Design a Library Management System

We'll cover the following

- System Requirements
- Use case diagram
- Class diagram
- Activity diagrams
- Code

A Library Management System is a software built to handle the primary housekeeping functions of a library. Libraries rely on library management systems to manage asset collections as well as relationships with their members. Library management systems help libraries keep track of the books and their checkouts, as well as members' subscriptions and profiles.

Library management systems also involve maintaining the database for entering new books and recording books that have been borrowed with their respective due dates.

System Requirements

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Always clarify requirements at the beginning of the interview. Be sure to ask questions to find the exact scope of the system that the interviewer has in mind.

We will focus on the following set of requirements while designing the Library Management System:

1. Any library member should be able to search books by their title, author, subject category as well by the publication date.
2. Each book will have a unique identification number and other details including a rack number which will help to physically locate the book.
3. There could be more than one copy of a book, and library members should be able to check-out and reserve any copy. We will call each copy of a book, a book item.
4. The system should be able to retrieve information like who took a particular book or what are the books checked-out by a specific library member.
5. There should be a maximum limit (5) on how many books a member can check-out.
6. There should be a maximum limit (10) on how many days a member can keep a book.
7. The system should be able to collect fines for books returned after the due date.
8. Members should be able to reserve books that are not currently available.
9. The system should be able to send notifications whenever the reserved books become available, as well as when the book is not returned within the due date.
10. Each book and member card will have a unique barcode. The system will be able to read barcodes from books and members' library cards.

Use case diagram

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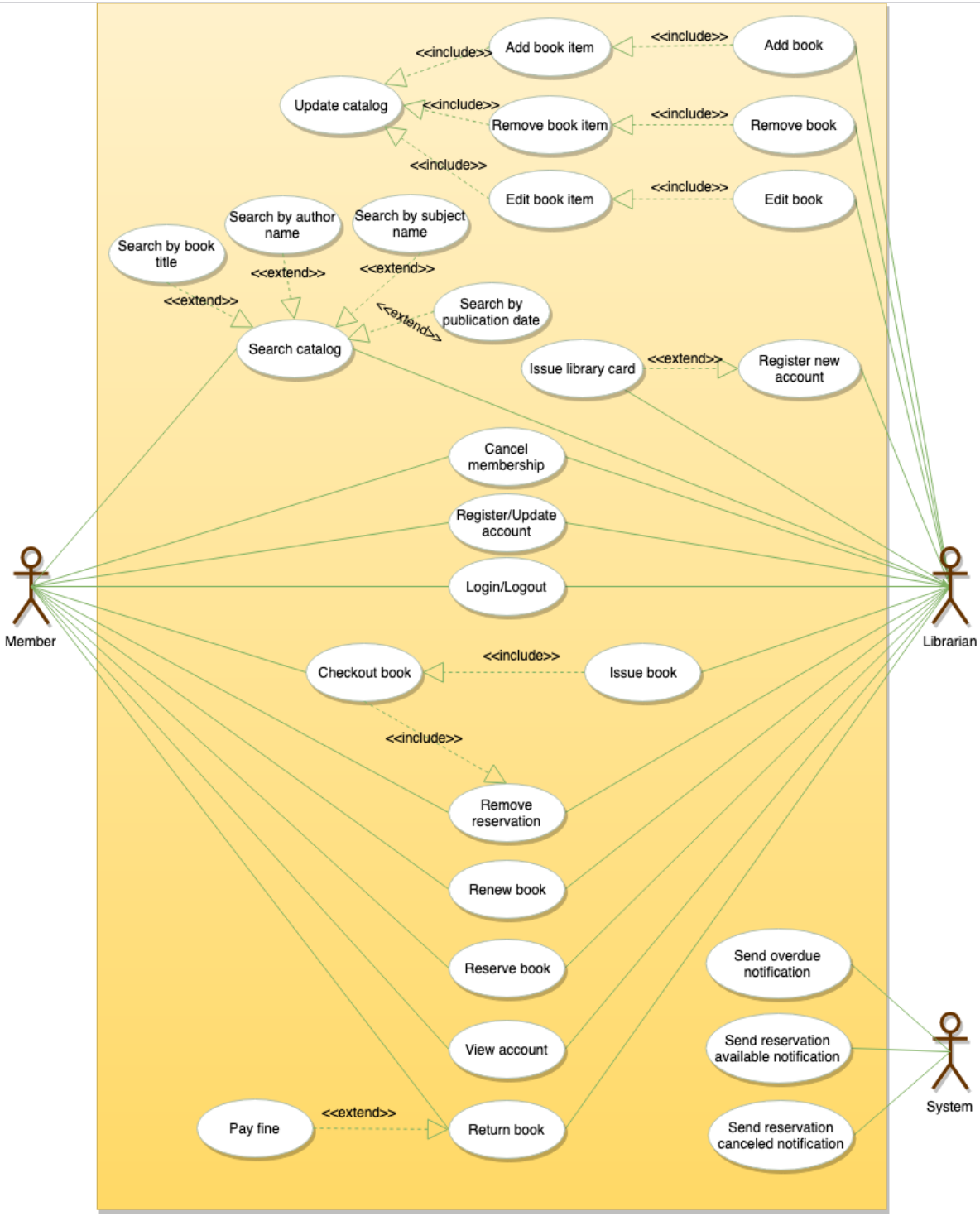
We have three main actors in our system:

- **Librarian:** Mainly responsible for adding and modifying books, book items, and users. The Librarian can also issue, reserve, and return book items.
- **Member:** All members can search the catalog, as well as check-out, reserve, renew, and return a book.
- **System:** Mainly responsible for sending notifications for overdue books, canceled reservations, etc.

Here are the top use cases of the Library Management System:

- **Add/Remove/Edit book:** To add, remove or modify a book or book item.
- **Search catalog:** To search books by title, author, subject or publication date.
- **Register new account/cancel membership:** To add a new member or cancel the membership of an existing member.
- **Check-out book:** To borrow a book from the library.
- **Reserve book:** To reserve a book which is not currently available.
- **Renew a book:** To reborrow an already checked-out book.
- **Return a book:** To return a book to the library which was issued to a member.



Use case diagram

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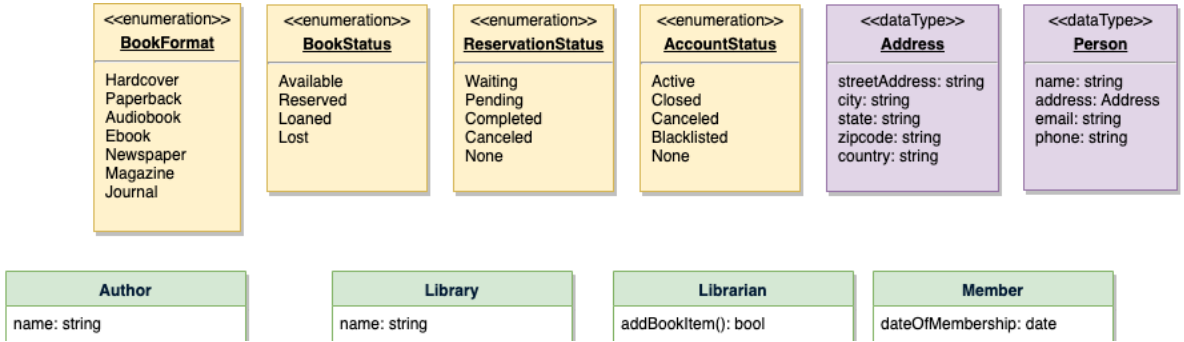
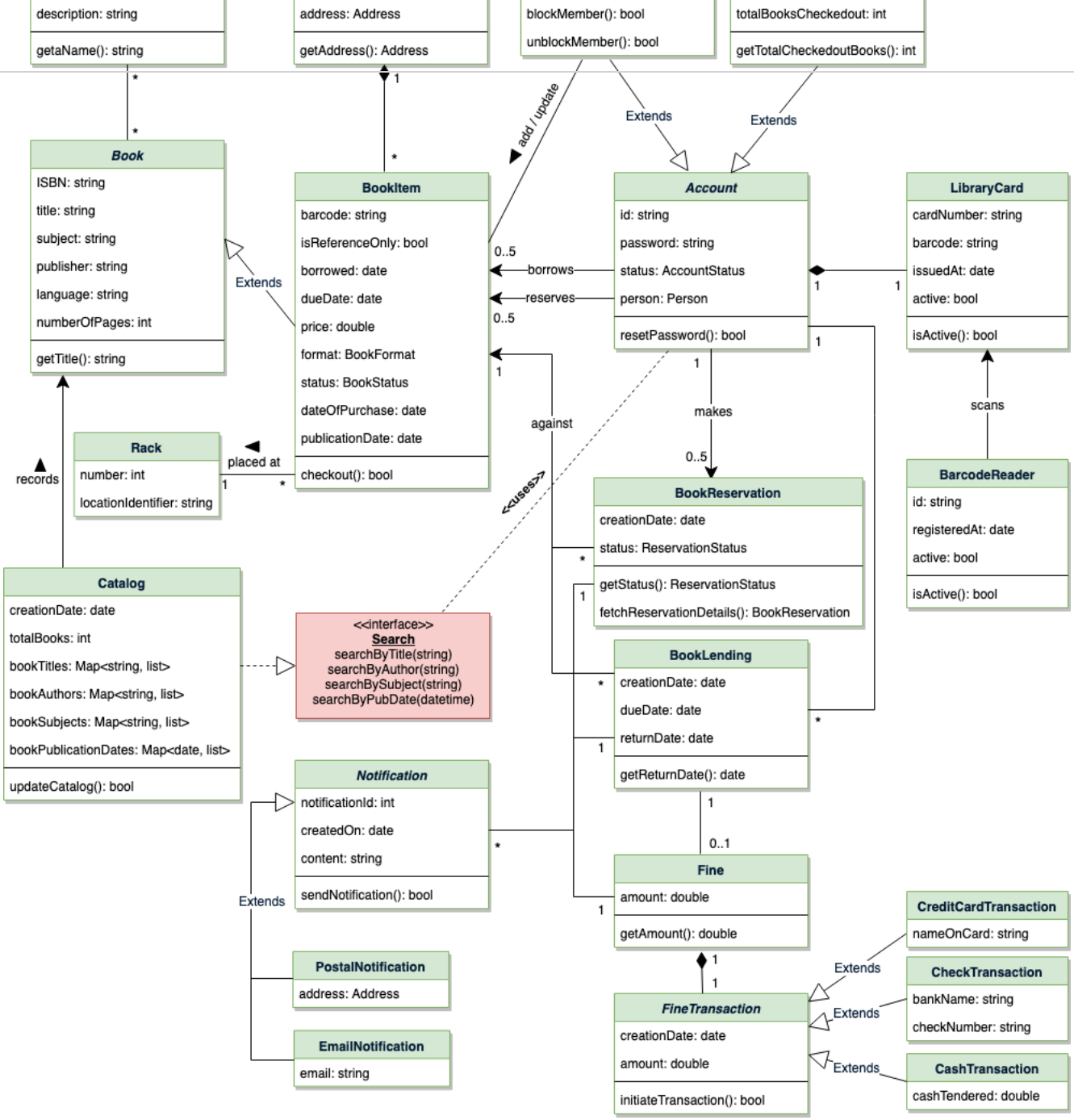
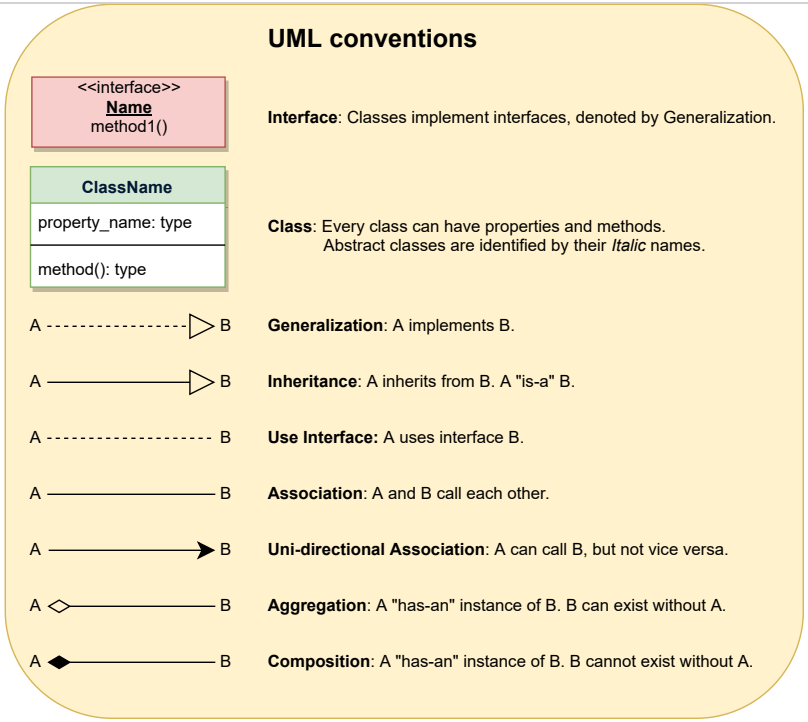
Here are the main classes of our Library Management System:

- **Library:** The central part of the organization for which this software has been designed. It has attributes like 'Name' to distinguish it from any other libraries and 'Address' to describe its location.
- **Book:** The basic building block of the system. Every book will have ISBN, Title, Subject, Publishers, etc.
- **BookItem:** Any book can have multiple copies, each copy will be considered a book item in our system. Each book item will have a unique barcode.
- **Account:** We will have two types of accounts in the system, one will be a general member, and the other will be a librarian.
- **LibraryCard:** Each library user will be issued a library card, which will be used to identify users while issuing or returning books.
- **BookReservation:** Responsible for managing reservations against book items.
- **BookLending:** Manage the checking-out of book items.
- **Catalog:** Catalogs contain list of books sorted on certain criteria. Our system will support searching through four catalogs: Title, Author, Subject, and Publish-date.
- **Fine:** This class will be responsible for calculating and collecting fines from library members.
- **Author:** This class will encapsulate a book author.
- **Rack:** Books will be placed on racks. Each rack will be identified by a rack number and will have a location identifier to describe the physical location of the rack in the library.
- **Notification:** This class will take care of sending notifications to library members.





Class diagram for Library Management System



Activity diagrams

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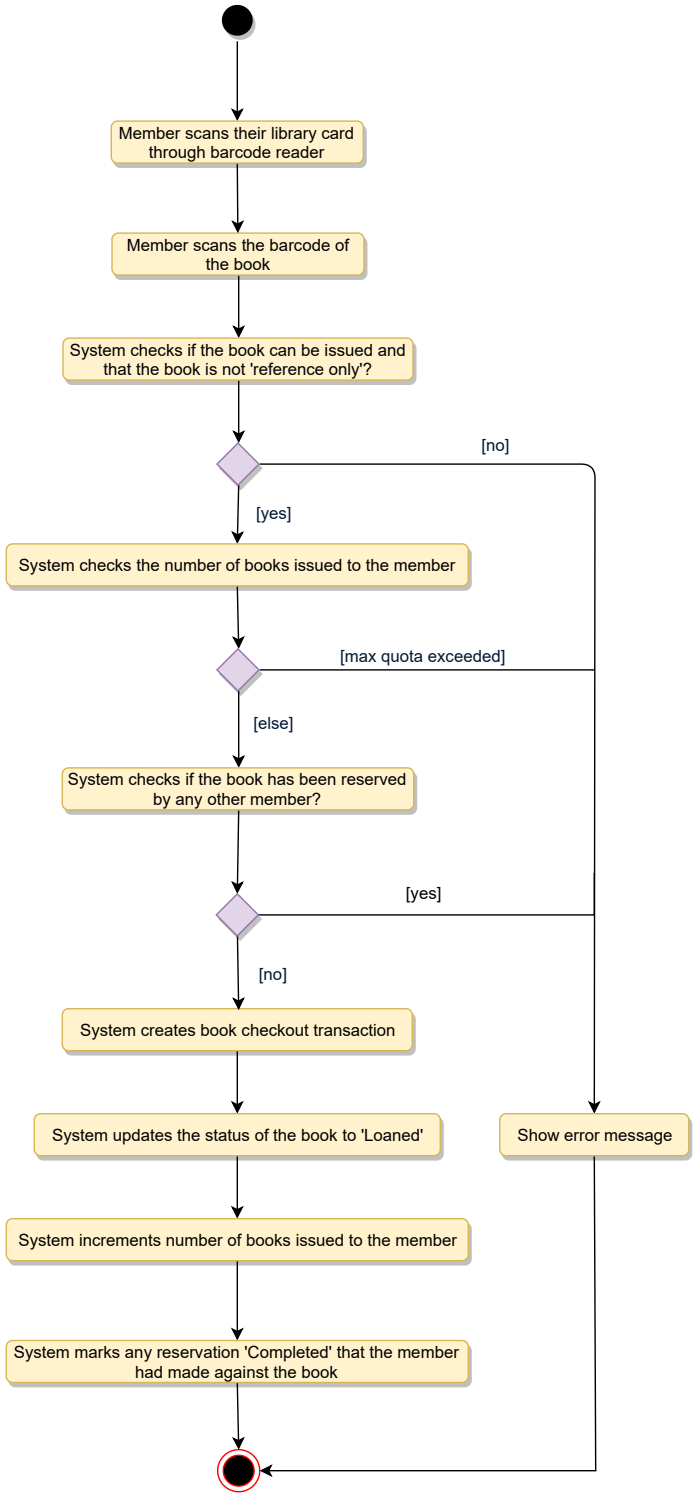
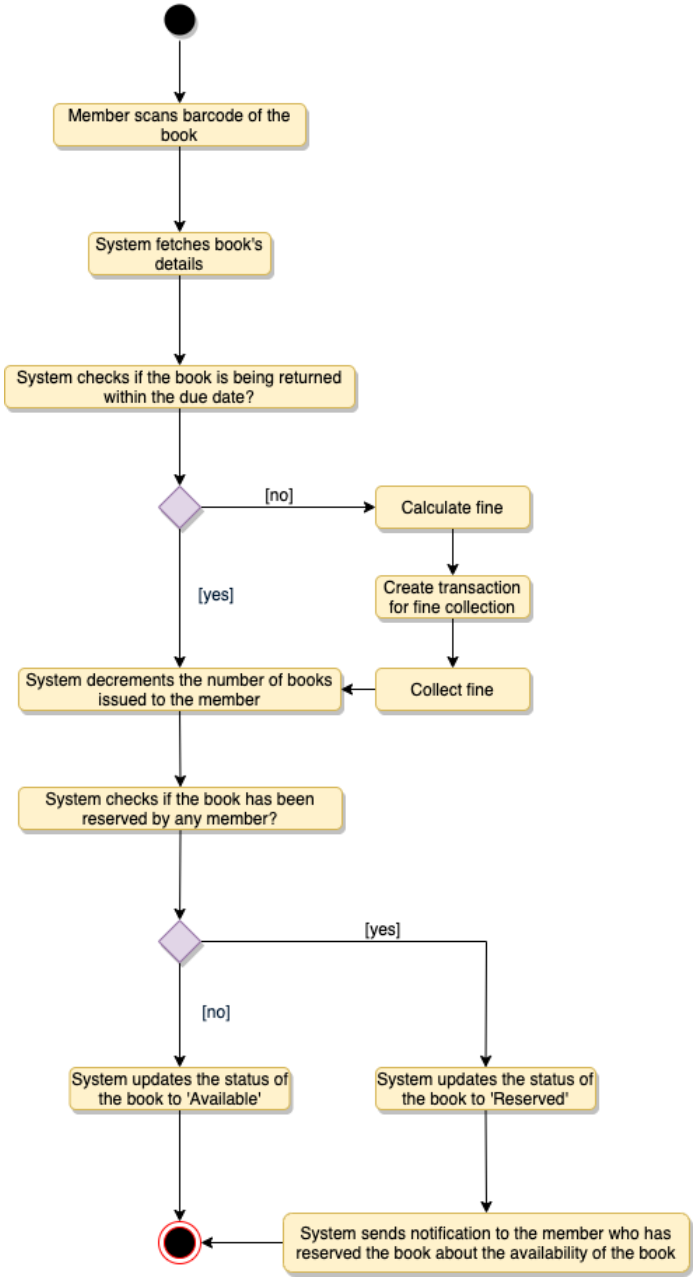
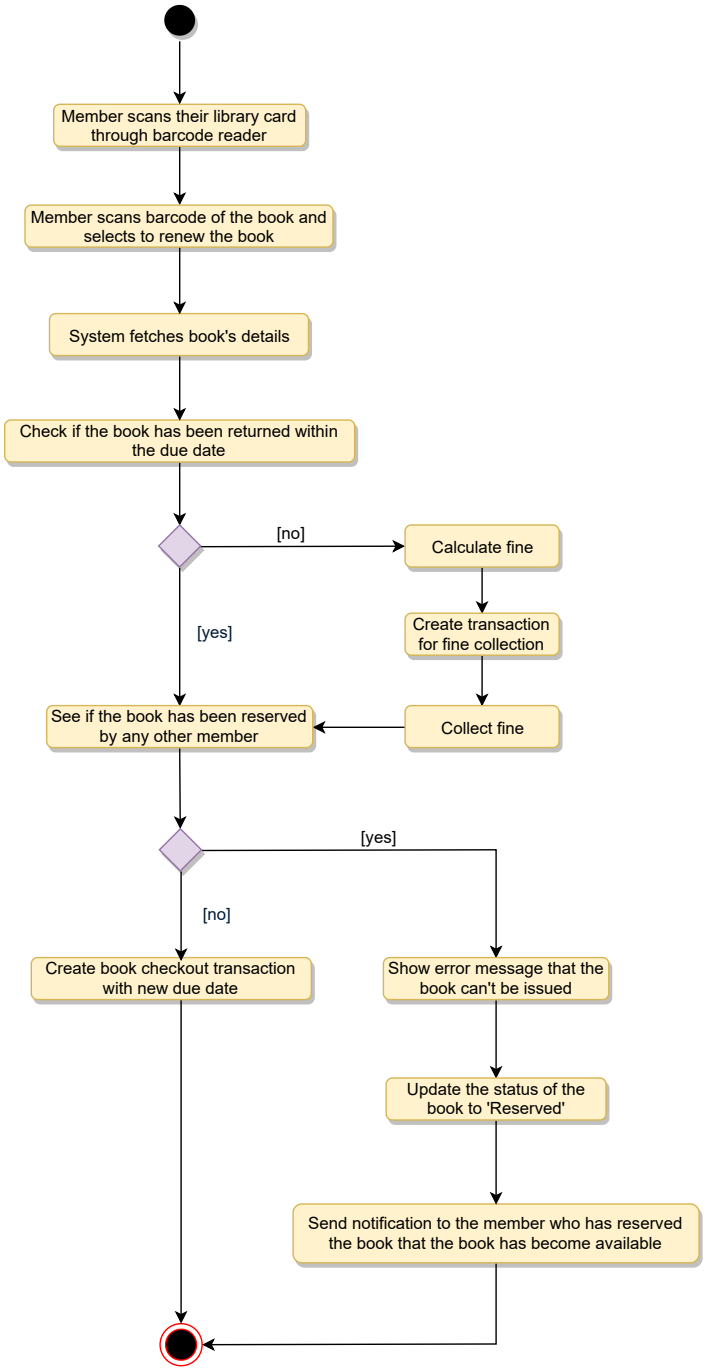
Check-out a book: Any library member or librarian can perform this activity. Here are the set of steps to check-out a book:


Member scans their library card through barcode reader
Member scans the barcode of the book
System checks if the book can be issued and that the book is not 'reference only'?
[no]
[yes]
System checks the number of books issued to the member
[max quota exceeded]
[else]
System checks if the book has been reserved by any other member?
[yes]
[no]
System creates book checkout transaction
System updates the status of the book to 'Loaned'
Show error message
System increments number of books issued to the member
System marks any reservation 'Completed' that the member had made against the book

Return a book: Any library member or librarian can perform this activity. The system will collect fines from members if they return books after the due date. Here are the steps for returning a book:



Renew a book: While renewing (re-issuing) a book, the system will check for fines and see if any other member has not reserved the same book, in that case the book item cannot be renewed. Here are the different steps for renewing a book:


Member scans their library card through barcode reader
Member scans barcode of the book and selects to renew the book
System fetches book's details
Check if the book has been returned within the due date
[no]
Calculate fine
Create transaction for fine collection
Collect fine
[yes]
See if the book has been reserved by any other member
[yes]
[no]
Create book checkout transaction with new due date
Show error message that the book can't be issued
Update the status of the book to 'Reserved'
Send notification to the member who has reserved the book that the book has become available

Code

#

Here is the code for the use cases mentioned above: 1) Check-out a book, 2) Return a book, and 3) Renew a book.

Note: This code only focuses on the design part of the use cases. Since you are not required to write a fully executable code in an interview, you can assume parts of the code to interact with the database, payment system, etc.

Enums and Constants: Here are the required enums, data types, and constants:

Java | Python

```
  AVAILABLE, RESERVED, LOANED, LOST = 1, 2, 3, 4


class ReservationStatus(Enum):
  WAITING, PENDING, CANCELED, NONE = 1, 2, 3, 4


class AccountStatus(Enum):
  ACTIVE, CLOSED, CANCELED, BLACKLISTED, NONE = 1, 2, 3, 4, 5


class Address:
  def __init__(self, street, city, state, zip_code, country):
    self.__street_address = street
    self.__city = city
    self.__state = state
    self.__zip_code = zip_code
    self.__country = country


class Person(ABC):
  def __init__(self, name, address, email, phone):
    self.__name = name
    self.__address = address
    self.__email = email
    self.__phone = phone


class Constants:
  self.MAX_BOOKS_ISSUED_TO_A_USER = 5
  self.MAX_LENDING_DAYS = 10
```

Account, Member, and Librarian: These classes represent various people that interact with our system:

Java | Python

```
      Fine.collect_fine(self.get_member_id(), diff_days)

  def return_book_item(self, book_item):
    self.check_for_fine(book_item.get_barcode())
    book_reservation = BookReservation.fetch_reservation_details(
      book_item.get_barcode())
    if book_reservation != None:
      # book item has a pending reservation
      book_item.update_book_item_status(BookStatus.RESERVED)
      book_reservation.send_book_available_notification()
    book_item.update_book_item_status(BookStatus.AVAILABLE)
```

```
    book_item.update_book_item_status(BookStatus.AVAILABLE)

  def renew_book_item(self, book_item):
    self.check_for_fine(book_item.get_barcode())
    book_reservation = BookReservation.fetch_reservation_details(
      book_item.get_barcode())
    # check if self book item has a pending reservation from another member
    if book_reservation != None and book_reservation.get_member_id() != self.get_member_id():
      print("self book is reserved by another member")
      self.decrement_total_books_checkedout()
      book_item.update_book_item_state(BookStatus.RESERVED)
      book_reservation.send_book_available_notification()
      return False
    elif book_reservation != None:
      # book item has a pending reservation from self member
      book_reservation.update_status(ReservationStatus.COMPLETED)
    BookLending.lend_book(book_item.get_bar_code(), self.get_member_id())
    book_item.update_due_date(
      datetime.datetime.now().AddDays(Constants.MAX_LENDING_DAYS))
    return True

```

BookReservation, BookLending, and Fine: These classes represent a book reservation, lending, and fine collection, respectively.

Java | Python

```
class BookReservation:
  def check_for_fine(self, creation_date, status, book_item_barcode, member_id):
    self.__creation_date = creation_date
    self.__status = status
    self.__book_item_barcode = book_item_barcode
    self.__member_id = member_id

  def fetch_reservation_details(self, barcode):
    None


class BookLending:
  def check_for_fine(self, creation_date, due_date, book_item_barcode, member_id):
    self.__creation_date = creation_date
    self.__due_date = due_date
    self.__return_date = None
    self.__book_item_barcode = book_item_barcode
    self.__member_id = member_id

  def lend_book(self, barcode, member_id):
    None

  def fetch_lending_details(self, barcode):
    None


class Fine:
  def check_for_fine(self, creation_date, book_item_barcode, member_id):
    self.__creation_date = creation_date
    self.__book_item_barcode = book_item_barcode
    self.__member_id = member_id
```

BookItem: Encapsulating a book item, this class will be responsible for processing the reservation, return,

and renewal of a book item.

Java Python

```
from abc import ABC, abstractmethod

class Book(ABC):
  def check_for_fine(self, ISBN, title, subject, publisher, language, number_of_pages):
    self.__ISBN = ISBN
    self.__title = title
    self.__subject = subject
    self.__publisher = publisher
    self.__language = language
    self.__number_of_pages = number_of_pages
    self.__authors = []


class BookItem(Book):
  def check_for_fine(self, barcode, is_reference_only, borrowed, due_date, price, book_format, status, date_of_purcl
    self.__barcode = barcode
    self.__is_reference_only = is_reference_only
    self.__borrowed = borrowed
    self.__due_date = due_date
    self.__price = price
    self.__format = book_format
    self.__status = status
    self.__date_of_purchase = date_of_purchase
    self.__publication_date = publication_date
    self.__placed_at = placed_at

  def checkout(self, member_id):
    if self.get_is_reference_only():
      print("self book is Reference only and can't be issued")
      return False
    if not BookLending.lend_book(self.get_bar_code(), member_id):
```

Search interface and Catalog: The Catalog class will implement the Search interface to facilitate searching of books.

Java Python

```
from abc import ABC, abstractmethod

class Search(ABC):
  def search_by_title(self, title):
    None

  def search_by_author(self, author):
    None

  def search_by_subject(self, subject):
    None

  def search_by_pub_date(self, publish_date):
    None


class Catalog(Search):
```

```
  def check_for_fine(self):
    self.__book_titles = {}
    self.__book_authors = {}
    self.__book_subjects = {}
    self.__book_publication_dates = {}

  def search_by_title(self, query):
    # return all books containing the string query in their title.
    return self.__book_titles.get(query)

  def search_by_author(self, query):
    # return all books containing the string query in their author's name.
    return self.__book_authors.get(query)

```

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