VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

SOFTWARE ENGINEERING

A smart printing service for students at HCMUT

SMART PRINTING SERVICE

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1 Overview

Domain Context: The domain of interest is the educational sector, specifically the student printing services at a university. HCMUT, like many higher institutions, requires efficient services that cater to the academic requirements of its student body. Students frequently need to print assignments, project reports, thesis papers, and various other documents. Providing a centralized printing service facilitates and ensures easy access and streamlined processing for these requirements.

Stakeholders and Their Needs: There are primarily two stakeholders:

a. **Students**: They require a hassle-free, accessible, and efficient printing service to cater to their academic needs. A system that allows them to upload files, choose specific printing properties, view their printing history, and top up their printing quota as needed is vital. Being able to access this service both on the web and mobile is crucial for on-the-go students.

b. **Student Printing Service Officer (SPSO)**: The SPSO is responsible for the management and maintenance of this system. They need to oversee printer availability and status, configure system properties, monitor student printing activities, and generate periodic usage reports.

Benefits for each Stakeholder:

a. **Students**, HCMUT-SSPS ensures a seamless printing experience. They can easily select their desired printer based on location and specs, customize their printing needs, and monitor their usage. This reduces time spent on manual printing processes and ensures they always have access to essential services.

b. **SPSO**, this service provides a centralized platform to manage, monitor, and report on the entire printing infrastructure of the

university. It simplifies administrative tasks, ensures service quality, and provides insights for continuous improvement.

2 Requirements

2.1 Functional Requirements

For **Students**:

- Students must be able to upload specific file types for printing.

- Students should be able to select a printer based on its ID, location, or other details.

- Students must have the option to specify printing properties like paper size, one-/double-sided printing, number of copies, etc.

- Students should be able to view their printing history for a specified time period.

- Students must be able to buy additional printing pages.

For **SPSO**:

- The SPSO should be able to add, enable, or disable a printer.

- The SPSO must have the ability to change system configurations such as permitted file types and default page allocations.

- The SPSO should be able to view the printing history of all students or a specific student for a specified time period and printer.

- The SPSO must be able to access monthly and yearly generated system usage reports.

2.2 Non-Functional Requirements

a. **Performance:** The system should be able to handle multiple student print requests concurrently without significant delays.

b. **Usability:** The system's user interface, whether web or mobile-based, must be intuitive and user-friendly, allowing students and SPSO to easily understand and use the system without requiring extensive training.

c. **Security:** Authentication is necessary for all users. All interactions with the system, especially financial transactions, should be encrypted to protect students' and SPSO's data.

d. **Scalability:** The system should be scalable, supporting the potential addition of more printers and increasing numbers of students.

e. **Reliability:** The system should have a high uptime, ensuring that students can print their documents whenever they need. It should also handle errors gracefully, giving users informative messages if something goes wrong.

f. **Interoperability:** The system should be compatible with the HCMUT_SSO authentication service and the university's BKPay system.

g. **Maintainability:** SPSO should be able to easily update system configurations, manage printers, and adjust default page numbers without requiring extensive system downtime or complex processes.

h. **Accessibility:** The system should cater to a wide variety of devices, including both desktop and mobile, and should be responsive to different screen sizes and resolutions.

i. **Data Retention and Backup:** Printing logs and monthly/yearly reports should be stored safely, and there should be a system for backup and recovery in case of data loss.

j. **Integration:** The system should seamlessly integrate with other platforms used within the university, such as online payment systems, without causing discrepancies or issues in data transfer.
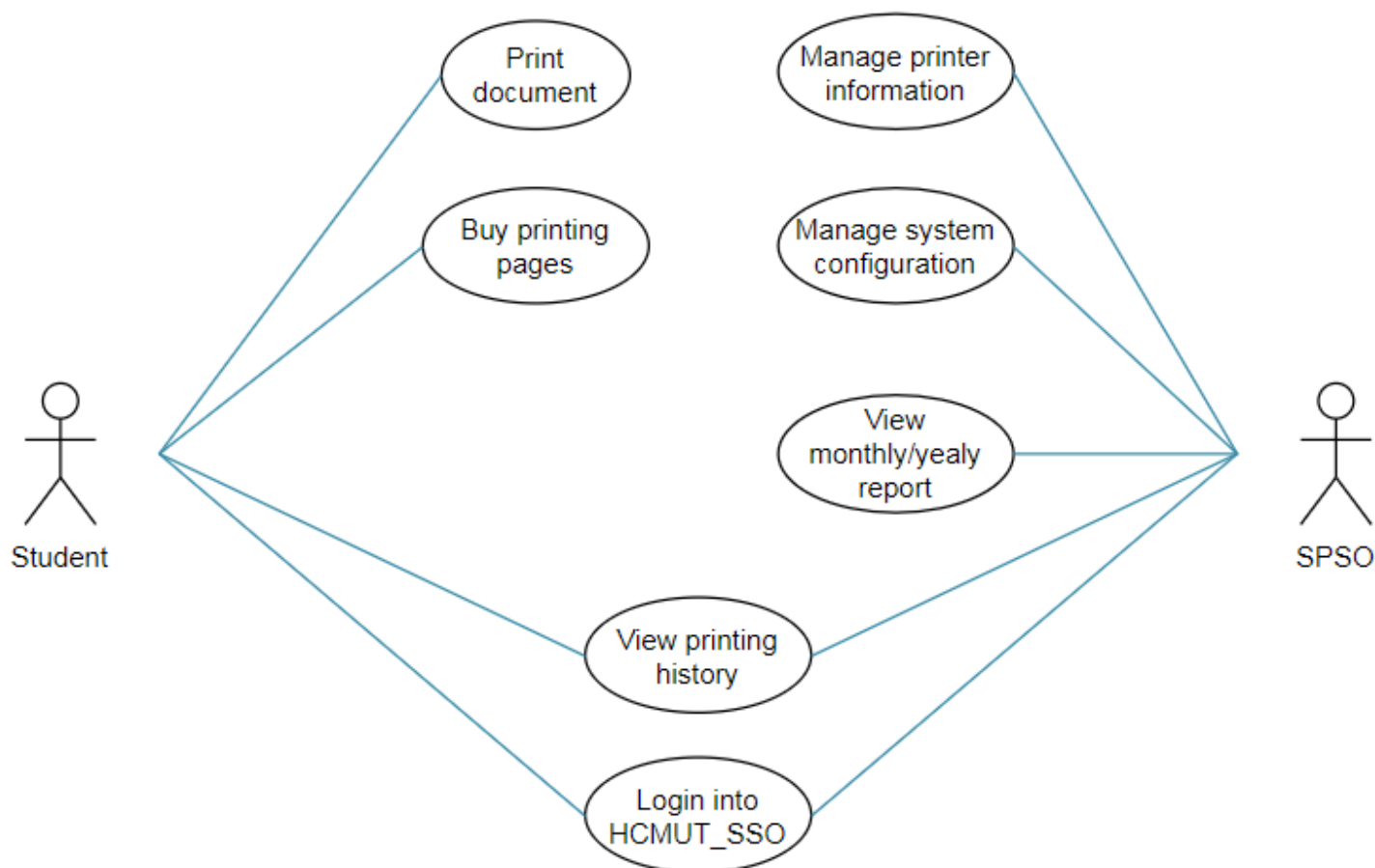
3 Use-Cases

3.1 Whole System

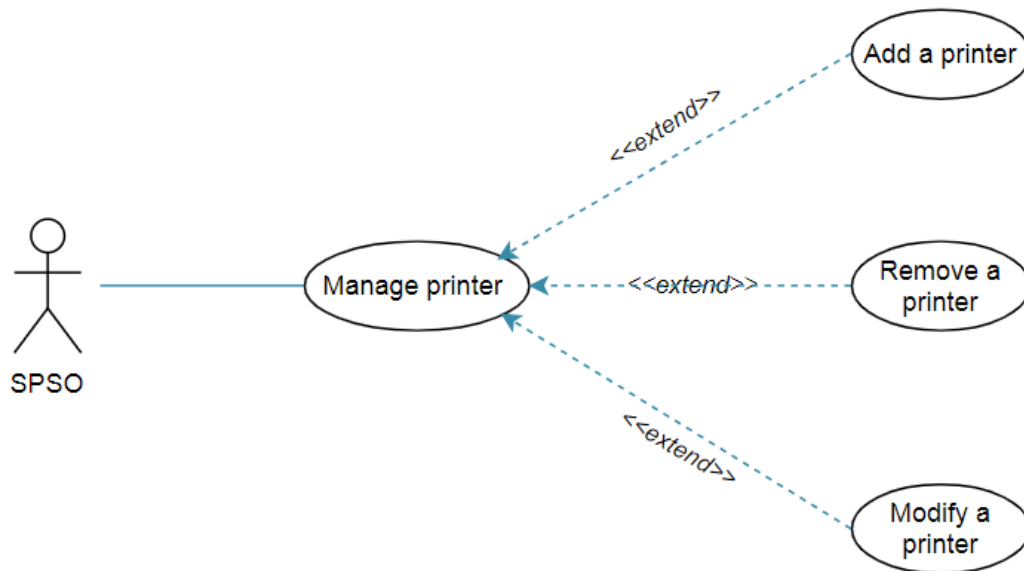Figure 1: Use-case diagram for the whole system

3.2 Printer Management

Figure 2: Use-case diagram for managing printer

Use-case	Manage Printer
Actor	SPSO
Description	Allows SPSO to manage the printers.
Trigger	SPSO chooses "Manage Printers" in the main menu.
Preconditions	SPSO is logged into the printing services portal.
Postconditions	Add/Remove/Modify printer success.
Normal flows	1. System opens the Manage Printers window. 2. System gets the list of printer. 3. System displays the list of printers. 4. Printer manager choose a printer from the list. 5. System gets the printer detail and shows.
Alternative flows	**Alternative 1:** *at step 3* 3.1. Search printer *Return to step 2 and continue in the normal flow* **Extended points:** *at step 5* Modify a printer, add a printer, remove a printer. *Return to step 2 and continue in the normal flow*
Exceptions	**Exception 1:** *at step 5* 5.1. If there's an issue, the user reports it to the system.

Use-case	Modify a Printer
Actor	SPSO
Description	Allows SPSO to manage the printers.
Trigger	SPSO clicks "Modify" button in the printer menu.
Preconditions	SPSO is logged into the printing services portal.
Postconditions	Modify printer success.
Normal flows	1. System changes into the edit mode. 2. Printer manager enable/disable the printer. 3. Printer manager selects "Save" button. 4. System saves the new detail.
Alternative flows	None
Exceptions	**Exception 1:** *at step 3* 3.1. Print manager selects "Cancel" button.

Use-case	Add a Printer
Actor	SPSO
Description	Allows SPSO to manage the printers.
Trigger	SPSO clicks "Add" button in the printer menu.
Preconditions	SPSO is logged into the printing services portal.
Postconditions	Add printer success.
Normal flows	1. System changes into the edit mode. 2. Printer manager add the detail. 3. Printer manager selects "Save" button. 4. System saves the new detail.
Alternative flows	None
Exceptions	**Exception 1:** *at step 3* 3.1. Print manager selects "Cancel" button.

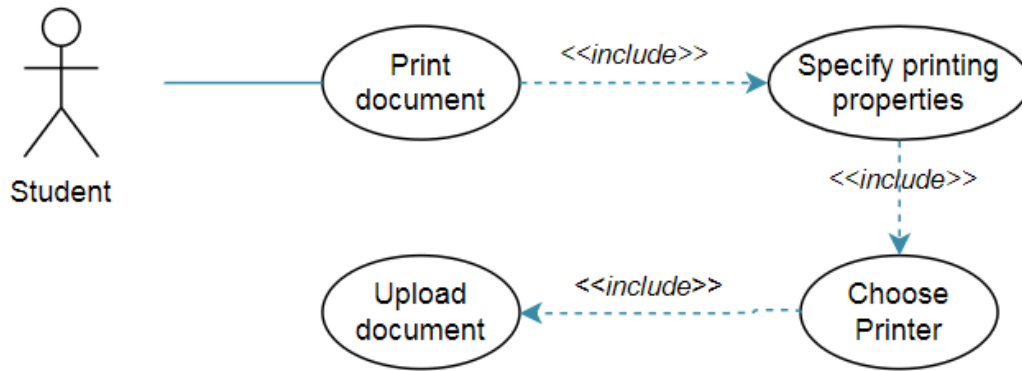| Use-case	Remove a Printer
Actor	SPSO
Description	Allows SPSO to manage the printers.
Trigger	SPSO clicks "Remove" button in the printer menu.
Preconditions	SPSO is logged into the printing services portal.
Postconditions	Remove printer success.
Normal flows	1. System changes into the edit mode. 2. Printer manager chooses the printer to remove. 3. System asks the printer manager to confirm the removing. 4. System saves the new detail.
Alternative flows	None
Exceptions	**Exception 1:** *at step 3* 3.1. Print manager selects "Cancel" button.

3.3   Printing Process

Figure 3: Use-case diagram for the printing process

Use-case	Upload Document
Actor	Student
Description	Allows students to upload specific file types for printing.
Trigger	Student chooses to print a document.
Preconditions	Student is logged into the printing services portal.
Postconditions	File is uploaded and ready for printing.
Normal flows	1. Student navigates to the "Upload File" section. 2. Student selects the desired file from their device. 3. System validates the file type. 4. Student confirms the upload. 5. System saves the file and queues it for printing. 6. System redirect the student to the "Choose Printer" section.
Alternative flows	**Alternative 1:** *at step 3* 3.1. If the file type is not supported, the system prompts the student to choose a different file. *Return to step 2 and continue in the normal flow* **Alternative 2:** *at step 4* 4.1. Student choose to upload a different document file for printing. *Return to step 2 and continue in the normal flow*
Exceptions	**Exception 1:** *at step 5* 5.1. If there's an error in saving or queuing the file, the system displays an error message to the student.

Use-case	Choose Printer
Actor	Student
Description	Enables students to select a printer based on its ID, location, or other details.
Trigger	Student wants to select a specific printer for their printing job.
Preconditions	Student has uploaded a file for printing.
Postconditions	Printer is selected and the file is queued for printing on the chosen printer.
Normal flows	1. Student get redirected to the "Choose Printer" section. 2. System displays a list of available printers with details. 3. Student selects a printer based on preference. 4. System confirms the printer selection. 5. System reserves the chosen printer for the student to use. 6. System redirect the student to the "Printing Properties" page.
Alternative flows	**Alternative 1:** *at step 4* 4.1. If the chosen printer is offline or unavailable, the system prompts the student to choose a different printer. *Return to step 2 and continue in the normal flow*
Exceptions	None.

Use-case	Specify Printing Properties
Actor	Student
Description	Provides students the option to specify printing properties like paper size, one-/double-sided printing, etc.
Trigger	Student wants to set specific printing properties for their document.
Preconditions	Student has uploaded a file and chosen a printer.
Postconditions	Printing properties are set and the file is queued with the specified settings. The chosen printer starts the printing process.
Normal flows	1. Student navigates to the "Printing Properties" section. 2. System displays available printing options. 3. Student sets desired properties (e.g., paper size, double-sided). 4. System presents a page with set properties. 5. Student confirms the printing properties. 6. System confirms the specified properties and save it for printing. 7. The chosen printer starts printing the uploaded document.
Alternative flows	**Alternative 1:** *at step 5* 5.1. Student choose to change the printing properties. *Return to step 2 and continue in the normal flow*
Exceptions	**Exception 1:** *at step 4* 4.1 If there's an error in setting the properties, the system displays an error message to the student.

4 Diagrams

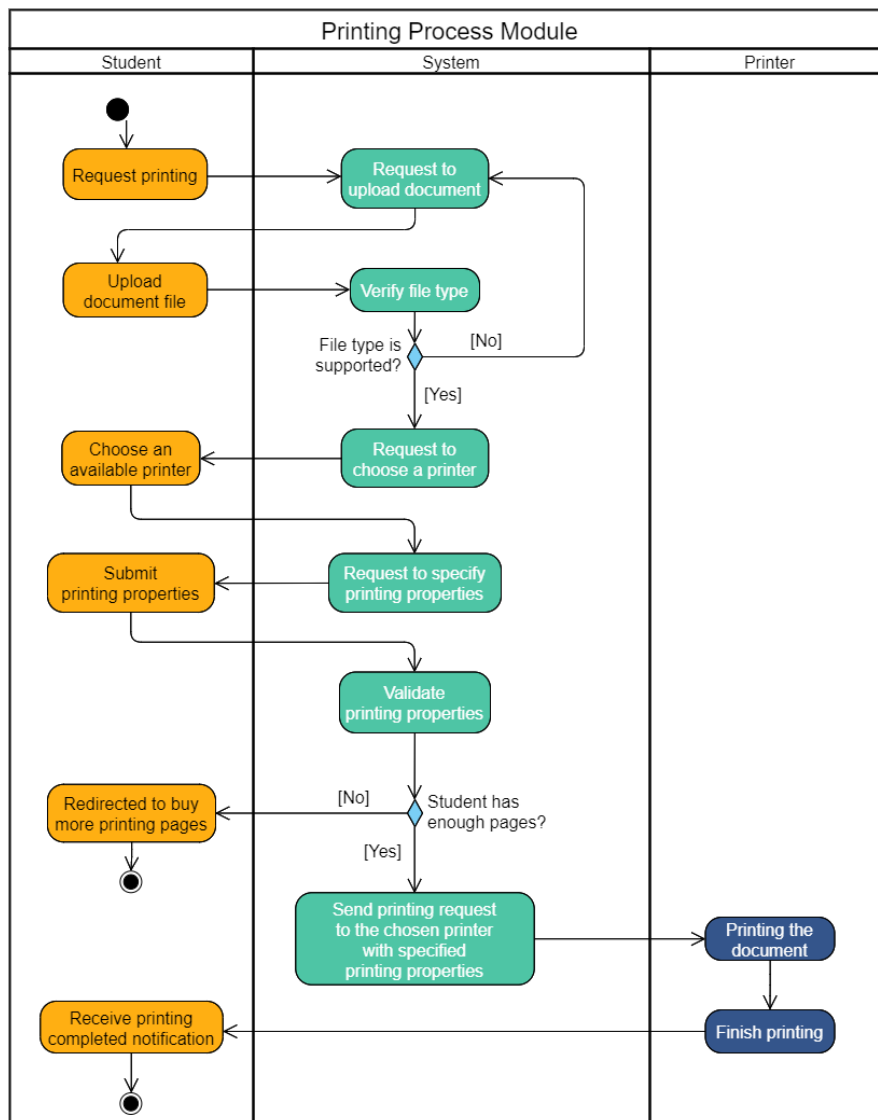## 4.1 Activity Diagrams

4.1.1 Printing Process Module

Figure 4: Activity diagrams for printing process module

- The user accesses the HCMUT_SSPS homepage and begins the printing process by uploading a document.

- After the document is uploaded, the system verifies if the file type is supported. If the file type is not supported, the system informs the user that the printer selection cannot proceed. The user may then choose to upload a different document or exit the process.

- If the file type is supported, the user is prompted to choose an available printer and specify printing properties.

- Upon submitting the printing properties, the system validates the chosen settings. If the student does not have enough printing pages, the system redirects them to purchase additional pages.

- If the student has enough pages, the system records the printing request and sends it to the selected printer. The document is then printed, and upon completion, the system notifies the user that the printing is finished.

- The user then receives a notification indicating that the printing has been completed successfully.

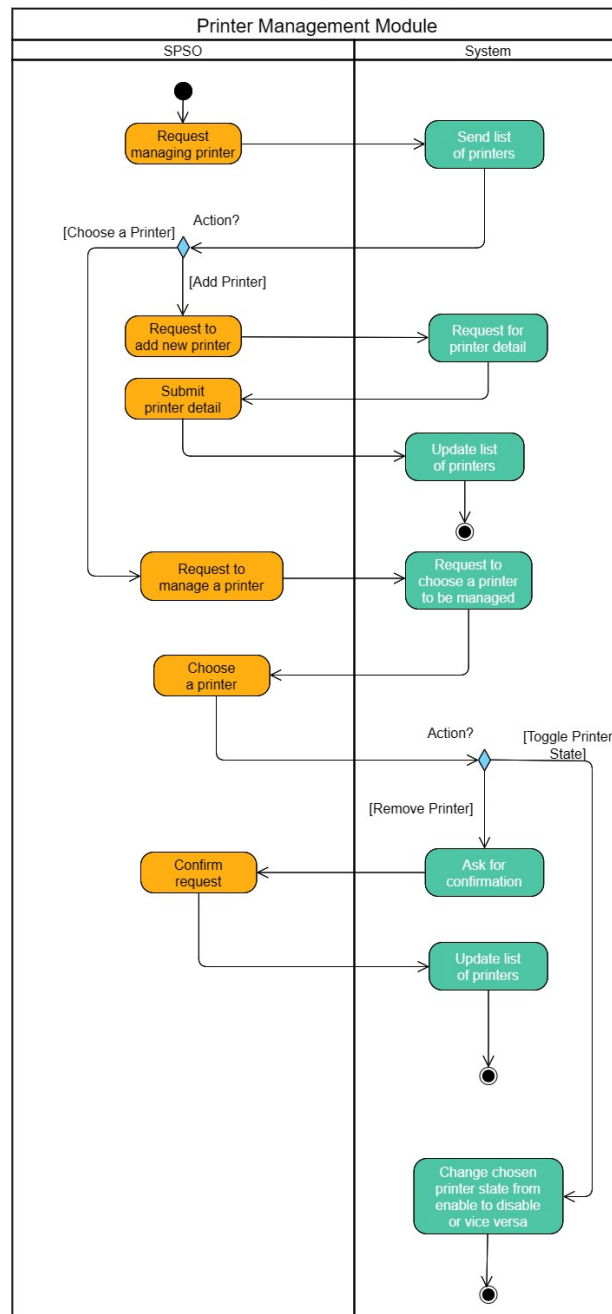### 4.1.2 Printer Management Module

Figure 5: Activity diagrams for printer management module

- The SPSO initiates printer management by sending a request to the system.

- The system responds by providing a list of printers to the SPSO.

  + If the action is to add a new printer, the SPSO sends a request to add and submits the printer details to the system.

  + If the action is to manage an existing printer, the SPSO requests to choose a printer to manage.

- For managing a printer, the SPSO selects a printer and confirms the management request.

  + If the printer's state is to be toggled, the system asks for confirmation, and upon receiving it, changes the printer state from enable to disable or vice versa.

  + If the printer is to be removed, after confirmation, the system updates the printer list by removing the chosen printer.

- The system updates the list of printers to reflect the changes made during the management process.

Throughout this module, the system ensures that the SPSO's management actions are executed properly and the printer list is kept current.

4.2 Sequence Diagrams
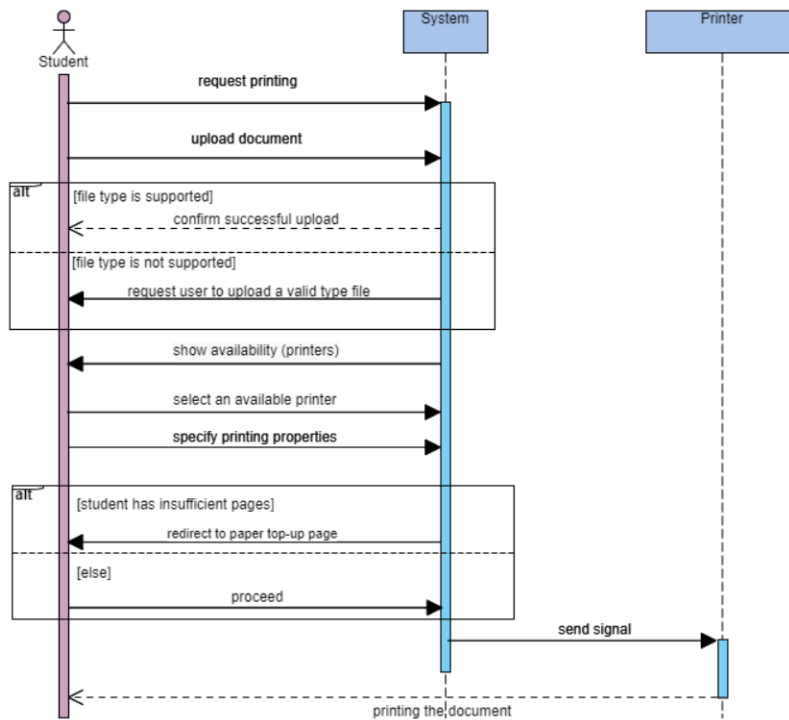
4.2.1 Printing Process Module

Figure 6: Sequence diagrams for printing process module

- The student begins the printing process by requesting to print and uploading a document to the system.

- The system then checks if the file type is supported.

  + If the file type is supported, the system confirms the successful upload of the document.

  + If the file type is not supported, the system requests the student to upload a document with a valid file type.

- Upon successful validation, the system displays available printers. The student then selects a printer and specifies the printing properties for the document.

  + If the student does not have enough pages available, the system redirects them to a page where they can top up their page count.

  + If there are no issues, the process continues.

- Finally, the system sends a signal to the chosen printer to proceed with printing the document.

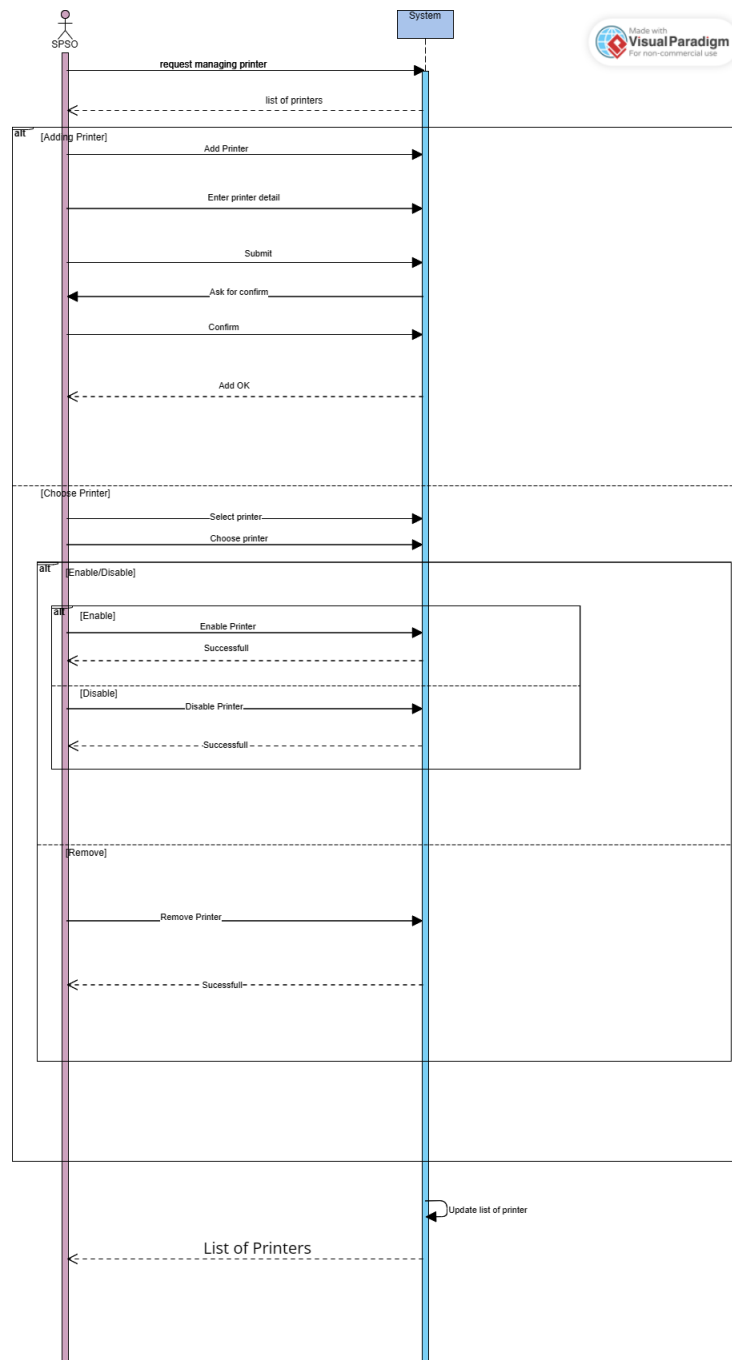### 4.2.2 Printer Management Module

Figure 7: Sequence diagrams for printer management module

- The SPSO starts the printer management process through the interface.

- The system receives the request and provides a list of printers, calculating the total number that needs to be managed.

- The SPSO, through the interface, decides on the management action to take. Here, two scenarios are possible:

  + If the decision is to add a printer:

    * The system will request printer details from the SPSO.
    * The SPSO, through the interface, provides the required information.
    * The system accepts the printer details, processes them, and returns the result of the addition.

  + If the decision is to change the state of a printer (enable/disable) or remove a printer:

    * The system will prompt the SPSO for confirmation via the interface.
    * Upon receiving the SPSO's confirmation, the system will either toggle the printer's state or remove the printer as requested.

- Finally, the system updates and stores the transaction information, reflecting the actions that have been performed.

4.3 Class Diagrams

4.3.1 Printing Process Module

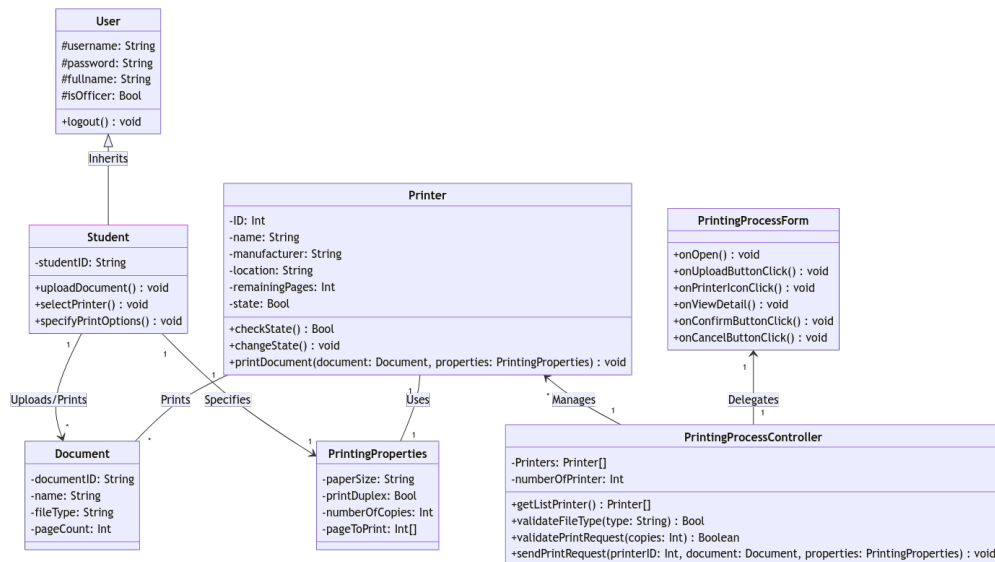Figure 8: Class diagrams for printing process module

Basic User:

The class diagram includes a User class with private attributes such as username, password, fullName, and isOfficer, denoting whether the user has administrative privileges. It also defines a public method for logging out. The Student class inherits from User and adds a unique studentID. It includes methods to upload documents, select a printer, and specify printing options.

File Upload:

Document objects are created when students upload files. This class has attributes like documentID, name, fileType, and pageCount to represent the document details.

Create Print Request:

The Printer class can print documents and manage its state and de-

tails, such as ID, name, manufacturer, location, and remaining pages. It has methods to check and change its state and print a document, taking a Document and PrintingProperties as parameters. Printing-Properties is a class that specifies details like paperSize, whether to print duplex, the number of copies, and specific pages to print.

Printer Interaction:

The PrintingProcessForm serves as a user interface allowing interaction with the printing process, with methods to handle various user actions, such as opening the form, uploading documents, and confirming or cancelling a print request. The PrintingProcessController manages an array of Printers and includes methods to retrieve a list of printers, validate file types, validate print requests, and send print requests.

Relationships and Cardinalities:

The diagram indicates the following relationships and cardinalities:

- A Student can upload and print multiple Documents (1 to many).

- A Document has specific PrintingProperties (1 to 1).

- A Printer uses PrintingProperties to print a Document (1 to many).

- The PrintingProcessForm delegates to the PrintingProcessController (1 to 1).
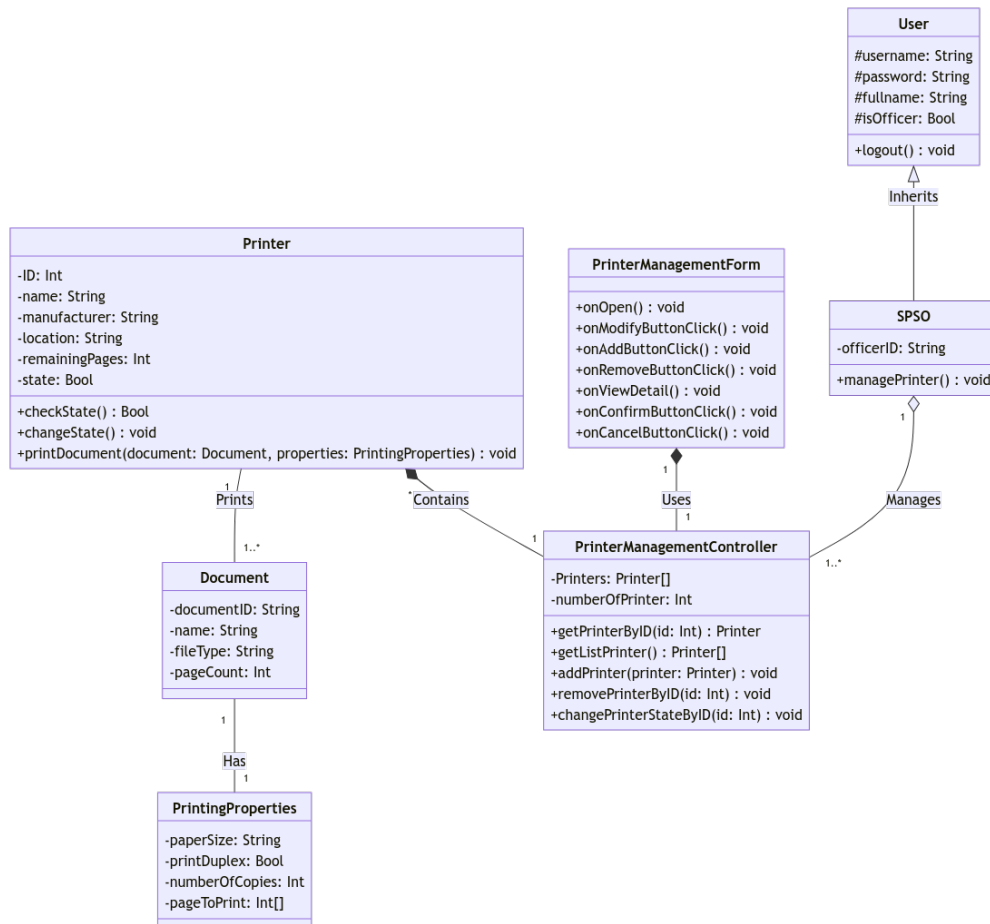
4.3.2 Printer Management Module

Figure 9: Class diagrams for printer management module

Basic User:

The class diagram features a User class with protected attributes such as username, password, fullName, and isOfficer, which indicates whether the user has administrative rights. The class provides a public method to log out. The SPSO class inherits from User and contains an additional attribute officerID. It has a method to manage printers, representing the SPSO's administrative capability within the system.

Printer Interaction:

The Printer class represents a printer with attributes like ID, name, manufacturer, location, remainingPages, and state. It includes methods to check the printer's state, change it, and print a document given a Document and its PrintingProperties.

Document and Printing Properties:

Document is a class with attributes documentID, name, fileType, and pageCount, necessary for defining the properties of a print job. It is associated with the PrintingProperties class, which includes paperSize, printDuplex, numberOfCopies, and pageToPrint, specifying the details required for printing.

Management Interface:

PrinterManagementForm is a user interface class with methods to handle various UI events like open, modify, add, remove, view details, confirm, and cancel actions. It uses the PrinterManagementController, which manages an array of Printers. The controller class provides methods to get printers by ID, list all printers, add or remove a printer, and change a printer's state by ID.

Relationships and Cardinalities:

- A Printer can print multiple Documents (1 to many).

- A Document contains specific PrintingProperties (1 to 1).

- The PrinterManagementController uses PrinterManagementForm to facilitate user interactions (1 to 1).

- The SPSO manages the PrinterManagementController (1 to 1).

5 Minimum Viable Product (MVP)

5.1 Printing Processing Module

5.1.1 Upload document

When the user wants a document to be printed, navigate to the uploading document interface, then choose the desired file.
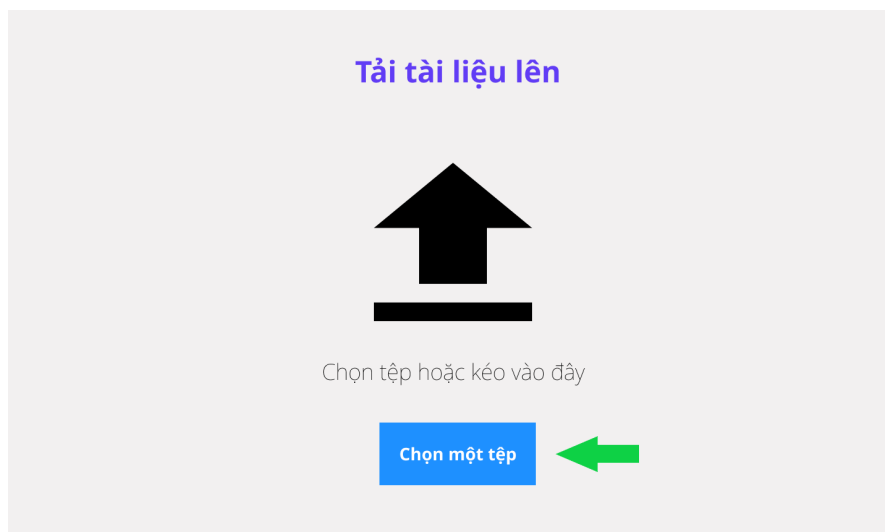

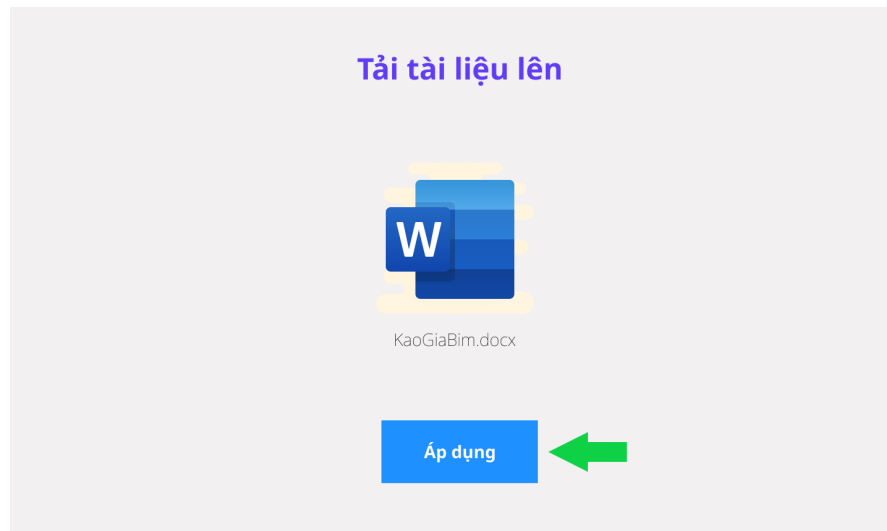Figure 10: Interface before uploading a document

Figure 11: Interface after uploading a document

No.	Name	Description	Action
1	Select File	Button to select upload file	Click to select upload file
2	Apply	Button to apply selected file	Click to apply selected file

Table 1: Table describing upload interface components

5.1.2 Choose Printer

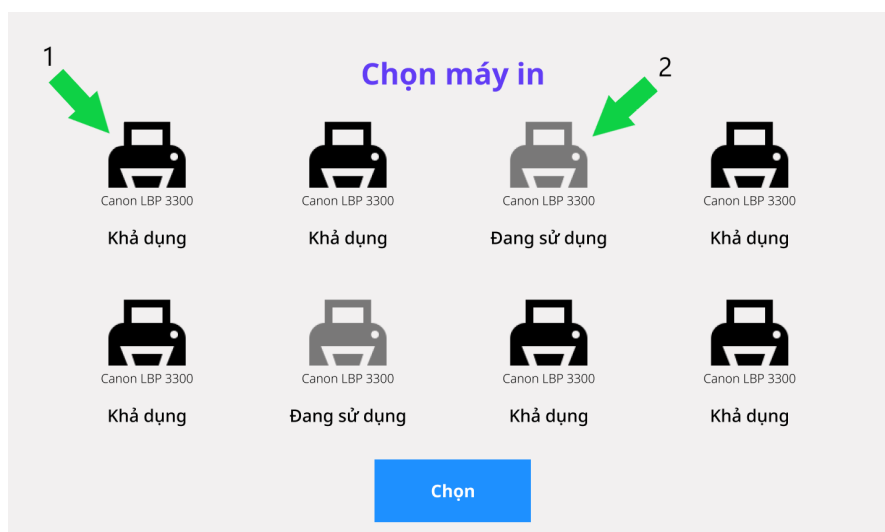Next, the user selects an available printer on the interface. The printers currently not in used will be highlighted for choosing.

Figure 12: Interface for selecting a printer
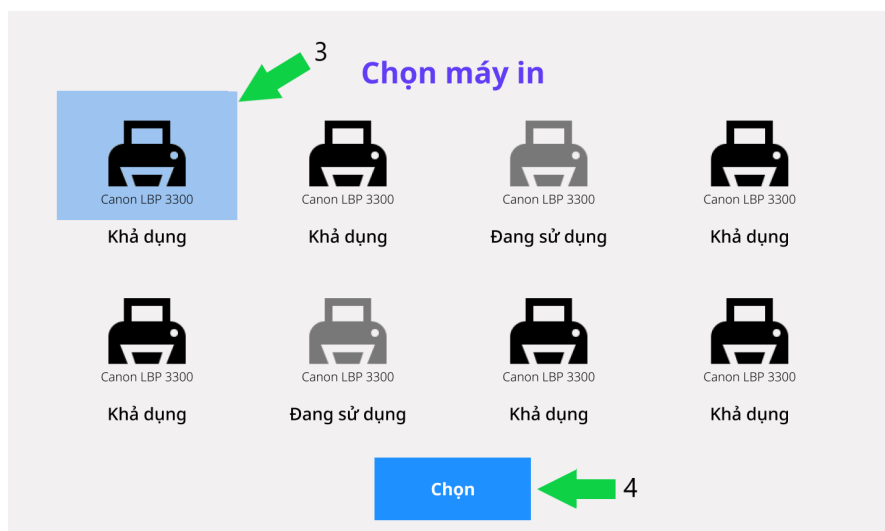
Figure 13: Interface when selecting a printer

No.	Name	Description	Action
1	Available Printer	Show available printer	None
2	Unavailable Printer	Show unavailable printer	None
3	Chosen Printer	Currently chosen printer	None
4	Select	Select button	Click to select the desired printer

Table 2: Table describing select printer interface components

5.1.3 Specify Printing Properties

After that, the user chooses different printing properties: numbers of copies, range of pages, number of pages on each side, and page sizes.
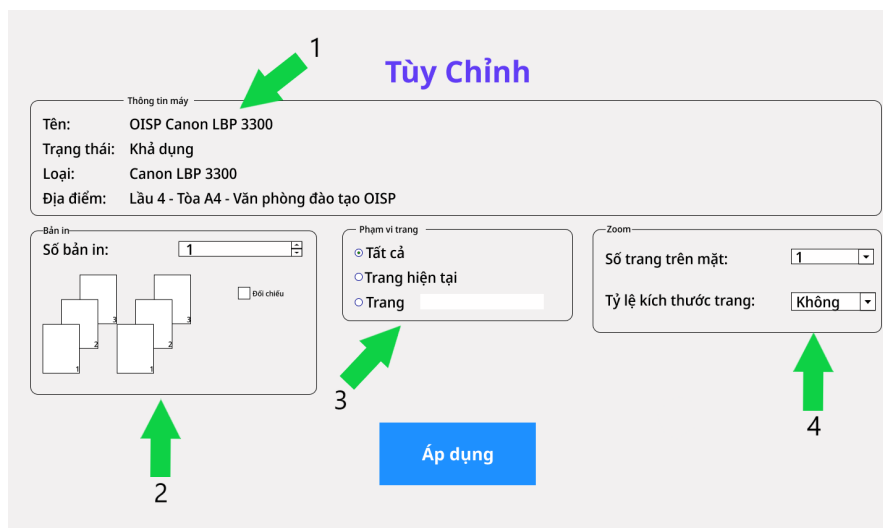

Figure 14: Interface for printing properties

Figure 15: Interface for specifying printing properties

No.	Name	Description	Action
1	Printers Information	Show printers information	None
2	Copies	Show the number of copies	Select the number of pages to print
3	Page Range	Show the option of page range	Choose from 'All', 'Current Page', or specify range
4	Zoom	Show the page per sheet and scale to page size	Select the page per sheet or scale to page size
5	Apply	Apply button	Click to apply the option

Table 3: Table describing specify printing properties interface components

5.1.4 Printing Process

When the user has uploaded their desired printing document, selected an available printer and specified printing properties, the system will send the corresponding document and properties to the chosen printer.
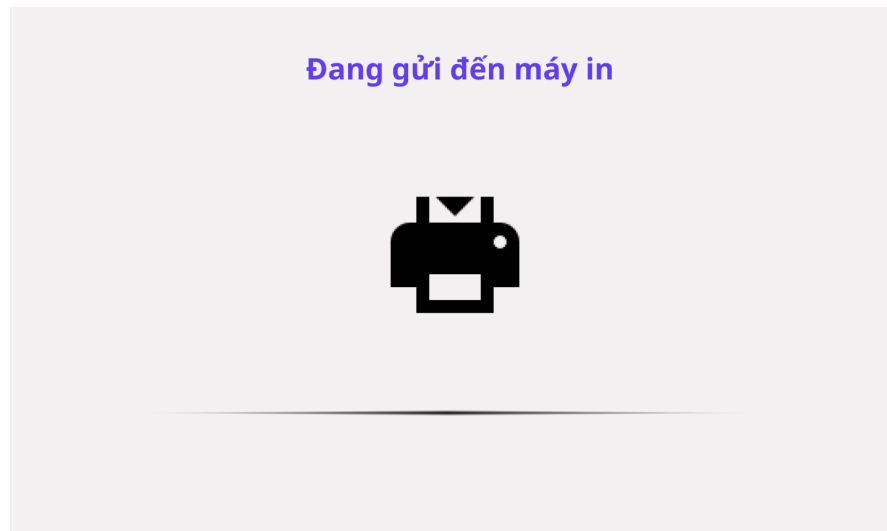
Figure 16: The system sending the document and properties to the printer

After the printer has received the uploaded document, it will take some time for it to start printing the document with the desired properties.

Figure 17: The user's document is being printed

When the printer has finished printing the document, a success notification screen will appear.
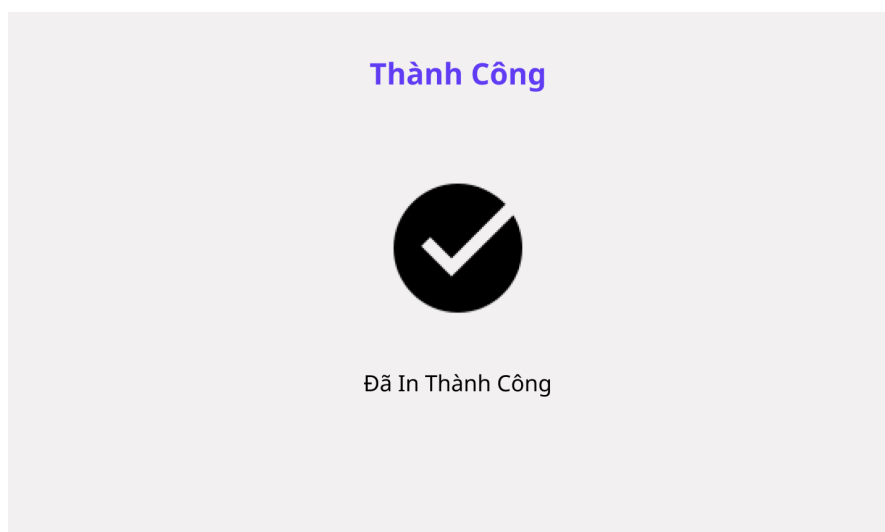
Figure 18: The printer has finished its printing request

The user will now be redirected to the main page of the app.

5.2 Printer Management

5.2.1 List of Printer

When user want to manage printers the system will response the list of printer for user.
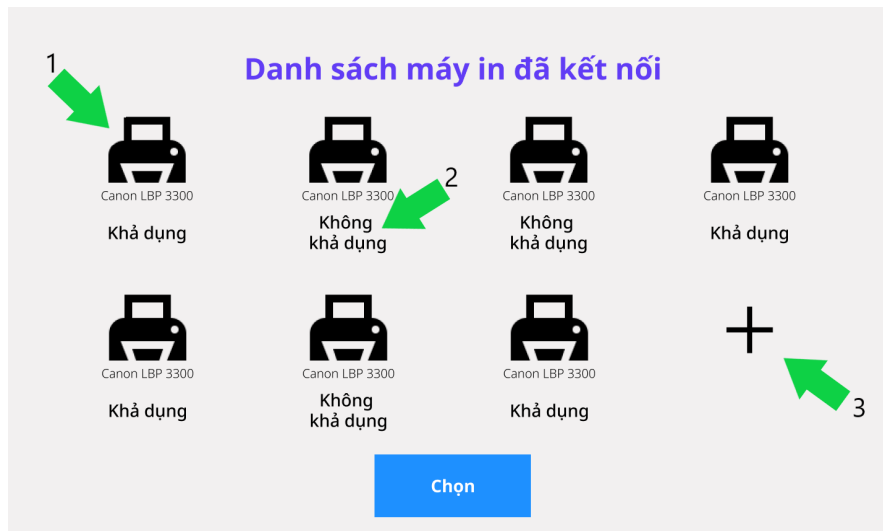
Figure 19: List of printer interface

No.	Name	Description	Action
1	Printer List	Displays the list of connected printers	None
2	Printer Status	Shows the availability status of the printer	None
3	Add Printer	Opens a form to enter new printer details	Click to open add printer form

Table 4: Table describing list of printer interface components

5.2.2 Add Printer

The user can add a new printer into the system by selecting to add a new printer, provide the name, brand and location of the printer.

Figure 20: Interface for adding a printer

No.	Name	Description	Action
1	Printer Name Field	Field to enter the name of the printer	Enter printer's name
2	Brand Field	Field to enter the printer's brand	Enter printer's brand
3	Location Field	Field to enter the printer's location	Enter printer's location
4	Add Button	Submits the new printer information	Click to add the printer

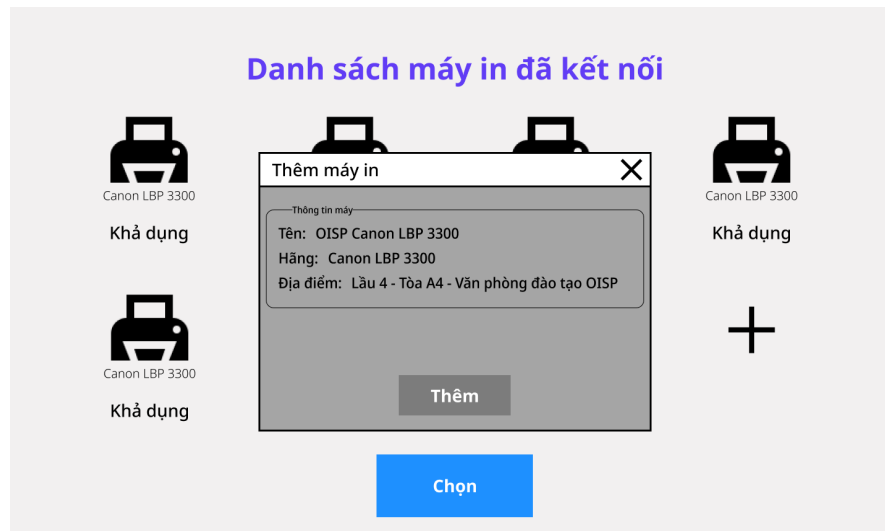Table 5: Table of Printer Addition Interface Components

Figure 21: Interface for adding a printer after providing necessary information

After user confirm adding a new printer into the system, the system will call itself to add a new printer to the list of printer, return new list of printer and wait for the next printer management request.
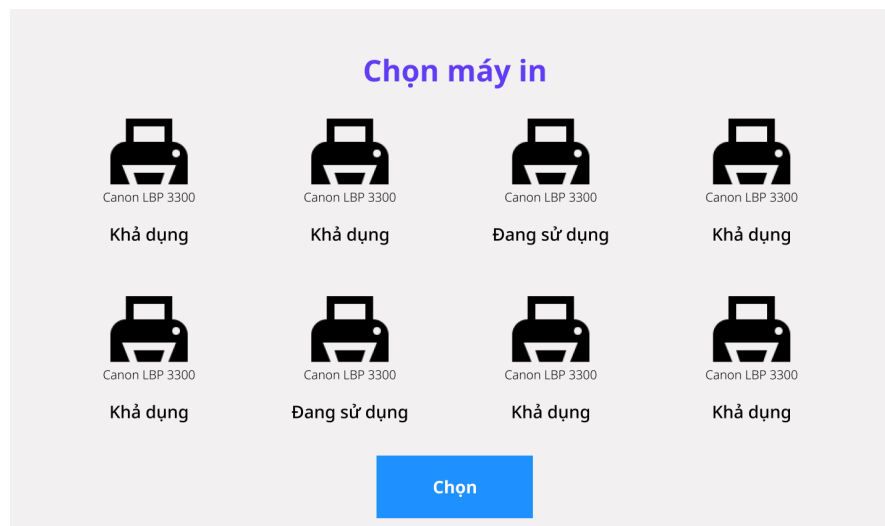

Figure 22: Interface for selecting a printer after adding a new printer

5.2.3 Choose Printer

When the user wants to configure a specific printer, navigate to the printer interface, then choose the desired printer.
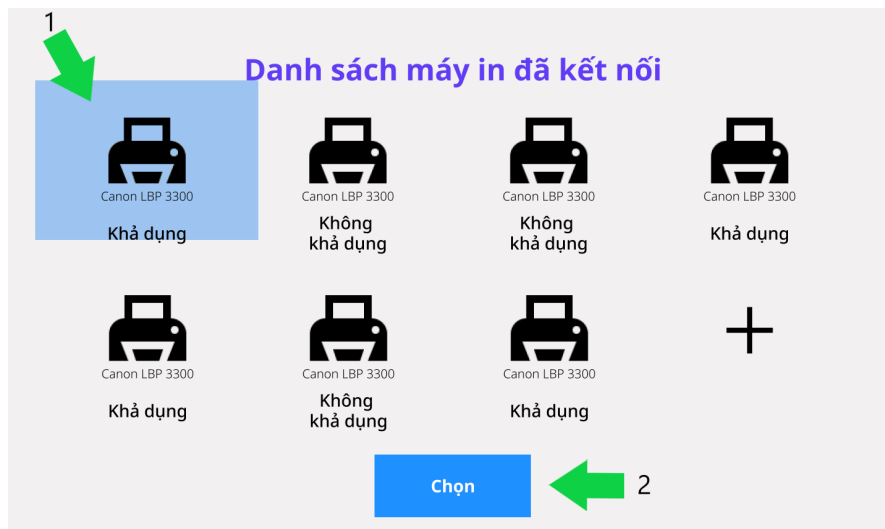

Figure 23: Interface when selecting a printer

No.	Name	Description	Action
1	Chosen Printer	Currently chosen printer	None
2	Select Button	Finalizes the printer selection process	Click to select printer

Table 6: Table describing select printer interface components

5.2.4 Manage Printer

After choose a specific printer, user will press enable/disable button for enable/disable or remove button to delete printer from system.
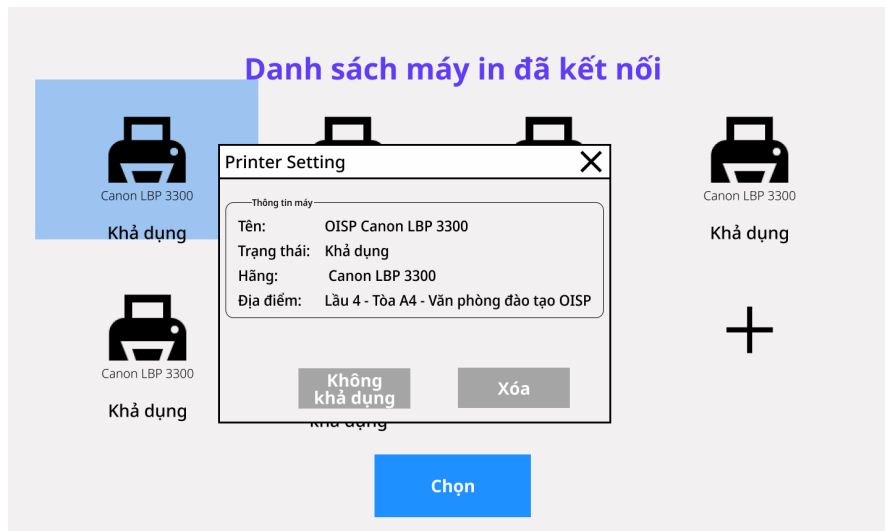
Figure 24: Interface for managing a printer

If pressing remove button, system will execute.When success, the system will call itself to delete printer from the list of printer, return new list of printer and wait for the next printer management request.
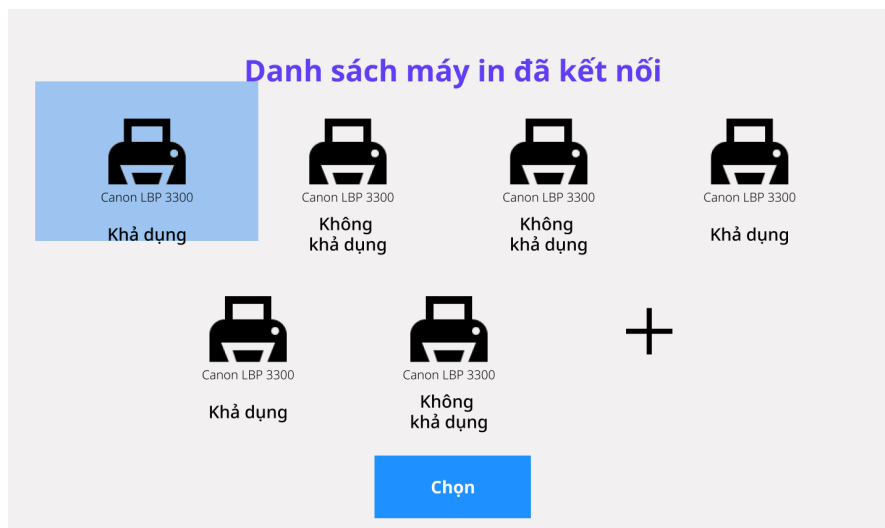

Figure 25: Interface for selecting a printer after a printer has been removed

If pressing enable/disable button, system will execute.When success, the system will call itself to permit/forbid printer of the list

of printer, return new list of printer and wait for the next printer management request.
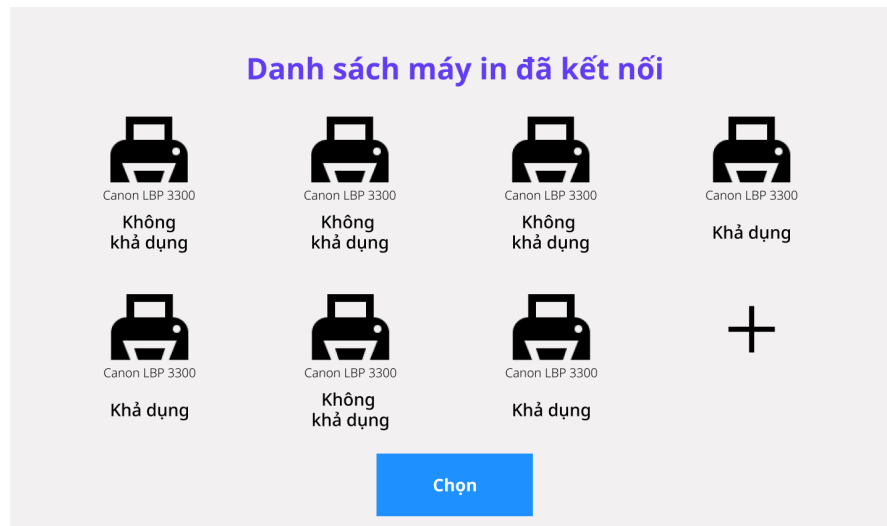

Figure 26: Interface for selecting a printer after a printer has been disable

Detailed prototype can be viewed here

6 Architecture design

6.1 Layered Architecture

Student Smart Printing System

Presentation Layer

Web-based UI   User input handling   Reporting and display

Application Layer

File handling   Printing handling   Printing tracking   Buying pages

Report generating   System configuration   Printing management

Business Layer

History archive   System settings   Report archive

User information   Printer information

Data Layer

Printer storage   User storage   History storage   Application storage

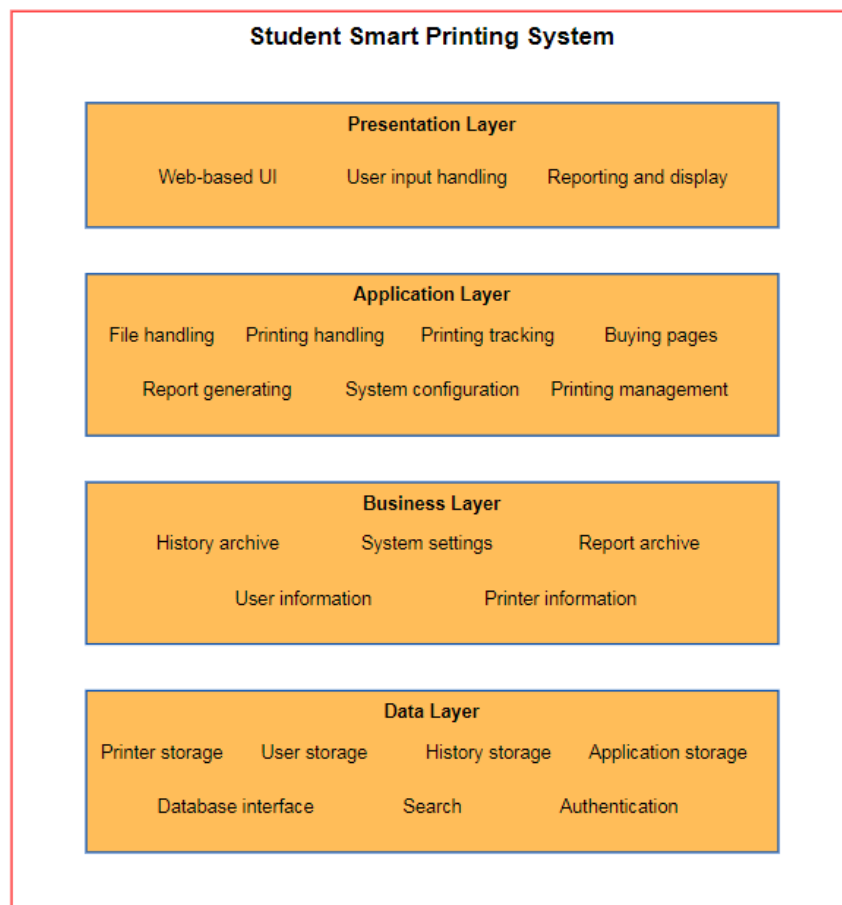Database interface   Search   Authentication

Figure 27: Layered architecture diagram

The Student Smart Printing System is structured into a multi-layered architecture to streamline operations and improve manageability. At the top, the Presentation Layer provides a Web-based User Interface (UI) for interactions, handling user input, and presenting reports and display outputs. The Application Layer beneath serves as the core operational level, managing file and printing processes, tracking printing jobs, facilitating the purchase of pages, generating reports,

and configuring system settings. The Business Layer is focused on the business logic, maintaining history and report archives, along with storing user and printer information. Finally, the Data Layer lays the foundation for data management, encompassing printer and user data storage, history and application-specific storage, offering a database interface, enabling search functionality, and managing authentication protocols. This hierarchical design ensures that each layer has a specific function, promoting organized data flow and easier maintenance.
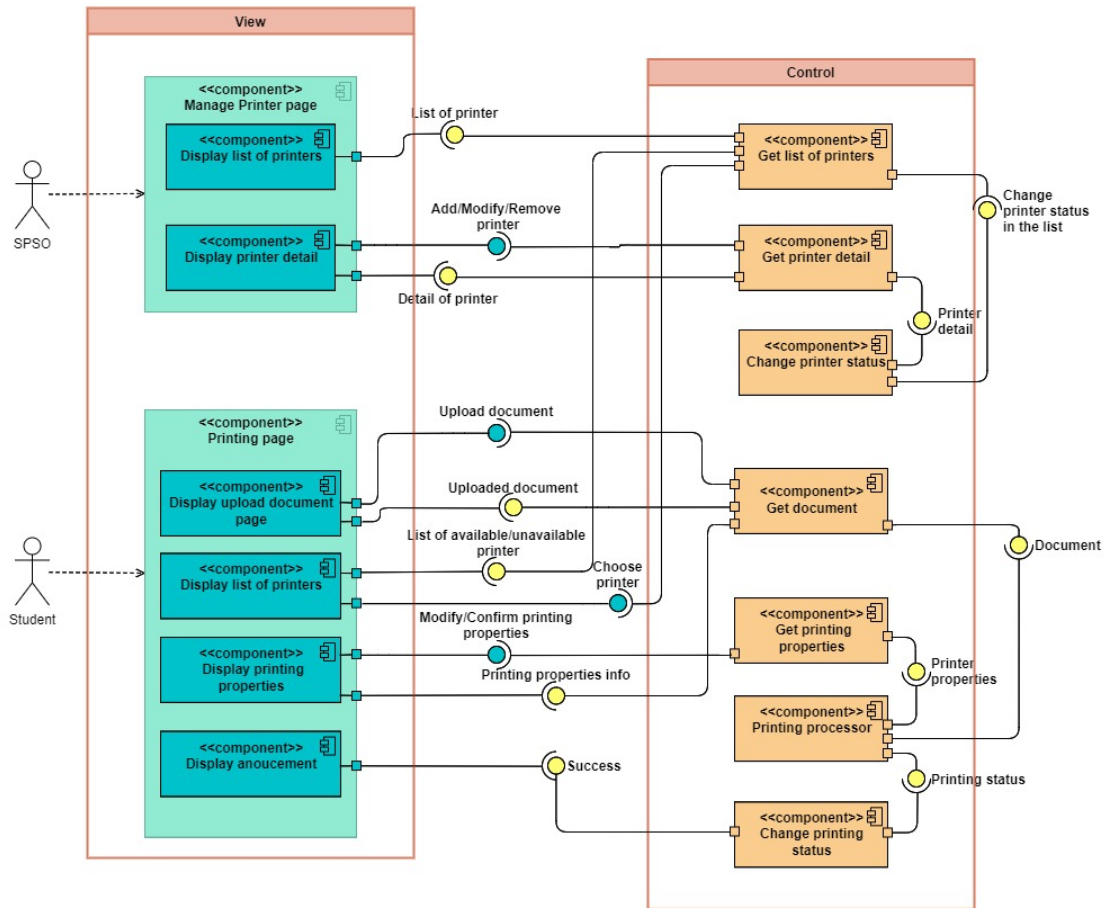
6.2 Component diagram

Figure 28: Component diagram for printing process module and printer management module

- When the SPSO selects to manage printers, the *Manage Printer page* component from the View section requests a list of printers using the *Get list of printers* component in the Control section, which is then displayed via the *Display list of printers* component.

- The SPSO may add, modify, or remove a printer. These actions are managed by corresponding components in the Control section, which interact with the system's model to update printer details or change the printer's status.

- When a Student uploads a document, the *Printing page* component in the View section provides an interface where the *Upload document* component in the Control section captures and processes the document.

- The system then presents a list of available or unavailable printers to the Student. The Student selects a printer using the *Choose printer* component, which retrieves available printers from the system's model.

- The Student can adjust and confirm the printing properties before the print job begins. This is managed by the *Get printing properties* component in the Control section, with the details displayed through the *Display printing properties* component.

- Upon a successful print, the *Printing processor* component processes the print job, and the *Change printing status* component updates the printing status. The result is then announced to the Student through the *Display announcement* component in the View section.