The Use of Design Thinking Methodology in the Design and Development of an Interactive Web-based Personalized Trip Planning Tool: A Case Study of Thailand

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***Abstract*—Thailand's economy relies heavily on tourism, drawing millions of visitors from around the globe. Despite the advances in e-tourism facilitated by internet technologies, existing platforms often fall short in fully representing Thailand's diverse attractions and frequently overlook local businesses, adversely affecting tourists' planning experiences. To tackle these challenges, we developed "Nimbus," an innovative web application created using design thinking methodology. Nimbus offers personalized trip plans generated by a machine learning algorithm that caters to user preferences and highlights both prominent and hidden local destinations. Utilizing cloud computing, a RESTful API, Next.js, and Flask, Nimbus provides scalable, server-side rendered interactions. This study underscores Nimbus as a transformative tool for enhancing Thailand's e-tourism by promoting local economies and has the potential to revolutionize global e-tourism practices. Usability testing affirms that Nimbus is effective and complies with established UI/UX guidelines, positioning it as a valuable tool for showcasing unique destinations worldwide. The results also validate design thinking as an effective approach for e-tourism, demonstrate the applicability of existing UX laws in designing e-tourism systems, and underscore the utility of the System Usability Scale (SUS) in evaluating such systems. This research paves the way for further exploration of design thinking in e-tourism, the implementation of advanced web technologies, and the relevance of SUS in assessing system usability.**

***Index Terms*—human-computer interaction, tourism, design thinking, software engineering**

I. Introduction

When people decide to travel, they must select a destination, sometimes while browsing through an overabundance of travel guides, cruise marketing, and alluring package deals, whether online or offline [45]. Renowned for its picturesque landscapes, rich culture, and history, Thailand has long been a prominent tourist destination among international travelers in South-East Asia and the world [20]. According to the Tourism Authority of Thailand [37], Thailand has consistently secured a prime position in numerous global tourism rankings in the past decade. The Ministry of Tourism and Sports Thailand also states that Thailand's tourism significantly bolstered the nation's economy, contributing 11.8% to the GDP in 2019. According to [30], Thailand's economy relies heavily on the tourism industry, which proved its resilience during the 2008 economic downturn when the tourism sector played a crucial role in driving the economy, creating numerous jobs, and minimizing the impact of the crisis. However, the global COVID-19 pandemic, which started in early 2020, severely impacted Thailand's tourism sector with stricter international travel regulations and border controls, significantly reducing international tourist arrivals between early 2020 and mid-2022 [26].

Consequently, tourism's contribution to Thailand's GDP significantly dropped to just 1% in 2021, and the number of foreign visitors plummeted from 39.8 million in 2019 to a mere 0.43 million in 2021 [35]. A significant decline in international tourist arrivals due to travel restrictions and fear of COVID-19 transmission led to a massive revenue loss in Thailand's tourism sector [1]. As the number of international tourists decreased in the wake of the pandemic, the country suffered a significant loss of revenue, which had a profound impact on businesses nationwide, including hotels, restaurants, and airlines that were particularly hard-hit, as they faced a substantial decrease in income [36], furthermore, as a direct consequence of this significant loss, the travel and tourism industry alone in Thailand experienced a staggering reduction of approximately 1.33 million jobs in 2021 [19].

These drastic changes underscore the pandemic's impact on Thailand's tourism industry, highlighting the need for developing resilient and sustainable strategies, such as promoting domestic tourism, attracting digital nomads, and ensuring sustainable tourism practices to secure and sustain the future of the tourism sector of Thailand. In 2019, although the number of domestic tourists in Thailand, which amounted to 34.8 million, exceeded that of international tourists, who numbered 61.6 million, the economic contributions made by the international tourists surpassed those of the local travelers [35]. This data clearly illustrates international tourism's significant role in boosting the country's economy. Also, the TAT had projected a considerable resurgence in tourism,

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forecasting approximately 25 million foreign tourists once COVID-19 restrictions were eased and lifted and the country reopened. This projection signified a more than twofold increase from the 11.81 million visitors recorded in 2022. Despite this encouraging growth, the anticipated numbers are still considerably lower than the peak of 39.8 million tourists Thailand welcomed in the pre-pandemic year of 2019[7]. Unlike the steady growth trends observed before the pandemic, several notable shifts have occurred in the nation's tourism market post-pandemic. Given these dynamics, Thailand must closely monitor and swiftly adapt to emerging tourist trends. Embracing these transformations will be essential for attaining and potentially exceeding the pinnacle of the country's tourism sector witnessed in 2019.

Advances in information technology have revolutionized the tourism sector, replacing traditional paper-based reservations with online bookings and databases, enhancing client-service communication, and elevating accessibility, mobility, and personalization through emerging technologies such as Virtual Reality (VR) and Artificial Intelligence (AI) [10]. This technological adoption has simplified travel procedures, ensured reliable information, and enabled safer, touch-free payment and booking systems, especially crucial during and after the COVID-19 pandemic [5]. For instance, in the existing study [8], the researcher analyzed an interactive webcam live-streaming campaign by a wildlife tourism operator during COVID-19 lockdowns, finding that such virtual tourism can promote tourism recovery and conservation action and serve as a cost-effective strategy for audience engagement during crises. Thailand's tourism industry, like others, is significantly influenced by these technological advancements. Such emerging technologies are also promising to promote Thailand's tourism and hospitality industry in the post-COVID-19 era. For instance, the study [25], states that since the GPT-3 prototype's launch in 2022, the conversational system ChatGPT has sparked immense interest, promising to revolutionize digital transformation, albeit with certain risks; the researchers introduce ChatGPT and offers preliminary guidelines for its use in the tourism sector.

Despite its transformative potential, information technology in tourism still faces significant challenges, particularly in web and mobile applications for e-tourism, including limitations such as lack of multifunctionality, personalization, and real-time data updates that can negatively impact user satisfaction. According to the Economist Intelligence Unit [13], Thailand must prepare for the requirements of tech-savvy young travelers, digital nomads, and remote workers visiting the country. Although the Thai tourism industry has adopted various technologies like online booking websites, digital advertising for tourism businesses, and smart devices in hospitality businesses, it has yet to develop a proprietary technology or tool for generating personalized trip schedules that cater to its tourists' preferences. Although Thailand is renounced for its popular tourist destinations, including beaches and ancient temples, there are many lesser-known locales nationwide, such as national parks in the north, Bangkok's Chinatown, and Phuket's Old Town, which also hold unique appeal. Due to inadequate promotional efforts, these hidden gems remain underutilized, confining the growth potential of the local tourism industry. This restricted range of suggested tourist sites impedes broader tourist distribution, causing some areas to miss out on higher visitor numbers. It's worth mentioning that, according to the authors' best knowledge, a digital platform currently does not exist to highlight lesser-known or undiscovered destinations within Thailand.

Furthermore, the COVID-19 pandemic has significantly impacted local and small-to-medium enterprises within the country, pushing many to the brink of bankruptcy. According to the United Nations [38], extant research indicates that these businesses must recover quickly. Hence, Thailand's authorities need to boost local businesses while attracting more local and international travelers to Thailand. Therefore, Thailand's leaders must implement effective digital strategies that rejuvenate local companies and entice more domestic and international travelers to the Kingdom. This could potentially involve enhancing the country's e-tourism infrastructure, such as online tourism platforms for better global reach, providing incentives for local tourism, promoting sustainable tourism practices, or spotlighting unique cultural and natural assets that make Thailand a compelling destination.

In response to the abovementioned challenges, this study presents "Nimbus," an interactive personalized trip planning tool harnessing cloud computing and application programming interface technologies. Using the 'design thinking' methodology, 'NimBus' is designed to streamline the trip planning experiences of travelers to Thailand and to spotlight lesser-known Thai destinations. This is accomplished through a machine learning algorithm that matches travelers' preferences with a wide range of suggested destinations across the country. The tool's algorithm further crafts a tailored itinerary based on various factors like a traveler's interests, constraints, preferred location types, operational hours, travel times, and transportation methods. The main goal of 'Nimbus' is to boost local businesses in Thailand, thus fostering a sustainable business ecosystem for travelers and business owners. This project's key contributions encompass the UX/UI of tourist destination recommendations, aiming to enhance and elevate visitors' experience in Thailand and stimulate the local economy through user-centric technology. This study's findings can help Thai authorities and IT researchers enhance tourism experiences in Thailand using emerging information technologies. This study aims to achieve the following objectives:

- To engineer a user-centered travel planning platform named 'NimBus' tailored to the unique needs of both international and local tourists in Thailand,
- To evaluate the usability and user experience offered by the 'NimBus' application, understanding the ease of its use and the overall satisfaction of its users,
- To understand the suitability of design thinking methodology in designing and developing the 'NimBus' application,
- To examine the practical feasibility of 'NimBus' within Thailand's dynamic tourism industry, determining its potential impact and effectiveness in real-world settings.

- To advocate for the broader implementation of Information and Communication Technology (ICT) applications within the Thai tourism sector as a catalyst for future growth and advancement.

The paper details 'Nimbus,' a personalized trip planning tool for tourists in Thailand, incorporating innovative approaches to e-tourism. It uses design thinking methodology to enhance empathy, iterative design, and real-world usability, diverging from traditional digital tourism tools. Nimbus employs a sophisticated algorithm that customizes itineraries based on user preferences, local insights, and real-time constraints like operational hours and transport options, promoting both well-known and lesser-visited sites. By spotlighting lesser-known attractions and local businesses, Nimbus not only supports local economies but also encourages tourist traffic distribution. The scalability of Nimbus is explored, indicating potential adaptations to other regions, enhancing its global applicability and contributing to the fields of Human-Computer Interaction (HCI) and tourism.

II. Literature Review

Although Thailand experienced a more significant influx of domestic tourists in 2019, the country's economy significantly benefited from international tourism, with a staggering 61.6 million international tourists compared to 34.8 million local travelers [37]. Of these international tourists, China was Thailand's most significant tourism source before the pandemic [37]. However, with the extension of China's zero-covid policy until 2023, Thailand must reduce its reliance on this specific market and diversify its target customers for the tourism and hospitality industry [32]. Consequently, there has been a decline in tourists from China compared to the numbers seen in 2019 [13]. During the reopening phase, the top visitors to Thailand are from the US, Germany, the UK, Japan, and South Korea, respectively [35]. Additionally, tourist arrivals from ASEAN, Europe, and the US have increased from January to August 2022. These statistics allow the Tourism Authority of Thailand (TAT) to diversify the country's tourism market and focus on new target groups, particularly visitors with higher average expenditure per person, such as Americans or Europeans [37].

Thanks to integrating information and communication technologies (ICTs) in the tourism sector, the convenience of visitors' experiences (e.g., trip planning) has significantly progressed over the past decade. Innovative tourist activities that can modify conventional experiences and give rise to fresh tourism experiences have been made possible by the ongoing development of new technology [27]. The current state of the tourist industry in Thailand and worldwide has been profoundly altered by revolutionary advances in information technology, resulting in the emergence of Ambient Intelligence (AmI) tourists, a customized, seamless travel experience utilizing technology [9]. One significant transformation is the shift from traditional cash transactions to modern cashless payment systems. Another step toward improving operational efficiency is the replacement of paper-based reservation methods with online booking and extensive booking databases. Additionally, the development and widespread use of the Internet has altered how people seek and communicate information online, considerably facilitating interactions between visitors and service providers. The body of extant research highlights the crucial part that ICTs have played in transforming the travel and tourism sector, improving the overall traveler experience, and streamlining several corporate procedures.

In recent years, the tourism industry of many countries has integrated emerging technologies to enhance services [5]. According to [28], the researcher discusses the effects of the digital revolution on tourism, focusing on "Tourism 4.0" and "Smart Tourism" shaped by Industry 4.0 and IoT. Furthermore, the study dissects the impacts on the industry, differentiating between the two tourism models and how digital shifts enhance travel experiences while presenting new challenges. Also, it recommends future tourism strategies emphasizing digital innovations, sustainability, circular economy, and social value to boost tourist experiences and destination competitiveness. Also, in the study [24], the researchers discuss the rise of Recommender Systems (RSS), especially Travel Recommender Systems (TRSs), as tools to mitigate information overload in sectors like e-commerce and e-tourism. TRSs provide personalized travel recommendations based on user's preferences. However, previous systems have overlooked user behavior. The authors suggest using the Activity and Behavior induced Personalized Recommender System (ABiPRS) to solve this. This hybrid approach includes user behavior to deliver Point of Interest (POI) suggestions that are more convincing. They also provide a brand-new group recommendation model that uses user connections. These novel strategies fared better than previous solo and standard hybrid approaches when evaluated on datasets from Yelp and TripAdvisor. Unquestionably, the advent of these cutting-edge tools and technology has great potential to improve tourism services, enhance visitor experiences, and streamline corporate processes in the sector.

Due to its growing impact on the tourist sector, which includes information search, decision-making practices, tourism promotion, and creating successful customer interactions, social media has emerged as a hot topic for research [43]. The qualitative study [23] investigated the substantial impact of social media on travelers' decisions, revealing its influence on six critical travel components—destination, transportation, lodging, food and eating, sights, and shopping and leisure activities. This influence, disclosed through interviews with 21 visitors, underscored four primary roles of social media in decision-making: acting as a need generator, supporter, guide, and approver. The authors also outline their results' theoretical and practical ramifications and recommend further study. According to [44], the tourism industry heavily depends on information technologies for promotions, sales, and customer relationships, with online word of mouth (eWOM) influencing tourists' destination choices. Researchers have noticed more tourists using digital media, leading to tailored offerings through advanced technologies. The emergence of Web 2.0 has transformed travel decision-making, with surveys showing that about 50% of people download travel apps for destination research before their trips. According to the literature, it is clear that the expansion and development of social media platforms have had a profound impact on the travel and tourism sector. They play important roles in influencing travel choices, reshaping how customers view places, and altering how business professionals handle promotions and client relationships.

Tourism sector stakeholders must recognize and accommodate this trend as more passengers rely on digital sources for information. Future study is urged to continue examining the psychological effects of social media on tourism, which will help the sector and its clients.

Recently, Virtual reality (VR) has been used as an alternative tool in the tourism and hospitality industries to improve tourists' user experiences and for marketing purposes. According to the existing research, Second Life has a wide range of possible applications, including the use of tourist marketing by a number of firms [29]. In [17], the study aimed to develop a framework informed by the Technology Acceptance Model and Hedonic Theory that would help design interesting 3D tourism sites and promote people's interest in the actual destinations. This framework would identify enjoyment, emotional involvement, positive emotions, and flow experience. According to [14], the study indicates that VR can revolutionize tourism planning and marketing by providing sensory-rich virtual tours. In [41], it suggests that post-COVID tourism recovery depends on arousing interest and positive emotions via products. The authors also propose a PEI framework outlining presence determinants and their impact on emotional responses and behavioral intentions, advocating for more research, especially on presence determinants' interaction with emotional responses in tourism. In the study [42], the researchers investigate virtual reality's role in tourism marketing. Through an experiment involving 72 participants, the researchers discovered that interactive VR environments evoke stronger positive emotions than traditional media, suggesting a shift in focus toward enhancing engagement mechanics in VR.

Other emerging technologies have also shown promise to improve experiences in tourism and hospitality worldwide. For instance, IoT-enabled smart hotels enhance the guest experience by using sensors for security, maintenance, and energy conservation, adjusting energy usage based on occupancy, and optimizing resource consumption [18]. Smart technology and ambient intelligence (AmI) enable real-time services, value co-creation, and enhanced consumer experience [6]. Also, in recent years, the surge in usage of mobile and web-based tools for users, including travelers and trip planners, has been facilitated by the broad availability of the Internet and affordable devices. For instance, Agoda, a user-friendly hotel booking and trip planning app in South-East Asia, has gained popularity due to its diverse content and positive user experiences. Globally, similar platforms like hotels.com, Expedia, and TripAdvisor have also grown in prominence. The appeal of these systems lies in their ability to offer a comprehensive travel planning platform, simplifying the process from purchasing airline tickets to booking hotel rooms and car rentals. According to [39], the widespread impact of the Internet on socioeconomic aspects of life is extensively documented. Yet, a lack of research explores how travelers' behaviors have evolved alongside Internet advancements. Leveraging data from national surveys conducted over six years (2007-2012), their study delineates the transformative trends observed in American travelers' Internet usage. The study reveals an emerging divide among online travelers: the traditionalists who rely on the Internet for conventional travel products and those exploring alternative platforms and offerings to seek more profound and unique user experiences. This research underscores the crucial implications of these trends, providing valuable insights for future studies and industry practices.

Cognitive Infocommunications (CogInfoCom) is a field emerging at the intersection of various disciplines, focusing on enhancing human cognitive capabilities through advanced technologies. It draws from anthropology, psychology, engineering, and more, uniting these fields to develop technologies like electronic calculators that enhance computational capacity and thereby cognitive functionality (Baranyi & Csapo, 2012) [46, 47]. As communication technologies evolve, CogInfoCom researchers study how users' cognition can co-evolve with devices such as mobiles and IoT sensors, emphasizing practical applications that enhance both individual and societal functions [51]. This multidisciplinary approach reflects the dynamic exploration within CogInfoCom, focusing on the interaction between human cognition and technological advancements. The concept of CogInfoCom is integral to our project as we aim to streamline the trip planning process, enhancing ease-of-use for tasks, navigation, and feedback. While existing literature has explored the implications of CogInfoCom in areas like technology for ageing [48] and virtual reality for social interaction [49, 50], research specifically addressing CogInfoCom applications within e-tourism and user experience remains limited. This gap highlights the potential for innovative applications of CogInfoCom principles in enhancing the digital travel planning experience, suggesting a need for further investigation into how cognitive and communicative interactions can be optimized in e-tourism platforms.

Drawing upon the review of existing literature, we have identified the importance of using emerging technologies to enhance tourists' experiences and plan a trip effectively and efficiently. Among these technologies, we've discovered several prevailing issues with the existing travel designing websites and applications. First, most sites and applications offer a particular function, such as accommodation booking, destination suggestion, or travel time estimation. This fragmented approach forces tourists to juggle between multiple platforms, leading to a disjointed and often frustrating user experience. Secondly, many popular platforms are developed and managed outside of Thailand. This results in recommendations that frequently spotlight popular tourist hubs, resulting in an overlook of unique local attractions in Thailand and a lack of personalization for tourists.

Additionally, the data provided by these applications often lack real-time updates and user feedback, negatively affecting user satisfaction. Furthermore, to the best of the authors' knowledge, there is a limited number of technologically advanced solutions dedicated to crafting personalized trip itineraries for tourists visiting Thailand. Recognizing these gaps, our study presents a unique proposition - a customized trip planning solution explicitly tailored for Thailand-bound tourists called 'NimBus.' This tool addresses the issues above and serves as a promotional platform for local businesses, significantly smaller enterprises that often miss out on substantial exposure. In line with the Economist Intelligence Unit's report [13] highlighting the growing global interest in

visiting Thailand, 'Nimbus' aims to be a comprehensive and personalized solution to this unmet demand. This study, therefore, presents 'Nimbus' as a timely and much-needed solution to enhance the travel experience in Thailand.

III. DESIGN THINKING

We opted for design thinking in this study for the following reasons. First, design thinking is an innovative, user-centric approach to product creation and problem-solving [15]. Second, it requires comprehending user requirements, testing presumptions, and developing alternate solutions. Third, it incorporates five non-linear iterative stages: understanding consumers' requirements through empathy, identifying key issues, formulating potential fixes, prototyping both the low-fidelity and high-fidelity versions of the product, and testing the prototype to obtain users' feedback [12]. To execute the study, 'emphasize' was the first step of the design and development process, during which our group discussed design concepts and developed a list of potential target audiences for more research. Surveys and interviews were used to get users' input and feedback on their requirements and issues. Moving on to the 'define' stage, various analysis tools and diagrams aid in narrowing down the project's scope and confirming the problem to be addressed on behalf of target users. Subsequently, the 'ideate' stage involved designing the solution to the identified problem, utilizing additional tools to generate functionalities and features for incorporation into the system prototype. The 'prototype' stage entailed crafting highly detailed user interfaces and devising evaluation plans to refine the design before implementation. Finally, in the 'test' phase, internal testing was conducted to refine and enhance the system before its official release. This section of the report will delve into the specifics of each stage as they relate to our trip planner web application.

A. *Understand Target Users*

During the 'empathize' phase of the project, we identified our target users as international tourists planning to visit Thailand in the post-COVID-19 era and domestic travelers interested in exploring different destinations within Thailand. We harnessed qualitative data by conducting structured and semi-structured interviews with university students in Thailand. This group included native Thai and foreign exchange students, and our goal was to understand and empathize with their trip-planning experiences, the resources they used, and the challenges they faced during and after the planning process. Additionally, we engaged with international tourists already in Thailand to fulfill similar objectives. Each interview lasted roughly 30 minutes, facilitated through a hybrid, either online or in-person, depending on the interviewee's convenience. We also obtained quantitative data via questionnaires containing 12 questions. These questions revolved around users' travel preferences, such as budget, location, duration, and type, along with difficulties they encountered during and post-trip planning and their motivations to plan or opt out of planning a trip. The insights from 35 interviews and 77 questionnaire responses underlined that users' primary concerns included modes of transportation, the reliability of tourist spot reviews, safety and cleanliness of accommodations, and the ability to stick to their plans amid unpredictable events. Notably, 92.2% of respondents regularly plan their trips, leaning on social media reviews, recommendations from friends, and YouTube videos as their guide. The remaining 7.8% chose not to plan their trips, mainly due to time constraints or lack of effort. In summary, the gathered data bolstered the idea that most participants preferred trips with prearranged itineraries while simultaneously acknowledging the challenges associated with trip planning. In relation to the difficulties experienced while planning a trip, we discovered that the current resources available were inadequate for tailoring a trip according to individual preferences. Furthermore, these tools were primarily geared toward promoting popular tourist attractions in Thailand. They fell short in providing information about lesser-known, yet worthy destinations (e.g., temples, beaches, and local eateries), creating a gap in comprehensive and personalized travel planning.

B. *Define User Needs*

Following the user requirement collection process, which included interviews and questionnaire surveys, we systematically classified the raw data to extract insights relevant to each target group. This data, in turn, informed the creation of two empathy maps, delineating our audiences' pain points and gains [21]. For this study, two distinct empathy maps were crafted (see Fig. 1), one for Thai students (local travelers) and another for international students (international tourists). Using these empathy maps as a foundation, we constructed two personas—fictional characters that encapsulate the characteristics of each target audience [16]. In this scenario, we crafted one persona to represent Thai undergraduate students aged 18-22 and another to represent international students under similar conditions (see Fig. 2). Subsequently, we developed a customer journey map—an 'as-is system'—to visually represent the sequence of experiences a customer goes through in traditional trip planning (see Fig. 3). With two personas and a customer journey map, we formulated How-Might-We (HMW) questions to address the personas' identified pain points and needs effectively. In this

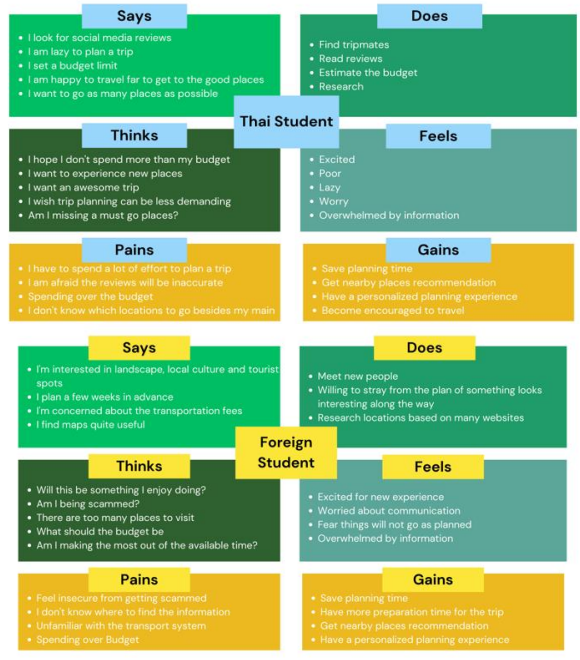

Fig. 1. Empathy maps

Fig. 2. Local student persona (above) and international student persona (below)

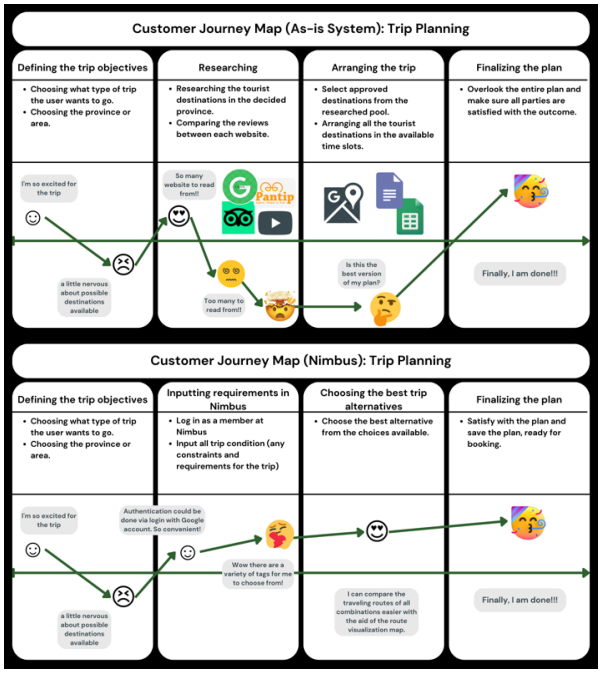

Fig. 3. Customer journey maps

study, our HMW questions included: 'How might we streamline the personalized trip planning process for tourists and create seamless experiences for them?', 'How might we promote lesser-known destinations in Thailand so that we can promote Thailand's tourism industry?' and 'How might we promote local businesses via the NimBus application?' These questions will guide the following stages of our project as we strive to provide solutions that address these challenges.

C. *Ideation*

During this phase, a brainstorming session focused on the aesthetic and technical aspects of our trip planner web application, outlining essential features based on users' needs. This early approach allowed for task allocation and efficient workflow management. We used insights from the definition phase to shape solutions and articulate system requirements, transforming them into application features. Our design was regularly reviewed and adjusted to better align with user needs. As mentioned previously, the primary goal of our solution is to streamline the complex and time-consuming process of trip planning; hence, we propose an approach that lets users input their preferences, after which they receive a customizable itinerary, reducing the complexity of self-coordinated trips while allowing for personalization. Users can further tailor the auto-generated itinerary.

Additionally, the 'NimBus' advanced algorithm provides recommendations tailored to users' interests, budgets, and time, which includes famous and unique attractions in Thailand. This offers a comprehensive, personalized exploration experience. Through a specific function and feature analysis, we revised our original design elements. For instance, the 'Plan Trip' function initially aimed to speed up trip planning, but we identified areas for further optimization. We replaced the quick initial quiz with a 'Choose Preset' function, allowing users to swiftly select and save pre-configured plans. This change streamlines planning and enhances user experience. We utilized a mind map to understand our project's functions, especially post-modifications (see Fig. 4), visually representing the primary use case. Predominantly, these functions stem from user insights. Table 1 presents the functionalities of the 'NimBus' application, formulated based on user needs and insights.

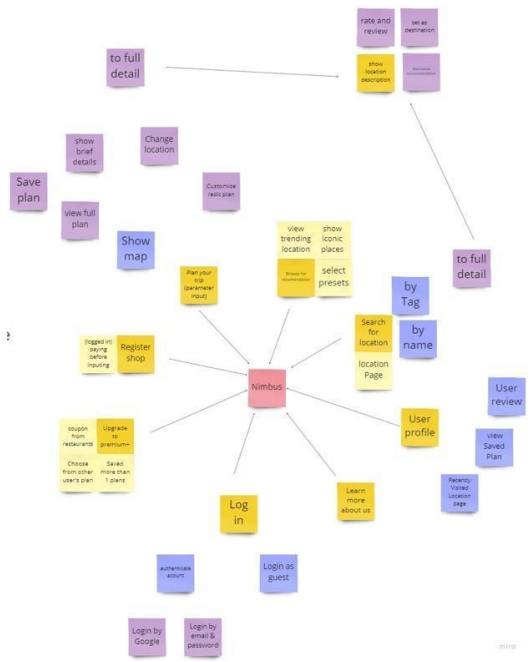

Fig. 4. Mind map

TABLE I.
SYSTEM'S FUNCTIONALITIES TABLE

The Main Features	How the feature helps as a solution
Plan Trip	This feature allows users to make an easy and quick trip plan with a detailed schedule and a map from the Google API by simply inputting various parameters onto the web. The user will also be able to customize their preference through the edit plan further and add and delete location functions.
Location Page	This feature allows the users to gather more information about the place in their Schedule or what they are interested in with detailed descriptions and a rating, along with reviews from other users on the site. The user can also select the location to be a destination in their trip plan.
Search for Location	This feature allows users to search on the web by location name or by their tags, which is part of the parameter to create a plan, to see the location they might be interested in. The user will not have to do much research on multiple sites.
Browse from recommendation	This feature gives users some recommendations about the places they might be interested in, so they don't have to go and do too much research on their own. The features can be separated into choosing presets, viewing iconic places, and trending locations.
Check User Profile	The user can view their saved plan here, revisit any location page they have recently visited, and see all the collective reviews they have posted on the site.
Log In	For the plan to be saved by a user, they must create an account to store their plan data.
Learn More About Us	The user can learn more about the site's creator and acquire a way to contact the creator when faced with questions and wants to ask for information.
Upgrade to Premium	This feature will allow users to access a more upgrade experience while helping the web maintain operations to help them with all their plans.
Register Shop	This feature allows the shop owner to advertise their shop and be included in the plans of our users, helping the shop owner generate more income and help users discover new places to visit.

TABLE II.
SYSTEM'S FUNCTIONALITIES TABLE

Principles	Applications in 'NimBus'
Fitts's Law	We strategically designed and placed crucial buttons like "Plan now," "Set as plan," "Edit," and "Select as a destination" on our digital platform. This enhances user experience by improving visibility, accessibility, and intuitive interaction with key features on both desktop and mobile.
Hick's Law	Our platform uses a step-by-step approach for trip planning, enhancing usability, and minimizing cognitive load. Users see a brief, actionable trip plan with additional features upon expansion. The initial interface showcases the first day's plan, with options to see more days or explore alternate locations, providing a tidy and flexible user experience.
Miller's Law	The navigation bar should have 5-9 items for a clean user experience. We've added a budget input field with automatic thousand separators for improved readability and user-friendliness.
Postel's Law	We'll implement an intelligent location input field for a better user experience, providing autocomplete suggestions. The budget field will only accept positive integers, and date fields will restrict past dates or illogical durations, enhancing accuracy and reducing confusion.
Aesthetic-Usability effect	Our app features a relaxing theme with a color palette drawn from calming travel elements. Rounded corners on components add visual comfort, while subtle transitions and animations enhance engagement. Overall, the design promotes a welcoming, enjoyable trip-planning experience.
Tesler's Law	Our application will include a feature to swap locations without restarting planning, boosting efficiency. We'll improve date fields with a calendar pop-up for simpler, error-free selection, making the planning experience more intuitive.
Doherty Threshold	The system will respond to user inputs within 400 ms to increase efficiency. We'll include a loading animation for longer tasks, keeping users informed and maintaining progress, improving the user experience.

As we prepare for the prototype phase with our core features, we must adhere to vital UX/UI principles. Firstly, simplicity and consistency are key for high user engagement and easy navigation. Secondly, optimizing responsiveness and speed enhances user satisfaction. Lastly, a good visual hierarchy guides users through the application, improving their experience. These principles, referenced in Table 2, will help us create a user-friendly, engaging web application. Applying these UX/UI principles will make our prototype functional and visually appealing.

D. Prototyping

The 'prototype' phase focuses on developing our web application's functionality and design based on user research insights. Each prototype iteration is refined through early usability tests. We began by creating basic, low-fidelity UI sketches, thoughtfully considering the placement of key components, screen layout, and app navigation. We then engaged in constructive discussions about the strengths of each sketch, which were subsequently integrated into a cohesive, low-fidelity UI design once we reached team consensus on the primary layout for essential web application

elements. Utilizing a combination of specific requirements and established UX/UI principles, we crafted a low-fidelity UI design focused on embodying the core functionalities of the application. Fig. 5 shows the low-fidelity prototypes of 'NimBus.'

Fig. 5. Hamburger menu and register place pages

1) Early Usability Test: Upon creating a low-fidelity prototype in Figma, the UX/UI team launched an early-stage evaluation and usability test to gather feedback on our interfaces. Given 'Nimbus' primarily serves Thai and foreign tourists and partner store owners, our user research was structured accordingly, involving six participants. Interviews, primarily conducted online, began with consent to record and use the session results. Participants tested the 'Nimbus' prototype and provided feedback on the completion of tasks. Results were logged into a Google Sheet for analysis. Initial feedback was encouraging, with users appreciating the app's visual appeal, coordinated color scheme, and intuitive interface. However, issues like inconspicuous arrow keys, random logout button placement, and ambiguous input options needed addressing. Unforeseen user interactions also provided valuable insights for user experience enhancement. In response, minor tweaks made the app more user-friendly, such as linking the 'Nimbus' logo to the homepage and adding location descriptions in plan details. The visibility of the 'next days' arrow was enhanced, the logout button was repositioned, and input options during plan generation were clarified. A fundamental improvement, strengthening the 'next days' arrow visibility, was guided by Fitts's law, increasing its size and clarity without disturbing the layout.

E. Hight-Fidelity Prototypes

Following an insightful round of the initial usability testing for 'NimBus,' we have streamlined and augmented the user interface and overall user experience. Expert advice and constructive criticism from UX professionals have been instrumental in this improvement journey and are now seamlessly woven into the design enhancements. The evolution of this process culminated in the final and high-fidelity prototypes of 'NimBus.' A showcase of the interface is depicted in Figure 6. The 'Home Page' serves as the heart of our platform, featuring a captivating banner that spotlights famous tourist sites across Thailand.

Fig. 6. Home page of '*NimBus*'

Furthermore, it also brings attention to 'trending' local gems that users might be intrigued to explore, encompassing a wide range of temples, shopping malls, museums, and gastronomic hotspots. One unique aspect of the home page, as illustrated in Figure 7, is the keyword-search feature. Users can enter specific interests or preferences, generating 'tags' such as 'art,' 'food,' or 'shopping.' This tailored approach facilitates an enriched exploration experience that aligns with individual user tastes. The algorithm-generated local attractions are another unique aspect of our service.

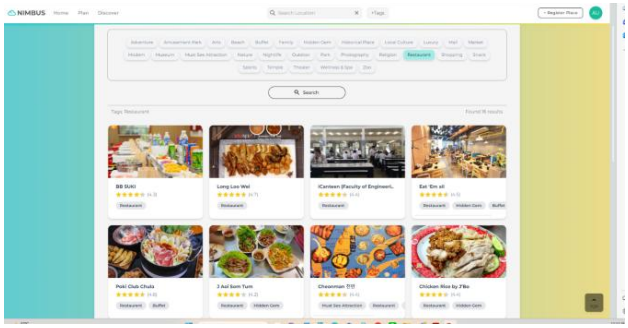

Fig. 7. User' tags

Furthermore, the local businesses (e.g., restaurants) are incorporated into the recommendation list based on the user's preferences and input parameters. Figure 8 provides recommendations such as 'Wat Hua Lamphong,' an iconic local temple less known to international travelers, thus creating an authentic, off-the-beaten-path travel experience.

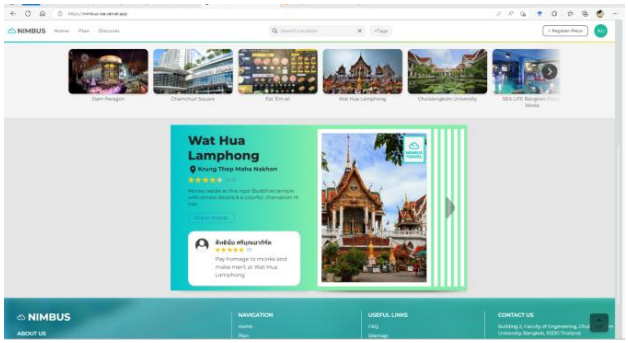

Fig. 8. A local place recommended by NimBus

Transitioning to the 'Planning Page,' users are empowered with customizable planning parameters, depicted in Figure 9. Users can specify their desired destinations, dates, and trip duration. They can also choose their travel style, for instance, 'adventure,' 'budget,' and 'mode of transportation.' After inputting these planning parameters, the system curates a comprehensive itinerary tailored to the user's preset preferences. The meticulously crafted trip planning, displayed in Figure 9, spans over three days, presenting a myriad of suggested locations for each day. Each recommended place comes with user reviews and essential information, fostering an informed decision-making process for the user (see Fig. 10). Should they wish to modify a specific location in their itinerary, a simple click on the 'edit' button provides alternate suggestions (see Fig. 11). Our map visualization feature, shown in Figure 12, aids users in understanding the distances between the recommended locations.

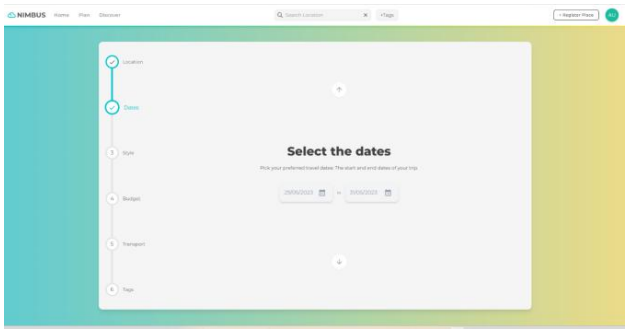

Fig. 9. Plan page

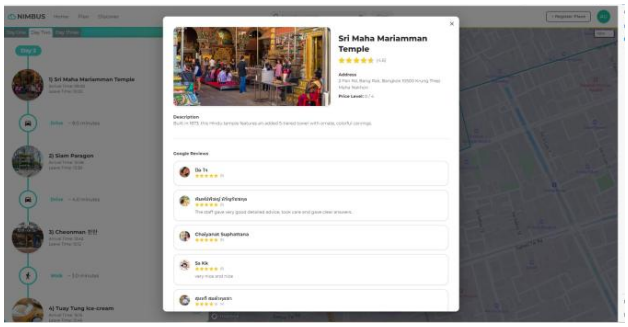

Fig. 10. Users' reviews

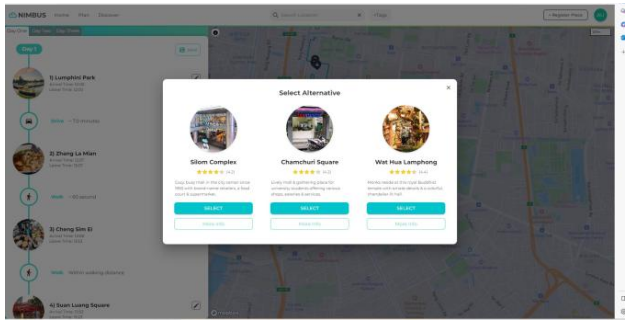

Fig. 11. Alternative destinations

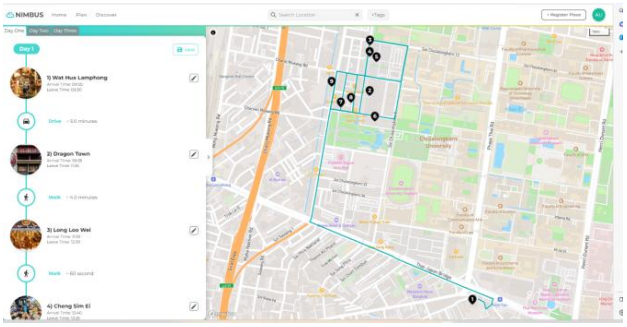

Fig. 12. Trip plan and map visualization

Additionally, it includes practical information such as estimated travel time and mode of transport, enabling users to make efficient travel decisions. Fig. 13 shows the overview of a 3-day trip plan generated by 'NimBus' based on the user's preferences. Any user pleased with the system-generated itinerary can save it within the system for easy retrieval upon subsequent logins, as seen in Figure 14. In addition, 'NimBus' provides a comprehensive user profile page where users can update their information and access current and past trip plans. Our algorithm personalizes the trip plan for repeat users of 'NimBus' based on their historical data (e.g., places visited). This feature significantly enhances the user experience, making each travel plan as unique as the user.

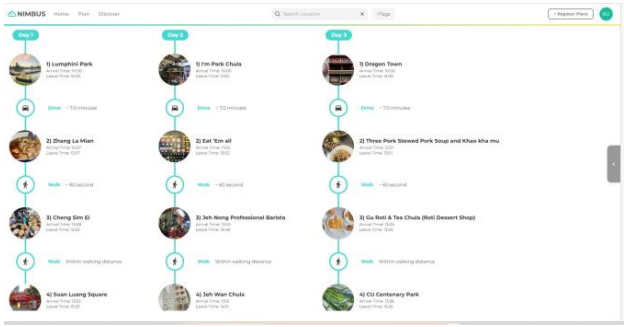

Fig. 13. Overview of the trip plan

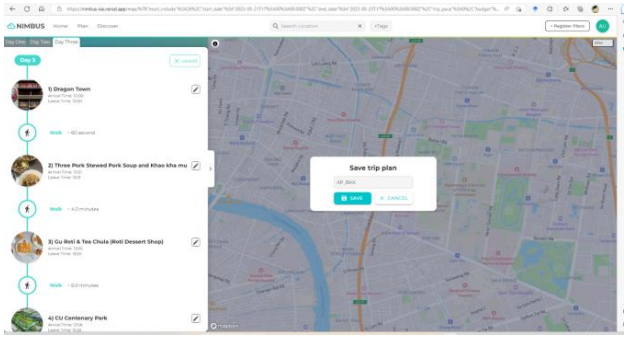

Fig. 14. Save plan

F. Development

Our system design utilizes a client-server framework, and RESTful API, facilitating efficient user-server communication. Developed with Next.js, the front end offers

server-side rendering for performance optimization. Its built-in features improve the development experience. This front end is deployed on Vercel, relieving developers from managing servers or infrastructure. Our backend uses Flask, integrating our Python-coded personalized itinerary algorithm. Flask's readability, simplicity, and database connectivity support a scalable web application, with the large developer community offering resources and assistance. We host this backend on Google Cloud, ensuring scalability and reliability while easing management through Cloud Logging and Monitoring tools. Our database, built on AWS using PostgreSQL, provides scalable and reliable data storage. The combination of PostgreSQL and AWS results in a resilient data storage solution. The system architecture design is depicted in Fig. 15.

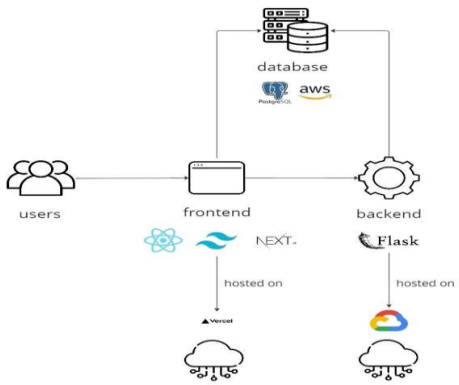

Fig. 15. System architecture design

G. NimBus's Algorithm Design and Development

Our trip-planning algorithm was designed and adapted from the study [22]. The algorithm in our study has been tailored to meet our unique specifications in creating personalized itinerary recommendations for travelers to Thailand. Generally, the Personalized Itinerary Recommendation problem (PIR) can be viewed as a non-linear problem, as selecting the destination location with the highest score sequentially is not feasible. Hence, our objective is to maximize the overall score of the entire itinerary, ensuring that the generated itinerary has the highest level of satisfaction compared to all other possible variations. To address this challenge, we have adopted the variation of the Monte Carlo Tree Search (MCTS) algorithm, which evaluates each state by averaging scores of simulations from that state. Unlike traditional minimax search algorithms, which consider all possible moves from a state, our MCTS approach considers the probabilistically best moves [2]. This characteristic proves advantageous when dealing with large search spaces that exhibit high branching factors, which is particularly suitable for the PIR problem due to the abundance of Points of Interest (POIs).

Furthermore, the MCTS algorithm offers a great deal of flexibility. It enables us to modify the scoring function according to our specific needs, thereby allowing us to effectively promote hidden gem locations in Thailand to users or travelers. By leveraging this adaptability, we can tailor the algorithm to provide personalized recommendations highlighting Thailand's unique and lesser-known attractions and businesses. Our algorithm also used the modified Monte Carlo Tree Search (MCTS) approach, consisting of three main steps: Selection, Expansion, and Backpropagation. Initialization begins with an empty tree and initializes the root node with all possible Points of Interest (POI) as a starting location (see Fig. 16).

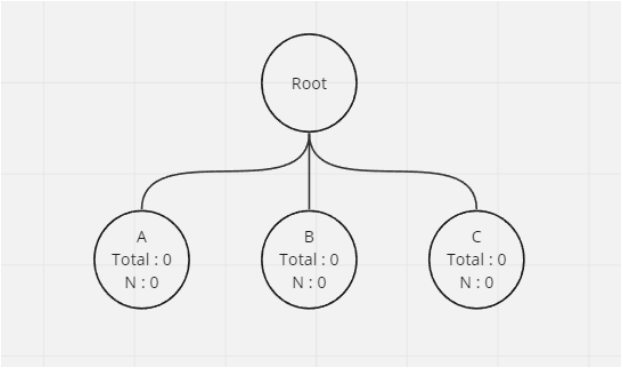

Fig. 16. Initialization

As shown in Fig. 17, it selects the highest score POI based on a scoring function.

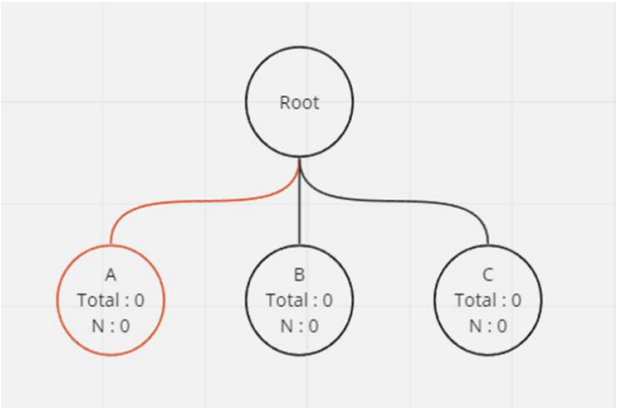

Fig. 17. Selection

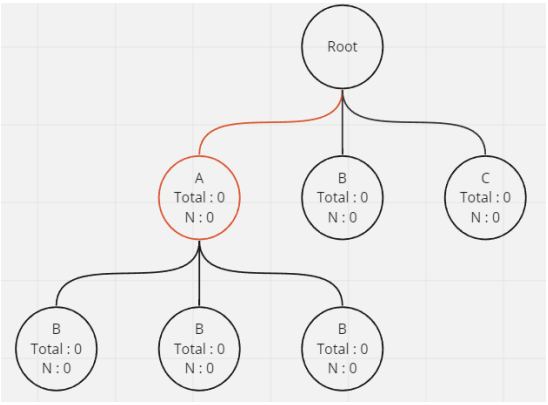

Fig. 18. Expansion

For expansion, as displayed in Fig. 18 and 19, it populates all available POI candidates that could be selected as the next destination, considering time constraints such as opening, closing, trip ending, and meal times. Then, it appends these POIs as children of the selected POI node from the previous step. (node A for this example). After that, it repeats steps 1 and 2 until the end of an itinerary is reached. (when the time has gone over the trip ending time).

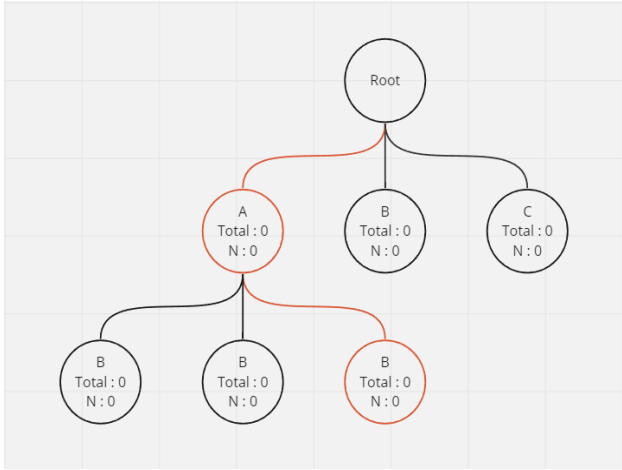

Fig. 19. Repetition

For backpropagation, when the end of the itinerary is reached, it propagates the total score and visit count(N) back up the tree (see Fig. 20).

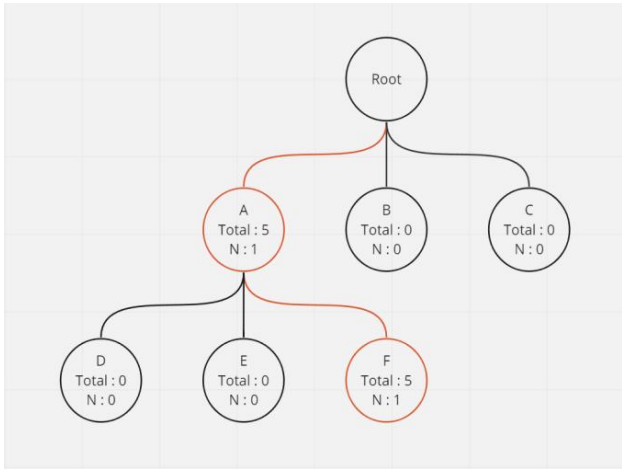

Fig. 20. Backpropagation

Then, this completes one cycle of the algorithm and repeats this process for 10,000 cycles to generate the final tree, which will be used for itinerary generation (see Fig. 21).

For itinerary generation, it selects the final itinerary by traversing the tree to the leaf and choosing the node with the highest average score per visit (total/N) (see Fig. 22).

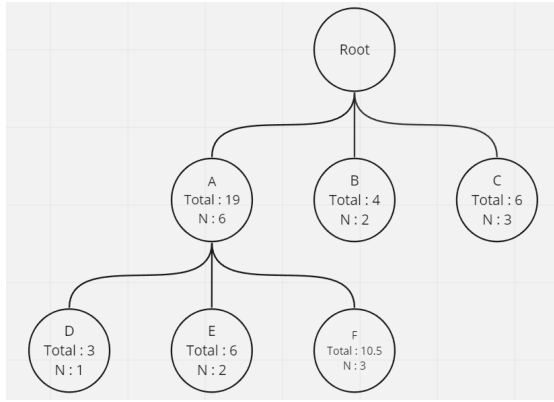

Fig. 21. Generating the final tree for itinerary generation

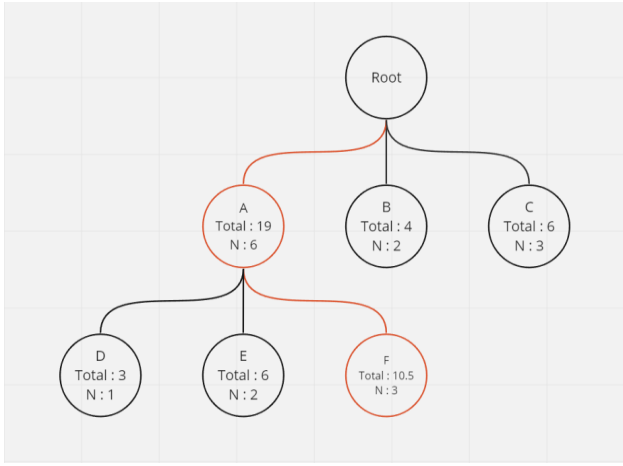

Fig. 22. Itinerary generation

The scoring function consists of two types of score: exploit score and explore score. First, for 'Exploit Score' represents the quality of the POI and is calculated based on factors such as location rating(S_rating), user-selected tags(S_tag, and travel time(D_ij). For 'Explore Score,' encourages the algorithm to explore new POI and is calculated using the formula shown in Fig. 23. Ns represents the visit count of the starting node, and Nd represents the visit count of the destination node. The explore score increases as the difference between Ns and Nd increases. In summary, this algorithm generates a user-centric and personalized trip plan with itinerary details for our target users.

$$exploit = \frac{S_{tag}^{(d)} + S_{rating}^{(d)}}{1 + D^{(s,d)}}$$

$$explore = C * \sqrt{\frac{1 + N_s}{1 + N_d}}$$

Where s = start, d = destination

Fig. 23. Exploit and Explore scores

IV. METHODOLOGY

Conducting usability testing with our target users is crucial to assess the usability, efficiency, and effectiveness of 'NimBus.' This procedure empowers us to collect invaluable user feedback, vital in developing a digital product that fulfills the target users' requirements [31]. Our primary objective is to achieve measurable and quantifiable results through usability testing. By doing so, we aimed to validate the functions and features of our web application, 'NimBus,' ensuring that it aligns with users' preferences and requirements. During the usability testing process, we focused on assessing three critical aspects of the system: system usefulness, information quality, and interface quality. Besides these metrics, we intended to supplement our data with quantitative feedback through questionnaires and qualitative insights using open-ended interview questions. This comprehensive feedback would provide an in-depth understanding and shed light on areas for potential improvement.

The first step to a successful usability test is recruiting appropriate participants. We aimed to recruit a minimum of 10 participants to ensure the credibility of the test results. The participants were selected based on the personas we created during the 'define' phase of design thinking. Our target user groups included Thai university students, foreign/exchange students, and business owners in Thailand. Once we had our participants, the usability testing was carried out as planned. The user interviews would primarily be conducted online, in line with the preferred communication mode of our target user groups, as well as the COVID-19 guidelines by the university. However, when necessary, in-person sessions were also undertaken with permission. In the study, at least two researchers were undertaking the test. For instance, one researcher could record test results on their devices, while the other researcher would ask interview questions to the participants. In addition, task completion time, error rate, task duration, and further participant comments would be logged into our shared project spreadsheet and Google forms for post-test questionnaires. The usability testing process could be broken down into three phases: pre-test, in-test, and post-test, as illustrated in Table 3. The participants were given an overview of the project and the testing procedure during the pre-test to use the test results for our study. If the test was administered online, we recorded the session. Before moving on to the in-test phase, we ensured each participant understood the testing method after obtaining the consent. The activities were presented, and the researcher recorded the participant's completion time during the in-test phase. The researcher would then only become involved when required, as when a participant seemed disoriented or encountered difficulties. Before the person tried the task assignment again, any problems, misconceptions, or need for an explanation would be addressed. Each task's duration and any challenges encountered will be noted after completion.

Upon completing all the participant tasks, we would commence the post-test section, beginning with a series of post-test questionnaires. This segment involved three distinct questionnaires: the System Usability Scale (SUS), the Post-Study System Usability Questionnaire (PSSUQ), and the Net Promoter Score (NPS). According to [33, 41], the SUS offers a reliable, practical assessment of perceived ease of use and

TABLE III.
USABILITY TESTING DESIGN AND PROCEDURE

Section	Procedure	Estimate Duration
Pre-Test	Introduction to the Project and the Usability Test	2 mins
	Request for consent	2 mins
In-Test	Task 1 - 6	2 mins
	Post Task Interview	1 min
	Task 7 - 15	4 mins
	Post Task Interview	1 min
	Task 16 - 19	2 mins
	Post Task Interview	1 min
Post-Test	Post Test Questionnaire (e.g., SUS, PSSUQ, and NPS)	3 mins
	Post Test Interview	5 mins

TABLE IV.
TASKS DESCRIPTION

No	Task description is given to users	Function
1.	Locate the Login/Sign-up function.	Authentication
2.	Look for an Iconic place and go through it	Browse for Recommendation
3.	Search for the Location Details of a place called '*Chamchuri'* Square	Location Detail
4.	Locate the Comment section for the review of '*Chamchuri'* Square	Location Detail
5.	Set '*Chamchuri'* Square as a destination to visit	Location Detail + Plan Trip
6.	Go back to the Home page.	Home Page
7.	Create a trip plan	Plan Trip
8.	Find more details about '*Chamchuri'* Square on the schedule page	Plan Trip
9.	Change "*SamyarnMitrtow*'n to "*Siam Paragon"* for the location to visit	Edit Plan
10.	Change the visiting order to go to "*Siam Paragon"* before "*Chamchuri"* Square.	Edit Plan
11.	Delete Siam Paragon from the list of locations to visit	Edit Plan
12.	Show Schedule for Day 3	Plan Trip
13.	Show Full Schedule	Plan Trip
14.	Save Plan	Plan Trip
15.	Go to the User Profile Page	User Profile
16.	Visit the "*Chamchuri'"* Square location page you visited before through this page.	User Profile + Location Detail
17.	View your saved plan.	User Profile + Plan Trip
18.	Request to register your store or place it into the system	Register Shop
19.	Find the sign-out function.	Authentication

learnability, utilizing a 5-point Likert scale. Similarly, the PSSUQ is a standardized tool designed to gauge the participant's satisfaction with the product, typically websites or software, using a 7-point Likert scale [34]. Lastly, the NPS is a loyalty metric, providing insights into whether the participant considers the product they are testing highly usable; it operates on a scale of 0-10 [4]. After finishing the final task in the test section, participants would receive a Google form containing 27 questions: 10 for the SUS, 16 for the PSSUQ, and a single question for the NPS. Once the post-test questionnaires were completed, participants would proceed to the post-test interview questions. These questions are designed to gain deeper insights into the performance of the current web application, facilitating future analysis and revisions. The research would document the participant's responses in a shared spreadsheet. After all interview questions had been addressed, recorded, and documented, the interviewer would notify the participant that the usability testing session had concluded.

V. Results and Findings

In our study, 10 participants, a blend of Thai and foreign exchange students, participated in the usability test. Averaging 21 years, our participants presented a gender distribution of 6 males and 4 females, while 3 of them were French, German, and Indonesian nationalities. They are currently enrolled in undergraduate studies at a Thai university. Each had prior experience planning at least one trip within Thailand or abroad, demonstrating their familiarity with digital trip planning tools like Airbnb, Agoda.com, Skyscanner.net, and Hotels.com. Our pre-study interviews found that participants mainly used existing tools such as Google Search and TripAdvisor for travel information, while a few experimented with AI tools like ChatGPT. This displayed an interesting shift towards AI in travel planning. We also delved into how participants perceive social media as a source of travel inspiration, their comfort using mobile booking applications, and their preferences in user interface designs. These findings provided valuable insights into today's tech-savvy travelers' prevailing habits and preferences. However, our goal extended beyond merely understanding their existing behaviors. We sought to identify potential areas of improvement and innovation in our digital solution 'NimBus' to create a more intuitive, user-friendly tool that aligns with modern travelers' changing trends and needs.

A. System Usability Scale

We analyzed and interpreted the data of the system Usability Scale (SUS) using a dataset containing mean scores and standard deviations across ten items (SUS1-SUS10). The results suggest that the system performed well in terms of perceived usability. The mean scores for positive items (SUS1, SUS3, SUS5, SUS7, and SUS9), which assess aspects such as ease of use and user confidence, were consistently high, ranging from 4.1 to 4.5 on a 5-point scale. These high mean scores demonstrate that users have a favorable perception of the system's usability, finding it intuitive and user-friendly. In particular, the trip planning task by 'NimBus' was found to be easy to use (SUS3, M = 4.5, SD = 0.707), and the users felt very confident while using it (SUS9, M = 4.4, SD = 0.699). On the other hand, mean scores for negative statements (SUS2, SUS4, SUS6, SUS8, and SUS10), which reflect the complexity, technical support requirement, inconsistency, and learning curve of the system, are noticeably low, ranging from 1.2 to 1.7. These low scores indicate that users did not encounter significant usability issues or challenges with the design, consistent with positive SUS items. For instance, users did not find the system unnecessarily complex (SUS2, M = 1.5, SD = 0.707) and did not need immediate and substantial technical support to use it (SUS4, M = 1.2, SD = 0.632). Additionally, the standard deviations for each of the ten categories are less than 1, which shows that responses were primarily centered around the mean and suggests that users' opinions on the system were generally in accord. As shown in Table 5, the System Usability Scale (SUS) analysis highlights a high level of satisfaction among users concerning the perceived usability of 'NimBus.' The consistency in these responses, reflected in the low standard deviations, further reinforces these findings. Thus, the system demonstrates exceptional usability based on this analysis, suggesting a well-received and user-friendly interface. In summary, respondents found the system easy to use, its functions well-integrated, and they felt confident in their usage. They also did not consider the system complex or inconsistent, nor did they believe they required extensive technical support or additional learning to use it effectively.

TABLE V.
SYSTEM USABILITY SCALE RESULTS

SUS Items	Item Description	Mean (M)	Standard Deviation (SD)
SUS1	I would like to use this system frequently.	4.1	0.99
SUS2	I found the system unnecessarily complex.	1.5	0.71
SUS3	I thought the system was easy to use.	4.5	0.71
SUS4	I think that I would need the support of a technical person to be able to use this system.	1.2	0.63
SUS5	I found the various functions in this system were well integrated.	4.5	0.53
SUS6	I thought there was too much inconsistency in this system.	1.4	0.70
SUS7	I imagine most people would learn to use this system very quickly.	4.5	0.71
SUS8	I found the system very cumbersome to use.	1.7	0.82
SUS9	I felt very confident using the system.	4.4	0.70
SUS10	I needed to learn many things before I could get going with this system.	1.3	0.67

We also quantitatively analyzed the individual SUS scores, encompassing 10 participants labeled P1 to P10. Based on the individual SUS results, the total SUS scores ranged from 60 to 100, with a total mean SUS score of 87.25, higher than 68. This is supported by the existing literature that, according to Sauro (2011), a SUS score above 68 can be considered 'above average,' and anything under 68 is labeled 'below average.' The standard deviation score was approximately 11.99, indicating some variability in the SUS

scores. The participant data shows a range of responses about usefulness, quality, and satisfaction. We divided participants' replies into metrics for our evaluation, such as SUS individual total scores, adjective rating, grade, acceptability, and percentage. The overall SUS scores for our 10 participants vary from 60 to 100. Most participants (P1, P2, P3, P4, P6, P7, P8, and P9) had a usability score of 85 or higher, regarded as an 'Excellent' result. P6, P7, and P9 even received ratings of 97.5 and 100, which are close to the top of the scale and denote a 'Best Imaginable' level of user experience. As stated in [3], the SUS adjective rating is another interesting metric. Most participants were characterized as 'Excellent' while some reached the highest descriptor of 'Best Imaginable.' Only one participant, P10, was described as 'OK,' suggesting room for improvement.

Regarding grading, eight out of ten participants received an 'A+' grade, implying high satisfaction with the system. Participant P5 received a 'B+,' and P10 scored the lowest with a 'D.' It is possible that P10 encountered more usability issues or found the system less intuitive than the others. When we look at the 'Acceptability,' it is 'Acceptable' for nine out of ten participants and 'Marginal' for one participant, again P10. This implies that while most participants found the system usable and satisfactory, certain aspects might need further improvement to cater to all types of users. The percentile ranges indicate the position of these participants' scores within a broader comparison group. Most of our participants (80%) are in the top 96-100 percentile, indicating that users find the product or system highly usable and well-designed. Only one participant, P5, fell into the 85-89 percentile range, and P10 was in the lower 15-34 percentile. From these results, it is clear that most participants found the system highly usable and satisfactory, indicating a successful user experience design. However, the lower scores from participants like P5 and especially P10 suggest that there might be areas in which the system's usability could be improved.

TABLE VI.
INDIVIDUAL SYSTEM USABILITY SCALE RESULTS

Participants	SUS Total Scores	Adjective Rating	Grade	Acceptability	Percentile
P1	85	Excellent	A+	Acceptable	96-100
P2	90	Excellent	A+	Acceptable	96-100
P3	85	Excellent	A+	Acceptable	96-100
P4	87.5	Excellent	A+	Acceptable	96-100
P5	77.5	Good	B+	Acceptable	85-89
P6	97.5	Best Imaginable	A+	Acceptable	96-100
P7	100	Best Imaginable	A+	Acceptable	96-100
P8	90	Excellent	A+	Acceptable	96-100
P9	100	Best Imaginable	A+	Acceptable	96-100
P10	60	OK	D	Marginal	15-34

B. Post-Study System Usability Scale

The Post-Study System Usability Questionnaire (PSSUQ) was used to objectively assess participant views as part of the "NimBus" usability study. System Usefulness (SYSUSE), Information Quality (INFOQUAL), and Interface Quality (INTERQUAL) were the three main dimensions of the questionnaire. It's important to note that in the PSSUQ, the lower the score, the more favorable the results are. The application's System Usefulness (SYSUSE) was evaluated highly by users, as suggested by an overall mean score of (M=1.65, SD = 0.497). For each item of SYSUSE, users found the system to be easy to use (M = 1.3, SD = 0.674), simple to use (M = 1.3, SD = 0.483), and felt comfortable using it (M = 1.5, SD = 0.527). The capacity to execute tasks rapidly had a somewhat higher mean score (M = 1.9, SD = 0.876), indicating space for system efficiency improvement. The system's learning curve was also steeper (M = 2, SD = 1.826), indicating the need for stronger initial training or more user guidance. A little higher than the SYSUSE score, Information Quality (INFOQUAL) has a mean M= 2.09 (SD = 0.517). Users regarded the system's error messages as helpful in solving issues (M = 2.9, SD = 1.174) but gave it a lower rating for its capacity to correct itself (M = 2.25, SD = 1.087). This could suggest the system's information quality regarding error handling and recovery procedures must be improved. The system's information clarity was rated as acceptable (M = 2.6, SD = 2.191), while the accessibility of the necessary information was rated as good (M = 1.7, SD = 0.823). Users thought the information on the system panels was organized (M = 1.5, SD = 0.707). According to the INTERQUAL results, the system earned an overall mean score of M=1.67 (SD = 0.177) on the interface quality, showing that most users were content with it. Users also believed the system had all the required features and capabilities (M = 1.6, SD = 0.966), while the interface was easy to use (M = 1.8, SD = 0.632). Finally, the overall PSSUQ score suggests that users were satisfied with the system (M = 1.5, SD = 0.7), indicating a positive assessment of its usability covering usefulness, information, and interface qualities.

These results highlight several important aspects of the 'NimBus' system (see Table 8). The high System Usefulness (SYSUSE) and Interface Quality (INTERQUAL) scores suggest that users found the system usable and the interface pleasant. The slightly lower Information Quality (INFOQUAL) score could be due to the system's error messages and the perceived difficulty in recovering from mistakes, indicating potential areas for system improvement. The scores also suggest that while users are comfortable with the system's interface and can easily navigate it, some struggle with its learning curve. More intuitive system guidance or tutorials might be beneficial to reduce this learning curve, and further attention to task efficiency could improve user satisfaction. Overall, users expressed a good level of satisfaction with the system. This is a promising result for a mobile-based personalized trip planning application targeting tourists traveling to Thailand. However, addressing the identified areas for improvement could enhance user experience and satisfaction. Future research might investigate the impact of these improvements on user satisfaction and system usability.

TABLE VII.
PSSUQ SCORES

		Mean	SD
SYSUSE	1. Overall, I am satisfied with how easy to use this system.	1.3	0.48
	2. It was simple to use this system.	1.3	0.67
	3. I was able to complete the tasks and scenarios quickly using this system.	1.9	0.88
	4. I felt comfortable using this system.	1.5	0.53
	5. It was easy to learn to use this system.	2	1.83
	6. I believe I could become productive using this system.	1.9	0.74
	Overall SYSUSE	**1.65**	**0.50**
INFOQUAL	7. The system gave error messages that clearly told me how to fix problems.	2.9	1.17
	8. Whenever I made a mistake using the system, I could recover easily and quickly.	2.25	1.09
	9. The information (such as online help, on-screen messages, and other documentation) provided with this system was clear.	2.6	2.12
	10. It was easy to find the information I needed.	1.7	0.82
	11. The information was effective in helping me complete the tasks and scenarios.	1.6	0.84
	12. The organization of information on the system screens was clear.	1.5	0.71
INTERQUAL	**Overall INFOQUAL**	**2.1**	**0.52**
	13. The interface of this system was pleasant.	1.8	0.63
	14. I liked using the interface of this system.	1.6	0.70
	15. This system has all the functions and capabilities I expect it to have.	1.6	0.97
	Overall INTERQUAL	**1.67**	**0.18**
Overall PSSUS	16. Overall, I am satisfied with this system.	1.5	0.70

C. Net Promoter Score

We also looked at the Net Promoter Score (NPS) data, a well-known method to measure how likely users are to suggest a product, service, or system in this study to others. It ranges from -1 to 1, representing a user's total pleasure with the perceived quality of a system. Generally, the NPS contains a single question "On a scale of 0-10, how likely are you to recommend our product/service to a friend or colleague?". Then, the NPS score is calculated based on the user's responses to the question, segmenting into three categories: Promoters (score 9-10), Passives (score 7-8), and Detractors (score 0-6). In this study, the NPS score for 'NimBus' is 0.5 high and favorable. According to this rating, most users are inclined to recommend this system to others, showing signs of excellent user satisfaction and loyalty. It can be found that there were 6 Promoters, 1 Detractor, and 3 Passives when the score was broken down into its components.

Also, the system appears to be well-liked overall, as seen by the relatively high proportion of Promoters compared to Detractors, which is consistent with the high NPS. These Promoters are essential since they are potentially the most devoted users of the system and are more likely to recommend it to others, fostering organic development and useful word-of-mouth promotion. It is noticeable that there are also 3 Passives, though, showing that they are usually content with the system; however, they are not motivated enough to aggressively promote it. They may be susceptible to competitive offerings, as their loyalty is not as solid. It would be beneficial to dig deeper into their feedback and understand what features or improvements might move them into the Promoter category. The existence of a single Detractor indicates that while the system is generally well-received, a small fraction of users have had negative experiences or find the system lacking in some ways (e.g., user experience). This feedback can be valuable for continuous improvement.

In summary, 'NimBus' has successfully generated a positive user experience overall, as evidenced by the NPS of 0.5. However, we should take it a step further by focusing on transforming Passives into Promoters and addressing the concerns of the Detractor. This can be done by maintaining an open communication channel for feedback, refining the user interface and functionality, or adding more personalized features. Moreover, regular usability evaluations should be conducted to keep abreast of changing user perceptions and needs.

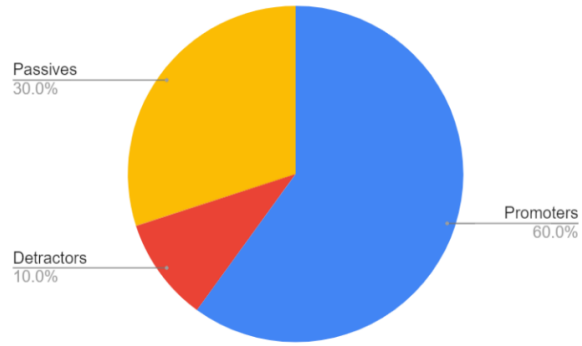

Fig. 24. NPS results

D. Interview Results

The qualitative analysis of the interview data from the usability testing of 'NimBus' yielded a number of insights and helpful criticism. The study has been divided into three categories based on user feedback: user interface design, prospective user interface changes, and additional suggestions for improving the user experience. Users generally agreed in the affirmative about user interface design. Most users commented that the 'NimBus' system was straightforward to use and comprehend for most responders, indicating a user-friendly design. However, opinions about intuitiveness varied. For instance, most users praised the tool's intuitiveness; however, some pointed out a few small places where it might be strengthened.

Regarding future improvements, the criticism was detailed and pointed out interface design elements. Here, the visibility and clarity of specific characteristics were a repeating topic. For example, the "Continue at the end of the page," "Show full schedule button," "View full plan," and "Tags" buttons could all use some user-friendliness and visibility improvements, according to the respondents' feedback. Also, it should be taken into consideration that screen compatibility also became problematic when a user reported a problem with the older version of the iPhone application's user interface. The navigational flow was brought up as another important issue, as suggested by the users. It was noted that the need to leave a

location description to access alternatives should be further improved, implying that changing the navigational structure would enhance the user experience.

Users also offered a variety of comments for further recommendations to improve the user experience. The supply of improved information stood out among these. For example, a user proposed making it possible for users to quickly copy the location's name and specifics so they may conduct more searches on Google and get more data. Another similar idea was to include location photo previews when users hovered over location pins, which may give them a visual indication. One user was perplexed since the tool only displayed sites around Bangkok, highlighting a restriction with the program's geographic coverage. On the plus side, customers acknowledged the tool's ease, its capacity to recommend various sites, and its well-organized and intuitive structure in their reviews. These advantages might be a barometer for future growth and development, such as improved screen compatibility, greater feature visibility, and improved navigational flow. Plan sharing and other tools like image previews might both be implemented. Users have also mentioned the product's ease of use and efficient structure as essential advantages. Enhancing these elements to maintain a positive user experience while making further improvements is important. In addition, they have identified areas that require improvement, specifically regarding feature visibility and navigational flow. Their suggestions include enabling the copying of place data for additional web research, incorporating location photo previews, and expanding geographic coverage. These developments aim to promote the planning process and provide users with a more comprehensive understanding of Thai locations, ultimately fostering more enriching travel experiences. Moreover, they have expressed appreciation for 'NimBus' in its ability to offer a wide range of Thai place recommendations, particularly in the current version's Bangkok area, contributing to diverse tourism opportunities. However, users have a consensus that screen compatibility needs to be enhanced to appeal to a broader audience.

According to user reviews, 'NimBus' is seen as a potential instrument that might increase tourism in Thailand through the wise use of ICT. Most users commented that the system's user-friendliness makes tourists' trip-planning tasks easier and more convenient than existing tools.

> *A user voiced, "Though 'NimBus' streamlines travel planning in Thailand, some aspects need improvements. Enhancing feature visibility and navigation and introducing location photo previews could significantly improve my planning process. It's commendable how it promotes various sites across Thailand, yet addressing the screen compatibility issue could cater to more users. With these modifications, I believe 'NimBus' has the potential to contribute to Thailand's tourism growth."*

In summary, the users think 'NimBus' can encourage growth and variety in Thailand's tourism sector and provide visitors with better services with these ICT-based upgrades based on user input. Based on the qualitative findings, 'NimBus' is praised for being simple to use and comprehend, although there is room for improvement.

VI. DISCUSSION

The usability testing conducted on 'NimBus' offers good evidence in favor of the usability and user-friendliness of digital solutions in enhancing tourists' user experiences and trip organization in Thailand. Also, the findings reveal a positive user perception of 'NimBus,' emphasizing its user-friendly interface, ease of use, and practical features. Thus, it underscores the potential and effectiveness of the system to revolutionize the current tourism industry, particularly in Thailand. Some critical elements distinct from the study's findings include the simplicity of the system's interface design, its well-balanced aesthetics and information organization, and effective navigation design. Generally, using a digital tool or platform to plan a trip may be complicated since it requires integrating extensive information, various visualizations, digital materials (e.g., images and videos), navigation, suggestions, and customization. Users can get frustrated when designing and developing an e-tourism system if the information and navigation are complex, leading to negative user experiences. The findings from the study highlight that it is important to focus on the user's experience and how they interact with the system while considering their specific needs and preferences, especially for systems meant for tourists and travel businesses.

The findings from the SUS and PSSUQ showed that users found the 'NimBus' system easy and simple to use. This indicates that two of our objectives, creating a user-friendly interface and understanding the system's usability and user-friendliness, were accomplished and well-received by the study's participants. The findings also demonstrate the efficacy of our efforts to reduce users' cognitive load by designing an intuitive system. The system's acclaim for user-friendliness can be primarily attributed to the strategic application of established UX principles, including Fitts's Law, as expounded by [40]. Users also found the system neither complex nor inconsistent, suggesting well-integrated features and coherent design, particularly important in the tourism and hospitality sector with diverse and dynamic user needs. Its simplicity indicates potential for real-world adoption. Based on the PSSUQ findings, INFOQUAL scores align with the SUS's results but point to possible error handling and recovery improvements. Users appreciated the system's precise, accessible data – a crucial element for a trip-planning tool.

Ongoing efforts to enhance information quality are thus important. INTERQUAL results also underline user satisfaction with the application's interface. Users enjoyed using the system and found it functionally comprehensive, attesting to its well-designed interface. However, incorporating user feedback for continuous interface optimization could lead to an even more gratifying user experience. The usability test results suggest that 'NimBus' inspires user confidence due to its intuitive navigation and streamlined processes. These also illustrate that the 'design thinking' strategy, applied in this research to develop the digital resource, successfully satisfied crucial user requirements, emphasizing the significance of user interface and experience[11]. This discovery fulfills our objective of assessing the suitability of the 'design thinking methodology, which holds significant relevance for tourism technology.

Furthermore, our tool is well-positioned for wide acceptance and usage among tourists, providing a seamless planning experience. This methodology caters to user needs and has the potential to transform technological engagement, making it more efficient and enjoyable. Also, the usability testing findings for the 'NimBus' system affirm the principles of CogInfoCom by demonstrating how user-centered design enhances tourists' cognitive experiences through ease of use, intuitive learning, and streamlined trip planning. These results underscore the system's capacity to effectively reduce cognitive load, making it a practical and user-friendly tool that aligns well with the CogInfoCom objective of evolving user cognition alongside technological advancements.

The Net Promoter Score (NPS) for our trip planning system, 'NimBus,' underscores user satisfaction, highlights the growth potential, and indicates areas where enhancements can be made. Among our users, the High Promoters demonstrate the system's strengths, the Passives provide valuable insights into areas that need improvement, and the Detractors offer critical feedback. To further improve our system, we aim to refine the interface, incorporate personal touches, maintain open feedback channels, convert Passives into Promoters, and address the issues raised by Detractors. Also, regular reviews will facilitate our system's progression and help us understand its potential in the market. While the results are promising, it's crucial to recognize the variations in user experiences. This diversity reinforces the need for continuous evolution and refinement, as users may exhibit unique needs, preferences, and tech-savvy levels. Such diversity is characteristic of the tourism sector; for instance, tourists visiting Thailand represent many cultural backgrounds and socioeconomic statuses, presenting a broad spectrum of needs and preferences. This underscores the opportunities for the development team to enhance and maintain 'NimBus continually.' Aligning with the 'design thinking' methodology, there's a requisite 'reflection' stage, allowing us to comprehend the accomplished tasks and plan the next steps. This iterative approach helps us to constantly evolve our product, adapting to users' feedback and enhancing the overall user experience.

Despite these positive assessments, users felt the system's ability to recover from mistakes was somewhat lacking, suggesting the need for improved resilience in the system's design. This could be addressed by developing more comprehensive error-handling protocols or automated recovery processes, leading to a more robust and user-friendly platform. However, the slightly higher score for completing tasks quickly and the perceived learning curve suggest room for efficiency enhancement and user guidance. These findings also demonstrate that despite the system's overall usefulness, some users can find it tiresome or time-consuming. To reduce the apparent learning curve and further simplify the user experience, it would be prudent to concentrate on developing features and functionalities that speed up work completion and offer additional guidance or training to users. The findings revealed overall user satisfaction with the system, an encouraging sign that its users perceive it positively. This suggests that the mobile-based personalized trip planning application can potentially bring substantial value to tourists traveling to Thailand by easing their planning process and enhancing their trip experience.

In light of these insights, it is crucial to consider recommendations for further improving the system. Firstly, the tool could be continually updated and refined to accommodate broader user preferences. For instance, by including features like multilingual support and accessibility options, we can reach a wider audience, aligning with e-tourism for local and global tourists. Second, the system is mostly intuitive, given the minimal need for technical support. However, an efficient online help system, like chatbots or an FAQ section, could ensure instant help. This proactive measure can reassure users and encourage continued tool use, even if they encounter minor difficulties. Lastly, the results from the participants who experienced the system as marginal or acceptable suggest there is room for improvement. More studies might be done to comprehend their particular experiences, obstacles, or challenges utilizing technology. This strategy could offer insightful information that can be used to improve the system and eventually improve user experience and performance.

In summary, while our application has shown promise and user satisfaction, the findings highlight specific areas for further research and development. Our application can enhance the tourism experience for international and local tourists traveling in Thailand through a continued refinement and user-focused design. The discussion in this section also has shed light on the potential of using the latest ICTs in Thailand's tourism sector, which is one of our study's objectives. This web-based personalized trip planning tool can potentially ease Thai travel planning for visitors worldwide and locals. The system usability analysis's results show high user satisfaction and the possibility for successful, wide-scale adoption. For sustained efficacy and significance in the evolving tourism sector, the system must be continually enhanced, fine-tuned, and adapted based on user feedback.

The research presented in this paper introduces 'Nimbus,' an innovative interactive web-based personalized trip planning tool designed for tourists in Thailand, which embodies multiple novel contributions to the field of e-tourism. A key innovation is the application of design thinking methodology to the development of the platform, emphasizing empathy, iterative design, and real-world usability, aspects not commonly integrated in digital tourism tools. Additionally, the study unveils a sophisticated algorithm capable of crafting personalized itineraries based on user preferences, local insights, and real-time logistical constraints, such as operational hours and transportation options. This approach not only suggests popular and lesser-known destinations but also effectively balances tourist distribution, thereby supporting under-visited areas. Unlike conventional trip planning tools that often focus on popular tourist sites, 'Nimbus' promotes local inclusivity by highlighting lesser-known attractions and local businesses, thereby fostering a more equitable distribution of economic benefits within the tourism sector. The research rigorously tests the usability of the tool through both qualitative and quantitative methods, ensuring that it meets the practical needs of users and providing a comprehensive analysis of user interaction and satisfaction. Furthermore, the scalability of 'Nimbus' is discussed, highlighting its potential adaptation to other geographical regions or tourism contexts, which underscores

the global applicability of the developed methodologies and technologies. These contributions significantly advance the field of Human-Computer Interaction (HCI) and tourism, offering new perspectives and practical tools for stakeholders in the tourism industry, thereby enhancing both user experience and industry practices.

Based on the quantitative and qualitative findings of the study, the following suggestions are made to further utilize information and communication technology (ICT) for Thailand's tourist industry in light of the study's findings.

- *Continual System Improvements*: Given the dynamic nature of user preferences and rapid technological advancements, it is essential that systems like 'NimBus' undergo regular updates and enhancements. By incorporating user feedback, the platform will be updated with relevant, relevant, and user-friendly technology. This aligns with the 'design thinking' philosophy and its iterative nature.
- *Enhance Customization*: The success of a digital platform depends heavily on customization. We can increase user involvement and satisfaction by including sophisticated features like personalized suggestions based on user preferences or profiles. The study's conclusions suggested how Thailand's tourist sector may better utilize information and communication technology (ICT).
- *Multilingual Support*: Given the nature of globalized tourism, adding multiple language options could improve the system's accessibility for non-English speakers, ultimately expanding its user base.
- *Robust Online Support:* Implementing an effective online support system, like chatbots or an easily navigable FAQ section, will help users resolve issues in real-time, boosting user confidence and satisfaction with the system [25].
- *Security and Privacy Measures:* As digital platforms often involve personal and financial data, it is crucial to implement stringent security measures to protect user information, maintaining trust in the platform.
- *Collaboration with Local Tourism Industry:* Partnering with local tour operators, hotels, restaurants, etc., can provide more accurate and extensive information to tourists, enhancing their overall travel experience in Thailand.

This study opens the door for the burgeoning development of digital technologies in Thailand's tourism sector, offering more efficiency and improved visitor experiences. However, there are some restrictions: our database mainly focuses on Bangkok, our algorithm needs more training, our usability testing sample size is constrained, and our business database needs an extension. Future development will involve expanding our content library, improving personalization, and improving our machine learning algorithm, all of which will increase the usefulness of our digital solution for the tourist industry. The study has several limitations, including a small sample size which may not fully represent the diverse range of tourist preferences, and the preliminary nature of the results which require further validation over an extended timeline and across broader data coverage to ensure the robustness and generalizability of the findings.

VII. CONCLUSION

This research designed a personalized web-based trip planner for tourists visiting Thailand, employing a design thinking methodology. This systematic approach allowed us to understand users' needs, leading to a highly intuitive tool. Our usability assessment, conducted with ten participants, including local and international tourists, indicated that the tool was well-received, with positive feedback. The success of this tool not only emphasizes the potential of Information and Communication Technologies (ICTs) in significantly contributing to tourism sectors worldwide but also suggests a positive impact on local economies reliant on tourism. Furthermore, these promising results invite future exploration into adapting the tool for different tourism types and contexts and integrating advanced features such as real-time updates, reviews, ratings, social sharing, and AI-driven personalized recommendations. In summary, this study highlights the transformative role of ICTs in the tourism sector, pointing to an exciting future for digital solutions in meeting evolving tourist needs and preferences.

VIII. DECLARATION

Conflict of interest: The author(s) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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