Software Requirements Specification Document

Kuching's Autonomous Rapid Transits

Contents

1.0 Introduction

This specification document aims to provide a detailed requirements specification for the development of a mobile application and a website for Kuching's Autonomous Rapid Transit (ART). The purpose of this system is to extend the current physical on-site ticketing operations to an online environment. This system will provide an opportunity to customers with various functionalities when they manage their transit activities online. Besides, the system will also provide valuable statistical insights on customer travel and demographic data for management.

By using the Tasks and Support method and identifying the key user tasks, this document aims to outline the functional and non-functional requirements and the quality features of the expanded on-site ticketing system.

2.0 Project Overview

The management of Kuching's ART has identified the need to improve its current physical on-site ticketing system by enhancing its mobile app and website. The existing system is only limited to counter-based operation, which creates many pain points for both customers and station managers and eventually leads to low productivity and a poor customer experience. Thus, ART's management has hired Swinsoft Consulting to analyse and develop the specifications for a new online ticketing system that improves the customer experience while enhancing operational efficiency for staff.

2.1 Domain Vocabulary

After identifying and analysing the case study, here are some domain vocabularies for the online ticketing system, which will be used in the following documentation:

Vocabulary	Explanation
ART	Autonomous Rapid Transits is the core service being offered. It is a transportation that runs on the road and the maximum capacity is up to 250 users (Sarawak Metro 2025).
User	Users are the primary actors in the system. They will interact with the mobile app or website to book trips, purchase merchandise, and manage their accounts.
Station Manager	Station manager who works at physical stations and assist users with on-site needs. This system allows them to focus on the user service and feedback resolution by offering online ticket bookings and cancellations.
Admin	Admins will manage the backend of the system such as promotions and data analysis. They rely on the system to generate statistics, apply discounts and ensure smooth operations.
Online ticketing system	A digital platform which integrates all functionalities to provide a good experience for users and efficient management for admins.
Booking	User can either book a trip, cancel or reschedule a trip in the online ticketing system. The system can handle multiple bookings simultaneously and provide real-time availability updates.
Payment	The system supports multiple payment methods for top up into e-wallet like FPX (online banking), debit card or credit card for user preferences.
Ticketing	Ticketing can be in the form of QR code or a pdf form for easy access and scanning. The systems ensure the tickets are secure, and downloadable for offline user
Feedback	User can give feedback or complaints by filling in feedback form. This feature helps to improve the services and address user concerns. Station managers can analyse feedback to identify areas for improvement.

Trip	Trips can be one-way or return and only chosen by the use. The system allows users to select trip types and provide reasonable pricing and scheduling information.
Promotion	Discounts or special offers for users to apply during booking process.
Point	Point or reward that will be given to the user after buying a ticket or purchasing a merchandise. This can be redeemed discounts or rewards when it reached certain points.
Merchandise	Merchandise can be purchased online or physically. The system includes an e-commerce platform for online sales, inventory management and order tracking.
Statistics	Statistics are generated by the system to analyse user behaviour and optimise services.
Notification	Notify the user to view the latest update and any confirmation details.
Voice prompt	Allow the user with disability to use this feature for booking purposes.

2.2 Goals

Below are the goals that the management of Kuching ART required to be achieved for the online ticketing system:

- Improving the effectiveness of the current system to allow more users to book trips online and view the real-time ART schedules.
- Provide users an alternative way to manage the tickets like cancel or reschedule and purchase merchandise online.
- Providing management to collect and analyse travel and demographics data over various periods. This can help to optimise the routes, schedules, and resource allocation.
- Minimise the time users queue at stations by changing the ticketing operations online.
- Send real-time notifications for delays, cancellations, and schedule changes.

2.3 Assumptions

Below are the assumptions made by the team during the design of the ART online ticketing system. Each assumption is based on the Sarawak cultural context, user behaviours, system functionality requirements, and operational expectations.

- ART's management already has a UI/UX guideline for any IT system it develops.
- Users are expected to register only one account per phone number and use their own phone number for account registration.

- Users can remember their own password to login or use a password recovery mechanism.
- The login module is assumed to always be secure, and the system will log changes for security and audit purposes.
- Users are expected to upload their identity card or passport for verification.
- Users have internet access and own a device to book trips at any time and from anywhere.
- Users can cancel the trips within 5 hours before departure, but last-minute cancellations are not allowed.
- Trips can only be rescheduled if there are available seats on a new date or time.
- Users are expected to review past or current bookings to manage their trips.
- Online transactions are assumed to be secure and trustworthy. Users are expected to top-up their accounts before booking.
- User's payment methods are reliable and compatible with the system and the system automatically calculates fees and discounts during checkout.
- System can handle a large number of users as well as transactions.
- Refunds will be processed within 20 minutes if the user requests to cancel a trip.
- Admins will create promotions within the company's feasible scope to make the company profitable. Users are expected to apply the promotional voucher when there is a voucher available to apply.
- Users will be motivated to earn points to redeem the vouchers and check their total points regularly to redeem rewards.
- Users are expected to understand the use of digital tickets.
- Users are assumed to buy merchandise during promotions.
- Admin will always keep the inventory updated to prevent overselling.
- Users will check past deliveries or reorder the items as needed.
- Users will provide useful feedback to help improve the system or services, and station managers will prioritize resolving the critical feedback.
- Admins will handle all account issues and use statistics to optimise services such as ART routes or schedules.
- Users will always check the notification every time they complete a transaction.
- Users will always rely on real-time schedules to plan their trips or activities.
- The system is expected to have a voice prompt to help users with disabilities.
- Users will only be allowed to print the ticket once to prevent cheating by printing multiple tickets.
- Users are expected to purchase two tickets if their trip requires a transit, as there is no direct route to the destination.

2.4 Scope

The ART's management wants a system that improves the efficiency of the existing system as well as provides various functionalities to enhance customer opportunity. More specifically, the system allows customers to sign up for a free account with binding their IC number to book a trip through the online ticketing system. Before user wants to book a trip, they need to verify their account and update their information inside the app or website first as well as they need to top-up first to pay the ticket money. User can book a trip by choosing a date, time and destination. If user books the wrong ticket, the system allows the customer to cancel the order, reschedule or refund the ticket. On the other hand, this system will also offer some merchandise for customers to purchase. In this system, customers can earn points by buying tickets and are able to redeem promotion or merchandise when reaching certain points. Besides, this system allows the customer to send their feedback by filling out a report form. If any user has issues with their refund or cannot receive OTP or more, the system also provides a help centre to let them find an admin to solve these kinds of issues. In addition, this system also provides a voice assistant to assist them in booking a trip, they just need to activate the voice prompt by clicking the mic icons or saying the wake word ("Hey ART").

3.0 Problem Domain

In this section, we will discuss the current pain points of the ART ticketing system, identify the domain entities and actors, and discuss the tasks of building an online ticketing system.

3.1 Pain Points

Below are the pain points faced by the management of Kuching ART:

- The current system is only available at physical stations, which causes very inconvenience for users who live far away to purchase tickets.
- Users must visit the station to buy tickets, and this causes long queues and wasted time.
- Users are not available to view the ART schedules online, which causes them to miss trips or arrive too early.
- Users cannot reschedule, cancel or refund tickets without visiting a counter, so the station managers must handle these requests manually, eventually increasing the workload and inefficiency.
- The current system makes it difficult for management to collect and analyse demographics and travel data over different periods.
- Users are not notified of real-time delays, cancellations, or schedule changes.
- Users cannot access tickets or schedules on their smartphones, which makes it inconvenient for users during peak hours.

3.2 Domain Entities

Below are the domain entities that will interact with each other throughout the whole ART system:

- User
- Admin
- Ticket
- Merchandise
- Booking
- Payment
- Feedback
- Promotion
- Point
- Voice prompt

3.3 Actors

Below are the actors that will be used in the tasks and how they interact with each other:

- User
- Station manager
- Admin
- Online ticket system

3.4 Tasks

Below are the tasks that are proposed for the ART online system. It consists of big modules, then further decompose into smaller tasks. Each task will then be described more in depth in the next section.

Modules	Tasks
User Management System	**1. Sign up new user account** • Allow user to register an account for the first time
	2. Sign in an account • Allow user to login with an account securely
	3. Sign out an account • Allow user to sign out their account
	4. Update user information • Allow user to edit or update the profile information
	5. Verify a user account • Allow user to verify the account
Booking System	**6. Book a trip** • Allow user to book a trip at anytime and anywhere
	7. Cancel a trip • Allow user to cancel a trip for purposes
	8. Reschedule a trip • Allow user to reschedule a trip if needed
	9. Review booking history • Allow user to view back the past or current booking
Payment System	**10. Process top-up** • Process the top-up to user account
	11. Process a payment • Process payments for booking the ticket and merchandise purchases
	12. Refund a purchase • Process refund when user cancels booking
Promotion System	**13. Manage promotions** • Allow admin to manage discount promotions or special offers
	14. Apply a promotion

	• Allow user to apply promotion when booking a trip
Point System	**15. Earn the points** • Allow user to earn ten points when buying a ticket or merchandise, or watching an advertisement
	16. Redeem the points • Allow user to view and redeem points
Ticketing System	**17. Print a ticket** • Allow user to print out the booking details
Merchandise System	**18. Purchase a merchandise** • Allow user to purchase merchandise items online
	19. Manage merchandise inventory • Allow admin to add or update the stock
	20. View merchandise order history • Allow user to view the purchase history
Feedback System	**21. Feedback submission** • Allow user to submit feedback or complaints
	22. Review user feedback • Allow the admin to review and respond to user feedback
Admin System	**23. Manage user account** • Allow admin to manage user account
	24. Analyse and Generate Usage Statistics for ART • Allow admin to view and analyse user demographics via statistics
Notification System	**25. Payment notification** • Allow user to receive notifications for successful payments
	26. View ART departure/arrival time • Allow user to view real-time ART schedule
Help Centre	**27. Report an issue** • Allow user to report an issue to address the issue
Voice prompt system	**28. Voice prompt** • Allow user to speak to book or cancel a trip and read upcoming trips

4.0 Functional Requirements and Task Descriptions

In this section, we will discuss all the functional requirements that have been mentioned in 3.4 by using Task and Support methods. All the tasks are provided with detail explanation to give an understanding on how each task are done by the actors.

Task 1: Sign up new user account

Task: Sign up new user account	
Purpose:	Validate the inputs and create new account for the user.
Trigger/Precondition:	User registers a new account for first time.
Frequency:	Average 100 users per days
Critical:	Users do not have a valid phone number.
Work Area:	Registration page
Subtasks:	**Example Solution:**
1. Sign up for the first time	User inputs personal details such as phone number and password.
2. Validate user input	System validates the input and sends OTP to verify the user.
3. Create an account	System creates a new account for user and sends SMS for verification.
Variants:	
1a. A user has already signed up the account	System prompts user to sign in option.
2a. User inputs wrong phone number or email	System prompts error messages until user inputs correct email or phone number.

Task 2: Sign in an account

Task: Sign in an account	
Purpose:	Sign in account to book a trip, purchase merchandise or view the real time ART schedule.
Trigger/Precondition:	User already have an account.
Frequency:	Average 1000 per day
Critical:	User forgets password or account stolen.
Work Area:	Login page
Subtasks:	**Example Solution:**
1. Sign in account	User enters the phone number and password.
2. Verify account credentials	System verifies the credentials that are input by the user.
3. Access account	System grants access if the user enters correct credentials.
Variants:	

1a. User already signed in the account.	System grants access to user without entering any credentials.
1b. User forgets password for the account.	System verifies the phone number/email then sends a temporary password or OTP to user and requires user to change the password once login.
1b a. User does not receive any temporary password or OTP.	User reports to the station manager on the help centre page.
2a. User enters wrong credentials	System denies the access and prompts an error message.
3a. User enters wrong credentials for 5 times.	System locks the account for 5 minutes.

Task 3: Sign out an account

Task: Sign out an account	
Purpose:	Sign out an account.
Trigger/Precondition:	User wants to sign out the account.
Frequency:	Average 10 per day
Critical:	-
Work Area:	Profile page
Subtasks:	**Example Solution:**
1. Sign out account	User signs out the account.
2. Sign out confirmation	System prompts a message to double confirm to the user's action.
Variants:	
2a. User discards to sign out.	System discards changes made by user and prompts user back to profile page.

Task 4: Update user information

Task: Update user information	
Purpose:	Make sure user details are all correct.
Trigger/Precondition:	User wants to edit or update their information.
Frequency:	Average 10 users per week
Critical:	User edits the information too frequently (3 times or more in a week).
Work Area:	Profile page
Subtasks:	**Example Solution:**
1. Edit or update personal details	User edits their personal details such as changing phone number, email or name.
2. Validate updated information	System validates the information updated by the user.

3. Update new information	System updates the new information done by user and refreshes the page.
Variants:	
2a. User enters invalid email or phone number format.	System shows error message and prompts user to enter again.

Task 5: Verify a user account

Task: Verify a user account	
Purpose:	Make sure user identify is accurate and verified.
Trigger/Precondition:	User updates personal identity in the application.
Frequency:	Average 10 users per week
Critical:	User uploads wrong identity information
Work Area:	Profile page
Subtasks:	**Example Solution:**
1. Upload personal identity information	User uploads personal identity information like identity card or passport.
2. Validate uploaded information	System validates the information uploaded by the user.
3. Confirm checking	System prompts user confirmation details to double check with the user.
4. Verify user identity	System updates the new information done by user and refresh the page.
Variants:	
2a. User identification is fuzzy.	System uses closest match algorithms.
2b. User uploads invalid photos.	System shows error message and prompts user to enter again.
3a. User discards changes made.	System clears all the information made by user.

Task 6: Book a trip

Task: Book a trip	
Purpose:	To book a trip at any time or anywhere.
Trigger/Precondition:	User wants to go to the place that they want.
Frequency:	Average 1000 users per day
Critical:	User books multiple trips in one time.
Work Area:	Booking page
Subtasks:	**Example Solution:**
1. Select date, time and destination	User selects date, time and destination at any time or anywhere.

2. View available trips	User views the available trip and book the ticket.
3. Select preferred trip	User selects their preferred trip.
4. Perform checkout	User performs checkout.
5. Booking confirmation	System makes a reservation for the trip.
Variants:	
2a. No available trip for selected date and time.	System shows no available trip and prompts user to book for other date and time.
4a. User credit balance is low.	System shows error message to indicate user balance is low.

Task 7: Cancel a trip

Task: Cancel a trip	
Purpose:	Allow user to cancel booked trip and get the refund.
Trigger/Precondition:	User wants to cancel the trip for purposes.
Frequency:	Average 5 users per week
Critical:	User cancels a trip but no refund.
Work Area:	Booking history page
Subtasks:	**Example Solution:**
1. Select booked trip ticket	User selects the booking that they want to cancel.
2. Cancel the trip	User cancels the booking within 5 hours before departure.
3. Confirm changes	System prompts confirmation message to notify the action made by user.
4. Update booking status	System processes the requests and updates the booking status and refund to user.
Variants:	
2a. User cancels the trip 1 hour before departure.	System rejects the request and shows error message.
3a. User does not want to cancel the trip.	System discards changes made by the user.

Task 8: Reschedule a trip

Task: Reschedule a trip	
Purpose:	Ensure user's trip is changed to other time slot after making rescheduling.
Trigger/Precondition:	User wants to change desired time for the trip.
Frequency:	Average 5 users per week
Critical:	User reschedules trip too frequently.
Work Area:	Booking history page

Subtasks:	Example Solution:
1. Select booked trip ticket	User selects the booking that they want to reschedule it.
2. Reschedule the trip	User reschedules the booking within 5 hours before departure.
3. Charge fee	System charges processing fee for rescheduling the trip.
4. Confirm changes	System prompts confirmation message and let user to double check the changes details.
5. Update booking status	System processes the requests and updates the booking status.
Variants:	
2a. User reschedules the trip 1 hour before departure.	System rejects the request and shows error message.
2b. No available seat for select date and time.	System shows error message and suggests the nearest slot for the date and time.
2c. ART is under maintenance and clashes with user trips.	System sends notification to request user reschedules their trip.
3a. User reschedules the trip to longer trip or shorter trip.	System charges additional fees for longer trip or refund the extra fee for shorter trip.
3b. System reschedules user trip due to ART maintenance.	No extra fee charges, and the system provides compensation to the users, such as giving 100 points. If the user declines and cancels the rescheduled trip, the system will process a refund within five hours after validation.

Task 9: Review booking history

Task: Review booking history	
Purpose:	Allow user to view back past or current booking.
Trigger/Precondition:	User has booked a trip or has booked trips previously.
Frequency:	Average 400 users per day
Critical:	User booking history only last for 3 months.
Work Area:	Booking history page
Subtasks:	**Example Solution:**
1. Display past and current bookings	System displays past and current booking made by user.
2. View the booking details	User views the booking details such as date, time and destination.
3. Request for invoice	User requests e-invoice for the references.
4. Generate an invoice	System generates an invoice to user.
Variants:	

1a. User booking history exceeds 3 months.	System clears the booking history from the page.
3a. User do not want to request an invoice.	No action is needed.

Task 10: Process top-up

Task: Process top-up	
Purpose:	Allow user to top-up money into account.
Trigger/Precondition:	User wants to buy ticket or merchandise.
Frequency:	Average 100 users per day
Critical:	Top-up amount exceeds 10k for one transaction.
Work Area:	Top-up page
Subtasks:	**Example Solution:**
1. Enter amounts to top-up	User top-up as much money as they want.
2. Select payment method	User selects which method to top-up such as credit card, online banking or e-wallet.
3. Update account balance	The system updates the user's account balance after done processing.
Variants:	
2a. User has set preferable payment method	System automatics selects the preferable method for top-up process.
2b. Bank account credit is low	System shows payment failure and let user to select other method.

Task 11: Process a payment

Task: Process a payment	
Purpose:	Authorise the transaction to make sure all transactions are accurate and correct.
Trigger/Precondition:	User wants to buy ticket or merchandise.
Frequency:	Average 1000 users per day
Critical:	The payment fee exceeds the user budget.
Work Area:	Checkout page
Subtasks:	**Example Solution:**
1. Perform checkout	User confirms the selected trip and proceed to purchase the ticket or merchandise.
2. Proceed to payment	System proceeds to the payment process.
3. Authorise the transaction	User enters the PIN number to authorise the transaction.
4. Payment confirmation	System confirms the transactions once authorised the user identity.
Variants:	
2a. User account credit is low.	User can choose FPX (online banking), credit card, or debit card to top up the e-wallet in the app.
3a. User enters wrong PIN number.	System prompts user to enter the Pin again for 5 times.

3b. User prompts wrong PIN number for 5 times.	System terminates the payment process and shows payment failure.
3c. User wants to use biometric to authorise the transaction.	System verifies the user's biometric and confirms the transaction.

Task 12: Refund a purchase

Task: Refund a purchase	
Purpose:	Make sure the funds are returned to users if they cancel the booking.
Trigger/Precondition:	User wants to cancel a booking.
Frequency:	Average 5 user per week
Critical:	System down or refund to wrong account.
Work Area:	Payment page
Subtasks:	**Example Solution:**
1. Cancel a booking	User cancels a booking or requests a refund.
2. Process the refund	System processes the refund and add into the user's account balance.
3. Generate refund confirmation	System generates refund confirmation to user.
4. Receives refund confirmation	User receives a refund confirmation via SMS/email.
Variants:	
2a. User does not receive the refund.	System checks user identity and resends the refund back to user account.
3a. User does not receive refund confirmation.	System resends the refund confirmation via SMS/email.

Task 13: Manage promotions

Task: Manage promotions	
Purpose:	Allow admin to manage discount promotions or special offers.
Trigger/Precondition:	Admin wants to add a promotion for users to use.
Frequency:	Average 2 promotions during festivals
Critical:	Admin add multiple promotions at a time.
Work Area:	Promotion page
Subtasks:	**Example Solution:**
1. Select promotion type	Admin selects the promotion type.
2. Add promotions	Admin can add, edit, or remove the promotions selected.
3. Confirm changes	System prompts admin to confirm the changes made.
4. Update the promotions list	System updates the promotions list after making changes.
Variants:	

2a. Admin wants to remove the promotions.	System accepts the request and delete the selected promotions.
2b. Admin wants to edit the promotion created.	System accepts the requests and allows admin to perform edit the promotion.

Task 14: Apply a promotion

Task: Apply a promotion	
Purpose:	Allow user to use promotion to get discount.
Trigger/Precondition:	User books a trip or purchases merchandise.
Frequency:	Average 50 users per day
Critical:	No available promotions in the list.
Work Area:	Payment page
Subtasks:	**Example Solution:**
1. Select available promotion	User selects promotion that available in the promotions list.
2. Apply or not apply the promotion	User applies the promotion selected, enter a promotion code or not apply.
3. Update promotion discount	System updates the total fee after using the promotion.
Variants:	
1a. No promotion available.	System shows empty promotion list.
2a. User applies invalid promotion code.	System shows error message and rejects the invalid promotion code.

Task 15: Earn the points

Task: Earn the point	
Purpose:	Enable users to earn points when they watch advertisement, purchase tickets or merchandise.
Trigger/Precondition:	User initiates a ticket or merchandise purchase.
Frequency:	Average 1000 users per day.
Critical:	User books multiple trips at once.
Work Area:	Booking page
Subtasks:	**Example Solution:**
1. Purchased a ticket or merchandise	User completes the ticket or merchandise purchase through the mobile app or website.
2. Earn the point	The system awards ten points per ticket and awards five points per merchandise purchased.
3. Update point balance	System updates the user's total points balance in their account.
Variants:	

2a. User receives bonus points for bulk purchases.	The system awards bonus points when user purchases multiple tickets in a single transaction.
2b. User can choose to watch the advertisement after purchased to earn more points.	System provides advertisement for user to earn bonus points.

Task 16: Redeem the points

Task: Redeem the points	
Purpose:	Allow user to check their current point balance and redeem points for rewards.
Trigger/Precondition:	User wants to redeem a reward.
Frequency:	Average 700 users per day.
Critical:	The point system not working.
Work Area:	Point page
Subtasks:	**Example Solution:**
1. Display point balance	System displays user's point balance in the account.
2. View the point	User views the available points.
3. Redeem reward	When point until a certain point, user able to redeem for a discount voucher or a merchandise.
4. Confirm redeem reward	System sends confirm message to user to confirm redemption.
5. Update point balance	System deducts certain point after user has redeemed the rewards.
Variants:	
3a. User wants to redeem merchandise but does not have enough points.	System prompts user the points required to complete the redemption.
4a. User wants to cancel redemption.	System discards redemption process and prompts user back to the page.

Task 17: Print a ticket

Task: Print a ticket	
Purpose:	Able to print ticket to board the ART.
Trigger/Precondition:	The user has completed a booking and wants to print the ticket.
Frequency:	Average 1000 users per day.
Critical:	User tries to print a ticket for a booking that has been cancelled.
Work Area:	Ticketing system page
Subtasks:	**Example Solution:**
1. Initiate ticket printing	User accesses their booking history and selects the trip to print the ticket.

2. Select ticket format	User chooses the format of the ticket, such as physical ticket or PDF which include the QR code.
3. Download ticket	User downloads the PDF of the ticket onto their mobile phone for digital use or later printing.
4. Self-printing	User prints out the ticket themself by using a self-service printing kiosk at the station.
Variants:	
3a. User faces internet connection issue when download the ticket.	System prompts user to reload the page and download the ticket again.
4a. User does not know how to use printer to print the ticket.	Station manager can assist user to print out the ticket at the station.
4b. User loses the printed ticket and requests reprint.	Station manager verifies the user's booking and allows a reprint if the ticket is still valid.

Task 18: Purchase a merchandise

Task: Purchase a merchandise	
Purpose:	Enable users to purchase merchandise through the mobile app or website.
Trigger/Precondition:	The user decides to purchase merchandise and has an active account with a valid payment method.
Frequency:	Average 300 users per day
Critical:	User purchases 10 or more merchandises at once.
Work Area:	Merchandise page
Subtasks:	**Example Solution:**
1. Browse merchandise	User browses through various categories of merchandise.
2. Select merchandise	Once the user identifies a desired item, they select it to view more details of the product.
3. Add merchandise to cart	User adds the selected item to the shopping cart and modifies the quantity or removes items as needed before proceeding to checkout.
4. Perform checkout	User confirms the items to be purchased and reviews the total cost.
5. Make payment	System proceeds to the payment process.
6. Receive receipt	User receives a receipt after making a successful payment.
Variants:	

5a. Failed payment due to low e-wallet balance.	The system will notify the user of insufficient balance then the user must top-up their e-wallet before retrying the transaction.

Task 19: Manage merchandise inventory

Task: Manage merchandise inventory	
Purpose:	Allow admin to monitor, update, and manage the inventory of merchandise.
Trigger/Precondition:	Merchandise is out of stock.
Frequency:	Average 700 inventory management actions per day.
Critical:	Certain merchandises may no longer for sale.
Work Area:	Inventory merchandise page
Subtasks:	**Example Solution:**
1. Display merchandise list	System displays current merchandise list to admin.
2. Select merchandise	Admin selects a merchandise based on their needs to update and manage.
3. Add merchandise quantity	Admin increases the merchandise quantity as needed.
4. Update stock levels	Admin updates the current merchandise stocks available into the merchandise list.
5. Set inventory thresholds and alerts	System notifies the admin to reorder or restock the merchandise when stock drops below the threshold.
Variants:	
2a. Admin wants to add new merchandise.	Admin adds new merchandise to the system's merchandise lists.
2b. Admin wants to remove out-of-stock merchandise.	Admin removes out-of-stock merchandise from the system's merchandise lists.
3a. Admin decreases the quantity of merchandise because accidentally adding too much quantity while update the restock level.	Admin decreases the merchandise quantity.
5a. Admin wants to disable the preset inventory threshold alerts.	The system stops sending notifications once the admin turns off the inventory threshold alerts.

Task 20: View merchandise order history

Task: View merchandise order history	
Purpose:	Allow user to view the past purchase merchandise.
Trigger/Precondition:	User wants to reorder the item.

Frequency:	Average 50 users per day
Critical:	The records disappear
Work Area:	Order history page
Subtasks:	Example Solution:
1. View purchased merchandise history	System displays the merchandise order history list.
2. Select desired merchandise	User selects the merchandise wants to buy again.
3. Perform checkout	User confirms the items they want to purchase again.
4. Proceed to payment	The system will bring the user proceed to make the payment.
5. Receive receipt	User will receive a receipt after successfully making payment.
Variants:	
4a. Failed payment due to e-wallet credit is low.	The system will notify the user of insufficient balance then the user must top-up their e-wallet before retrying the transaction.

Task 21: Submit a feedback

Task: Feedback submission	
Purpose:	Collect feedback from users after using the ART for improvement.
Trigger/Precondition:	Has experienced an ART service.
Frequency:	Depends on whether users choose to fill out the feedback form after using the ART.
Critical:	Users may fill out multiple feedback forms.
Work Area:	Feedback page
Subtasks:	Example Solution:
1. Fill out the feedback form	User rates or comments on the experience based on satisfaction, ART's environment, pricing and merchandise quality.
2. Submit the feedback form	System submits the feedback form on the feedback page once submitting.
3. Update feedback list	The system automatically updates the feedback list once user submits it successfully.
Variants:	
2a. User fails to submit the feedback form.	System prompts the user back to the page and try to resubmit.

Task 22: Review user feedback

Task: Review user feedback

Purpose:	Allow station manager to read feedback about the ART's overall condition.
Trigger/Precondition:	Station manager accesses the feedback page.
Frequency:	Station manager can check feedback at any time.
Critical:	Some feedback may be the same issues.
Work Area:	Feedback page
Subtasks:	Example Solution:
1. Display feedback	System displays all feedback submitted by the users.
2. Read and categorize feedback	Station manager reviews user feedback (satisfaction, ART's environment, pricing, and merchandise quality) and categorizes issues for station manager attention.
3. Respond to feedback	Station manager addresses user feedback when serious issues are identified and require a response.
4. Update and improve the services	Station manager updates the system feedback after station managers implement necessary service improvements.
Variants:	
2a. No available feedback to respond	No action is required.
3a. Station manager found that feedback is not relevant to the ART services.	Station manager ignores feedback that is not important.
3b. Feedback details may be the same as other feedback.	Station manager options to ignore the feedback that are repeated.

Task 23: Manage user account

Task: Manage user account	
Purpose:	Admin add an account or remove an account.
Trigger/Precondition:	Admin wants to create an account for special case like person with disabilities and elderly. Admin wants to remove inactive account.
Frequency:	Average 1 user per day/week
Critical:	User refuses to give their phone number or email.
Work Area:	User management page
Subtasks:	**Example Solution:**
1. Request phone number or email	Admin requests the phone number or email from user to create account.
2. Add an account	Admin adds an account and fills the required details like phone number.

3. Verify the details	System verifies the details filled by admin.
4. Confirmation checking	System prompts the admin with a confirmation message to double-check the admin's action.
5. Update changes	System updates the changes and refreshes the account lists.
Variants:	
2a. Admin wants to remove an account.	Admin selects the inactive targeted account for five year and removes the account.
3a. Admin enters invalid details.	System sends error message and prompts admin to enter details again.
4a. Admin discards to create the account.	System clears all the details entered by admin.

Task 24: Analyse and generate usage statistics for ART

Task: Analyse and generate usage statistics for ART	
Purpose:	To analyse the app's daily usage, increase the quantity of ART during peak hours.
Trigger/Precondition:	Users use the mobile app and web application.
Frequency:	Daily collect user data
Critical:	ART is out of services
Work Area:	Statistic page
Subtasks:	**Example Solution:**
1. Collect user data	System collects the user data like the app usage per day using an AI tool.
2. Analyse the data	System analyses which period has the most users opening the app or website to purchase tickets.
3. Generate the statistics	System generates statistics through visual representations like histograms, bar charts, and line charts for better understanding and analysis.
4. Arrange the use of ART	ART company increases ART frequency on high-demand routes or introduces new routes during peak hours to accommodate more users.
Variants:	
4a. More ART trips are scheduled at peak hours	System increases ticket availability to allow more users to purchase tickets during peak hours.
4b. Reduce ART trips	ART company adjust ART deployment by reducing the number of ART on routes with lower user demand.

Task 25: Payment notification

Task: Payment notification	
Purpose:	Notify users whether their payment was successful or failed
Trigger/Precondition:	A transaction is initiated for the purchase of a ticket or merchandise
Frequency:	Occurs whenever a user attempts a payment
Critical:	Fail to send notification
Work Area:	Pop-up notification
Subtasks:	Example Solution:
1. Initiate payment notification	The system triggers a notification process to notify the user of the payment status once a user completes the payment.
2. Verify payment status	System verifies whether the payment has been processed successfully or failed.
3. Send notification	The system sends a notification if the payment is successful.
Variants:	
3a. Successful payment	System redirects the user to a confirmation page.
3b. Failed payment	System sends a notification explaining the failure and suggesting the next steps (provide retry options).

Task 26: View ART departure/arrival time

Task: View ART departure/arrival time	
Purpose:	Allows users to track real-time ART schedules and notify users of ART departure and arrival times so they can board on time or prepare to alight.
Trigger/Precondition:	The user has successfully purchased a trip ticker
Frequency:	Occurs before the ART departs or arrives from a station
Critical:	Miss boarding or failing to get off at the right station
Work Area:	Pop-up notification
Subtasks:	Example Solution:
1. Notify users of ART's upcoming departure	System sends a departure reminder 3 minutes before the ART leaves the station.
2. Display real-time ART status	Users track ART arrival and departure times through the app.

3. Notify users of ART's upcoming arrival	System sends an arrival reminder 3 minutes before the ART reaches the station.
Variants:	
1a. ART delays occur.	If there is a delay, the system sends additional alerts with updated departure times.
1b. ART is under maintenance.	System notifies user that the ART is under maintenance and prompts them to reschedule their trip.
3a. User successfully gets off at the right station.	No further action is needed.
3b. User misses the designated station.	Disembark at the next station and book a return ART to reach the intended destination.

Task 27: Report an issue

Task: Report an issue	
Purpose:	User reports an issue and station manager solves the issue.
Trigger/Precondition:	User faces issues when using the system.
Frequency:	Occurs when users forget password and require changing password, user's successful top-up but does not receive the money as well as users cancel or reschedule the booking but does not receive the refund money.
Critical:	Station manager does not respond immediately
Work Area:	Help centre page
Subtasks:	**Example Solution:**
1. Select the method	User chooses either phone calls to station manager or chatbot through help centre.
2. Report the issue	User reports the issue faced to station manager or chatbot.
3. Request user personal email	Station manager requests the user personal email for record purposes.
4. Send a notification	Station manager notifies the user through email once the issue is solved.
Variants:	
1a. No respond in phone call	Station manager might busy in that period
3a. User gives wrong personal email	Station manager prompts user to resend the personal emails again.
4a. Station manager forgets to send a notification to user.	User contacts back to the station manager who are in charge the user issue.

Task 28: Voice prompt

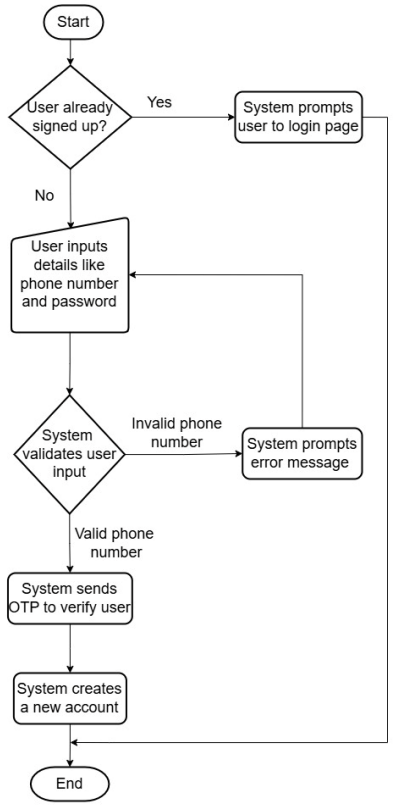
Task: Voice prompt	
Purpose:	User speaks to book or cancel a trip.
Trigger/Precondition:	User activates the voice prompt feature.
Frequency:	Occurs when user with low vision or inconvenient can use the voice prompt.
Critical:	Limited vocabulary in the voice command library, non-standard user language, it can only book a trip and user device's microphone not good.
Work Area:	Top right of every page.
Subtasks:	**Example Solution:**
1. Activate voice prompt	User clicks the mic icon or say wake word ("Hey ART"). After the system successfully activate then it will play auditory cue ("How can I help?")
2. Cue all upcoming destination	System speaks all the upcoming destination. If not, it will play auditory cue ("You have not any booking yet, you want to book a trip?")
3. Cue voice command	User speaks a command ("I want to Book a trip to Kuching Central later at 5 PM") or ("I want to cancel a trip for today's 5 PM trip which destination at Kuching Central").
4. Convert voice to text	System converts the speech to text and validates keywords (date, time, destination)
5. Confirm action	System reads back details to confirm the booking ("Confirm booking to Kuching Central at 5 PM later?") or cancellation ("Confirm cancel the booking?")
6. Execute command	System processes the booking or cancellation and replies ("Trip booked, ticket sent to your notification") or ("Trip has been cancelled, processing refund money, please wait")
Variants:	
2a. User does not book any trip	System prompt user message by playing auditory cue ("You have not any booking yet, you want to book a trip?").
3a. User speak different language	System prompts ("Sorry, I didn't understand, please switch to Malay or Mandarin")
3b. User give multi-step command	System prompts ("Cancelled 9 AM trip. Booked 11 AM trip")
3c. User background noise too loud	System prompts ("Please speak clearly")

5.0 Workflow

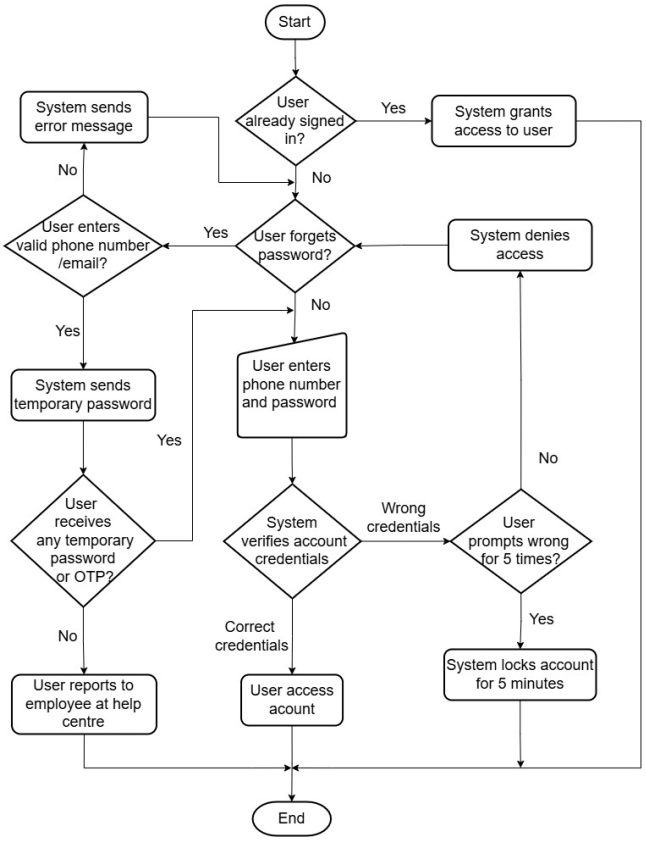
After completing all the functional requirements by using Task and Support method, below are the proposed workflows for each task. More specifically, each workflow will go through step-by-step flow chart to describe the interaction between the actors.

Task 1 and Task 2

Task 1: Sign up new user account

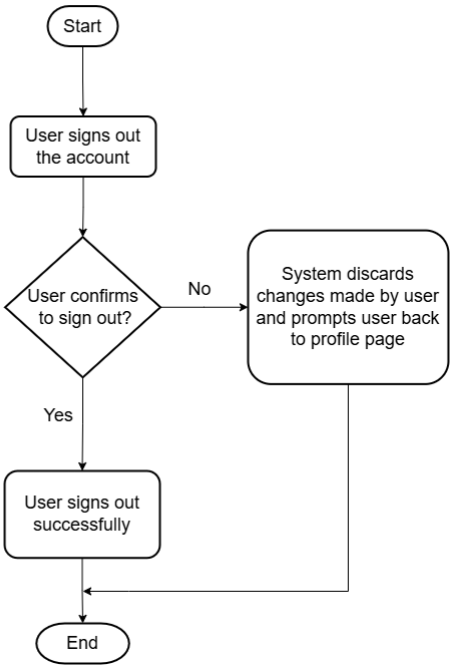


Task 2: Sign in an account

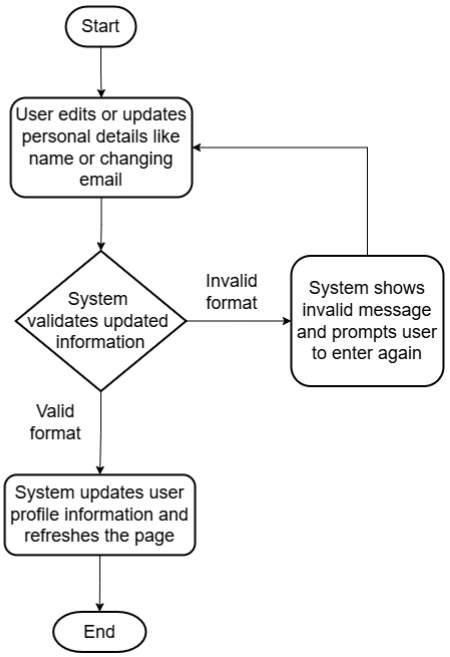


Task 3 and Task 4

Task 3: Sign out an account

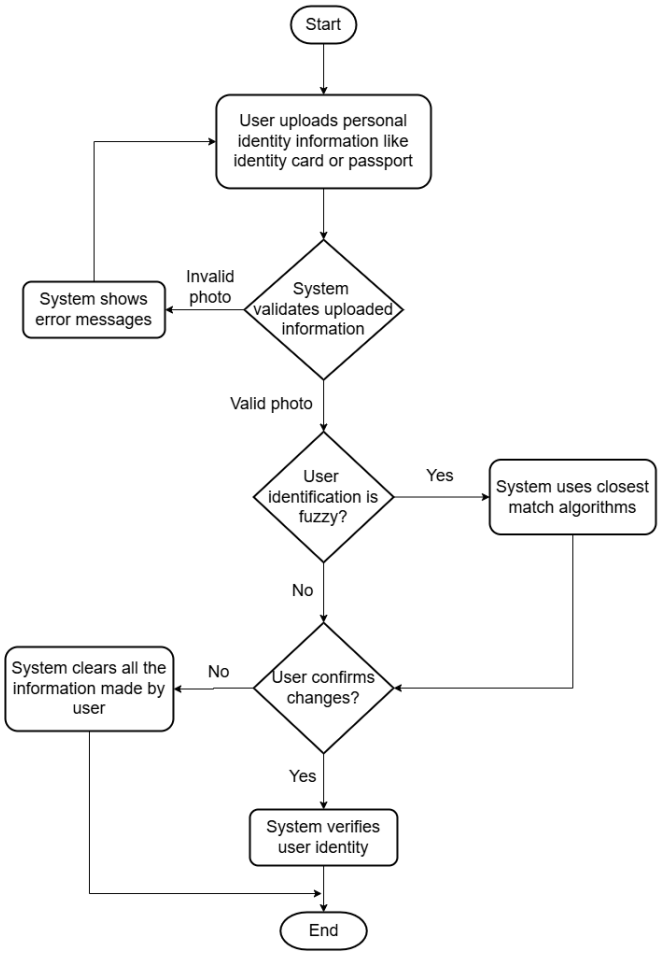


Task 4: Update user information

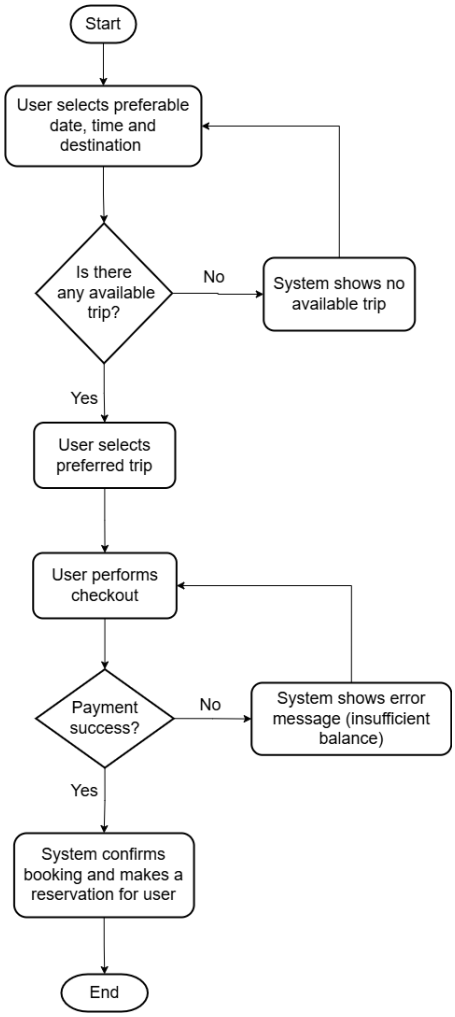


Task 5 and Task 6

Task 5: Verify a user account

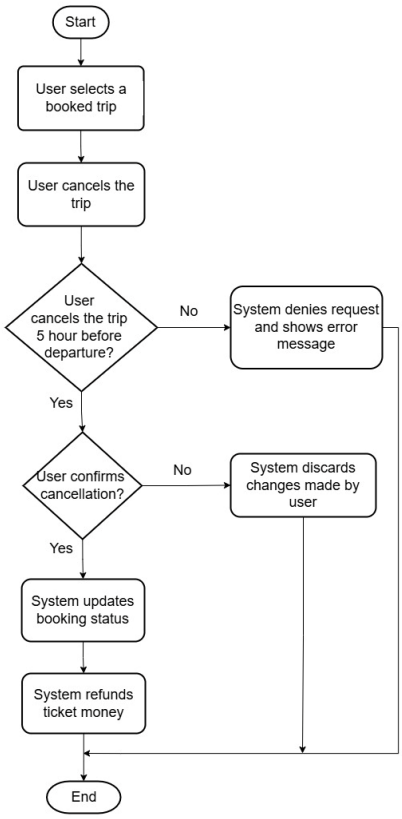


Task 6: Book a trip

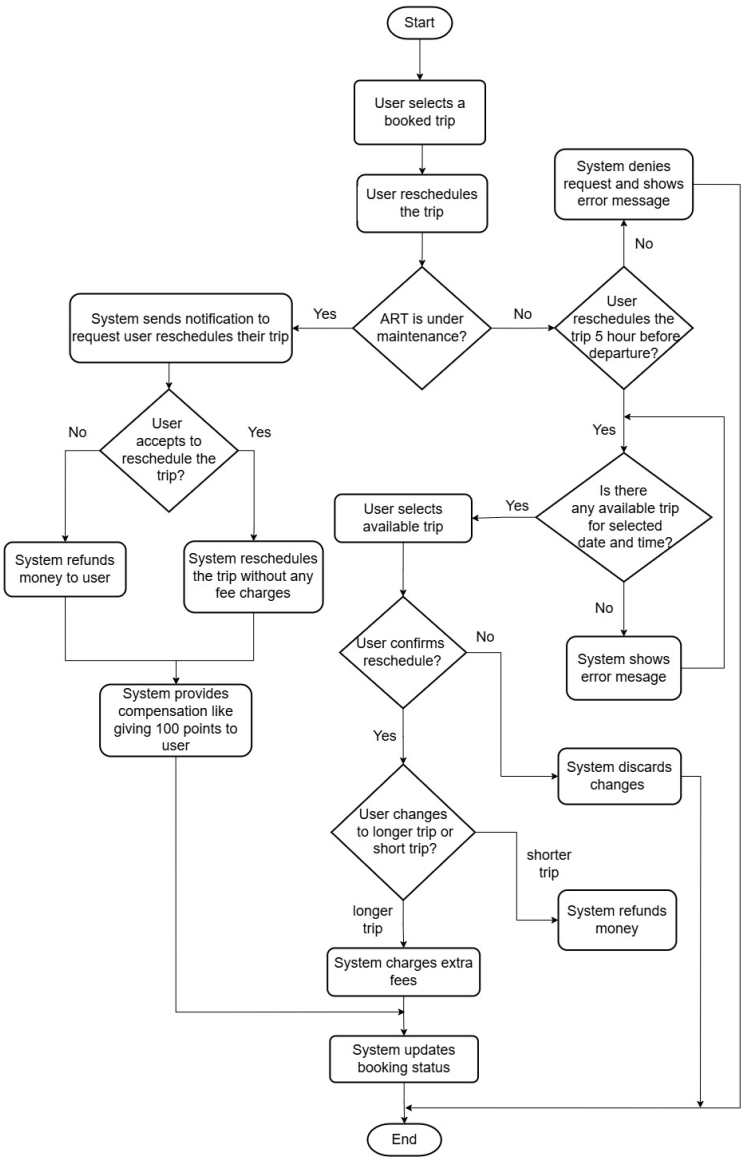


Task 7 and Task 8

Task 7: Cancel a trip

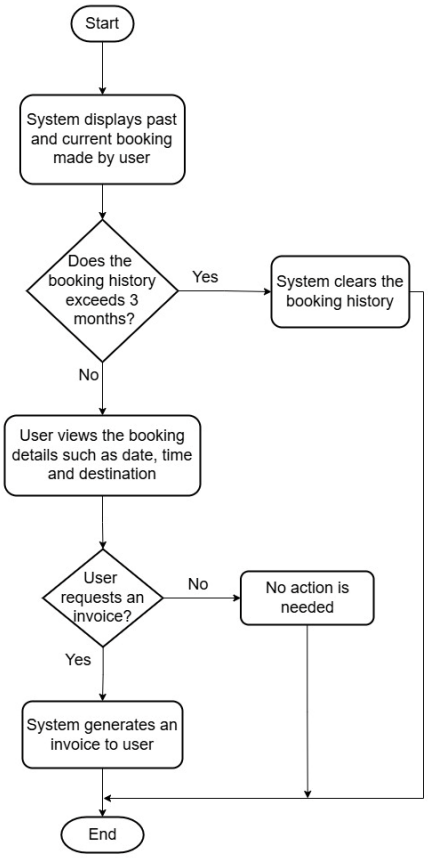


Task 8: Reschedule a trip

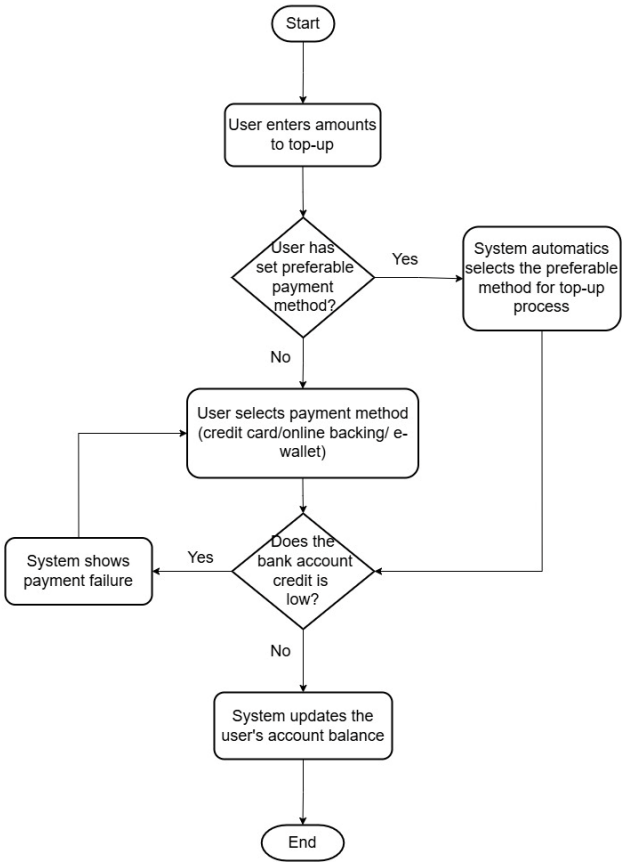


Task 9 and Task 10

Task 9: Review booking history

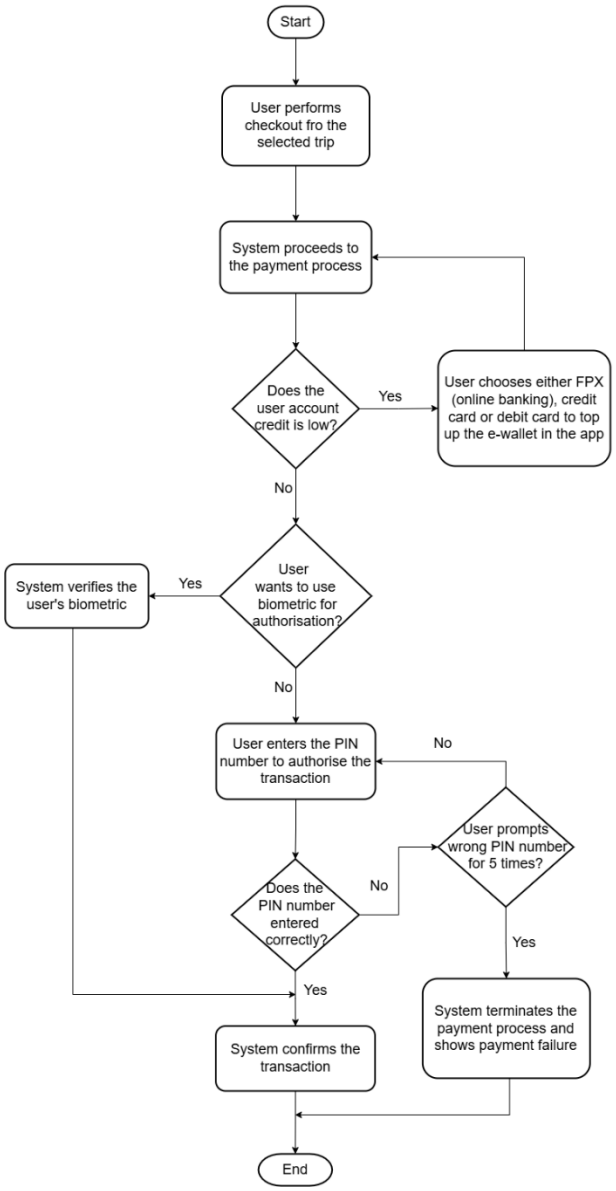


Task 10: Process top-up

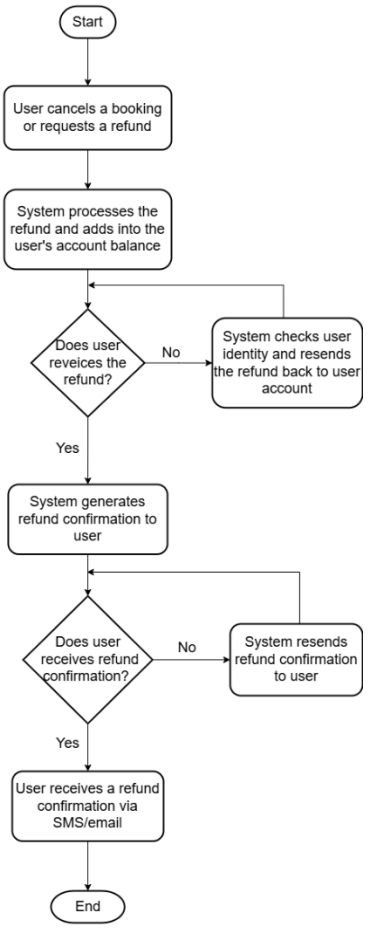


Task 11 and Task 12

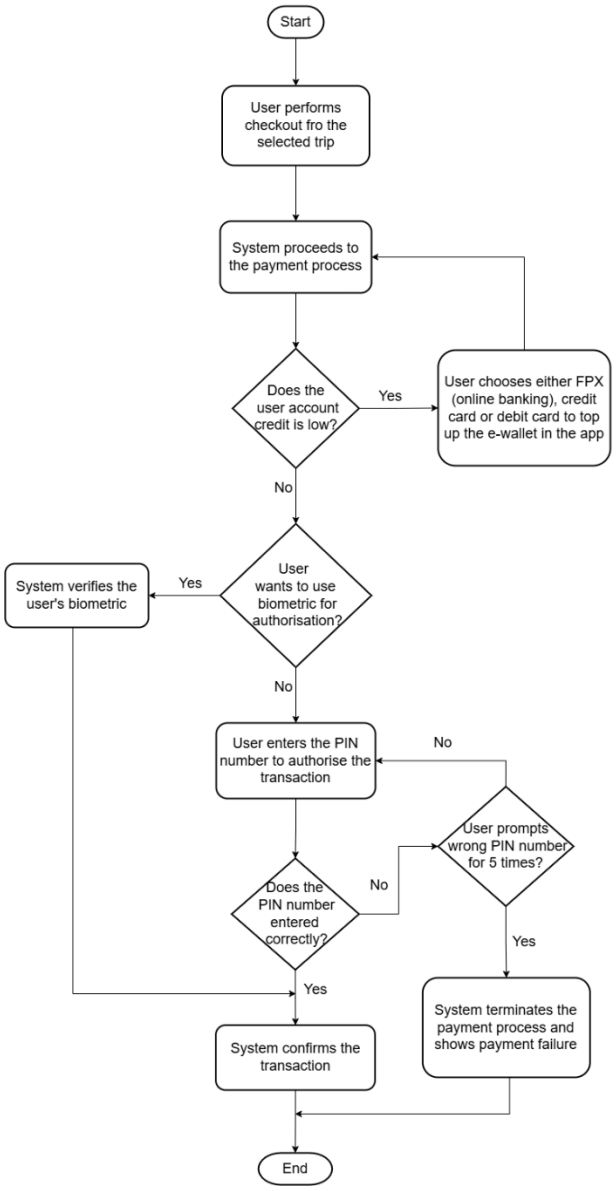
Task 11: Process a payment



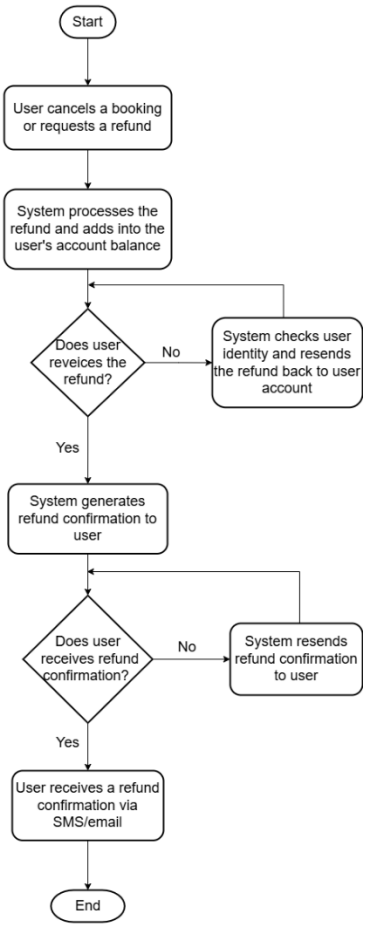
Task 12: Refund a purchase



Task 11: Process Payment

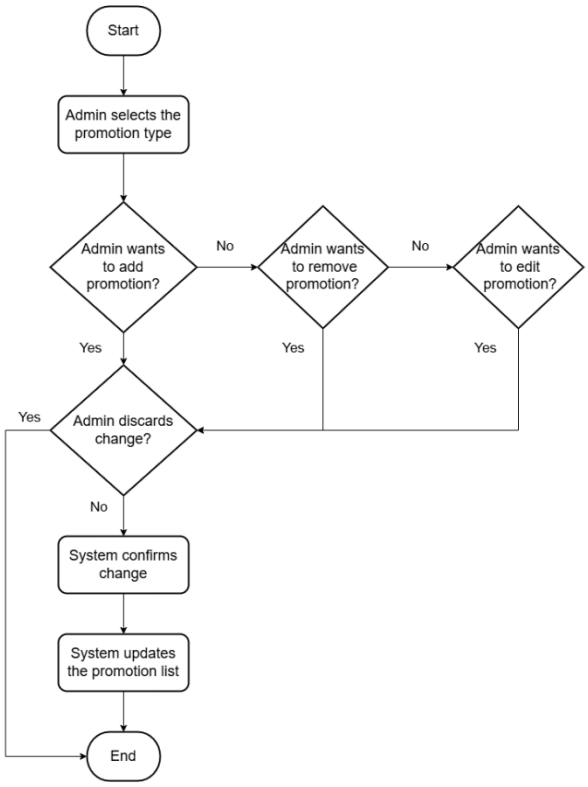


Task 12: Refund purchases

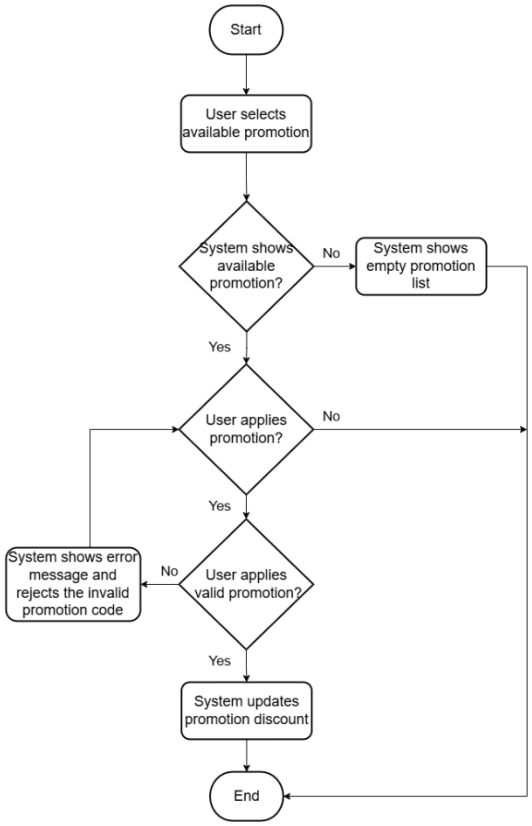


Task 13 and Task 14

Task 13: Manage promotions

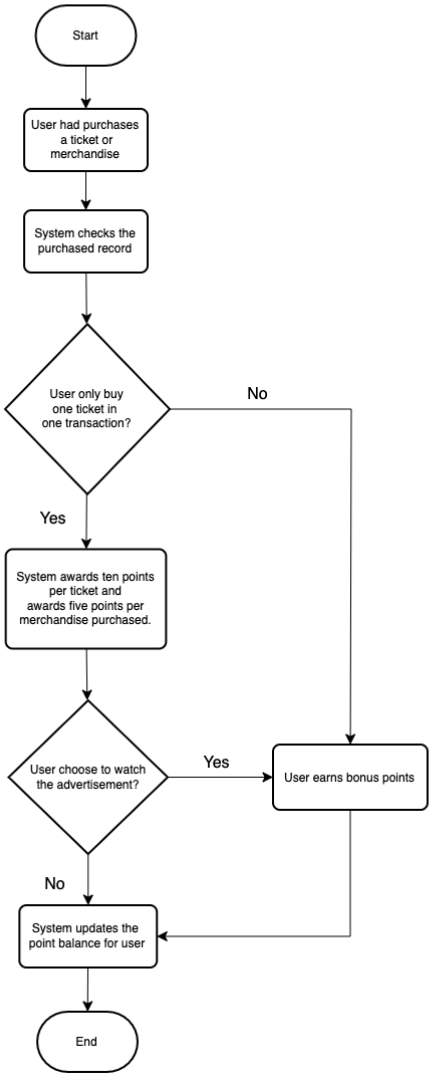


Task 14: Apply a promotion

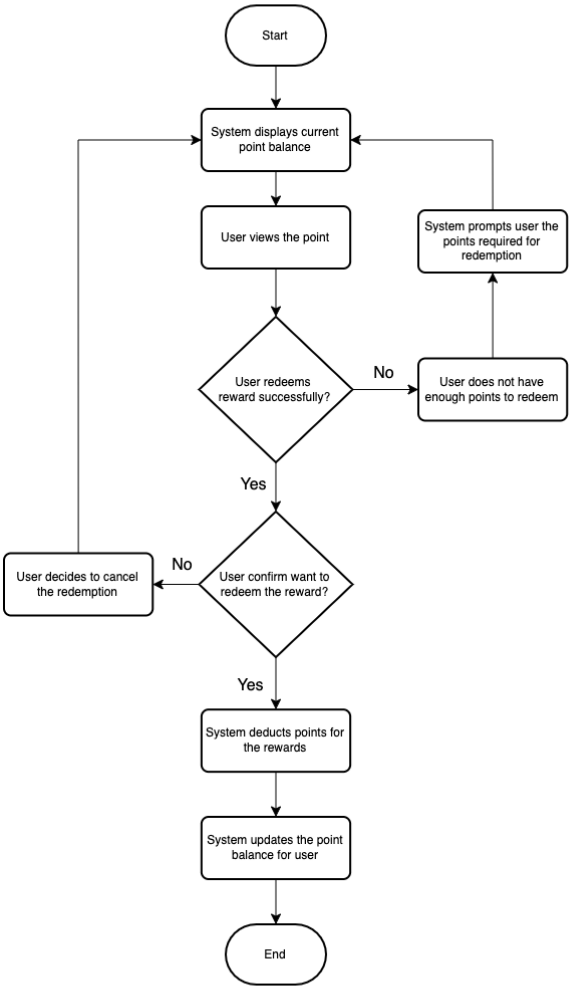


Task 15 and Task 16

Task 15: Earns the point

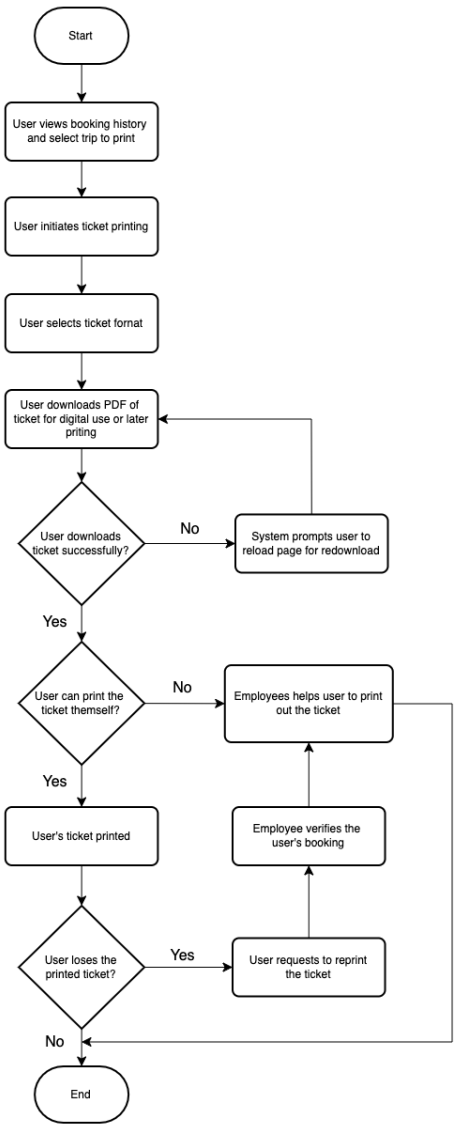


Task 16: Redeem the points

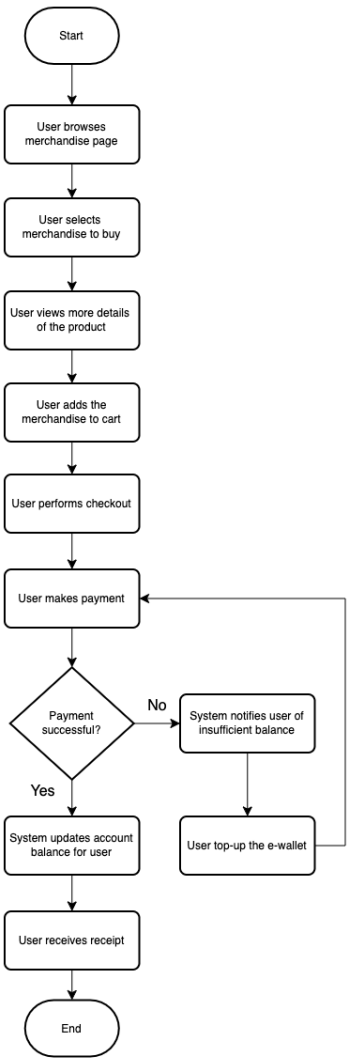


Task 17 and Task 18

Task 17: Print a ticket

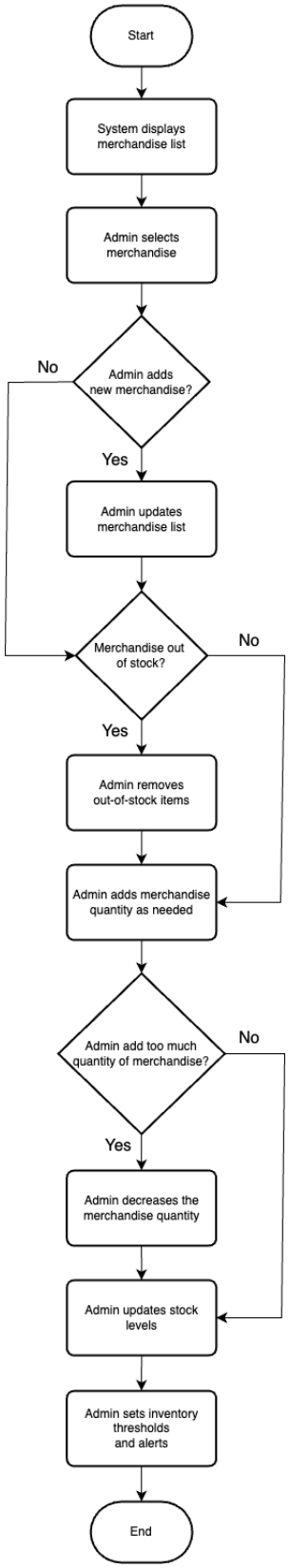


Task 18: Purchase a merchandise

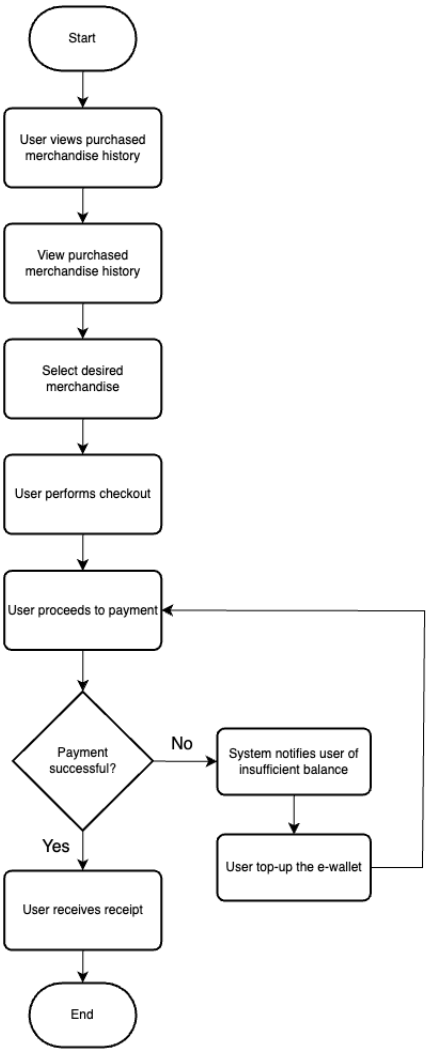


Task 19 and Task 20

Task 19: Manage merchandise inventory

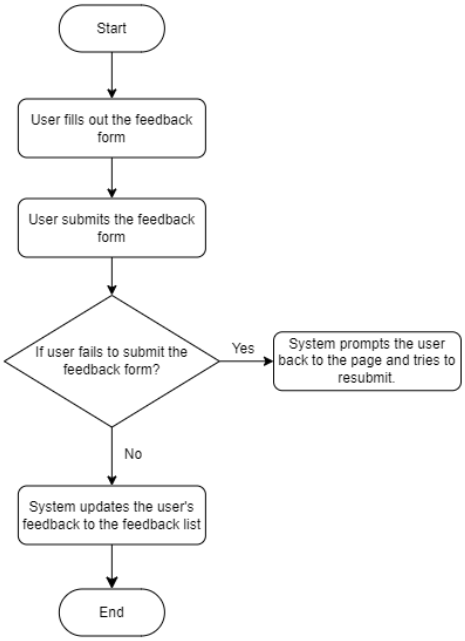


Task 20: View merchandise order history

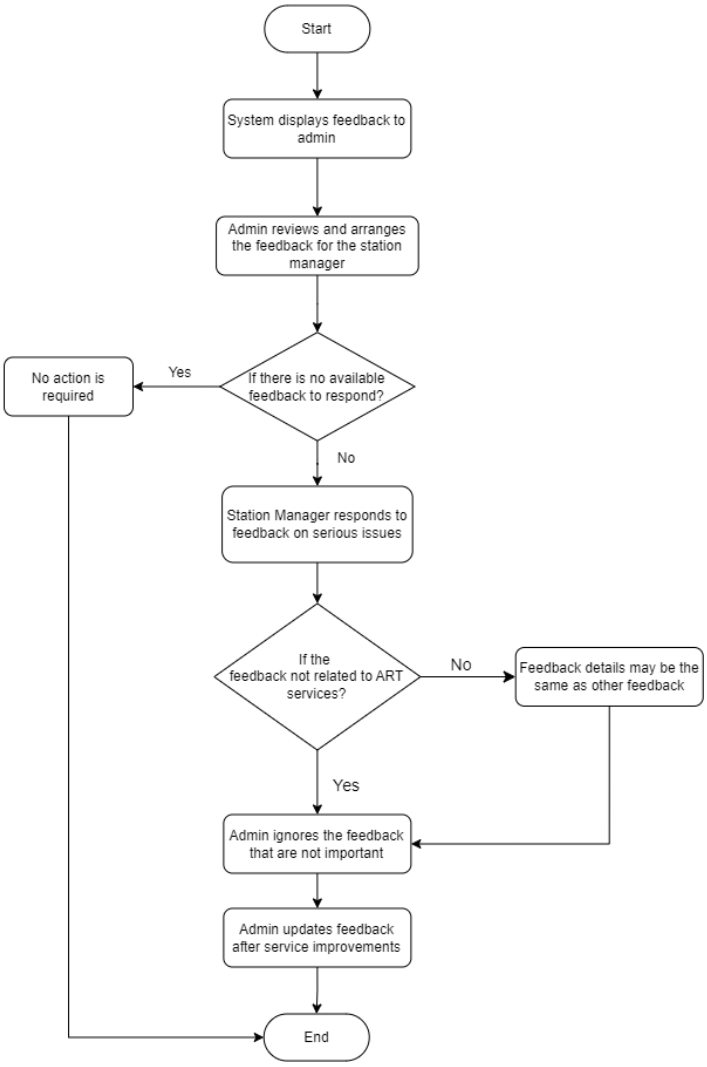


Task 21 and Task 22

Task 21: Submit a feedback

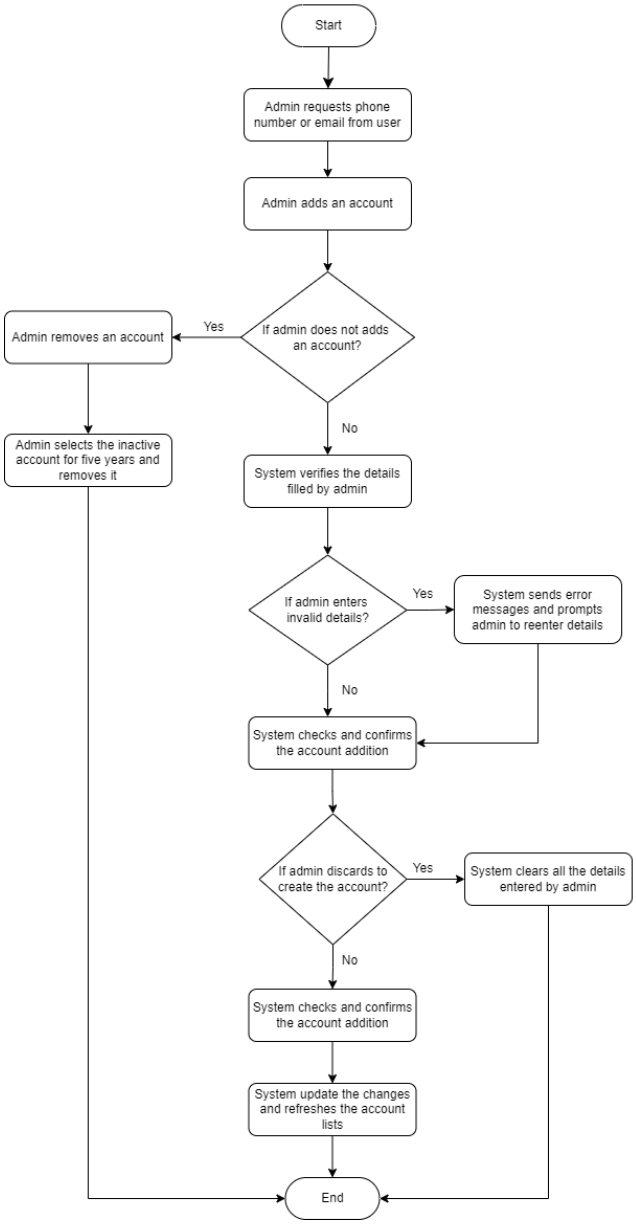


Task 22: Review user feedback

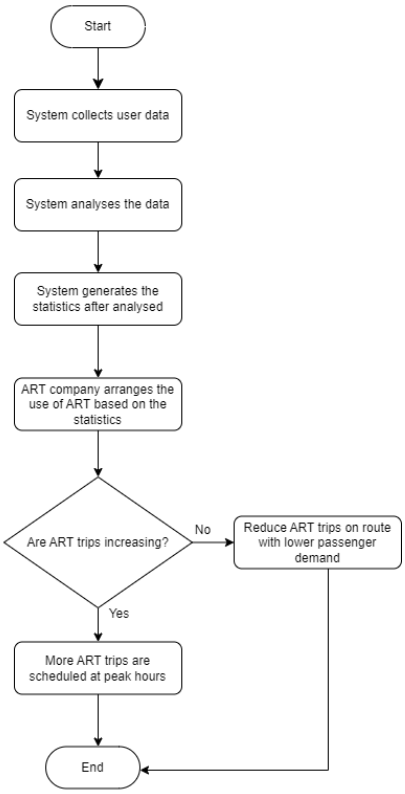


Task 23 and Task 24

Task 23: Manage user account

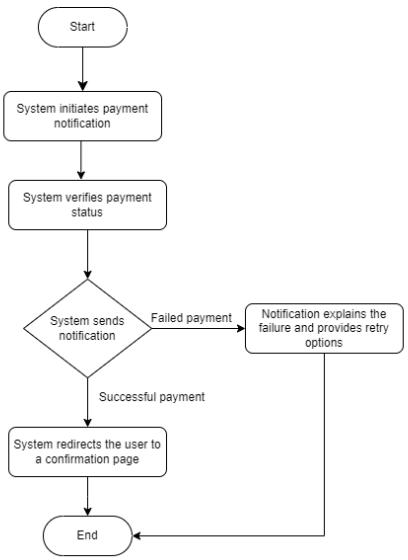


Task 24: Analyze and generate statistics usgae statistics for ART

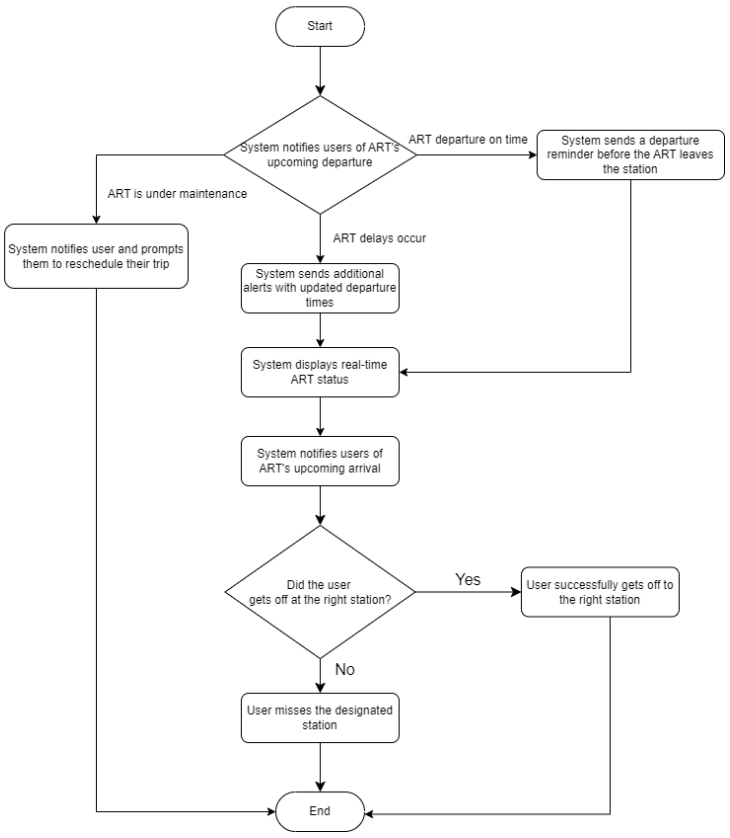


Task 25 and Task 26

Task 25: Payment Notification

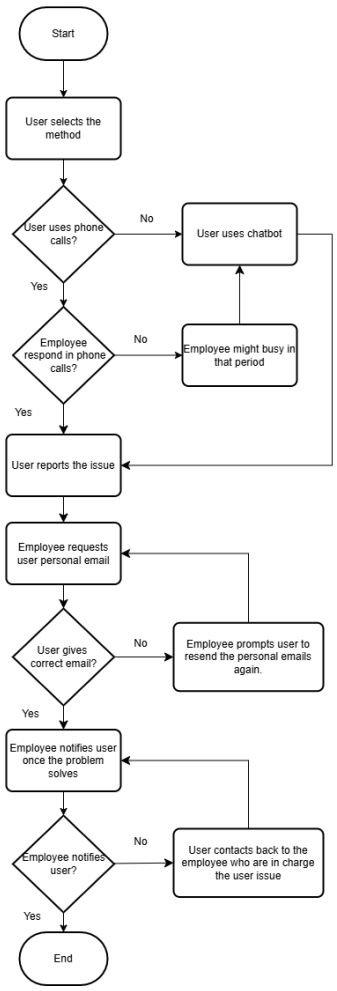


Task 26: View ART departure/arrival time

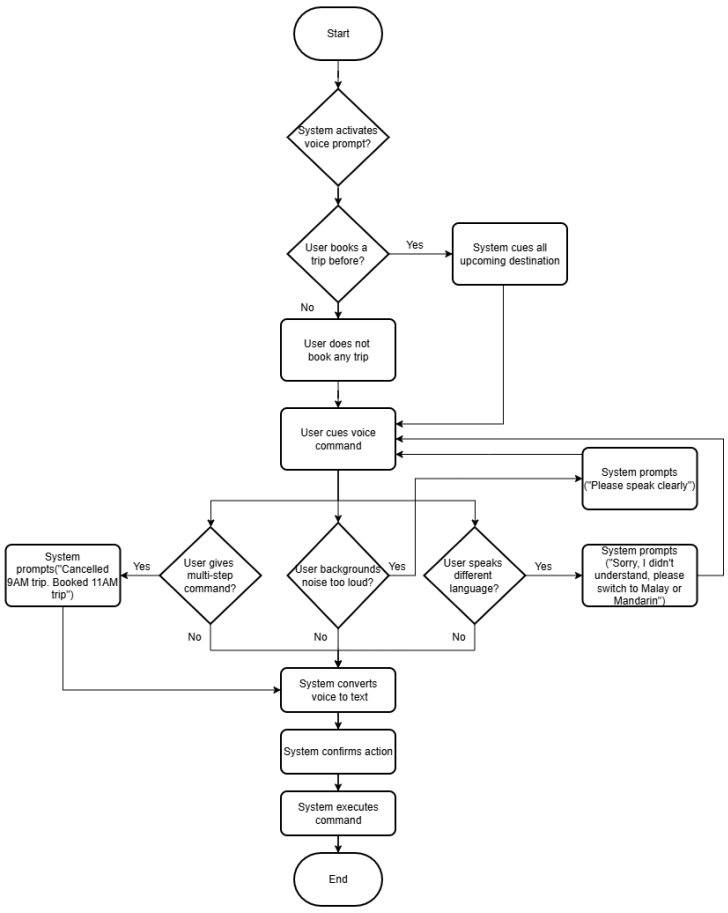


Task 27 and Task 28

Task 27: Report an issue



Task 28: Voice prompt

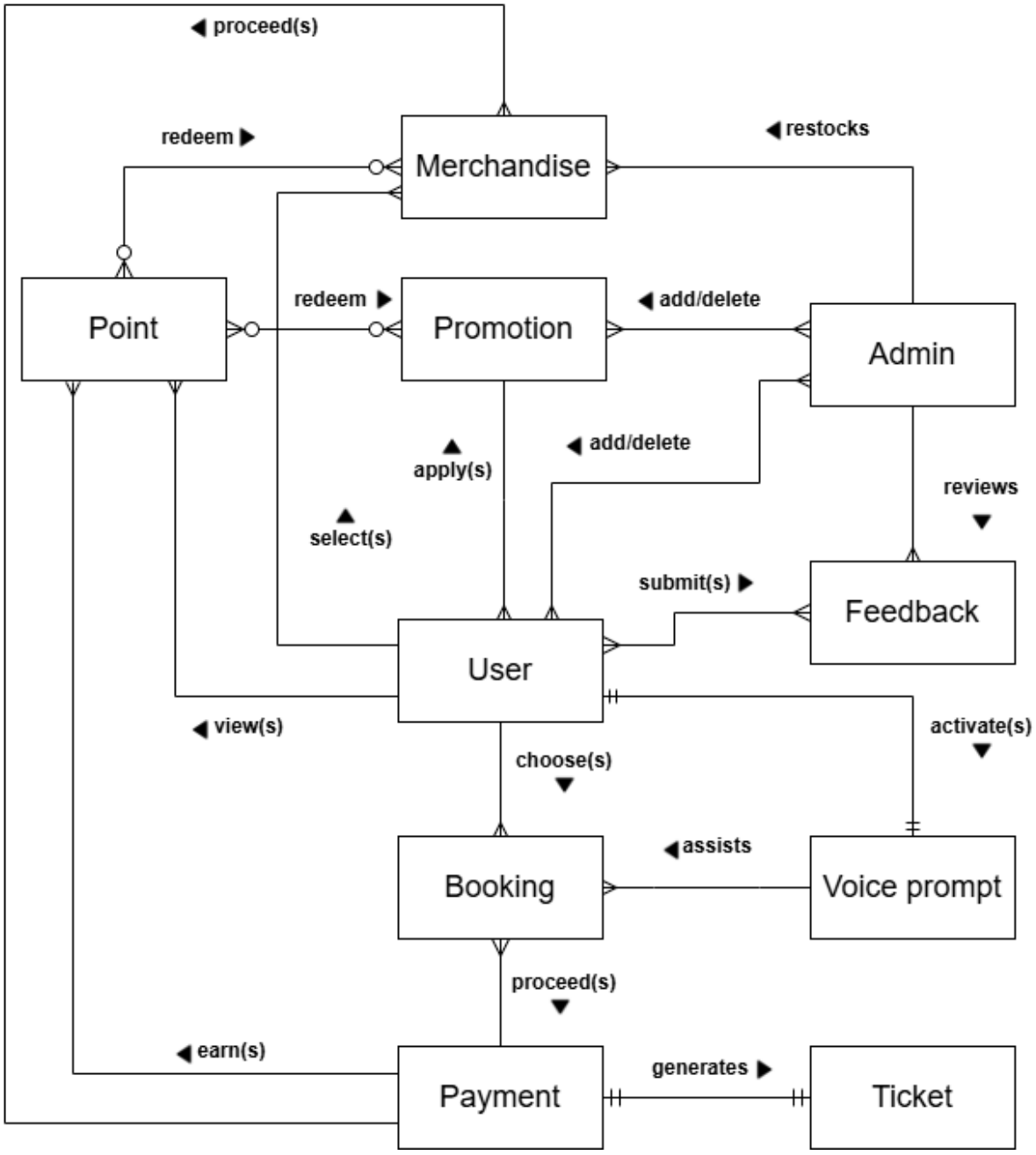


6.0 Data model

In this section, we will discuss the overall architecture of the ART online ticketing system and the relationship of each entity along with the explanation. This provides a fundamental understanding of the ART system and how data is connected and managed within the system.

6.1 Domain Model

The below figure is the modelling of the ART system. It consists of several classes, and it is designed to give a clear visualisation of how each entity is related to the others.



6.2 Entity Descriptions

After seeing the data model and the entities relationship of the ART system, this sub-section provides a detailed description of the main entities within the system. Below are the entities and their respective definitions that are involved in the ART system.

Entities	Descriptions
User	Users can interact with the system to book a trip, purchase merchandise, submit feedback, view ART schedules and receive notifications.
Admin	The admin can create promotions, restock merchandise, analyse user demographics, and review it.
Ticket	A physical or digital ticket is generated after a user books a trip. It includes a QR code for scanning and is available to download in PDF format.
Merchandise	User can buy merchandise and user earns points after purchased
Booking	A reservation made by a user for a specific trip. The booking details include the date, time, and destination of the trip.
Payment	A transaction made by a user to book tickets or purchase merchandise.
Feedback	User can submit feedback about their experience with the ART system. The admin can view the feedback and respond to the feedback.
Promotion	Admin will create promotions like discounts or special offers, and user can choose to use the voucher or not while buying tickets or merchandise.
Point	Users can earn points during booking tickets or purchasing merchandise.
Voice prompt	Need to be activated by user, and able to assist user to book one or more trip.

7.0 Quality Attributes of System

In this section, we will discuss the quality attributes of the ART online ticketing system.

7.1 Usability

The Sarawak ART online ticketing system must be developed to accommodate users of all ages, from young children to the elderly. According to the Department of Statistics Malaysia (2024), the majority of Sarawak's population is between the ages of 15 and 64, which is around 1,792,816 people (71.2%). Additionally, there are 219,066 elderly people (8.7%) in the state. Thus, the system must provide an inclusive and user-friendly experience that caters not only to youngsters but also to elderly users.

To meet this quality requirement, the system must:

- **Design with a clean and user-friendly interface**
  The app should provide a clean and straightforward design with large buttons and clear fonts to make it easy to use for all age groups, especially for the elderly person. In addition, the app can include Sarawak's cultural elements to make it more visually appealing and accessible to local users.

- **Provide transparent pricing and all-inclusive fee display**
  The system must display the total cost, including base fare, taxes, and service fees on the checkout page. It is to avoid any hidden charges or last-minute additions during payment. Furthermore, the system should provide discounts for Sarawak locals like senior citizens or students to promote inclusivity.

- **Support multi languages for diverse communities**
  Since 51% of the population in Sarawak is made up of Bidayuh, Iban and Dayak (AKA Bumiputera), while Malay consists of 25.2% and Chinese 23.3% (Department of Statistics Malaysia 2024), thus the ART system will use Malay as the primary language because it is widely spoken across the state. However, the system also supports English and Chinese to cater to Sarawak's varied population. This will enhance the user experience and ensure that both locals and tourists can easily use the system.

7.2 Performance

The online ticketing system should give quick responses to the users' requests, especially during the transaction process and the ART schedules updates. Besides that, the system should be able to support high number of concurrent users during peak hours to avoid any system down.

To meet this quality requirement, the system must:

- **Provide fast booking and payment processing**

  The system must allow users to complete the entire booking process from selecting a trip to receiving a confirmation within 5-15 minutes. Moreover, the payment processing should have a response time of less than 5 seconds to make sure users have a good experience.

- **Provide real-time ART updates and clear instructions**
  Users should get real-time updates on ART departure and arrival times within 5 seconds. Besides that, the system should provide clear and real-time instructions to avoid any confusion occur. For example, the system could give real-time ART routes that tell users where the ART is and when it will arrive based on the estimated time.

- **Offer fast route suggestions**
  The system should suggest optimal routes and estimate travel times to help users plan their trips efficiently. For example, the system should notify users when the ART arrives at the station before 3 minutes. This feature is useful for tourists who are unfamiliar with Sarawak's transportation network.

7.3 Reliability

The system must provide high reliability to ensure users can consistently access and use the system without any interruption, especially in Sarawak, where the infrastructure can vary across urban and rural areas. A reliable system is crucial to ensure that payments and bookings are processed accurately and securely, minimizing downtime to provide seamless service to all users, even in remote locations.

To achieve this requirement, the system must:

- **Provide 99.9% uptime**
  The system should use multiple servers to avoid any downtime or interruptions. If one of the servers fails, the system can still run normally as the other servers will take over seamlessly. This is especially important in Sarawak's vast, rural regions, where the users may depend on the system for essential services like transportation. This reliability ensures that users can make payments and bookings without worrying about any disruption, which is vital when services like the ART are being used for important travel needs.

- **Maintain a high success rate to 99.5%**
  The system should maintain a high success rate of 99.5% for payments and bookings. It is essential to process payments accurately and securely to gain the trust of Sarawak's diverse user base. Accurate payment processing helps to build confidence in the system and ensures that both users in Kuching and those from more remote areas can feel secure when using the system.

- **Daily automated backups**
  The system must back up all the sensitive information daily and store it securely in the cloud to protect against data loss due to hardware failures, software bugs, or cyberattacks. This is particularly important for Sarawak, where some areas might face unreliable power or internet connections. Ensuring that all important data can be restored quickly in case of disaster or system failure guarantees that users, regardless of location, will not lose their information, especially when it comes to critical booking details.

7.4 Portability

Portability is crucial for the online ticketing system as it ensures that users across Sarawak can access the system from a variety of devices and platforms, regardless of their OS or internet connectivity. Due to Sarawak's diverse landscape, which includes both rural kampungs and isolated longhouses as well as busy cities like Kuching, accessibility on different devices is essential for inclusivity.

To achieve this quality requirement, the system must:

- **Support multiple platforms**
  The system must support multiple platforms to ensure that users can access the system from different devices and operating systems. Sarawak has a diverse population, and many users may switch between their smartphones, tablets, or computers. Whether they are in the city or more isolated regions, all users should have a consistent experience and be able to navigate the system easily to reduce the learning curve for those who may not be as familiar with the technology.

- **Offer offline access**
  The system should offer offline access for users to download tickets in formats like QR codes or PDFs. This is especially important in rural and remote areas of Sarawak where internet access can be inconsistent, which may cause the users to face internet connection problems. Enabling offline access to tickets ensures that everyone can board the ART without worrying about network problems regardless of where they are.

7.5 Scalability

Scalability refers to having a strong system that is able to handle the growth of users, transactions, and data, and the system will still be able to run smoothly. This scalability is very important to user experience because it determines whether users will continue using this online system.

To achieve this quality requirement, the system must:

- **Handle many concurrent users**
  System should be able to handle the growth of concurrent users, especially during peak hours. At least 10000 concurrent users should be handled by the system without substantially affecting performance.

- **Efficient to the transaction processing**
  The system should be able to handle a high volume of transactions per second (TPS), especially during peak booking periods. At least 1000 transactions per second should be handled by the system without delays or failure.

- **Scalable for data management**
  The system should be able to manage large volumes of data, including all the history (transactions, purchased merchandise, purchased tickets, top-ups) as well as user profiles. The database should be designed to scale horizontally that enable the addition of additional processing and storage capacity. For example, system can split the data like users with IDs 1 to 1000 go to shard 1, 1001 – 2000 to shard 2, the same method goes to those history.

7.6 Accessibility

Accessibility guarantees that the system is usable to everyone such as people with disabilities and the elderly. To guarantee that this system is inclusive and usable by wide variety of users, the system should agree to international accessibility standards, such as Web Content Accessibility Guidelines (WCAG) 2.1 from W3C (2024).

To achieve this quality requirement, the system must:

- **Screen reader and compatibility**
  The system must work perfectly with screen readers (technology that helps users who have difficulties seeing the digital content) so that those who are blind, have a visual disability or are elderly can access the website and mobile app. All forms, buttons and images have the proper labels and alt text.

- **Keyboard Navigation**

The system needs to be completely navigable with just a keyboard and no mouse needed. This is crucial for users who rely on keyboard shortcuts or assistance devices due to motor limitations (users with physical limitations in movement).

- **High contrast and scalable text**
  The system should have enough colour contrast between the text and background to ensure users with visual disabilities can read the text. The font size should be able to change by users without affecting the website or app's look, so that users are able to see the text clearly.

- **Voice assistance and text-to-speech**
  Additionally, integrate a voice assistant and text-to-speech functionality to assist users with disabilities, allowing them to book tickets, check schedules, and receive updates through voice commands.

7.7 Availability

The ART system is always highly available and fully operational to provide a seamless and uninterrupted user experience. This ensures that users can reliably access essential services such as ticket booking, payments, and real-time tracking without disruptions, except during scheduled maintenance periods.

To meet this availability requirement, the system supports:

- **24/7 System Accessibility**
  The system must be available 24/7, allowing users to book tickets, make payments, or redeem points anytime. This ensures that users can access the system anytime, regardless of their time zone or travel habits.

- **Load Balancing**
  Distribute traffic across multiple servers to prevent system overload during peak hours. During festivals and holidays, many people return for family reunions or celebrations, making reliable booking services crucial. Without proper load balancing, ticketing systems may crash, leading to frustration and difficulty securing transport.

7.8 Security

Security is a top priority since the ART system handles user information and payment transactions. The system must be designed to safeguard against unauthorized access and prevent fraudulent activities, ensuring users' secure and trustworthy experience.

To meet this security requirement, the system will implement:

- **One-Phone-Number, One Account Policy**
  Since SIM card registration is linked to identity documents, impersonation and fraudulent activities are minimized. To enhance security, the system is designed so that each phone number can only be linked to one registered account, reducing the risk of duplicate or fraudulent accounts.

- **User verification**
  Users must verify their identity using their identity card to ensure account security and prevent unauthorized access. In addition, the system must use AES algorithm to encrypt the sensitive data. The system has explicit consent and robust security measures in place to protect this sensitive data, as mandated by the Personal Data Protection Act (PDPA).

- **Role-Based Access Control**
  Restrict system access to only what is relevant to each user's role, ensuring that users can only perform authorized actions. Admin manages user accounts, analyses user demographics, and reviews feedback, while users are limited to booking tickets, making purchases, and redeeming points for discounts. In short, admins has the highest privilege level in this system, followed by station managers and last is the users. This enhances security by protecting user information and sensitive data, enhancing overall system security.

- **Authentication Transactions**
  The system only allows payments using the in-app e-wallet, requiring users to top up before purchasing. To ensure secure transactions, users must enter a PIN code every time they make a payment, whether purchasing tickets or merchandise, which prevents unauthorized transactions and enhances user protection.

- **Secure Redemption Process**
  Users must verify their identity by entering a PIN code when redeeming points for discount vouchers or merchandise. This ensures that only the rightful account owner can access and use their rewards securely.

- **Mitigating Unauthorized Voice-Based Fraud**
  According to Li et al. (2023), attackers may mimic user voices to execute unauthorized actions, such as trip cancellation or rescheduling, so to mitigate this risk, it is essential to implementing speaker verification (SI models) to authenticate users before processing sensitive commands and requiring multi factor authentication. For example, PIN or biometric verification for high risks actions.

8.0 Other Requirements

This section outlines the additional product-level and design-level and requirements for the ART online ticketing system.

8.1 Product Level Requirements

These requirements define the capabilities that the ART system must support:

- Multiple languages such as English, Malay, and Chinese
- Provide real-time notifications for arrival, departure, delays, bookings and payment confirmations.
- Ensure secure payment processing for top-up to the e-wallet with encrypted transactions.
- Generate e-receipt or e-invoice after successful payment.
- Allow users to earn points on ticket purchases, which can be redeemed for discount vouchers or merchandise.
- Provide real-time ART tracking, allowing users to view current locations and estimated arrival and departure times.
- The system provides a guide for first-time users upon login, helping them navigate the process of browsing routes, booking tickets, and redeeming points.
- Response time for user interactions such as ticket booking and payment processing shall be under 3 seconds.
- The system ensures the security of user data, including encryption for sensitive information such as passwords and payment details.

8.2 Design Level Requirements

The ART system's user interface is designed for ease of use, accessibility, and efficiency, ensuring a smooth experience across mobile and web platforms.

- The system shall provide native mobile applications for iOS and Android.
- The web application shall be responsive and compatible with major browsers such as Chrome, Safari, Firefox, and Edge.
- The system shall support QR code generation for digital ticket validation at entry points.
- The system shall use encrypted QR codes to prevent imitation and unauthorized duplication.
- The system shall include QR code scanning functionality as mobile devices or kiosks for seamless check-in.
- The system shall support regular updates without service interruption.
- The system shall implement automated backup and disaster recovery procedures.
- The system should provide user-friendly error messages with troubleshooting steps.

- Use an efficient database structure to handle huge amounts of user data, ticket bookings, and transaction records without causing delays.

9.0 Validation of Requirements

In this section, the team will conduct a validation process for each task that have been listed in section 3.4 by using the CRUD check (Create, Read, Update and Delete).

CRUD Check

Task/Entity	User	Admin	Booking	Payment	Merchandise	Point	Promotion	Feedback	Ticket
Sign up a new user account	C								
Sign in an account	R	R							
Sign out an account	R	R							
Update user information	R,U	R,U							
Verify a user account	R,U	R,U							
Book a trip			C	C		C			C
Cancel a trip			D	D					R,D
Reschedule a trip			U	U					R,U,D
Review booking history	R	R	R	R		R			R
Process top-up	R			C					
Process a payment				C					
Refund a purchase			D	D					R,U,D
Manage promotions		C,R,U,D					C,R,U,D		
Apply a promotion				U			R		
Earn the points						C			
View the points	R					R			
Print a ticket			R	R					C,R
Purchase a merchandise				C	C				
Manage merchandise inventory		C,U,D			C,U,D				
View merchandise order history	R			R	R				
Submit a feedback	R							C	
Review user feedback		R						R	
Manage user account		C,U,D							
Analyse and generate usage statistics for ART		C,R,U							
Payment notification	R			R					
View ART departure/arrival time	R	C,R,U,D							
Report an issue	C	R							
Voice prompt	R		C	C		C			C

10.0 Possible Solutions

Web-Based Online ART Ticketing System

As part of ART's digital transformation, implementing a web-based online ticketing system provides users with a convenient platform to access services from anywhere with internet access. Optimized for desktop and laptop users, the system offers a broader interface and detailed layout. This system allows users to register accounts, browse ART routes and schedules, make bookings, view past trips, and track transaction history. Unlike traditional methods, users can perform all these actions without visiting a physical station, making the experience more streamlined and accessible.

Additionally, the web portal includes an admin dashboard for the admin only. Admins can use the platform to manage user accounts, monitor system activity, and generate in-depth analytical reports. These reports help analyze user behaviour, travel trends, and demographic data to support strategic decision-making, such as scheduling more ART trips during peak hours or reducing trips to destinations with consistently low passenger demand.

Although tickets purchased through the web-based system are immediately confirmed and accessible online, digital tickets and e-receipts will also be synced and available in the ART mobile app for added convenience. However, users who choose not to install the mobile app must save the ticket PDF on their device so it can be presented during boarding. Users who prefer a physical copy can find printing services available at ART stations.

A major benefit of the web-based system is its enhanced usability on larger screens, making it ideal for users conducting detailed route comparisons or managing multiple bookings, reducing the need to switch between views or scroll excessively constantly. This interface is particularly beneficial for users who prefer a wider visual experience, such as the elderly or those with visual impairments, as it offers better readability, larger fonts, and easier navigation.

However, the web-based system does come with certain limitations. Even though payments can be initiated through the web, users must still complete the top-up process using their mobile phones, especially for e-wallet verification and authentication. This dependency on mobile devices may slightly inconvenience users who expect a fully web-only experience. Additionally, if users want to access the web-based system while outside, they must carry a laptop, which is less convenient compared to using a mobile phone. Desktops are not portable, and laptops, although portable, are heavier and require more effort to set up, such as finding Wi-Fi and opening a browser. This reduces the system’s convenience for users who prefer quick, on-the-go access.

Mobile-Based Online ART Ticketing System

The mobile-based online ticketing system is designed to provide users with a convenient and flexible way to manage their ART travel needs using their smartphones. This solution takes the advantages of the widespread use of mobile devices, allowing users to register their accounts, book trips, purchase tickets, and make payments directly from their phones. The mobile application offers unique features that enhance the user experience, such as real-time push notifications that keep users informed about schedule changes, delays, cancellations, and booking confirmations. Besides, the e-wallet within the application ensures a fast and secure payment process, while the ability to store and present tickets as PDFs, which include QR codes of the ticket, allows for a seamless and paperless travel experience.

Furthermore, the mobile application is also designed with accessibility in mind, offering voice commands and voice navigation for users who are inconvenience, making it easier for them to interact with the system. Moreover, users can access their tickets and schedules online, ensuring that they can manage their trips even they are not at the station. The mobile application provides users with a responsive and easy-to-use experience thanks to its user-friendly layout, which is optimised for touchscreen devices.

However, there are challenges to consider. Some users may be hesitant to adopt mobile technology, so it is important to maintain alternative methods for booking and assistance, such as website or in-person support. The mobile application can also be power-intensive, especially when running background processes like notifications, so optimizing battery usage will be crucial. Moreover, ensuring robust security measures, such as encryption and secure payment gateways, will be essential to protect sensitive user data.

Overall, the mobile-based system offers a modern, efficient, and user-friendly solution for ART users who prefer to manage their travel digitally. By offering features such as real-time notifications, e-wallet transactions, online access to schedules anywhere, and voice assistance, the mobile application enhances convenience and accessibility in ways that traditional ticketing methods cannot match for users. While there are challenges to address, the benefits of a mobile application particularly its flexibility and ease of use make it an ideal choice for streamlining the ART ticketing experience.

User-Centered Self-Service ART System

As automation and self-service technologies continue to advance, the ART system can evolve into a more customer-centric platform which minimizes reliance on staff while improving user convenience. This approach allows users to manage their transportation needs independently through digital self-service options, such as a mobile application and website portal by using their devices.

Through these platforms, users can easily register accounts, book trips, purchase tickets, and make payments, all without needing to visit a physical station. This transition eliminates the need for on-site ticket purchases, reducing long queues at stations and saving users both time and energy. While the digital platform will handle most user needs, the physical ticket counters will remain available at the stations to assist those who prefer in-person service or need extra help.

A significant advantage of this system is its efficiency, especially during peak travel periods, such as rush hours or busy holidays and festivals, when more people will rely on ART for transportation. With the mobile application or website, users can purchase tickets in advance to ensure that they are not only saving time but also eliminating concerns about seat availability, as the system will display real-time availability before confirming bookings.

However, there are some challenges to consider. The system may be difficult for certain user groups, such as children, the elderly, or individuals in remote areas who might not be familiar with the digital platforms. These users may find it challenging to navigate the application or website and may require additional assistance. To address this, continued availability of physical ticket counters or alternative support methods like phone-based booking or in-person guidance will be essential to ensure accessibility for all users.

On-Site Kiosks with Smart Card ART Ticketing System

This solution is an existing method that is still being used in peninsular Malaysia. Basically, this smart card ticketing system provides a modern solution for Kuching ART by merging actual smart cards and self-service kiosks. This system allows users to load credit onto reusable contactless cards such as identity cards, 'Touch n Go' cards, and Watsons cards, which can then be tapped at ART gates for easy boarding. Users can use the kiosks to top up their accounts, buy tickets, cancel a trip, and check real-time schedules without the need for mobile apps or internet connection. This system aims to solve current issues such as long queues, inefficient cash handling, and a lack of real-time ART schedule updates by digitizing payments while keeping physical infrastructure. This bridges the gap between full digitalization and traditional ticketing, making it appropriate for Kuching's diverse population, including the elderly and rural users who may be unfamiliar with online-based ticketing system.

Users can interact with the system through a kiosk, which offers multilingual interfaces (Malay, English, and Chinese) and voice assistance for accessibility, especially to the elderly, the ones with disabilities, and tourists who are unfamiliar with our native language. The s mart cards enable for quick taps at the entry gates with a reasonable fee deduction, which speeds up the boarding procedure when compared to paper tickets. For users who require assistance, the station manager remains available to handle card issuance, complex refunds, and troubleshooting. This balanced approach ensures that, human assistance is still available to those who require it while the system automates most transactions. The kiosks also provide departure times and service notifications, so users can stay informed even without personal mobile device.

Moreover, this system offers various advantages over the existing physical system. It significantly reduces queue times by decreasing cash transactions and allowing for quick top-ups. The smart cards securely keep trip histories and balances, allowing for simple refunds and eliminating the possibility of lost paper tickets. For the functionality parts , the system will generate useful ridership data to help admins to optimize ART scheduling and resource allocation during the peak hours. Reusable cards are also more sustainable than disposable tickets, and they meets with United Nations (2025) environmental goals such as Goals 11 and 12. In addition, PIN protection and encrypted card data improve security while lowering the risk of fraud related with cash processing. Importantly, the system able to work despite internet outages, which ensuring resilience in locations with poor connectivity.

However, this solution comes with challenges during implementation. Some users like senior citizens or those living in rural areas may initially be resistant to using smart cards due to their unfamiliarity. To address it, some public education initiatives would be required to achieve a smooth transition. The initial costs of putting kiosks and card readers in all stations might be huge, as could ongoing maintenance costs to prevent

vandalism and technical concerns. Unlike mobile apps, the system has limited support for dynamic promotions and requires human participation for the majority of transactions. These constraints indicate that, while the hybrid system solves many existing difficulties, it may eventually need to interface with digital platforms to meet future needs for increased convenience and personalization.

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