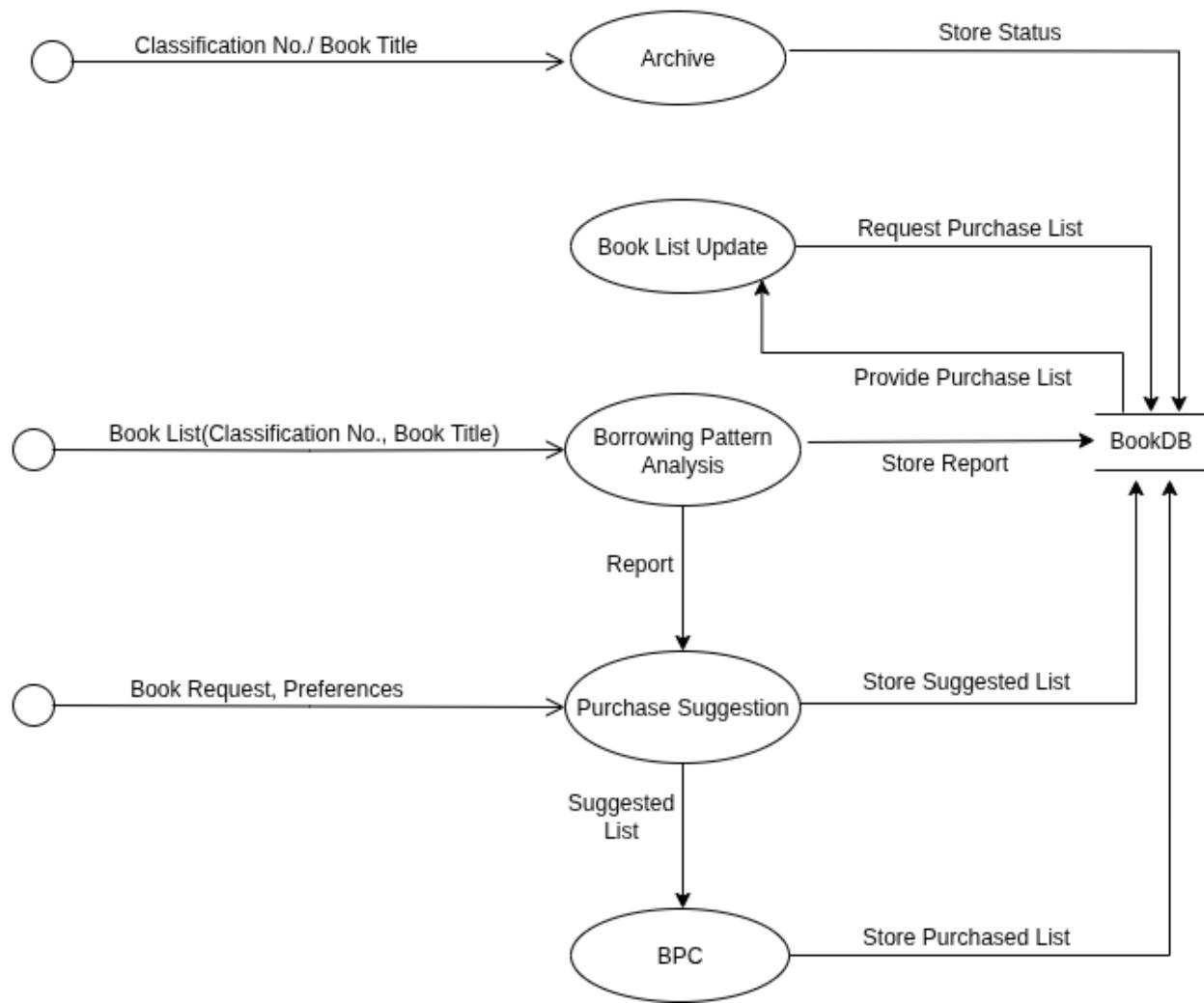


Figure 59: DFD of Level 1.6