



FPT UNIVERSITY

Capstone Project Document

RFID LIBRARY MANAGEMENT SYSTEM

Group GSP21SE16	
Group members	Phan Hoàng Trâm - SE130038 Phạm Minh Hoàng - SE130054 Nguyễn Trung Kiên - SE130154 Nguyễn Đỗ Nhật Khang - SE130148
Supervisor	Nguyễn Thế Hoàng
Capstone Project Code	RLMS

- Ho Chi Minh, 13 January 2021 -

ACKNOWLEDGEMENT

We would like to express sincere appreciation to our lecturers and the FPT University for facilitating such a positive learning environment for us.

This project could not have been completed without the support of Mr. Nguyễn Thế Hoàng – our supervisor. His immense knowledge, plentiful experience and passion have encouraged us during our project.

We would also like to express our gratitude to Mr. Lại Đức Hùng who gave us the opportunity to do this project at the beginning.

Finally, our team also appreciate all the support we received from Mr. Đinh Trường Lâm - Manager at FPTU HCM Library, Mr. Lê Quang Tường - Manager at FPTU Cần Thơ Library, and Ms. Hồ Yên Thực – FPTU HCM Lecturer.

Thank you to everyone and it has been a pleasure to work with you all.

The RLMS Team

Table of Contents

List of Figures.....	4
List of Tables.....	5
I. Project Introduction.....	6
1. Overview.....	6
1.1. Project Information.....	6
1.2. Project Team.....	6
2. Product Background.....	6
3. Existing Systems.....	7
3.1. FPTU Hồ Chí Minh Library System.....	7
3.2. FPTU Cần Thơ Library System.....	7
3.3. Văn Lang University Library System.....	7
4. Problem Identification.....	8
5. Proposed solution.....	8
6. Project Scope & Limitations.....	9
6.1. Major Features.....	9
6.2. Limitations & Exclusions.....	10
7. Terms and Definitions.....	10
II. Project Management Plan.....	12
III. Software Requirement Specification.....	13
1. Overall Description.....	13
1.1. User Requirement Overview.....	13
2. User Requirements Specification.....	14
2.1. Use Case.....	14
2.2. Use Case Specifications.....	19
3. Entity Relationship Diagram.....	52
IV. Software Design Document.....	54
1. System Architecture Design.....	54
2. Component Diagram.....	55
3. System Details Design.....	57
3.1. Class Diagram.....	57
3.2. State Machine Diagrams.....	59
3.3. Sequence Diagrams.....	61
4. Physical Diagram.....	64
5. Technology Solution.....	66

5.1. RFID Technology.....	66
5.2. Security Gate.....	72
5.3. Book Drop.....	74
5.4 Obstacles and Solutions.....	76
V. Software Testing Documentation.....	78
VI. Release Package & User Guides.....	78
VII. Appendix.....	78

List of Figures

Figure 1 <Fishbone diagram> Major Features.....	9
Figure 2 <Use Case Overview> RLMS Use Case Diagram.....	15
Figure 3 <Use Case> Return book at kiosk.....	19
Figure 4 <Use Case> Return book at book drop.....	22
Figure 5 <Use Case> Check in with patron card.....	25
Figure 6 <Use Case> Borrow books at kiosk.....	27
Figure 7 <Use Case> Renew a book.....	30
Figure 8 <Use Case> Borrow books for a patron.....	32
Figure 9 <Use Case> Return books for a patron.....	36
Figure 10 <Use Case> Tag a book copy.....	39
Figure 11 <Use Case> Create book copies.....	41
Figure 12 <Use Case> Index book copy location.....	43
Figure 13 <Use Case> Find misplaced book copies.....	46
Figure 14 <Use Case Overview> Security Scanner.....	49
Figure 15 <Use Case> Detect not checked out books.....	49
Figure 16 <Use Case> Log violated cases.....	51
Figure 17 Entity Relationship Diagram.....	53
Figure 18 Architecture Diagram.....	54
Figure 19 Component Diagram.....	56
Figure 20 Class Diagram.....	59
Figure 21 <State Machine Diagram> Book Status.....	59
Figure 22 <State Machine Diagram> Book Copy Status.....	60
Figure 23 <Sequence Diagram> Return Book at Book Drop.....	61
Figure 24 <Sequence Diagram> Librarian return books.....	62
Figure 25 <Sequence Diagram> Librarian checkout book.....	63
Figure 26 <Sequence Diagram> Librarian renew for a patron.....	64
Figure 27 Physical Diagram.....	66

List of Tables

Table 1 Terms and Definitions.....	12
Table 2 System Actors.....	16
Table 3 Use Case List.....	18
Table 4 <Use Case> Return book at kiosk.....	21
Table 5 <Use Case> Return book at book drop.....	24
Table 6 <Use Case> Check in with patron card.....	27
Table 7 <Use Case> Borrow book at kiosk.....	29
Table 8 <Use Case> Renew a book.....	32
Table 9 <Use Case> Borrow books for a patron.....	35
Table 10 <Use Case> Return books for a patron.....	38
Table 11 <Use Case> Tag a book copy.....	40
Table 12 <Use Case> Create book copies.....	43
Table 13 <Use Case> Index book copy location.....	45
Table 14 <Use Case> Find misplaced book copies.....	48
Table 15 <Use Case> Detect not checked out books.....	50
Table 16 <Use Case> Log violated cases.....	52

I. Project Introduction

1. Overview

1.1. Project Information

- Project name: RFID Library Management System
- Project code: RLMS
- Group name: GSP21SE18
- Software type: Web application, Windows form

1.2. Project Team

1.2.1. Supervisor

Full name	Email	Phone Number	Title
Nguyễn Thế Hoàng	hoangnt2@fpt.edu.vn	0986628525	Lecturer

1.2.2. Team Members

Full name	Email	Phone Number	Role
Phan Hoàng Trâm	tramphse130038@fpt.edu.vn	0853899403	Leader
Nguyễn Trung Kiên	kienntse130154@fpt.edu.vn	0909317688	Member
Phạm Minh Hoàng	hoangpmse130054@fpt.edu.vn	0938072401	Member
Nguyễn Đỗ Nhật Khang	khangndnse130148@fpt.edu.vn	0857664974	Member

2. Product Background

The library is very important in schools. Libraries provide a quiet place for the students to study by themselves and do homework. All the documents inside the library can also be research materials for students. With many kinds of books available, libraries also encourage students to read more. Libraries are especially important for university students because besides attending lectures most of their time will be spent on self-study. That is why libraries should be available whenever a student needs access to it.

Many school libraries in Viet Nam still depend only on the librarians for borrowing and returning documents. Students and teachers (patrons) normally visit the library during their break times and lunch breaks, thus making those periods busy and patrons need to stand in a queue to borrow books at the

librarian counter. Sometimes new classes start before it is their turn at the librarian counter, and they have to come back again later to borrow the documents they wanted. Furthermore, the working hours of school libraries also depend on the working hours of librarians. So librarians have to work early in the morning until late in the evening or patrons will not be able to use the library before or after school hours (which is when they need to do homework and research).

Currently, to checkout or return books, librarians are using barcodes to identify the patron and books. This process is not fast enough to meet the demand for the library's busy hours. And because barcode labels are usually just a piece of paper applied outside of a book it is easy to be scratched and damaged. Damaged labels cannot be scanned and must be input manually by the librarian, making the process taxing for the librarian.

3. Existing Systems

3.1. FPTU Hồ Chí Minh Library System

The current library of FPT University Hồ Chí Minh, to function, relies on 2 separate systems, which are the electromagnetic (EM) system and the barcode system. The EM system - which consists of EM security gates, EM-labels, and an EM-labels activate/deactivate machine - is for security measures. And the barcode system - which consists of barcode labels, barcode labels printer, and barcode readers- is for identifying and managing library documents. Every time new books are added to the library, the librarian has to print and apply a new barcode on the book cover, then an EM label is also applied to a random page of the book.

Currently, to checkout or return books, librarians would have to scan the barcode on the patron's ID card (only when checkout) and then by each book, scan the book barcode and deactivate/activate the electromagnetic label inside the book.

In this system librarians have to keep track of both EM labels and barcode labels. As mentioned earlier, the borrowing and returning process is slow, making it harder for patrons to borrow and return books if the library is constantly busy. And students and lecturers also cannot borrow or return books after school hours because by then the library is already closed.

3.2. FPTU Cần Thơ Library System

The current library of FPT University Cần Thơ has already replaced the EM system and the barcode system with the RFID system, which consists of an RFID reader and RFID tags. All of their documents are tagged with an RFID tag. RFID technology allows the librarians to scan books easily without having to make sure the RFID tag is in line of sight of the reader, unlike the barcode label. Moreover, an RFID tag can also be used to detect documents thievery.

RFID technology allows users to scan multiple tags at the same time instead of scanning one at a time. But the current management software of their library only supports scanning one book at a time. And like FPTU Hồ Chí Minh Library, students and lecturers can only use the library service (like borrow and return books) through the librarians.

3.3. Văn Lang University Library System

Like FPTU Hồ Chí Minh Library, the Văn Lang University library system also uses the barcode system and electromagnetic system. Each book is put on the shelf alphabetically by the book's call number. The book shelves are arranged into sections, shelves in each section will have similar subjects. For example,

there are the Social Science section, Computer Science section, Literature section, etc. This helps patrons to look for books that are related to the subjects that they are studying.

But if the patron is searching for a specific book, they still have to spend time looking for it. Because even when the books are sorted by their call number, they are not always put into their right place. So sometimes the patrons still need help from the library staff to get the books for them.

4. Problem Identification

- Patrons always have to depend on librarians to borrow and return books. This makes the library only usable during working hours of librarians. And working hours of librarians can overlap class timetables.
- Librarians can only scan one book at a time, which makes checkout and return of books inefficient.
- Librarians have to remind the patrons to return books manually by phone calls or emails.
- Security system and management system are separated.
- Barcode labels are applied outside of books which makes them vulnerable to damage and become blurred or torn. A damaged barcode label cannot be scanned by the scanner.
- Books are sometimes misplaced from their shelves, making them difficult to find. And keeping track of the book position frequently is taxing for the library staff.

5. Proposed solution

To solve these problems, our team proposes a system called RLMS (RFID Library Management System) that will be integrated with the current library management system. RLMS aims to support the librarians and make the library more accessible for students and teachers (patrons). The system will allow the library to be open even when there are no librarians available. Patrons will be able to borrow and return books directly by themselves. The system will also aid the librarians by making the book scanning process more efficient and remind patrons to return books automatically. Our team has chosen UHF RFID technology because it can help to reduce the time and effort of scanning and identifying books while replacing both, electromagnetic system and barcode system. This technology has already been used by many libraries in the world and it is becoming more and more affordable. Using RFID technology also makes it easier for our system to add new functions in the future.

Such system will provide the following main features:

- Tagging of Books
- Self-checkout of books for patrons
- Self-return of books for patrons
- Book drop box
- Anti-theft protection
- Automatic mailing
- Remind patrons of due date
- Manage book and book copies
- Find book using RFID reader
- Find misplaced books on a shelf using RFID reader

6. Project Scope & Limitations

6.1. Major Features

- FE-01: Allow patrons to self-checkout books using the kiosk.
- FE-02: Allow patrons to self-return books using the kiosk and the book-drop.
- FE-03: Allow patrons receive notifications over email.
- FE-04: Allow patrons to renew their borrowing.
- FE-05: Allow patrons to search for book information.
- FE-06: Allow patrons to add a book to wishlist when it is not available.
- FE-07: Allow manager to manage accounts.
- FE-08: Allow managers to view and manage policies.
- FE-09: Allow librarians and managers to checkout and return books using RFID technology.
- FE-10: Allow librarians and managers to tag a pre-existing book with new RFID technology.
- FE-11: Allow librarians and managers to manage books and book copies.
- FE-12: Allow librarians and managers to renew.
- FE-13: Allow librarians and managers to add a book to wishlist when it is not available.
- FE-14: Allow the library using the system to assure security (RFID technology security gate).

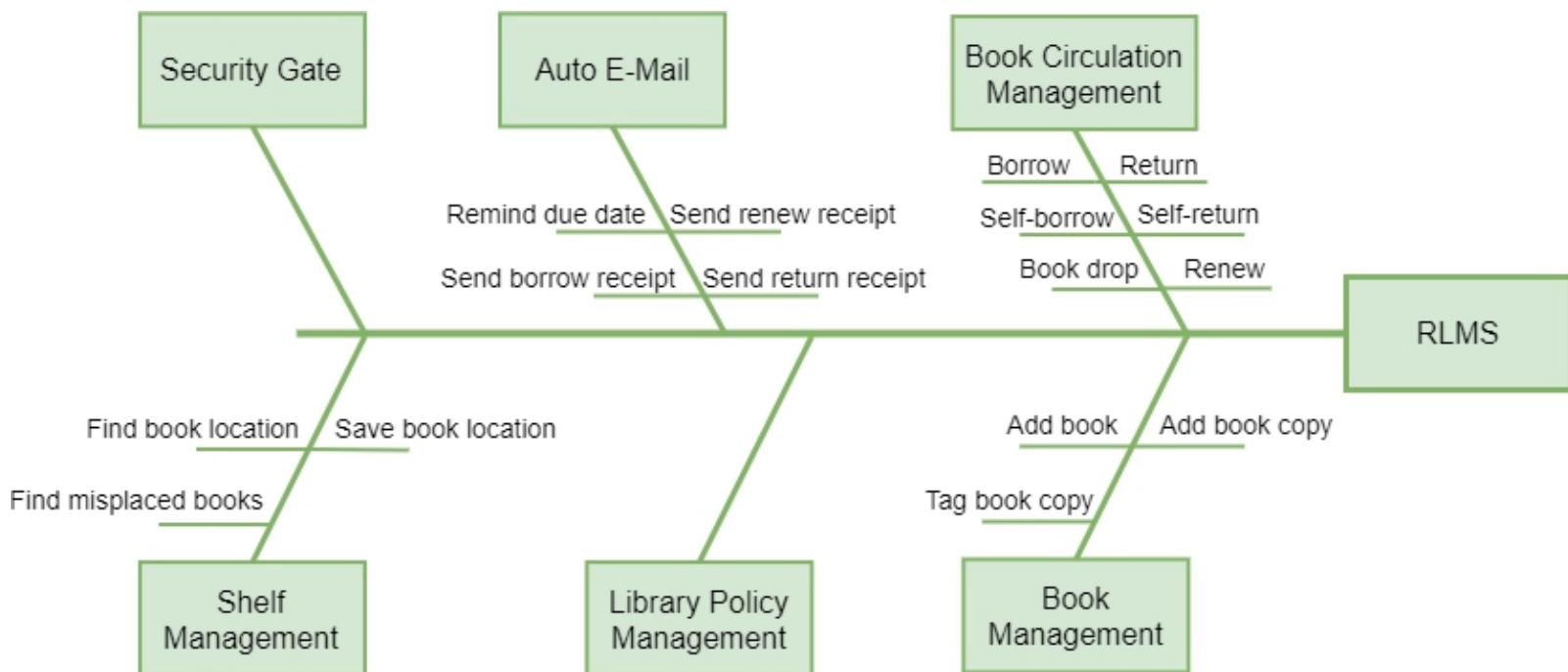


Figure 1 <Fishbone diagram> Major Features

6.2. Limitations & Exclusions

- LI-01: RLMS can only send notifications via Emails. It cannot send push notifications.
- LI-02: RLMS assumes that patrons have university email accounts.
- LI-03: RLMS assumes that patrons' id cards use RFID technology.
- LI-04: RLMS assumes that there is a previous working library management system, a legacy system and RLMS only integrates to that system.
- LI-05: RLMS only works with physical book copies.
- LI-06: RLMS assumes that the library systems use LAN to connect to each other.
- LI-07: RLMS assumes that all of the library books are on shelves.
- LI-08: RLMS only manages user accounts in the system.
- LI-09: RLMS is using a customized third party UHF RFID scanner software.

- EX-01: RLMS does not provide communicative features between librarians and patrons.
- EX-02: RLMS does not provide payment features or financial management features.
- EX-03: RLMS does not provide features to check books' physical state such as damages or book sizes.
- EX-04: RLMS does not provide features to manage the bookshelves inside the library
- EX-05: RLMS does not provide features to manage the library expenses (total lost book price, etc.)
- EX-06: RLMS does not provide features to do accounting or make an inventory.
- EX-07: RLMS does not provide features to check if the book is available on the market or not.
- EX-08: RLMS does not provide features to manage damaged books.
- EX-09: RLMS does not provide features to manage authors.

7. Terms and Definitions

Term	Definition
RLMS	Stands for "RFID Library Management System"
Book copy	Is a physical copy of a book inside the library
Unauthenticated User	Is someone who uses the RLMS without logging in or checking in.
Patron	Is a person who borrows books from the library. There are different types of patrons (for example: students, lecturers, etc.). A patron has a patron account in the RLMS.
Librarian	Is a person who works at the library. A librarian has a librarian account in the RLMS.

Manager	Is a librarian who also manages other librarians and the library. A manager has a manager account in the RLMS.
Borrow Policy	<p>A policy that determines:</p> <ul style="list-style-type: none"> ● Which patron type can borrow which book copy type. For example, Students can only borrow Textbooks, but Teachers can borrow Textbooks and Reference books. ● How many copies of a copy type can be borrowed by a patron type. For example, a student can borrow 3 reference books but can borrow 10 textbooks. ● How many times a book copy can be renewed ● How long a book copy can be borrowed by the patron. ● How long a book can be borrowed after it is renewed.
Patron Policy	A policy that determines the maximum books that a patron type can borrow at a time. For example, a student can borrow 20 book copies in total across all book copy types.
Fee Policy	A policy that determines the parameters in the fine calculating formula.
Fine (VND)	The amount of money a patron has to pay when returning overdue book copies. For example if the fine rate is 2 000 VND, and the patron is returning a book copy 3 days late, then the patron will have to pay 6 000 VND for the fine.
Fine rate (VND)	Fine per overdue days. Is determined in Fee Policy
Call number	Is an address for a book. A call number also represents some of the book information like what is the content of the book, etc. Books in the library are arranged in call number order (numerical and alphabetical). The two common methods for classifying call numbers are DDC and LC. For this project, the call number format will be: DDC + Author information + publish year. For example "100 JOH 2007"
DDC	Dewey Decimal Classification System (Is normally used for libraries with a smaller collection size). List of DDC numbers:
LC	Library of Congress Classification System (Is normally used for libraries with a larger collection size)
Borrow Period (days)	The time period that a patron is allowed to keep a borrowed book

	copy
Renew Period (days)	The time period that will be added to the current due date of a renewing book copy.
Checkouts Allowed (count)	The number of book copies from a specific patron is allowed to borrow
Renewals Allowed (times)	The number of times a patron is allowed to renew a book copy
Patron Type	Different types of patrons, for example: students, lecturers, etc. Each patron type will follow different policies.
Book Copy Type	Different types of book copies, for example: reference books, textbooks, etc. Each book copy type will have different borrow policies.
Books Tagging	Book tagging is a process where the librarian labels the book with the RFID tag to save and identify that book in our system. Every book in the library has a unique RFID tag.
Barcode	Barcode is used to identify the book in case RFID tag is broken. The barcode in our project has 14 digits: <ul style="list-style-type: none"> • 1st to 2nd digits are Book copy type • 3rd to 6th digits are library's ID • 7th to 15th digits are book copy's ID Every book in the library has a unique barcode.
Security Gate	Security gate is an RFID enabled device, used to detect, warn and log violated cases where not checked out books exit the library.

Table 1 Terms and Definitions

II. Project Management Plan

(References to “RFID_Library_Management_System_Full.pdf”)

III. Software Requirement Specification

1. Overall Description

1.1. User Requirement Overview

1.1.1. Unauthenticated User Requirements

Unauthenticated Users are people who have not been identified by the system. They can use the following features:

- Login
- Check in
- Return at the kiosk inside library
- Return at the book drop outside library

1.1.2. Authenticated User Requirements

Authenticated Users are people who have identified themselves by the system. They can use the following feature:

- Logout
- Search books
- View book details
- Search book in the library by UHF reader

1.1.3. Patron Requirements

Patrons are authenticated users with a “Patron” role. They can use the following features:

- Check out books at the kiosk inside library
- View checkout information: returned books, overdue books, borrowing books
- Renew a holding book
- View renew history of a borrowed book
- Add an available book to wishlist
- View and update profile
- Receive receipt after checkout, return via email
- Receive notification if a book in the wishlist is available via email
- Receive account information to log into the system via email
- View policies

1.1.4. Librarian Requirements

Librarians are authenticated users with a “Librarian” role. They can use the following features:

- Check out books for patron
- Return books for patron
- Manage books
- Manage book copies
- View a patron’s checkout information
- Renew a book for patron

- View renew history
- Add an available book to patron's wishlist
- Report lost book
- Manager patron account (excludes add, update)
- Check misplaced and missing books
- Print multiple barcodes
- View policies

1.1.5. Manager Requirements

Librarians are authenticated users with a “Librarian” role. They can use all the features that librarian can do and the following features:

- Manage patron account
- Manage librarian account
- Manage policies
- Manage patron type
- Manage book copy type

2. User Requirements Specification

2.1. Use Case

2.1.1. Use Case Diagram

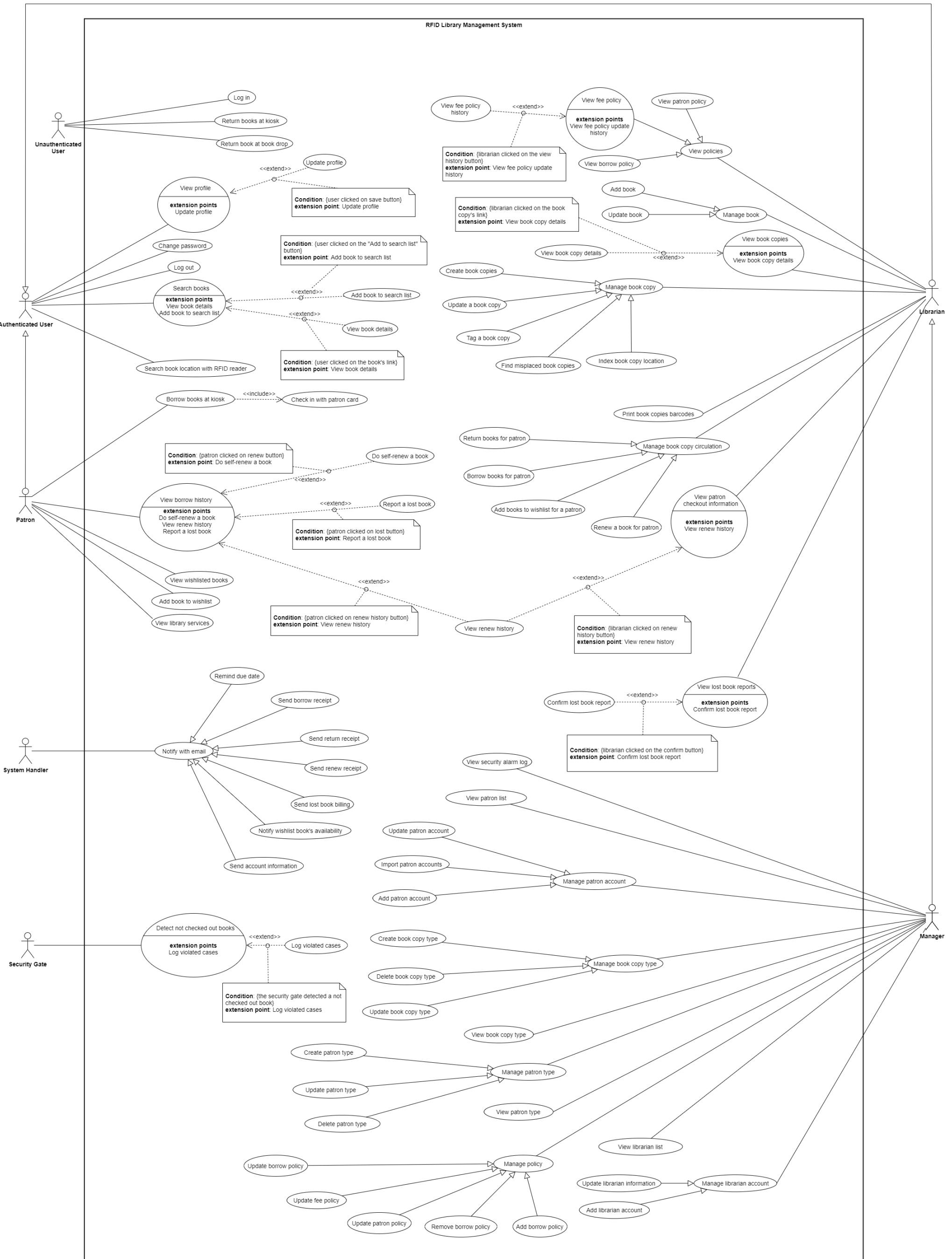


Figure 2 <Use Case Overview> RLMS Use Case Diagram

2.1.2. System Actors

#	Actor	Description
1	Unauthenticated User	Users have not logged into RLMS
2	Authenticated User	Users have logged into RLMS
3	System Handler	RLMS system
4	Patron	Users have logged into RLMS as patron role
5	Librarian	Users have logged into RLMS as librarian role
6	Manager	Users have logged into RLMS as manager role
7	Security Gate	Security gate in library

Table 2 System Actors

2.1.3. Use Case List

ID	Use Case	Primary Actor
01	Log in	Unauthenticated User
02	Return book at kiosk	Unauthenticated User
03	Return book at book drop	Unauthenticated User
04	Log out	Authenticated User
05	Search books	Authenticated User
06	View book details	Authenticated User
07	Change password	Authenticated User
08	Add book to search list	Authenticated User
09	Search book location by RFID reader	Authenticated User
10	View profile	Authenticated User
11	Update profile	Authenticated User
12	Check in with patron card	Patron
13	Borrow books at kiosk	Patron
14	Add book to wishlist	Patron
15	View wishlisted books	Patron
16	View borrow history	Patron

17	Do self-renew a book	Patron
18	View renew history	Patron, Librarian
19	Report lost book	Patron
20	View library services	Patron
21	Borrow books for patron	Librarian
22	Return books for patron	Librarian
23	Add book	Librarian
24	Update book	Librarian
25	Tag a book copy	Librarian
26	Create book copies	Librarian
27	Update a book copy	Librarian
28	View patron policy	Librarian
29	View borrow policy	Librarian
30	View fee policy	Librarian
31	View patron checkout information	Librarian
32	Renew a book for patron	Librarian
33	View fee policy history	Librarian
34	View book copies	Librarian
35	View book copy details	Librarian
36	Add books to wishlist for a patron	Librarian
37	View lost book reports	Librarian
38	Confirm lost book report	Librarian
39	Index book copy location	Librarian
40	Find misplaced book copies	Librarian
41	Print book copies barcodes	Librarian
42	Add borrow policy	Manager
43	Update borrow policy	Manager
44	Remove borrow policy	Manager
45	Update patron policy	Manager
46	Update fee policy	Manager

47	View librarian list	Manager
48	Add librarian account	Manager
49	Update librarian information	Manager
50	Add patron account	Manager
51	Update patron account	Manager
52	View security alarm log	Manager
53	Import patron accounts	Manager
54	View book copy type	Manager
55	Create book copy type	Manager
56	Update book copy type	Manager
57	Delete book copy type	Manager
58	View patron type	Manager
59	Create patron type	Manager
60	Update patron type	Manager
61	Delete patron type	Manager
62	View patron list	Manager
63	Send return receipt	System Handler
64	Send borrow receipt	System Handler
65	Remind due date	System Handler
66	Notify wishlist book's availability	System Handler
67	Send account information	System Handler
68	Send lost book billing	System Handler
69	Send renew receipt	System Handler
70	Detect not checked out books	Security Gate
71	Log violated cases	Security Gate

Table 3 Use Case List

2.2. Use Case Specifications

2.2.1. Unauthenticated User

2.2.1.1. Return book at kiosk

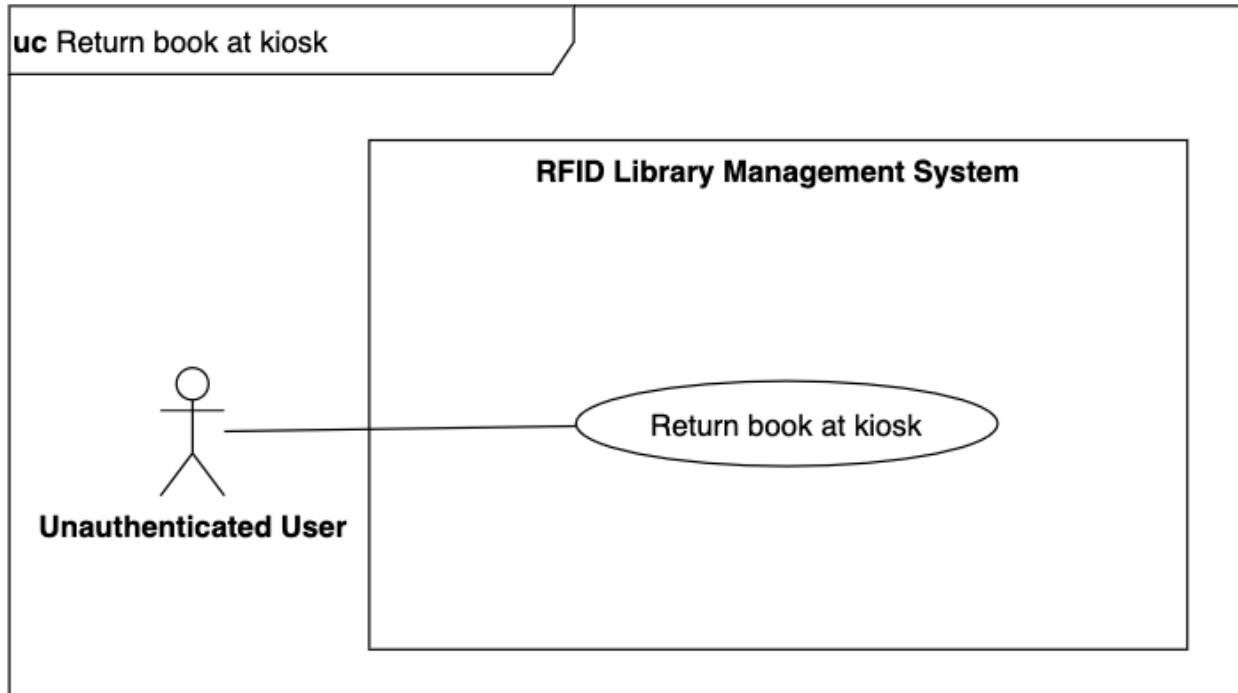


Figure 3 <Use Case> Return book at kiosk

ID and Name:	UC_02 Return book at kiosk		
Created By:	TramPH	Date Created:	13/01/2021
Primary Actor:	Unauthenticated user	Secondary Actor:	N/A
Description:	Let the users return borrowed books by themselves inside the library at self-service kiosks.		
Trigger:	Unauthenticated users request to return books.		
Preconditions:	PRE-1: Users have borrowed books.		
Postconditions:	POST-1: The system shows a list of returned books. POST-2: If return failed, show error message.		

Normal Flow:	Step	Actor action	System response
	1	The users click the “Return” button.	RLMS redirects to the return page and the session counts down.
	2	The users put borrowed books on the UHF scanner.	RLMS returns the list of scanned books. [Exception 1]
	3	The users click the “Confirm” button. [Alternative 1] [Alternative 2]	RLMS return the list of returned books also books cannot return with reason.
Alternative Flows:	Step	Actor action	System response
	1.1	The users use the return service for up to 4 minutes.	Session is expired and the RLMS closes the return page.
	2.1	The users click the “Cancel” button.	RLMS show cancel confirm dialog.
	2.2	The users click the “Yes” button.	RLMS closes the return screen.
Exceptions:	No.	Cause	System response
	1	RLMS cannot find the scanned book in the system.	RLMS shows error messages and asks the user to scan books again.
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. The users cannot return overdue books at the kiosks, they must return at the librarian counter. 2. The users can return multiple copies at the same time. 3. After scanning books, the system shows: <ul style="list-style-type: none"> • Book information: image, title, subtitle, edition, authors, group 4. After returning books, the system shows: <ul style="list-style-type: none"> • Book information: image, title, subtitle, edition, authors, 		

	<p>group</p> <ul style="list-style-type: none"> ● Return information: borrower, overdue day(s), fine (VND), returned time (if returned) or message (if couldn't return) <p>5. Overdue days excludes Saturdays and Sundays</p> <p>6. Fine is calculated based on fee policy at the time users borrowed those books</p> <ul style="list-style-type: none"> ● Fine = overdue days * fine rate ● Max fine = book copy's price * max overdue fine percentage / 100 <p>7. Book copy's status will be updated depends on Book's status:</p> <ul style="list-style-type: none"> ● If Book's status is "IN_CIRCULATION", book copy's status is "AVAILABLE" ● If Book's status is "OUT_OF_CIRCULATION", book copy's status is "OUT_OF_CIRCULATION" ● If Book's status is "LIB_USE_ONLY", book copy's status is "LIB_USE_ONLY" <p>8. Each session lasts 4 minutes by default, after that the system will close the return process. That makes sure the users do not use the kiosk for a long time.</p>
Other Information	<ol style="list-style-type: none"> 1. The users shall be able the cancel book-returned process. 2. Session shall be paused when the system's making a request to the service. 3. If there is no internet connection, the system cannot load the image of book
Assumptions:	N/A

Table 4 <Use Case> Return book at kiosk

2.2.1.2. Return book at book drop

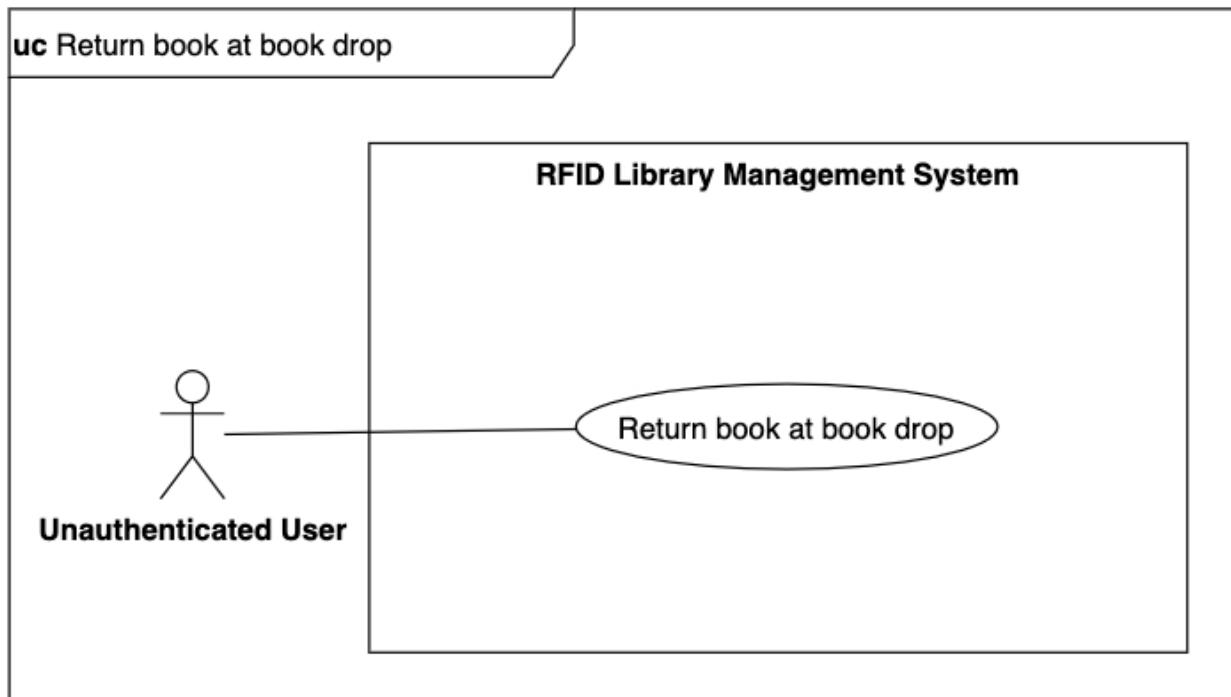


Figure 4 <Use Case> Return book at book drop

ID and Name:	UC_03 Return book at book drop		
Created By:	TramPH	Date Created:	13/01/2021
Primary Actor:	Unauthenticated user	Secondary Actors:	N/A
Description:	Let users return borrowing books by themselves outside the library.		
Trigger:	Unauthenticated users request to return books.		
Preconditions:	PRE-1: Users have borrowed books.		
Postconditions:	POST-1: The system shows the returned book successfully. POST-2: If return failed, show error message.		
Normal Flow:	Step	Actor action	System response
	1	The users click the "Start" button.	RLMS shows session counting down. Front door opens and asks the user to put a book into the box.

	2	The users insert a book into the box.	The front door closes and the system starts scanning the book.
	3		RLMS opens the back door, lets the book drop into library storage, then closes the back door. The system showed the return successfully. [Exception 1] [Exception 2] [Exception 3] [Exception 4] [Exception 5]
Alternative Flows:	Step	Actor action	System response
	1.1	The users use the return service for up to 4 minutes.	Session is expired and the RLMS reset the return page.
Exceptions:	No.	Cause	System response
	1	The users do not insert any book.	RLMS shows error messages and reset the return process.
	2	The users insert more than 1 book.	RLMS shows error messages and opens the front door after 5s then closes the front door.
	3	The users insert the overdue book.	RLMS shows error messages and opens the front door after 5s then closes the front door.
	4	The users insert a book that cannot be found in the system.	RLMS shows error messages and opens the front door after 5s then closes the front door.
	5	The users insert a book that has not been borrowed.	RLMS shows error messages and opens the front door after 5s then closes the front door.
Priority:	High		
Frequency of Use:	Usually		

Business Rules:	<ol style="list-style-type: none"> 1. The users cannot return overdue books at the kiosks, they must return at the librarian counter. 2. The users can only return 1 copy at the time. 3. After returning books, the system shows: <ul style="list-style-type: none"> • Book information: image, title, subtitle, edition, authors, group • Return information: borrower, overdue day(s), fine (VND), returned time (if returned) or message (if couldn't return) 4. Overdue days excludes Saturday's and Sundays 5. Fine is calculated based on fee policy at the time users borrowed those books <ul style="list-style-type: none"> • Fine = overdue days * fine rate • Max fine = book copy's price * max overdue fine percentage / 100 6. Book copy's status will be updated depends on Book's status: <ul style="list-style-type: none"> • If Book's status is "IN_CIRCULATION", book copy's status is "AVAILABLE" • If Book's status is "OUT_OF_CIRCULATION", book copy's status is "OUT_OF_CIRCULATION" • If Book's status is "LIB_USE_ONLY", book copy's status is "LIB_USE_ONLY" 7. Each session lasts 4 minutes by default, after that the system will reset the return process. That makes sure the users do not use the book drop for a long time. 8. Back door only opens when returning successfully.
Other Information	<ol style="list-style-type: none"> 1. Session shall be paused when the system's making a request to the service. 2. Once the door is closing, the users cannot interrupt the closing process. 3. If there is no internet connection, the system cannot load the image of book
Assumptions:	<ol style="list-style-type: none"> 1. The book drop can only contain lightweight and medium sized books.

Table 5 <Use Case> Return book at book drop

2.2.2. Authenticated user

(References to “RFID_Library_Management_System_Full.pdf”)

2.2.3. Patron

2.2.3.1. Check in with patron card

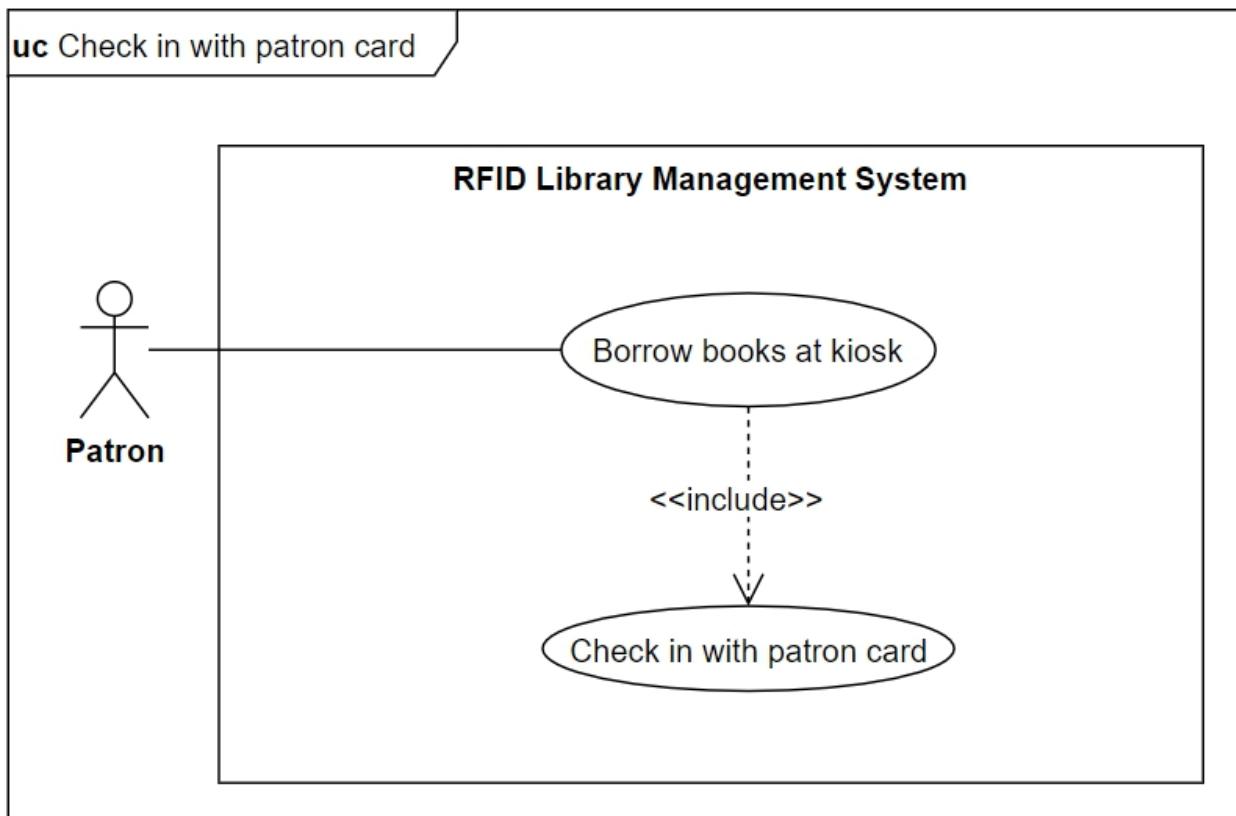


Figure 5 <Use Case> Check in with patron card

ID and Name:	UC_12 Check in with patron card		
Created By:	TramPH	Date Created:	13/01/2021
Primary Actor:	Patron	Secondary Actors:	N/A
Description:	Let the patron get access to the self-checkout function at the kiosk		
Trigger:	The patron scan the patron card at the self-service kiosk in the library		
Preconditions:	PRE-1: User has an patron card		
Postconditions:	POST-1: User is authenticated and authorized to check out books. POST-2: If check in failed, show error message.		

Normal Flow:	Step	Actor action	System response
	1	The users click on “Borrow” button	RLMS redirects to the check in page and the session counts down.
	2	The users put their ID card on the ID card reader at the library self-checkout and return machine. [Alternative 1]	The system validates user’s ID card information. Then the system opens a session for the user and redirects the user to the checkout screen. [Exception 1] [Exception 2] [Exception 3]
Alternative Flows:	Step	Actor action	System response
	1.1	The users use the check-in service for up to 2 minutes.	Session is expired and the RLMS closes the login page.
Exceptions:	No.	Cause	System response
	1	The user’s ID card is not valid as a patron role or inactivated.	RLMS shows the user error message.
	2	The user has overdue books.	RLMS shows the message and closes the login page.
	3	The user scans the invalid card at the third time.	RLMS shows the message and closes the login page.
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. The patron has to check in by their patron card before checkout books 2. The users can only check in at the kiosks as a patron role and be activated. 3. The patron has any overdue book cannot check in at the kiosks 4. The patrons are allowed to scan the invalid ID card 3 times. After the third invalid time, the system will automatically close the check-in process 5. Each check-in session lasts 2 minutes by default, after that the system will close the check-in process. That makes sure the users do not use 		

	the kiosk for a long time.
Other Information	<ol style="list-style-type: none"> Session shall be paused when the system's making a request to the service.
Assumptions:	<ol style="list-style-type: none"> The patron had an ID card from school. They can be student cards, lecturer cards, etc. They must be RFID cards.

Table 6 <Use Case> Check in with patron card

2.2.3.2. Borrow books at kiosk

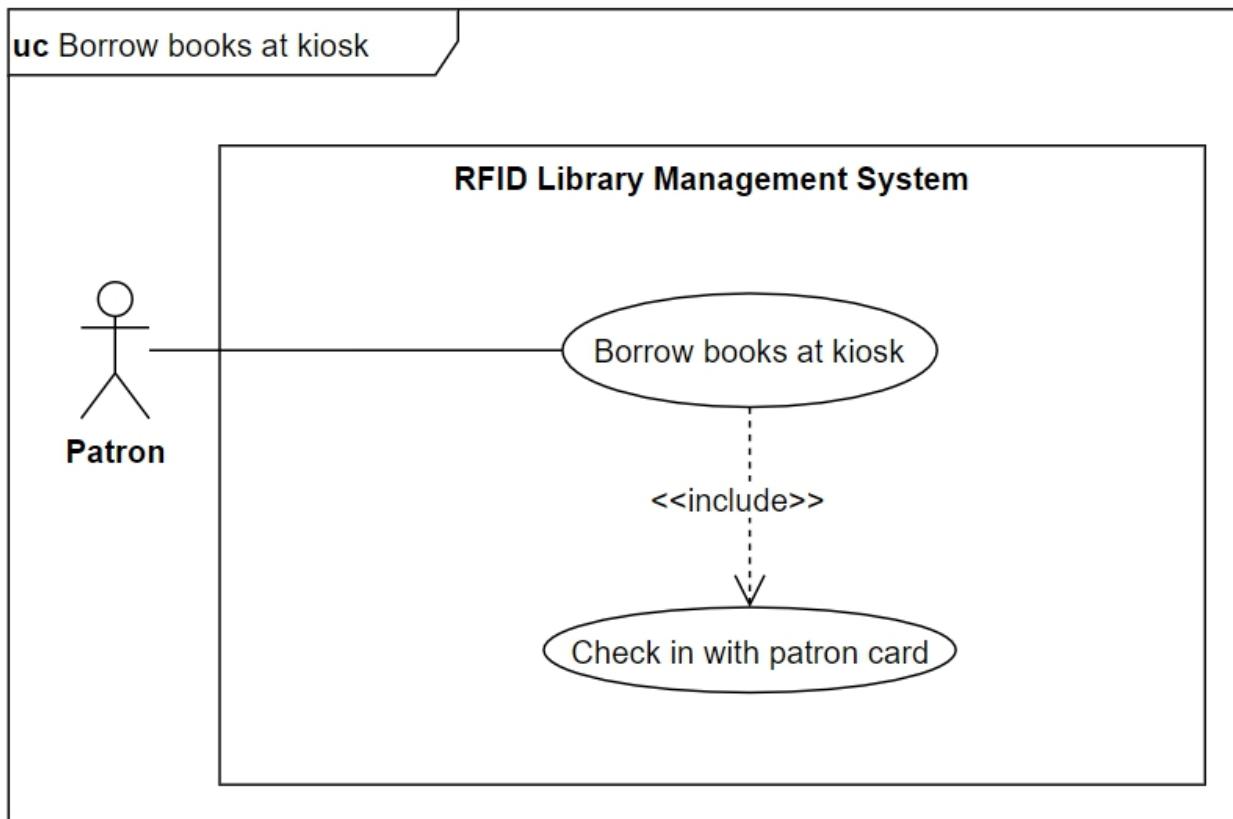


Figure 6 <Use Case> Borrow books at kiosk

ID and Name:	UC_13 Borrow books at kiosk		
Created By:	TramPH	Date Created:	15/01/2021
Primary Actor:	Patron	Secondary Actors:	N/A
Description:	Let patrons borrow books by themselves inside the library.		

Trigger:	The patrons send requests to check out books.		
Preconditions:	PRE-1: The patrons have checked in successfully as a patron role PRE-2: The patrons do not keep any overdue book.		
Postconditions:	POST-1: The system shows a list of borrowed books. POST-2: If checkout failed, show error message.		
Normal Flow:	Step	Actor action	System response
	1	The patrons check in successfully.	RLMS redirects to the checkout page and the session counts down.
	2	The patrons put books on the UHF scanner.	RLMS returns the list of scanned books. [Exception 1]
	3	The patrons click the “Confirm” button. [Alternative 1] [Alternative 2]	RLMS returns the list of borrowed or cannot borrow books then system send receipt via email to the patron [Exception 2] [Exception 3]
Alternative Flows:	Step	Actor action	System response
	1.1	The patrons use the check-out service for up to 4 minutes.	Session is expired and the RLMS closes the check-out screen.
	2.1	The patrons click the “Cancel” button.	RLMS show cancel confirm dialog.
	2.2	The patrons click the “Yes” button.	RLMS closes the check-out screen.
Exceptions:	No.	Cause	System response
	1	RLMS cannot find the scanned book in the system.	RLMS shows error messages and asks the patrons to scan books again.

	2	The patrons borrow over the limit allowed.	RLMS shows error messages and asks the patrons to scan books again.
	3	The patrons borrow duplicated books.	RLMS shows error messages and asks the patrons to scan books again.
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. The patrons can borrow multiple books at the same time by using UHF reader 2. The patrons can only borrow book copy with status “AVAILABLE” and must comply with borrow policy and patron policy. 3. The patrons cannot borrow duplicated books: <ul style="list-style-type: none"> • Duplicated with books scanning at the kiosk. • Duplicated with books the patrons are keeping 4. After scanning books, the system shows: <ul style="list-style-type: none"> • Book information: image, title, subtitle, edition, authors, group 5. After borrowing books, the system shows <ul style="list-style-type: none"> • Book information: image, title, subtitle, edition, authors, group • Checkout information: due date, borrowed time (if borrowed) or message (if couldn't borrow) 6. Due date is calculated based on borrow policy: <ul style="list-style-type: none"> • Due date = borrowed date + maximum borrow days • If the due date is Saturday or Sunday, move the due date to the next Monday. 7. Checked out copy status is updated to “BORROWED” after being borrowed 8. The patron cannot borrow book if they are inactivated or keeping any overdue book 9. The self-checkout session will last 4 minutes by default, after that the system will close the borrowing process. That makes sure the users do not use the kiosk for a long time. 		
Other Information	<ol style="list-style-type: none"> 1. Session shall be paused when the system's making a request to the service. 		
Assumptions:	N/A		

Table 7 <Use Case> Borrow book at kiosk

2.2.3.3. Renew a book

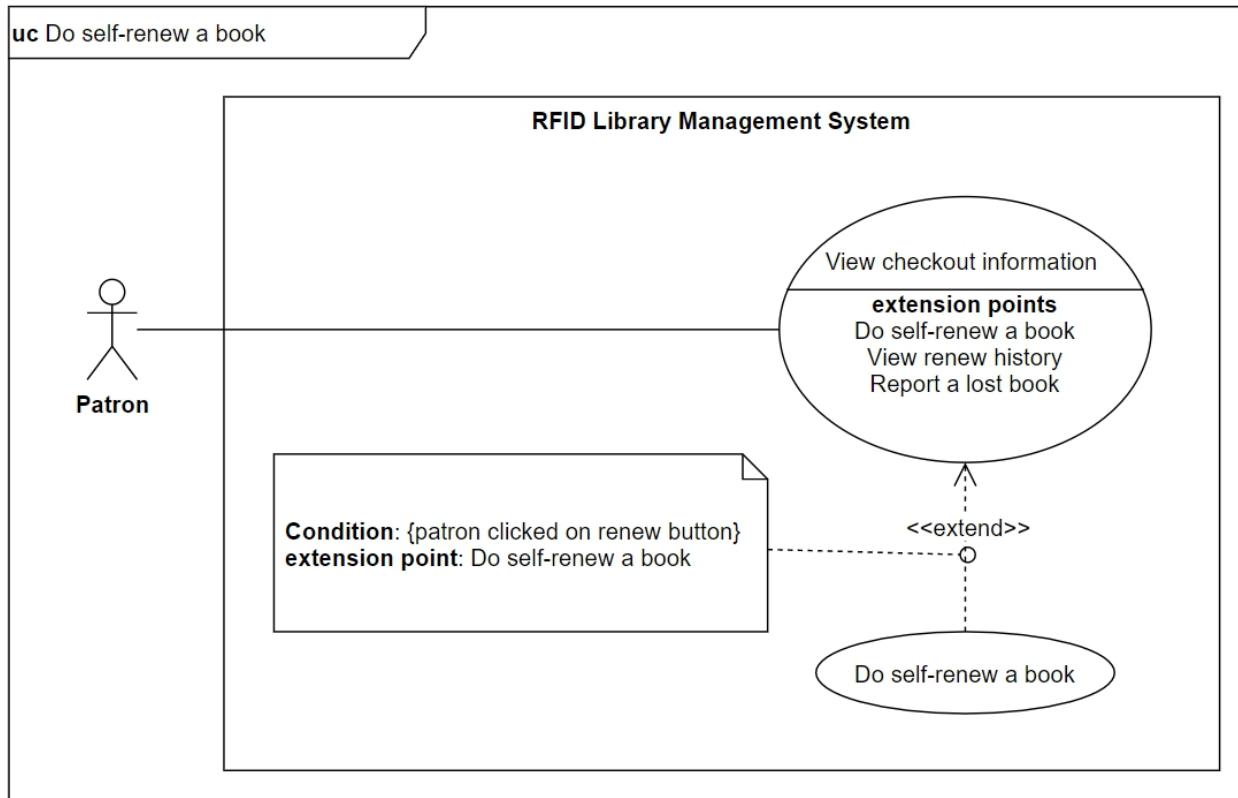


Figure 7 <Use Case> Renew a book

ID and Name:	UC_17 Renew a book		
Created By:	TramPH	Date Created:	25/02/2021
Primary Actor:	Patron	Secondary Actors:	N/A
Description:	Let the patron renew a borrowing book.		
Trigger:	The patron sends a request to renew a borrowing book.		
Preconditions:	PRE-1: The user has logged in as Patron role PRE-2: Borrowing book is not overdue.		
Postconditions:	POST-1: The system renews the borrowing book and shows a successful message. POST-2: If failed, show error message		

Normal Flow:	Step	Actor action	System response
	1	The patron clicks on the “Renew” button.	RLMS checks the borrow policy and show confirmation dialog with new due date [Exception 1] [Exception 2] [Exception 3]
	2	The patron clicks on the “Confirm” button [Alternative 1]	RLMS processes renewing the borrowing book and shows a successful message.
Alternative Flows:	Step	Actor action	System response
	1.1	The patron click on the “Back” button	RLMS closes the confirmation dialog.
Exceptions:	No.	Cause	System response
	1	The patron is keeping overdue books.	RLMS shows error messages.
	2	The patron violates the borrow policy	RLMS shows error messages.
	3	The patron is not allowed to borrow this book copy type anymore.	RLMS shows error messages.
Priority:	High		
Frequency of Use:	Occasionally		
Business Rules:	<ol style="list-style-type: none"> 1. The patron keeping any overdue book copies or violating any borrow policy cannot renew a book. 2. Cannot renew if the patron type is no longer allowed to borrow the book copy type 3. The system shows the new due date first to let the patron decide whether to renew or not 4. New due date = old due date + renew period (renew period is set on 		

	the Borrow Policy)
Other Information	N/A
Assumptions:	N/A

Table 8 <Use Case> Renew a book

2.2.4. Librarian

2.2.4.1. Borrow books for a patron

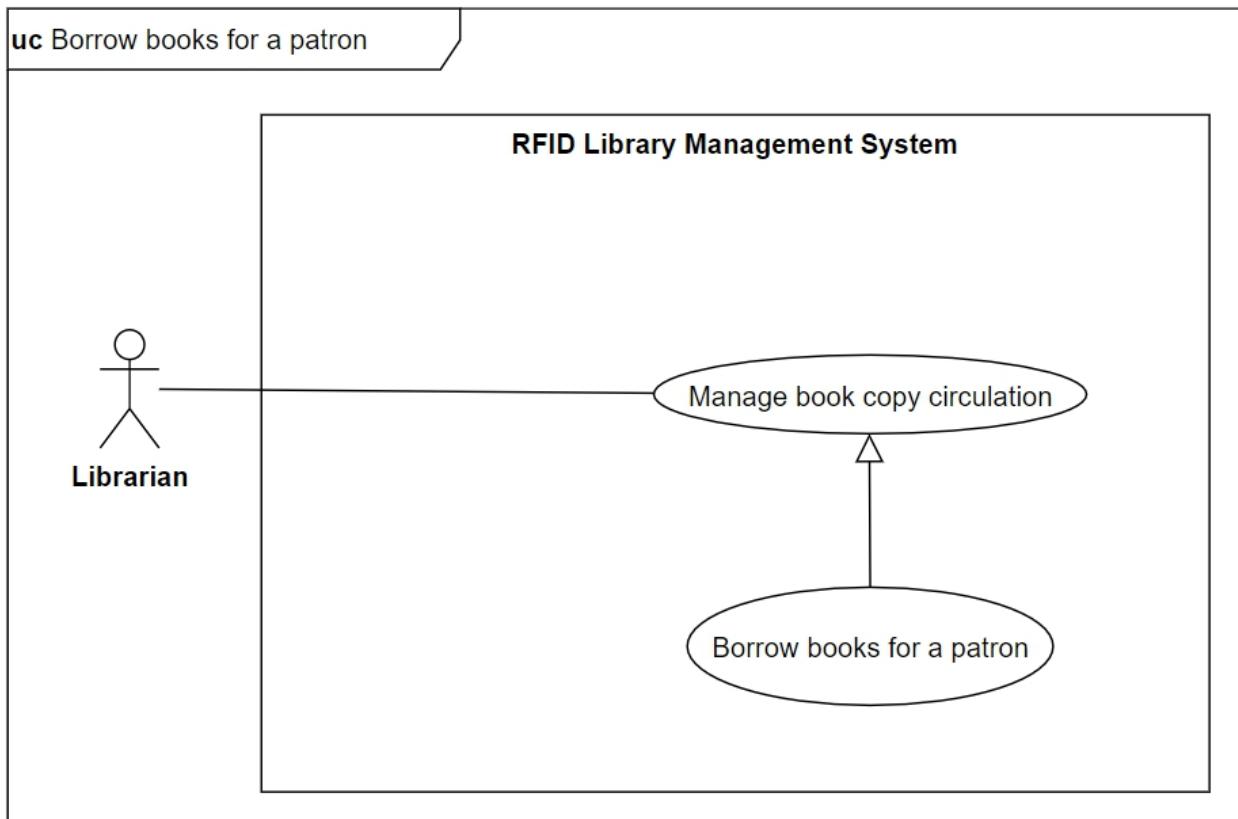


Figure 8 <Use Case> Borrow books for a patron

ID and Name:	UC_21 Borrow books for a patron		
Created By:	KhangNDN	Date Created:	18/02/2021
Primary Actor:	Librarian	Secondary Actors:	System handler, Patron

Description:	Let the librarian check out books for a patron.		
Trigger:	The librarian requests to check out books for a patron.		
Preconditions:	PRE-1: User has logged in as Librarian role		
Postconditions:	POST-1: Show success message, the patron receives a checkout receipt email POST-2: If checkout failed, show error message		
Normal Flow:	Step	Actor action	System response
	1	The librarian clicks on the checkout button on the sidebar	The RLMS displays the checkout UI
	2	Librarian scan patron's ID card or enter the patron's email and click on the search button	The system searches for patron information and displays the results to the screen. [Exception 1]
	3	The librarian scans all the checkout books or scan the book barcode and click on the search button	The system retrieves data from the database and checks borrow policy then shows those books information on the screen. [Exception 2]
	4	The librarian checks if all the books are shown on screen. The librarian can rescan the book(s) that are not shown on screen. The librarian can also click the delete button on the book that the patron does not want to borrow. Then, the librarian clicks Checkout button [Alternative 1]	The system checks patron policy then shows confirmed modal and warning messages (if any).
	5	The librarian clicks Confirm button [Alternative 2]	The system processes the checkout transaction, then shows the checkout success message. Then the system sends a receipt email to the

		[Alternative 3]	patron.
Alternative Flows:	Step	Actor action	System response
	1.1	Librarian clicks Clear button	The system clears all scanned books and patron's information.
	2.1	Incase if the checkout is violating any policy, the librarian must input borrowing reason and then clicks Confirm button	The system processes the checkout transaction, then shows the checkout success message. Then the system sends a receipt email to the patron.
	3.1	Librarian clicks Cancel button	Confirm modal closes and returns to the checkout UI
Exceptions:	No.	Cause	System response
	1	User is not found in the database or the user's role is not Patron.	The system shows an error message.
	2	Book is not found in the database	The system shows an error message.
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. Librarian can only check out for patrons' ID card 2. Book information: Image, title, subtitle, edition, barcode, genre, ISBN and due date. 3. The librarian can only click the Checkout button if the <i>Borrow Policy</i> allows the patron type to borrow all the checkout copies. 4. If scanned books violate the <i>Borrow Policy</i>, error message would be shown. 5. Only book copy with status "AVAILABLE" can be checked out. 6. Before checking out, the RLMS must validate and show warning message when: <ul style="list-style-type: none"> • Borrowing book copies violate <i>Borrow Policy</i> • Borrowing book copies violate <i>Patron Policy</i> • Does not exist a <i>Borrow Policy</i> for the patron type and the book copy type (The patron is not allowed to borrow the book copy type) 		

	<ul style="list-style-type: none"> ● Borrowing more than 1 copy of a same book ● The patron is keeping any overdue book copy ● The borrowing book copy is not “AVAILABLE” <p>7. Confirm modal includes: Warning message, list of borrowing books and borrowing reason.</p> <p>8. Librarians can still checkout for patrons (must provide reasons) if:</p> <ul style="list-style-type: none"> ● Borrowing book copies violate <i>Patron Policy</i> ● Borrowing book copies violate <i>Borrow Policy</i> ● The patron is keeping any overdue book copy ● Borrowing more than 1 copy of a same book <p>9. The RLMS will be able to checkout multiple book copies at a time.</p> <p>10. Checkout book copies can be scanned by UHF RFID scanner or by barcode reader. The librarian can also enter the book barcode manually.</p> <p>11. Due date is calculated for each checkout book copy by adding n day(s) to the current date, (n days is taken from <i>Borrow Policy</i>). If the due date is on Saturday or Sunday, then move the due date to Monday.</p> <p>12. Checked out copy status is updated to “BORROWED”</p> <p>13. Cannot checkout if patron is inactive</p> <p>14. Security alarm is deactivated for checked out book copies</p>
Other Information	<p>1. If there is no internet connection, the system cannot load the book image</p>
Assumptions:	N/A

Table 9 <Use Case> Borrow books for a patron

2.2.4.2. Return books for a patron

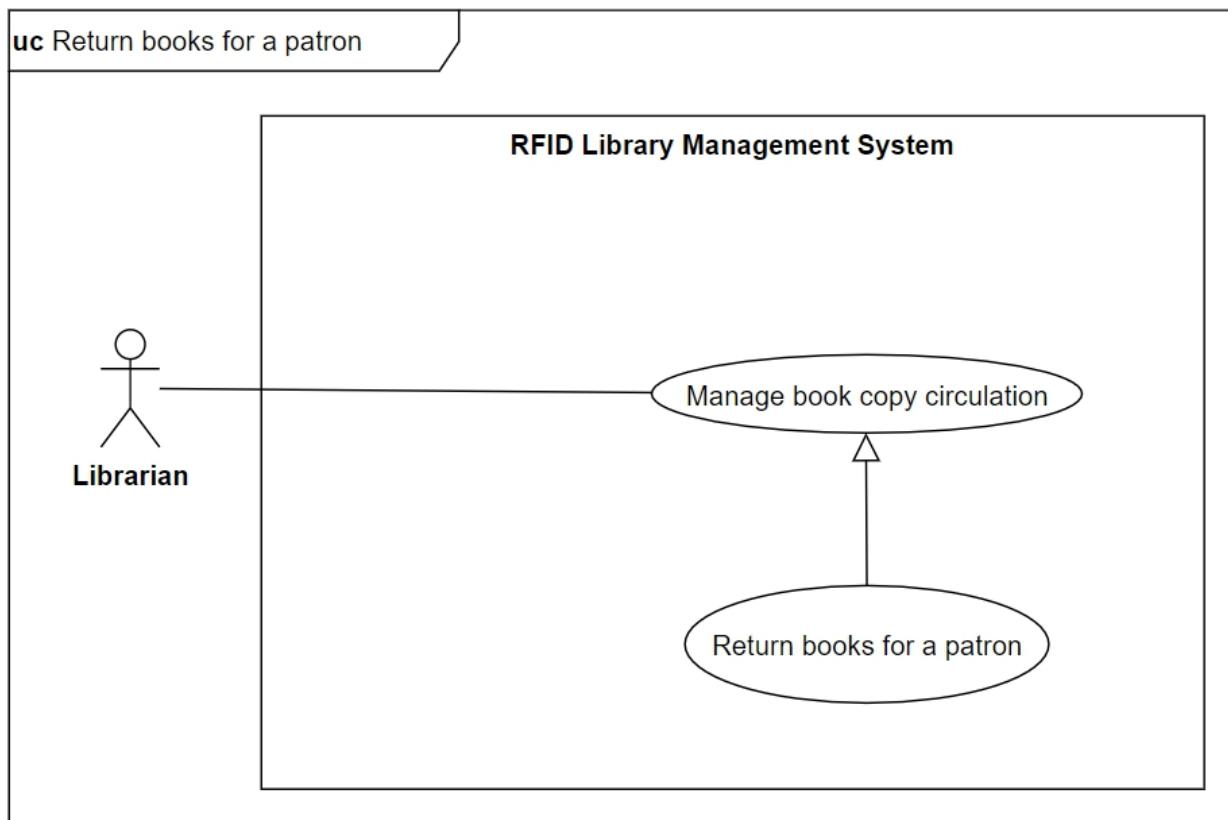


Figure 9 <Use Case> Return books for a patron

ID and Name:	UC_22 Return books for a patron		
Created By:	KhangNDN	Date Created:	18/02/2021
Primary Actor:	Librarian	Secondary Actors:	System Handler
Description:	Librarian can return books for a patron		
Trigger:	The librarian requests to return books for a patron		
Preconditions:	PRE-1: User has logged in as Librarian role		
Postconditions:	POST-1: Show success message, the patron receives a return receipt email POST-2: If return failed, show error message		
Normal Flow:	Step	Actor action	System response

	1	The librarian clicks on return button on the side bar	The RLMS displays the return UI
	2	The librarian scans the books with RFID scanner or barcode scanner.	The system retrieves data from the database then shows those books information on the screen. [Exception 1]
	3	The librarian checks if all the books shown on screen are correct. The librarian can rescan the book(s) that are not shown on screen. The librarian can also click the delete button on the book that the patron does not want to return. Then, the librarian clicks the Return button. [Alternative 1]	The system then shows the confirmed modal.
	4	The librarian clicks Confirm button [Alternative 2]	The system processes the return transaction, then shows the return success message. Then the system sends a return receipt to the patron via email.
	Alternative Flows:	Step	Actor action
	1	Librarian clicks Clear button	The system clears all scanned books.
	2	Librarian clicks Cancel button	Confirm modal closes
Exceptions:	No.	Cause	System response
	1.1	Book is not found in the database	The system shows an error message.
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	1. Librarian scan to show book copy information before clicking Return		

	<p>button</p> <ol style="list-style-type: none"> 2. Book copy information: Image, title, subtitle, edition, barcode, genre, borrower, due date and overdue day(s). 3. The RLMS allows users to return multiple book copies at a time. 4. Overdue book copies will require the patron to pay a fine <ul style="list-style-type: none"> • Fine = overdue day(s) * fine rate (fine rate is taken from <i>Fee Policy</i>). Overdue days does not include Saturdays and Sundays • Max fine = book copy's price * MAX OVERDUE FINE / 100 (MAX OVERDUE FINE is taken from <i>Fee Policy</i>) 5. A returned book copy status will be updated based on its book status. If the book status is: <ul style="list-style-type: none"> • IN_CIRCULATION update book copy status to AVAILABLE • OUT_OF_CIRCULATION update book copy status to OUT_OF_CIRCULATION • DISCARD update book copy status to DISCARD • LIB_USE_ONLY update book copy status to LIB_USE_ONLY 6. The librarian is not required to scan patron card when returning book copies 7. The version of Fee Policy used when returning is based on the version of the policy when the book copy is borrowed 8. Inactive patrons can still return book copies. 9. Reactivate security alarm for returned book copies
Other Information	<ol style="list-style-type: none"> 1. If there is no internet connection, the system cannot load the book image
Assumptions:	N/A

Table 10 <Use Case> Return books for a patron

2.2.4.3. Tag a book copy

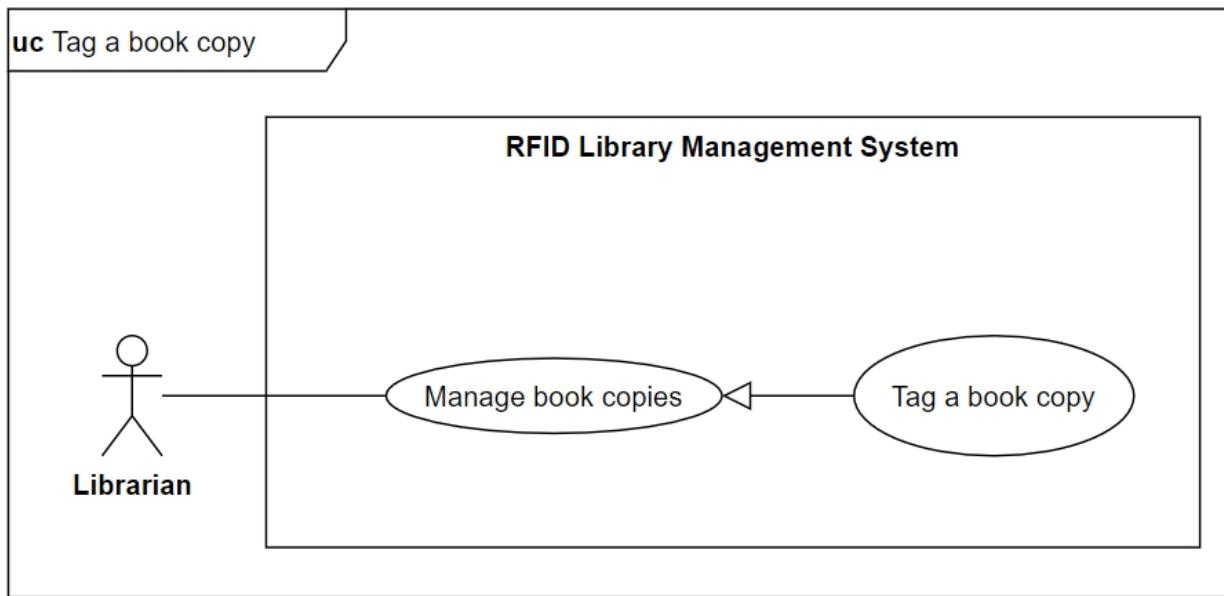


Figure 10 <Use Case> Tag a book copy

ID and Name:	UC_25 Tag a book copy		
Created By:	HoangPM	Date Created:	22/02/2021
Primary Actor:	Librarian	Secondary Actors:	N/A
Description:	In order to be in circulation, a book must be tagged with an RFID tag by the Librarian		
Trigger:	The Librarian sends request to tag a book copy		
Preconditions:	PRE-1: The user has logged in as Librarian role		
Postconditions:	POST-1: Show success message POST-2: If update failed, show error message		
Normal Flow:	Step	Actor action	System response
	1	Librarian requests to update existing book	The system requires librarian to enter book copy's barcode and new RFID UID

	2	The librarian fills in required fields and click Confirm button	The system processes the request transaction, then shows the success message. [Exception 1]
Alternative Flows:	N/A		
Exceptions:	No.	Cause	System response
	1	There's already a book copy tagged with the same RFID code (Duplicate RFID code)	The RLMS returns a warning message, telling the librarian that the RFID code must be unique
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. Book information must be shown after the librarian has entered the book copy's barcode. 2. Both barcode and RFID fields must be filled. 3. After being tagged, book copy's status will be updated depends on Book's status: <ul style="list-style-type: none"> • If Book's status is "IN_CIRCULATION", book copy's status is "AVAILABLE" • If Book's status is "OUT_OF_CIRCULATION", book copy's status is "OUT_OF_CIRCULATION" • If Book's status is "LIB_USE_ONLY", book copy's status is "LIB_USE_ONLY" 4. Book copy RFID UID is unique 5. Barcode can be inputted by scanning or entering with keyboard manually 6. Can only tag book copy if the copy is "IN_PROCESS" or "AVAILABLE" 		
Other Information	<ol style="list-style-type: none"> 1. The librarian must have the UHF reader to complete the tagging process. 		
Assumptions:	N/A		

Table 11 <Use Case> Tag a book copy

2.2.4.4. Create book copies

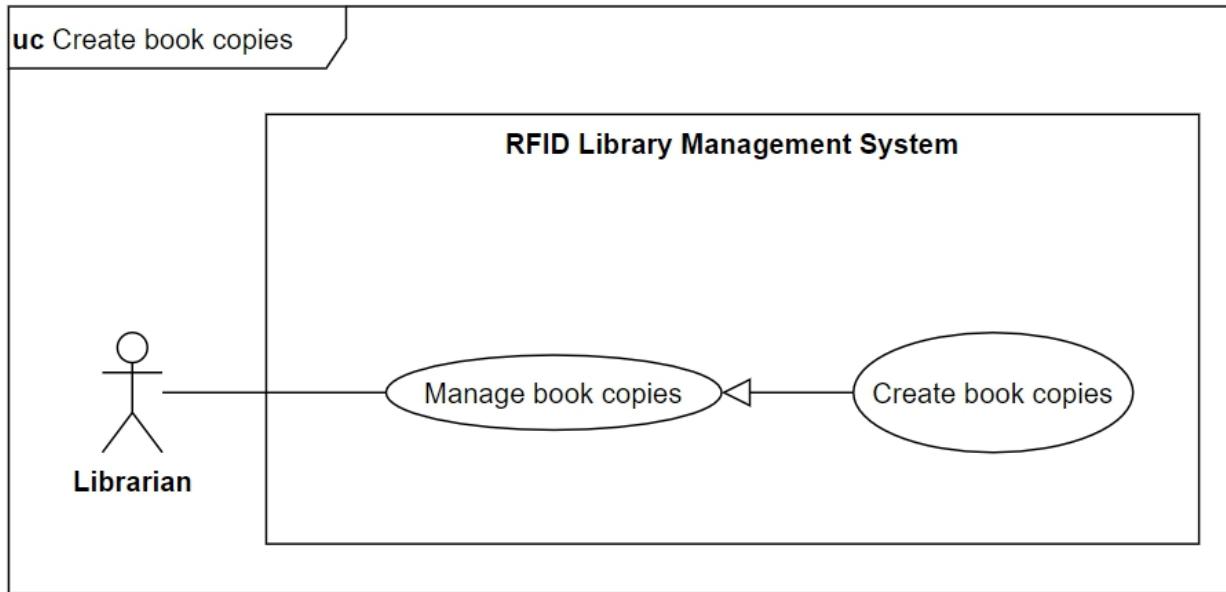


Figure 11 <Use Case> Create book copies

ID and Name:	UC_26 Create book copies		
Created By:	HoangPM	Date Created:	22/02/2021
Primary Actor:	Librarian	Secondary Actors:	N/A
Description:	Provide the librarian with the ability to create multiple book copies for a book		
Trigger:	The Librarian sends request to create copies for a book title		
Preconditions:	PRE-1: The user has logged in as Librarian role or Manager role PRE-2: The book is already in the system PRE-3: The book copy types are already in the system		
Postconditions:	POST-1: Show success message POST-2: If update failed, show error message		
Normal Flow:	Step	Actor action	System response
	1	Librarian request to add copies for a book by pressing "Make copy" button	The system returns a screen requiring the librarian to enter the book copy type, price and total

			number of adding copies.
	2	The librarian fills in required fields and click on Save button	The system generates a barcode for each copy, then shows the generated barcodes to the librarian for confirmation.
	3	The librarian re-check the information then click on Confirm button	The system processes the request transact, auto start to download a generated barcodes file on the user's browser and show success message
Alternative Flows:	N/A		
Exceptions:	N/A		
Priority:	High		
Frequency of Use:	Occasionally		
Business Rules:	<ol style="list-style-type: none"> 1. The barcode is 14 digits: <ul style="list-style-type: none"> • 1st to 2nd digits are Book copy type • 3rd to 6th digits are library's ID • 7th to 15th digits are book copy's ID 2. Book copy barcodes are unique 3. Book copy status after adding is "IN_PROCESS" 4. The function requires the librarian to enter the following fields: <ul style="list-style-type: none"> • Price: required, min = 1 000, max = 1 000 000 000 • Price Note: details about the book copy price (like if the shipping fee is included or not). If the user does not input anything, a default note will be inserted to the RLMS. • Number of copies: required, min = 1, max = 5000 • Copy type: required, must be selected from a list • Price note: required, max = 500 5. The total number of copies of the book will be increased by the number of copies that will be added 6. The system generates barcode base on Code-39 barcode format 7. The pdf file name has format: ISBN-Book Copy Type-Price 		
Other Information	<ol style="list-style-type: none"> 1. The barcode label has the following dimension: 2.25" x 1" 		

	<p>2. While already having RFID tags, we still keep the barcode system as a fail-safe, in case the RFID tag is broken.</p>
Assumptions:	<p>1. Barcodes format is different from libraries to libraries. For this project, the barcode is 14 digits:</p> <ul style="list-style-type: none"> • 1st to 2nd digits are Book copy type • 3rd to 6th digits are library's ID • 7th to 15th digits are book copy's ID <p>2. The RLMS does not manage the barcode printers, so we assume that the library is equipped with printers according to our barcode label dimension. (We recommend this printer: Zebra GX430t Thermal Transfer Desktop Printer, and this barcode label: BETCKEY - 2.25" x 1" label)</p>

Table 12 <Use Case> Create book copies

2.2.4.5. Index book copy location

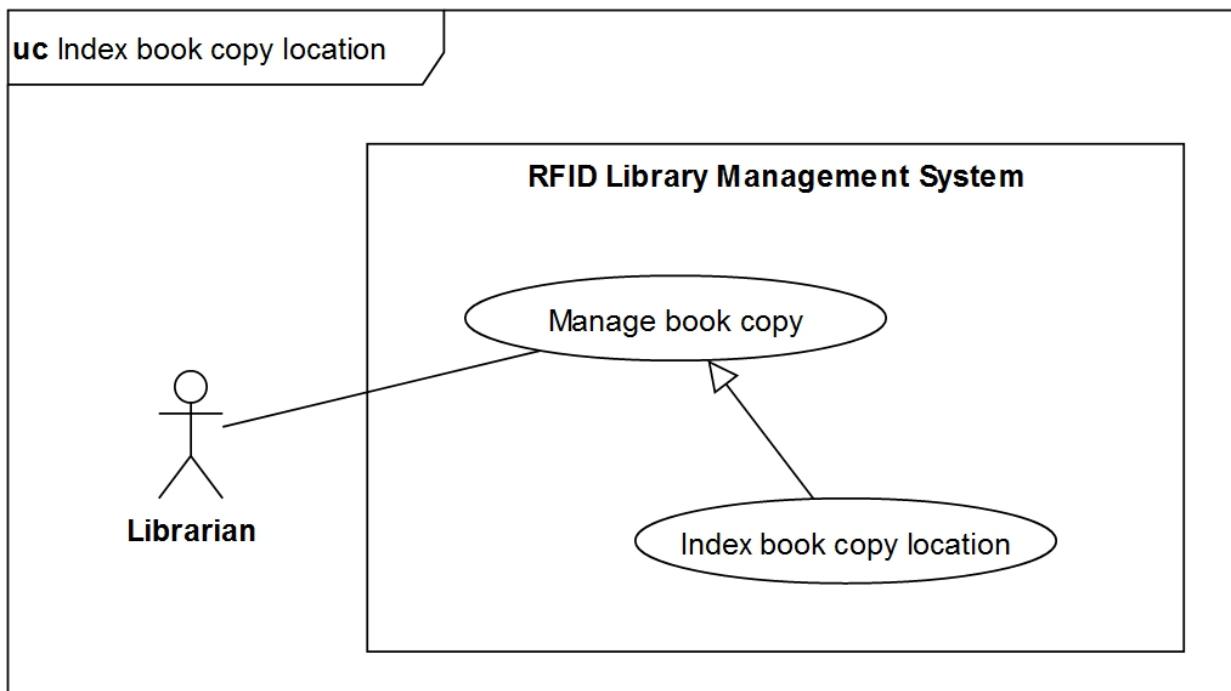


Figure 12 <Use Case> Index book copy location

ID and Name:	UC_39 Index book copy location		
Created By:	KienNT	Date Created:	23/03/2021
Primary Actor:	Librarian	Secondary Actors:	N/A

Description:	Let the librarian index/save book copies to a row of a shelf		
Trigger:	The librarian sends request to save books location		
Preconditions:	PRE-1: The Librarian has logged in successfully as a Librarian role		
Postconditions:	POST-1: The system shows success message POST-2: In case of failure, the system displays an error message		
Normal Flow:	Step	Actor action	System response
	1	The librarian clicks on the Sample button	The RLMS shows a the Sample screen and starts to receive shelf's RFID UID from the UHF reader
	2	The librarian selects shelf and row then clicks on the Scan button [Alternate 1]	The RLMS starts to receive book copy RFID UID from the UHF reader
	3	The librarian uses the UHF Reader to scan books on the shelf's row	The RLMS shows the scanned books table on the screen
	4	The librarian clicks on the Finish Button [Alternate 2] [Exception 1]	The RLMS saves new books onto the shelf's row
Alternative Flows:	Step	Actor action	System response
	1.1	The librarian uses the UHF Reader to scan the shelf's row RFID tag	The RLMS shows the shelf information on screen
	1.2	The librarian clicks on the Scan button	The RLMS starts to receive book copy RFID UID from the UHF reader
	1.3	The librarian uses the UHF Reader to scan books on the shelf's row	The RLMS shows the scanned books table on the screen
	1.4	The librarian clicks on the Finish Button [Alternate 2]	The RLMS saves new books onto the shelf's row

		[Exception 1]	
	2.1	The librarian click “Cancel” button	RLMS clears the scanned book table
Exceptions:	No.	Cause	System response
	1	One or more scanned books is “BORROWED” or “DISCARD” or “LOST”	RLMS shows error message
Priority:	Medium		
Frequency of Use:	Rarely		
Business Rules:		<ol style="list-style-type: none"> 1. Can only save location for books that are “AVAILABLE” or “LIB_USE_ONLY” 2. When saving new books to a shelf’s row, previous books that were on that row would be removed, and their location would become blank 3. Finish button can only be clicked when there are books in the scanned books table 4. Shelf and row must be selected before clicking the Scan button 5. After clicking the Scan button shelf and row cannot be changed unless the librarian clicked on the Cancel button 6. the scanned books table will show the book’s: <ul style="list-style-type: none"> ● Barcode ● RFID ● Call Number ● Title ● Author ● Edition 7. Shelf can be input manually or by scanning shelf RFID tag 8. Books are saved to shelf’s row by shelf’s row 	
Other Information	N/A		
Assumptions:	N/A		

Table 13 <Use Case> Index book copy location

2.2.4.6. Find misplaced book copies

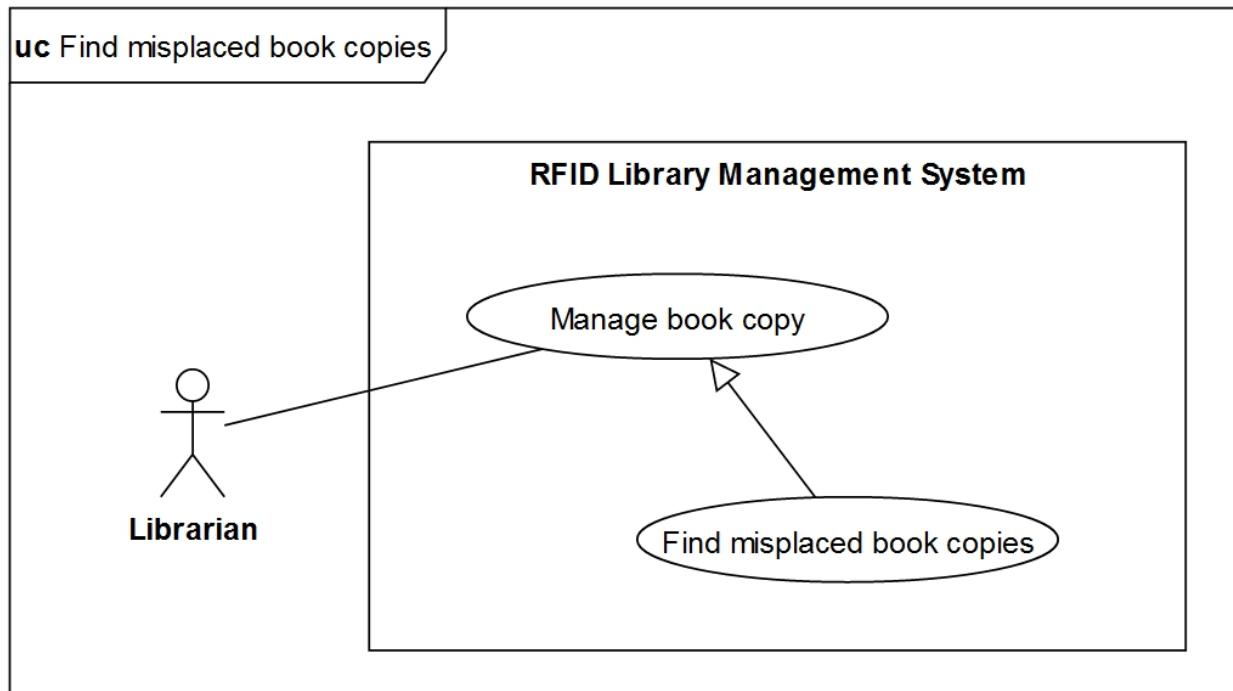


Figure 13 <Use Case> Find misplaced book copies

ID and Name:	UC_40 Find misplaced book copies		
Created By:	KienNT	Date Created:	23/03/2021
Primary Actor:	Librarian	Secondary Actors:	N/A
Description:	Let the librarian check for misplaced or missing books of each shelf's row		
Trigger:	The librarian sends request to check books location		
Preconditions:	PRE-1: The Librarian has logged in successfully as a Librarian role		
Postconditions:	POST-1: If there are any missing books from the shelf row, show a table of missing books POST-2: If there is any misplaced books on the shelf row, highlight the record in the scanned books table		
Normal Flow:	Step	Actor action	System response
	1	The librarian clicks on the	The RLMS shows a the Check screen

		Check button	and starts to receive shelf's RFID UID from the UHF reader
	2	The librarian selects shelf and row then clicks on the Scan button [Alternate 1]	The RLMS starts to receive book copy RFID UID from the UHF reader
	3	The librarian uses the UHF Reader to scan books on the shelf's row	The RLMS shows the scanned books table on the screen
	4	The librarian clicks on the Finish Button [Alternate 2]	The RLMS clears the scanned books table
Alternative Flows:	Step	Actor action	System response
	1.1	The librarian uses the UHF Reader to scan the shelf's row RFID tag	The RLMS shows the shelf information on screen
	1.2	The librarian clicks on the Scan button	The RLMS starts to receive book copy RFID UID from the UHF reader
	1.3	The librarian uses the UHF Reader to scan books on the shelf's row	The RLMS shows the scanned books table on the screen
	1.4	The librarian clicks on the Finish Button [Alternate 2]	The RLMS clears the scanned books table
	2.1	The librarian click on the Finish button and there are books missing from the shelf's row	RLMS returns a table of missing books
	2.2	The library clicks on the Clear button	RLMS clears the scanned books table
Exceptions:	N/A		
Priority:	High		
Frequency of Use:	Occasionally		

Business Rules:	<ol style="list-style-type: none"> 1. The books table must contain: <ul style="list-style-type: none"> ● Initial location (“N/A” if book is not assigned to a location) ● Barcode ● RFID ● Call Number ● Title ● Author ● Edition 2. Only check “AVAILABLE” and “LIB_USE_ONLY” books 3. Book is misplaced if it is put on a different row from its initial row. Misplaced books on the shelf are marked when shown on screen. 4. Shelf can be input manually or by scanning shelf RFID tag 5. Books location are checked by each shelf’s row
Other Information	N/A
Assumptions:	N/A

Table 14 <Use Case> Find misplaced book copies

2.2.5. Manager

(References to “RFID_Library_Management_System_Full.pdf”)

2.2.6. System Handler

(References to “RFID_Library_Management_System_Full.pdf”)

2.2.7. Security Gate

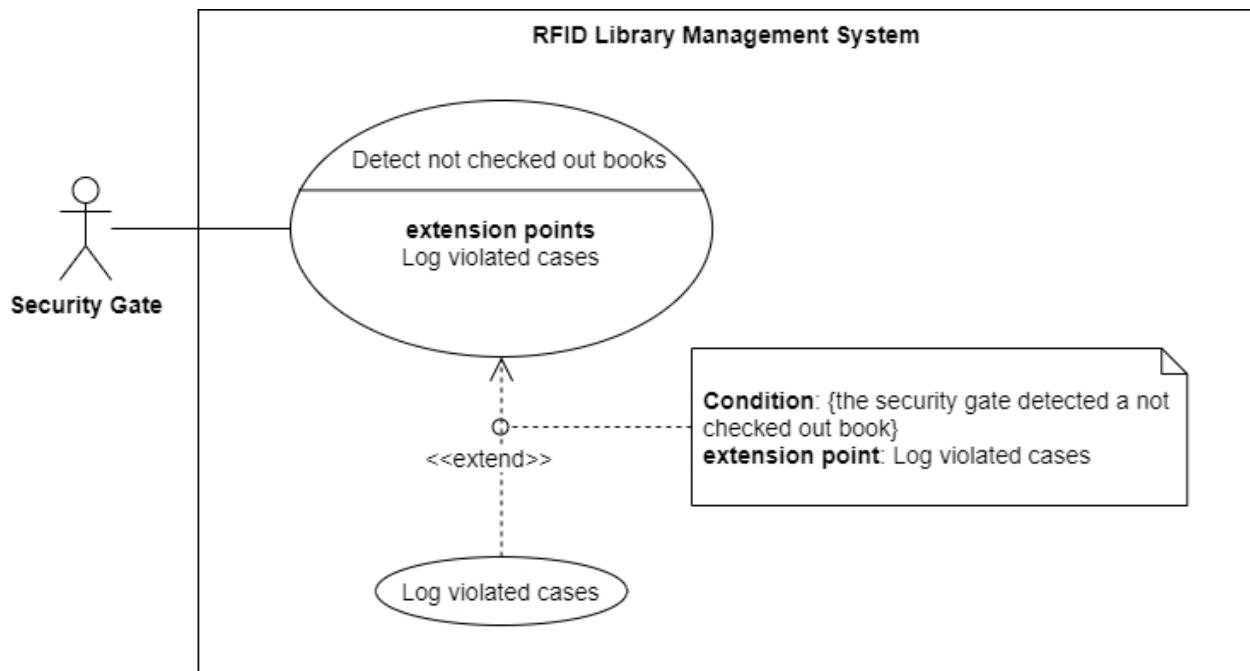


Figure 14 <Use Case Overview> Security Scanner

2.2.7.1. Detect not checked out books

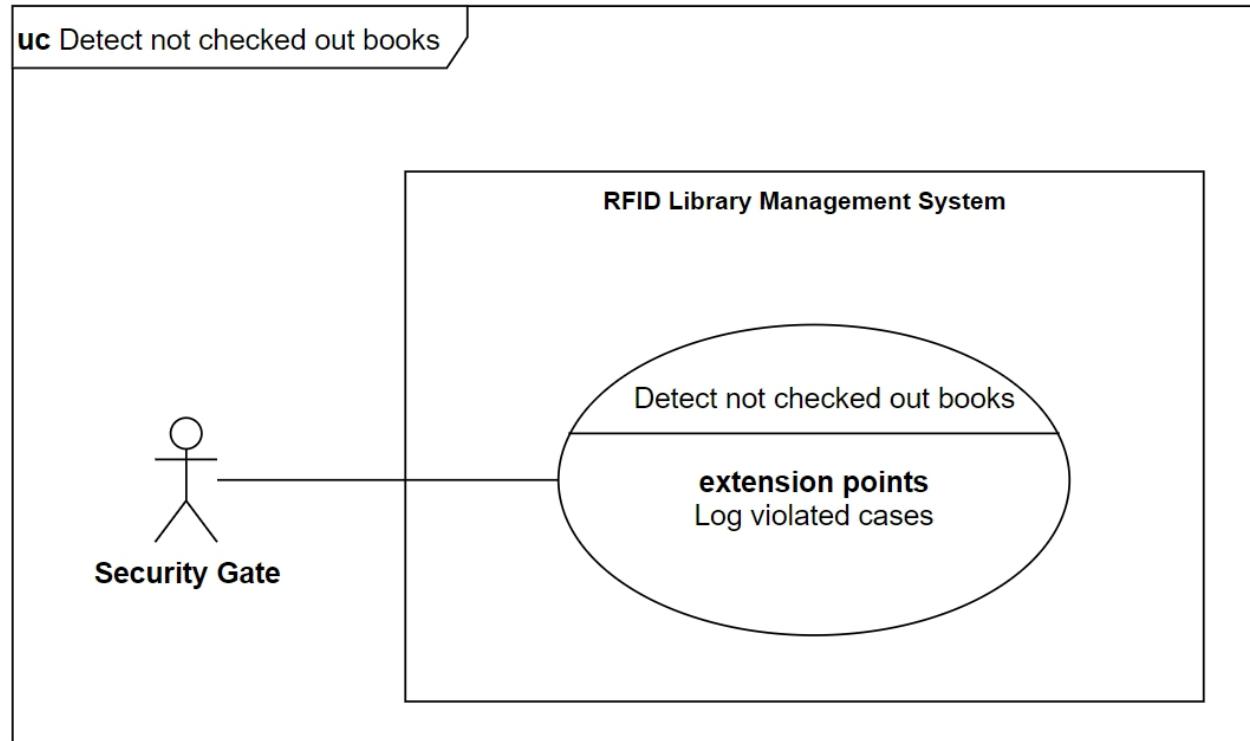


Figure 15 <Use Case> Detect not checked out books

ID and Name:	UC_70 Detect not checked out books		
Created By:	HoangPM	Date Created:	26/02/2021
Primary Actor:	Security Gate	Secondary Actors:	N/A
Description:	The security scanner will be able to detect and raise alarm if it detects a not checked out book passing by		
Trigger:	The security scanner detects a book presence		
Preconditions:	PRE-1: The UHF reader and alarm module is connected to the security gate controller		
Postconditions:	POST-1: Raise the alarm if detects a not checked out book		
Normal Flow:	Step	Actor action	System response
	1	Security Scanner detects a book presence and send request to check that book	RLMS processes the request. If the book is not checked out, the RLMS logs the book information and tells the security scanner to raise the alarm, else do nothing.
Alternative Flows:	N/A		
Exceptions:	N/A		
Priority:	High		
Frequency of Use:	Usually		
Business Rules:	<ol style="list-style-type: none"> 1. The security gate should be able to check multiple books at a time 2. The security gate logs the book information if the book is not checked out 		
Other Information	N/A		
Assumptions:	1. Patrons are not allowed to bring their bags inside the library		

Table 15 <Use Case> Detect not checked out books

2.2.7.2. Log violated cases

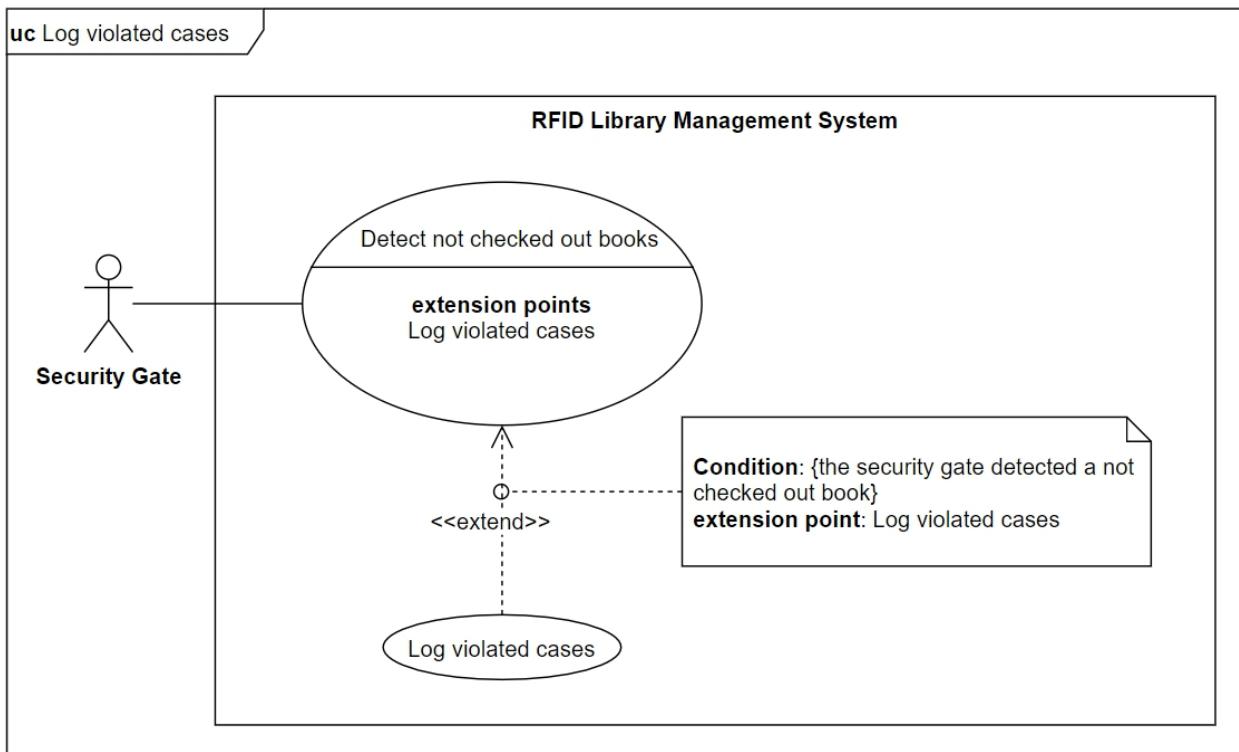


Figure 16 <Use Case> Log violated cases

ID and Name:	UC_71 Log violated cases		
Created By:	HoangPM	Date Created:	03/03/2021
Primary Actor:	Manager	Secondary Actors:	N/A
Description:	Provide the security scanner with the ability to save security alarm log		
Trigger:	After the alarm was raised, the security scanner sends a request to insert a new log record to the database		
Preconditions:	N/A		
Postconditions:	POST-1: A new log record is inserted into the database		
Normal Flow:	Step	Actor action	System response
	1	The security scanner sends a request to log a new record to	The RLMS processes the request and inserts a new log record to the

		the database	database
Alternative Flows:	N/A		
Exceptions:	N/A		
Priority:	Low		
Frequency of Use:	Rarely		
Business Rules:	1. The logging time is based on when the alarm was raised		
Other Information	N/A		
Assumptions:	N/A		

Table 16 <Use Case> Log violated cases

3. Entity Relationship Diagram

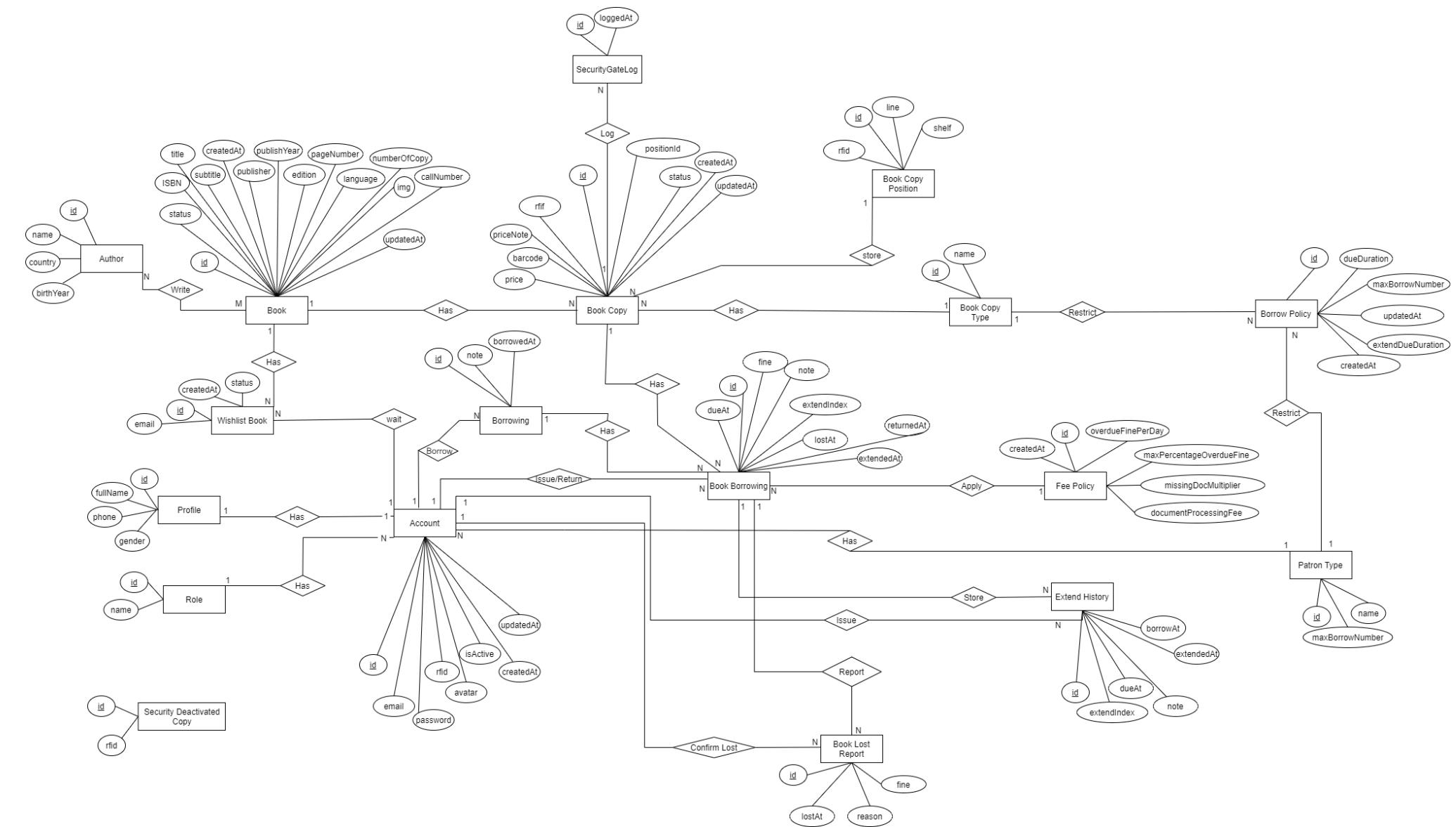


Figure 17 Entity Relationship Diagram

IV. Software Design Document

1. System Architecture Design

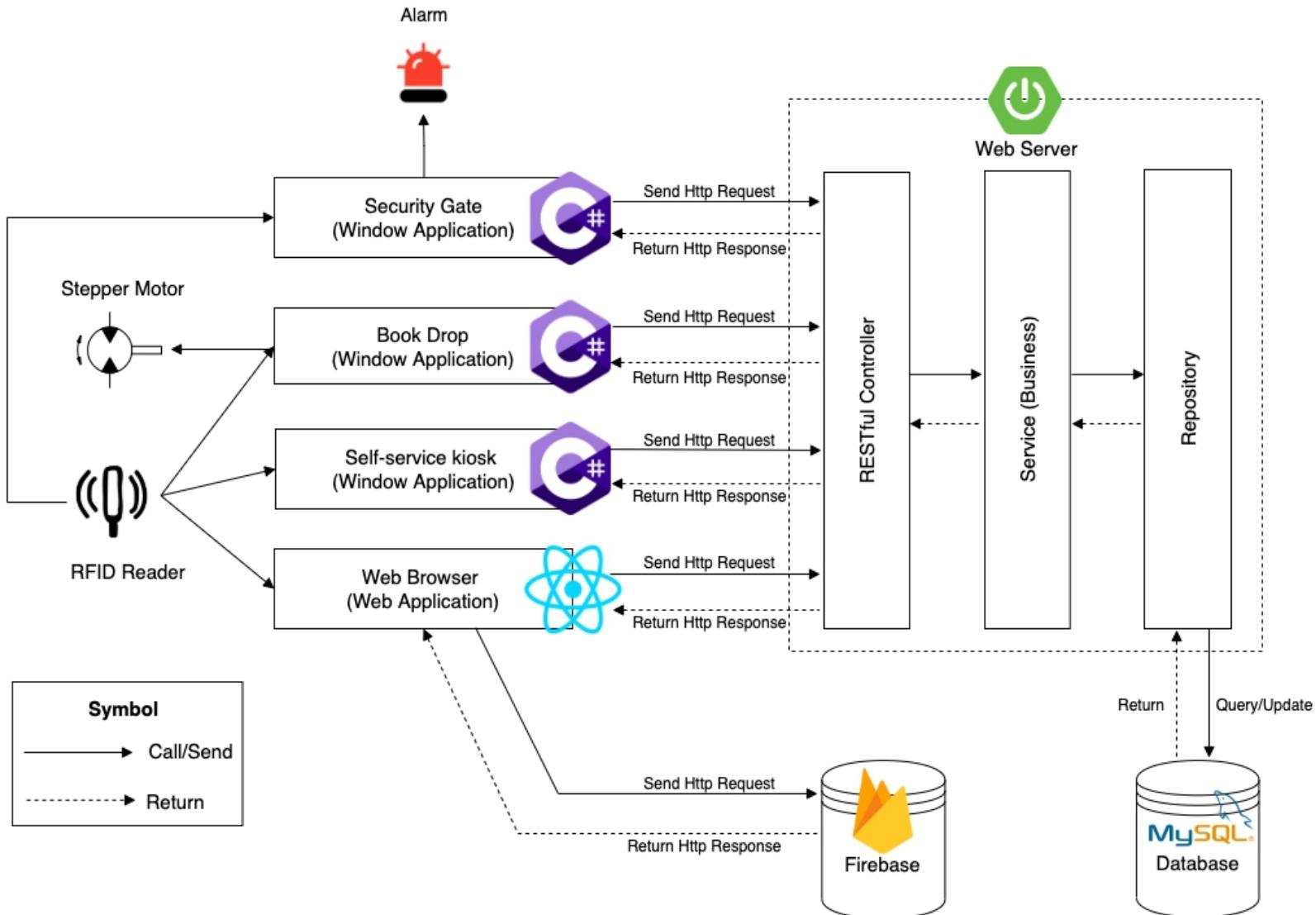


Figure 18 Architecture Diagram

The RLMS consists of following sub-systems:

- Web Server: receives requests from the front end applications (web application, Window application) then returns the corresponding response. Web server is built base on Spring Boot Framework, Restful API, Three Tier Architecture (Controller - Service - Repository), Data Transfer Object pattern
- Security Gate, Book Drop, Self-service kiosk: send http requests to the web server and receive http response from it. They are Window applications using .Net Framework.

- Web Browser: sends http requests to the web server and receives http response from it. Web browser apply: React JS, Redux for managing states

We also use MySQL database to store the operating system information and Firebase storage to store images of the system.

There are supporting devices applied in our system (check Technology Solution for further information)

- RFID readers: scan and send RFID key to sub-systems
- Stepper motor: control the doors of the book drop
- Alarm for security gate

2. Component Diagram

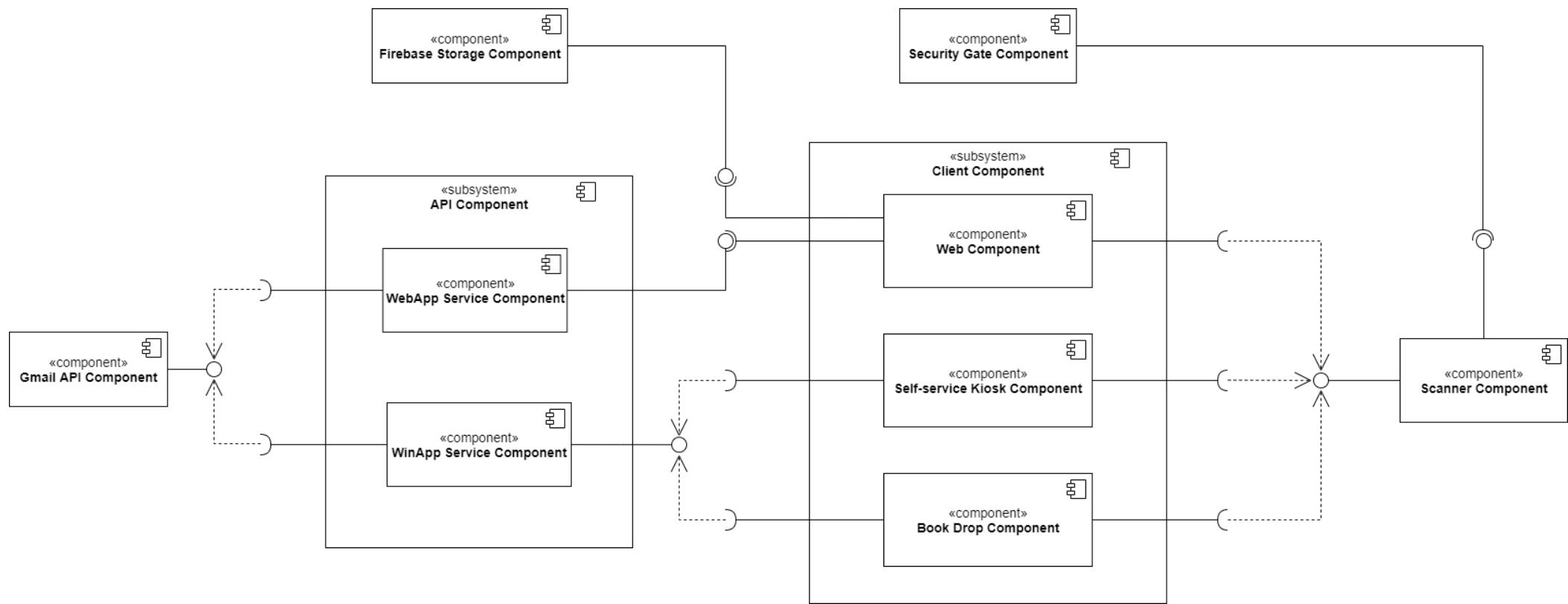


Figure 19 Component Diagram

3. System Details Design

3.1. Class Diagram

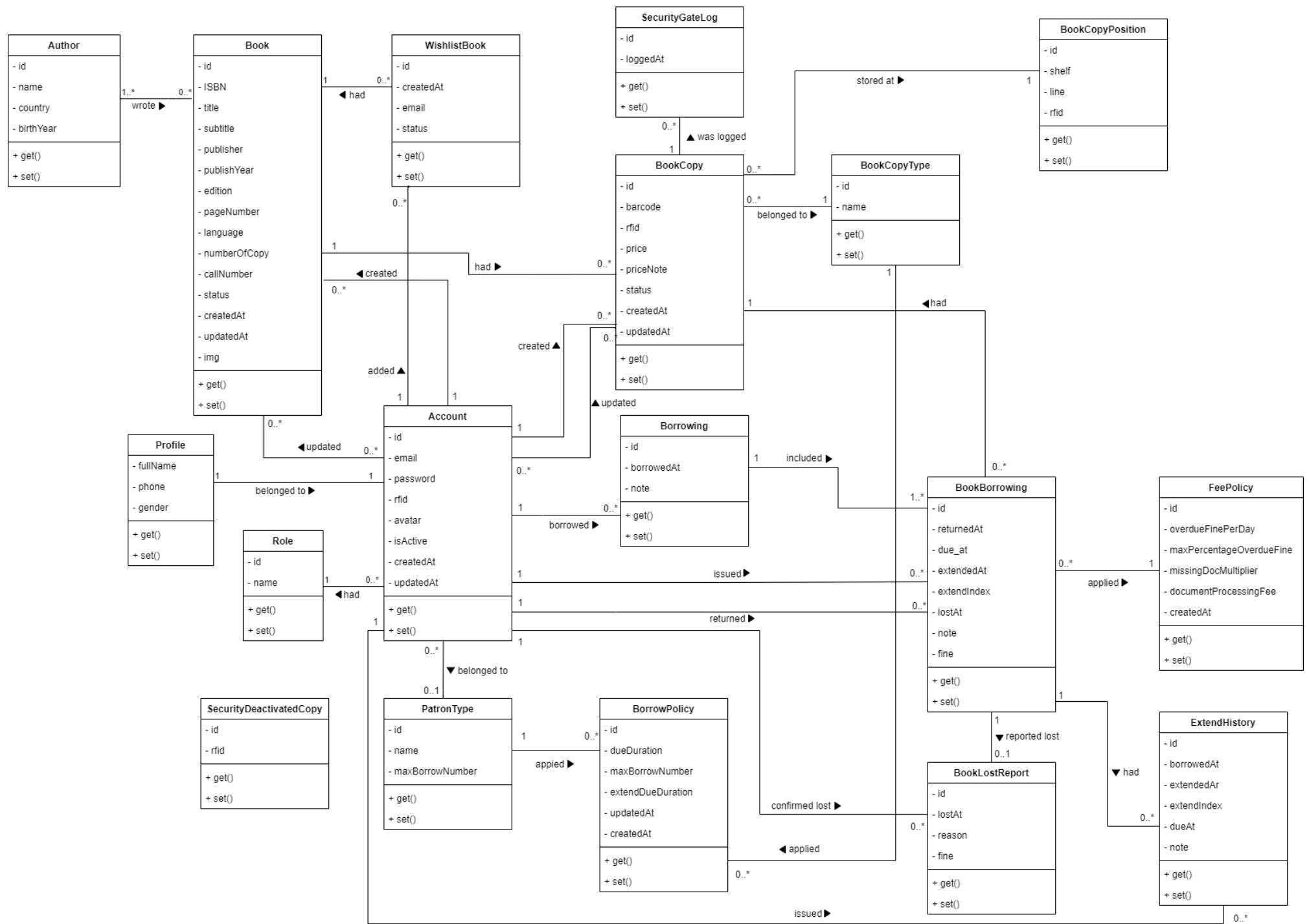


Figure 20 Class Diagram

3.2. State Machine Diagrams

3.2.1. Book Status

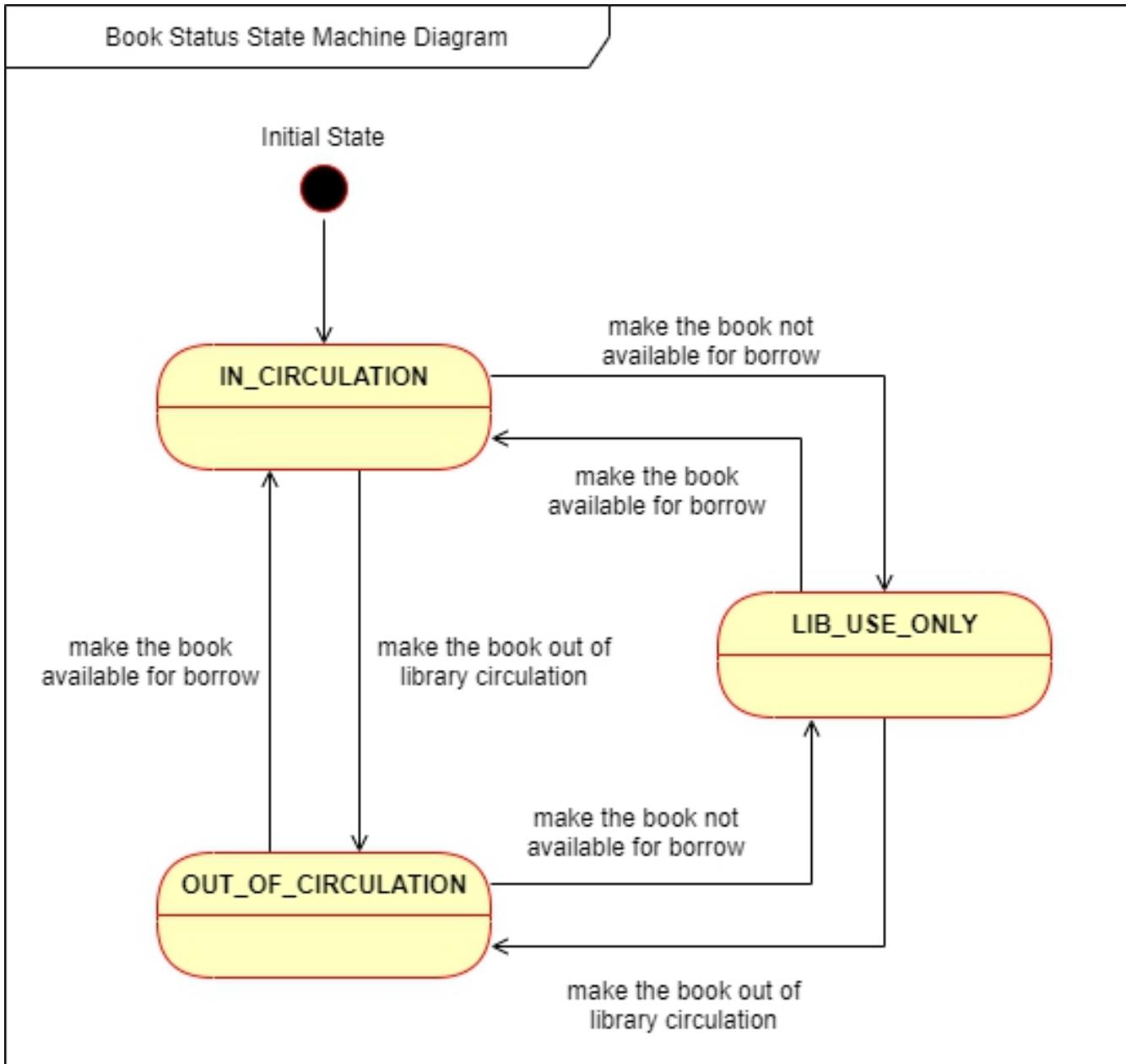


Figure 21 <State Machine Diagram> Book Status

3.2.2. Book Copy Status

Book Copy Status State Machine Diagram

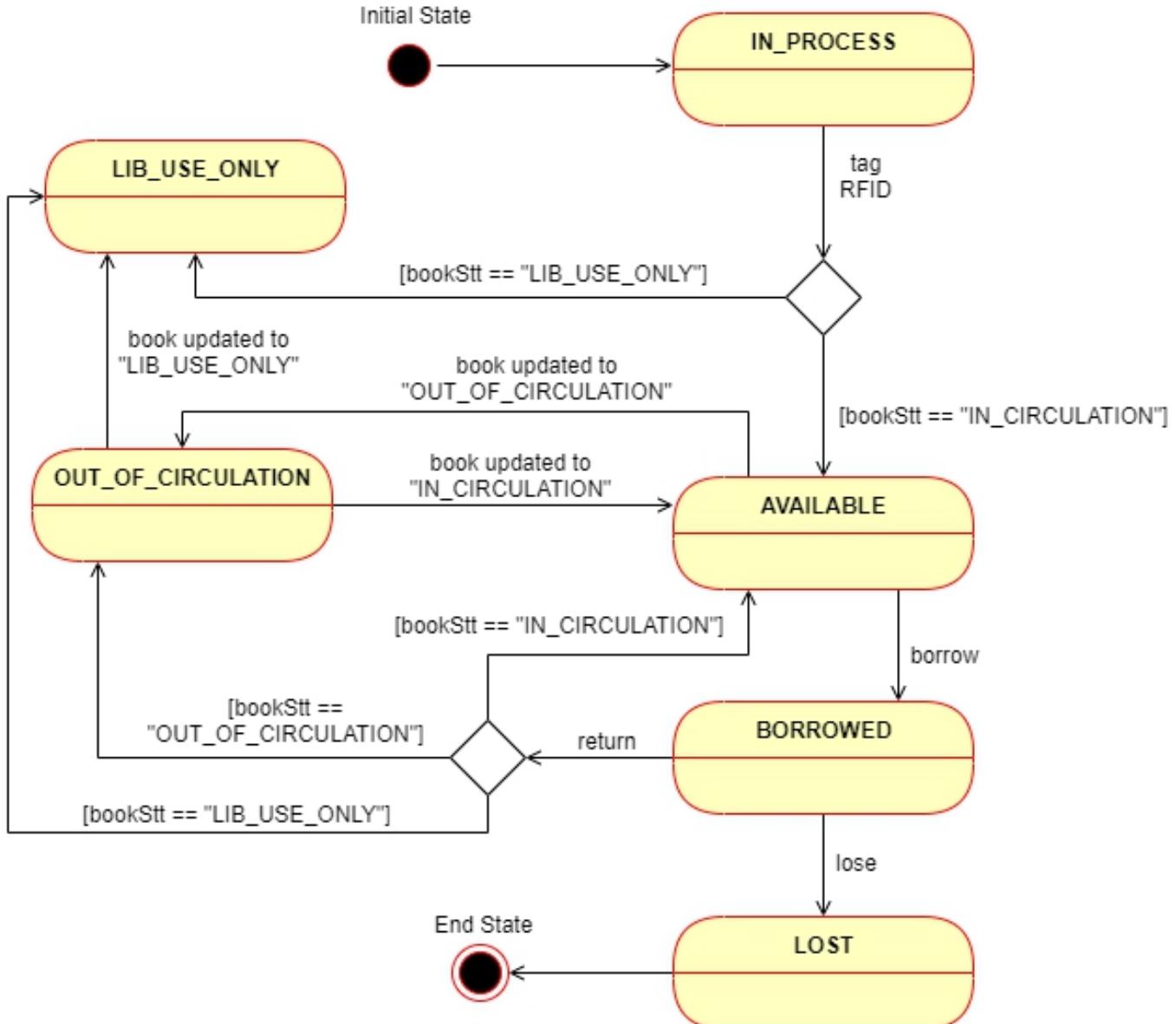


Figure 22 <State Machine Diagram> Book Copy Status

3.3. Sequence Diagrams

3.3.1. Return Book at Book Drop

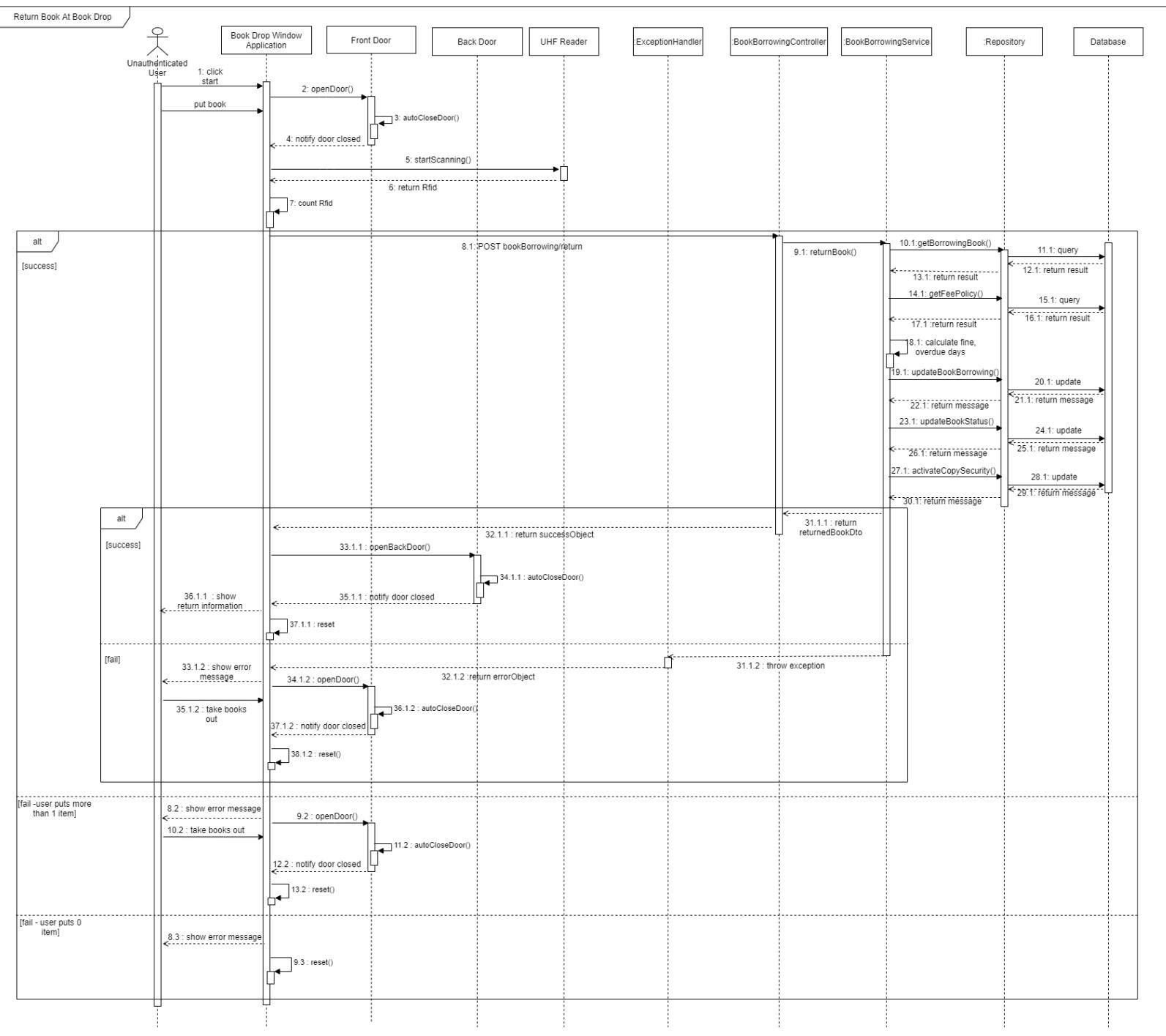


Figure 23 <Sequence Diagram> Return Book at Book Drop

3.3.2. Librarian return books

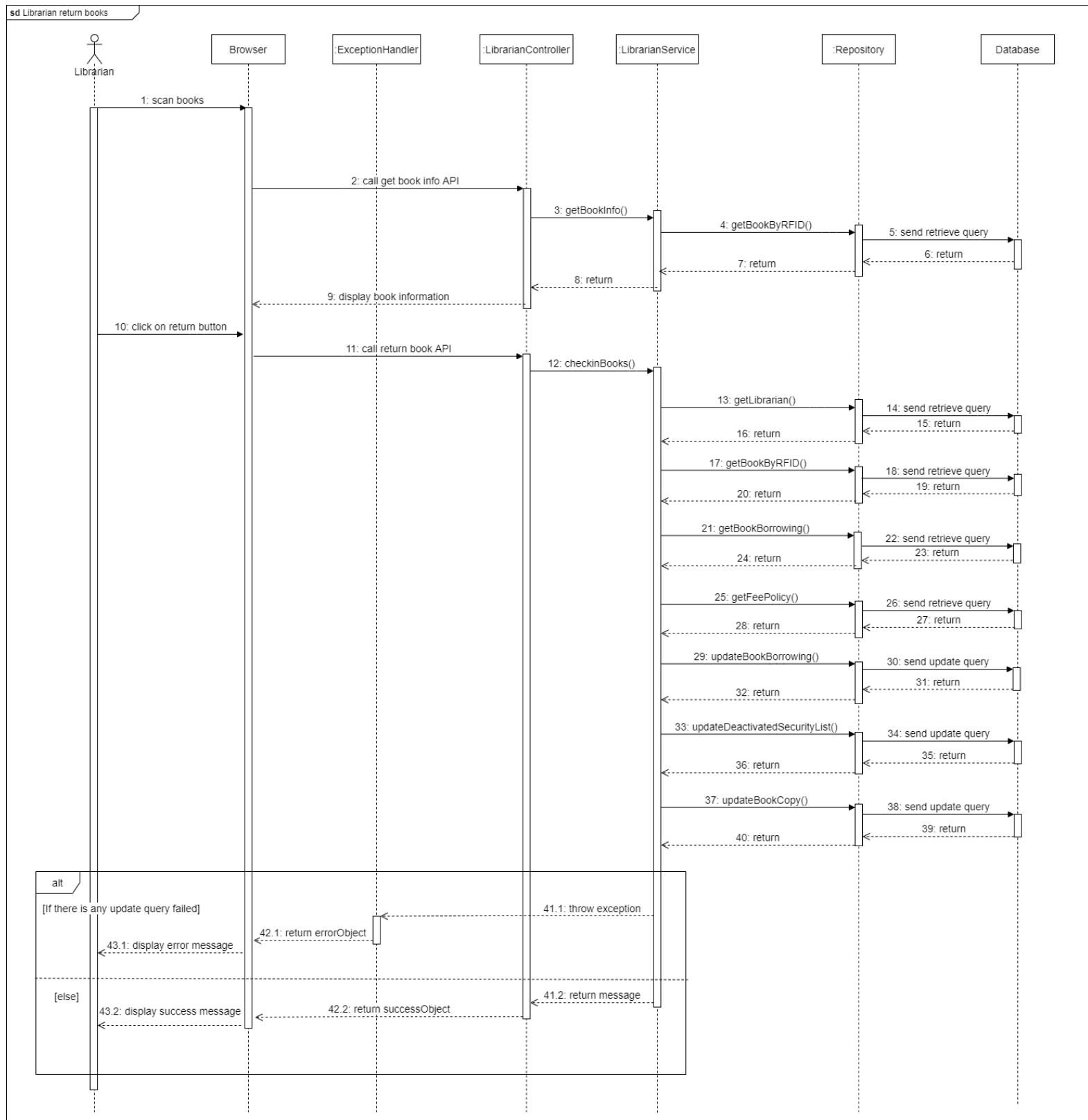


Figure 24 <Sequence Diagram> Librarian return books

3.3.3 Librarian checkout book

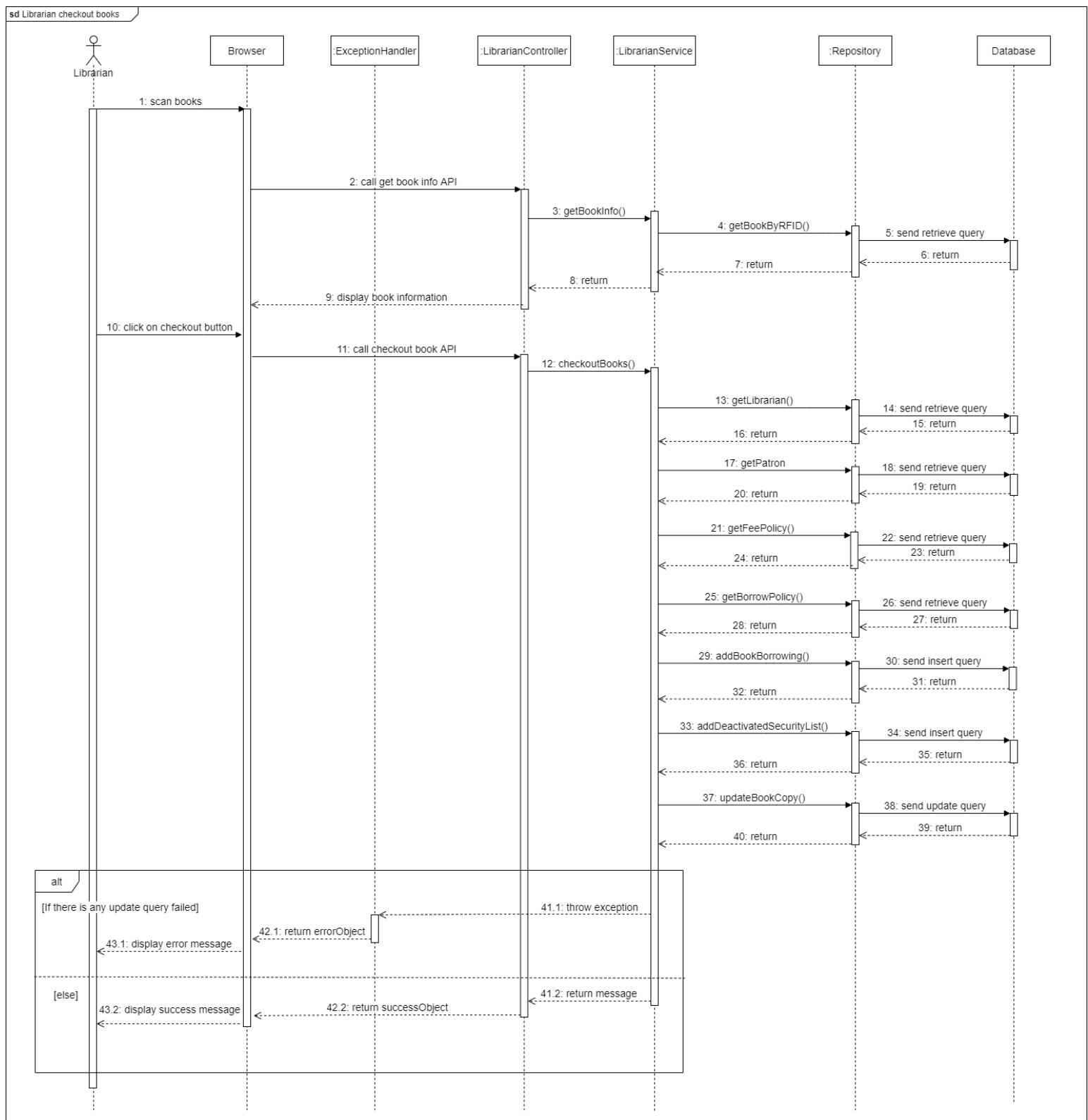


Figure 25 <Sequence Diagram> Librarian checkout book

3.3.4. Librarian renew for a patron

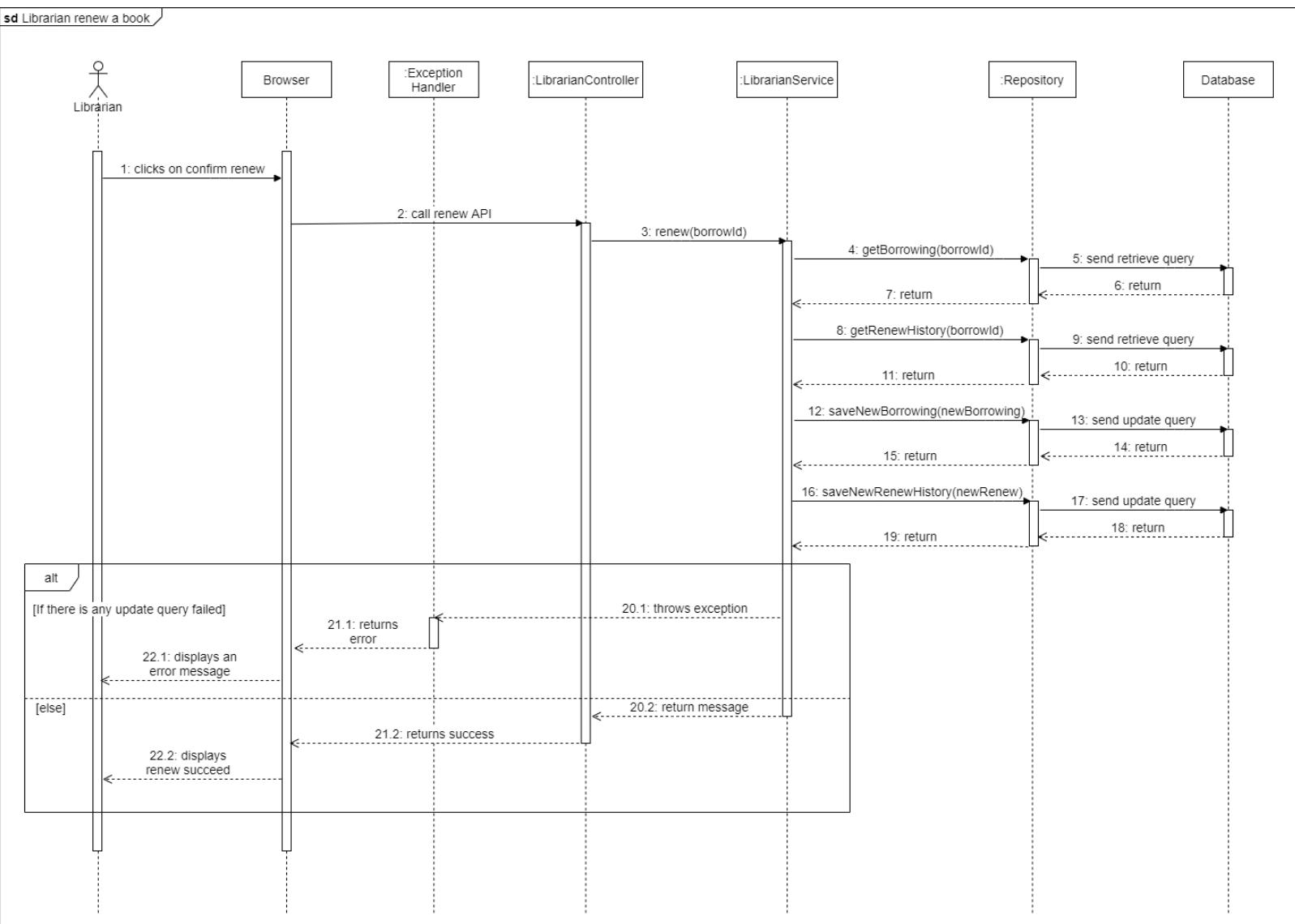


Figure 26 <Sequence Diagram> Librarian renew for a patron

4. Physical Diagram

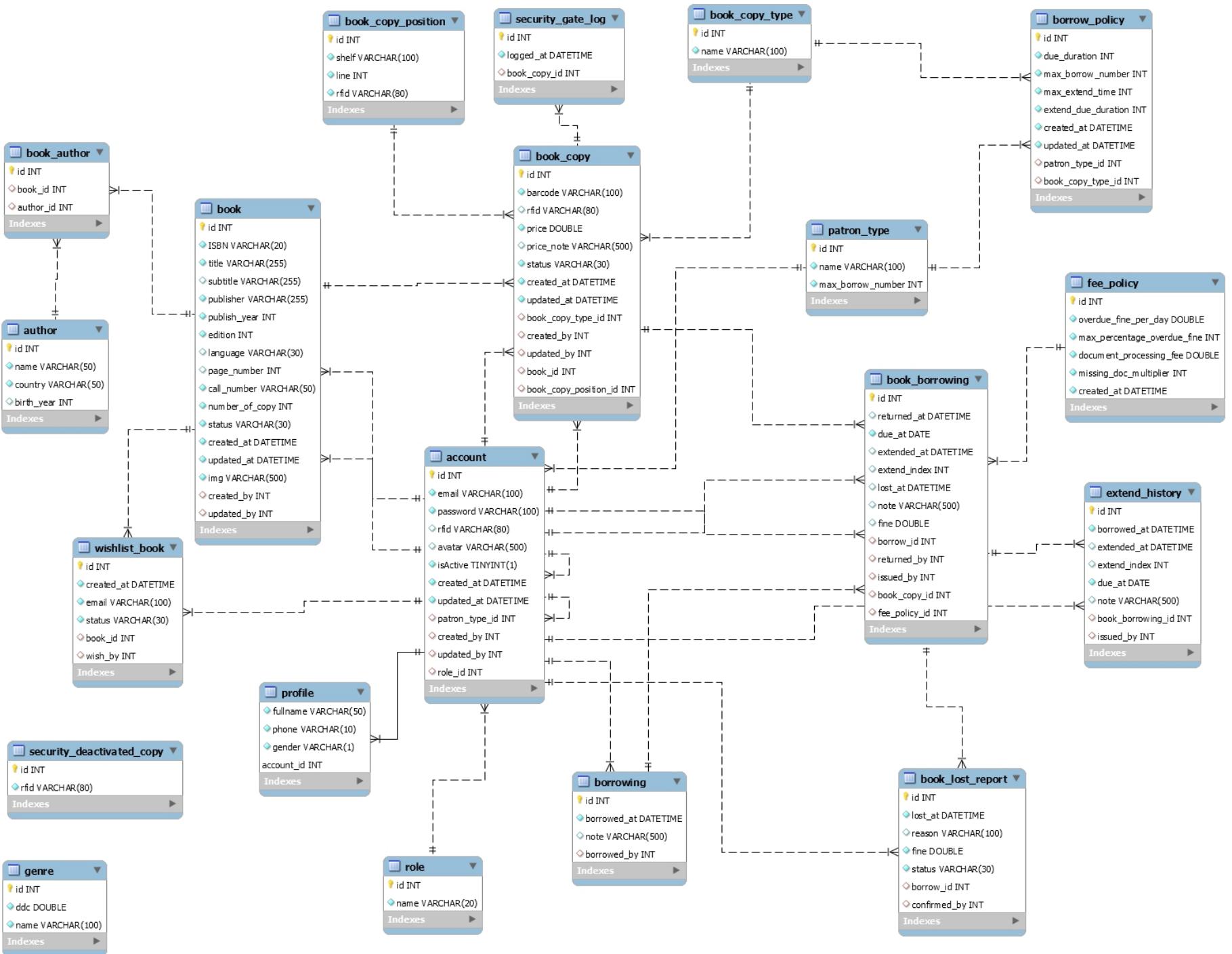


Figure 27 Physical Diagram

5. Technology Solution

5.1. RFID Technology

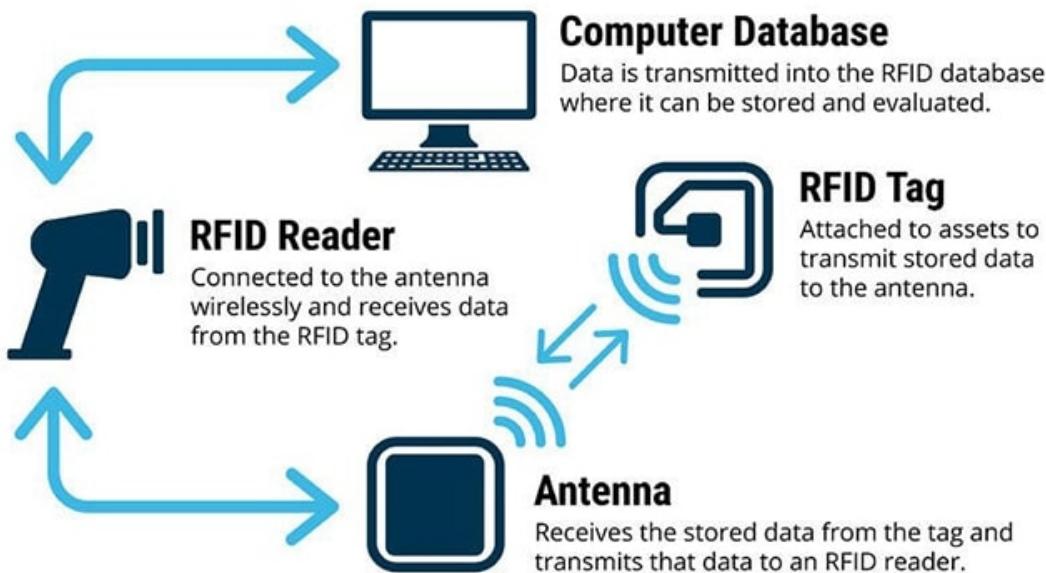
5.1.1. Definition

RFID or Radio Frequency Identification is a technology that allows digital data encoded in RFID tags (or labels) to be read by an RFID reader via radio waves (the tags and readers must have the same operating frequency).

A RFID reader sends out radio waves in a specific frequency through its antenna. If an object with RFID tag is within the reading range of the reader, it will send data back to the reader. By processing the data returned by the tag, the reader can identify the object. The read distance is determined by the capacity of the reader to emit power and by the operating frequency of the RFID system.

There are 2 main types of RFID tag:

- Passive tag: does not have an internal power supply, is powered by the reader's radio wave
- Active tag: has an internal power supply, does not relies to be powered by the reader



How RFID system works. Reference: <https://comparsoft.com/assets-tracking-software/rfid-asset-tracking/>

RFID systems can be categorized by their operating frequency band. Each category has their characteristics:

- Low frequency band (LF)
 - 30KHz - 300KHz
 - Reading range: <10cm (depends on reader)
 - Reading speed is lower than the other two
- High frequency band (HF)

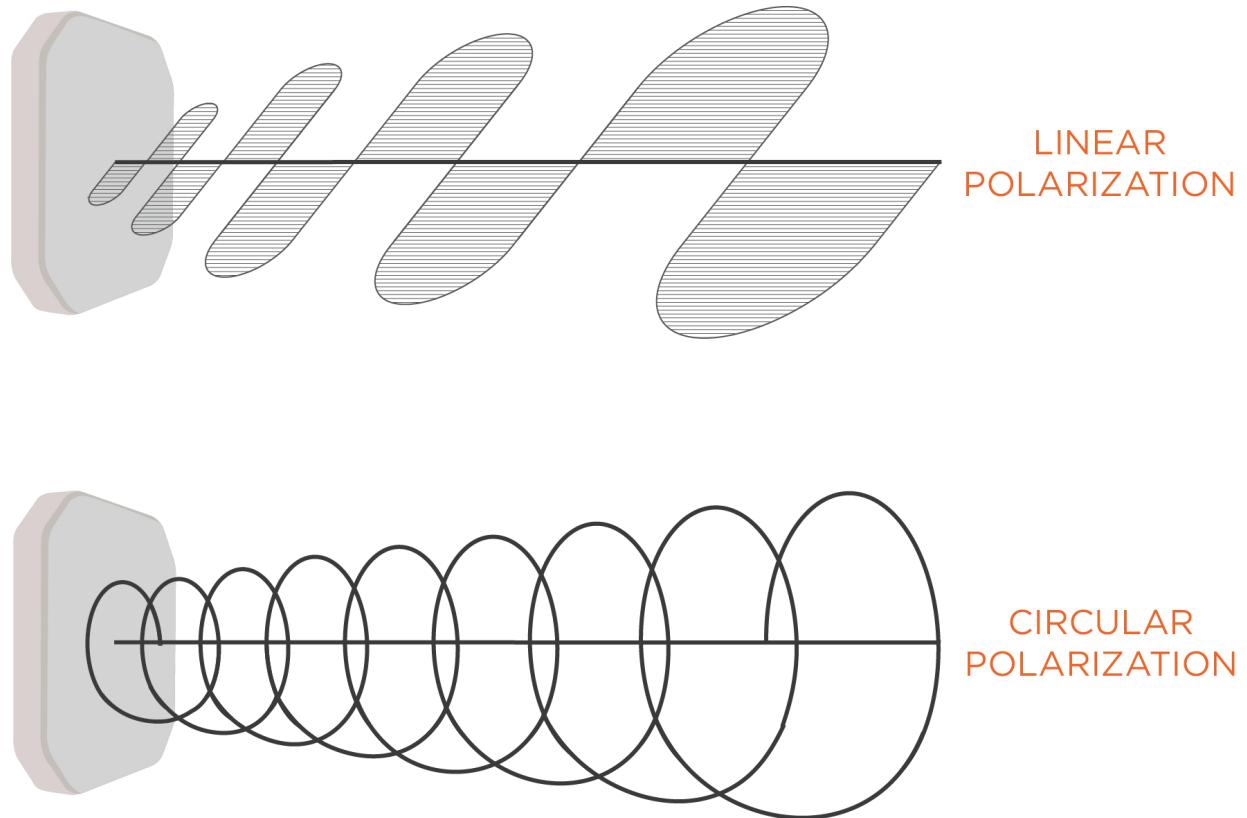
- 3MHz - 30MHz
 - Reading range: <1m (depends on reader)
- Ultra-high frequency band (UHF)
 - 300MHz - 3GHz
 - Reading range: <12m (depends on reader)
 - Reading speed is highest of the 3 categories
 - More sensitivity to radio wave interference

An RFID tag's internal memory is divided into 4 sections (EPC, TID, User Memory and the reversed). TID or Tag Identifier is the section where the tag's UID (Unique ID) is stored. This section cannot be edited. EPC or Electronic Product Code is the section where the tag's NUID is stored (Non-unique ID). This section is editable; users can use it to store the ID of the object they want to track with the RFID tag.

There are different types of RFID reader antennas (Linearly Polarized antennas and Circularly Polarized antennas). Polarization can be understood as the direction of the radio wave's oscillation.

Linearly Polarized antennas radiate waves on a horizontal plane. The receiving tag must be horizontal to the reader as well as being in a consistent distance for the reader to be able to read.

Circular polarization antennas are more flexible because the receiving tag can be read from different angles. But the downside is that we cannot control the precise reading direction of the reader.



Antenna Polarization. Reference: <https://www.atlasrfidstore.com/9-tactics-for-choosing-an-rfid-antenna/#circularlinear>

5.1.2. Application to our project

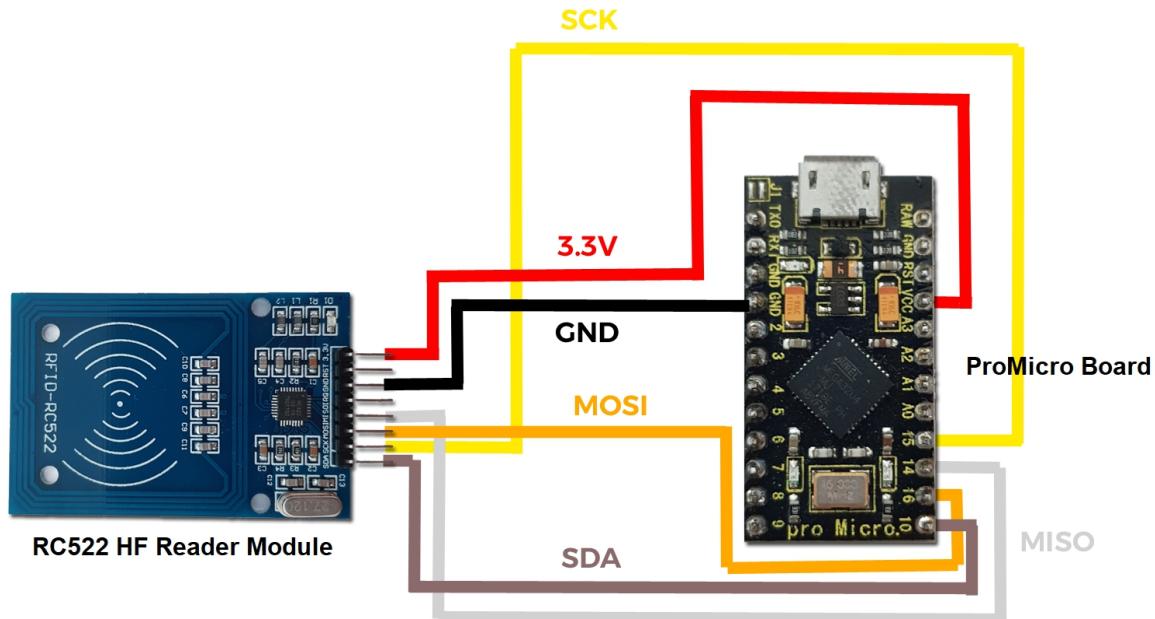
Our team has decided to choose passive tags for our project, they are more reliable than active tags since we don't have to worry about the internal power supply going bad. And they are also cheaper, making maintenance easier since we only need to replace the damaged RFID tag with a new tag.

For RFID operating frequency, we have chosen HF for patron cards and UHF for book tags. We chose HF for the patron card because it has a low reading range, so the card can only be read when the patron intendedly put their card on the scanner. When HF is compared with LF, HF tag has higher memory capabilities while being relatively at the same price. We use UHF for book tags because it has the highest reading range as well as reading speed, allowing us to quickly identify multiple books from distanced.

5.1.3. RFID Readers and Tags

5.1.3.1. Patron Card Reader - HF Reader

For HF readers our team decided to use a RC522 HF reader module because it is capable of both reading and writing while being relatively cheap and easy to find in the market. Instead of connecting RC522 with the popular Arduino UNO board, our team chose the ProMicro Board because it has a ATmega32U4 chip, capable of simulating keystrokes of a computer keyboard.



HF Reader Wiring Schematics. Reference: <https://www.hackster.io/xxlukas84/unlock-your-pc-by-arduino-using-phone-or-rfid-card-970d27>

5.1.3.2. Patron Card - HF Tags



MIFARE Classic 1K card

5.1.3.3. Book Tags Reader - UHF Reader

Because UHF reader modules are hard to find in the market, our team decided to build our own patron card reader but buy a commercial book tag reader from aliexpress.

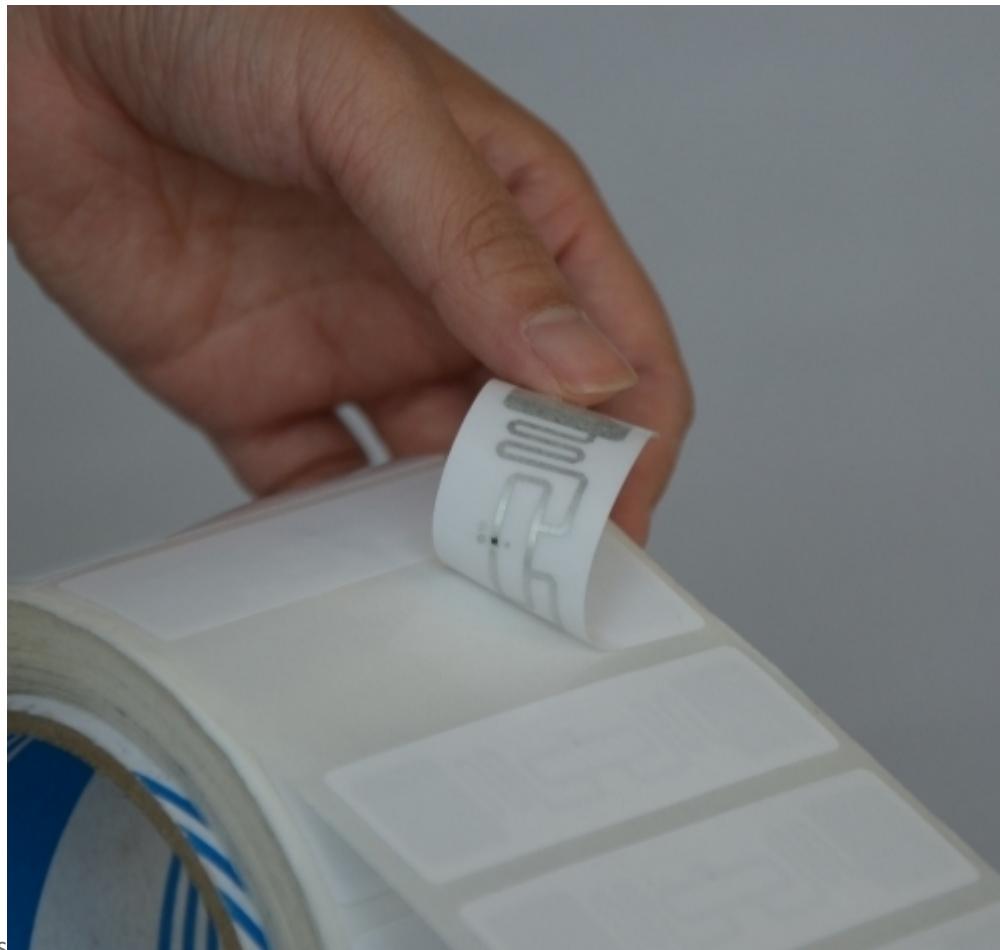


Geenfc GEE-UR-2100 Desktop UHF RFID Reader

Physical	
Material	ABS enclosure
Size	122.4mm(L) x84 mm (W) x 20mm (H) Default: USB, RS232/ RS485, GPIO
Interface	Option A : USB, RS232/ RS485, WG Option B: USB HID virtual keyboard, RS232/ RS485, WG (once configured as virtual keyboard, write function will be deactivated permanently)
Antenna	Built-in circular polarization antenna
Weight	0.6 kg
Protocol	ISO18000-6C & EPCglobal Class I Gen 2
RF & Electrical	
Frequency	US 902~ 928 Mhz, EU 865~ 868 Mhz
RF ouput	0- 26 dBm (software adjustable)
Read/ write Distance	1 meter / 0.5 meter
Polarization	circular polarized
Inventory speed	> 50 tags/ second
Tag buffer	370 tags@128 bit EPC
RSSI	Support
Power Supply	USB d.c 5V or external d.c +9V
Other features	
Software	Demo software, SDK, DLL
Anti-collision	Tag processing algorithm, multiple tags operation allowed
Extension	Allow connect to access controller
Environment	
Operating condition	-20 - 60 C, 5- 95% RH, no condensation
Storage condition	-5- 45 C, 5- 95% RH, no condensation
Certification	CE, ROHS
Accessory	
USB cable	1x

GEE-UR-2100 Specification. Reference: <https://www.aliexpress.com/item/32965153182.html>

5.1.3.4. Book Tags - UHF



Tags

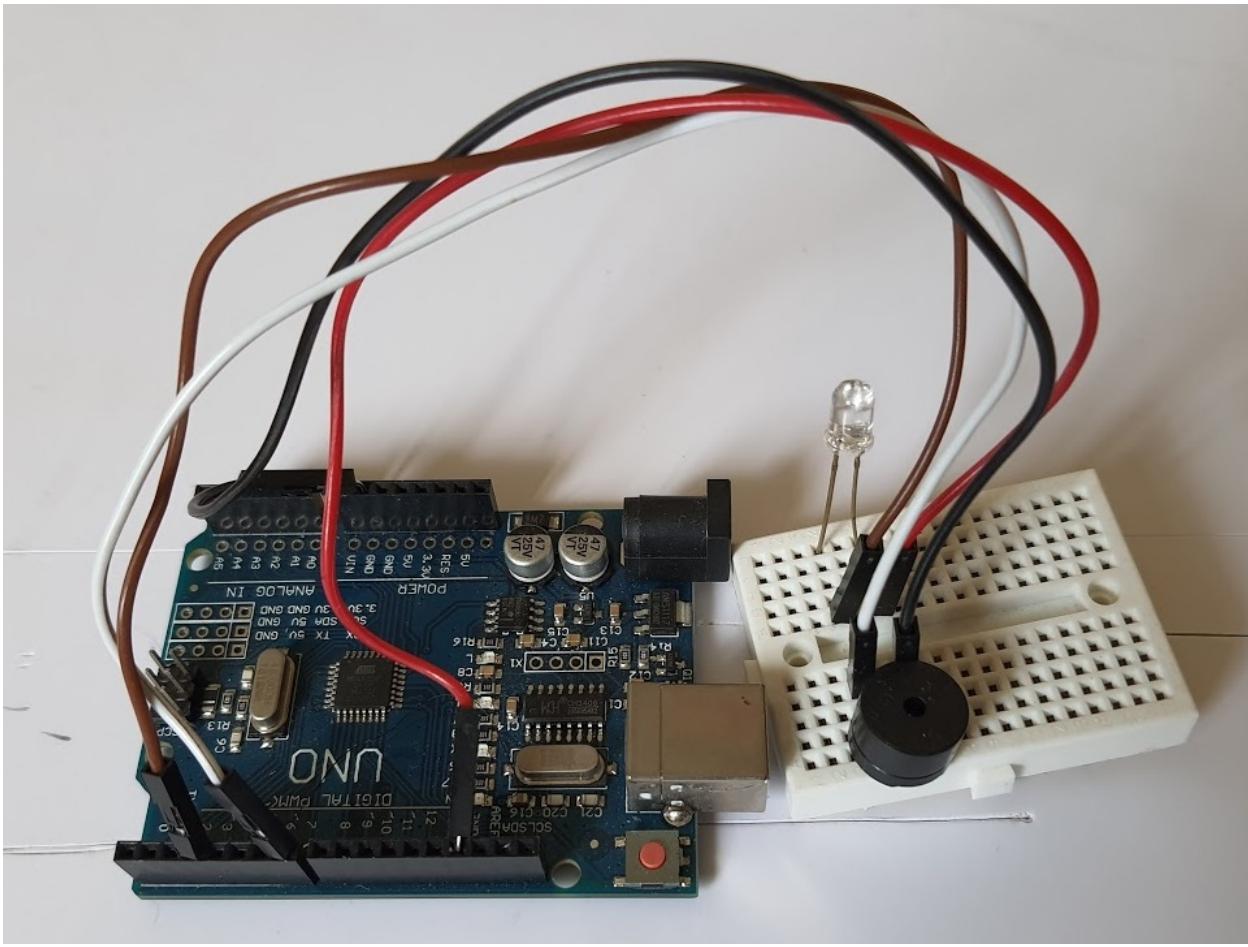
860MHz tag. Reference: <http://www.atdtech.com/index.php/vi/product/rfid/the-dan-rfid-tan-so-cao>

5.2. Security Gate

5.2.1 Description

The purpose of the security gate is to identify and raise the alarm if necessary. The security gate consists of:

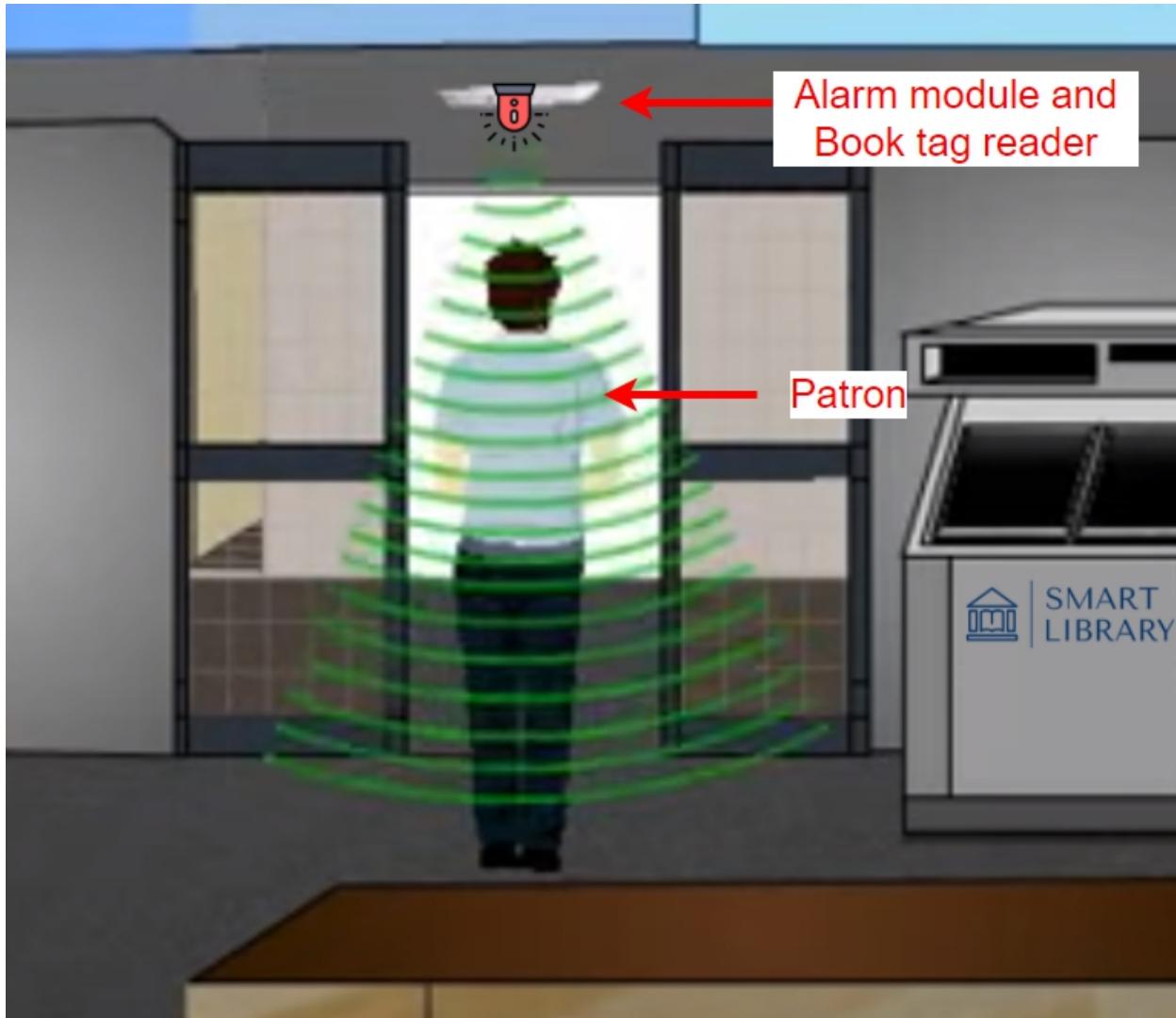
- Book tag reader
- Alarm module:
 - Passive buzzer
 - LED
 - Arduino UNO
 - Breadboard



Alarm Module

5.2.2 Installation

The security gate will be installed above the entrance of the library with the direction of the book tag reader antenna faces downward.



Security Gate Installation

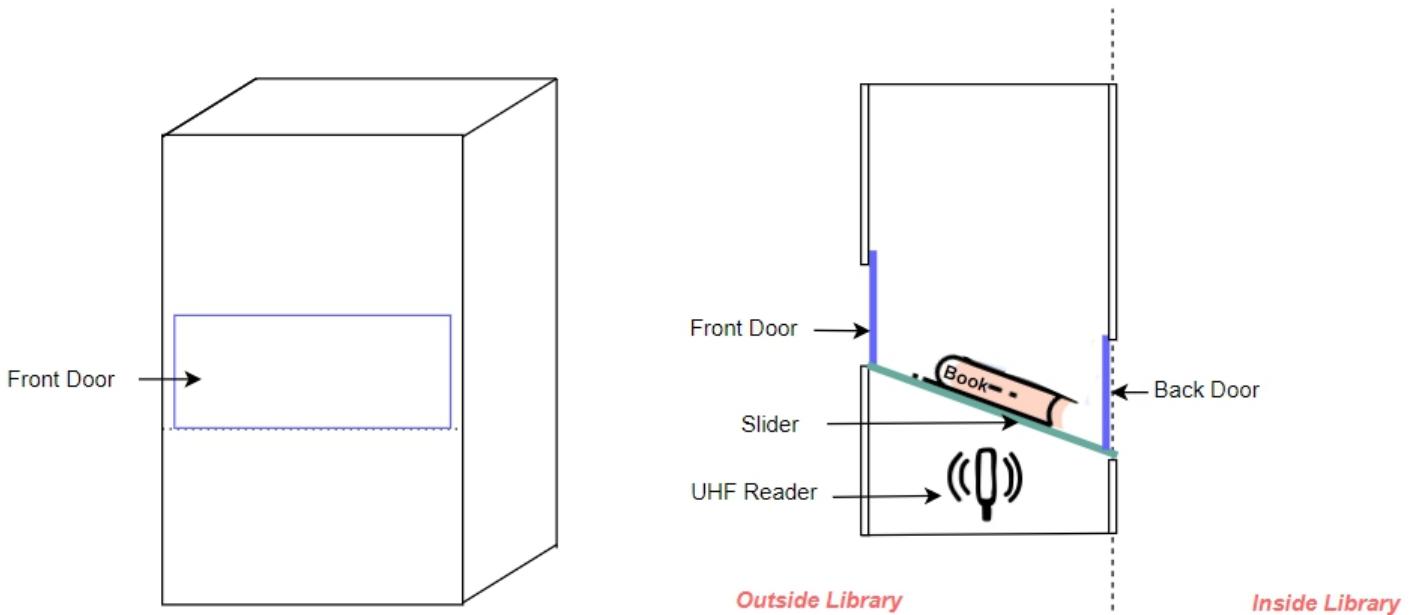
5.2.3 Limitation

The security gate heavily depends on the quality of the book tag reader (reading range and accuracy of the reader).

5.3. Book Drop

5.3.1. Description

We built a window application that is embedded in the book drop station that allows the patron to return a book outside the library. The book drop is designed as figure below:



Book Drop Design

The book drop is made from plastic foams which has the following main components:

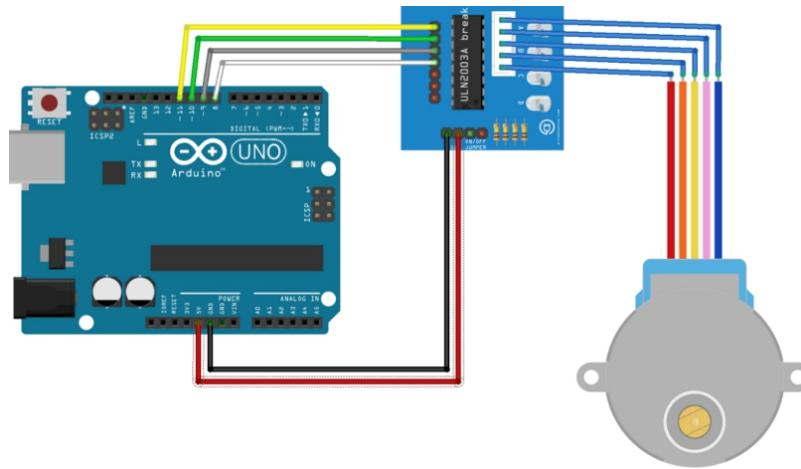
- Front door: allow the patron to open and put the book on the slider inside the box
- Back door: only open to let the book go inside the library when that book is returned successfully
- Slider inside the box from front door to back door: that allows the book to slide down smoothly to the library's storage
- An upper drawer that store stepper modules that monitor the motion of two doors

There is a window application that simulates a whole book drop from front door to back door and the RFID reader. The application runs on a computer that connects with two stepper motors and the UHF reader through USB. Each device is assigned to a particular port and communicates with each other through serial communication. The window application plays as a main controller that orders those devices to do particular functions. For example, the application sends a message asking the stepper motor to rotate in order to open the door.

5.3.2. Devices

To implement to book drop station, we use the following devices:

- Book tag reader to scan book
- Stepper motor modules to monitor front door and back door:
 - Stepper motor
 - Stepper motor controller
 - Arduino UNO



Stepper Motor Wiring Schematics. Reference: <https://www.aranacorp.com/en/control-a-stepper-motor-with-arduino/>

5.3.3. Limitation

The book drop heavily depends on the quality of the UHF reader (reading range and accuracy of the reader). The scanning range must not reach out the box to make high security. However, we have limits to control the UHF's scanning range.

5.4 Obstacles and Solutions

5.4.1 Security Gate

Because the devices are not compatible with each other out of the box, our team has implemented some middleware applications to control and connect devices together via serial ports.

For the security gate, we have implemented an application to connect the Book tag reader with the alarm module via serial port. Each time the book tag reader detects a book it will send the book's ID to our application, the application will decide whether to tell the Alarm module to raise the alarm. (Illustration 5.4.1)

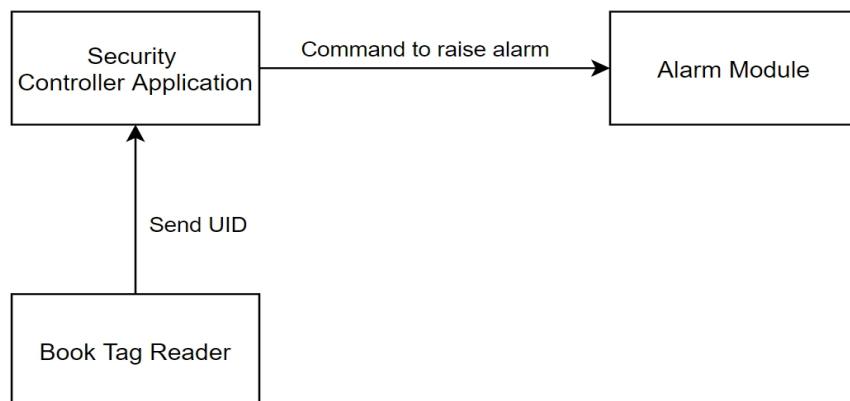


Illustration 5.4.1

5.4.2 Book Tag Reader (UHF RFID Reader)

Because the UHF RFID reader will be read from a far - not in close contact like a patron card reader (HF RFID reader), polarization is an important factor of book tag reader. Although having a less precise reading direction, because of the ability to read tags from different angles is required for the security gate our team has decided to pick a circularly polarized antenna for our book tag reader. This affects the accuracy of locating books location functionality of our system. To overcome the problem, our team has decided to reduce the reading range of the book tag reader when it is used to locate book location and increase the reading range when it is used as the security gate.

The book tag reader has 2 data-output modes: simulating a keyboard or output through serial port. We cannot use the keyboard mode for the book drop and security gate. Because in that mode, the reader only reads each book's RFID tag once when it detects a tag presence (in order to read the same tag again, we would have to take the card out of the reading range first before trying to read it again). And because this mode is not fast enough for the security gate. So we chose the output via serial port mode which can quickly read every tag within the reading range of the reader at the same time. But this mode can only be used via "UHFRReader86Demo V1.11" - an application provided by the manufacturer. However, our team has limited control over the third party application and it does not work well with our system.

So we have customized the 3rd party application source code and implemented a console application called Middleware application for the book drop. Our Middleware application will act as a buffer between UHFRReader86Demo V1.11 and our system. When the patron is returning a book, after the book drop front door has closed completely, the book drop will request the Middleware application to return the book's RFID tag information that it received from the 3rd party application (Illustration 5.4.2).

For the security gate, our Security Controller Application is able to work directly with the customized UHFRReader86Demo V1.11 without having to go through the Middleware application. Every time the UHF RFID reader detects a book tag, it will send the tag information to UHFRReader86Demo V1.11 and then UHFRReader86Demo V1.11 will send that information to our system.

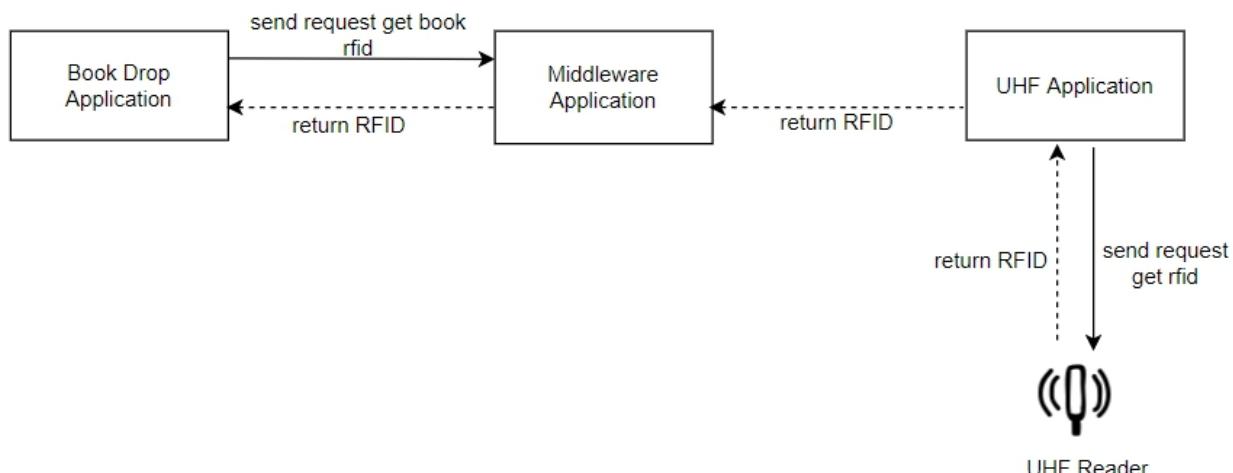


Illustration 5.4.2

5.4.3 Serial Ports

Finding a way to connect different devices and 3rd party applications to our system was a big challenge for our team. Since there isn't any interface for them to communicate with each other. After doing research, our team has decided to create an interface for the components to communicate by letting them send and receive messages to each other via serial ports. In order to do that, we created virtual COM ports and linked them together using Eltima Software's Virtual Serial Port Driver (<https://www.eltima.com/products/vspdvp/>). And then we implemented each component in our system so that they can send and receive messages from other components through serial ports.

V. Software Testing Documentation

(References to "RFID_Library_Management_System_Full.pdf")

VI. Release Package & User Guides

(References to "RFID_Library_Management_System_Full.pdf")

VII. Appendix

(References to "RFID_Library_Management_System_Full.pdf")