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Software Engineer

(CO3001)

Software Requirements Specification for

SMART PRINTING SERVICE

Version 4.0 approved

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Revision

Name	Date	Reason For Changes	Version
Task 1.3	29/9/2024	Write report for task 1.3 (Diagram)	2.0
Task 2	27/10/2024	Write report for task 2	3.0
Task 3	08/11/2024	Write report for task 3	4.0

1 Requirement elicitation (1.1, 1.2)

1.1 Domain context

1.1.1 Overview

Student Smart Printing Service (HCMUT_SSPS) is a printing system develop for university student at HCMUT for printing purpose. This system contains features like printers, printing management, authenticating methods, pages quotas, online payments, configuration tools and report of usages.

1.1.2 Actors and Roles

- **Student:** printing, purchasing for more pages, view history of printing.
- **Administrator:** handle internal bugs, upgrade system.
- **Student Printing Service Officer (SPSO):** manage printers, report usage.
- **IT department:** User support, system monitoring and responses to incidents.

1.1.3 Key concepts and Interactions

- **Printers:** contain ID, brand/manufacturer name, printer model, short description, location.
- **Printing features:** file uploaded, printing customize.
- **Page quotas:** limit number of A4 pages available.
- **Online payment:** increase quotas.
- **Report:** store all printing activities.

1.1.4 Domain rules

Users are authenticated by the HCMUT_SSO authentication service. Printers, setting, file types, page quotas and day of receiving page quotas are managed by the SPSO. An A3 page is consider as 2 A4 pages. Reports are generated automatically. Administrators manage users access and system's setting. IT department handle the system's integration

1.1.5 Domain events

Upload files, request service, complete printing, purchasing for more pages, receiving pages after a period of time, SPSO change setting and printers. Administrators determine setting and features. IT department maintaining system's security and functions.

1.1.6 Relationships

Students are linked to page quotas and history, printing job connect with printers and preferences, SPSO manage printers and setting, report contains all usage activities. Administrators manage SPSO. IT department maintaining system.

1.2 Stakeholders and Needs

- **Students (Users):** The primary users of the system. They access the Student Smart Printing Service (HCMUT_SSPS) to print documents, manage their available page balance, and check their printing history.
- **Student Printing Service Officer (SPSO):** The SPSO oversees the system's administration, handling printer management, configuring system settings, and reviewing printing logs and reports.
- **HCMUT Administration:** This group is tasked with ensuring the efficient delivery of printing services to students. They make decisions regarding resource allocation and potential service improvements based on trends in service usage.
- **HCMUT IT Department:** Responsible for maintaining the secure installation and integration of the smart printing service within the university's network. They handle the system's integration with existing services, such as HCMUT_SSO Authentication Service.

1.3 Benefits of the System

The HCMUTSSPS is aimed to make the document printing process more efficient and user-friendly.

1.3.1 Students (Users)

- **Convenience:** The HCMUT-SSPS system provides an easy and convenient method to access to the printers across campus through a web-based or mobile app. This enhances flexibility for students, allowing them to easily access any available printer from any location. Moreover, displaying printer locations enables students to identify the nearest available printer, saving them time and effort in finding one.
- **Transparency:** The transparent page-balance management allows students to clearly see and track their remaining pages available for printing, with the option to purchase additional pages through BKPay. Additionally, providing students with a printing log enables them to review their past printing decisions. This ensures that students can efficiently and properly manage their printing needs, preventing any unintentional usage.

1.3.2 Student Printing Service Officer (SPSO)

- **Efficient system management:** The HCMUT-SSPS provides SPSO with a user-friendly interface for managing the printer system, allowing them to easily add, enable, or disable printers. This ensures smooth and effective maintenance and control of the service.
- **Configuration management:** The system allows SPSO to configure file-type permissions and set a default number of pages, ensuring that the printing requirements of students are met and aligned with school policies.

- **Usage observation:** The automated generation of monthly and yearly reports helps maintain oversight of system usage trends, facilitating data-driven decisions for service improvements.

1.3.3 University administration

- **Resource management:** University admin benefits from streamlined resourced allocation. With detailed reports generated by the system, the administration can track printing usage patterns and optimize printer deployment based on actual demand. This data-driven approach helps in reducing waste, managing costs, and improving the overall efficiency of campus services.
- **Improved service experience:** By offering students a hassle-free printing solution, this also enhances student satisfaction, aligning with its broader goal of improving campus life and supporting academic activities.

1.3.4 HCMUT IT Department

- **Management and security:** the system is integrated with HCMUT_SSO, ensuring that user authentication is secure and streamlined. This reduced the risked of unauthorized access and simplifies user management.
- **Operational monitoring:** the centralized platform allows the IT Department to easily monitor the system's performance, manage updates, and troubleshoot issues remotely. This improves overall operational efficiency and minimizes downtime, ensuring the smooth functioning of the printing services across the campus.

1.4 Functional Requirements

1.4.1 For Students

- **File uploading:** Students can upload a document file for printing.
- **Printer choosing:** Students can select a printer for printing the document.
- **Printing configuration:** Students can specify printing properties such as paper size, pages (of the file) to be printed, one-/double-sided, number of copies, etc.
- **Printing checking log:** Students can view his/her printing log for a time period.
- **Summary checking log:** Students can view a summary of the number of printed pages for each page size in the student's printing log..
- **Page purchasing:** Students can buy additional printing pages using the online payment system.
- **Page checking balance:** Students can view the remaining pages available for printing.

1.4.2 For Student Printing Service Officer (SPSO)

- **History log viewing for one student:** SPSO can view the printing history of a student by one or multiple printers in a specified time period.

- **History log viewing for all students:** SPSO can view the printing history of all students by one or multiple printers in a specified time period.
- **Printer management:** SPSO can add, enable, and disable printers in the system.
- **Default page changing:** SPSO can change the default number of pages.
- **File permitting:** SPSO can specify the permitted file types for uploading.
- **Allocate Default Pages:** SPSO can specify the dates on which the system will allocate the default number of pages to all students.
- **Report viewing:** SPSO can view the monthly and annual reports.

1.4.3 For HCMUT Administrator

- **User Account Management:** The administrator must have the ability to create, modify, disable, or remove user accounts, including those for students and SPSOs (Student Printing Service Officers), ensuring proper account control and system access.
- **Access to Payment History:** The administrator should be able to view and audit the complete payment history for each student account, allowing real-time access for financial oversight and troubleshooting.
- **Report Generation and Access:** The administrator must have the ability to generate and access detailed monthly and yearly reports, comparing printing usage, student statistics, and financial data with previous time periods for strategic analysis.
- **System Configuration Control:** The administrator should have the authority to configure and update system settings, including print quotas, pricing models, and service schedules, to optimize system performance and user satisfaction.
- **Printer Monitoring and Management:** The administrator must be able to monitor the status of all printers, manage printer settings, and address system malfunctions or printer downtimes remotely.
- **Audit Log Access:** The administrator should have access to system audit logs, allowing them to track user activities, identify security breaches, and ensure compliance with institutional policies.

1.4.4 IT department

- **User support:** The IT department can provide technical support and assistants to students , SPSO and administrators to resolve any issues related to the smart printing service.
- **Integration with HCMUT_SSO:** The IT department can integrate the smart printing service with the HCMUT_SSO authentication service to ensure secure user's authentication across the network.
- **Incident responses:** The IT department can establish and maintain an incident response plan to address any security problem or system failures.
- **System monitoring:** The IT department can monitor the smart printing service for performance issues, security threats, systems issues.
- **Secure installation:** The IT department can perform secure installation of the smart printing service on university servers to project against unauthorized access.

1.5 Non-Functional Requirements

1.5.1 For Students

- **Data privacy:** Printed content needs to be kept confidential and know only by the student own that information.
- **User interface:** Students are required to log-in their account. The printer should have a good user interface avoid mis-understanding about all the functions of the printer.
- **System performance:** The system requires to operate stable and continous 24/24 without interuption. Virus or hazard softwares should not be found in the system.
- **Sheets count:** The system count exactly the number of sheet students used to print documents each time.

1.5.2 For students printing Service Officer

- **User's manual:** A detailed guidebook providing the operation and instructions for students to use it properly step-by-step (eg. Pause/Stop printer, configuring sheets to print, specified pages the way students desire, etc).
- **Configuration:** Configuration updates by the SPSO must be applied to all the printer in the system in 1 minutes.

1.5.3 For HCMUT Administrator

- **Account Management Effciency:** Changes in user-account made by the administrator should be update to the printing system within 10 minutes. (eg. Enabled/Disabled some functions the student can/can't use when operating the printer,etc)
- **Availability:** The system must be available 99.9% of the time to ensure that administrative staff can access real-time data and reports at any time.
- **Scalability:** The system should be able to accommodate growing numbers of users and increasing amounts of data over time without degradation in performance.
- **User Access Control:** The system must provide role-based access control, ensuring that only authorized administrative staff have access to sensitive data and system settings.

1.5.4 HCMUT IT Department

- **Upgrade:** Any system upgrade and verification in HCMUT_SSO made by IT Department in university's network also update in the printer.
- **Technical support:** Students technical reports will be save and sent to the supervisor at the end of every week.

2 Use-case Diagrams (1.3)

2.1 Use-case Diagrams for the Whole system

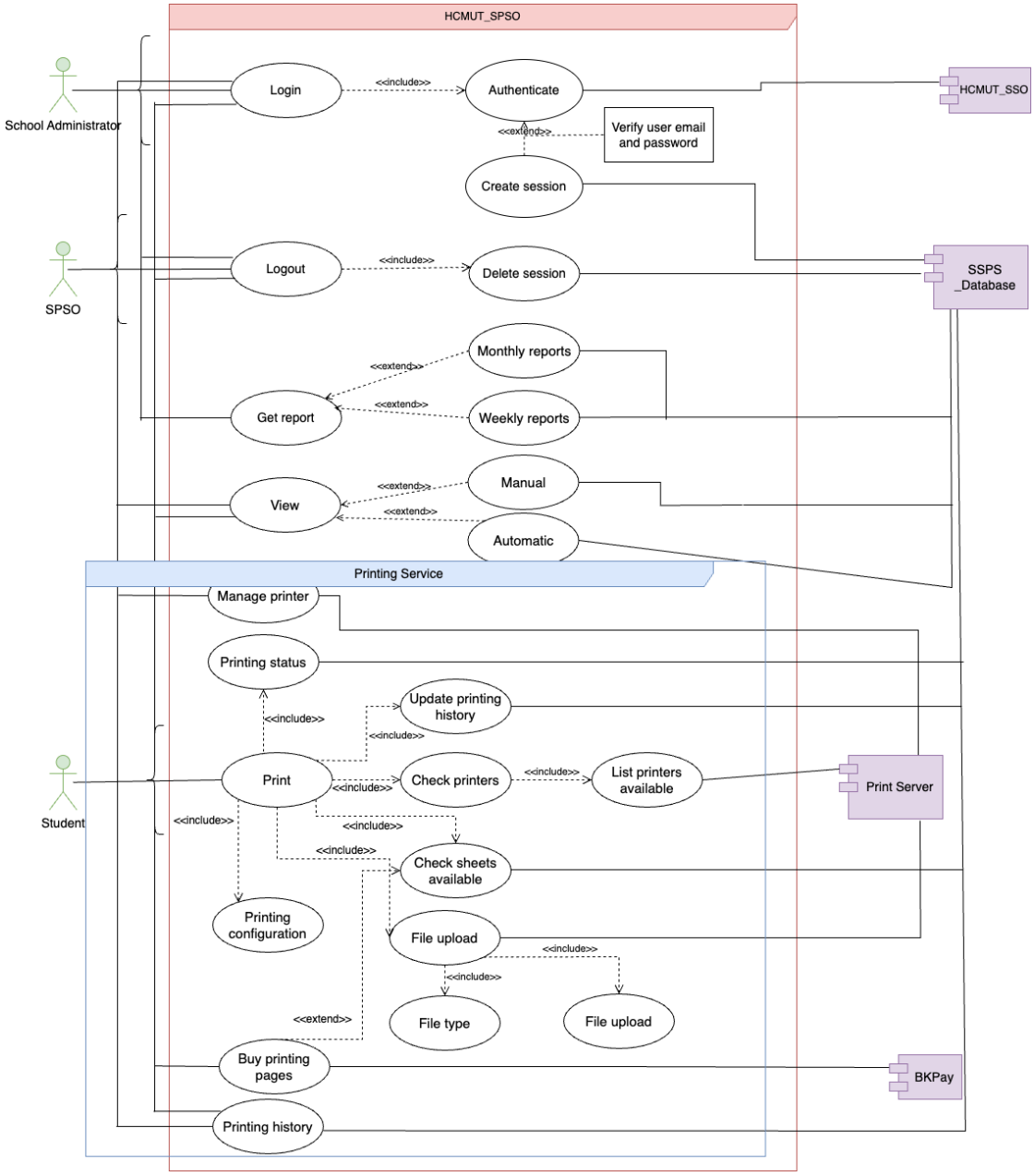

Figure 1. Use-case Diagram for Whole system

The entire system of the Smart Student Printing Service is made up by 5 modules:

- **Account Management Service:** This module is in responsible for managing accessibility

of all user's accounts with in the system, especially for those who have administrating accesses and permissions. It give access to major administration's function and give the administrators the power and tools to manage other accounts like creating, redefining, deactivating or deleting user accounts, including those of Student Printing Service Office (SPSO).

- **User Authentication Service:** This service ensure the security of user account as well as the limit the permissions of accessing administration's function and protect the security and stability of the whole system. It utilizes the HCMUT_SSO authentication service to verify the identity of students and other users before giving the the permission to access more features.
- **Payment Service:** This module is responsible for online payments of students in order to purchasing more page quotas. It is linked to payment systems BKPay of HCMUT for extending the amount of printing pages which is controlled by the system, to make sure the purchasing process is valid and be able to response as soon as they complete purchasing.
- **Printing Service:** The Printing Service is an essential feature that allows students to initiate and oversee print tasks. It manages document uploads, printer selection, setting printing preferences (such as paper size and page range), and tracks the history of print activities. Additionally, it ensures page balance monitoring and alerts users when their balance is low.
- **Report service:** The Reporting Service automatically creates and stores reports that summarize system usage. It gathers data on page consumption, the number of students utilizing the service, and offers comparisons with previous time periods (both monthly and yearly). These reports are essential for evaluating resource usage and aiding in informed decision-making regarding the printing service.

2.2 Use-case Diagram for Printing Job module

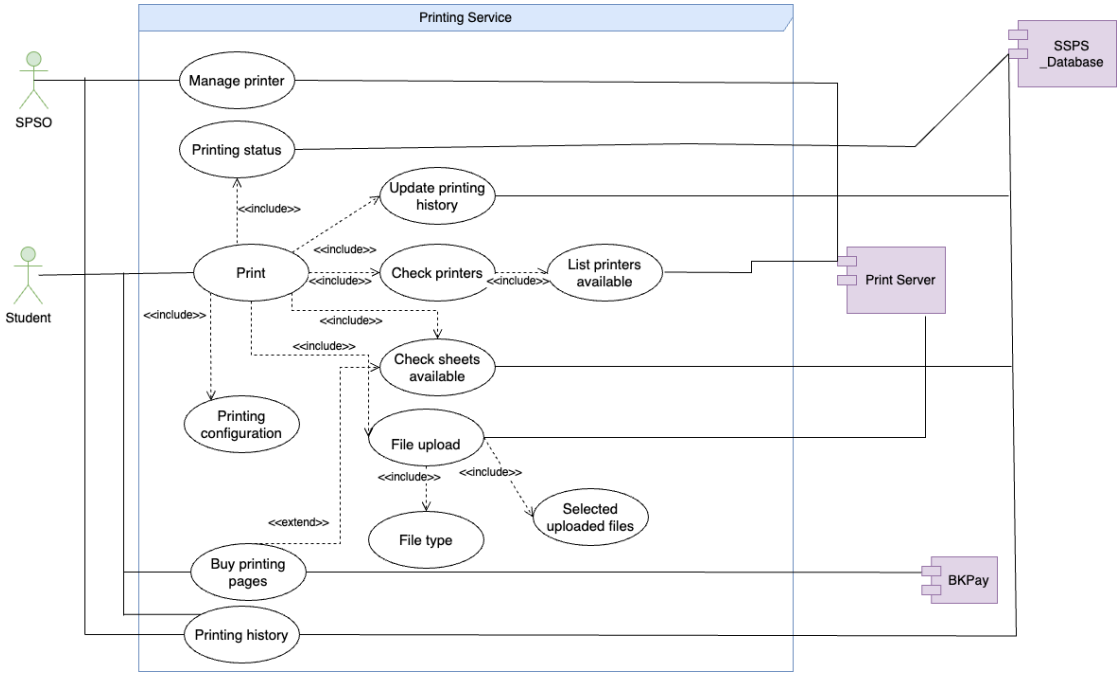

Figure 2. Use-case Diagram for Printing Job module

Use Case Name	Printing Job
Actors	SPSP, Student User, Printing Service, Print Server, BKPay, SSPS_Database
Description	Students perform Print function to to print documents in the system.
Trigger	User clicks on "+ New Print" button on the sidebar
Preconditions	User is logged in with an active user session. The document to be printed is uploaded and accessible.
Postconditions	The print job is successfully submitted for processing, and the user is notified when the print job is completed.

Normal Flows	1. User selects the desired printer for the print job. 2. User selects the document to be printed. 3. User specifies printing properties such as paper size, single-/double-sided, number of copies, and other preferences. 4. User confirms the print job submission. 5. System processes the print job and adds it to the print queue. 6. User receives a confirmation message that the print job has been successfully submitted. 7. User is notified when the print job is completed.
Alternative Flows	**From 2a.** User clicks on Uploaded Files tab: 2a.1. User clicks on their uploaded file from the list. 2a.2. Proceed with step 3 and onwards as in the normal flow. **From 2b.** User clicks on Integrations tab: 2b.1. User clicks on the integration button (e.g., Google Drive, OneDrive). 2b.2. User follows the integration flow to select a file. 2b.3. Proceed with step 3 and onwards as in the normal flow. **From 7b.** If the user runs out of page balance and chooses the Get More Balance button: 7b.1. User clicks the "Get More Balance" button. 7b.2. User is redirected to the page for adding more balance to their account. 7b.3. Proceed with the balance addition process. 7b.4. After successfully adding more balance, return to the print job confirmation step (step 4) and continue with the normal flow.
Exceptions	**From 5a.** If the selected printer is unavailable or offline, display an error message and allow the user to choose an alternative printer. **From 7a.** If the user runs out of page balance and chooses Cancel, display a notification and do not proceed with printing.

Bảng 1: Printing Job module

3 Activity Diagram

3.1 Printing Service

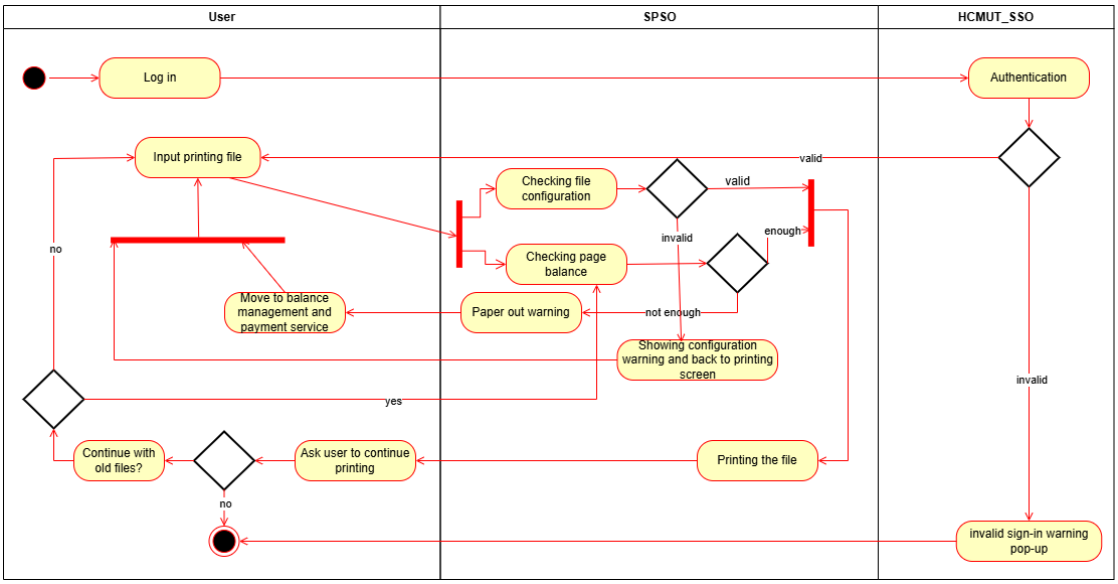

Figure 3. Activity Diagram

The printing service illustrates the document printing process. To start, users must log in to their accounts. Once logged in, they submit the files and wait for the system to verify two conditions: whether the file configuration is acceptable and whether the page balance is sufficient. If either condition is not met, the system will display an error message, and the user will be redirected to the file submission interface. If both conditions are satisfied, the files will be printed successfully, and the system will prompt the user to continue printing if desired.

3.2 Account Viewing

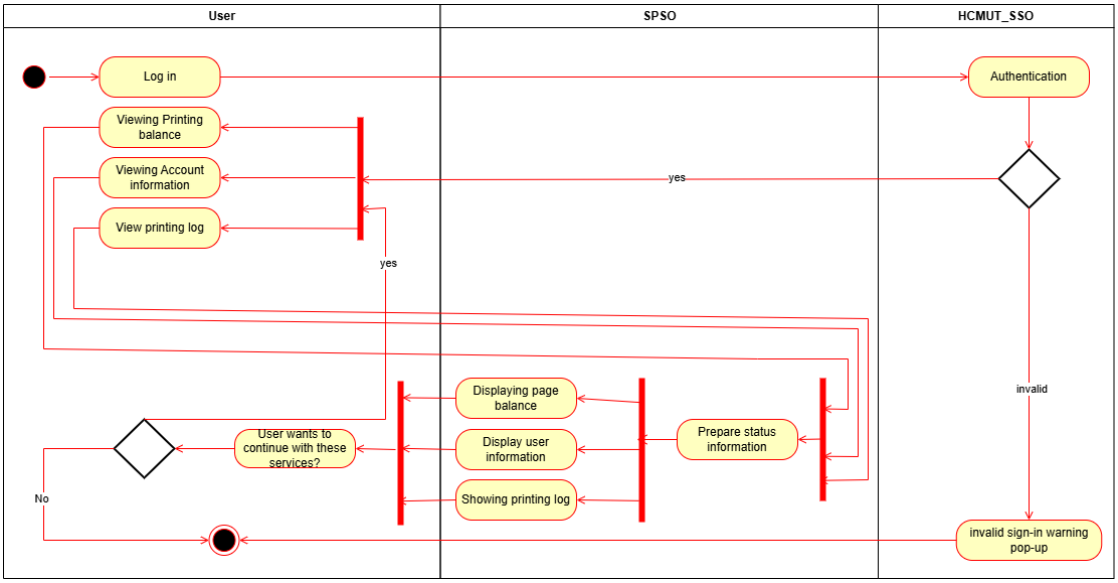

Figure 4. Account Viewing

The account viewing feature allows users to access their personal information. They can view details such as their password, account name, printing balance, and printing history. All actions require the user to log in successfully. Once logged in, the SPSO system will generate any requested documents for the user.

3.3 Payment Service

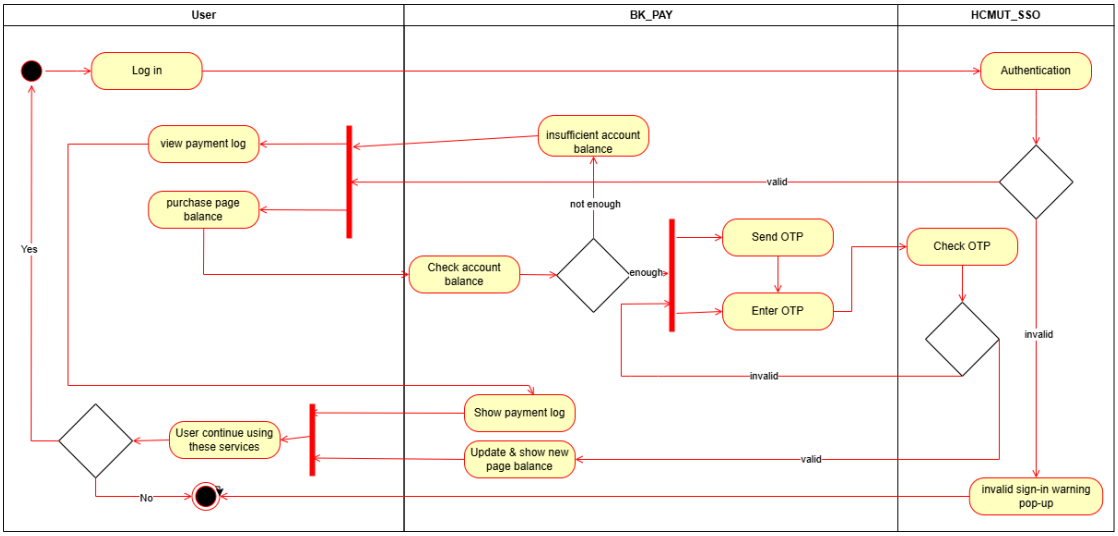

Figure 5. Payment Service

The payment service allows students to purchase additional printing credits and review their past payment history. Users must first log in to access these features.

If they choose to review past payments, they can view their transaction history. To purchase more pages, the system will check their remaining account balance. If the balance is insufficient, the user will receive a warning and be redirected to the payment interface. If the balance is sufficient, the user must enter the OTP code sent by BK_PAY to complete the payment, ensuring additional security through two-factor authentication (2FA). Once the payment is successful, both the account and page balances will be updated. The system will then ask if the user wishes to continue using the service.

3.4 Report Service

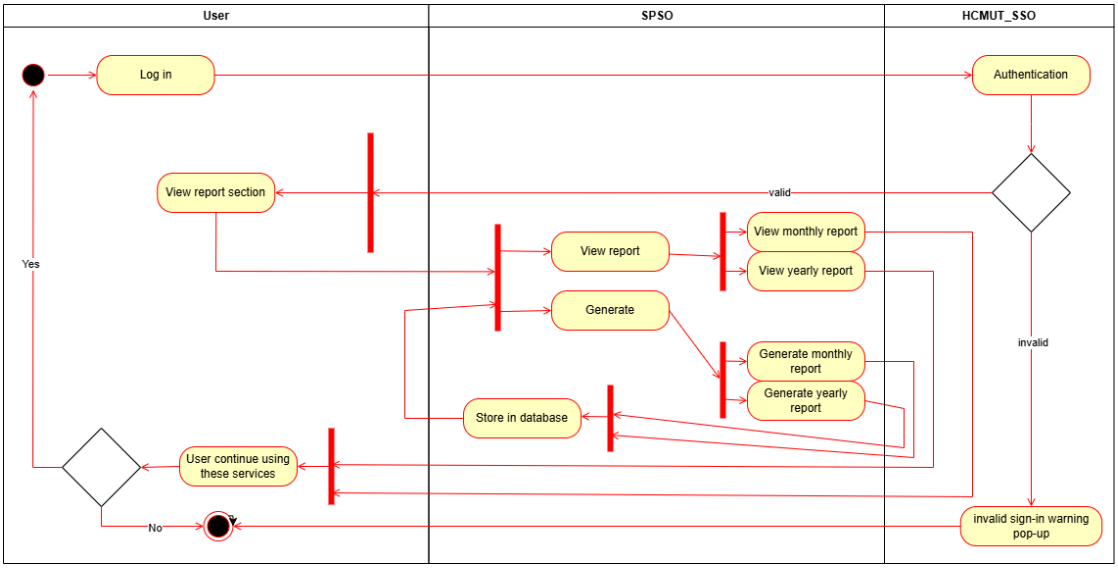

Figure 6. Report Service

The user report feature allows users to view their printing reports. First, users must log in. After logging in, they can access automatically generated reports from the past or create new weekly and yearly reports through Student Printing Service Officer. The generated reports are stored in the database.

4 Sequence Diagram

4.1 Login and Authentication

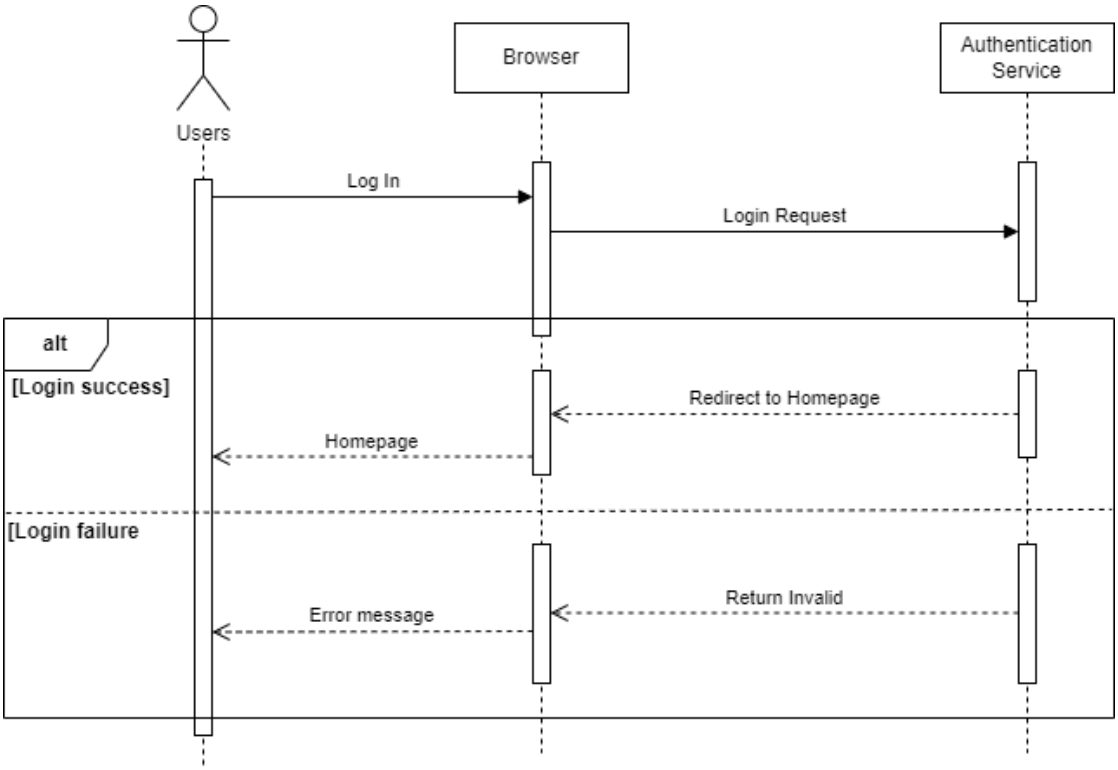

Figure 7. Login and Authentication

A user enters their email address and password for the login process, then the browser forwards to the Authentication service as a login request. The Authentication Service will verify the email address and password and then return either a successful login, then redirect to the homepage or a failure then display an error message.

4.2 Printer Management

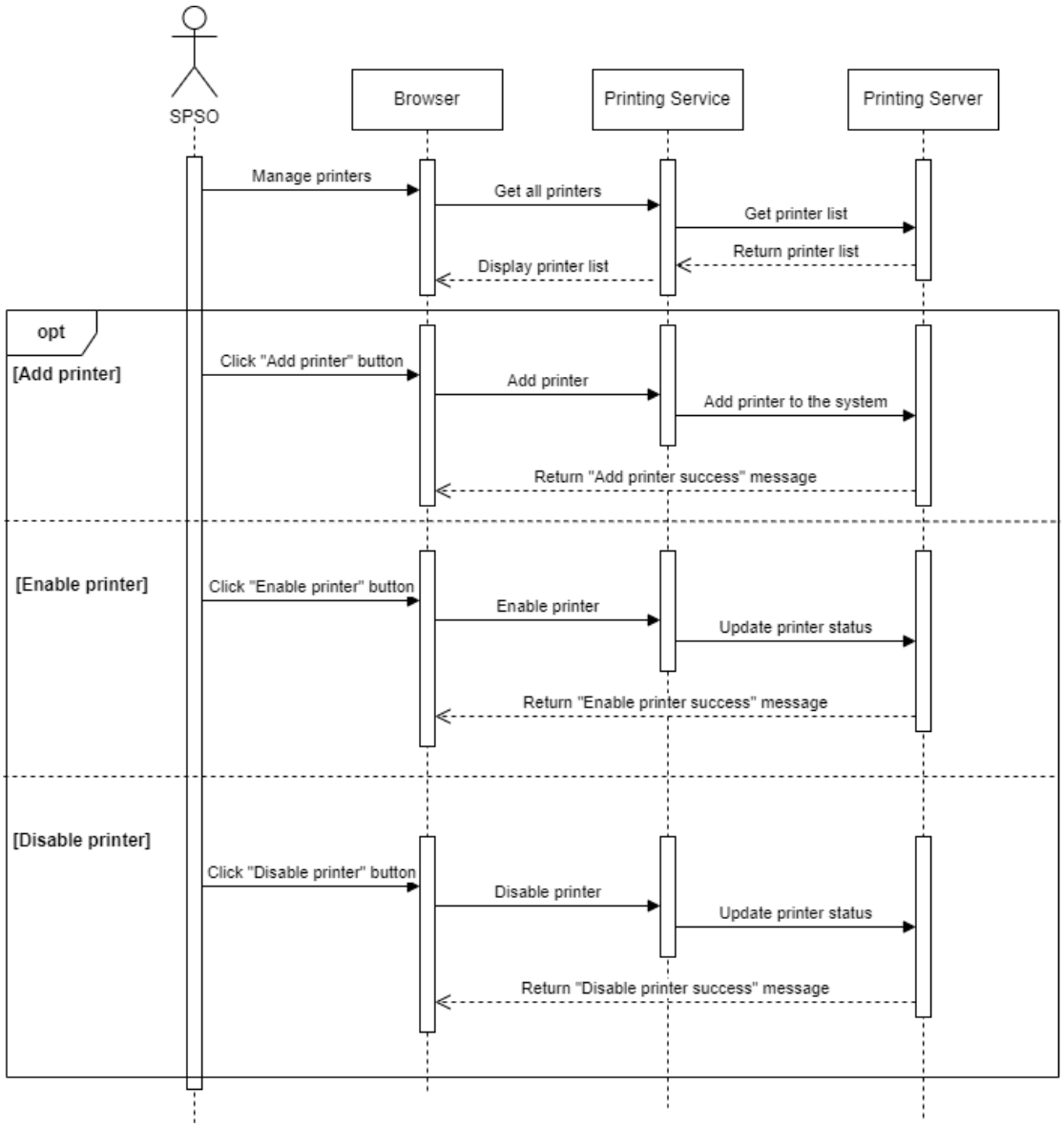

Figure 8. Printer Management

The Student Printing Service Officer (SPSO) wants to manage the printers in the office. They choose the “manage printer” in the browser, then the browser will send the get all printers to the printing service and the printing service will come to the printer server to get the printer list. The printing server then will return the list of printers to the printing service so they display to the SPSO via browser. After that, the SPSO will have three options: add printer, enable printer and disable printer. If the SPSO wants to add a new printer, they click the “Add printer” button in the browser. This action tells the browser to send an add printer request to the printing service.

The printing service then forwards this request to the printer server to add the printer to the system. The printer server then returns an "Add printer success" message to the printing service which is displayed to the SPSO through the browser. Similarly, to enable or disable a printer, the SPSO clicks the “Enable printer” or “Disable printer” button in the browser. The browser then sends a “enable/disable printer request” to the printing service, which contacts the printer server to update the printer status to enable/ disable the printer and return the message to the SPSO.

4.3 Viewing history

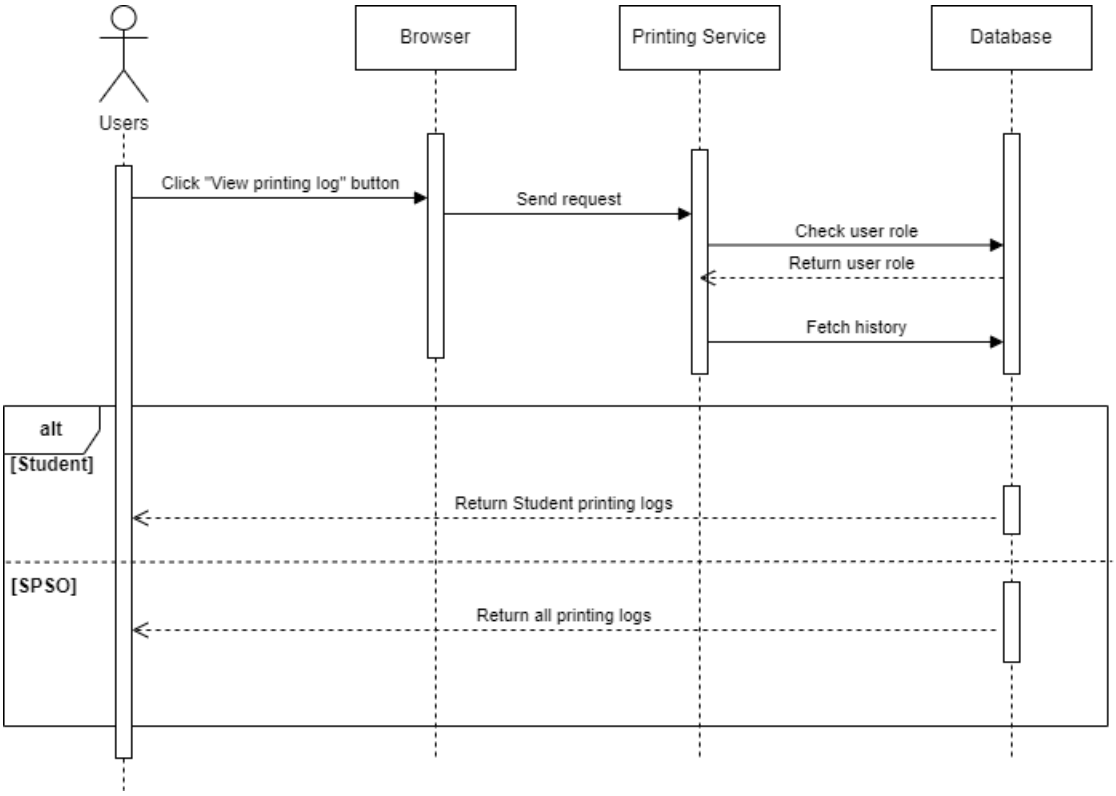

Figure 9. Viewing history

The user views the printing history by clicking on the “View printing log” button, then the browser sends the request to the printing service. The Printing Service then checks the user’s role by querying the database. The database returns the user’s role; if the user is a student, the system returns only the student’s printing logs; if the user is an SPSO, the system returns all available printing logs. Then the logs are sent back to the browser for the user to view.

4.4 Buy printing page

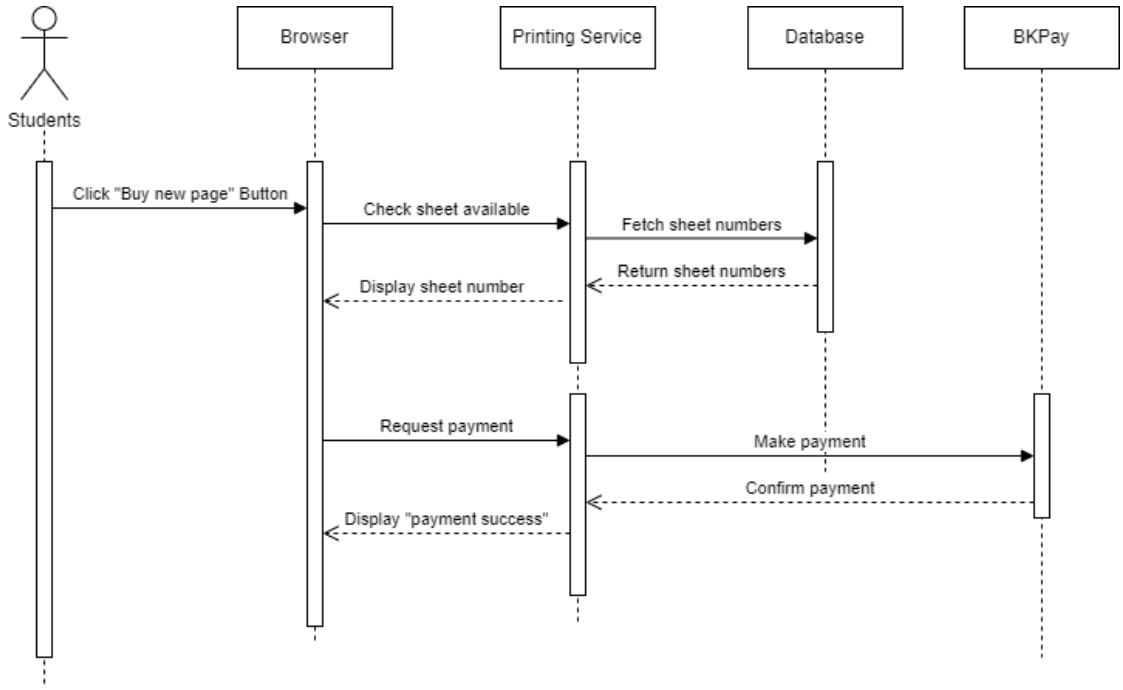

Figure 10. Buy printing page

The user buys new pages by clicking on the “By new page” button. Then the browser sends a request to the Printing Service to check the number of available sheets. The Printing Service then queries the database to fetch the available sheet numbers and return to the printing service, then display to the user via browser. After that, once the user confirms the request payment, the browser sends a payment request to BKPay, which processes the payment. When the payment is successful, it will return to the printing service so as to display a “payment success” to the user through the browser.

4.5 Printing Service

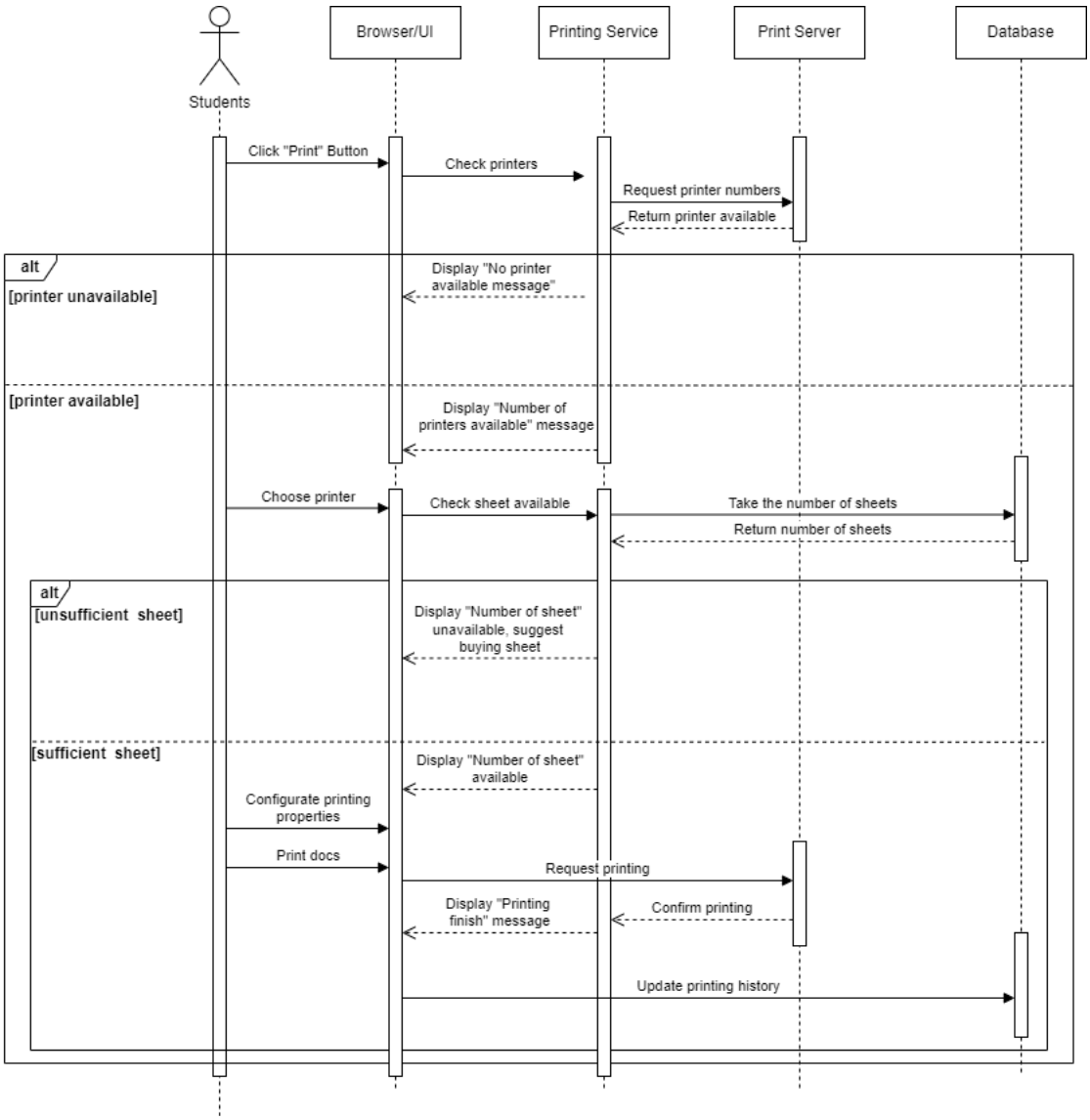

Figure 11. Printing Service

The student prints the document by clicking on the “Print” button. Then the browser sends a request to check the availability of printers through the Printing Service. The Printing Service requests the number of the availability printers from the printing server. If no printers are available, the system displays a "No printer available" message; otherwise, the remaining printer is displayed to the student. The student then selects a printer, and the system will check the availability of sheets by querying the database. If there are insufficient sheets, a message is displayed, suggesting the student purchase more sheets. If the number of sheets is available, the student continues by configuring printing properties and initiating the print request. The

Printing Server then processes the printing job, and once completed, the Printing Server will send a “confirm printing” logs to the printing service, then display a "Printing finish" message to the student and update the user’s printing history in the database.

5 Class Diagram

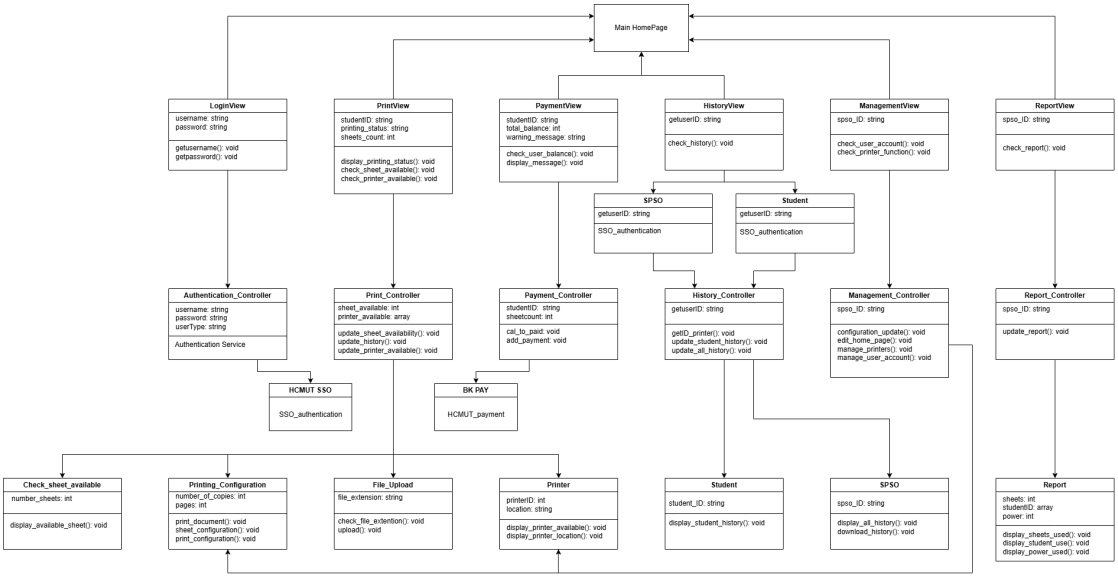

Figure 12. Class Diagram

Below is the class diagram created in drawio. You can see the complete diagram at this Drawio link.

The class diagram outlines a comprehensive school management system, covering areas like printing services, payment processing, user history tracking, and report generation. It includes a **LoginView** class for user authentication, linked to a **LoginController**. There’s an inheritance structure where **SPSO** classes inherit from **Student** and **User**, representing different user types. The **HistoryController** is connected to two views, suggesting it handles historical data for both staff and students. The **ReportController** oversees report generation, while the **PaymentController** manages financial transactions. The **Printer** class is closely integrated with **PrintProperties** and **DocumentUpload**, showing that printing is a key feature of the system.

Overall, the diagram suggests a robust, modular system that handles administrative tasks efficiently, maintaining a clear separation of concerns for easier maintenance and scalability.

6 MVP Wireframe (2.4)

6.1 Student View

Below is the MVP wireframe created in Figma. You can see the complete diagram at this Figma link. The MVP (Minimum Viable Product) wireframe for the "Student Smart Printing

Service" provides a clear and intuitive interface that caters to the core functionalities of the system.

6.1.1 Dashboard

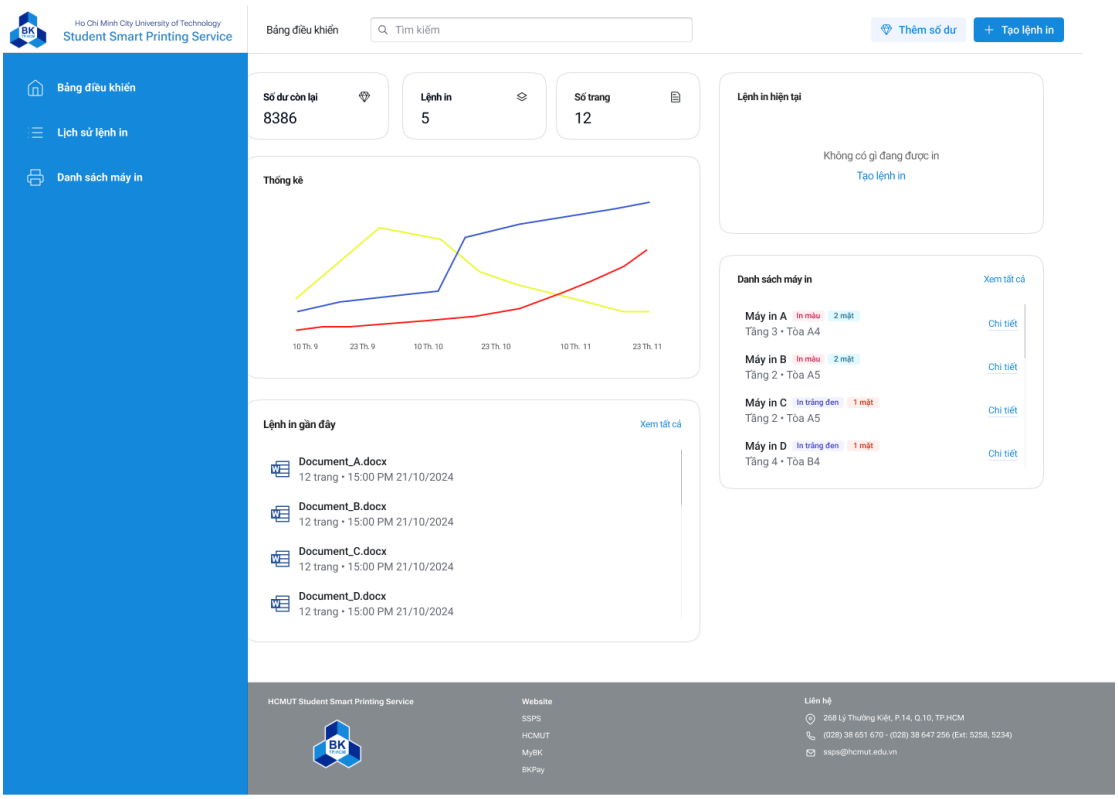

Figure 13. Dashboard

As seen in the dashboard design, users can easily track their printing credit balance, number of pending print jobs, and recent printing history.

The inclusion of statistics, such as page count and real-time updates on printer status, ensures a seamless experience for students managing multiple print tasks. Furthermore, the interface clearly highlights available printers and their respective locations, offering detailed machine information. The sidebar contains links that enable users to access different features of the application.

6.1.2 Create printing job

From the dashboard, clicking on "Tạo lệnh in" on the top right will open the Print dialog.

1. **File Upload and Seclect**

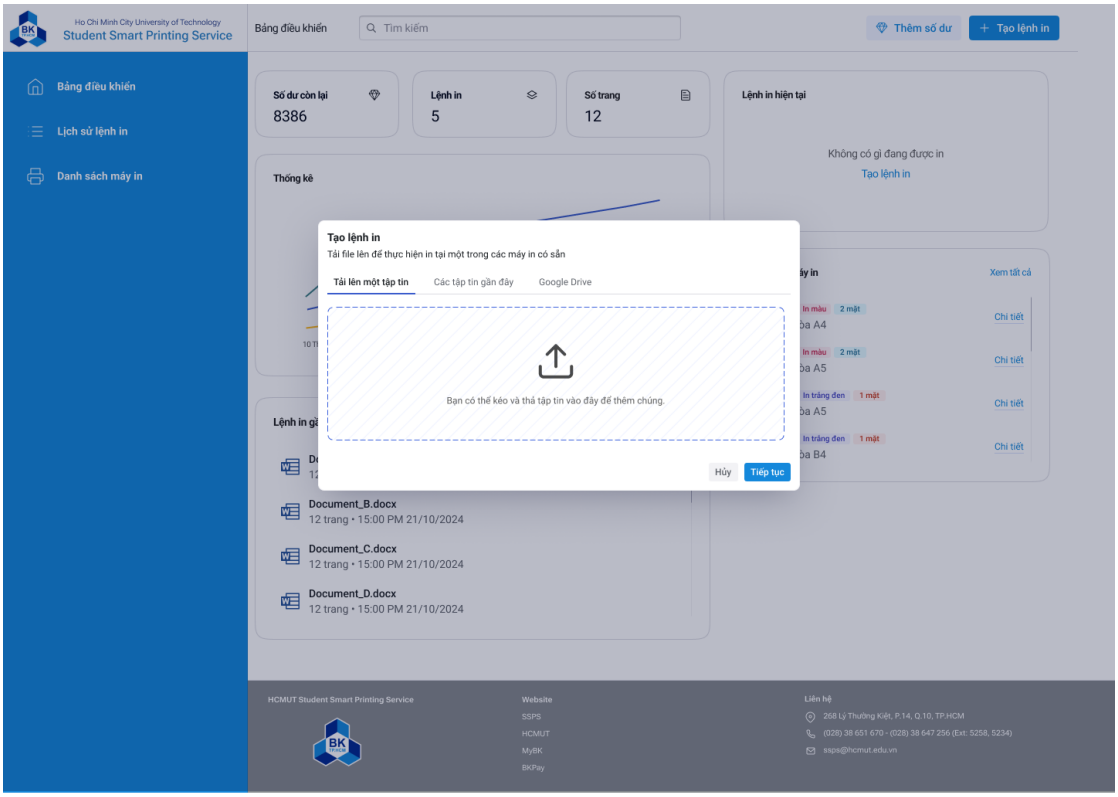

Figure 14. Print Dialog - Upload file

The user has the option to upload a new file, choose from recently uploaded files, or select a file through integrated storage providers like Google Drive, OneDrive, and others.

2. **Printer Selecting**

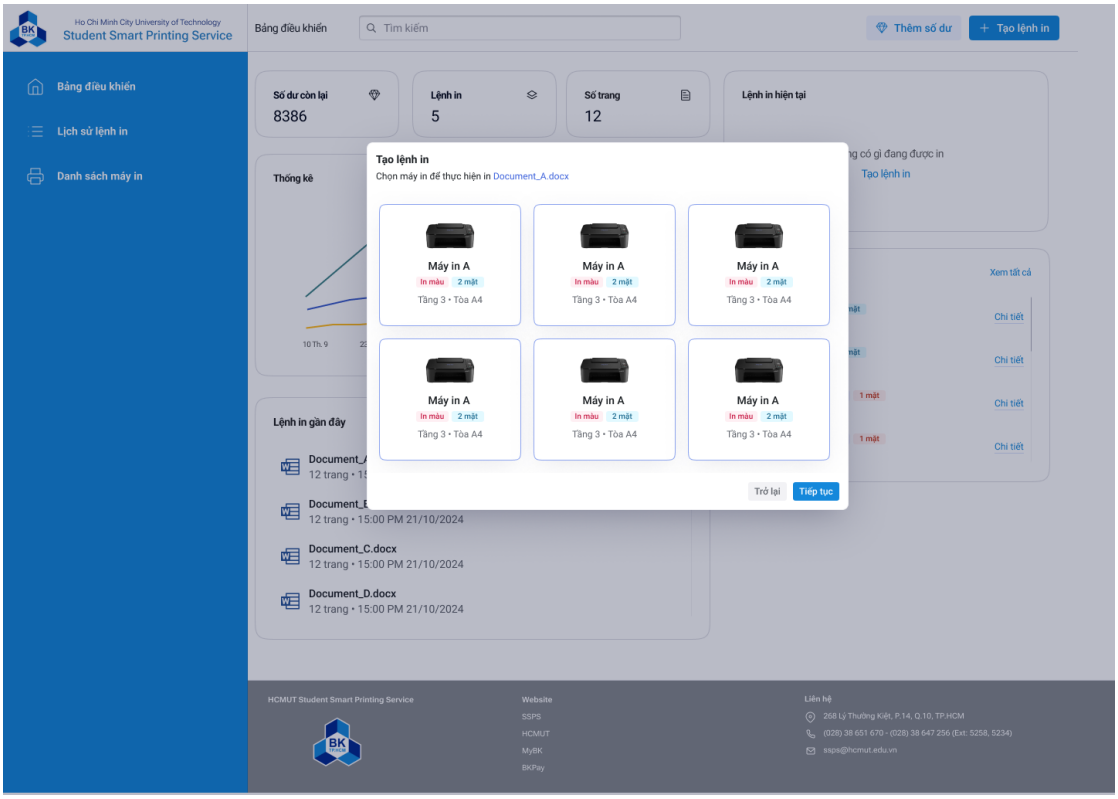

Figure 15. Print Dialog - Printer Select

Once a file is selected, the user must choose the printers they wish to use. Each printer card displays details such as the printer's capabilities and its location.

3. **Select Propertises**

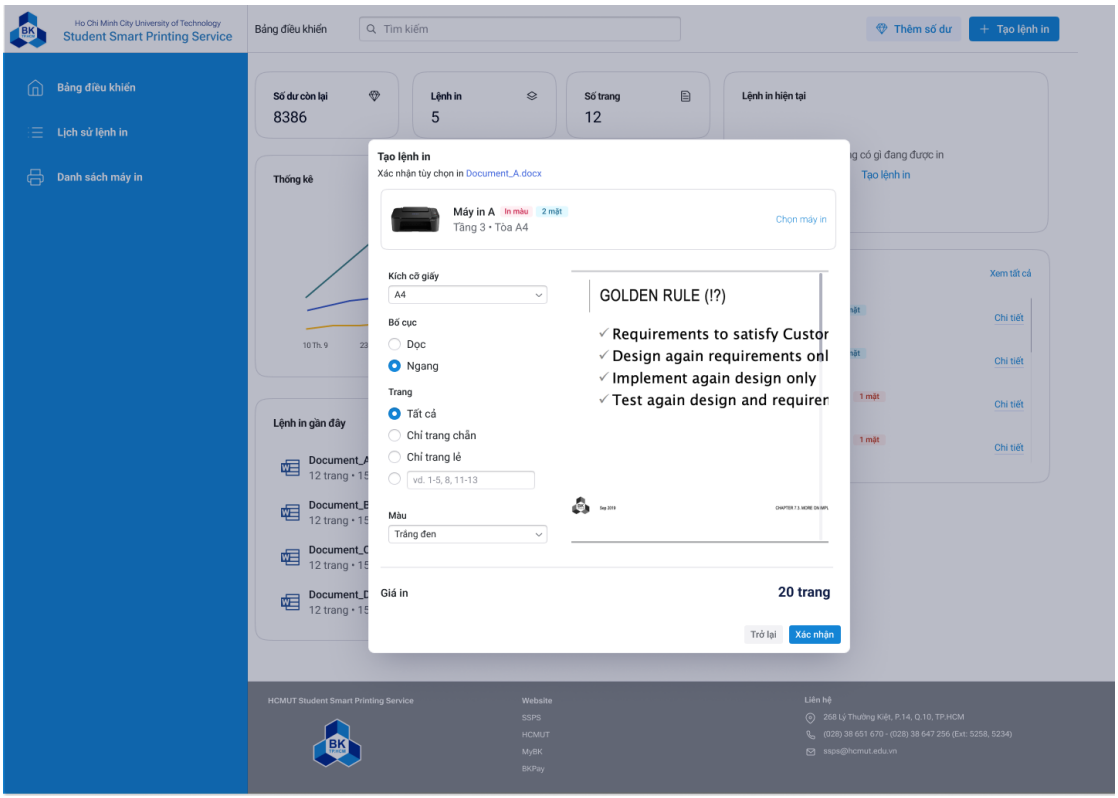

Figure 16. Print Dialog - Print Properties

Finally, the user will need to choose the print properties for their file. The available options will depend on the configuration of the selected printers.

6.1.3 Print History

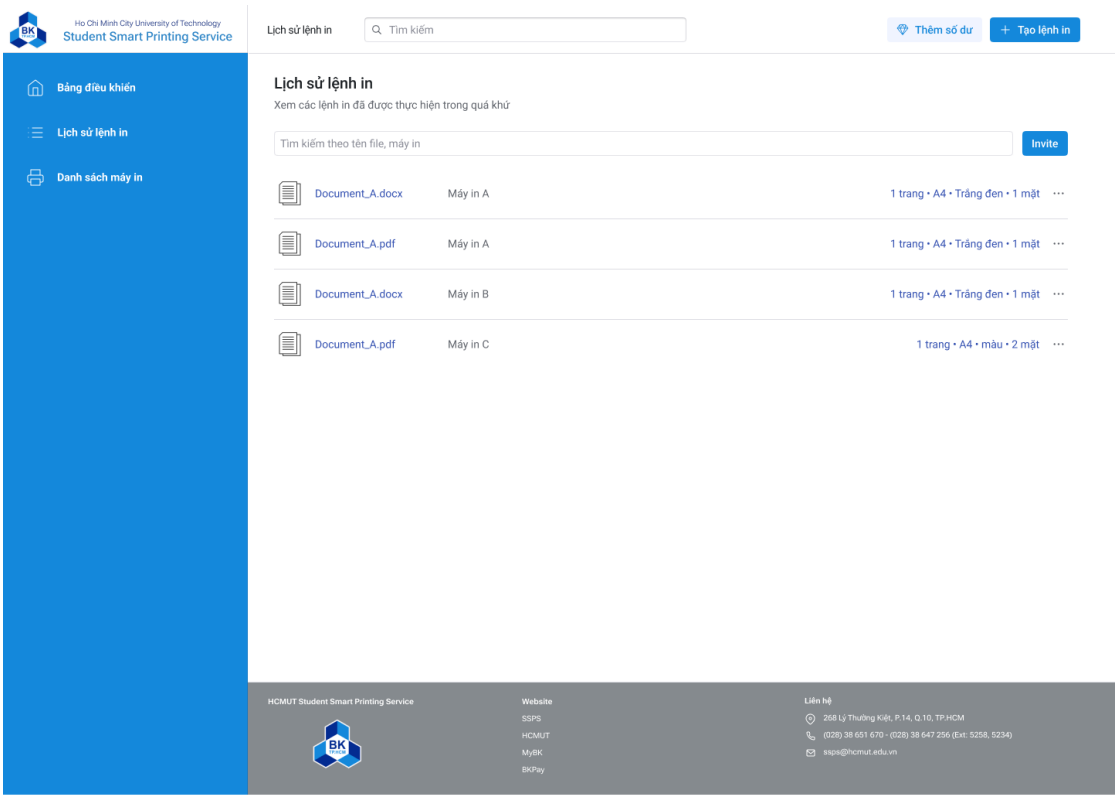

Figure 17. Print History

The Print History screen enables users to review all their previous print requests and check the status of any ongoing print jobs.

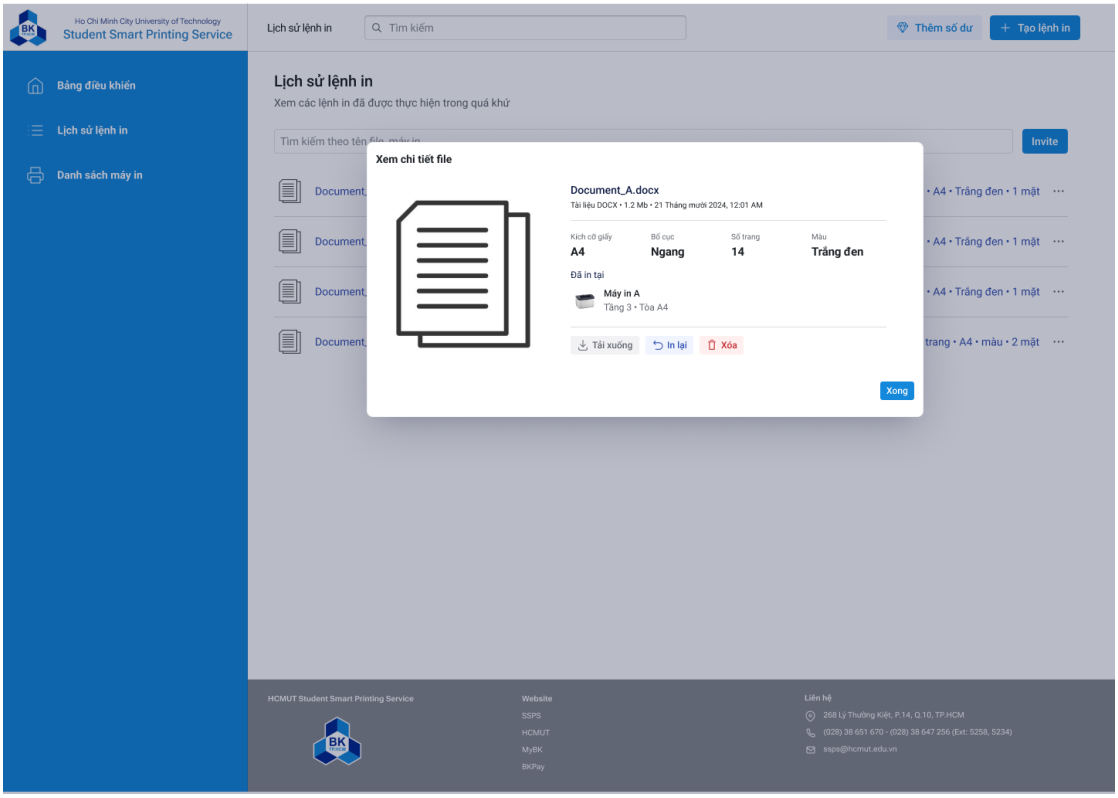

Figure 18. Print history in Detail View

By clicking on an item from the list, the user can access the detailed view, where they can see all relevant information and perform actions such as "Reprint the file," "Download the file," or "Delete the file."

6.1.4 Printer List

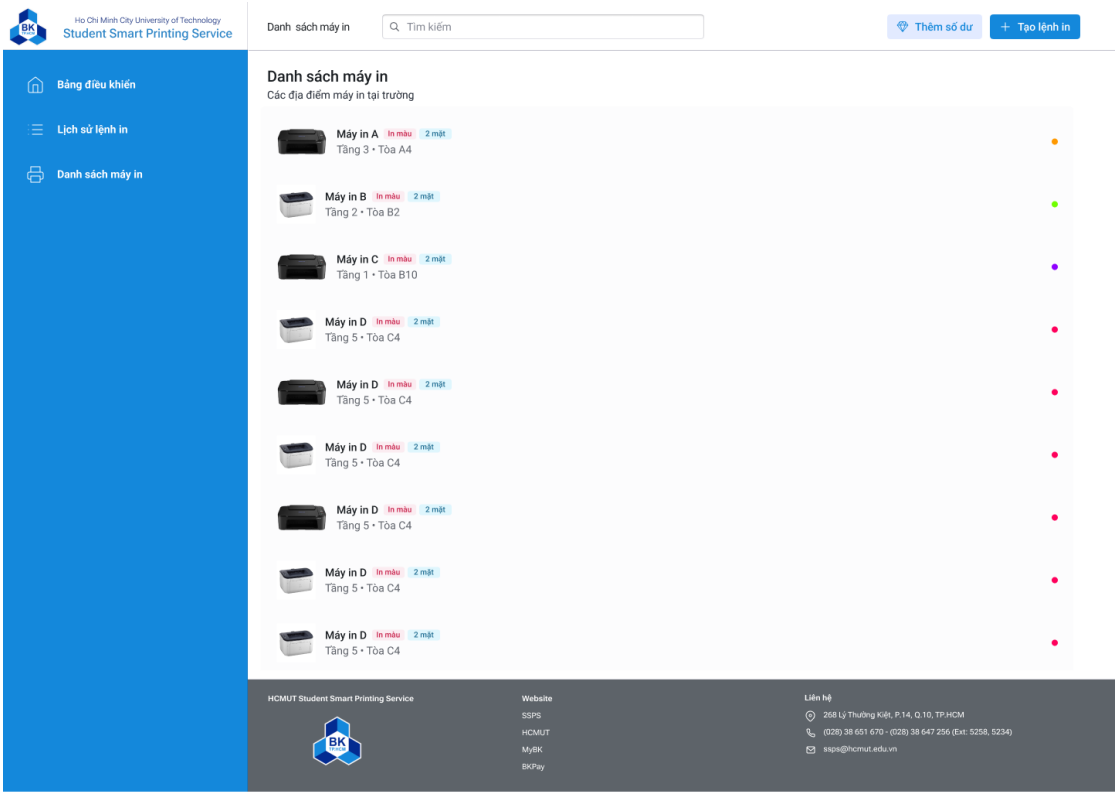

Figure 19. Printer List

The Printer List view provides users with a comprehensive overview of all available printers, along with their capabilities and locations.

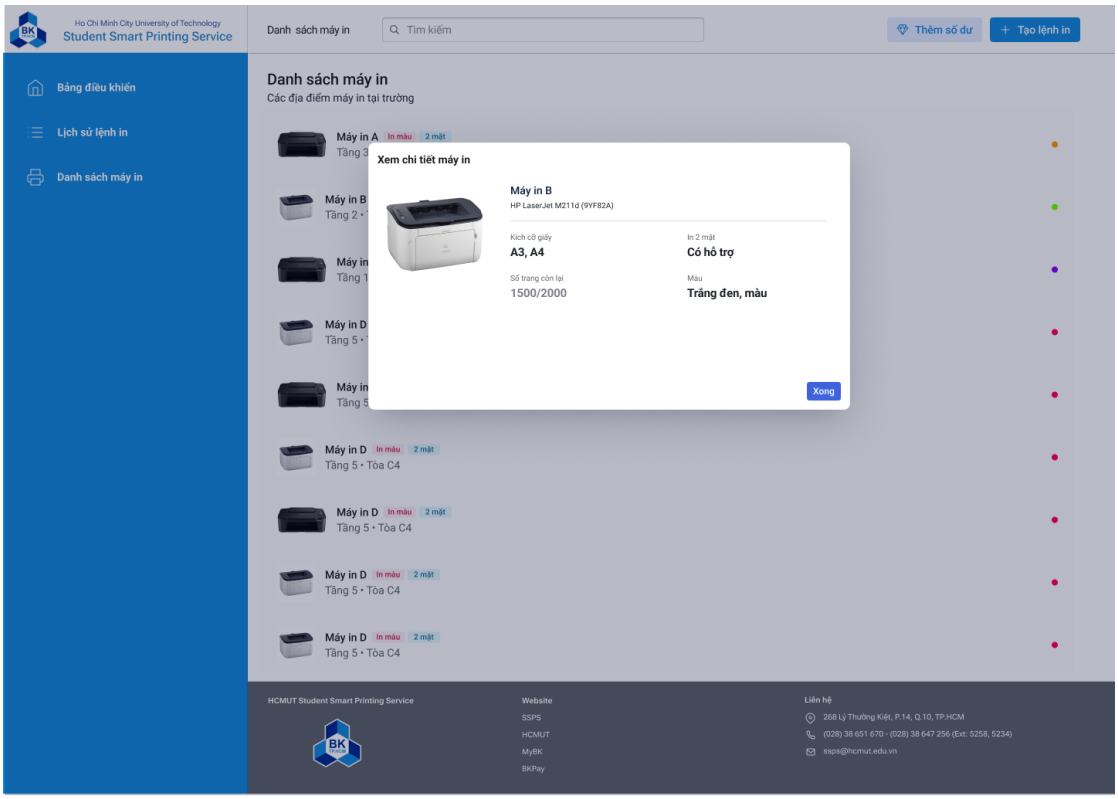

Figure 20. Printer List in Detail View

6.2 Admin View

6.2.1 Dashboard

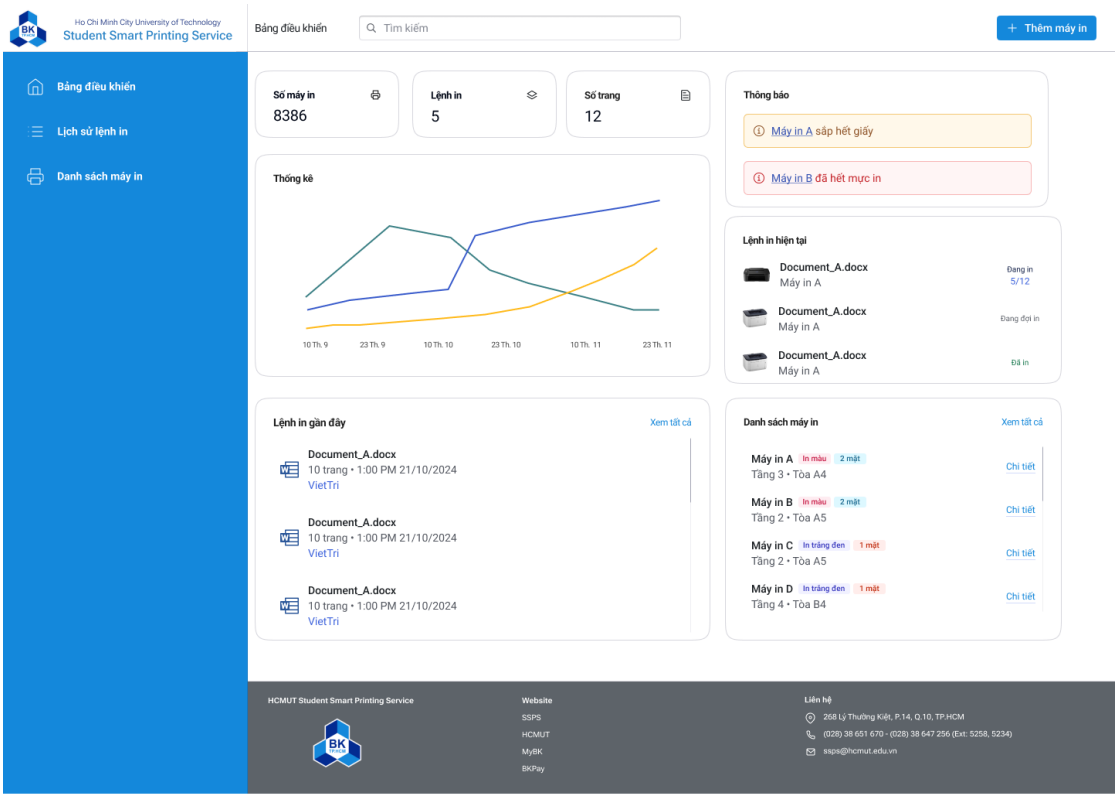

Figure 21. Dashboard

The Dashboard admin view is accessible via the same URL as the student view. However, the content displayed varies based on the user's account role. In addition to showing printing statistics, the admin dashboard offers a broader perspective by aggregating data from all students, allowing administrators to monitor overall system usage. This view includes total print jobs, pages printed, and resource usage, which can be valuable for analyzing trends, optimizing printer management, and identifying potential issues such as high-volume usage or technical problems.

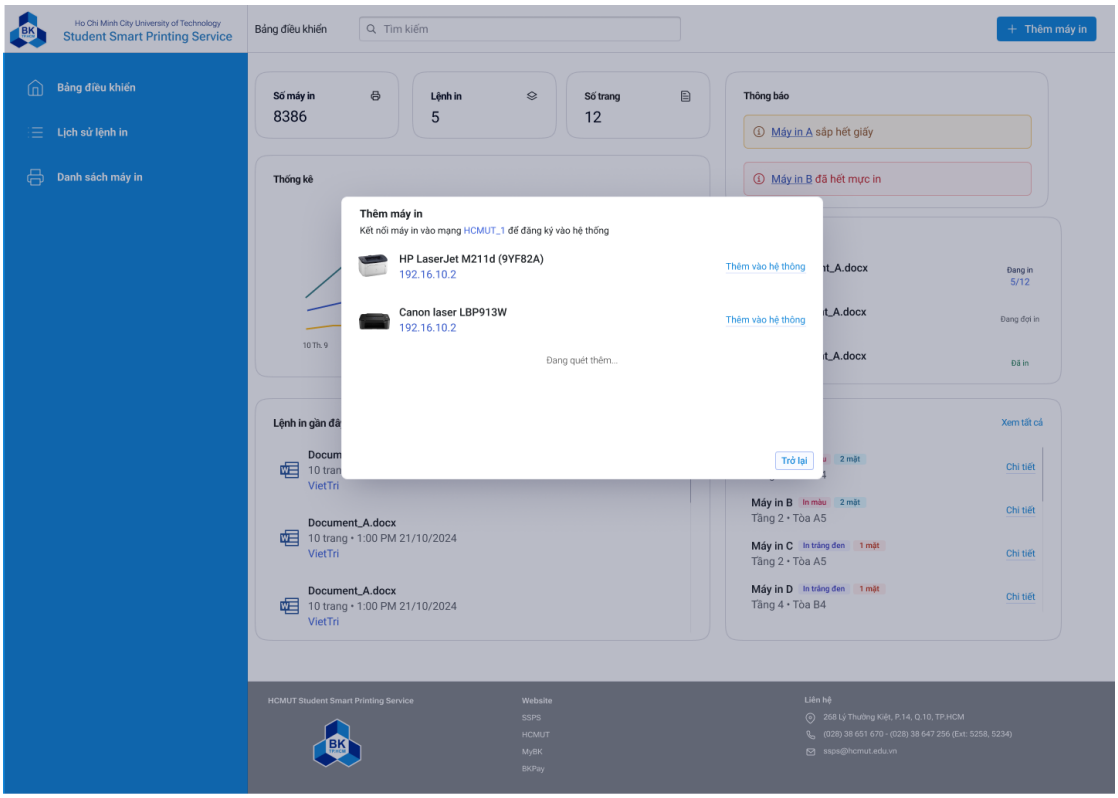

Figure 22. Add new printer

The admin has the ability to add new printers by clicking the "Thêm máy in" button located in the top right corner. Afterward, they can either select a printer that is discoverable on the network or manually enter an IP address to connect the printer.

6.2.2 Printer List

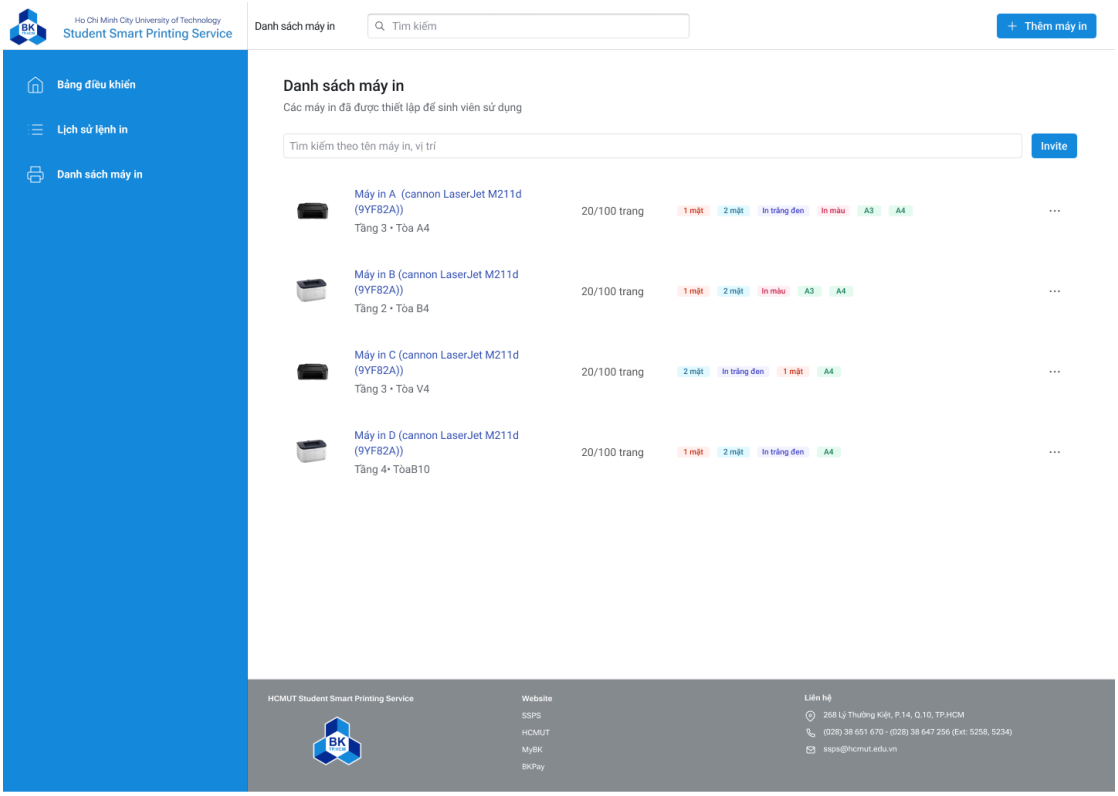

Figure 23. Printer List

The admin printer list displays all printers along with their configurations. By clicking on a specific printer, the admin can open the printer configuration dialog, where they can view and modify the printer's settings as needed.

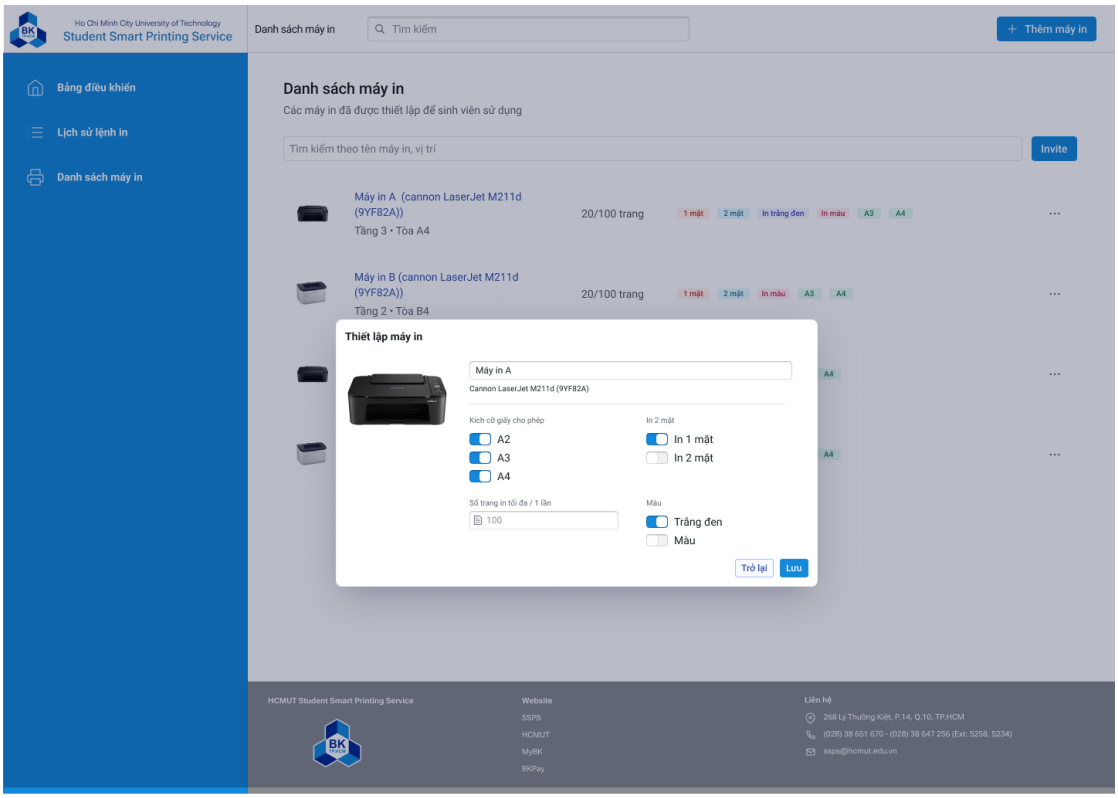

Figure 24. Configure Printer

The admin can then configure the printer properties, which will define the available options for users when they submit a print request. These configurations control aspects like paper kind,or other customizable settings based on the printer's capabilities.

7 Layered Architecture

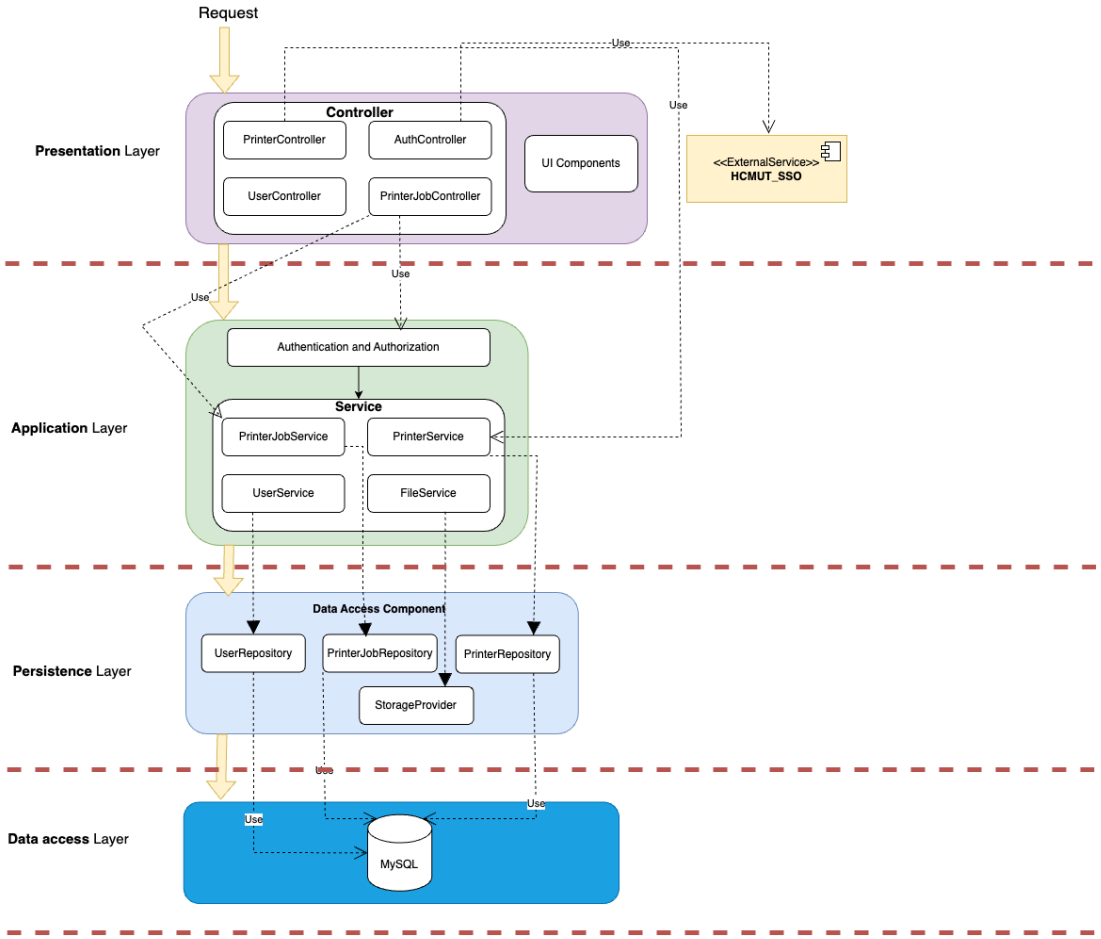

Figure 25. Architecture Diagram

The architecture diagram above is structured into a four-layer architecture, each serving distinct functions.

In the designed architecture of our system, data is structured to flow in one direction, where each higher layer retrieves data from the layer below it, without any reverse flow of data from lower layers back to the upper ones.If the system does not maintain a unidirectional flow of data, issues such as cyclic dependencies may arise. For example, if a presentation component retrieves data from a business logic component, which then tries to pull data from the presentation component, it creates a circular dependency. This can lead to increased coupling, where components are tightly interconnected, making the system more complex and difficult to manage or modify.

7.1 Presentation Layer

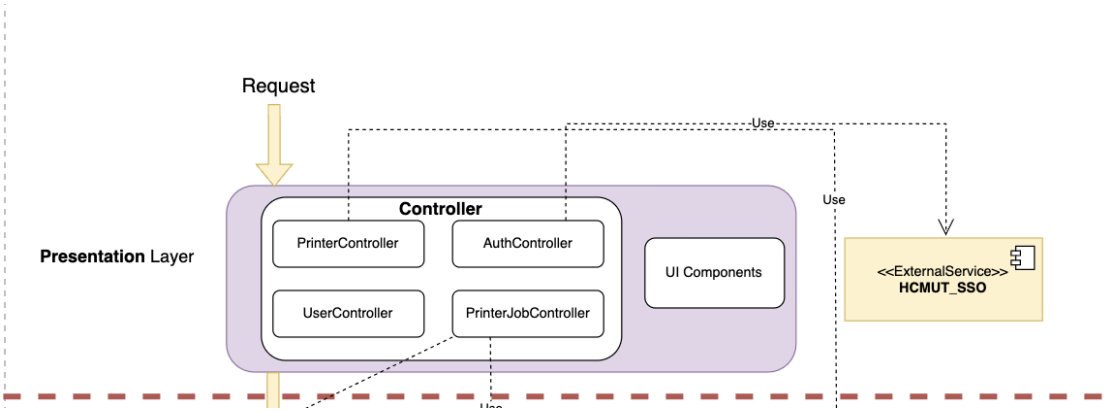

Figure 26. Persistence Layer

Presentation Strategy:

Our presentation layer is designed with a focus on separating the user interface from the business logic, ensuring that each controller handles specific user interactions seamlessly. The PrinterController, AuthController, UserController, and PrinterJobController are configured to manage different aspects of user requests effectively, directing these requests to appropriate services in the application layer. This modular approach improves maintainability and scalability, as UI components can be updated or replaced with minimal impact on the underlying logic. This strategy aligns with best practices recommended in Microsoft's MVC guidelines, which advocate for a clear separation of concerns Microsoft's MVC Guide[1].

Response Formation and UI Display:

- The controller layer then constructs an appropriate response based on the results obtained from the service layer. This response might include data to be displayed or a confirmation of successful operation.
- The response is relayed back to the client, where the presentation layer updates the user interface to reflect the new state or provide feedback based on the operation performed.

Controllers in the presentation layer manage crucial functions such as redirecting users to external authentication services like HCMUT_SSO and handling callbacks to complete the authentication process. Additionally, before passing user input to lower layers, controllers ensure that all data is properly validated and formatted. This not only secures the application by preventing common vulnerabilities but also maintains the integrity and consistency of the data processed by the application.

7.2 Application Layer

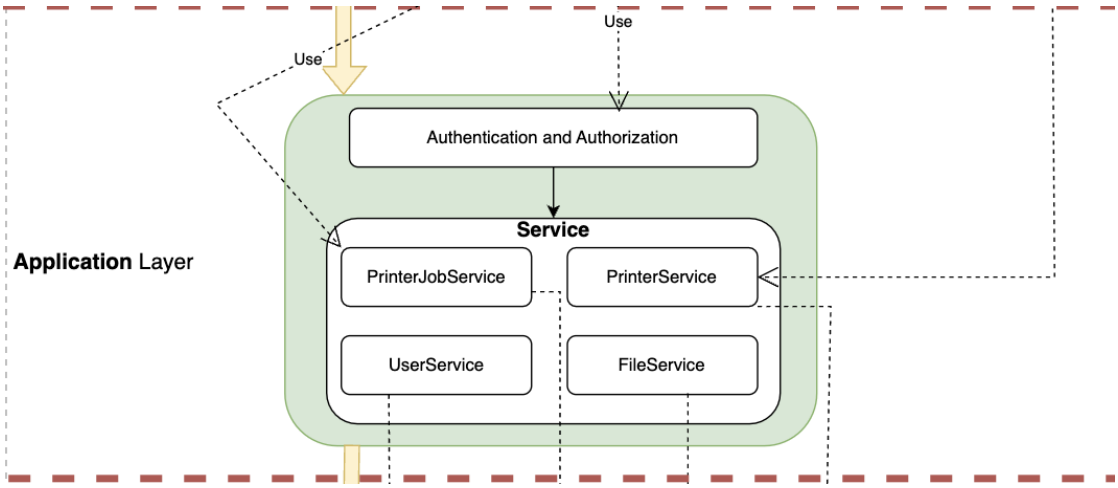

Figure 27. Application Layer

7.2.1 API Management

API management is handled through a well-structured service layer that mediates communication between the presentation layer and the data access components. This layer is crucial for the authentication and authorization of user requests, interfacing with external services like HCMUT_SSO for security purposes. By implementing a service-oriented architecture (SOA), we ensure that our services are reusable across different parts of the application and are easier to manage.

7.2.2 Authentication and Authorization Processes

- Authentication: Initially, the user's identity is verified using the AuthenticationService within the business logic layer. This step confirms that the user is indeed who they claim to be, a process typically facilitated by checking credentials against stored data.
- Authorization: Subsequent to authentication, the Authorization logic takes over to determine the user's rights. It ensures that users access only the resources pertinent to their privileges. For instance, a regular user can only view or manipulate their uploaded documents, while administrative rights are required to alter printer configurations.

7.2.3 Service layer

- PrinterJobService: Manages the queueing, scheduling, and execution of print jobs.
- PrinterService: Directly handles the communication with physical or virtual printers.
- UserService: Manages user profiles, including credentials, preferences, and settings.
- FileService: Responsible for file management tasks such as storage, retrieval, and sharing of documents.

7.3 Persistence Layer

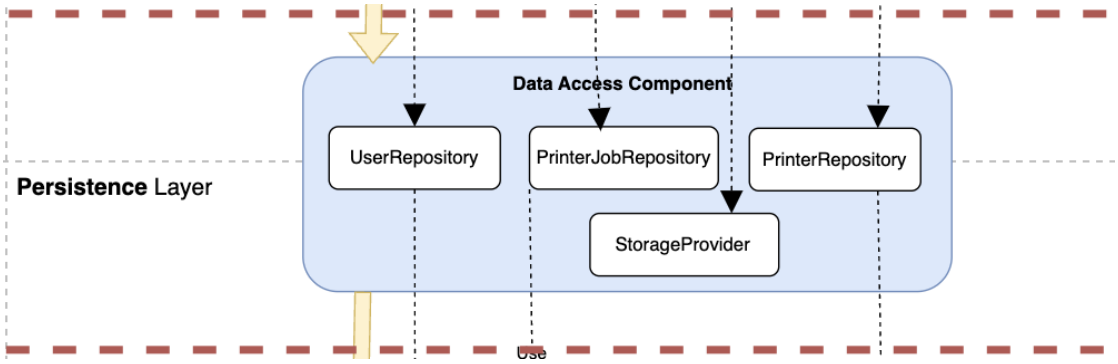

Figure 28. Persistence Layer

7.3.1 Data Storage Approach

Our application employs a robust data storage strategy using MySQL as the foundational database within the Data Access Layer, managed through various repositories like UserRepository, PrinterJobRepository, and PrinterRepository.

7.3.2 Description about layer

This layer acts as an abstraction that not only handles CRUD operations efficiently but also ensures that modifications to the data schema do not impact the higher layers. By using repository patterns, we encapsulate the logic required to access data sources, which helps in keeping the data access layer scalable and interchangeable.

Acting as an intermediary between the Service and underlying data provider, this layer consists of repositories for consistent and secure data transactions. They are abstractions to manage data storage and retrieval processes (operations to save, update, delete and query data). The abstraction of data source is helpful because it allows changes in the data storage without impacting the higher layer

7.4 Data Access Layer

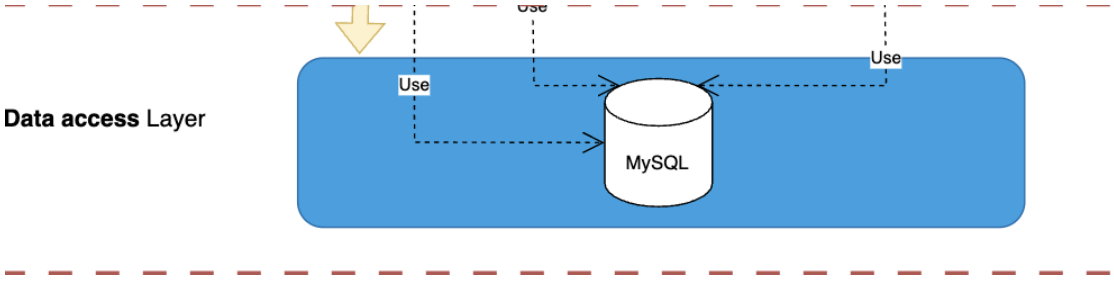

Figure 29. Data Access Layer

This layer manages all database operations including CRUD operations (Create, Read, Update, Delete) and querying data. It acts as the interface between the higher application layers and the database, ensuring that data retrieval and manipulation are efficiently handled.

8 Component Diagrams

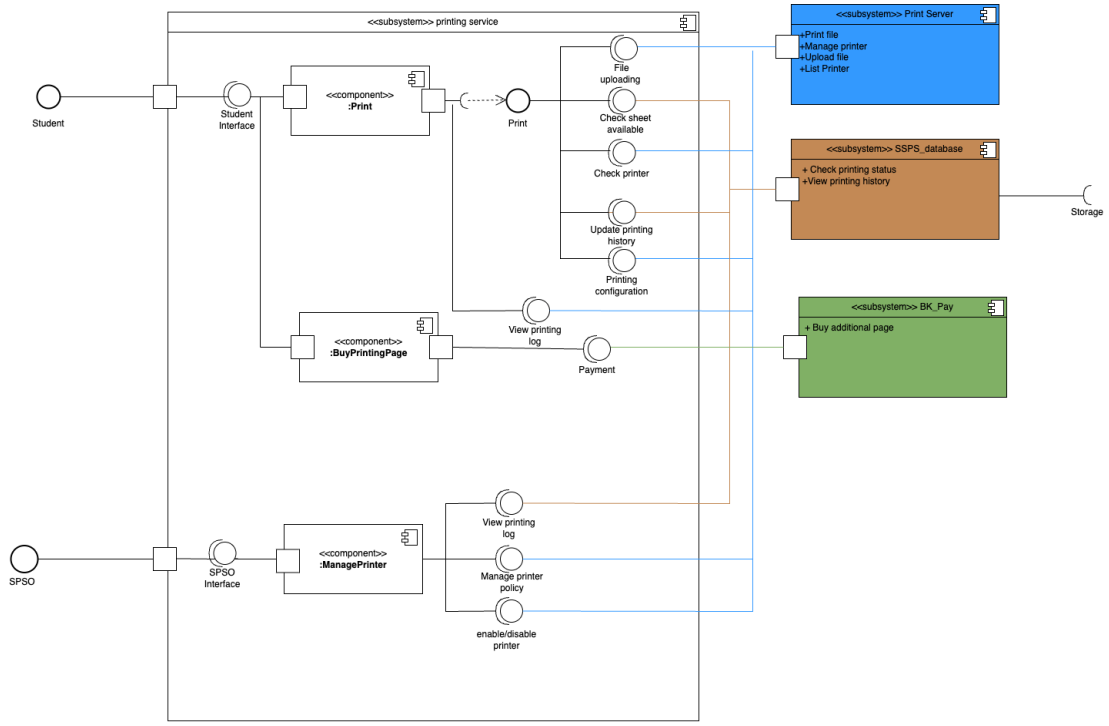

Figure 30. Printing Service Component Diagram

This diagram represents the architecture of the printing service system with several key components:

- Student: Represents the user component interacting with the system. Through the Student Interface, students can access functionalities such as uploading files, checking printer status, and purchasing additional printing pages.
- SPSO: A component responsible for managing and adjusting printing services. Using the SPSO Interface, SPSO staff can manage printer settings, view printing logs, and set printer policies.
- Print Component: This component allows students to print and configure print requests. It provides access to sub-functions such as File uploading, Check sheet availability, Check printer, Update printing history, and Printing configuration.
- Print Component: This component allows students to print and configure print requests. It provides access to sub-functions such as File uploading, Check sheet availability, Check printer, Update printing history, and Printing configuration.

- BuyPrintingPage Component: This component manages the purchase of additional printing pages by integrating with the BKPay subsystem.
- ManagePrinter Component: Accessible by the SPSO, this component offers printer management features, including View printing log, Manage printer policy, and Enable/disable printer. It provides SPSO with control over printer operations and policy settings.
- BuyPrintingPage Component: This component manages the purchase of additional printing pages by integrating with the BKPay subsystem.
- ManagePrinter Component: Accessible by the SPSO, this component offers printer management features, including View printing log, Manage printer policy, and Enable/disable printer. It provides SPSO with control over printer operations and policy settings.
- Subsystems:
  - Print Server: A back-end subsystem responsible for handling core printer interactions, including printing files, managing printer configurations, file uploads, and listing available printers.
  - SSPS Database: A storage subsystem that maintains essential data for the system, such as printing status and printing history for monitoring and printing history.
  - BKPay: An external payment subsystem used for handling student payments when they purchase additional pages.

References

[1] Microsoft. *Overview of ASP.NET Core MVC*. Accessed: 2023-11-01. 2022. URL: https://docs.microsoft.com/en-us/aspnet/core/mvc/overview.