In this chat, I provided the Ai with the features of the system, the domain classes of the system as well as their attributes and the description of the system. As in every other phase using this LLM, the AI understood extremely well and fast what to do and the connections between the classes. It generated all the domain/services/DAOs code without me prompting it to, and then with only 2 prompts it generated all the step definitions of all the features. Overall, the code was pretty good, many times very close to the real system, and it had a lot of detail in each step, without taking the easy route and just asserting or printing things in the step definitions.

Phase 3 Chat 1

User

Act as a software developer. I have a library system application written in java and I have created some Gherkin Scenarios based on different features of the library application. I will provide you with these features/scenarios and the name of all the domain classes with their attributes , and then I will ask you to provide me the implementation code of the Step definitions for each feature, in java. I want your architecture to have Domain classes, Data Access Objects for saving/deleting entities and Service classes. Do you have any questions?

ChatGPT

No, I don't have any questions. I'm ready to help you with the implementation of the Step definitions for your library system application. Please provide me with the Gherkin Scenarios, the name of the domain classes along with their attributes, and any other details you think are necessary.

User

The domain classes are:

1)class "Book" with the attributes:

private ISBN isbn,

private String title,

private String publication,

private int publicationyear,

private Publisher publisher,

private Set<Item> items = new HashSet<Item>(),

private Set<Author> authors = new HashSet<Author>()

2)class "Borrower" with the attributes:

private int borrowerNo,

private TelephoneNumber telephone,

private EmailAddress emailAddress,

private Address address,

private BorrowerCategory category,

private Person person = new Person(),

private Set<Loan> loans = new HashSet<Loan>()

3)class "BorrowerCategory" with the attributes:

private String description,

private int maxLendingItems,

private int maxLendingDays,

private Money dailyFine

4)class "Item" with the fields:

private int itemNumber = 0,

private Book book,

private ItemState state = ItemState.NEW

5)enum class "ItemState" with no attrbutes outside the enum values

6)class "Loan" with the attributes:

private LocalDate loanDate = SystemDate.now(),

private LocalDate returnDate,

private Borrower borrower,

private Item item

7)class "Person" with the fields:

private String firstName,

private String lastName

In the next message I will provide you with the features/scenarios

ChatGPT

Great, I have noted down the domain classes and their attributes. Please go ahead and provide the Gherkin Scenarios for the features of your library application, and I will help you with the implementation of the Step definitions in Java, adhering to the specified architecture with Domain classes, Data Access Objects (DAOs), and Service classes.

User

The Gherkin scenarios are :

The first feature is :

Feature: Borrower handling by the system

The system can register a new person, modify their credentials or delete their account

User Story: As a librarian,

I want to efficiently manage the loaning process of books to registered borrowers

So that borrowers can easily borrow books from the library.

Scenario: Registering a new borrower

This scenario describes the process of registering a new borrower in the library system

Given George Red is not registered as a borrower

When George Red gets registered in the system with a unique borrower number and his details

Then the system successfully stores the borrower's details

Scenario: Borrower trying to register has registered before

This scenario describes what happens when the system tries to register a new borrower who has already registered before

Given George Red is registered as a borrower

When the system attempts to register George Red with a unique borrower number and his details

Then the system informs that the user already exists

Scenario: Updating the borrower's details when he is registered

This scenario describes the process of updating the details of a borrower who has already registered before

Given George Red is registered as a borrower

When George Red updates his borrowing details

Then the system saves the changes

Scenario: Updating the borrower's details when he hasn't registered

This scenario describes what happens when the system tries to update the details of a borrower who has not registered before

Given George Red is not registered as a borrower

When George Red tries to update his borrowing details

Then the system displays an error message indicating that George Red does not exist

Scenario: Deleting a borrower

This scenario describes the process of deleting the account of a borrower who has already registered

Given George Red is registered as a borrower

When the system deletes George Red's account

Then the system removes George Red's details

Scenario: Deleting a borrower when he hasn't registered

This scenario describes what happens when the system tries to delete the account of a borrower who has not registered before

Given George Red is not registered as a borrower

When the system attempts to delete George Red's account

Then the system informs that the borrower does not exist

Scenario: Handling unreturned items of books

This scenario describes what happens when the system tries to delete the account of a borrower who has pending items to return

Given George Red is registered as a borrower

And George Red has pending items

When the system attempts to delete George Red's account

Then the system does not remove George Red's details

And the system informs about the pending items

The second feature is :

Feature: Delayed Return Notification

User Story

a Library Manager

I want the loan system to automatically notify via email those who have delayed the return of an item

So that borrowers are informed when they have delayed the return of an item

Scenario: Notifying the borrower via email

This scenario handles the case where an item hasn't been returned on time and the system must notify the borrower via email

Given George Red has borrowed the item Harry Potter

And Harry Potter's due date has passed

And George Red has an email address

When the system executes the delayed return notification process

Then George Red receives an email notification for the return of the item

Scenario: Borrower does not have an email address

This scenario handles the case where an item hasn't been returned on time and the system must notify the user via email but he doesn't have one

Given George Red has borrowed the item Harry Potter

And Harry Potter's due date has passed

And George Red does not have an email address

When the system executes the delayed return notification process

Then George Red does not receive an email notification for the return of the item

The third feature is :

Feature: Loaning items

The library application allows for the librarian to loan an item of a book to a borrower based

on some conditions of the system

User story: As a library member

I want to be able to borrow items

So that I can study them at home

Scenario: Successful loaning of an item

This scenario describes the successful process of loaning an item to a borrower that is entitled to borrow

Given the library has the item Harry Potter available

And George Red is a registered borrower

And George Red has 2 pending items to be returned

And George Red has been assigned a maximum lending limit of 5

When George Red borrows the item Harry Potter

Then the system successfully loans the item Harry Potter to George Red with a due date set

And George Red's pending items increase to 3

Scenario: Borrower can borrow only one item due to his lending limit

This scenario describes the successful process of loaning only one but not two items to a borrower that is entitled to borrow only one item

Given the library has the items Harry Potter and Moby Dick available

And George Red is a registered borrower

And George Red has 2 pending items to be returned

And George Red has been assigned a maximum lending limit of 3

When George Red tries to borrow both items

Then the system successfully loans the item Harry Potter to George Red with a due date set

And the system does not loan Moby Dick to George Red due to the lending limit reached

And George Red's pending items increase to 3

Scenario: Item not found

This scenario describes the edge case where the library system cannot find the item, so the loan isn't happening

Given the item Harry Potter is in the library but not in the system

And George Red is a registered borrower

When George Red tries to borrow the item Harry Potter

Then the system returns an error due to the item's status

And the system withdraws the item Harry Potter

Scenario: The borrower is not eligible to borrow

This scenario describes the unsuccessful process of loaning an item to a borrower that has reached his max lending limit

Given the library has the item Harry Potter available

And George Red is a registered borrower

And George Red has 3 pending items to be returned

And George Red has been assigned a maximum lending limit of 3

When George Red tries to borrow the item Harry Potter

Then the system doesn't allow the loan

And George Red's pending items remain 3

and the last feature is :

Feature: Returning a borrowed item to the library

The borrower returns the book copy in the library and then the system needs to accept it based on some conditions

User story: As a librarian

I want to accurately record the return of one or more books

So that books are returned on time, and late returns are fined

Scenario: Successful return of an item

This scenario describes the successful process of returning an item by a borrower

Given George Red borrowed the item Animal Kingdom 5 days prior to today's date

And George Red has been assigned maximum lending days of 10

When the return of Animal Kingdom is processed

Then the system marks the state of Animal Kingdom as AVAILABLE

And George Red has one less pending item

And George Red does not pay a fine

And the return date of the loan is set to today's date

Scenario: Late return of an item from a borrower

This scenario describes what happens when a borrower returns a loaned item late and has to pay a fine

Given George Red borrowed the item Animal Kingdom 10 days prior to today's date

And George Red has been assigned maximum lending days of 7

When the return of Animal Kingdom is processed

Then the system marks the state of Animal Kingdom as AVAILABLE

And George Red pays a fine based on the borrower category

And the return date of the loan is set to today's date

ChatGPT

### Step Definitions for Feature: Borrower handling by the system

Below are the Java step definitions using Cucumber framework:

#### Domain Classes

First, ensure you have the domain classes defined as follows (simplified for brevity):

```java

public class Book {

private String isbn;

private String title;

private String publication;

private int publicationyear;

private Publisher publisher;

private Set<Item> items = new HashSet<>();

private Set<Author> authors = new HashSet<>();

// Getters and Setters

}

public class Borrower {

private int borrowerNo;

private TelephoneNumber telephone;

private EmailAddress emailAddress;

private Address address;

private BorrowerCategory category;

private Person person = new Person();

private Set<Loan> loans = new HashSet<>();

// Getters and Setters

}

public class BorrowerCategory {

private String description;

private int maxLendingItems;

private int maxLendingDays;

private Money dailyFine;

// Getters and Setters

}

public class Item {

private int itemNumber;

private Book book;

private ItemState state = ItemState.NEW;

// Getters and Setters

}

public enum ItemState {

NEW, AVAILABLE, BORROWED, RETURNED;

}

public class Loan {

private LocalDate loanDate = LocalDate.now();

private LocalDate returnDate;

private Borrower borrower;

private Item item;

// Getters and Setters

}

public class Person {

private String firstName;

private String lastName;

// Getters and Setters

}

```

#### DAO Interfaces

Create Data Access Objects interfaces to manage persistence.

```java

public interface BorrowerDAO {

Borrower findByBorrowerNo(int borrowerNo);

void save(Borrower borrower);

void update(Borrower borrower);

void delete(Borrower borrower);

}

```

#### Service Class

A service class to handle business logic.

```java

public class BorrowerService {

private BorrowerDAO borrowerDAO;

public BorrowerService(BorrowerDAO borrowerDAO) {

this.borrowerDAO = borrowerDAO;

}

public void registerBorrower(Borrower borrower) throws Exception {

if (borrowerDAO.findByBorrowerNo(borrower.getBorrowerNo()) != null) {

throw new Exception("Borrower already exists");

}

borrowerDAO.save(borrower);

}

public void updateBorrower(Borrower borrower) throws Exception {

if (borrowerDAO.findByBorrowerNo(borrower.getBorrowerNo()) == null) {

throw new Exception("Borrower does not exist");

}

borrowerDAO.update(borrower);

}

public void deleteBorrower(int borrowerNo) throws Exception {

Borrower borrower = borrowerDAO.findByBorrowerNo(borrowerNo);

if (borrower == null) {

throw new Exception("Borrower does not exist");

}

borrowerDAO.delete(borrower);

}

}

```

#### Step Definitions

The step definitions for the feature using the Cucumber framework.

```java

import static org.junit.Assert.\*;

import java.util.HashMap;

import java.util.Map;

import cucumber.api.java.en.\*;

public class BorrowerHandlingSteps {

private BorrowerService borrowerService;

private Map<Integer, Borrower> borrowers;

private Borrower currentBorrower;

private Exception exception;

public BorrowerHandlingSteps() {

// Assuming BorrowerDAO is properly implemented

BorrowerDAO borrowerDAO = new InMemoryBorrowerDAO();

borrowerService = new BorrowerService(borrowerDAO);

borrowers = new HashMap<>();

exception = null;

}

@Given("George Red is not registered as a borrower")

public void george\_Red\_is\_not\_registered\_as\_a\_borrower() {

currentBorrower = null;

}

@When("George Red gets registered in the system with a unique borrower number and his details")

public void george\_Red\_gets\_registered\_in\_the\_system() {

try {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(1); // Unique borrower number

currentBorrower.setPerson(new Person("George", "Red"));

borrowerService.registerBorrower(currentBorrower);

} catch (Exception e) {

exception = e;

}

}

@Then("the system successfully stores the borrower's details")

public void the\_system\_successfully\_stores\_the\_borrowers\_details() {

assertNull(exception);

assertNotNull(borrowers.get(1));

}

@Given("George Red is registered as a borrower")

public void george\_Red\_is\_registered\_as\_a\_borrower() {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(1);

currentBorrower.setPerson(new Person("George", "Red"));

borrowers.put(1, currentBorrower);

}

@When("the system attempts to register George Red with a unique borrower number and his details")

public void the\_system\_attempts\_to\_register\_George\_Red() {

try {

borrowerService.registerBorrower(currentBorrower);

} catch (Exception e) {

exception = e;

}

}

@Then("the system informs that the user already exists")

public void the\_system\_informs\_that\_the\_user\_already\_exists() {

assertNotNull(exception);

assertEquals("Borrower already exists", exception.getMessage());

}

@When("George Red updates his borrowing details")

public void george\_Red\_updates\_his\_borrowing\_details() {

try {

currentBorrower.getPerson().setTelephone(new TelephoneNumber("1234567890"));

borrowerService.updateBorrower(currentBorrower);

} catch (Exception e) {

exception = e;

}

}

@Then("the system saves the changes")

public void the\_system\_saves\_the\_changes() {

assertNull(exception);

assertEquals("1234567890", borrowers.get(1).getPerson().getTelephone().getNumber());

}

@When("George Red tries to update his borrowing details")

public void george\_Red\_tries\_to\_update\_his\_borrowing\_details() {

try {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(2); // New borrower number

currentBorrower.setPerson(new Person("George", "Red"));

borrowerService.updateBorrower(currentBorrower);

} catch (Exception e) {

exception = e;

}

}

@Then("the system displays an error message indicating that George Red does not exist")

public void the\_system\_displays\_an\_error\_message\_indicating\_that\_George\_Red\_does\_not\_exist() {

assertNotNull(exception);

assertEquals("Borrower does not exist", exception.getMessage());

}

@When("the system deletes George Red's account")

public void the\_system\_deletes\_George\_Red\_s\_account() {

try {

borrowerService.deleteBorrower(1);

} catch (Exception e) {

exception = e;

}

}

@Then("the system removes George Red's details")

public void the\_system\_removes\_George\_Red\_s\_details() {

assertNull(exception);

assertNull(borrowers.get(1));

}

@When("the system attempts to delete George Red's account")

public void the\_system\_attempts\_to\_delete\_George\_Red\_s\_account() {

try {

borrowerService.deleteBorrower(2);

} catch (Exception e) {

exception = e;

}

}

@Then("the system informs that the borrower does not exist")

public void the\_system\_informs\_that\_the\_borrower\_does\_not\_exist() {

assertNotNull(exception);

assertEquals("Borrower does not exist", exception.getMessage());

}

}

```

#### In-Memory DAO Implementation

To test the above steps, you may need an in-memory DAO implementation.

```java

public class InMemoryBorrowerDAO implements BorrowerDAO {

private Map<Integer, Borrower> database = new HashMap<>();

@Override

public Borrower findByBorrowerNo(int borrowerNo) {

return database.get(borrowerNo);

}

@Override

public void save(Borrower borrower) {

database.put(borrower.getBorrowerNo(), borrower);

}

@Override

public void update(Borrower borrower) {

database.put(borrower.getBorrowerNo(), borrower);

}

@Override

public void delete(Borrower borrower) {

database.remove(borrower.getBorrowerNo());

}

}

```

### Summary

This implementation includes the domain classes, a DAO interface, a service class for business logic, and Cucumber step definitions. Modify as needed to fit your specific requirements and test setup. Provide the same structure for the other scenarios and features.

User

Provide all the step definitions for all the other features as well

ChatGPT

### Step Definitions for Feature: Delayed Return Notification

#### Step Definitions

```java

import cucumber.api.java.en.\*;

import java.time.LocalDate;

import static org.junit.Assert.\*;

public class DelayedReturnNotificationSteps {

private BorrowerService borrowerService;

private LoanService loanService;

private Borrower currentBorrower;

private Loan currentLoan;

private Exception exception;

private EmailService emailService;

private boolean emailSent;

public DelayedReturnNotificationSteps() {

// Assuming the necessary DAOs are properly implemented

BorrowerDAO borrowerDAO = new InMemoryBorrowerDAO();

LoanDAO loanDAO = new InMemoryLoanDAO();

borrowerService = new BorrowerService(borrowerDAO);

loanService = new LoanService(loanDAO);

emailService = new EmailService();

exception = null;

emailSent = false;

}

@Given("George Red has borrowed the item Harry Potter")

public void george\_Red\_has\_borrowed\_the\_item\_Harry\_Potter() {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(1);

currentBorrower.setPerson(new Person("George", "Red"));

Item harryPotter = new Item();

harryPotter.setItemNumber(1);

harryPotter.setBook(new Book("Harry Potter", "JK Rowling", 1997));

currentLoan = new Loan();

currentLoan.setBorrower(currentBorrower);

currentLoan.setItem(harryPotter);

loanService.save(currentLoan);

}

@Given("Harry Potter's due date has passed")

public void harry\_Potter\_s\_due\_date\_has\_passed() {

currentLoan.setReturnDate(LocalDate.now().minusDays(5));

}

@Given("George Red has an email address")

public void george\_Red\_has\_an\_email\_address() {

currentBorrower.setEmailAddress(new EmailAddress("george.red@example.com"));

}

@When("the system executes the delayed return notification process")

public void the\_system\_executes\_the\_delayed\_return\_notification\_process() {

try {

emailService.sendDelayedReturnNotification(currentLoan);

emailSent = true;

} catch (Exception e) {

exception = e;

}

}

@Then("George Red receives an email notification for the return of the item")

public void george\_Red\_receives\_an\_email\_notification\_for\_the\_return\_of\_the\_item() {

assertTrue(emailSent);

assertNull(exception);

}

@Given("George Red does not have an email address")

public void george\_Red\_does\_not\_have\_an\_email\_address() {

currentBorrower.setEmailAddress(null);

}

@Then("George Red does not receive an email notification for the return of the item")

public void george\_Red\_does\_not\_receive\_an\_email\_notification\_for\_the\_return\_of\_the\_item() {

assertFalse(emailSent);

assertNotNull(exception);

assertEquals("Email address not found", exception.getMessage());

}

}

```

### Step Definitions for Feature: Loaning Items

#### Step Definitions

```java

import cucumber.api.java.en.\*;

import java.util.HashMap;

import java.util.Map;

import static org.junit.Assert.\*;

public class LoaningItemsSteps {

private BorrowerService borrowerService;

private ItemService itemService;

private LoanService loanService;

private Borrower currentBorrower;

private Item currentItem;

private Map<Integer, Item> items;

private Exception exception;

public LoaningItemsSteps() {

// Assuming the necessary DAOs are properly implemented

BorrowerDAO borrowerDAO = new InMemoryBorrowerDAO();

ItemDAO itemDAO = new InMemoryItemDAO();

LoanDAO loanDAO = new InMemoryLoanDAO();

borrowerService = new BorrowerService(borrowerDAO);

itemService = new ItemService(itemDAO);

loanService = new LoanService(loanDAO);

items = new HashMap<>();

exception = null;

}

@Given("the library has the item Harry Potter available")

public void the\_library\_has\_the\_item\_Harry\_Potter\_available() {

currentItem = new Item();

currentItem.setItemNumber(1);

currentItem.setBook(new Book("Harry Potter", "JK Rowling", 1997));

currentItem.setState(ItemState.AVAILABLE);

items.put(1, currentItem);

itemService.save(currentItem);

}

@Given("George Red is a registered borrower")

public void george\_Red\_is\_a\_registered\_borrower() {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(1);

currentBorrower.setPerson(new Person("George", "Red"));

borrowerService.save(currentBorrower);

}

@Given("George Red has 2 pending items to be returned")

public void george\_Red\_has\_pending\_items() {

currentBorrower.getLoans().add(new Loan(LocalDate.now().minusDays(2), null, currentBorrower, currentItem));

currentBorrower.getLoans().add(new Loan(LocalDate.now().minusDays(2), null, currentBorrower, new Item()));

}

@Given("George Red has been assigned a maximum lending limit of 5")

public void george\_Red\_maximum\_lending\_limit() {

BorrowerCategory category = new BorrowerCategory();

category.setMaxLendingItems(5);

currentBorrower.setCategory(category);

}

@When("George Red borrows the item Harry Potter")

public void george\_Red\_borrows\_the\_item\_Harry\_Potter() {

try {

loanService.loanItem(currentBorrower, currentItem);

} catch (Exception e) {

exception = e;

}

}

@Then("the system successfully loans the item Harry Potter to George Red with a due date set")

public void system\_successfully\_loans\_the\_item() {

assertNull(exception);

assertEquals(ItemState.BORROWED, currentItem.getState());

assertNotNull(currentLoan.getLoanDate());

}

@Then("George Red's pending items increase to 3")

public void george\_Red\_pending\_items\_increase() {

assertEquals(3, currentBorrower.getLoans().size());

}

@Given("the library has the items Harry Potter and Moby Dick available")

public void library\_has\_multiple\_items() {

currentItem = new Item();

currentItem.setItemNumber(1);

currentItem.setBook(new Book("Harry Potter", "JK Rowling", 1997));

currentItem.setState(ItemState.AVAILABLE);

items.put(1, currentItem);

itemService.save(currentItem);

Item mobyDick = new Item();

mobyDick.setItemNumber(2);

mobyDick.setBook(new Book("Moby Dick", "Herman Melville", 1851));

mobyDick.setState(ItemState.AVAILABLE);

items.put(2, mobyDick);

itemService.save(mobyDick);

}

@Given("George Red has been assigned a maximum lending limit of 3")

public void george\_Red\_max\_lending\_limit() {

BorrowerCategory category = new BorrowerCategory();

category.setMaxLendingItems(3);

currentBorrower.setCategory(category);

}

@When("George Red tries to borrow both items")

public void george\_Red\_tries\_to\_borrow\_both\_items() {

try {

loanService.loanItem(currentBorrower, items.get(1));

loanService.loanItem(currentBorrower, items.get(2));

} catch (Exception e) {

exception = e;

}

}

@Then("the system does not loan Moby Dick to George Red due to the lending limit reached")

public void system\_does\_not\_loan\_due\_to\_limit() {

assertNotNull(exception);

assertEquals("Lending limit reached", exception.getMessage());

assertEquals(ItemState.AVAILABLE, items.get(2).getState());

}

@Then("George Red's pending items increase to 3")

public void george\_Red\_pending\_items() {

assertEquals(3, currentBorrower.getLoans().size());

}

@Given("the item Harry Potter is in the library but not in the system")

public void item\_not\_in\_system() {

currentItem = null; // Item is not in the system

}

@When("George Red tries to borrow the item Harry Potter")

public void george\_Red\_tries\_to\_borrow\_item() {

try {

loanService.loanItem(currentBorrower, currentItem);

} catch (Exception e) {

exception = e;

}

}

@Then("the system returns an error due to the item's status")

public void system\_returns\_error\_due\_to\_status() {

assertNotNull(exception);

assertEquals("Item not found", exception.getMessage());

}

@Then("the system withdraws the item Harry Potter")

public void system\_withdraws\_item() {

assertNull(items.get(1));

}

@Given("George Red has 3 pending items to be returned")

public void george\_Red\_3\_pending\_items() {

currentBorrower.getLoans().add(new Loan(LocalDate.now().minusDays(2), null, currentBorrower, currentItem));

currentBorrower.getLoans().add(new Loan(LocalDate.now().minusDays(2), null, currentBorrower, new Item()));

currentBorrower.getLoans().add(new Loan(LocalDate.now().minusDays(2), null, currentBorrower, new Item()));

}

@Given("George Red has been assigned a maximum lending limit of 3")

public void george\_Red\_max\_limit\_

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3() {

BorrowerCategory category = new BorrowerCategory();

category.setMaxLendingItems(3);

currentBorrower.setCategory(category);

}

@When("George Red tries to borrow the item Harry Potter")

public void george\_Red\_tries\_to\_borrow\_item\_harry\_potter() {

try {

loanService.loanItem(currentBorrower, currentItem);

} catch (Exception e) {

exception = e;

}

}

@Then("the system doesn't allow the loan")

public void system\_does\_not\_allow\_loan() {

assertNotNull(exception);

assertEquals("Lending limit reached", exception.getMessage());

}

@Then("George Red's pending items remain 3")

public void george\_Red\_pending\_items\_remain\_3() {

assertEquals(3, currentBorrower.getLoans().size());

}

}

```

### Step Definitions for Feature: Returning a Borrowed Item to the Library

#### Step Definitions

```java

import cucumber.api.java.en.\*;

import java.time.LocalDate;

import static org.junit.Assert.\*;

public class ReturningBorrowedItemsSteps {

private BorrowerService borrowerService;

private ItemService itemService;

private LoanService loanService;

private Borrower currentBorrower;

private Item currentItem;

private Loan currentLoan;

private Exception exception;

public ReturningBorrowedItemsSteps() {

// Assuming the necessary DAOs are properly implemented

BorrowerDAO borrowerDAO = new InMemoryBorrowerDAO();

ItemDAO itemDAO = new InMemoryItemDAO();

LoanDAO loanDAO = new InMemoryLoanDAO();

borrowerService = new BorrowerService(borrowerDAO);

itemService = new ItemService(itemDAO);

loanService = new LoanService(loanDAO);

exception = null;

}

@Given("George Red borrowed the item Animal Kingdom 5 days prior to today's date")

public void george\_Red\_borrowed\_animal\_kingdom() {

currentBorrower = new Borrower();

currentBorrower.setBorrowerNo(1);

currentBorrower.setPerson(new Person("George", "Red"));

currentItem = new Item();

currentItem.setItemNumber(1);

currentItem.setBook(new Book("Animal Kingdom", "Author Name", 2020));

currentItem.setState(ItemState.BORROWED);

currentLoan = new Loan();

currentLoan.setLoanDate(LocalDate.now().minusDays(5));

currentLoan.setBorrower(currentBorrower);

currentLoan.setItem(currentItem);

loanService.save(currentLoan);

}

@Given("George Red has been assigned maximum lending days of 10")

public void george\_Red\_max\_lending\_days\_10() {

BorrowerCategory category = new BorrowerCategory();

category.setMaxLendingDays(10);

currentBorrower.setCategory(category);

}

@When("the return of Animal Kingdom is processed")

public void return\_of\_animal\_kingdom\_processed() {

try {

loanService.returnItem(currentBorrower, currentItem);

} catch (Exception e) {

exception = e;

}

}

@Then("the system marks the state of Animal Kingdom as AVAILABLE")

public void system\_marks\_animal\_kingdom\_available() {

assertEquals(ItemState.AVAILABLE, currentItem.getState());

}

@Then("George Red has one less pending item")

public void george\_Red\_one\_less\_pending\_item() {

assertEquals(0, currentBorrower.getLoans().size());

}

@Then("George Red does not pay a fine")

public void george\_Red\_no\_fine() {

assertNull(exception);

}

@Then("the return date of the loan is set to today's date")

public void return\_date\_set\_to\_today() {

assertEquals(LocalDate.now(), currentLoan.getReturnDate());

}

@Given("George Red borrowed the item Animal Kingdom 10 days prior to today's date")

public void george\_Red\_borrowed\_animal\_kingdom\_10\_days\_ago() {

currentLoan.setLoanDate(LocalDate.now().minusDays(10));

}

@Given("George Red has been assigned maximum lending days of 7")

public void george\_Red\_max\_lending\_days\_7() {

BorrowerCategory category = new BorrowerCategory();

category.setMaxLendingDays(7);

currentBorrower.setCategory(category);

}

@Then("George Red pays a fine based on the borrower category")

public void george\_Red\_pays\_fine() {

assertNotNull(exception);

assertEquals("Late return fine", exception.getMessage());

}

}

```

### In-Memory DAO Implementations for Testing

```java

public class InMemoryItemDAO implements ItemDAO {

private Map<Integer, Item> database = new HashMap<>();

@Override

public Item findByItemNumber(int itemNumber) {

return database.get(itemNumber);

}

@Override

public void save(Item item) {

database.put(item.getItemNumber(), item);

}

@Override

public void update(Item item) {

database.put(item.getItemNumber(), item);

}

@Override

public void delete(Item item) {

database.remove(item.getItemNumber());

}

}

public class InMemoryLoanDAO implements LoanDAO {

private Map<Integer, Loan> database = new HashMap<>();

@Override

public Loan findByLoanId(int loanId) {

return database.get(loanId);

}

@Override

public void save(Loan loan) {

database.put(loan.getItem().getItemNumber(), loan);

}

@Override

public void update(Loan loan) {

database.put(loan.getItem().getItemNumber(), loan);

}

@Override

public void delete(Loan loan) {

database.remove(loan.getItem().getItemNumber());

}

}

```

### Services for Business Logic

```java

public class ItemService {

private ItemDAO itemDAO;

public ItemService(ItemDAO itemDAO) {

this.itemDAO = itemDAO;

}

public void save(Item item) {

itemDAO.save(item);

}

}

public class LoanService {

private LoanDAO loanDAO;

public LoanService(LoanDAO loanDAO) {

this.loanDAO = loanDAO;

}

public void save(Loan loan) {

loanDAO.save(loan);

}

public void loanItem(Borrower borrower, Item item) throws Exception {

if (item == null) {

throw new Exception("Item not found");

}

if (borrower.getLoans().size() >= borrower.getCategory().getMaxLendingItems()) {

throw new Exception("Lending limit reached");

}

item.setState(ItemState.BORROWED);

Loan loan = new Loan();

loan.setBorrower(borrower);

loan.setItem(item);

loanDAO.save(loan);

}

public void returnItem(Borrower borrower, Item item) throws Exception {

Loan loan = loanDAO.findByLoanId(item.getItemNumber());

if (loan == null) {

throw new Exception("Loan not found");

}

LocalDate today = LocalDate.now();

int daysBorrowed = (int) java.time.temporal.ChronoUnit.DAYS.between(loan.getLoanDate(), today);

if (daysBorrowed > borrower.getCategory().getMaxLendingDays()) {

throw new Exception("Late return fine");

}

loan.setReturnDate(today);

item.setState(ItemState.AVAILABLE);

loanDAO.update(loan);

}

}

public class EmailService {

public void sendDelayedReturnNotification(Loan loan) throws Exception {

if (loan.getBorrower().getEmailAddress() == null) {

throw new Exception("Email address not found");

}

// Simulate sending an email

System.out.println("Email sent to: " + loan.getBorrower().getEmailAddress().getEmail());

}

}

```

### Summary

This implementation includes the complete step definitions for all the provided features and scenarios, using in-memory DAO implementations for testing purposes. The service classes encapsulate the business logic, and the step definitions use these services to fulfill the scenarios. Adjust the implementation details to fit your specific requirements and environment.