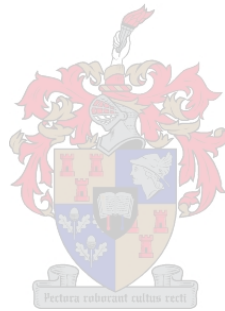


Development of an architecture and web-based demonstrator for tourist itinerary planning

by

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Engineering (Industrial Engineering) in the Faculty of Engineering at Stellenbosch University

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: 31 August 2022

Abstract

The international Travel and Tourism sector has shown significant growth in recent years and is an exceptionally lucrative industry. It is continuously expanding, improving business processes and incorporating technological advancements that create an abundance of travel opportunities. An area of the industry that has gained more attraction recently is trip planning, as it is arguably one of the most important aspects of a tourist's journey regardless of their background or income level. With the wide variety of travel websites, online booking platforms and tourist recommendations available on the internet and social media, the task of creating an itinerary can be daunting. Every prospective tourist has different needs and preferences and, therefore, the itinerary planning process requires careful deliberation and comparison of options in order to make suitable and realistic choices. The researcher surmised that there is a need for a *personalised* itinerary planner which allows the user to specify the budget.

To address this need, a research study was conducted in which engineering technologies, information systems, computer programming and web development were combined to develop a new and original tourist itinerary planning (TIP) demonstrator. A literature study revealed that two essential aspects of trip planning, namely personalisation and budgeting have, to some extent, been neglected in previous works. Therefore, the TIP demonstrator presented in this study is focused on providing tourists with an itinerary that satisfactorily fulfils their travel preferences and helps them stay within their desired budget. The TIP demonstrator also offers a unique interactive process of trip planning where the itinerary is constructed with continuous input from the user. This is realised using a TIP architecture, algorithm, database and browser user interface that collectively facilitate the itinerary planning process.

After development and implementation, the TIP demonstrator has been tested on different scenarios imitating real-life travel planning behaviours and preferences. The evaluation of the TIP demonstrator showed that it is viable to develop a fully deployable system of this nature and that there exists a business case for it. This study showed, once again, that industrial engineering principles can be applied and integrated systems developed in the services sector.

Opsomming

Die internasionale reis en toerisme sektor het oor die laaste paar jaar beduidende groei ervaar en is 'n uiters winsgewende industrie. Dit brei voortdurend uit, verbeter besigheidspesesse en inkorporeer tegnologiese ontwikkelings wat oorvloedige reisgeleentheid bied. 'n Area van die industrie wat onlangs meer aandag begin trek het, is reisbeplanning. Dit is een van die belangrikste aspekte van 'n toeristiese reis, ongeag hul agtergrond of inkomstevlak. As gevolg van die groot verskeidenheid reiswebtuistes, aanlyn besprekingsplatforms en toeristiese aanbevelings wat op die internet en sosiale media beskikbaar is, kan die proses om 'n reis te beplan uitdagend wees. Elke voornemende reisiger het verskillende behoeftes en voorkeure, en daarom vereis die reisbeplanningsproses noukeurige oorweging asook vergelyking van opsies om te verseker dat aanvaarbare en realistiese keuses gemaak word. Die navorser het dus tot die gevolgtrekking gekom dat daar 'n behoefte is vir 'n *persoonlike* reisbeplanner wat ook die gebruiker se begroting in ag neem.

Om hierdie behoefte aan te spreek, is 'n navorsingstudie uitgevoer waarin ingenieurstechnologieë, inligtingstelsels, rekenaarprogrammering en webbladontwikkeling gekombineer is om 'n nuwe, oorspronklike reisbeplanningsdemonstreerder (hierna verwys as TIP) te ontwikkel. 'n Literatuurstudie het uitgewys dat twee noodsaaklike aspekte van reisbeplanning tot 'n sekere mate in vorige werke afgeskeep was, naamlik verpersoonliking en begroting. Daarom is die TIP demonstreerder van hierdie studie daarop gefokus om aan gebruikers 'n reisplan te verskaf wat hul voorkeure bevredig en hul help om binne hul verlangde begroting te bly. Die TIP demonstreerder bied ook 'n unieke interaktiewe proses van reisbeplanning waar die gebruiker die reisplan met deurlopende insette opstel. Dit word gerealiseer met die gebruik van 'n TIP algoritme, databasis en webblaaier wat gesamentlik die reisbeplanningsproses fasiliteer.

Na die ontwikkeling- en implementeringfases is die TIP demonstreerder getoets op verskillende scenarios wat regte-wêreld reisbeplanningsgedrag en -voorkeure gebruik. Die evaluering van die TIP demonstreerder het gewys dat die ontwikkeling van 'n volledige implementeerbare stelsel van hierdie aard lewensvatbaar is en dat dit 'n besigheidsgelentheid bied. Hierdie studie het weereens getoon dat bedryfsingenieurswese beginsels in die diensesektor toegepas kan word en dat geïntegreerde stelsels daarvoor ontwikkel kan word.

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Nomenclature

Acronyms

ABM	Activity-based modelling
AD	Architectural description
B&B	Bed and Breakfast
BUI	Browser user interface
CSS	Cascading Style Sheets
DD	Data Dictionary
DSS	Decision Support System
EDP	Engineering Design Process
EERD	Extended Entity-Relationship Diagram
FB	Food and beverage
FB_POI	Food and beverage point-of-interest
GDP	Gross Domestic Product
HTML	HyperText Markup Language
ICT	Information and communication technologies
IS	Information system
IT	Information Technology
MS	Microsoft
OPCAT	Object-Process CASE Tool
OPD	Object-Process Diagram
OPL	Object-Process Language
OPM	Object-Process Modelling
p.p.	Per person

NOMENCLATURE

SD	System Diagram
SD1 - SD4	Sub-diagrams
SDLC	Software Development Lifecycle
SDSS	Spatial decision support system
SQL	Structured Query Language
SSP	Shortest path problem
T&T	Travel and Tourism
TIP	Tourist itinerary planning
WTTC	World Travel & Tourism Council

Chapter 1

Research proposal

This study aims to apply engineering methods, skills and tools in conducting research and developing a *demonstrator* for a new and improved method of tourist itinerary planning (TIP). The demonstrator will serve as a prototype of how such an itinerary planner would be used, displaying all the required features and functions thereof.

This chapter describes the research background with the accompanying research statement, research objectives, project scope and research methodology to be followed. Finally, the structure of this document will be detailed.

1.1 Research background

The primary theme of this work is itinerary planning for tourists, either as individuals or as groups. The main premise is that the itinerary is relatively complicated with many activities, modes of transportation and places to see, and that the user has limited time and usually a limited budget. The planner should be hosted on the web and will thus be an electronic information system with decision support.

The international travel and tourism (T&T) sector is currently one of the biggest platforms for new market ideas and innovations, with a broad field of opportunities for businesses to expand their services and benefit from its increasing stream of income. It is the third fastest growing sector worldwide, higher than the healthcare and retail sectors, with a growth rate of 3.5% and an income of 8.9 trillion USD in 2019, as reported by the [World Travel & Tourism Council \(2020\)](#). This report also indicates that one out of every ten of all jobs in 2019 were in T&T, and one in every four *new* jobs created in the last five years.

The sector's increasing success is greatly because of the incorporation of technological advancements in the different industries, commodities and components of T&T. It is easy for a potential tourist with internet access to virtually visit almost all popular and lesser-known destinations, which allows the tourist to plan a journey with more knowledge and also with more specific desires. This encourages more participation in the sector since it promises an increasingly effortless and enjoyable travel experience. T&T also has an extensive customer base with people from different backgrounds and income levels, with a wide variety of needs and preferences that are then easier to fulfil.

One of the most important aspects of a trip is undoubtedly the planning process. It is essential to use all available resources to make the process as simple and efficient as possible. The incorporation of technology in T&T provides many ways in which this can be done, for example, online

1.1 Research background

booking systems, mobile recommendation “apps”, online visa applications, audio walking tours, virtual assistants, pre-planned packages and online itinerary planners, which is the one of interest to this study. People are constantly seeking ways to minimise the amount of effort, time and money spent on the planning process, without compromising on specifics that they want included. This led to the growing popularity of services such as travel agencies that manually put together itineraries for prospective travellers. According to [Chuba \(2018\)](#), the current approach of travel planning is not sufficient anymore since 90% of travellers would like more personalised options and procedures. Because of this, personalised itinerary planning has become one of the most popular trends in T&T.

The use of online tourist itinerary planners is one solution, but it has not yet become popular enough to be considered the primary method of itinerary planning. Many online applications and programs incorporate specific aspects of itinerary planning, such as accommodation, transport and tourist attractions, and a few even combine multiple of these components, such as [TripHobo \(2020\)](#), [Inspirock \(2020\)](#) and [Planapple \(2020\)](#). However, the problem is that even though some are quite inclusive in terms of these aspects, many finer details are still not considered. T&T includes many additional industries, namely food and beverage services, retail trade, culture and sports and recreation services, which present an opportunity for even greater personalisation of customers’ itineraries.

Travellers are all individuals with unique preferences that span further than simply whether they prefer train or bus, hotel or Bed and Breakfast (B&B). Some are, for example, morning persons who would like to start exploring at 7 am, whereas others would rather wake up a bit later and first enjoy a hearty breakfast before starting their day of travels. Another example is people’s food choices: would they want to include fine dining in their itinerary or stick to local street food? These details are often neglected despite being vital to creating a realistic and practical (and satisfying) itinerary.

Therefore, the purpose of this study is to create a demonstrator for tourist itinerary planning that would require minimal input from the user while supplying an itinerary that would encompass all possible aspects of a traveller’s experience from beginning to end. A scenario illustrating this is as follows: A 40-year-old male living in South Africa would like to plan a trip for him and his wife to Paris for a week, where they would like to travel only by train and stay in a hotel. They are early risers who enjoy sunrises and would like to incorporate that into their itinerary. They would like to see as many art galleries and museums as possible and have no interest in fancy restaurants or shopping malls. Additionally, they would also like to experience the authentic French culture through food and drink. They would like to have all this as part of their itinerary while spending no more than R3 000 on activities and attractions. The demonstrator would use this information to provide a step-by-step itinerary with accommodation, transport, attractions, restaurants, prices and the time they have to visit each one. This is an example of how the demonstrator would operate and what it would deliver, and the steps to achieve this will be presented next.

1.2 Research statement

The research in this study comprises finding a suitable architecture and identifying the system elements for an information-based service in the tourist industry. This service will allow tourists to plan personalised itineraries while considering budget constraints. The proof-of-concept will be done via a web-based demonstrator for tourist itinerary planning by using data and information systems together with elements of near-optimisation and programming.

Given this and the problem background from the previous section, the research will be done by solving the following problem:

Develop a web-based **demonstrator** for personalised, budget-constrained tourist **itinerary planning**.

1.3 Research objectives

The study must meet the following objectives:

- I *Acquire* knowledge on the topics of *information systems in the travel industry and tourist itinerary planners*.
- II *Develop* a system architecture as the basis for the itinerary planner demonstrator.
- III *Study* software to acquire the skills needed to build the demonstrator.
- IV *Create* a database of relevant establishments and activities referred to as points-of-interest (POIs).
- V *Develop* a suite of software algorithms to enable decision-making for the user.
- VI *Create* different scenarios that will be used to test the operation of the demonstrator.
- VII *Do* verification and validation experiments using these scenarios.
- VIII *Analyse* all constructed itineraries provided by the itinerary planner demonstrator.

1.4 Project scope

T&T comprises an extensive range of categories, resources and elements that are combined for travellers to explore. Therefore, an itinerary planner should contain all of the different options for the user to choose from in terms of transport, accommodation, food and beverage establishments and leisure activities for it to provide the best possible itinerary. Since this study is limited to the development of a *demonstrator* for an itinerary planner, the following limitations will dictate this study:

1.5 Research methodology

- The demonstrator will be limited to a scope of a few cities (which will be decided upon later in the study).
- Mode of transportation used for the user to move between attractions and activities:
 - ◊ Car rental
 - ◊ Bus
 - ◊ [Uber \(2020\)](#)
 - ◊ Train/Metro
- Types of accommodation used during customer's stay:
 - ◊ Hotels and hostels
 - ◊ [Airbnb \(2021\)](#)
 - ◊ B&B and guest houses

1.5 Research methodology

This section presents the research methodology that will be followed to address the research statement stated in Section 1.2 and each of the objectives presented in Section 1.3. A set procedure of steps and phases is required to perform research and develop a sufficient and satisfactory demonstrator as end-product. Therefore the *Engineering Design Process* (EDP) will be followed as the research methodology. The steps and procedure thereof are illustrated in Figure 1.1.

Step 1 of the EDP is **Ask**, which includes the identification of the needs and constraints of this study. This was executed in Sections 1.1 to 1.4 through the problem background, research statement, project objectives and project scope.

This step is followed by the **Research** phase relating to Objective I, during which the different aspects of the problem and related topics will be studied and presented in the literature study. This will be divided into two main sections, each presented in a separate chapter: Itinerary planners and information systems in T&T. These topics will be researched and discussed in great detail to obtain the knowledge required to start planning the demonstrator. The literature study will therefore be used to understand the application of information systems in the T&T industry and how they can maximise customer experience using personalised itinerary planners.

The third step is **Imagine**, during which the possible solutions to the research statement stated in Section 1.2 will be developed. In Section 1.1 it was identified that there is a gap in the market of itinerary planners in terms of personalisation. Different scenarios are envisioned (using examples of what people typically want included when compiling an itinerary), and it will be determined

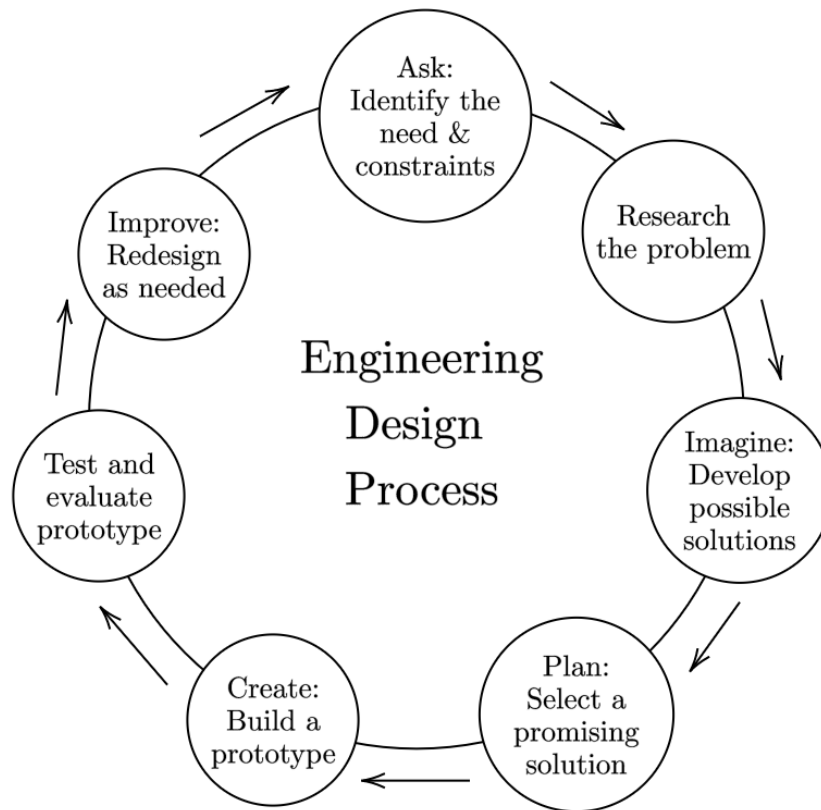


Figure 1.1: Engineering Design Process (Teach Engineering, 2016)

how these could be solved, taking into consideration what has previously been done as found in the *Research* step. Also, decision-making methods will be considered.

The fourth step of the EDP is **Plan**. This step includes selecting the solution that best suits the problem discussed in Section 1.1. This solution will be realised by defining an architecture that will then be developed for the demonstrator. An information system will be created to incorporate the various aspects involved in planning an itinerary, such as accommodation, transportation and leisure activities. This step, therefore, adheres to Objective II.

The fifth step of this methodology is **Create** further achieving Objective II, which will be addressed by building a TIP demonstrator using appropriate software (also fulfilling Objectives III, IV and V). This will serve as a prototype that can be developed into an entirely usable itinerary planner as part of the future work recommended for this project. The demonstrator will be built using the completed information system and model created during the previous step, where each component is combined and implemented in the appropriate software. The demonstrator will display the various functions, options and recommendations of the itinerary planner and how it can be used to plan a trip for a prospective traveller.

The sixth step is the **Test** and **Evaluate** phase, which is performed to achieve Objectives VI to

VIII. During this step, the demonstrator developed in the previous step will be used to test different scenarios of prospective travellers and their specific preferences of travel. The recommended itinerary the demonstrator creates will be evaluated to determine if it is realistic and effective. This will serve as the verification and validation of the itinerary planner demonstrator.

The final step of the EDP is **Improve** which also relates to Objective **VIII**, which will address possible changes identified in the previous phase. Improvements required to ensure sufficient functionality of the demonstrator will be incorporated and a redesign implemented if needed.

1.6 Structure of the thesis

This thesis document is structured as follows:

Chapter 1 addresses the problem to be solved and the planning of how this will be accomplished, using a research background, research statement, objectives, scope and methodology.

Chapters 2 and 3 contain the literature study of research completed to gain knowledge on the topics of interest to this study is presented. Chapter 2 contains the discussion of itinerary planners as a new development in Travel and Tourism, together with currently available existing planners. Chapter 3 presents the research performed on the topic of information and data systems and their application in Travel and Tourism.

Chapter 4 provides the design of a system architecture to facilitate the development of the tourist itinerary planning demonstrator.

Chapter 5 presents the testing and evaluating of the developed demonstrator using different scenarios to verify and validate the functionality thereof.

Chapter 6 contains the testing and evaluating of the developed demonstrator using different scenarios to verify and validate the functionality thereof. This also includes a discussion of the overall performance of the demonstrator as a realistic and accurate itinerary planner.

Chapter 7 presents the thesis conclusion together with recommendations for improvement/re-design and possible future work.

Finally, this thesis includes a bibliography as well as appendices, providing additional information as stated in each chapter.

1.7 Conclusion: Research proposal

This chapter introduces the research and provides the research background, research statement, objectives and project scope. The research methodology was discussed and, lastly, an overview of the structure of the thesis was given.

The subsequent chapter will provide the first topic of the literature study. This includes research on the T&T sector, current trends in the industry and the tourist itinerary planning process.

Chapter 2

Travel and Tourism Sector

The opening chapter introduced this study with the research proposal, which included, among others, the thesis objectives in Section 1.3. To fulfil Objective I, research was conducted on the global Travel and Tourism (T&T) sector with a focus on personalised itinerary planning. This was completed according to the steps in the research methodology presented in Section 1.5. The research conducted for this study was divided into two main aspects: the *technical* side of itinerary planning and the focus on *humans* as travellers and the process they follow when planning for an upcoming trip.

This chapter includes research on the universal T&T sector to understand it as a whole. This consists of a general discussion of the history, growth, future and employment implications of T&T. Next, the current trends in tourism are discussed with a more detailed look at personalisation in the different T&T industries. Lastly, information on tourist behaviour and the trip planning process is presented, with a look at online itinerary planners as a conclusion.

2.1 Travel and Tourism sector

This section provides the first topic of research for this study, the global T&T sector. It focuses on T&T as a global economy sector and discusses the sector's growth and future. Finally, the implications of T&T on international employment will be presented.

T&T, as a collective term, refers to the activities and movement of people outside their usual environment for business or leisure purposes, with a duration of up to one year ([World Travel & Tourism Council, 2019](#)). This includes domestic and international travel and trips of any distance. Tourism specifically refers to instances where the traveller returns to the starting point of their journey, and a traveller can be classified as a tourist if they travel for business or leisure *and* stay overnight ([Revfine, 2020b](#)). T&T, therefore, refers to all actions, industries and elements accommodating tourists' needs and preferences.

T&T is part of the tertiary sector of the economy, which includes all industries providing abstract products and services ([Pettinger et al., 2019](#)). The T&T sector can be subdivided into three primary *forms*: domestic, inbound and outbound tourism. Domestic refers to residents travelling in their home country, inbound refers to foreign visitors travelling in a specific region and outbound tourism refers to residents visiting a foreign country. Different combinations of these create the three distinct *categories* of T&T: internal, national and international tourism ([Theobald, 2005](#)). Figure 2.1 illustrates how these fit together under the scope of T&T.

The T&T sector comprises all arrangements, businesses, industries, exports and professions relating to tourists, as well as the income generated from these activities. Companies and services

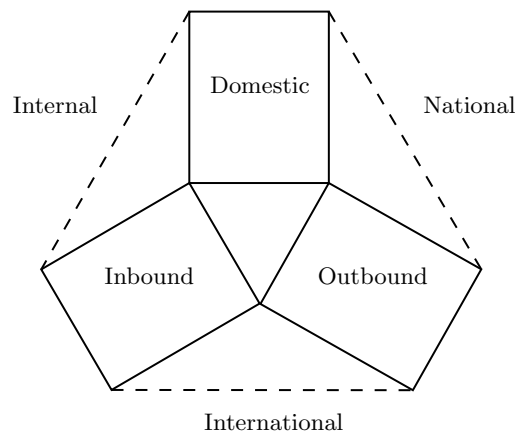


Figure 2.1: Relationship between the forms and categories of T&T (Theobald, 2005)

in the T&T sector can be divided into four main categories: accommodation, transportation, food and beverage and entertainment. T&T also includes other services such as travel agents and operators, tourism organisations and educational services such as conferences and exhibits (Revfine, 2020b). These are all integrated to create impactful and memorable experiences for visitors that effectively fulfil their reason for travel and in turn provide a steady income for the economies of the respective regions/countries they travel to. This has led T&T to be one of the most significantly growing economic and employment sectors locally and internationally, as discussed in Subsections 2.1.2 and 2.1.3. It is also important to note the distinction between the private and public sectors within T&T. Both are equally important in the success of tourism in any region; the private sector focuses mainly on providing products and services to visitors and tourists, whereas governments and related organisations paying specific attention to the employment and sustainability consequences of all T&T-related activities (World Tourism Organization (Madrid) and Network *et al.*, 1997).

The following section provides a brief look at the history of T&T as a foundation for the multi-dimensional growth of the sector.

2.1.1 History of tourism

The T&T sector is constantly evolving due to the continuous development and growth. Over the years, various social, political and cultural factors have influenced the evolution of T&T and paved the way for future innovations as a result (Shackley, 2007). The motivations behind movement and travel have also evolved dramatically through the years, from religious convictions, war, trade and migration to economic profit, leisure and many others (Theobald, 2005).

The earliest instances of travel documented took place in early Greek history around 500 BC and the Roman empire between 300 BC and 300 AD people visited nearby cities for sightseeing, religious gatherings and events like the Olympic games. In 170 AD, the first ever travel guide, *A Guide to Greece*, was also published, that contained landmarks that Roman tourists could visit when

2.1 Travel and Tourism sector

exploring Greece. T&T also became more popular in Asia, as many residents owned second homes or travelled to resorts in China and Japan. The growth of the T&T sector reached a plateau during the Middle Ages, despite the first packaged tour being created in the 15th century. It was sold as an itinerary for travel from Venice to the Holy Land and included transportation, accommodation, meals, donkey rides and bribe money to avoid red tape. Later, the industrial revolution caused many social and economic changes, leading to the growth of the middle class and consequently increasing the demand for leisure travel ([World Tourism Organization \(Madrid\) and Network *et al.*, 1997](#)).

This escalated even more during the 1980s, which stands out as the years when recreational travel grew significantly ([Voase, 2007](#)). According to [World Tourism Organization \(Madrid\) and Network *et al.* \(1997\)](#), it is the “combination of desire, mobility, accessibility and affordability” combined with innovations and technological advancements that has sped up the increase of mass tourism. These modern technologies in the global T&T sector are explored further in [Section 2.2](#).

The common factor these sources all share is the importance of understanding the significance of the history of T&T. [Walton \(2005\)](#) also supports this by stating how vital it is that the history of T&T is considered in any new development or future work in the field of tourism. It is also interesting to see how travel planning has been evident in times as early as BC, as well as the great benefit it presented to travellers worldwide. The next subsection will continue the discussion of the evolution of T&T with the growth of the sector in more recent years.

2.1.2 The growth and future of Travel and Tourism

Modern T&T has been expanding intensely each year due to tremendous growth in the global population, a general increase in disposable incomes, faster transportation and occupation, social and residential changes ([Gössling *et al.*, 2018](#)). Therefore it has become a significantly dependable and profitable sector for economies and employment worldwide. As the representative of the global T&T sector, the World Travel & Tourism Council (WTTC) conducts annual reviews of the global T&T sector. It provides reports on the impact on the world economy and Gross Domestic Product (GDP). According to [World Travel & Tourism Council \(2020\)](#), in 2019, 10.3% of the global GDP was provided by T&T, with a total contribution of 8.9 trillion USD. This shows just how valuable the sector is and the importance of continuous development in every aspect thereof.

Since 2011, the growth of T&T has outperformed that of the global economy every year, showing a 3.5% increase in GDP in 2019, which supports these efforts to expand the sector constantly. This growth is also the third largest increase of all sectors in 2019, growing more than the healthcare, retail and wholesale and agriculture sectors.

Another significant aspect is the number of tourists travelling each year. There was an estimated 1.5 billion tourist arrivals worldwide in 2019, yet again showing the sector’s growth. To demonstrate this, [Figure 2.2](#) presents the number of international tourist arrivals per month from 2016 to 2019.

2.1 Travel and Tourism sector

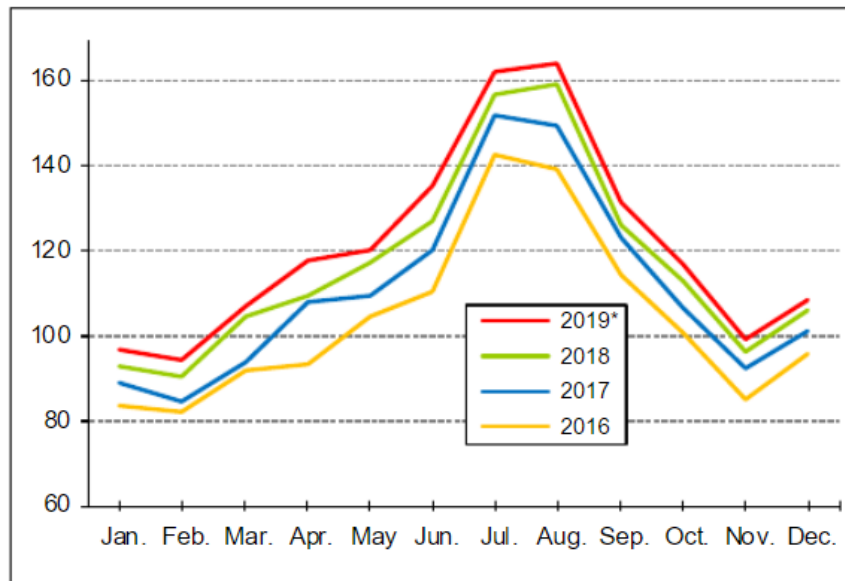


Figure 2.2: International tourist arrivals by month from 2016 to 2019 in millions (UNWTO, 2020)

It can be expected that by 2030 there will be 1.8 billion tourists travelling across the world, according to the current growth of the T&T sector and the trend increase illustrated in Figure 2.2 (UNWTO, 2020). One factor contributing to this increase is the potential of the sector to provide a more stable income than other trade channels, such as commodity exports (Tennant, 2018). Another is the diversification of trends and new sub-sectors, such as the increasing popularity of different niche tourism groups like dark tourism and religious tourism, as discussed in more detail in Section 2.2.

The future of T&T also depends on other world affairs and unexpected factors influencing the global economy year by year. For example, the Covid-19 pandemic caused an enormous hit to the entire T&T sector as part of the global economy in 2020. It is, however, noticeable that as certain countries experience a more immense shock during these times, other destinations can experience an *increase* in tourists. Any events, incidents or epidemics that hinder people from travelling will likely eventually cause the tourism industry to bounce back since people will be even more eager to make up for their cancelled travel plans.

Another excellent prospect for the sector is that T&T is expected to develop significantly in emerging countries' economies in the 21st century, with an estimated 57% of international tourists visiting these countries in 2030, according to World Travel & Tourism Council (2019). This is promising for the future of the sector since developing countries such as Dominica, St Kitts & Nevis, and Kyrgyzstan were among those leading the *growth* in GDP in 2019 (World Travel & Tourism Council, 2020), as seen in Table 2.1.

2.1 Travel and Tourism sector

Table 2.1: Fastest growing countries in Travel and Tourism GDP in 2019 ([World Travel & Tourism Council, 2020](#))

Country	2019 Rank	2019 T&T GDP growth (%)
Dominica	1	43.6
Anguilla	2	19.0
St Kitts and Nevis	3	14.6
Saudi Arabia	4	14.0
Kyrgyzstan	5	14.0
Tunisia	6	12.9
Sierra Leone	7	12.9
Uzbekistan	8	12.3
Greece	9	12.1
Mongolia	10	11.9

2.1.3 Employment implications of tourism

The focus of T&T expands further than simply the revenue generated from tourist activities by including its incredible impact on job creation worldwide. The sector accounted for 330 million jobs in 2019, accounting for one-tenth of jobs worldwide. T&T has also been responsible for one in every four new jobs created from 2016 to 2019. This illustrates the great opportunity the sector presents for combatting unemployment and strengthening a country's economy ([World Travel & Tourism Council, 2020](#)).

Apart from the services and companies directly involved in the T&T sector, it also indirectly interacts with industries in other sectors such as manufacturing, construction and financial services. This results in an estimated 1.5 additional job opportunities created in these indirect channels for every job created in direct tourism services ([Rifai, 2017](#)).

Even with international tourism growing significantly in recent years, the domestic tourism market is still the sector's primary source of income, accounting for 71.3% of the sector compared to 28.7% of that of the international market ([World Travel & Tourism Council, 2020](#)). This provides an excellent opportunity for regional industries to create new developments in tourism and build their local economies. Furthermore, T&T promotes micro, small and medium-sized enterprise growth and entrepreneurship, providing more job opportunities ([Rifai, 2017](#)).

The statistics provided regarding the growth of T&T in recent years suggest that the sector will continue to thrive as a global sector. Therefore, the number of opportunities for expansion and development within the sector will also increase as it gains more attention in all parts of the world.

These innovations and evolution of T&T will also depend on the specific trends that are evident in the sector at this time, which will be presented in the following section.

2.2 Trends in Travel and Tourism

The previous section described the significance of the T&T sector as a part of people's lives and the economy today, with its considerable growth. This section will discuss the different trends and new developments that contribute to this growth and overall success.

T&T is a dynamic sector with its channels constantly expanding as people's preferences and travel needs become more complex. From the planning process to movement at a destination to reflecting on a journey, the list of options is expanding greatly as people discover all the interesting and newly-introduced innovations the sector has to offer. According to [TourWriter \(2019\)](#), people are embracing change with the introduction of new technologies and new types of travel. Over the past decade, many other sectors have also been incorporated into T&T, creating an even broader spectrum of sub-sectors, such as medical tourism, which is linked to the healthcare sector and shopping tourism through retail and craft ([Koo et al., 2017](#)). Apart from these, many of the current trends revolve around enhancing customer experience. Travellers and tourists desire every aspect of their travel experience to be comfortable, easily accessible and memorable, and therefore businesses are focusing on ensuring customers' satisfaction and loyalty.

According to [Jansens \(2020\)](#) and [Chuba \(2018\)](#), some of the most popular trends in the modern T&T sector are:

- **Technological advancements** such as recognition technology, mobile applications and social media, augmented and virtual reality, Internet of Things (IoT), robotics, artificial intelligence and the incorporation of information technology (IT), which will be explored in Subsection [2.2.1](#).
- **Online booking systems:** 57% of all yearly reservations for travel commodities such as flights and accommodation are made using online resources ([Abramovich, 2020](#)). Online booking systems are one of the many technological advancements that have transformed T&T and given customers in the sector more freedom to make arrangements themselves without the use of a travel agent. This trend will be discussed further in Subsection [2.2.2](#).
- **Personalisation:** The current approach of travel planning seems not to be sufficient anymore, since 90% of travellers would like more personalised options and procedures for their travel experience ([Chuba, 2018](#)). This has caused businesses to experiment with innovations such as itinerary planners and recommender systems, which will be discussed in more detail in Subsection [2.2.3](#).

2.2 Trends in Travel and Tourism

- **Solo travel:** Regardless of age or place of origin, a global poll of 21 000 respondents found that 76% of people had experienced solo travel or want to do so in the future (Klook, 2019). With a wide range of new possibilities and ways to stay connected, people are progressively expanding their horizons and embracing the unique benefits of travelling alone.
- **Sustainability and Eco travel:** Tourism policies and authorities are including sustainability as a requirement in travel practices to preserve the nature, culture and communities of tourist destinations. This trend has been adopted by businesses and tourists alike as awareness spreads and is incorporated into aspects such as transport, accommodation and even choice of destination (Rambhai, 2016). For example, resorts and hotels are now incorporating sustainable technologies such as towel and linen reuse programs, using local, sustainably sourced produce in their food preparation, offering healthier, more organic food options, and even getting rid of modern plastic room key cards (Hard, 2019).
- **Niche travel markets:** In recent years, the different motives people have for travelling to specific destinations or taking part in specific activities have led to the evolution of individual markets or channels within T&T. There are many niche markets currently rising in popularity, such as adventure travel, medical tourism, *bleisure* travel (people travelling for business purposes which extend their stay also to incorporate leisure activities), boat cruises, religious and spiritual tourism and *gastro-tourism* (travel specifically related to experiencing culture through cuisine). Activities such as people travelling to Bali for Yoga retreats, hiking/walking the Camino route in Spain for spiritual enlightenment and exploring various cathedrals and religious sites in Europe are a few examples of niche-specific trips people are undertaking (Gale, 2018; Levet, 2019).

2.2.1 Technological advancements in Travel and Tourism

Incorporating new technological advancements gives tourist businesses the competitive advantage they need to stay relevant in the tourism market and encourage tourists to experience all that the sector has to offer. Technology also provides a transformative power that can help these businesses keep up with their customers' wants and needs, which has become more and more complicated to fulfil in modern times. Tourists have specific preferences in terms of their method of payment, selection, purchasing, sharing and experience of their travels, which can all be enhanced by the use of different technological innovations (Sigala, 2018). A discussion of these tourist preferences and their influence on developments in T&T will be presented in Section 2.3.

Technology within the T&T sector extends to many different areas and applications, growing continuously to adhere to change as a constant theme in the sector (TourWriter, 2019). According to Sigala (2018), it has become a tool that combines the use of data, connectivity, interaction and

2.2 Trends in Travel and Tourism

smartness within T&T, creating the new concept *smart tourism*: a modern technology-enhanced form of tourism that incorporates information and communication systems together with smart devices, for example, travellers being able to make payments and bookings using their mobile phones (Stainton & Bavister, 2020). This concept will be explored further in the subsequent chapter. Additionally, the evolution of the IoT (used in close conjunction with smart tourism) also has an immense impact on the growth of T&T.

Apart from enhancing the tourist experience, many other technological advancements are used to improve various business functions and operations across the sector. These include machine learning, robotics, virtual reality, chatbots and artificial intelligence, big data, recognition and voice technology, blockchain and augmented reality (Chuba, 2018; Revfine, 2020a). These are incorporated in the supply chain, marketing, customer relationship management, advertising, finances, logistics, service development and even crisis management within tourism companies (Sigala, 2018). This emphasises how technology influences the “giver” and “receiver” in any tourism channel, making it an essential multi-disciplinary tool to be utilised to its total capacity.

Sigala (2018) also includes the following points in their summary of the roles of technology in the T&T sector:

- A method of expressing individuality, for example, people showcasing their travels and experiences on social media platforms and companies creating their image within the sector.
- Transforming traditional travel experiences through developments like audio tour guides and virtual walking tours.
- Enabling the collecting, storing, analysing and interpreting of big data in the tourism industry.
- Providing an integrated platform to improve connectivity and functionality within the sector, with features such as review websites and online recommendation sites.
- Promoting concepts like open innovation and crowdsourcing as new management techniques.
- Offering programmable and automated tasks as a substitution for specific positions and actions in tourism businesses.
- Providing many decision support systems for both tourists and companies in T&T, with tools for things like price comparison, logistics and recommendations.

The continuous growth of technology within T&T is inevitable as the modernisation of society continues and calls for new and innovative ideas to bring people the best, most memorable travel experiences. This brings the opportunity for improvements to technologies already available in the sector, which this study strives to accomplish.

2.2 Trends in Travel and Tourism

2.2.2 Popular travel websites, mobile applications and social media

Apart from the technological advancements mentioned above, one of the biggest current trends in T&T is the use of online platforms, websites and applications. These digital channels have become an increasingly popular solution for tourists' travel-related needs, as more than 57% of all travel reservations, including flights, accommodation and other travel-related bookings, are made online. Research also shows that within the next ten years, digital travel platforms will have earned up to 11.5 trillion USD (Chuba, 2018), which is a significant stream of income for any economy.

People are incorporating technology into every aspect of their daily lives and using it wherever possible to have accessibility and keep up with the latest trends, including for travelling. Tourists are progressively replacing all traditional methods of finding travel inspiration, planning trips, making travel arrangements and reservations, communicating with T&T companies, participating in activities on their journeys, and sharing their experiences with technological developments.

With modern online developments such as e-tickets and electronic visas gaining great popularity in recent years, the concept of e-tourism has grown significantly. (It is important to note that the terms e-tourism, digital tourism and smart tourism are all unique but interrelated terms within T&T that will be discussed individually in the relevant sections.) E-tourism is the digitalisation of all processes within the T&T sector, incorporating information and communication technologies (ICTs) and the internet (Buhalis & Jun, 2011; Watkins *et al.*, 2018). The succeeding chapter will discuss the topic of information systems within e-tourism in more detail.

As part of e-tourism and this new era of digitalised travelling, the internet integrates new capabilities with different forms of existing media, providing more interactivity and connectivity. Social media is a fundamental part of digital growth in T&T and provides advantages for tourists and travel companies. Tourists and travellers can share experiences and details of their journeys through their personal Facebook and Instagram accounts and travel blogs. Research shows that 60% of tourists and 97% of millennial tourists share photos of their travels nowadays. This emphasises how social media increases the exposure people get to new places and travel opportunities that their peers are exploring. These posts made by friends, influencers and online acquaintances have a significant influence on tourists' decisions of places and activities to include in their travels, making their journey of planning the trip and physically experiencing it “non-linear” (Brown, 2017).

Together with booking and recommendation websites such as [Booking.com](#) (2020) and [TripAdvisor](#) (2020), these platforms provide a platform for peer-to-peer communication (Zsarnoczky, 2018). Potential travellers now have immediate access to all forms of travel information, from industry experts' recommendations, inspiration from travel videos and photography, experience and advice from fellow travellers, planning tips from peers or options from travel agencies. People also discover new places and journeys without looking for them since the internet and all these applications are intricately linked.

2.2 Trends in Travel and Tourism

Apart from the benefits these platforms offer travellers, it also enables tourist companies to enhance their digital marketing schemes and improve their competitive advantage (Mkwizu, 2019). Companies can now monitor customers' internet and browser activity to offer carefully planned deals that are specific to each customer's travel preferences. They can use this to be strategic in getting ahead of their competitors concerning their products and keeping up with the latest T&T trends. Therefore, the advancement of technology in T&T brings more and more opportunities for companies within the sector to expand their services and increase revenues, making a noticeable contribution to the economy.

2.2.3 Personalisation as a trend in Travel and Tourism

According to Buhalis & Amaranggana (2015), personalisation can be defined as the "process that escalates the content of information to its relevance for the individual", as well as creating offers adhering to the specific preferences and needs of the customer. It has become one of the modern T&T trends that have gained significant popularity in recent years. It has become an important factor in what tourists want included in their travel experience. Of all worldwide travellers, 90% declare that the standard travel procedures are no longer sufficient and that they would prefer more personalised options (Chuba, 2018). Since creating satisfied travellers and memorable experiences are of utmost importance to companies in T&T, they have started incorporating personalisation into various services and products.

To keep up with this current trend, the focus in the T&T sector has shifted beyond that of *mass tourism* and towards the increasing demand for customised solutions to individual preferences (Zsarnoczky, 2018). Mass tourism is an extensive term that has been given many different definitions in the field of T&T, one of which refers to a set tourism style that does not change or alter based on context (Vainikka, 2013). Additionally, as stated by Naumov & Green (2016), it includes standardised packages and large-scale use. Mass tourism became popular since it creates significant revenue from a large stream of tourists in specific destinations. Still, the over-crowded, over-commercialised atmosphere has caused many to change their expectations of what their leisure time or a real "vacation" looks like. American Express conducted a study in which 85% of respondents admitted that they would prefer customised itineraries rather than standard mass-market options (Gigante, 2018).

Apart from these changing views influencing modern tourism, individualism has also been mentioned regularly in T&T literature. It is a social state of mind in which one desires personal control and is eager to be unique and different compared to one's peers (Voase, 2007). This notion has infiltrated people's perspective on travelling, causing them to want unique trips and activities in their travels instead of simply choosing from the existing "mainstream" options available. However, creating such an experience can often require a lot of effort and time in research, decisions, bookings, and during the trip itself. Therefore, many companies in T&T are replacing the generalised, generic

2.2 Trends in Travel and Tourism

offerings in the market with tailor-made alternatives, adhering to these new priorities and demands of modern tourists (Zsarnoczky, 2018). Additionally, tourists' expectations have also increased significantly (Buhalis & Amaranggana, 2015), emphasising the importance of companies *understanding* their customers' needs and preferences while utilising the opportunity for product and service development. Table 2.2 indicates what customers often expect in terms of personalised services in T&T.

2.2 Trends in Travel and Tourism

Table 2.2: Tourist expectation on personalised services (Buhalis & Amaranggana, 2015)

Dimension	Phase		
	Before	During	After
Transportation	<ol style="list-style-type: none"> 1. Planning: navigation and information (duration, types of transportation, schedule and fare) 2. Recommender system: trail package and offerings 3. Time savings: booking, check-in 	<ol style="list-style-type: none"> 1. Real-time schedule 2. Personalised greetings 3. Personalised meals 4. Suggest alternative 5. Universal card 	<ol style="list-style-type: none"> 1. Feedback loop 2. Promotional update 3. Luggage finder
Accommodation	<ol style="list-style-type: none"> 1. Planning: navigation and information (location, reviews, room type, price and surrounding events) 2. Time savings: booking and check-in 3. Personalised welcome message 	<ol style="list-style-type: none"> 1. Personalised welcome message 2. Awareness on customer preference 3. Personalised customer service 4. Room control over customer services 	<ol style="list-style-type: none"> 1. Feedback 2. Promotional offers 3. Maintaining engagement 4. Post customer service
Gastronomical	Information (special dietary, variety of meals, navigation, food ingredients and restaurant information)	<ol style="list-style-type: none"> 1. Integration service 2. Real-time information: customer awareness and social context 	<ol style="list-style-type: none"> 1. Promotion 2. Prolong engagement
Attraction	<ol style="list-style-type: none"> 1. Recommender system 2. Information provider 	<ol style="list-style-type: none"> 1. Co-creation through digital maps 2. Real-time information 3. Information on surrounding events 	<ol style="list-style-type: none"> 1. Sharing platform 2. Prolong experience 3. News update 4. Recommender system
Ancillaries		<ol style="list-style-type: none"> 1. Navigation 2. General information 3. Instantly exchanging information 	

Personalisation is popular with both business and leisure travellers and groups such as solo travellers, with 52% indicating a higher interest in travel customisation (TourWriter, 2019). Tourists now desire personalisation that also stretches across all the different industries within T&T: accommodation, transportation, choice of leisure activities, food and drink options, etc. Section 2.3 will

2.2 Trends in Travel and Tourism

present more detail on the different aspects of planning a trip and creating an itinerary according to these specifics.

Including personalised choices in the different aspects of T&T holds many advantages for both tourists and companies within the T&T sector. One important benefit is the increased comfort that tourists experience physically and emotionally, as well as simplified decision-making in all stages of a trip (Buhalis & Amaranggana, 2015).

The travel technology company Amadeus hosted a poll to reveal the largest benefit of personalisation in T&T. The results are shown in Figure 2.3.

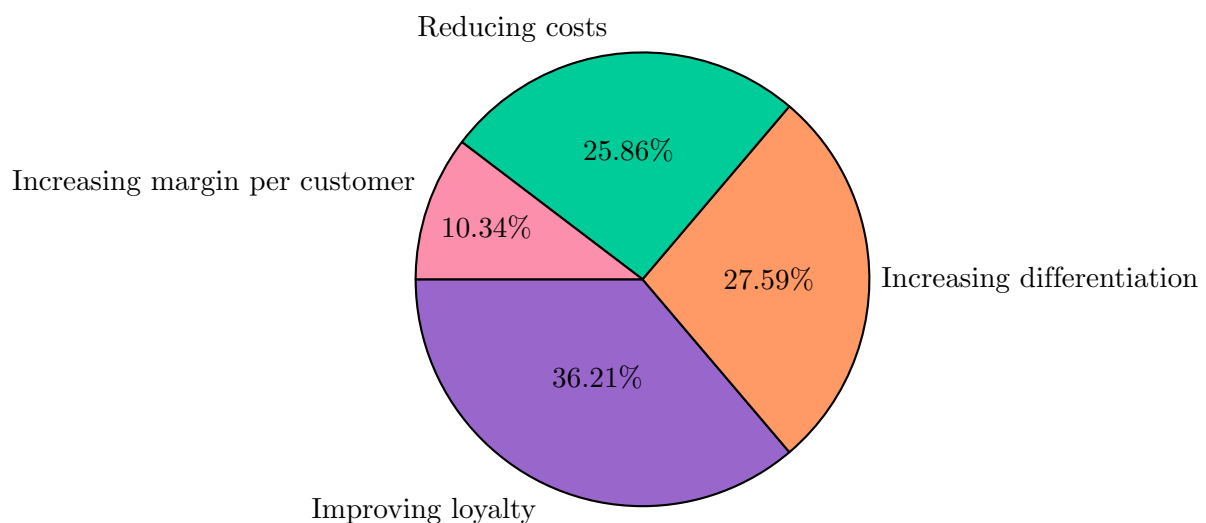


Figure 2.3: Benefits of personalisation in T&T (Batchelor, 2015)

As indicated by Figure 2.3, it was discovered that **improving loyalty** was the most important benefit of personalisation for tourists. This shows how focusing on providing personalised products and services can help companies to receive a stable income from existing customers. It also emphasises the great opportunity for developments and innovations in all aspects of travelling that companies can utilise to their full extent. The other benefits that are indicated are the increase in differentiation, cost reduction and the increase in margin per customer. Therefore, it is clear that increasing the focus on personalisation can be seen as a “win-win” situation that companies *and* tourists can benefit from.

The field of personalisation has developed to a very complex subject, with many subdivisions representing different levels of customisation. This is a concept that must be understood thoroughly to be incorporated correctly into future personalised developments in T&T, such as customised itinerary planners. The research that has been done on this also emphasises its importance within modern T&T which is more attentive to detail and specific needs and preferences. Figure 2.4 provides an illustration of these functions and how they form the evolution from standardisation

2.2 Trends in Travel and Tourism

to mass customerisation, which focuses more on what the customer's individual needs are. Different companies in the T&T sector provide different combinations of these to work together in ensuring customers receive the best possible travel experience (Wind & Rangaswamy, 2001).

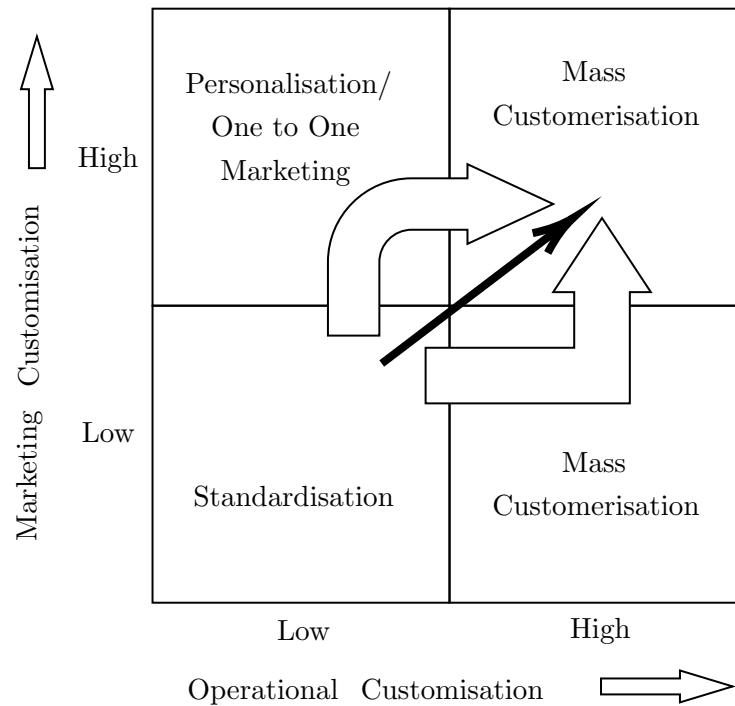


Figure 2.4: Evolution from standardisation to mass customerisation (Wind & Rangaswamy, 2001)

To explain the difference between mass *customisation* and mass *customerisation*, which can easily be confused, Babu & Subramoniam (2016) presents realistic scenarios from different industries in T&T, which are given in Table 2.3. The scenarios serve as examples of these two concepts within the broader scope of T&T.

2.3 Tourist behaviour and the trip planning process

Table 2.3: Customerisation possibilities for companies in T&T (Babu & Subramoniam, 2016)

Industry	Mass Customisation	Mass Customerization
Restaurant	Ice-cream with customised toppings at marketing stage	Vitamins and calories for each topping to be incorporated at operations stage
Hotel	Room temperature and other settings to suit customer based on information from earlier stay	Designing the rooms in consultation with probable clients over the Internet to gain operational advantage over others
Travel	Offer package options for business and leisure travellers regarding destinations	Capture the changing taste of the customers and incorporate them into the product or service using blogs
Travel packages	Select accommodation and destinations from a list provided, assembled through the internet and booked online	Selected accommodation or destination is ranked through a mashup. Make a destination less feasible if destination found fragile through price rise

Personalising tourists' travel experiences requires an intricate process of collecting personal data. This has caused a few concerns among travellers regarding the protection of their privacy, online security and harmful marketing schemes (Buhalis & Amaranggana, 2015). Therefore, personalisation must be handled with consciousness and great detail to ensure the customers' safety. Companies must also be sure to provide only necessary and helpful information without overwhelming customers with an inconvenient amount thereof. The incorporation of information systems and the wide variety of online resources have made this considerably more accessible.

This section has provided the modern developments evident in the growing T&T sector. These trends and advancements pave the way for the future of T&T and create opportunities for improvement. The following section discusses the planning phase of a trip and the current market offerings that provide assistance to tourists when planning their travels.

2.3 Tourist behaviour and the trip planning process

This section focuses on the process a tourist or traveller follows to plan a trip, including the different types of travellers, their individual needs and preferences, and the different dimensions of any journey. Itinerary planners as a solution to planning a successful and fulfilling trip will also be discussed with its many advantages.

2.3 Tourist behaviour and the trip planning process

Each trip taken by any traveller can be divided into three phases: the *before*, *during* and *after*. Each involves various arrangements to be made and contributes to the traveller's overall perception of their trip. It also influences the decisions the traveller will make the next time they plan another trip, such as which aspects they would like to include again, or what they would do differently.

This work is focused on the *before*, which is the planning process and everything it entails. In the discussion of the history of T&T in Subsection 2.1.1, it was expressed how travel planning and packages have been used in times as early as the 1400s. Travel planning refers to the decisions and preparations for a future trip, along with the expectations, time constraints and social norms involved (Nyblom, 2014), which will all be incorporated in the tourist itinerary planning demonstrator of this study. During this planning process, the prospective traveller requires considerable information regarding every aspect of their travels. This would then enable them to make an informed decision ensuring a successful journey. Even though the end goal is always the trip itself, the overall trip experience also greatly depends on the convenience of the planning process (Xiang *et al.*, 2015). Thorough preparation can decrease travellers' stress before and during a journey significantly and help them navigate the destinations comfortably. Furthermore, it will assist the traveller in managing uncertainty, which is inevitable when exploring new or unfamiliar places and cultures, even for experienced travellers.

The preparation of an upcoming trip is performed in the form of an *itinerary*. An itinerary typically consists of information regarding the accommodation, transport and activities, depending on what each unique traveller would prefer to include. This would depend on whether the trip is intended for business or leisure, the level of spontaneity the tourist would like on a journey and the individual's personal taste. The complexity of creating such an itinerary is often underestimated since it can be somewhat difficult to ensure that all needs and preferences are met while also taking other vital components, such as cost, into consideration. The subsequent section will serve as an introduction to this by discussing the process tourists go through to create an itinerary, as well as the opportunity this creates for services providing assistance in travel planning.

2.3.1 Tourist preferences during the planning process

Lyons (2006, p.201) provides the following statement on what influences a traveller's decisions during the planning process:

A key presumption is that travellers are rational and objectively weigh up the costs and benefits of the different travel options before them [...] and choose the most cost effective option where 'cost' is seen to encompass factors including comfort, convenience, financial cost, journey duration and reliability.

2.3 Tourist behaviour and the trip planning process

This statement highlights some of the main factors travellers consider when planning a trip, but also how companies or other organisations in the T&T sector often misunderstand what a prospective traveller's thinking process typically entails. It is therefore of utmost importance that tourist preferences for each stage of a trip are carefully studied and understood.

When creating an itinerary, people use various resources such as websites, recommender systems and other travellers' past experiences (Tam & Pun-Cheng, 2012). Filtering through all of the options these resources provide can be a challenging and timely process, not to mention the issue of staying within their budget. This is why many travellers use some kind of support so that all elements are covered thoroughly in their planning. Therefore, people have turned to travel companies for assistance, with 63% indicating that their overall travel experience is improved when using the services of a travel company (Ostdick, 2017). These services range from pre-determined itinerary packages to personalised packages tailored to specific individual preferences. Some travellers want more freedom within their itinerary, whereas others would like as little hassle as possible through the use of an intensely detailed outline of their trip. This emphasises the importance of acknowledging the individuality of each traveller yet again, as mentioned in Subsection 2.2.3, and is also the reason behind many of the products available in the T&T market.

The classification of travellers and their motives are important within the scope of tourism supply and demand, which then influences product development in T&T. Theobald (2005) presents the original classification of travellers developed by the United Nations in 1979 to aid in travel planning and marketing, which is illustrated in Figure 2.5.

Some of the main motivations for travel in this model include:

- Leisure and vacations
- Business and professional
- Friend/Family Visits
- Religious trips or pilgrimages
- Healthcare

2.3 Tourist behaviour and the trip planning process

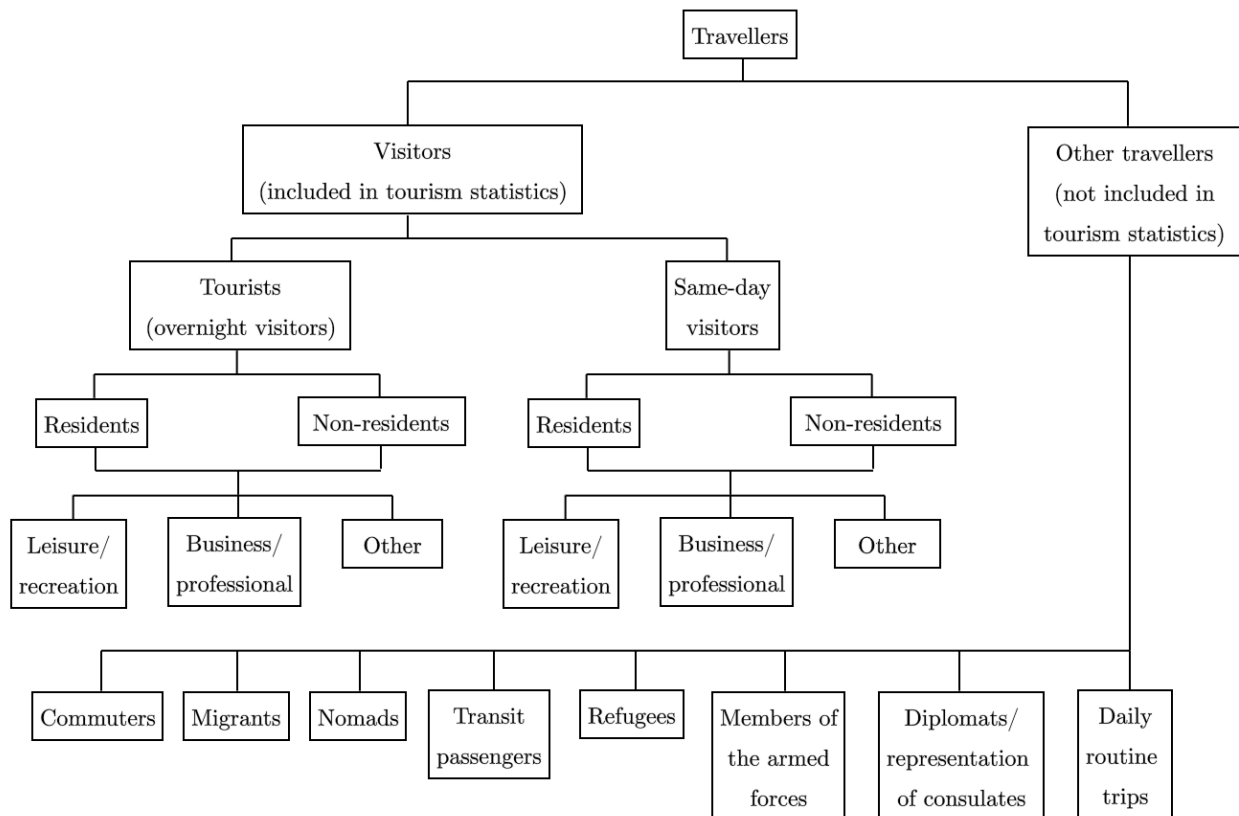


Figure 2.5: Classification of travellers (Theobald, 2005)

Apart from the people’s reasons for travelling, Theobald (2005) also mentions other measures that provide context to tourism demand:

- Trip destination
- Duration of trip
- Starting point of journey/country of origin
- Mode of transportation
- Accommodation used

Apart from the unique preferences and needs that accompany these motivations, each also has a different budget. The cost of each measure mentioned has a significant influence on the range of options and what decisions will ultimately be made. As stated above by Lyons (2006), this element is often overlooked on the “supply” side of the T&T sector. Therefore, companies offering products and/or services in T&T need to place significantly more focus on adhering to a customer’s individual budget. Leal *et al.* (2016) also supports this by stating that tourists typically seek options that are compatible with their interests, context and tastes, as well as their monetary limitations.

2.3 Tourist behaviour and the trip planning process

Research shows that modern tourists would like a product that integrates all of these elements in the travel planning phase as well as during the trip, by including the available options at a specific destination, making accommodation bookings, researching the leisure activities in the area and have access to any relevant information. Additionally, there is considerable potential for new technologies and innovations to provide services to tourists focused on their *actual* behaviour and individual requirements. Therefore, it is crucial for the development of these offerings to be “user-oriented” (McCabe *et al.*, 2012).

Many of the products currently on the market do not combine *all* of the necessary components of planning a trip, or it is not as successful as intended since it was not adequately tailored to fit the customer’s needs. As a result, there is a gap in the T&T market for products that would assist travellers in creating a customised, realistic itinerary or create such an itinerary *for* them. The following section will present one solution to this.

2.3.2 Online itinerary planners

The previous section described the important topic of what tourists and travellers generally expect regarding tourism services. It was highlighted that the current market offerings in T&T are not entirely adequate to satisfy these expectations. This section presents personalised itinerary planners as a proposed solution to this issue and discusses some existing itinerary planners.

As mentioned in the previous section, there are many different dimensions to planning a trip, with various options and possibilities that must be integrated to provide the best possible combination. This is precisely the need that itinerary planners strive to fulfil. Itinerary planners, as a broader term, includes any method of putting together activities and arrangements to form a trip, either for business or leisure purposes. One example of this is manual itinerary planners that require a person to create plans and routes to create one single itinerary, either on paper or computer/mobile device. This is also part of travel agencies’ responsibilities to provide to their customers. Travel agencies link T&T services and customers with the use of information, reservation, distribution and other services, enabling them to suggest the best possible offers and itineraries (Lam & Cheung, 2009). This involves direct interaction with customers to attend to their specific travel needs, which requires continuous communication and negotiation from both parties.

To provide tourists with the most convenient and efficient travel planning experience, those elements need to be minimised to save as much time and effort as possible. Online itinerary planners are an excellent way to achieve this by saving time and effort in the planning process and during the trip itself (Pabel & Prideaux, 2016). The incorporation of technology and the internet in the field of itinerary planning has led to the growing popularity of such *online* itinerary planners, as found by Adeola & Evans (2019) who states that travel-based mobile applications are among the categories

2.3 Tourist behaviour and the trip planning process

that have the most downloads and that they are increasingly preferred for leisure travel planning by these smartphone users.

Online itinerary planners offer a simplified alternative for making arrangements in terms of accommodation, transportation, leisure activities and more, as opposed to making use of a travel agent or similar travel service. The development of such an itinerary planner can be challenging since it requires advanced skills, knowledge and insight into the field of T&T and must exhibit exceptional system integration. The online itinerary planners that are currently on the market all differ in the level of detail, method of obtaining information and extensiveness of available options. McCabe *et al.* (2012) argues that there has not been sufficient and in-depth research into the intricate characteristics of the T&T sector, which is why many of the mobile travel applications have not been particularly successful. For example, many European projects have been focused on the technological potential and their economic prospects instead of being user-centred and providing specifically what the *user* wants.

Carmagnola & Cena (2009) also support this statement by emphasising the importance of *user-adaptive systems* within the field of travel planning. It is argued that many different methods can be used to create a close to accurate user profile in an online application, which can be used to accomplish this. Existing services in travel planning use methods such as tracking online users' habits, questioning customers on their needs and preferences or creating stereotypes of travellers exhibiting similar behaviour. This information is then used to identify the most suitable strategy to fulfilling the user's needs, adapting the developed model as required and obtaining any additional information needed to create a satisfactory solution (Carmagnola & Cena, 2009).

Despite the significant input required to create it, a detailed and well-constructed itinerary planner can greatly enhance a tourist's entire travel experience. Customised online itinerary generators are the solution that could produce an output the closest to this compared to other similar methods. The next section presents the advantages of using such a development to plan any type of trip.

2.3.3 Advantages of using itinerary planners

There are many notable advantages to using an online itinerary planner as the primary method of constructing a step-by-step guide for a future trip. Apart from those already mentioned in the previous section, some additional advantages are listed below.

- Customised itinerary planners act as an ancillary service in the travel planning process that greatly simplifies the preparation tasks that must be performed to create a comprehensive itinerary. This also saves the user time as it reduces the amount of research required.
- Apart from time saved *before* the trip, online itinerary planners also save the traveller time *during* the journey. A well-constructed itinerary will be extensive in including all necessary

2.3 Tourist behaviour and the trip planning process

information regarding the specific destination, allowing the traveller to optimise their time there without needing to do any additional planning while on the trip itself. Such an itinerary planner will also consider factors about the destination in advance that a tourist might only become aware of when arriving or experiencing the destination firsthand (Silva, 2019).

- The previous point leads to the important advantage of reducing stress during all stages of a trip. People experience travel stress on a different level and intensity depending on their personality, travel history and their ability to deal with unanticipated events. Feeling anxious and overwhelmed can easily create a negative travel experience and even trigger mental health problems (International Association for Medical Assistance to Travellers, 2017). Therefore, minimising this through the use of itinerary planners is a great benefit.
- An online itinerary planner provides one comprehensive platform that covers all aspects of the travel planning process. Arrangements regarding transportation, accommodation, tourist attraction bookings, optimal route determination and time allocation of activities can all be handled in one place, making it easier for the user to see the bigger picture of their trip as a whole.
- Following a trip plan created by an efficient itinerary planner can reduce congestions and delays since the itinerary planner can more accurately determine the duration of plane and train rides, covering walking distances and waiting time for certain activities than what is possible with manual planning (Buhalis & Amaranggana, 2015). Furthermore, an online itinerary planner can provide an optimal travel route with recommended transport and a suggested order of activities to ensure efficient movement between destinations (Tam & Pun-Cheng, 2012).
- Another advantage mentioned by Buhalis & Amaranggana (2015) is the ability of online itinerary planners to supply real-time information according to changes that can be input during the trip as well, offering the user with alternatives to best suit their preference. This enables travellers to adapt when external factors cause their journey to not go as planned, for example delayed or cancelled flights.
- The software on which online itinerary planners are built can be updated continuously to encompass the newest technologies for recommendations, cost calculation, route mapping, *etc.* It can also be programmed to connect to new future developments in the field such as improved algorithms for recommendations for example.
- Travellers can set up a more accurate budget and keep track of their expenses since the different costs can be estimated in advance. They can also make the most of their available budget since online itinerary planners will display any possible discounts and special offers available (Silva, 2019).

2.4 Conclusion: Travel and Tourism Sector

- Customised itinerary planners can also help travellers to be realistic in their travel planning by showing which activities and excursions actually fit into the available schedule. This will help travellers to realise what elements are most important to them and prioritising their plans accordingly.

These advantages emphasise the significant role that an online itinerary planner can have in one's travel planning process.

2.4 Conclusion: Travel and Tourism Sector

This chapter provided the research performed on the topic of the global T&T sector and its subdivisions. The first part of the literature study was conducted to obtain the information needed to gain a sufficient understanding of all aspects of the sector together with the importance of T&T. Additionally, focus was placed on the available opportunities within the different industries in T&T.

Firstly, a general discussion of the T&T sector as a whole was given, which included the history, growth and future of the sector as well as the employment implications thereof. This provided a thorough background required to fully grasp the subsequent, more condensed topics. Next, the current trends in T&T were provided. This section introduced the most popular trends in the sector today and the technological advancements, popular websites and applications in the sector, with a focus on personalisation. It was discussed how prominent personalisation has become in a wide variety of industries within T&T and the opportunities it has created. The final section of this chapter explored the behaviour, needs and preferences of tourists during all stages of a trip, but particularly the planning process. The different types of travellers with their unique motivations for travel were presented together with a discussion of innovations that address these. Lastly, online itinerary planners were reviewed as a solution to the demand for more personalised itinerary planning services and what the advantages are of using them in any traveller's planning process.

The next chapter will discuss the research on integrating information systems and itinerary planning. Many modern concepts have been incorporated in the T&T sector, or have great potential to be, which will be explored in the subsequent chapter. These include the application of user-adaptive systems, cross-system personalisation, co-creation, big data, information and communications technology and tools for optimisation. Additionally, decision support systems as basis for an online itinerary planner will be explored together with examples of existing options in the market today.

Chapter 3

Information systems and itinerary planning

The previous chapter presented the first part of the literature study and discussed the universal Travel and Tourism (T&T) sector with a focus on personalisation as a growing element in its various subsectors. To complete Objective I, this section presents the second and final part of the literature study; the research performed on information systems and itinerary planning.

Firstly, information on decision support systems and how they can be used for customised itinerary planning is provided, followed by a report on popular concepts in itinerary planning literature. The final section presents existing online trip planners that exhibit qualities and features considered valuable in designing a successful automated itinerary planner.

3.1 Decision support systems for customised itinerary planning

This section presents the integration of information systems and itinerary planning as a recent innovation in the T&T sector. This concept was briefly introduced in Subsections 2.2.1 and 2.3.2, expressing the great opportunity it presents for services in the sector. Information systems is a broad field that applies to many industries and products. Consequently, this section presents how it can be used to fill specific gaps created by modern demands in the T&T sector.

As discussed in Subsection 2.2.3, the trend of personalisation within travel products and offerings is on the front lines of new developments in T&T. Identifying customer needs and preferences and consequently offering customised, current and comprehensive products is crucial to ensure customer satisfaction and high-quality T&T services. Modern tourism customers also expect informative, aesthetically pleasing tools and resources that allow interaction throughout travel planning (Buhalis & Jun, 2011). Since the world is constantly changing with the introduction of new technologies, traditional methods of addressing these needs are not sufficient any more. Contributions from other fields need to be considered, and therefore the application of **information systems (IS)** in T&T is chosen as an excellent solution.

Zwass (2017) defines an information system as “an integrated set of components for collecting, storing and processing data for providing information, knowledge and digital products”. It controls a company’s operations, organise supplier and customer interactions, establishes its place in the market and manages supply chains. These abilities and the expansion of technologies in processing and recording information have created new opportunities and capabilities for companies in many industries. Zwass (2017) also states the main components that comprise an IS as a whole:

3.1 Decision support systems for customised itinerary planning

- Computer hardware: computers such as smartphones, tablets and laptops, sensors, storage disks and telecommunications devices.
- Computer software: system software in the form of an operating system controlling the data, hardware, program files and other resources as well as presenting a user interface, or application software as programs for different user tasks.
- Databases and data warehouses: a collection of interrelated data stored for future reference or retrieval (database) and the archiving of data over time to be used for future developments or analysis (data warehouses).
- Telecommunications: wired or wireless technologies used to network and connect computer systems and devices through information transmission.
- Human resources: qualified and technical employees trained to work with the development, operation and analysis of the IS.
- Procedures: all activities regarding the use, operation, maintenance and documentation of the IS.

These components create the basis of an IS in any industry. However, the field of IS has evolved to much more than merely the integration of these components. Not only does it create an organised and effective course of action for companies to handle customer data, but it has also become a complex source of *interoperability*, offering a “realistic alternative to standardisation” (Buhalis & Law, 2008). This interoperability offers suppliers and customers with the opportunity to connect and communicate electronically; interacting directly to ensure that the correct information and most efficient timing and cost are offered. This interaction between supplier and customer is required when developing a customised itinerary planner, which is why an IS is the solution to be explored in this study.

A field closely related to IS, and which is particularly significant in a study of developments within T&T, is **information and communication technologies (ICTs)**. ICT is “an integrated system of networked equipment and software, which enables effective data processing and communication for organisational benefit towards transforming organisations to e-businesses” (Buhalis & Jun, 2011). Over the past 30 years, the T&T sector has been linked to the advancement of ICTs in general, with it becoming a critical component of most tourism services. The combination of ICTs and tourism has led to the formation of a new term in this field: **e-tourism**. It is the digitisation of value chains and processes in T&T through the application of ICTs in different subsectors such as hospitality, transportation and shopping. Therefore, it combines information systems, business management and tourism (Buhalis & Jun, 2011).

3.1 Decision support systems for customised itinerary planning

The following statement from [Watkins *et al.* \(2018\)](#) clearly emphasises the importance of ICTs in T&T and the power it has in the success of new developments such as a customised itinerary planner:

ICT has generated a new paradigm shift, restructuring the tourism industry and developing a range of opportunities and threats; it is a powerful tool that strengthens the tourism industry's strategy and operations, being a driving force behind the tourism industry.

ICT supports the shift of focus from the supplier to the customer in T&T, where much of the success of future developments lie. Instead of offering products according to data about customers' past travels and experiences, the focus needs to be shifted forwards instead of backwards, by looking at what the customer specifically wants included in their upcoming travels. [Buhalis & Law \(2008\)](#) states that ICT development encourages this new generation of tourists who are more informed and expect greater value in the services and products they receive. This includes the planning process and the physical experience at the destination, which can be significantly enriched with ICT developments ([Buhalis & Amaranggana, 2015](#)), and should be the overall goal of any business in the T&T sector. It also highlights how new dynamic packaging in the T&T market is remarkably causing standard packaged tours to lose popularity. Using ICT and IS in this way to create unique, innovative options for travel and itinerary planning has many other advantages for both the customer and supplier ([Buhalis & Jun, 2011](#)):

- ICT provides better internal efficiency and management of the available capacity within the itinerary planning system.
- It can significantly boost sales of the product since it will be more innovative and personalised.
- It offers the introduction of location-based services such as Google Maps and/or Google Earth through the data and multimedia resources.
- It provides easier interaction between suppliers and customers to personalise their itinerary.
- It enables partners to cooperate efficiently in offering a product covering all aspects of the travellers' journey, such as the accommodation and transportation services.

Using ICT and IS to customise an itinerary online can be seen as a digital, more personalised version of a travel agency. The services provided by both are similar, with the exception of the greater focus on personalisation during such online itinerary planning.

The specific development in the field of IS used to formulate solutions for online itinerary planning is decision support systems (DSSs). [Ocalir-Akumal \(2016\)](#) defines DSSs as “computer technology

3.2 Popular concepts in itinerary planning literature

solutions that can be used to support complex decision-making and problem solving”. Therefore, a DSS serves as a useful system to facilitate the itinerary planning process since decision-making in travelling is a significant topic in modern T&T literature ([Amalina *et al.*, 2019](#)). The components present in a typical DSS tool are ([Ocalir-Akunal, 2016](#)):

1. Sufficient database management capabilities for easy access to all internal and external data and information.
2. A model management system with strong modeling capabilities.
3. Simple and capable user interface designs for handling queries, graphing functions and reporting.

The subsequent section will expand on this by exploring other popular concepts in itinerary planning literature.

3.2 Popular concepts in itinerary planning literature

There are many different methods of implementing a DSS for customising journeys and itineraries, as seen in modern T&T literature. As described in the previous section, a DSS is a framework specifically designed to perform a specific function for a desired outcome. This includes the application of different algorithms, network designs, modelling, databases, calculations and interfaces, of which the best combination is found. This section presents research on specific works that use a DSS for problems in the T&T sector related to online automated itinerary planning.

The works mentioned in this section include different formulations and perspectives on the itinerary planning problem, providing unique approaches and algorithms to solving it. Therefore, it is important to evaluate them to identify the concepts most applicable to this study. It is also useful in determining which aspects of itinerary planning have not been addressed sufficiently in previous works and, in doing so, highlight the possible improvements that can be explored in this study.

3.2.1 Fuzzy analytic hierarchy process

[Amalina *et al.* \(2019\)](#) presents a fuzzy analytic hierarchy process for selecting a tourist destination for a specific customer. This method is created by combining the analytic hierarchy process (AHP) and fuzzy decision-making. AHP is used to break up the complex problem into smaller subproblems by creating a hierarchy of the attributes, sub attributes, alternatives and goals. Pair-wise comparisons are also incorporated to provide higher precision during decision-making. Fuzzy decision-making helps solve problems in an uncertain environment, which is the case with travel-related problems

3.2 Popular concepts in itinerary planning literature

dependent on qualitative assessment of people's choices or behaviours. It can also be used to rank and select solutions.

Integrating these concepts allows the system to identify a main attribute by collecting the most influential elements and modelling the problem based on those attributes. Another notable feature of this DSS is that it focuses on the budget factor of a travel decision-making problem. This specific system is significant in that it combines a travel recommender system and decision model, focusing on "travel interactive decision aids" and digital technology instead of only considering customer behaviour as many other studies in the field do (Amalina *et al.*, 2019).

The concept applied in this work can be used in many other areas of T&T, including online itinerary planning since travel decision-making is a very significant topic in recent T&T research. Therefore it presents an idea that can be evaluated further as a possible solution to the problem in this study.

3.2.2 Dynamic programming-based algorithm for the itinerary planning problem

This section presents the work of Zografos & Androutsopoulos (2008), who developed a new algorithm as solution to the itinerary planning problem that can be used in multimodal transportation systems. This new formulation is an excellent example of combining different IS concepts to solve a problem in the T&T sector, which is exactly what this study strives to accomplish.

The aim of this work is to create an itinerary by optimising a set of criteria such as travel time, transfers and waiting time, from the start of the journey at the original destination to the arrival at the final destination, within the specified period. They describe the itinerary planning problem as "a multi-criteria shortest path problem (SPP) in a multimodal time schedule network with time-dependent travel times".

Their formulation of the itinerary planning problem indicates its complexity due to the multiple criteria to be satisfied. This also shifts the focus from one optimal solution to a non-dominated solution. However, this can become a difficult task if a large network is involved, which is usually the case in an itinerary planning problem that includes multiple transportation methods. This work can create one itinerary from multiple criteria specified by the user, which is then incorporated as constraints.

The scheduling constraints that are incorporated into this algorithm are:

- Total travel time
- Number of transfers
- Walking and waiting time, *i.e.* total transfer time

3.2 Popular concepts in itinerary planning literature

The algorithm also compensates for additional stops at intermediate nodes if required by the user. The traveller, therefore, has the option to include activities between their destinations.

The new dynamic programming-based algorithm that [Zografos & Androutsopoulos \(2008\)](#) has developed uses lexicographical ordering to solve the itinerary planning problem. This is one of the four aspects that it has incorporated into previous schedule-based approaches, together with:

- Ensuring that arrival and departure times are within the defined time windows.
- Including intermediate stops if required (as mentioned above).
- Assuming time dependent travel times.

The lexicographical ordering is a concept included in this algorithm to evaluate alternative itineraries and consequently save time. The user is provided with *one* itinerary according to their specifications instead of having to choose between a selection of non-dominated solutions.

For more information on previous works that are used as background to this publication, as well as a numerical example of the algorithm, see [Zografos & Androutsopoulos \(2008\)](#).

The algorithms discussed in this section present an efficient method of selecting an itinerary in a fixed scheduled network with urban and interurban transport services and also outperformed previous similar algorithms in terms of computational effort. It is also an excellent example of providing the user with only a single itinerary incorporating various time constraints relevant during any journey. However, it does not consider the cost involved, which is argued in this study to be an equally important factor during any trip. The conclusion of this work also highlights this by stating that the developed algorithms can be used to their full potential when combined with a cost factor. Therefore, this will be taken into consideration when developing the proposed solution in Chapter 5.

3.2.3 Personalised recommendation for travel decision-making

In this section, the work of [Ricci & Del Missier \(2004\)](#) is presented as another example of combining relevant concepts in IS and a DSS to address an issue in the field of travel planning. The previous two subsections discussed concepts that are notable for the optimisation and calculation functions of an online itinerary planner. As stated in Section 1.2, this study aims to combine those elements with personalisation. Therefore, the work studied in this subsection is a good representation of how itinerary planning as part of travel decision-making can be approached.

As stated in this work, the process of planning a journey or itinerary that satisfies the traveller can be challenging and requires extensive decision support tools. Therefore, it focuses on providing the specific type of content and structure the user wants, whether it is a complete itinerary, an all-inclusive travel product or only a specific component of their travels. This is achieved through the

3.2 Popular concepts in itinerary planning literature

integration of collaborative filtering techniques, case-based reasoning, cooperative query answering and content-based models while having the user's perspective as the most important input.

Ricci & Del Missier (2004) states that "trying to fill the gap between the travel decision models and 'digitized' decision behaviour is a valuable but difficult task, which requires the design and test of new models and aids". To obtain the user preferences as the first step to this development, a *recommendation session* is used for the interaction between the system and the user. The stages are:

Stage 1: Acquisition of travel preferences: the user provides personal and desired trip information such as group composition, destinations, preferred accommodation, activities and method of transportation to assist the system in predicting their decision behaviour. These serve as collaborative features that the system will then use to search a case base for similar *recommendation sessions*.

Stage 2: Search for travel products: *Content features* are presented to the user and they choose a product related to an activity, event, *etc.* or a destination according to certain requirements. The system then presents the results that satisfy the requirements. If too many options are available, the system *tightens* the query by prompting the user for additional content features to eliminate less interesting products. If the system finds no results, it *relaxes* the query by recommending a minimum number of query modifications and asking the user to remove some content features accordingly.

Stage 3: Choice: The final results are sorted and presented to the user. These are compared to similar previous recommendation sessions identified by the system through a ranking criterion and also presented to the user. Finally, the products chosen by the user are then accepted as the *travel plan*.

These stages show the level of detail that is applied during user interaction, which is crucial in providing a user-centred product. For example, factors such as the knowledge the user has of the destination as well as their budget are considered, which are factors that will be incorporated in the demonstrator to be developed in this study.

The *recommendation session* also illustrates *cooperative query answering*, which is an important element of an online itinerary planner. The objective is to develop a system that analyses the user query to understand its meaning and, in doing so, recommend and generate a response from the data available. Another notable aspect of this work is its method of addressing the development of a tourism-related product, which is also a good example of how the development of an itinerary planner can be approached. It entails actions like pre-evaluation qualitative assessment, system restrictions and evaluation goals, experimental design and procedural user-system interaction.

3.2 Popular concepts in itinerary planning literature

The conclusion to the work of Ricci & Del Missier (2004) “shows that it is possible to design personalised applications for the travel domain”. This study strives to achieve that by reviewing and building on similar past works, such as what is presented in this subsection.

3.2.4 Decision support system for urban journey planning

This subsection presents the work of Bahrehdar & Moghaddam (2014), which addresses the journey planning problem with the development of a decision support system named Rahyar. The DSS designed in this work is similar to what the DSS to be developed in this study aims to achieve in terms of structure and the multitude of criteria considered when planning an itinerary. It includes many aspects and features that will be incorporated in the development process of this study and is, therefore a valuable example of how those are realised in a DSS.

Their work clearly explains the concept of the “desirability of an itinerary”. It is stated that a weighted sum of criteria represents a disutility function which then determines the desirability of the itinerary. These weights are obtained by prompting the user for their preferences to certain attributes such as cost and travel time. It is also important that the time available is optimally utilized by creating the most efficient itinerary possible.

It is also important that the itinerary is planned to utilize the time available in the most efficient manner. Identifying such an itinerary manually can be challenging since travel time and movement are codependent and thus complicates the selection process. Therefore, multimodal route planning (which this work is based on) offers the user the best possible route from starting to final destination using the appropriate modes of transportation.

The Rahyar system is another DSS designed to plan an efficient itinerary after meticulous interaction with the user. It is defined as a “multimodal planning system with public transit databases and accounts for users’ preferences and constraints” that aims to determine the most desirable feasible itinerary. This paper describes the journey planning problem as a multi-criteria, multi-destination shortest tour problem with time windows, *i.e.* a travelling salesman problem with time windows (TSPTW). Rahyar was developed as a solution to this, resulting in a new and unique DSS in the field of itinerary planning. What sets this development apart from other existing trip planners is that it can incorporate multiple criteria simultaneously, it is multimodal, and offers multi-destination trip planning, and that it is tailored to meet specific user requirements through the adjustment of preference weights. Therefore, it is a notable development in itinerary planning literature.

The Rahyar journey planner is comprised of four main components:

1. **Infrastructure manager:** Used to apply the attribute updates and changes in the transportation network or any related data in the database. It includes data of the dynamic and static networks, geo-referencing for points of interest (POIs) and travel routes, time schedules, and network coverage (*i.e.* transit-related data).

3.2 Popular concepts in itinerary planning literature

2. **User input manager:** Collects visiting locations, user preference and constraint information to define an itinerary development problem. These are then used as the user inputs that are sent to the *journey optimiser*, which includes the starting and final locations of the trip, additional locations that are to be visited with the estimated time spent at each, the transportation modes available and user preference towards the options and constraints on the timing and sequence of each POI.

The locations are categorised as *hard* (a specific place where an activity is completed) or *soft* (alternative locations for activities) to identify valid options for the itinerary since Rahyar only considers hard locations. Another constraint is the classification of transportation modes as dynamic or static depending on what the user has access to. The transportation mode is *static* when the user does not have access to it or prefers not to use that particular mode and *dynamic* when other conditions or complications arise during the planning of the itinerary, such as operating hours.

3. **Journey optimiser:** Facilitates the analysis of user input information, development of possible itineraries and rating thereof using preference scores. The optimiser first creates a basic transit network from available transportation modes and operating lines, after which it obtains all the user preferences and identifies nodes as POIs. Arcs are then created to connect these nodes, and the shortest path between all possible pairs of locations is established according to the criteria and constraints. The TSPTW, which “involves finding the minimum cost tour in which all cities are visited once within their requested time windows” (Savelsbergh, 1985), is used for this. The journey optimiser then orders the locations in the shortest sequence and calculates the duration at each location and the time required for intermediate travel. Finally, the optimiser compares the itinerary with the user constraints to determine its feasibility and, if feasible, calculates the itinerary attributes. Otherwise, the shortest sequence is redetermined and the subsequent steps are repeated. For a more detailed illustration of how the journey optimiser operates, see Bahrehdar & Moghaddam (2014) for a flow chart illustrating these steps.
4. **System output manager:** Displays the proposed itinerary to the user as well as related attributes if requested. These include visit sequences, total travel distance, walking distance and disutility of itinerary, waiting time and number of transfers.

Figure 3.1 illustrates the connection between these components and how they connect to the central database. Theoretical examples and a case study is used to demonstrate the working of the Rahyar system. It also mentions other similar trip planners to take note of, such as Google Transit Planner and available transit planners of large cities, for example Los Angeles, New York City and Seattle.

3.2 Popular concepts in itinerary planning literature

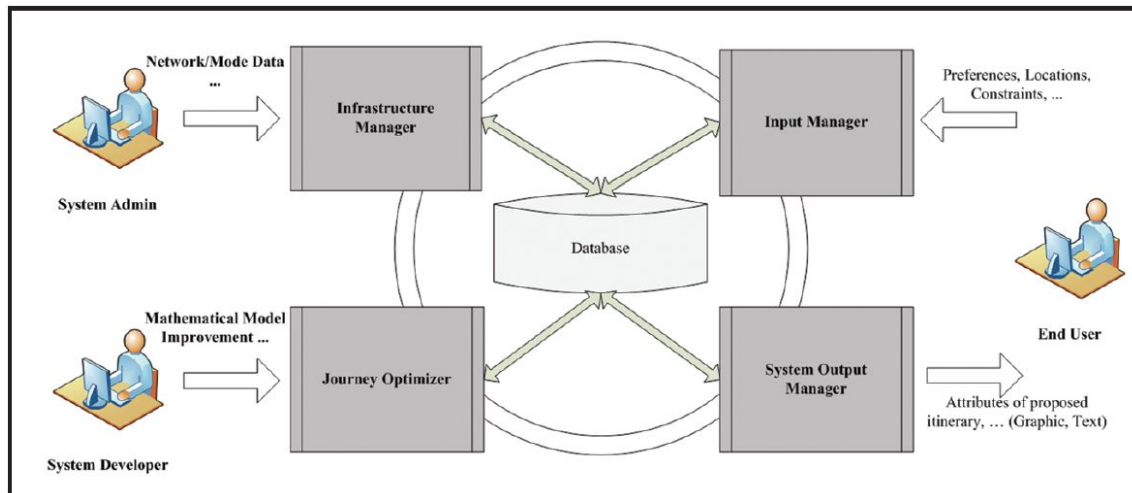


Figure 3.1: Components of Rahyar system (Bahrehdar & Moghaddam, 2014)

As stated by Bahrehdar & Moghaddam (2014), “the development of Rahyar represents an ambitious effort to incorporate many features into one software package for travel planning”. Even though these features are more extensive than other related works, the level of detail with which the user preferences are studied and prompted can be increased even more, which is what this study aims to achieve. This work presents an excellent example of the necessary components of a travel planner, as well as the mathematical computing incorporated to solve the journey planning problem. It also includes a useful description of how constraints can be approached and adhered to according to specifications made by the user. The research included as background to this work highlights the same concerns and necessities of an itinerary planner as those found thus far in the research of this study. These, as well as the other important elements illustrated in this work, will therefore be given particular attention during the development stage of this study.

3.2.5 Activity-based modelling for trip planning

It follows the works discussed in the previous subsections that the itinerary planning problem must be approached using a combination of IS concepts to find a comprehensive solution. The work presented in this subsection is another example of this, with its integration of even more IS theories. Kolyaie *et al.* (2008) discusses the development of a DSS incorporating activity-based modelling (ABM), the travelling salesman problem and multimodal networks to solve semi-structured spatial decision problems resulting from real-world situations.

The SPP is a useful tool in itinerary planning but does not always provide an applicable solution. Kolyaie *et al.* (2008) mentions that although the SPP finds the optimum path between destinations while taking cost into account, it does not consider the time to reach each location. ABM is, therefore, a useful alternative to the SPP for addressing the time issue in itinerary planning; hence it being used in the DSS discussed in this subsection. It focuses on the impact of constraints on how activities

3.2 Popular concepts in itinerary planning literature

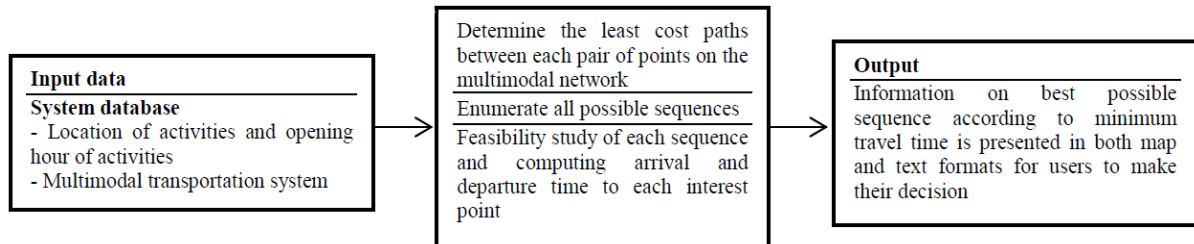


Figure 3.2: Proposed algorithm for itinerary planning by [Kolyaie *et al.* \(2008\)](#)

are planned and executed, as it “emphasises both temporal and spatial dimensions of decisions as well as considering the preferences of passengers”. In this work, this is used in the development of a spatial decision support system (SDSS).

[Malczewski \(1997\)](#) defines an SDSS as “an interactive, computer-based system designed to support a user or a group of users in achieving a more effective decision by solving a semi-structured spatial problem”. These spatial decision problems can include many decision alternatives, which are evaluated using multiple qualitative and/or quantitative criteria, depending on the user preferences. A geographic information system (GIS) is also incorporated into the SDSS of [Kolyaie *et al.* \(2008\)](#) to help manage the spatial data involved in itinerary planning. This GIS-based SDSS is designed to collect and analyse relevant data to determine the sufficient path(s) according to specified user preferences and accompanying constraints. These paths and supporting information are then given to the user in text and map form.

Another element incorporated in this development is the travelling salesman problem, which is used when the traveller is indifferent of the order the locations they have chosen are arranged to be visited. There are many solutions to the travelling salesman problem identified to date, but using an exhaustive search or brute force is used in this SDSS.

This SDSS also includes data of multimodal transportation networks to aid in the planning and arrangement of multiple destinations chosen by the user. This information and any other details needed for the SDSS to supply the required itinerary are found in a spatial database. The algorithm used to obtain the necessary input data, identify the best route and output the trip plan to the user is illustrated in [Figure 3.2](#).

The implementation of the algorithm is illustrated with an applicable example in the work of [Kolyaie *et al.* \(2008\)](#).

The SDSS discussed in this subsection is similar to the work of [Bahrehdar & Moghaddam \(2014\)](#) presented in [Subsection 3.2.4](#) seeing as both use an overview of inputs, itinerary creation and outputs. Although the level of detail of the information prompted to the user as well as the methods used to identify the shortest path between destinations differ, these works serve as effective examples of the process of designing an efficient DSS.

3.3 Existing online itinerary planners

Subsections 3.2.1 to 3.2.5 explored various IS concepts and related theories that have been incorporated in travel planning literature. The works discussed in these subsections all include ideas that can be considered in the DSS development of this study. The next section will present the existing online itinerary planners with their respective features and products.

3.3 Existing online itinerary planners

The previous section presented past literature containing the integration of information systems and itinerary planning. This section will explore existing online itinerary planners and other related technologies to see how these previous theoretical works can be realised in practice. This section will provide a discussion of the most popular websites and mobile applications in the field of itinerary planning, including the features of each one and the level of personalisation they offer.

There are many popular companies and online resources such as [Booking.com \(2020\)](#), [Airbnb \(2021\)](#) and [TripAdvisor \(2020\)](#) that address different aspects of the planning process, for example booking flights or accommodation, as well as companies like [Contiki \(2020\)](#) and [TopDeck \(2020\)](#) that offer pre-packaged tours and experiences. There are also many web-based tools that provide customised travel support and services in order to maximise the traveller's experience. The research presented in this section is focused on the two most popular of these tools that specifically focus on automated itinerary creation, namely [TripHobo \(2020\)](#) and [Inspirock \(2020\)](#), since personalisation is the main aspect that will be incorporated in the proposed demonstrator of this study.

3.3.1 TripHobo itinerary builder

[TripHobo \(2020\)](#) is a web-based travel agency that offers an online itinerary planner for users to build their customised trip plan. It serves as a platform where users can create a profile and plan multiple trips simultaneously either by entering their desired preferences and receiving a suitable customised itinerary or by manually browsing through standard recommendations and pre-packaged itineraries. This allows the user to decide the level of input they would like to have in the planning process.

Planning a trip with TripHobo

When entering the "Trip Planner" web page on the TripHobo website, the user is asked what destinations they want to travel to and the dates during which they would like their trip to take place. Secondly, the user can add additional locations and place them in the desired order, as well as edit the home and returning cities. Next, the "About your trip" page asks the user whether they want accommodation, transportation or "things to do", or a combination of the three included in the suggested itinerary. In the final "About you" section, the user indicates who they are travelling

3.3 Existing online itinerary planners

with (*i.e.* solo, as a couple, with family or friends) and within what age range they are. The resulting itinerary that is generated includes a transportation option to and from the destination(s), recommended accommodation and activities during the day. The layout of this overview presented to the user is given in Figure 3.3.

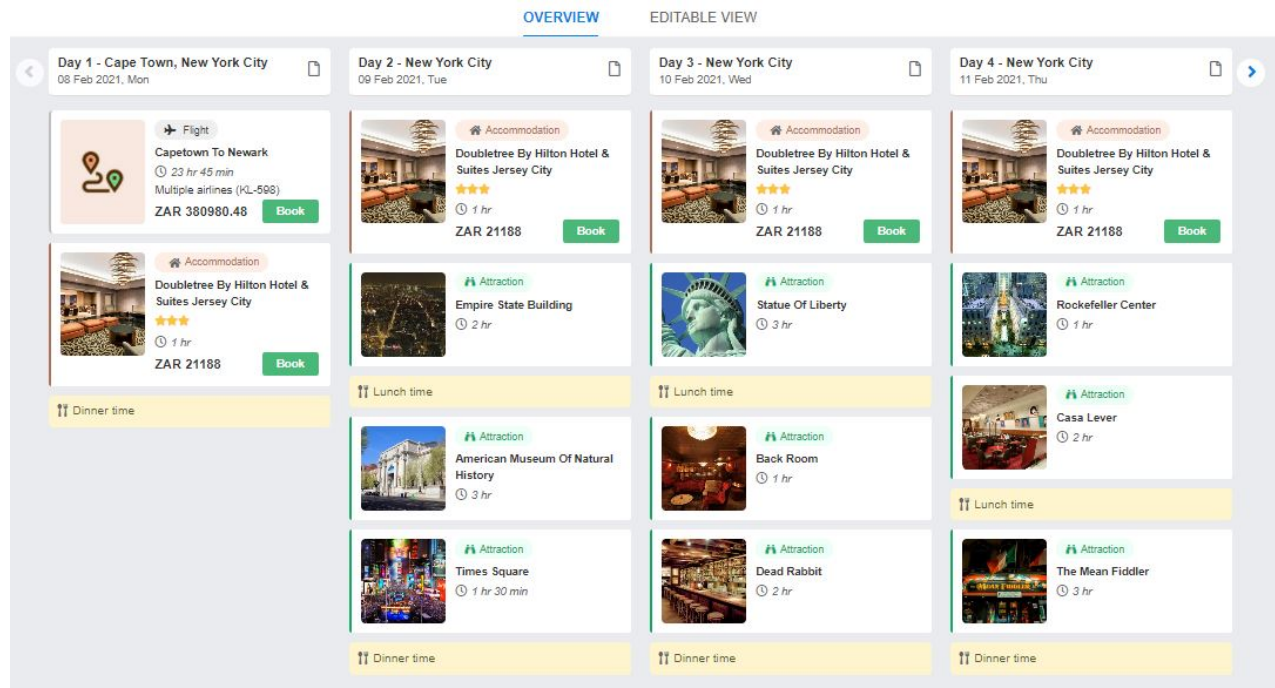


Figure 3.3: Example of the layout of an itinerary generated by [TripHobo \(2020\)](#)

Notable features

The TripHobo trip planner possesses a few notable features that are valuable when constructing an itinerary, such as:

- An option to talk to a travel agent if the user wishes to take the next step and start booking the suggested trip.
- Providing the user with the ability to edit the proposed itinerary by replacing, adding or removing options if they are not entirely satisfied with the particular suggestions.
- Incorporating lunch and dinner times in between activities.
- Estimating the time it would take to complete each activity or visit each attraction.
- Providing an estimate of the cost of the transportation and activities.
- Presenting the user with the option of creating an account to record and keep track of their searches and trips.

3.3 Existing online itinerary planners

- Allowing the user to create/work on multiple trips simultaneously.

These features all contribute to the success of this online trip planner and are a good example of what a useful itinerary planner should include.

Limitations

The following are limitations or areas of improvement in the TripHobo trip planning process:

- Dinner and lunch are only inserted as time slots in between activities; no recommendations are made for restaurants and/or other food and drink options.
- The times the user is occupied with activities during the mornings and afternoons sometimes vary significantly from one day to the next (instead of tailored to how busy the user would like their day to be).
- No prompts regarding the user's interests and consequently what type of attractions and/or activities they would like in their itinerary.
- There are only activities and attractions scheduled for the morning and afternoon, no options are provided after dinner (even though some people might want to use their full day for activities).
- No options for transport in between activities, only flights to and from destinations provided.
- No provision is made for the user's available budget.

These shortcomings will be carefully considered when designing the algorithm for the demonstrator of this study. Different solutions and ways to incorporate these missing features will be studied to provide users with an even more customisable itinerary, and enhance their overall planning experience.

This concludes the research on the attributes and elements of the TripHobo trip planning process. The following subsection will briefly study the web-based trip planner Inspirock.

3.3.2 Inspirock trip planner

[Inspirock \(2020\)](#) is another online trip planner that “enables users to quickly and easily explore a destination's offerings and create personalised sightseeing itineraries by utilising local expertise and cutting-edge artificial intelligence”. Figure 3.4 presents a simple illustration of the four main steps incorporated in the Inspirock trip planning process.

The Inspirock trip planning tool is available as a website and a mobile app and is designed to simplify the trip planning process by supplying a free, customised day-to-day itinerary to its clients.

3.3 Existing online itinerary planners

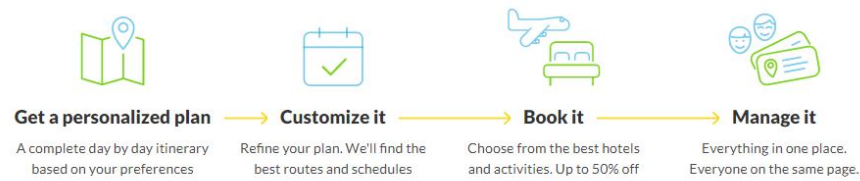


Figure 3.4: Four basic steps of the [Inspirock \(2020\)](#) trip planning process

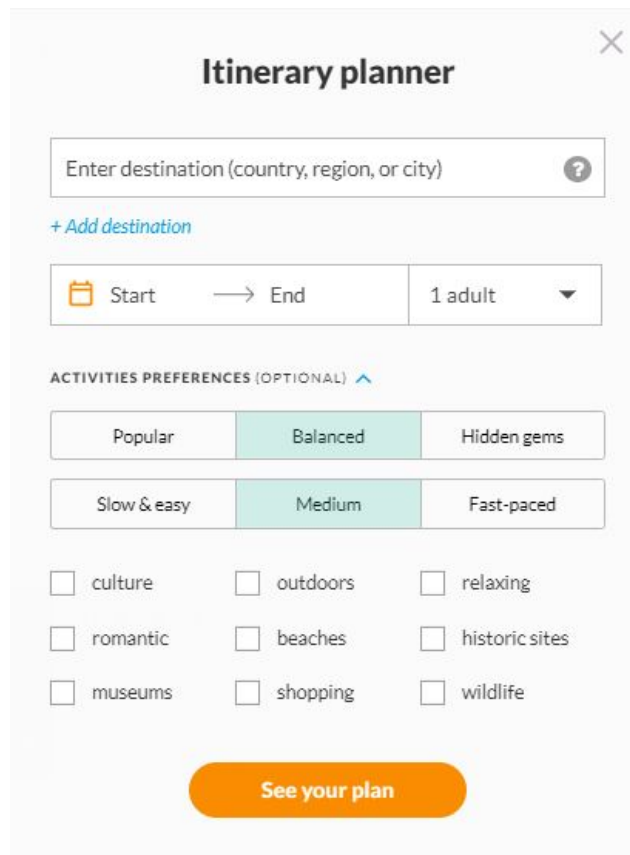
It introduces a higher level of personalisation than that offered by TripHobo, which allows for options that are more specifically tailored to the user’s preferences. Inspirock also provides the user with the option of creating a personal account where they can work on multiple trip plans simultaneously. The Inspirock system also provides additional tour recommendations and a space to explore activities and sights according to their characteristics, such as culture, outdoors and shopping.

Planning a trip with Inspirock

The first step in the trip planning process presented by Inspirock, as illustrated by Figure 3.5, consists of the following user prompts:

- The country, region or city (*i.e.* the **destination**) they want to visit.
- The **dates** they would like to tour these destinations.
- The **number of adults, teens and/or children** who will be present during the trip.
- Optional “**Activities Preferences**”: the user can specify whether they are interested in popular attractions or hidden gems and if they prefer slow and easy or fast-paced travelling, as well as select characteristics they would like to have incorporated in the options of their itinerary such as culture, relaxing, wildlife, romantic, etc.

3.3 Existing online itinerary planners



The screenshot shows a web form titled "Itinerary planner" with a close button (X) in the top right corner. The form includes a text input field for "Enter destination (country, region, or city)" with a help icon (?). Below this is a link "+ Add destination". The next section contains a "Start" field with a calendar icon, an "End" field with a right-pointing arrow, and a "1 adult" dropdown menu. Underneath is a section for "ACTIVITIES PREFERENCES (OPTIONAL)" with an expand/collapse arrow. This section contains two rows of buttons: "Popular", "Balanced" (selected), and "Hidden gems" in the first row; "Slow & easy", "Medium" (selected), and "Fast-paced" in the second row. Below these are three columns of checkboxes for "culture", "outdoors", "relaxing", "romantic", "beaches", "historic sites", "museums", "shopping", and "wildlife". At the bottom of the form is a large orange button labeled "See your plan".

Figure 3.5: Opening prompt on the [Inspirock \(2020\)](#) website

After the user has entered the required information and selected their preferences (if desired), the website generates their personalised trip plan. The itinerary is presented on a web page with four “tabs”, each providing different information and tools regarding the proposed trip:

- **Route:** provides an overview of the destinations (including a map with location pins) and accompanying trip durations with the option of editing these details.
- **Day by day:** choice of a timeline, calendar or map layout presenting the sights and attractions scheduled for each day, including the transit times in activities.
- **Where to stay:** users can search for accommodation options using the direct connection to the [TripAdvisor \(2020\)](#) and [Airbnb \(2021\)](#) websites provided.
- **Checklist:** a progress bar showing the level of completion of the user’s planning process, with tips and information regarding important travel arrangements such as visa requirements, travel insurance, luggage storage and the weather forecast.

3.3 Existing online itinerary planners

Notable features

There are a few notable features of the Inspirock trip planner that are significant to its effective itinerary formulation, including:

- Incorporating transit times between scheduled activities for both driving and walking and also providing the recommended duration of attractions (similar to that of TripHobo).
- Providing the option of exploring additional “side trips” that can be added to the itinerary according to specific characteristics chosen by the user.
- Recommending popular pre-planned tours for the selected destination(s).
- An option to request a travel agent if the user requires further advice or assistance.
- Adding day trips in the surrounding area to maximise the user’s experience of the destination.
- Allowing users to create and add their own *custom* events (apart from their ability to edit the given itinerary by adding *existing* events).

Limitations

The following limitations were noted in the Inspirock itinerary planning system:

- There are no flights or accommodation included in the itinerary, there are simply connection portals for these arrangements and the user must explore the options themselves.
- No provision is made for meal times.
- No intermediate transportation suggestions are included; there are only time slots allocated for it.
- The generated itinerary starts at 10:00 and ends at 18:00 and is therefore not personalised according to the specific user. If the user wishes to add extra activities outside of those times they must enter it manually.
- No provision is made for the user’s available budget.

These shortcomings help put into perspective which elements and features should receive more attention when creating such an itinerary planner. For example neither Inspirock nor TripHobo incorporate the available budget of the user into the creation of the itineraries and thus the user will have to decide for themselves what activities they would be able to include considering the monetary constraints. This is a valuable feature that has a significant impact on a traveller’s decisions, but is neglected by current online itinerary planners. The traveller’s available funds are a critical variable

3.4 Conclusion: Information systems and itinerary planning

that will be incorporated in the demonstrator of this study, and will be explored further in Chapter 5.

Despite these limitations, the Inspirock trip planner does, however, provide an excellent example of a working online itinerary generator with a focus on personalisation.

3.4 Conclusion: Information systems and itinerary planning

This chapter presented research on the final part of the literature study: information systems and itinerary planning. The final part of the literature study was conducted to acquire the necessary knowledge of how information systems can be applied to itinerary planning and how it can enhance the personalisation capabilities of such an innovation.

Firstly, an introduction to ICTs and decision support systems within the T&T sector as *e-tourism* was provided. This included how these technologies can be incorporated into itinerary planning as well as the potential of growth it brings to the field. This was followed by a discussion of various popular concepts that have been explored in itinerary planning literature. This included a fuzzy analytic hierarchy process, dynamic programming-based algorithm, shortest path problem, personalised recommendation system, DSS for urban journey planning and an activity-based model for trip planning.

The final section of this chapter presented the two most popular existing online itinerary planners that offer automated customisable itineraries: TripHobo and Inspirock. The different offerings and qualities of each was discussed, with a focus on how the user can plan a trip on their website/mobile application, the notable features and shortcomings of each system.

The succeeding chapter will describe the system architecture as well as the online itinerary planning process that will be performed by the proposed demonstrator.

Chapter 4

System architecture

To initiate the development and design of the tourist itinerary planning (TIP) demonstrator, following the research presented in the two preceding chapters, a system architecture must be created. This chapter presents the design of this system architecture using a combination of Software Systems Architecture (Rozanski & Woods, 2005a) and Object-Process Methodology (OPM) (Dori, 2002), which fulfils Objective II. Firstly, the general concept development of the demonstrator will be presented as background to the construction of the system architecture. The proposed TIP process will then be discussed, after which a description of system architecture and OPM and the purpose of both will be presented, followed by the application thereof in this study. Lastly, an overview of the concept development will be given, as well as a short discussion of the three main components of the proposed demonstrator.

4.1 Informal description of the itinerary planner

The itinerary planner demonstrator developed in this study aims to provide the user with a TIP process that is user-friendly, exhibits excellent functionality, and produces an itinerary satisfactorily tailored to their *personal preferences while considering the user's budget*.

To start the TIP process, the user will access the opening web page of the demonstrator. There, the user will be asked to answer a few mandatory questions to continue, such as their destination and the length of their trip. Next, there will be an optional section with prompts for the user's preferences regarding accommodation. Next will follow queries about the type of trip the user wants, preferences of time, transportation, food choice and also more in-depth questions regarding the user's typical travel routine while on a trip. The specific questions and prompts will be discussed in Section 5.3. The system then uses this multitude of answers to assemble the user's personal itinerary, and they are presented with it on a logical and user-friendly display page. Also included on this web page are alternative options to certain elements (such as activities or restaurant recommendations) of the proposed itinerary. The user can then make adjustments to fit their preference.

For a typical day, the user will select their maximum budget for the day, the start and end times of their day and then the *types* of points-of-interest (POIs) they would like to visit. These are subject to the budget the user provides. The day will typically be divided into sessions, for example, a morning session for visiting an art exhibition, a short lunch session, and an afternoon session during which the user would like to do some shopping, followed by a long dinner. The user may choose to be at leisure during any sessions, meaning they need not be actively visiting the POIs since the demonstrator will be *descriptive* rather than *prescriptive*. Ultimately, the TIP demonstrator will

provide the user with an itinerary within budget. The following section will describe the system architecture built to achieve this.

4.2 System architecture

According to [Faisandier & Roedler \(2020\)](#), a system architecture is “abstract, conceptualization-oriented, global, and focused on achieving the mission and life cycle concepts of the system”. Therefore, it is used to identify and structure the functions, components, objects and processes that need to be performed by the demonstrator to ultimately provide a working online itinerary planner.

This section presents the system architecture built in this study together with a discussion of the functional and non-functional requirements of the TIP demonstrator. This includes the applicable project stakeholders, viewpoints and perspectives that define the system. The systems architecture approach followed to develop the TIP demonstrator is that of [Rozanski & Woods \(2005a\)](#) since it is a software system and thus applicable to the nature of this study. It is, therefore, also referred to as a *software* architecture.

They provide the universally accepted definition of **software architecture** which is “the architecture of a software-intensive system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them.” To develop the proposed itinerary planner, different types of software need to be integrated, and therefore the use of a software architecture is necessary. This process includes understanding and identifying the main concepts of software architecture as defined in [Table 4.1](#) .

4.2 System architecture

Table 4.1: Software architecture concepts (Rozanski & Woods, 2005a)

Software architecture concept	Definition
Architectural element	A fundamental piece from which a system can be considered to be constructed.
Stakeholder	A person, group or entity with an interest in or concerns about the realization of the architecture.
Concern	A requirement, an objective, an intention or an aspiration a stakeholder has for that architecture.
Architectural description (AD)	A set of products that documents an architecture in a way its stakeholders can understand and demonstrates that the architecture has met their concerns.
View	A representation of one or more structural aspects of an architecture that illustrates how the architecture addresses one or more concerns held by one or more of its stakeholders.
Viewpoint	A collection of patterns, templates, and conventions for constructing one type of view.
Perspective	A collection of activities, tactics, and guidelines that are used to ensure that a system exhibits a particular set of related quality properties that require consideration across a number of the system's architectural views.

These core concepts are integrated and used to create the system architecture. This can be summarised as: the architecture is documented by an **architectural description (AD)** for the **stakeholder**. The AD is comprised of **views**, that each conforms to a **viewpoint** addressing a specific **concern**. The views are also shaped by **perspectives** that address the concerns.

4.2.1 Project stakeholders

Kessler & Sweitzer (2007) describes stakeholders as “the people who affect the success of your software product, and are affected by it”. It is important for the software developer to understand the stakeholders' concerns since they dictate the system requirements. The software developer can then also prioritise tasks and features according to these concerns.

Table 4.2 provides the different stakeholder roles as identified by Rozanski & Woods (2005a).

4.2 System architecture

Table 4.2: Stakeholder roles (Rozanski & Woods, 2005a)

Stakeholder class	Description
Acquirers	Oversee the procurement of the system or product.
Assessors	Oversee the system's conformance to standards and legal regulation.
Communicators	Explain the system to other stakeholders via its documentation and training materials.
Developers	Construct and deploy the system from specifications (or lead the teams that do this).
Maintainers	Manage the evolution of the system once it is operational.
Suppliers	Build and/or supply the hardware, software, or infrastructure on which the system will run.
System administrators	Run the system once it has been deployed.
Testers	Test the system to ensure that it is suitable for use.
Users	Define the system's functionality and ultimately make use of it.

Stakeholders in this study

The stakeholders are all the entities involved in building, testing, operating, repairing and enhancing the system. These are identified and described in Table 4.3.

Table 4.3: Applicable stakeholders

Stakeholder class	Stakeholder	Description
Acquirers	Study leader	The study leader will oversee the procurement of the proposed demonstrator.
Assessors	Study leader	The study leader will oversee that the demonstrator conforms to the expected standards.
Developers	Student	The student is responsible for the design and programming required to create the TIP demonstrator from specifications.
System administrator	Student	The student acts as system administrator for managing POI information.
Testers	Student and study leader	The student and study leader will test the system to ensure that it is suitable for use.
Users	Student, study leader and external clients	The student and study leader will act as pseudo-clients and use the system to define its functionality.

4.2.2 Architectural definition and the Software Development Lifecycle

According to [Rozanski & Woods \(2005a\)](#), there are three key software development activities: requirements analysis, architecture definition and construction. Figure 4.1 shows the Three Peaks Model that illustrates how interrelated each aspect is.

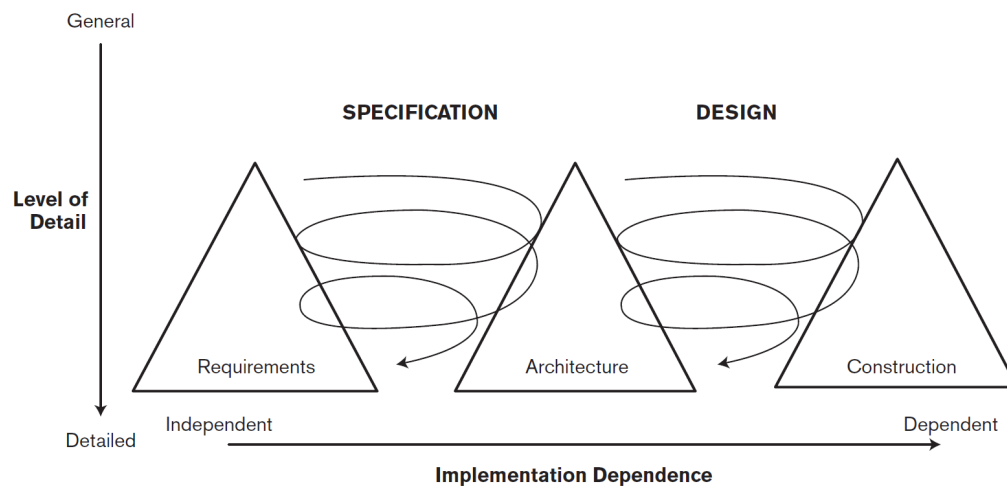


Figure 4.1: Three Peaks Model ([Rozanski & Woods, 2005a](#))

In this study, architecture definition is used as part of the software development lifecycle (SDLC) (originally defined by [Royce \(1987\)](#)). As stated in [Alshamrani & Bahattab \(2015\)](#) and [Balaji & Murugaiyan \(2012\)](#), there are multiple different SDLC models. Still, in this study, a combination of the Waterfall Model and Agile Model will be used.

4.2.2.1 Waterfall model

Figure 4.2 shows the Waterfall model with all tasks performed during the software development process. Each task receives inputs from the previous task and produces outputs to be used during the next task. This then forms a linear sequence of all the tasks, where each can feed information forwards to the following task *and* backwards to the preceding task.

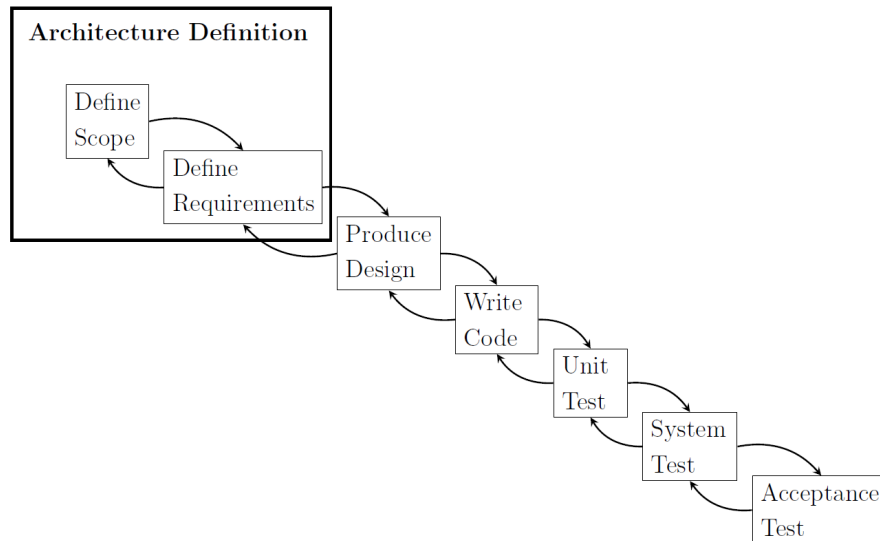


Figure 4.2: The Waterfall model of development (Rozanski & Woods, 2005a)

These steps will be followed during the development of the proposed TIP demonstrator since the design and construction of the demonstrator might require revisiting previous stages as different functions and code is continuously evaluated and adapted.

4.2.2.2 Agile model

Agile methods used in software architecture focus on adaptability, agility and continuously validating the system being developed to deliver the software as quickly as possible. An agile model consists of multiple iterations of the software development steps, including design, coding and testing, with the goal of improving the output with every iteration (McCormick, 2012). Agile models also involve continuous interaction between the software developers and the customer (Rozanski & Woods, 2005a). Figure 4.3 describes the *core practices*, *activities*, *values* and *resources* of the agile methodology and how they are connected.

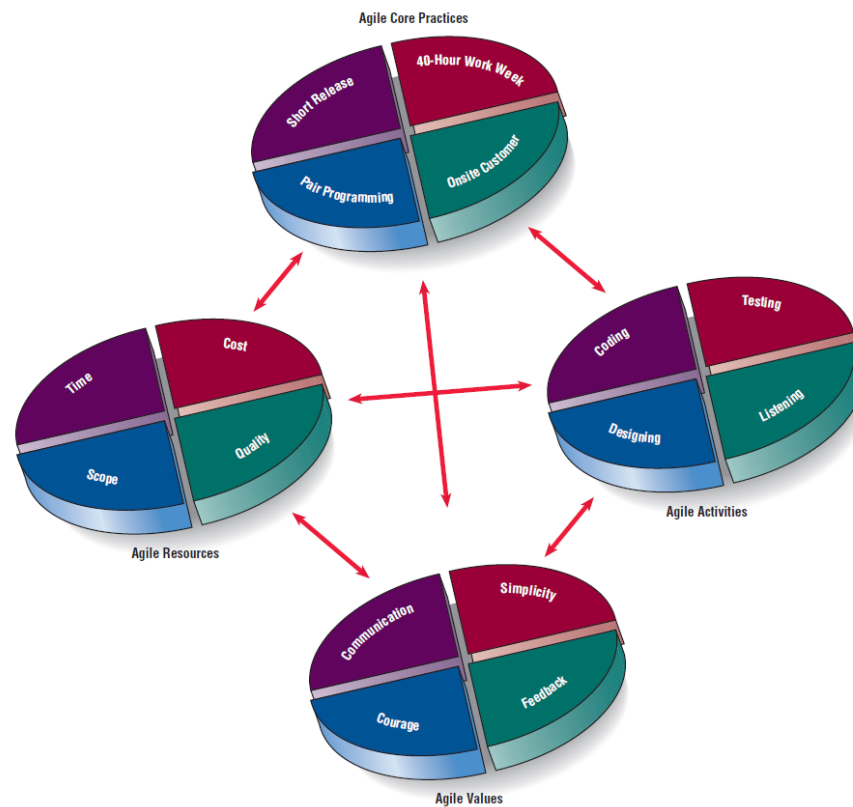


Figure 4.3: The Agile model of development (Kendall & Kendall, 2014)

In this study, a combination of the Waterfall and Agile models will be used since the development of the TIP demonstrator requires a continuous revisiting of steps in the design, coding and testing process. However, this will not be done in complete iteration cycles but according to the Waterfall model described in the previous subsection. The focus on agility and adaptability of the Agile model and the thought process thereof is essential in this study; therefore it is decided that combining these two models will deliver the most efficient and successful demonstrator.

4.2.3 Views and viewpoints

A system that includes multiple components and channels of information, such as the TIP demonstrator to be designed in this study, will be very difficult to interpret if it is described using only one all-inclusive model. Hilliard *et al.* (2012), Rozanski & Woods (2005a) and Purhonen *et al.* (2004) all state that it is much more productive to approach the system from multiple points of view and use a combination of smaller models. Rozanski & Woods (2005a) states that “a complex system is much more effectively described by using a set of interrelated views, which collectively illustrate its functional features and quality properties and demonstrate that it meets its goals”.

Using different views allows the developer to capture all the necessary details to create a clear and accurate system representation. There must be a good balance in the level of detail since too

4.2 System architecture

much detail can be unnecessary and overwhelming, although a vague description can leave room for incorrect assumptions.

There are six core viewpoints as identified and defined by [Rozanski & Woods \(2005a\)](#):

1. **Functional:** Describes the system's functional elements, responsibilities, interfaces and primary interactions. A Functional View is the cornerstone of most ADs and is often the first part of the description that stakeholders try to read.
2. **Information:** Describes how the architecture stores, manipulates, manages, and distributes information.
3. **Concurrency:** Describes the concurrency structure of the system and maps functional elements to concurrency units to identify the parts of the system that can execute concurrently and how this is coordinated and controlled.
4. **Development:** Describes the architecture that supports the software development process. Development views communicate the aspects of the architecture of interest to those stakeholders involved in building, testing, maintaining, and enhancing the system.
5. **Deployment:** Describes the environment into which the system will be deployed, including capturing the dependencies the system has on its runtime environment.
6. **Operational:** Describes how the system will be operated, administered, and supported when running in its production environment.

Of these six viewpoints, only the functional, information and development viewpoints are applicable in this study and will be discussed in the following two subsections. These discussions are based on the descriptions of [Rozanski & Woods \(2005a\)](#) in the context of this study.

4.2.3.1 Defining the functional viewpoint and requirements

The functional viewpoint “describes the system's runtime functional elements and their responsibilities, interfaces, and primary interactions” ([Rozanski & Woods, 2005a](#)). The following concerns, models, pitfalls and stakeholders involved in the functional viewpoint are applicable in this study:

Concerns: The main stakeholder concerns regarding the functional viewpoint are the functional capabilities, internal structure, external interfaces and design philosophy of the proposed itinerary planner.

Models: A functional structure model consisting of an activity diagram and data flow diagram will be used to illustrate the functional capabilities and interfaces of the proposed system.

Pitfalls: Possible problems in this viewpoint include poorly defined interfaces, infrastructure modelled as functional elements, poorly understood responsibilities, unacceptable level of detail, difficulty in reconciling different stakeholders' needs and too many dependencies.

Stakeholders: All relevant stakeholders could show concern regarding the functional view.

4.2.3.2 Defining non-functional viewpoints and requirements

1. Information viewpoint:

This viewpoint “describes the way that the architecture stores, manipulates, manages and distributes information” (Rozanski & Woods, 2005a). The following concerns, models, pitfalls and stakeholders involved in the information viewpoint are applicable in this study:

Concerns: Stakeholder concerns include information structure and content, information flow, data ownership, references, transaction management and recovery, data quality and regulation of all data described in Subsection 4.5.2.

Models: Extended Entity-Relationship Diagram (EERD).

Pitfalls: Problems within the information viewpoint can include data incompatibilities, key matching deficiencies, interface complexity and the combining of data from different sources.

Stakeholders: Most stakeholders have the same level of interest in this viewpoint, but primarily users, developers, acquirers and maintainers are the most invested.

2. Development viewpoint

The development viewpoint “describes the architecture that supports the software development process” (Rozanski & Woods, 2005a). The following concerns, models, pitfalls and stakeholders involved in the development viewpoint are applicable in this study:

Concerns: The main concerns of this viewpoint include standard processing, standardisation of design and testing, instrumentation and choice of the software environment.

Models: Test regime.

Pitfalls: Too much detail can be a problem in this viewpoint, as well as lack of developer focus, lack of precision and problems with the specified environment.

Stakeholders: Software developers and testers are involved in this viewpoint.

4.2.4 Architectural perspectives

As described in the previous subsection, the different views and viewpoints are created separately. However, certain quality requirements can apply to more than one viewpoint. The solution is using architectural perspectives to enhance and modify the existing viewpoints. This is done by reviewing the architecture models to ensure that the software architecture displays the desired quality properties.

[Rozanski & Woods \(2005b\)](#) formally define architectural perspectives as “a collection of activities, checklists, tactics and guidelines to guide the process of ensuring that a system exhibits a particular set of closely related quality properties that require consideration across a number of the system’s architectural views”. Therefore, these perspectives create a formal framework to guide the process of incorporating quality properties.

Many architectural perspectives can be applied to a software architecture if it is relevant to the particular system. [Table 4.4](#) provides a complete list of the perspectives together with a description of each.

The architectural perspectives and quality properties in [Table 4.4](#) are not all applicable to all software architectures. Different types of systems have different quality requirements, and the development of such systems also has time constraints that limit the number of perspectives that can be applied. Therefore, the most relevant perspectives and quality properties are identified and applied.

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Table 4.4: Architectural perspectives

Perspective	Desired quality
Accessibility	The ability of the system to be used by people with disabilities.
Availability and resilience	The ability of the system to be fully or partly operational as and when required and to effectively handle failures that could affect system availability.
Development resources	The ability of the system to be designed, built, deployed and operated within the known constraints around people, budget, time and materials.
Evolution	The ability of the system to be flexible in the face of the inevitable change that all systems experience after deployment is balanced against the cost of providing such flexibility.
Internationalisation	The ability of the system to be independent of any particular language, country or culture group.
Location	The ability of the system to overcome problems brought about by the absolute location of its elements and the distances between them.
Performance and scalability	The ability of the system to predictably execute within its mandated performance profile and to handle increased processing volumes.
Regulation	The ability of the system to conform to local and international laws, quasilegal regulations, company policies and other rules and standards.
Security	The ability of the system to reliably control, monitor and audit who can perform what actions on what resources and to detect and recover from failures in security mechanisms.
Usability	The ease with which people who interact with the system can work effectively.

The applicable perspectives and viewpoints are illustrated in a graph that shows how they intersect, as in the example presented in Figure 4.4.

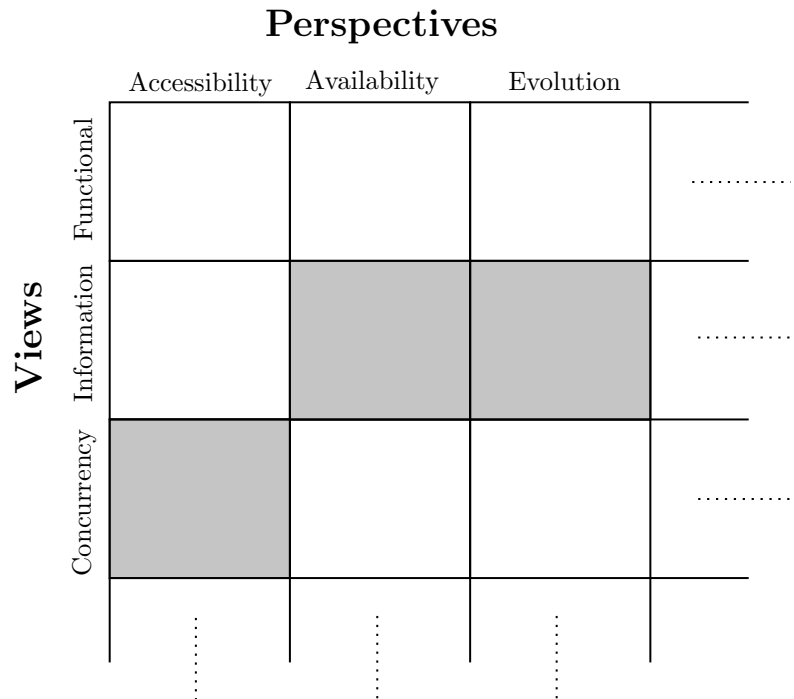


Figure 4.4: Example of applying perspectives to viewpoints (Rozanski & Woods, 2005a)

Each intersection, illustrated with a square in Figure 4.4, represents the application of the *perspective* (on the horizontal axis) to the *view* (on the vertical axis). The content of that intersection is then the concerns and important qualities that must guide the design of the architecture when looked at from that specific viewpoint and perspective.

4.2.5 Applying perspectives to viewpoints

The three perspectives that are relevant to the development of the TIP demonstrator are availability, performance and usability. In Subsection 4.2.3, the three main viewpoints that are applicable to this study were identified as the **functional**, **information** and **development** viewpoints. Figure 4.5 displays a graph of where these perspectives and viewpoints intersect, with a number describing each intersection.

Since a prototype is developed in this study, not all of the perspectives are considered. Should the prototype in future be developed into a full-scale product, the perspectives must be reconsidered. It is common practice to tailor the perspectives to a specific system.

		Perspectives		
		Availability	Performance	Usability
Views	Functional	1	2	
	Information	3	4	5
	Development		6	7

Figure 4.5: Applying the selected perspectives to viewpoints

The intersections indicated in Figure 4.5 are the system and software properties that the TIP demonstrator will display:

- 1** Functions, including the algorithm, interfaces and connections between components, must enable the system to always be available for use. All functions will be designed and programmed to have 99% availability, thus reducing the risk of software failure.
- 2** The algorithm and query execution will run smoothly and not cause any problems during the process of the user operating the TIP demonstrator. This will ensure the overall satisfactory performance of the system and the construction of a final itinerary that conforms to the user preferences.
- 3** Information regarding the points-of-interest (POIs) and the user preferences will be connected to the algorithm to ensure continuous accessibility.
- 4** The database will be of a size that the algorithm and that functions can handle without hindering the system's performance.
- 5** All data and information stored in the demonstrator database will be accurate, consistent and relevant and also conveyed to the user as such.
- 6** The development of the algorithm, database and interfaces of the TIP demonstrator will be focused on performing the necessary tasks to provide a working TIP demonstrator. This will be elaborated in Sections 5.3 to 5.6.

4.3 Overview of concept development

- 7 The interfaces will allow for interaction between the user and the system and will be designed to be easy to follow, aesthetically pleasing and logical in order to provide a positive user experience.

This concludes the description of the system architecture constructed to guide the development of the TIP demonstrator, which will be presented in the succeeding chapter. The next section serves to introduce the concept development of this study.

4.3 Overview of concept development

Following the informal TIP process description in Section 4.1, an overview of the TIP demonstrator to be developed in this study is presented in this section. This includes an explanation of the TIP process it will offer and a discussion of the incorporation of personalisation and budget as two critical elements of the proposed demonstrator.

4.3.1 The itinerary planner concept

The conceptualisation of the proposed TIP demonstrator can be split into three main elements: the input requirements of the system, the internal functions of the demonstrator itself and what it will deliver as output to the user. The demonstrator's functions, elements, tasks, subdivisions, processes and features will be designed to ensure that these three elements are connected during the entire TIP process. The **inputs** of the demonstrator include the details and preferences of the user as well as the data of all possible options and travel information from external sources and will be discussed in Subsection 4.5.2.

The system architecture developed in Section 4.2 provides a framework that allows for the design of a personalised TIP process as described in Section 4.1, including all inner functions and programming. This will be achieved in the succeeding chapter by incorporating the relevant concepts, principles, components and characteristics of the proposed final demonstrator identified in Section 4.2. This system architecture will be visualised using OPM and will be discussed in the next section.

The proposed **output** of the demonstrator is the final personalised itinerary, which will be displayed on the web page. This will include all of the information regarding activities, prices and available transportation, as well as budget calculation results. A comprehensive explanation of the final personalised itinerary and the additional features offered will be given in Section 5.7.

This final itinerary will be created using a combination of inputs, programming, data processing, detailed comparison and the written algorithm. A comprehensive explanation of the personalised itinerary and the additional features offered will be given in Section 5.4.

To convert this concept into a working demonstrator, various database functions, programming, mathematical calculations, queries and engineering concepts will be used. The demonstrator consists

4.3 Overview of concept development

of three main components that facilitate these elements: a **web browser user interface (BUI)**, **database** and **TIP algorithm**. Figure 4.7 provides the bigger picture of the entire web-based TIP concept, including where and how these components fit in.

These components must be carefully integrated and operate together satisfactorily to provide the final output. However, each must also independently perform its functions to ensure that the entire TIP process runs smoothly and all requirements are fulfilled. The execution of this will be described in detail in the subsequent chapter.

The purpose of each component and how it contributes to the overall performance of the demonstrator is presented in Subsections 4.5.1, 4.5.2 and 4.5.3.

4.3.2 Incorporation of key aspects: personalisation and budget

The preceding chapter provided a detailed review of existing online trip planners, such as [TripHobo \(2020\)](#) and [Inspirock \(2020\)](#), including their positive qualities and drawbacks. Following this analysis, the main features that were lacking in those trip planners were:

- The recommendations provided are not personalised to the degree that will best accommodate the user's needs.
- The scheduling of activities is rigid and supplied as a fixed set, which could feel too forced for certain users.
- The filtering of options does not consider the cost of POIs or budget, and therefore the cost of the activities selected could be higher than what the user had planned to spend.
- When no alternative options are given other than the single identified POI, which occurs when using these planners, it creates the possibility of the user losing interest in the trip planner and resorting to their own research for the trip.
- In the case of the user being prompted to identify the type of activities they would prefer to include in their trip, there is a limited amount of categories to choose from, which can reduce their level of satisfaction with the given itinerary.

Following the research presented in the previous chapter and the observations stated in the list above, it is clear that a greater focus on *personalisation* and *budget* in a web-based TIP process can greatly improve the usefulness and user experience of the web application. Therefore, the planning, development, functions and programming in this study will be executed with an emphasis on these two elements.

The major focus on incorporating personalisation and budget in this study is what differentiates it from other online itinerary planners, such as those discussed in Subsection 3.3.1. These elements

4.4 Object-Process Methodology

are implemented to create a new and unique web-based itinerary planner that works and performs differently than other alternative trip planning software and provide a more user-focused output.

To accomplish this, the list of prompts directed to the user will be extensive and detailed to create a comprehensive set of preferences to be used as the constraints for the TIP algorithm. The questions must be very specific to obtain all of the necessary information about the user's wants regarding their upcoming trip. This will ensure that the best possible combination of POIs that the user will *want* to use can be determined.

4.4 Object-Process Methodology

This section will discuss OPM as a method of expressing the system architecture and its components, including the relationships between these components and all the processes and functions involved. A software system such as the one to be developed in this study is complex and therefore requires a modelling paradigm that is clear and easily understandable, which is the main objective of OPM.

Dori *et al.* (2010) defined OPM as “a holistic approach for conceptual modelling of complex systems”. It provides a framework for the study and development of an artificial system and its entire life cycle using clear and concise symbols and language. Through this, the *structural*, *behavioural* and *functional* aspects of a system can be integrated and expressed using a combination of simple graphics and natural language sentences.

OPM has also become part of the ISO Standard 19450 which states the use of “the concepts, semantics and syntax of OPM as a modelling paradigm and language for producing conceptual models at various extents of detail” (ISO, 2015).

The graphical representation of the system is known as the Object-Process Diagram (OPD), accompanied by the Object-Process Language (OPL), which describes the diagram in simple sentences. These will subsequently be discussed.

4.4.1 Object-Process Diagram

The OPD is an illustration of the *processes*, *objects* and *states* of a system, collectively known as the bricks, that are connected using structural or procedural links. This creates a clear picture of the system and provides context to the flow of control, timeline and object states and conditions (Dori *et al.*, 2010). The symbols and conventions used in the OPDs of this study are described in Appendix A.

The three types of entities in an OPM are:

- **Objects:** all the physical or informatical components within the system.
- **Processes:** transform the objects by consuming them, creating them or changing their states.

- **States:** description of the objects.

Figure 4.6 is an OPD illustrating the three OPM entities with an example of how they can be connected. In this OPD, the object is originally in State 1 but is then transformed through the process to be in State 2, with the arrows indicating the input/output procedural link pair.

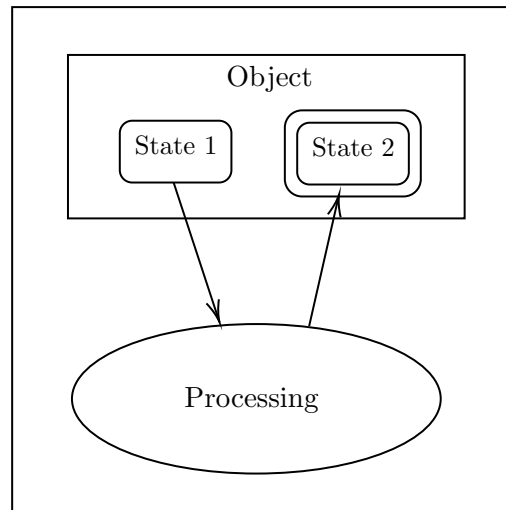


Figure 4.6: Object-Process Diagram example (Dori *et al.*, 2010)

More details regarding the symbols of the OPD can be found in Dori (2002).

4.4.2 Object-Process Language

OPL is the accompanying textual description to the OPD automatically generated by the OPM software. It is an unambiguous explanation of the OPD in natural language using simple terms, allowing a broader audience to understand the OPM models.

Together, the OPD and OPL create a symbolic representation of the objects in a system and their structural relations and functions. In addition, the combined use of the OPD and OPL also bridges the gap between the *requirement* specifications and *system* specifications.

4.4.3 Application of Object-Process Methodology in this study

This section will present the application of the OPM model in this study. The development of an OPM for the proposed demonstrator allows for the identification of the objects and processes involved in the TIP process and how they are linked together. The software that was used to facilitate this development is the Object-Process CASE Tool (OPCAT) by Dori (2002).

The proposed TIP process will be illustrated with a top-level OPD, referred to as the System Diagram (SD) and presented in Subsection 4.4.4, and four sub-diagrams (SD1 - SD4) in Subsections 4.4.5 to 4.4.8. The **SD** is a visualisation of the entire system that includes details of both the

4.4 Object-Process Methodology

structural and procedural elements of the system. It shows the main processes and objects (as well as their states, behaviours and relationships) that must satisfactorily perform the TIP function.

The sub-diagrams, **SD1**, **SD2**, **SD3** and **SD4**, will provide a detailed look at each individual process in the **SD**. This includes a top-down “zoomed-in” version of their respective processes to display sub-processes, objects and links. The specific process that each sub-diagram represents will be stated in Subsections 4.4.5 to 4.4.8.

Each subsection will include a diagram as the visual representation and an accompanying textual description. Together, these diagrams create a cohesive representation of the system and an understanding of the elements and processes that will be included and executed in developing the TIP demonstrator.

The figures included in the following subsections show the links between the processes and objects, but for a more detailed description, refer to [Dori et al. \(2010\)](#).

4.4.4 System diagram (top-level Object-Process Diagram)

Figure 4.7 presents the **SD** (top-level OPD) of the system, which displays all main processes, objects and links.

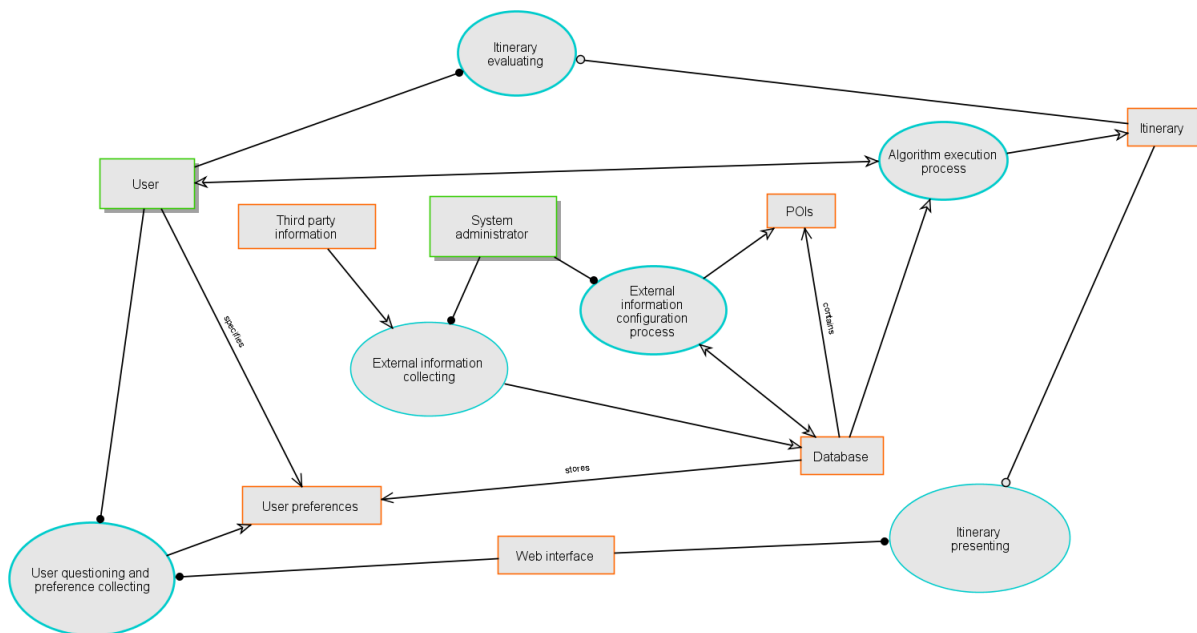


Figure 4.7: System diagram (top-level OPD)

The TIP demonstrator will include the following processes as illustrated in the **SD**:

1. User questioning and preference collecting (detailed in **SD1**).
2. External information collecting.

4.4 Object-Process Methodology

3. External information configuration process (detailed in **SD2**).
4. Algorithm execution process (detailed in **SD3**).
5. Itinerary presenting.
6. Itinerary evaluating (detailed in **SD4**).

The objects included in Figure 4.7 are the following:

- Agents (humans):
 1. User
 2. System administrator (represented by the researcher)
- Instruments (non-humans):
 3. User preferences
 4. BUI
 5. Database
 6. Itinerary/Recommendations
 7. Third party information

Figure 4.8 provides the textual counterpart to the **SD** (in the original format as extracted from OPCAT), which describes the diagram in simple, natural language.

```

User is physical.
User specifies User preferences.
User handles User questioning and preference collecting and Itinerary evaluating.
Database contains POIs.
Database stores User preferences.
Web interface handles User questioning and preference collecting and Itinerary presenting.
System administrator is physical.
System administrator handles External information configuration process and External information collecting.
Algorithm execution process affects User.
Algorithm execution process consumes Database.
Algorithm execution process yields Itinerary.
Itinerary evaluating requires Itinerary.
User questioning and preference collecting yields User preferences.
Itinerary presenting requires Itinerary.
External information collecting consumes Third party information.
External information collecting yields Database.
External information configuration process affects Database.
External information configuration process yields POIs.

```

Figure 4.8: System diagram Object-Process Language description

4.4.5 SD1: User questioning and preference collecting

Figure 4.9 presents sub-diagram 1, a “zoomed-in” version of the “User questioning and preference collecting” process with all sub-processes, objects and links.

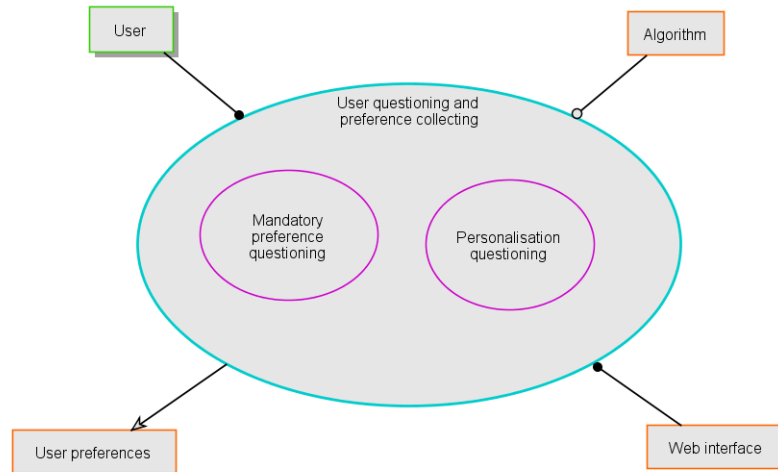


Figure 4.9: Sub-diagram 1: User questioning and preference collecting

The user questioning and preference collecting will include the following sub-processes:

1. Mandatory preference questioning.
2. Personalisation questioning.

Figure 4.10 provides the textual counterpart to **SD1** that describes the diagram in simple, natural language.

User is physical.
 User handles User questioning and preference collecting.
 Web interface handles User questioning and preference collecting.
 User questioning and preference collecting consists of Mandatory preference questioning and Personalisation questioning.
 User questioning and preference collecting requires Algorithm.
 User questioning and preference collecting yields User preferences.
 User questioning and preference collecting zooms into Mandatory preference questioning and Personalisation questioning.

Figure 4.10: Sub-diagram 1 Object-Process Language Description

4.4.6 SD2: External information configuration process

Figure 4.11 presents **SD2**, a “zoomed-in” version of the “External information configuration process” with all sub-processes, objects and links.

4.4 Object-Process Methodology

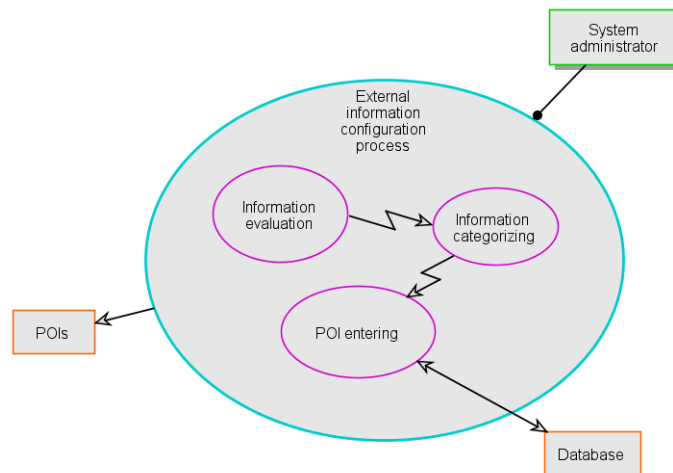


Figure 4.11: Sub-diagram 2: External information configuration process

The external information configuration process will include the following sub-processes:

1. Information evaluation.
2. Information categorizing.
3. POI entering.

Figure 4.12 provides its textual counterpart to **SD2**.

System administrator is physical.
 System administrator handles External information configuration process.
 External information configuration process consists of Information evaluation, Information categorizing, and POI entering.
 External information configuration process yields POIs.
 External information configuration process zooms into Information evaluation, Information categorizing, and POI entering.
 Information evaluation invokes Information categorizing.
 Information categorizing invokes POI entering.
 POI entering affects Database.

Figure 4.12: Sub-diagram 2 Object-Process Language description

4.4.7 SD3: Algorithm execution process

Figure 4.13 presents **SD3**, a “zoomed-in” version of the “Algorithm execution process” with all sub-processes, objects and links.

4.4 Object-Process Methodology

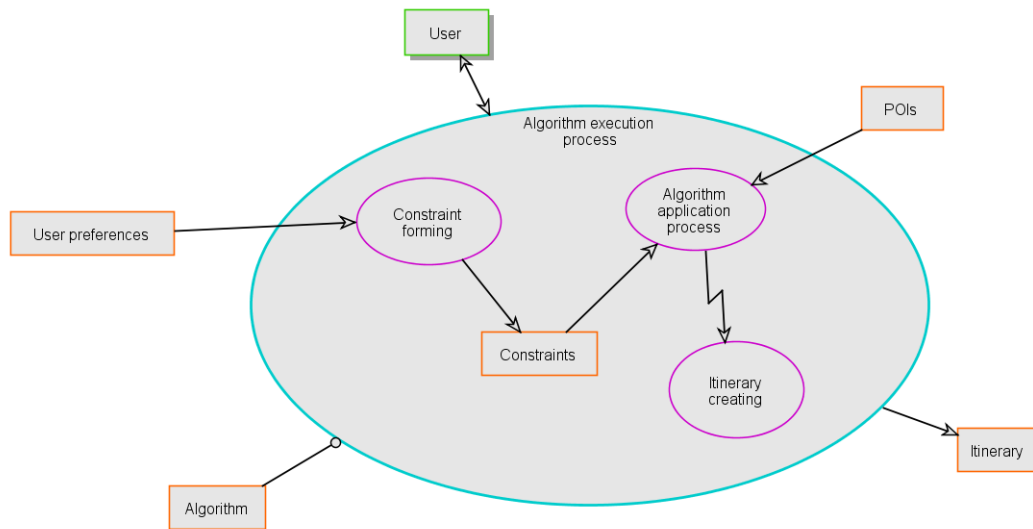


Figure 4.13: Sub-diagram 3: Algorithm execution process

The algorithm execution process will include the following sub-processes:

1. Constraint forming.
2. Algorithm application process.
3. Itinerary creating.

A sub-object, Constraints, is also formed during the algorithm's execution, as indicated by Figure 4.13. Figure 4.14 provides the textual counterpart to the **SD3**.

User is physical.
 Algorithm execution process exhibits Constraints.
 Algorithm execution process consists of Constraint forming, Algorithm application process, and Itinerary creating.
 Algorithm execution process requires Algorithm.
 Algorithm execution process affects User.
 Algorithm execution process yields Itinerary.
 Algorithm execution process zooms into Algorithm application process, Constraint forming, and Itinerary creating, as well as Constraints.
 Algorithm application process consumes Constraints and POIs.
 Algorithm application process invokes Itinerary creating.
 Constraint forming consumes User preferences.
 Constraint forming yields Constraints.

Figure 4.14: Sub-diagram 3 Object-Process Language description

4.4.8 SD4: Itinerary evaluating

Figure 4.15 presents **SD4**, a “zoomed-in” version of the “Itinerary evaluating” process with all sub-processes, objects and links.

4.5 Main components of development

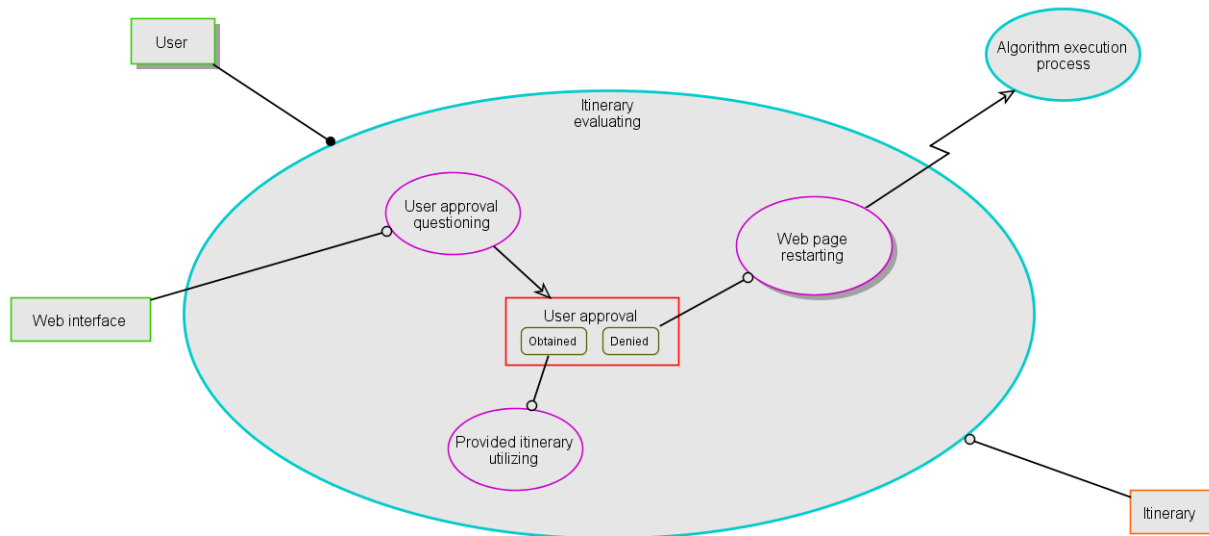


Figure 4.15: Sub-diagram 4: Itinerary evaluating

The itinerary evaluating process will include the following sub-processes:

1. User approval questioning.
2. Provided itinerary utilizing.
3. Web page restarting.

The user approval sub-object is also indicated in Figure 4.15, which can be in a state of *Obtained* or a state of *Denied*. Figure 4.16 provides the textual counterpart to the **SD4**.

```

User is physical.
User handles Itinerary evaluating.
Itinerary evaluating exhibits User approval.
Itinerary evaluating consists of User approval questioning, Web page restarting, and Provided itinerary utilizing.
Itinerary evaluating requires Itinerary.
Itinerary evaluating zooms into User approval questioning, Web page restarting, and Provided itinerary utilizing, as well as User approval.
  User approval can be Obtained or Denied.
  User approval questioning requires Web interface.
  User approval questioning yields User approval.
  Web page restarting is physical.
  Web page restarting requires Denied User approval.
  Web page restarting invokes Algorithm execution process.
  Provided itinerary utilizing requires Obtained User approval.

```

Figure 4.16: Sub-diagram 4 Object-Pprocess Language description

The architectural elements presented in the previous sections will be used to guide the development of the demonstrator.

4.5 Main components of development

This section introduces the three components that form the TIP demonstrator: the web BUI, database, and algorithm to be developed. This includes a discussion of the role of each component

4.5 Main components of development

in the overall functionality and performance of the proposed demonstrator, how they are connected and specific details of their operations.

4.5.1 Browser user interface

The BUI is the component that connects the user to the system by introducing a platform that allows for communication and trading of information. It is a user-friendly, aesthetically pleasing, simple yet effective interface that must grab the user's attention and keep it throughout the entire TIP process. Therefore, their interactions with the BUI are an informative and rewarding step towards their ultimate goal of creating an unforgettable trip.

The BUI accommodates all interactions between the user and the system (regarding inputs *and* outputs of the system) and the communication of data. The BUI provides the user prompts initiated by the system to gather all the necessary details required to execute the TIP process. This information includes the preferences and specifications the user enters regarding their upcoming trip.

Apart from collecting the user inputs, the BUI also presents the final product to the user. It displays the layout of the personalised itinerary, clearly showing the options identified for each time slot with its accompanying information and prices. The BUI shows the alternative options made available if the user would like additional suggestions.

The design and presentation of the BUI will be given in the subsequent chapter.

4.5.2 Demonstrator database

As mentioned in Subsections 4.3.1 and 4.5.1, there are different channels of data that the TIP demonstrator must process. Therefore, an extensive database is required to organise and store all relevant information from every stage of the TIP process (*i.e.* all the information to be used by the designed algorithm). This includes details obtained from queries directed to the user and information gathered from external sources, supporting websites and participating companies.

The database will be connected to the BUI (to collect and exchange data to and from the demonstrator), third parties for relevant tourism information and the TIP algorithm to be designed.

4.5.2.1 User preferences

From the start of the TIP process, the database will store every piece of data the user provides following the system prompts. A detailed list of these prompts will be included in the succeeding chapter, but a few of the mandatory user inputs include:

- Total budget
- Destination

4.5 Main components of development

- Transportation preferred
- Types of activities, for example, sightseeing, cultural and adventure activities
- Accommodation preferences
- Start time of day

These user preferences are captured and stored in the database to be used later during the application of the TIP algorithm.

4.5.2.2 Data from external sources

The primary type of data in the demonstrator database will be the information gathered from third parties providing the POIs. For the demonstrator to present a professional, detailed itinerary, an extensive list of options must be available. This will ensure that after the user preference constraints are applied, the demonstrator will have multiple possibilities (referred to as the POIs) to choose the best alternative.

The database will contain information gathered from businesses and other establishments offering relevant services in the tourism industry. The data collected from these sources include details such as:

- Trading hours
- Prices
- Industry/Category for example Sports, Sightseeing and Culture
- Average time spent at an attraction or to complete activity
- Type of accommodation

The data from the third parties will then be stored and categorised for easy access during the application of the TIP algorithm. Together with the user preference constraints, the TIP algorithm will then generate suitable POIs. This will result in a carefully constructed itinerary for the user to review and backup options for each POI.

Furthermore, the succeeding chapter includes an in-depth explanation of the demonstrator database and how it connects to every element of the itinerary planner developed in this study.

4.6 Conclusion: System architecture

4.5.3 Algorithm requirements

The most important aspect of the proposed TIP demonstrator is its ability to provide a satisfactorily customised travel plan, which will be executed using a carefully constructed algorithm. This is the chosen method of solving the problem statement in Section 1.2 since it allows the incorporation of a high level of personalisation and can be designed to retrieve information from multiple sources and third parties and subsequently piece together a full itinerary within the user's specified budget.

To realise this, the algorithm is connected to the BUI and demonstrator database. The main functions that the algorithm must be capable of performing are:

- Retrieving and handling the user preferences and specified budget as it is captured by the BUI.
- Forming suitable constraints from this information to narrow down the search for accommodation, transportation, activities, *etc.*
- Creating queries using these constraints.
- Accessing the POI data and attributes from the database.
- Identifying and filtering all suitable POIs through the execution of the queries.
- Creating different combinations of POIs and calculating the cost of each combination.
- Testing the combinations by comparing them to the specified budget.
- Sending the final itinerary to the BUI.

The software that will be used to write and develop the algorithm for the TIP demonstrator will be described in Section 5.1. These tools will facilitate creating an algorithm with the necessary capabilities, steps and features to perform the functions listed above. A combination of programming and information systems knowledge will be applied during the process to ensure the best performance of the algorithm.

The steps of the algorithm will also be specifically designed to include the **personalisation** and **budget** aspects of the TIP demonstrator. Since these two elements make the TIP demonstrator unique compared to other online itinerary planners in the field, great focus will be placed on incorporating them throughout the algorithm.

4.6 Conclusion: System architecture

In this chapter, the system architecture that facilitates the design and development of the web-based TIP demonstrator is discussed in detail. First, the proposed TIP process that the final demonstrator will perform is described. This was followed by an extensive discussion of the system

4.6 Conclusion: System architecture

architecture concepts relevant to this study, including the project stakeholders, views and viewpoints, and perspectives. The TIP concept and the application of OPM were also discussed, and, finally, the main components of development were introduced: the BUI, database and algorithm. The succeeding chapter will document the *implementation* of the system architecture discussed in this chapter.

Chapter 5

System implementation

This chapter describes the implementation of the web-based tourist itinerary planning (TIP) process following the system architecture built in the previous chapter. It starts by listing the technology, tools and programming languages used to facilitate this implementation, after which an overview of the TIP demonstrator and its 3 500 lines of front- and back-end code will be discussed.

Next, each browser user interface (BUI) component will be described. The accompanying algorithm that performs the functions and calculations required to create the final itinerary will be presented. Lastly, a discussion of the display of the final itinerary to the user will be given. These elements of development all contribute to the fulfilment of Objectives III, IV and V.

5.1 Technology, tools and programming languages used

This section provides the technology, platforms, tools and programming languages selected and used to perform the required functions and operations of the demonstrator. Choosing the most suitable software tools and technology is crucial to the effectiveness and quality of the final demonstrator, and therefore many options were considered for this study.

Below is a list of the software tools and programming languages used in this study:

1. **Object-Process CASE Tool (OPCAT)**: A desktop software for performing Object-Process Modelling (OPM) used to model the TIP process visually and textually (Dori, 2002). As a result, a clear overview of the system architecture is provided, which can be found in Section 4.4.
2. **HyperText Markup Language (HTML)**: The standard mark-up language used to structure and display the web page of the demonstrator (HTML, 2022).
3. **Cascading Style Sheets (CSS)**: The standard language that controls the look of the web page, including the fonts, headings, background colours, font sizes, text colours, *etc.* (CSS, 2020).
4. **JavaScript**: The scripting language used to extend the web page's functionality. The JavaScript code provides features that create a more dynamic and responsive web page and is the link that enables the web page to be connected to a back-end (JavaScript, 2018).
5. **Python**: "A high-level, interpreted, general-purpose programming language" chosen for coding the algorithm (Python, 2022).

5.2 Overview of web application

6. **Microsoft (MS) SQL Server:** A relational database management system used to access, store, manipulate and interpret data (Microsoft, 2019).
7. **Svelte:** A framework that can connect a web app’s front- and back-end (Svelte, 2022).

The following two subsections will explain how these software tools and technologies are used in this study.

5.2 Overview of web application

The previous chapter conceptualised the TIP process that the demonstrator must provide. It described the system architecture and laid out the three main components that form the TIP demonstrator: the BUI, database and TIP algorithm.

This section describes the front- and back-end of the web app developed to realise those three components as described in Section 4.5. It is crucial that a reliable front- and back-end is built that can communicate requests, information and responses, and therefore an explanation of how they are connected is also provided in this section.

5.2.1 Front-end development

A front-end must be built for the system and the user to communicate through the web app. The front-end development involves all programming required to provide an interactive platform between the user and the system and is therefore also referred to as “client-side” programming. It includes everything operated and displayed by the BUI, such as the visuals, text and navigation of the web page and is one of the critical elements of ensuring a positive user experience. The quality of the front-end development is essential since it handles all elements on the web page that are directly accessed by the user and can, therefore, significantly impact the user’s overall impression of the web app. Most importantly, it must be programmed to provide a working TIP demonstrator.

As mentioned in Subsection 4.2.5, the availability, performance and usability perspectives are focused on in this study. The front-end development specifically affects the *availability* and *usability* of the system. Therefore the front-end was programmed to ensure that these perspectives were met.

In this study, the front-end development consisted of designing the desired appearance of the web page and the functions it must carry out, together with the code used to achieve it. The programming languages used for coding the front-end of the TIP demonstrator are HTML, CSS and JavaScript. The role of each language in the TIP demonstrator is as follows:

1. **HTML:** Handles the layout and operations of the web page by structuring the different components (described in Section 5.3) that the user interacts with. It navigates the user through

5.2 Overview of web application

the web page by providing forms, text, buttons, drop-down menus and lists. It provides a responsive page that can receive the raw user input and display the calculated output.

2. **CSS:** Is used to create a professional-looking web page that encourages the user to use the web app and also keep their attention throughout their use of the online trip planner. The font, font size, background colour and text colours were chosen to present a web page that is professional-looking, visually pleasing and easy to read.
3. **JavaScript:** The JavaScript code captures the information entered on the web page and sends the data to the back-end of the web app. This is performed using a request sent to the Python algorithm. The JavaScript code then also receives the returning responses from the back-end after the execution of the algorithm.

5.2.2 Back-end development

The back-end of the TIP demonstrator is the programming environment where all the inner workings are executed to deliver the final itinerary. It handles all activities related to the server, algorithm and database and is therefore also referred to as “server-side” programming. It retrieves and sends data to the front-end and performs the functions as requested. Back-end development powers the front-end features and also expand their abilities, which is why it is imperative for the TIP demonstrator to have a robust back-end.

As mentioned in Subsection 4.2.5, the availability, performance and usability perspectives are focused on in this study. The back-end development specifically affects the *availability* and *performance* of the system. Therefore the back-end was programmed to ensure that these perspectives are met.

In this study, the back-end development consisted of coding the TIP algorithm in Python and creating the database in MS SQL Server. The roles of these are the following:

1. **Python:** The Python code written for the algorithm receives requests and information sent from the front-end of the demonstrator (*i.e.* from the JavaScript code) and executes functions, writes SQL queries and performs calculations using that data. It then sends a response back to the front-end with the required data. A detailed description of the Python algorithm and its functions will be provided in the following three sections.
2. **MS SQL Server:** Stores all the relevant data about the points-of-interest (POIs). It receives queries from the Python code and executes them, which produces the filtered list of POIs and other information that must be displayed on the web page. Section 5.6 provides a more detailed description of the database and the MS SQL Server software.

5.3 Browser user interface components

5.2.3 Framework for connecting the front- and back-end

The front- and back-end of the TIP demonstrator must be connected for the TIP process to be executed correctly. A framework must be chosen that fits the specific system's needs and objectives, and consequently ensures an efficient deployment process. Although the front-end and back-end work independently, they serve the same goal and therefore need a channel where information and data can be easily communicated without disruptions.

As mentioned in the previous two subsections, the front-end development consists of HTML, CSS and JavaScript programming and the back-end development includes an algorithm written in Python and a database in MS SQL Server. To link these components together, a [Svelte \(2022\)](#) the framework was built.

Svelte is a front-end compiler used to individually develop smaller components and merge them into one complete web app. It is a unique new software tool that adds extensions to the existing HTML, CSS and JavaScript of the front-end instead of forming the connection in the user's browser while the web page is running, like other frameworks such as [React \(2022\)](#) or [Angular \(2022\)](#). The Svelte framework also allows for highly interactive web pages, complex visualisations and better performance ([MDN Contributors, 2022](#)).

The Svelte framework built in this study provides a single platform where all of the programming (in Python, HTML and JavaScript) can be coded in one place. As a result, the BUI, algorithm and database can work together to create the final TIP demonstrator. Each section of the algorithm that handles a different set of inputs and outputs, for example, the programming for the "breakfast" section, is programmed in one Svelte *component*. All of the individual components were then included in one larger component that handles the full web page display. The following section will discuss each component in detail and provide more information on the Svelte code itself.

5.3 Browser user interface components

As described in Subsection [4.3.1](#), the user will be guided through a TIP process where they will be prompted to answer questions about each day of their trip. These prompts are split into different groups of inputs, such as mealtimes, accommodation preferences and general information required to run the TIP algorithm. These groups will be discussed in the following subsections and are the

- Initial user inputs
- Accommodation inputs
- Daily inputs
- Mealtime inputs

5.3 Browser user interface components

- Activity session inputs

These groups of inputs are then split into smaller *sessions* that each has its own front- and back-end development. The user is prompted to answer questions about each session, and the algorithm will guide them further according to their responses. Figure 5.1 provides an illustration of the navigation of the user through the web page and the different prompts.

5.3 Browser user interface components

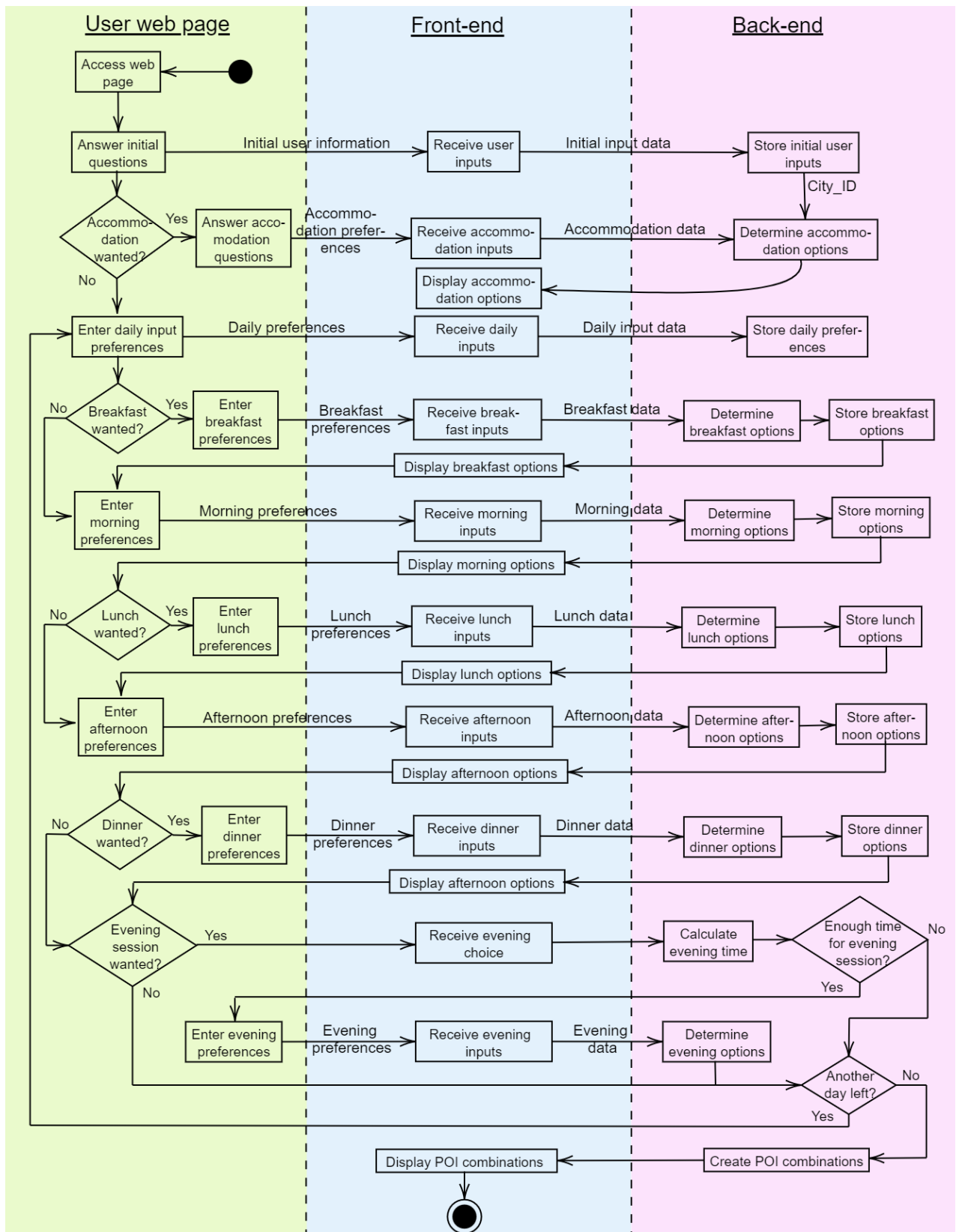


Figure 5.1: Activity diagram of the TIP demonstrator

5.3 Browser user interface components

As described in the previous section, individual Svelte components were built for each separate *session*. There are also Svelte components for certain calculations in the system, but these will be discussed in Section 5.5. The following is a list of all Svelte components developed in this study (in the order they are executed):

- “Home” component that initiates the web page
- Initial user inputs
- Accommodation preferences
- “Day” component that is executed for each individual day
- Daily inputs
- Breakfast preferences
- Morning session preferences
- Lunch preferences
- Afternoon session preferences
- Dinner preferences
- Calculation of whether evening session is included or not
- Evening session type specification
- Evening session preferences
- Calculations for the day
- Calculation of total trip cost

Not all of these components are executed with each run of the algorithm, this depends on the user inputs as they navigate the web page.

All front-end coding and processing of information are performed within the Svelte component. Each user prompt is executed by the HTML code, and the information entered is captured by the accompanying JavaScript code when the “Submit” button is pressed. A request is created within the submit function that sends the captured data to the back-end, where it will be used by the Python algorithm. Therefore, the BUI will be *dynamic* and allow continuous communication between the user and the system. The data processing completed in the back-end programming will be described in Sections 5.4 and 5.6.

Each of the subsequent subsections provides descriptions of these Svelte components, including the specific user prompts, display of results and the programming behind it.

5.3 Browser user interface components

5.3.1 Initial user inputs

The first Svelte component on the web page asks the user general questions about their upcoming trip. These questions are only presented once and are stored as global variables for use in the Python algorithm. Figure 5.2 presents the initial user input component as displayed upon accessing the web app.

INITIAL USER INPUTS

DESTINATION

Cape Town ▾

LENGTH OF TRIP

1 days

TOTAL BUDGET

R Total trip budget

MODE OF TRANSPORT PREFERRED:

Car ▾

Submit

Figure 5.2: Display of the initial user inputs

Upon accessing the web page, the user is prompted to select a **destination** from a drop-down list of predetermined world cities like Cape Town, Amsterdam, Paris, Johannesburg and New York City. Next, the web page asks for the **length of the trip** as well as the **total budget** that the user would like to hold to, which can both be entered as numeric inputs. The last prompt in this component is for the **mode of transport** the user would prefer to use, which can also be chosen from a drop-down list with the options: car, [Uber \(2020\)](#), bus and train.

5.3.2 Accommodation inputs

Next, the web page allows the user to enter their accommodation preferences. This is optional, and therefore the user can skip this section if they have already booked or planned their accommodation and are only looking for activities to fill their days. The accommodation component functions independently on the web page and is not part of the itinerary creation process in the algorithm.

Figure 5.3 presents the accommodation component, which also appears when the web page is initially opened, together with the initial inputs.

5.3 Browser user interface components

ACCOMMODATION

TYPE

MINIMUM RATING

POPULAR OR HIDDEN GEM:

MINIMUM PRICE P.P.

NICHE:

MAXIMUM PRICE P.P.

Figure 5.3: Display of the accommodation inputs

After the user has entered the required initial inputs, they are navigated to the accommodation component on the web page. The following questions are asked here:

- The **type** of accommodation they would prefer to stay in from a drop-down list with the options: hotel, [Airbnb \(2021\)](#), hostel or bed and breakfast (B&B).
- The user chooses whether they want their accommodation to be a **popular** establishment or considered a **hidden gem**. Accommodation options that are smaller, independent and not widely known are considered hidden gems.
- The specific **Niche** they want the accommodation to be identified as. A drop-down list offers the options: modern, boutique, franchise and luxury.
- **Minimum acceptable rating** (out of 5) entered as a numeric input.
- **Minimum and Maximum price per person (p.p.) per night** the user is willing to pay.

The display of the results for accommodation options will be discussed in Section [5.7](#).

5.3.3 General daily inputs

After the user has entered the required information described in Subsection [5.3.1](#) (and completed the accommodation section if needed), they are presented with questions about their desired travel day. This component, together with those discussed in the subsequent subsections, will be repeated for

5.3 Browser user interface components

the number of days the user specified in the initial input component. Figure 5.4 presents the daily input section of the web page.

DAY 1:

BUDGET FOR THE DAY:
What is the maximum you would like to spend today?
R 0

START OF DAY:
Choose a time to start your day:
--:--

END OF DAY:
Choose a time to end your day:
--:--

BREAKFAST INCLUDED:
 Yes No

SHOPPING OR ACTIVITY DURING MORNING SESSION:
▼

LUNCH INCLUDED:
 Yes No

SHOPPING OR ACTIVITY DURING AFTERNOON SESSION:
▼

DINNER INCLUDED:
 Yes No

EVENING POI INCLUDED:
 Yes No

Submit

Figure 5.4: Display of general daily inputs

The following user inputs are required for each day, as illustrated in Figure 5.4:

- The user's **budget for the day**. This is for all morning, afternoon and evening activities the user might complete, *excluding* meals and shopping.
- The **start of day**, which is the time the user would like to begin their day, either with breakfast or an activity.
- The **end of day**, referring to the latest time that their dinner or evening activity can finish.
- If **breakfast** must be included in the itinerary for the specific day (Yes/No).
- A choice between Shopping and Activity for the **morning session** of the day, *i.e.* if the user would like to do a specific activity or rather have their own time for shopping, browsing and strolling around the city.
- If **lunch** must be included in the itinerary for the specific day (Yes/No).
- A choice between Shopping and Activity for the **afternoon session** of the day (the same as for the morning session).
- If **dinner** must be **included** in the itinerary for the specific day (Yes/No).

5.3 Browser user interface components

- If the user would like an **evening session included** in their day (Yes/No). The alternative is free time to follow their own plans during the evening.

As mentioned in Subsection 5.2.3, an individual Svelte component was developed for each section of the user's day, including Breakfast, Morning, Lunch, Afternoon, Dinner and Evening. The main Svelte application that controls these components is programmed to display only the sections the user wishes to have included in their day and has indicated as such on the web page (refer to Figure 5.1 for a better understanding of this). Therefore, the web page will look different for each day since it is tailored to every individual day of the trip. The following two subsections will describe these components with the questions they direct to the user.

5.3.4 Mealtime inputs

There were Svelte components developed for the **breakfast**, **lunch** and **dinner** sessions of the day that each has the same layout, programming and questions. Figure 5.5 presents the morning, afternoon and evening sections of the web page.

The figure displays three identical forms side-by-side, each for a different mealtime: Breakfast, Lunch, and Dinner. Each form is titled with its respective mealtime in red, underlined text. Below the title is a question in green: 'HOW LONG WOULD YOU LIKE FOR BREAKFAST?' (or Lunch/Dinner). This is followed by a time input field showing '02:00' and 'hours'. Below that is another green question: 'TYPE OF BREAKFAST PLACE:' (or Lunch/Dinner), followed by a dropdown menu currently set to 'Restaurant'. The final green question is 'POPULAR/HIDDEN GEM:', followed by two radio buttons labeled 'Popular' and 'Hidden gem'. At the bottom of each form is a 'Submit' button.

Figure 5.5: Display of the mealtime inputs

The mealtime components' inputs include:

- The amount of time the user would like to use for their meal (referred to as the **breakfast duration**, **lunch duration** and **dinner duration**).
- The **type** of food and beverage (FB) establishment they want to have their meal at, chosen from a drop-down list with the options: restaurant, café, takeaways, fine dining, bar or market.
- The user chooses whether they want to eat at a **popular** establishment or one that is considered a **hidden gem**. Options that are smaller, independent and not widely known are considered hidden gems.

The display of the results for breakfast, lunch and dinner options will be discussed in Section 5.7.

5.3 Browser user interface components

5.3.5 Activity session inputs

There were Svelte components developed for the **morning**, **afternoon** and **evening** times of the day, and all three have the same layout, programming and questions. The “morning session”, for example, is the time left after the user has enjoyed breakfast or the entire morning if they do not wish to set apart time for breakfast. The same process was followed for the afternoon and evening sessions. As explained in Subsection 5.3.3, the user can choose between *shopping* and *activity* for each session, and the process followed for each choice is described next.

5.3.5.1 Activity inputs

Figure 5.6 illustrates the questions asked when the user selects “Activity” for their afternoon session (as an example).

AFTERNOON SESSION:

INTEREST TYPE:

- Adventure & Nature
 - Art
 - Culture
- Entertainment
 - Relax
- Sightseeing
 - Sports

POPULAR OR HIDDEN GEM:

- Popular Hidden gem

Display afternoon activity options:

Figure 5.6: Display of the activity inputs (example of afternoon session)

The user inputs required for each of the morning, afternoon and evening components for an *activity*:

- The user’s three main **interests** selected from a drop-down list with the options: adventure and nature, arts, culture, entertainment, relax, sightseeing and sports.
- **Popular or hidden gem.**

5.4 Algorithm structure and functions

5.3.5.2 Shopping inputs

Figure 5.7 illustrates the questions asked when the user selects “Shopping” for their morning session (as an example).

MORNING SESSION:

SHOP CATEGORY RECOMMENDATIONS WANTED:

Figure 5.7: Display of the shopping inputs (example for morning session)

The user inputs required for each of the morning, afternoon and evening components of *shopping* only include the type of shops they would like to visit. This choice is made by selecting an option from a drop-down list including shopping malls, tourist shops, groceries, luxury stores and shops specialising in hobbies.

The display of the results for the morning, afternoon and afternoon options will be discussed in Section 5.7.

This section presented the BUI components with visual examples and descriptions of the inputs of each component. Together, these components form the front-end of the TIP demonstrator. The algorithm responsible for using the inputs from these components to create the resulting itinerary, will be discussed in the subsequent section.

5.4 Algorithm structure and functions

The previous section presented the front-end Svelte components and how they are displayed on the web page. It was also described how a request is sent *from* each front-end component *to* the corresponding section of Python code in the back-end. Together, these sections of code that respond to the Svelte requests form the complete algorithm programmed in the back-end.

This section discusses the programming completed for each component to perform the required data processing, query building and calculations needed to identify suitable POIs. It describes the coding of each separate component, which includes: what data is received, functions performed, SQL queries built and executed, and the response sent back to the front-end.

It is important to understand this *request-and-respond* relationship since it is how the front- and back-end of the TIP demonstrator are able to communicate. The code discussed in this section is what comes in between the *request* and *respond* actions.

5.4 Algorithm structure and functions

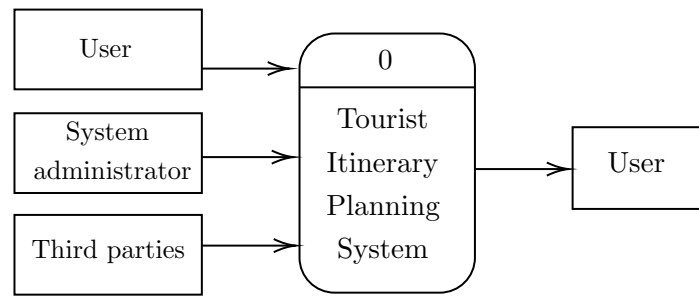


Figure 5.8: Data flow diagram of the Itinerary Planning System

Figure 5.8 provides a data flow diagram of the main *process*, the Itinerary Planning System, together with the flow of *data* to and from the *objects* present in the system. This provides a clear indication of where the algorithm obtains the information used to plan the itinerary as well as to whom it is given after execution.

All components receiving data from the user are discussed. The components that are related to the cost calculations of the itinerary will be discussed in the following section.

In each subsection, there will be referred to an ID of certain data records, which is the number given to every unique record in its respective table in the database. A further explanation of this will be provided in Section 5.6. Also, if a variable is written in capital letters, it is an indication that it is a global variable.

5.4.1 Code description: Initial inputs component

Table 5.1 presents an overview of the initial user input request and what the Python code produces in order to send back the required response. In certain cases, a variable received in the request is sent back in the response without any changes. This is still required when a *global variable* is to be created from that variable, which is performed when the Python response is received in the front-end.

5.4 Algorithm structure and functions

Table 5.1: Python code description of the initial user input component

Request received	<i>InitialInputRequest</i>
Data received in request	Destination, length of trip, total budget and mode of transport.
Functions performed in Python	Importing request data. Creating an array of the trip length. Write and execute SQL queries to obtain the City_ID and Transport_ID.
Data sent back in response	The trip length (to be stored as a global variable). The trip length array was created. The destination (to be stored as a global variable). The City_ID. The budget limit (to be stored as a global variable). The transport preference (to be stored as a global variable). The Transport_ID.

5.4.2 Code description: Accommodation component

Table 5.2 describes the accommodation request and what the Python code produces in order to send back the required response.

Table 5.2: Python code description of the accommodation component

Request received	<i>AccommRequest</i>
Data received in request	Accommodation type, POI type, niche, minimum rating, minimum price, maximum price and the CITY_ID.
Functions performed in Python	Importing request data. Create and execute SQL query to obtain the AccType_ID, POIType_ID and Niche_ID. Write and execute a SQL query to select the name of the accommodation records that fit the user constraints.
Data sent back in response	The list of accommodation recommendations.

5.4.3 Code description: Daily inputs component

Table 5.3 describes the daily inputs request and what the Python code produces in order to send back the required response. The programming for this component and those described in the following subsections are all repeated for each day of the trip (according to the length of the trip the user has specified).

5.4 Algorithm structure and functions

Table 5.3: Python code description of the daily inputs component

Request received	<i>DayInputRequest</i>
Data received in request	Daily budget, start of day time, end of day time, breakfast included/not, morning preference, lunch included/not, afternoon preference, dinner included/not, evening session wanted/not and the current day number.
Functions performed in Python	Importing request data. Creating dictionaries to store the preferences for each individual day for: breakfast, morning session, lunch, afternoon, dinner and evening session.
Data sent back in response	The daily budget. The start time of that day. The end time of that day. The dictionaries for breakfast included, morning preference, lunch included, afternoon preference, dinner included, and evening session wanted.

5.4.4 Code description: Mealtime components

The programming behind the breakfast, lunch and dinner components are similar, with minor differences because of the different times of the day at which they occur.

5.4.4.1 Breakfast component

Table 5.4 describes the *breakfast* request and what the Python code produces in order to send back the required response.

5.4 Algorithm structure and functions

Table 5.4: Python code description of the breakfast component

Request received	<i>BreakfastRequest</i>
Data received in request	Breakfast duration, breakfast enterprise type, breakfast POI (popular/hidden gem), start of day time, CITY_ID and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Write and execute SQL queries to obtain the POIType_ID and FoodBevType_ID.</p> <p>Define the breakfast Mealtimes_ID as '1' (breakfast) or '4' (brunch).</p> <p>Calculating the morning session start time.</p> <p>Write and execute a SQL query to select the name and transport of the FB records that fit the user constraints for breakfast.</p> <p>Adding these breakfast recommendations to the breakfast dictionary.</p>
Data sent back in response	<p>The breakfast duration.</p> <p>The morning session start time.</p> <p>The list of breakfast options.</p> <p>The updated breakfast dictionary.</p>

5.4.4.2 Lunch component

Table 5.5 describes the *lunch* request and what the Python code produces in order to send back the required response.

5.4 Algorithm structure and functions

Table 5.5: Python code description of the lunch component

Request received	<i>LunchRequest</i>
Data received in request	Lunch duration, lunch enterprise type, lunch POI (popular/hidden gem), CITY_ID and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Write and execute SQL queries to obtain the POIType_ID and FoodBevType_ID.</p> <p>Set the lunch start time to 12:00.</p> <p>Define the lunch Mealtimes_ID as '2' (lunch), '4' (brunch) or '5' (lunch and dinner).</p> <p>Calculating the afternoon session start time.</p> <p>Write and execute a SQL query to select the name and transport of the FB records that fit the user constraints for lunch.</p> <p>Adding these lunch recommendations to the lunch dictionary.</p>
Data sent back in response	<p>The lunch duration.</p> <p>The afternoon session start time.</p> <p>The list of lunch options.</p> <p>The updated lunch dictionary.</p>

5.4.4.3 Dinner component

Table 5.6 describes the *dinner* request and what the Python code produces in order to send back the required response.

5.4 Algorithm structure and functions

Table 5.6: Python code description of the dinner component

Request received	<i>DinnerRequest</i>
Data received in request	Dinner duration, dinner enterprise type, dinner POI (popular/hidden gem), CITY_ID end of day time and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Write and execute SQL queries to obtain the POIType_ID and FoodBevType_ID.</p> <p>Set the dinner start time to 18:00.</p> <p>Define the dinner Mealtime_ID as '3' (dinner) or '5' (lunch and dinner).</p> <p>Calculating the evening session start time.</p> <p>Write and execute a SQL query to select the name and transport of the FB records that fit the user constraints for dinner.</p> <p>Adding these dinner recommendations to the dinner dictionary.</p>
Data sent back in response	<p>The dinner duration.</p> <p>The evening session start time.</p> <p>The list of dinner options.</p> <p>The updated dinner dictionary.</p>

5.4.5 Code description: Morning and afternoon components

The coding behind the morning and afternoon components are similar except that they are for different time blocks of the day. The evening component is handled differently and is therefore described separately in Subsection [5.4.7](#).

5.4.5.1 Morning component

Table [5.7](#) describes the *morning* request and what the Python code produces in order to send back the required response.

5.4 Algorithm structure and functions

Table 5.7: Python code description of the morning session component

Request received	<i>MorningRequest</i>
Data received in request	Morning preference (activity/shopping), CITY_ID, start of day time, breakfast included/not, morning interests <i>or</i> shopping category (depending on morning preference) and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Set minimum budget used for the day to 0.</p> <p>Set maximum budget used for the day to 0.</p> <p>Calculate morning session start time (depending on breakfast being included or not).</p> <p>If <i>activity</i> was chosen:</p> <p>Create an array of tables to search for afternoon options (the user can choose up to three).</p> <p>Write and execute SQL queries to obtain the POIType_ID and Interest_IDs.</p> <p>Write and execute a SQL query to select the activity names of the activity records that fit the user constraints for the morning session.</p> <p>Write and execute SQL queries to find the record with the lowest and highest prices respectively.</p> <p>Adding the lowest price to the <i>minimum budget used</i> variable and the highest price to the <i>maximum budget used</i> variable.</p> <p>Write and execute a SQL query to select the activity name of the activity record with the lowest price (<i>i.e.</i> the “cheapest” option).</p> <p>Adding the above information to their respective dictionaries.</p> <p>If <i>shopping</i> was chosen:</p> <p>Write and execute a SQL query to obtain the ShopCategory_ID.</p> <p>Write and execute a SQL query to select the names of the shopping records that fit the user constraints.</p>
Data sent back in response	<p>The list of morning options (activity or shopping).</p> <p>The updated morning dictionary.</p> <p>The minimum budget used thus far.</p> <p>The maximum budget used thus far.</p>

5.4.5.2 Afternoon component

Table 5.8 describes the *afternoon* request and what the Python code produces in order to send back the required response.

5.4 Algorithm structure and functions

Table 5.8: Python code description of the afternoon session component

Request received	<i>AfternoonRequest</i>
Data received in request	Afternoon preference (activity/shopping), CITY_ID, lunch included or not, minimum budget used, maximum budget used, afternoon interests, <i>or</i> shopping category (depending on afternoon preference) and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Calculate afternoon session start time (depending on lunch being included or not).</p> <p>If <i>activity</i> was chosen:</p> <p>Create an array of tables to search for afternoon options (the user can choose up to three).</p> <p>Write and execute SQL queries to obtain the POIType_ID and Interest_IDs.</p> <p>Write and execute a SQL query to select the activity names of the activity records that fit the user constraints for the afternoon session.</p> <p>Write and execute SQL queries to find the record with the lowest and highest prices respectively.</p> <p>Adding the lowest price to the <i>minimum budget used</i> variable and the highest price to the <i>maximum budget used</i> variable.</p> <p>Write and execute a SQL query to select the activity name of the activity record with the lowest price (<i>i.e.</i> the “cheapest” option).</p> <p>Adding the above information to their respective dictionaries.</p> <p>If <i>shopping</i> was chosen:</p> <p>Write and execute a SQL query to obtain the ShopCategory_ID.</p> <p>Write and execute a SQL query to select the names of the shopping records that fit the user constraints.</p>
Data sent back in response	<p>The list of afternoon options (activity or shopping).</p> <p>The updated afternoon dictionary.</p> <p>The minimum budget used thus far.</p> <p>The maximum budget used thus far.</p>

5.4.6 Code description: Evening calculations component

The calculations in this component are only required if the user specifies that they would like evening recommendations in their itinerary. The code in this component determines whether there is enough time to include an evening session in the user’s day or not. This is calculated by evaluating if dinner is included, how long the dinner session is and what time the user wants to end their itinerary for the day.

5.4 Algorithm structure and functions

Table 5.9 describes the *evening calculations* request and what the Python code produces in order to send back the required response.

Table 5.9: Python code description of the evening calculations component

Request received	<i>EveningCalcRequest</i>
Data received in request	Dinner included/not, DINNER DURATION, evening session wanted, the end of day time and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>If dinner <i>is</i> included: Calculating the start time of the evening session using the dinner duration.</p> <p>If dinner <i>is not</i> included: Set the start time of the evening session to 18:00.</p> <p>Calculating the evening time available using the evening session start time and the end of day time. If the evening time available is less than two hours and the end of day time is earlier than 22:00, there is not enough time to include an evening session. Creating a dictionary to store if the evening session is included or not (eveningPOIncl).</p>
Data sent back in response	<p>The updated eveningPOIncl dictionary.</p> <p>The evening session start time.</p> <p>The time available for an evening activity.</p>

5.4.7 Code description: Evening components

There are two additional components that complete the programming of the evening session. Tables 5.10 and 5.11 describe the *evening inputs* and *evening* requests and what the Python code produces in order to send back the required response.

Table 5.10: Python code description of the evening inputs component

Request received	<i>EveningInputRequest</i>
Data received in request	The evening session preference (activity/nightlife) and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Creating and updating the dictionary for the evening session preferences of each day.</p>
Data sent back in response	The updated evening session preference dictionary.

5.5 Trip cost calculations

Table 5.11: Python code description of the evening component

Request received	<i>EveningRequest</i>
Data received in request	Evening session preference (activity/nightlife), CITY_ID, evening session start time, evening time available, minimum budget used, maximum budget used, the current day number, evening POI (popular/hidden gem) and evening interests.
Functions performed in Python	<p>Importing request data. Creating the dictionary for the evening session options.</p> <p>If <i>activity</i> was chosen: Creating an array of tables to search for evening options (user can choose up to three). Write and execute SQL queries to obtain the POIType_ID and Interests_IDs. Write and execute a SQL query to select the activity names of the activity records that fit the user constraints for the evening session. Write and execute SQL queries to find the record with the lowest and highest prices respectively. Adding the lowest price to the minimum budget used variable and the highest price to the maximum budget used variable. Write and execute the SQL query to select the activity name of the activity record with the lowest price (<i>i.e.</i> the “cheapest” option). Adding the above information to the evening dictionary.</p> <p>If <i>nightlife</i> was chosen: Write and execute SQL queries to select the names of the nightlife records that are available and fit the user constraints. Adding the above information to the evening dictionary.</p>
Data sent back in response	<p>The list of evening options (activity or nightlife). The updated evening dictionary. The minimum budget used thus far. The maximum budget used thus far</p>

This concludes the section that describes the inner workings of the Python algorithm, excluding the sections that perform the larger calculations. The following section will address these remaining calculation components.

5.5 Trip cost calculations

This section describes the programming behind the two remaining components: the daily cost calculations and the total trip cost calculations. These are required in order to create the combinations

5.5 Trip cost calculations

of morning, afternoon and evening activities for each day that fit within the specified budget. The mealtimes, shopping and nightlife POIs are not included in these calculations since the amount spent at these establishments would be different for each individual. This is also to create a balance between the fixed itinerary options while also providing the traveller with some freedom within the itinerary.

The data from the previous section is used in these calculations, including the available activity options for each session, the minimum and maximum budget used per day and the “cheapest” option of the day.

The following subsections will describe the use of coding to provide the daily combinations of activities presented to the user.

5.5.1 Code description: Daily cost calculations component

Table 5.12 describes the *daily cost calculations* request and what the Python code produces in order to send back the required response.

Table 5.12: Python code description of the cost calculations component

Request received	<i>CostCalcRequest</i>
Data received in request	Morning, afternoon and evening preferences, options and dictionaries, daily budget, evening session included/not, evening session preference (activity/nightlife) and the current day number.
Functions performed in Python	<p>Importing request data.</p> <p>Identifying combinations within budget.</p> <p>Assigning indexes (for the combinations array) according to which sessions include activities for the day.</p> <p>Creating all possible combinations of morning, afternoon and evening activity options.</p> <p>Removing combinations with duplicate activities (for when the user specified the same interest for two sessions).</p> <p>Calculating the total cost of the day for each combination by adding the prices of the activities for each day.</p> <p>Comparing these costs to the specified budget for the day.</p> <p>Identifying the combinations that are within budget.</p> <p>Finding the minimum and maximum cost of the day.</p> <p>Identifying the combination with the lowest cost.</p>
Data sent back in response	<p>The list of available combinations (within budget).</p> <p>The cost of the available combinations.</p> <p>The “cheapest” available option.</p>

The programming of the cost for each day involves calculations using the prices of the activity

5.5 Trip cost calculations

options of the specific day. Since the user can specify whether the itinerary must include a morning, afternoon and/or evening session, as well as if they want to perform an *activity* during that session, the calculations will include only the relevant data corresponding to the activity sessions included. For example, if the user specifies that a morning session involving an *activity*, an afternoon session involving *shopping* and no evening session must be included in the day's itinerary, the calculations would only include the prices of the morning activities.

Figure 5.9 illustrates an example of how the total cost of a day is calculated. In this specific scenario, the user selected *activity* as their preference for the morning, afternoon and evening sessions and therefore all three sessions are included in the cost calculation.

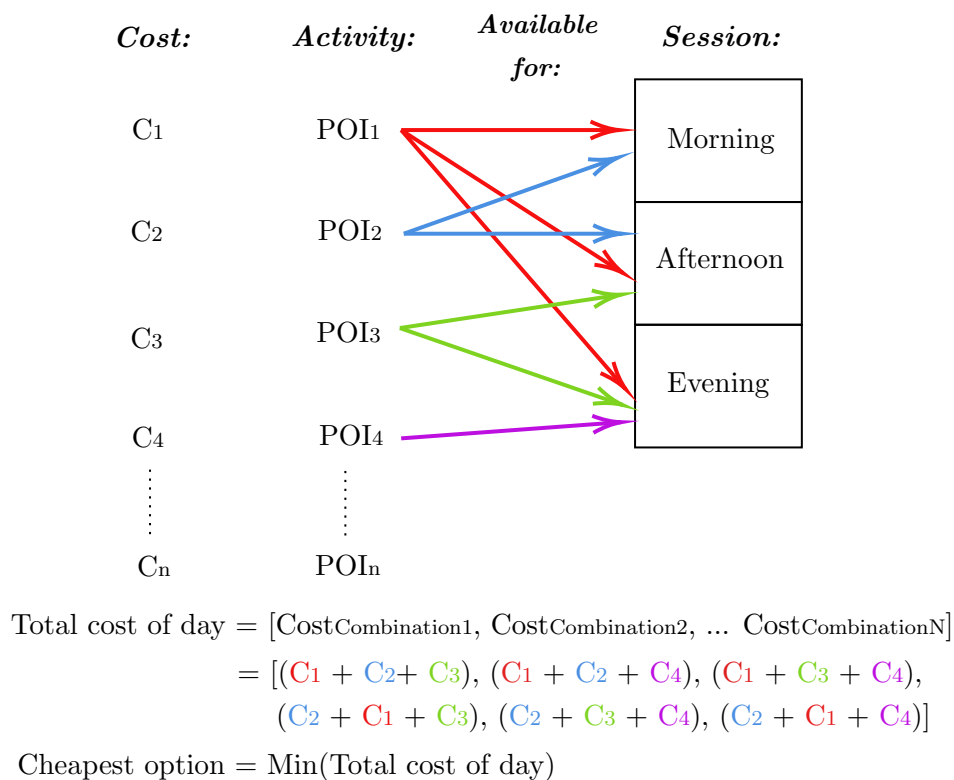


Figure 5.9: Example of creating combinations

As the user is navigated through the web page and the different questions, the morning, afternoon and evening session components were executed. As described in Tables 5.7, 5.8 and 5.11, these components contain a function that identifies all POIs that are available and conform to the user preferences for that specific session. Those POIs are listed as POI_1 to POI_4 in Figure 5.9 for this example, with their accompanying costs C_1 to C_4 . The arrows indicate the sessions during which each POI is available to be visited (according to the time available for the session and the trading hours).

Combinations are then created of the POIs available for the morning session, afternoon session and evening session. The “Total cost of day” array indicated in Figure 5.9 consists of the costs of

5.6 Database implementation

all possible combinations for the day. These combination costs are then evaluated and only those combinations within the specified budget are displayed to the user on the web page. The “cheapest” option is also determined and the user is then presented with the POIs they can visit if they would like to pursue this option.

5.5.2 Code description: Total trip cost calculations component

The previous subsection described how combinations of activities are created for each *individual day*. The next step is to join all of the days into a single itinerary, which is completed by comparing the different combinations of days. For example, each combination for Day 1 is joined with each combination for Day 2 and the total accumulative cost is determined. These new combinations are then compared in terms of price and the itinerary with the lowest cost is determined.

Table 5.13 describes the *total itinerary cost calculations* request and what the Python code produces in order to send back the required response.

Table 5.13: Python code description of the *total* itinerary cost calculations component

Request received	<i>BudgetCalcRequest</i>
Data received in request	All variables in cost calculations response.
Functions performed in Python	Importing request data. Adding the lowest price of each day together to create the total itinerary cost. Comparing this to the total budget specified in the initial inputs request. Establish what combinations of each day together provide the lowest total cost.
Data sent back in response	The total cost of the “cheapest” itinerary option. The accompanying activity combinations for each day of the itinerary (<i>i.e.</i> the final itinerary option).

5.6 Database implementation

For the TIP demonstrator to find suitable combinations for the user, it requires the construction of a database. This section describes the design, software, implementation and data procurement that were done to create this database as well as how it connects to the algorithm. This includes an explanation of each data entity and its role in the larger system and a discussion of how the content of the data entities was obtained.

The first step in the design of the database was to identify the data entities that must be created, and establish the relationships between them. This was done using an Extended Entity-Relationship Diagram (EERD). In the EERD, the *data entities* are the objects, events or people about which

5.6 Database implementation

data can be collected and that are represented by a *table*. Each entity contains *records*, represented by the *rows* in the table, and *attributes*, represented by the table *columns*. The EERD illustrates which entities can be associated with one another with the use of *relationships*.

Figure 5.10 presents the EERD developed for the database in this study. For an explanation of the conventions used, refer to Appendix B.

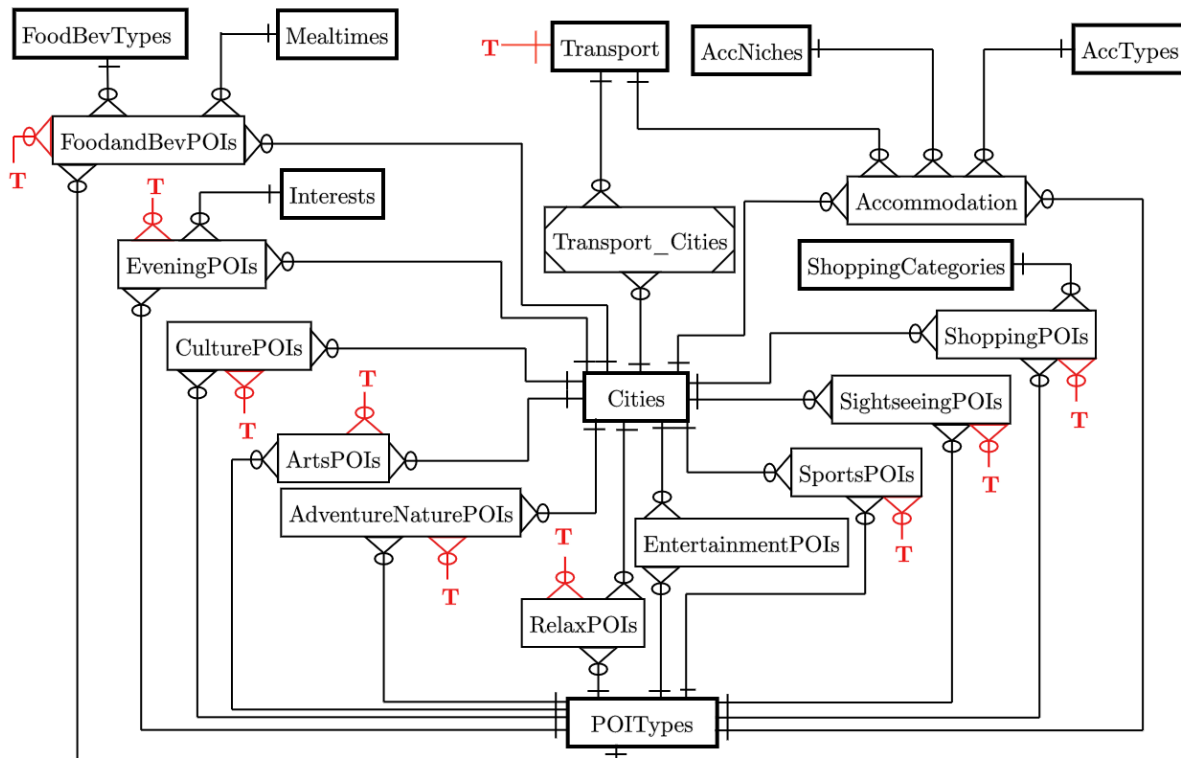


Figure 5.10: Extended Entity-Relationship Diagram (EERD) of the TIP system (note that the red symbols indicate cross-connections)

The entities and relationships illustrated in Figure 5.10 were implemented using MS SQL Server and the individual table for each entity was populated with the relevant data. In this study, the data is obtained through research performed by the system administrator, which is portrayed by the researcher as described in Section 4.3. Following this implementation, the database is created and queries can be executed to find suitable POI options.

The connection created to link the algorithm to the database allows it to receive queries from the Python code and executed them within MS SQL Server. After each query has run, the results are captured by the Python code and used in the TIP algorithm.

The following subsections present the different entities in the EERD. It includes a discussion of each entity and why it is required, each with an accompanying data dictionary (DD) that can be found in Appendix B.

5.6.1 Accommodation entities

The accommodation entities include all tables that contain data relating to the accommodation options recommended to the user:

- *Accommodation Types*: The primary entity that stores the different *types* that the accommodation POIs can be categorised as. The options are:
 1. Hotel
 2. [Airbnb \(2021\)](#)
 3. Hostel
 4. B&B
- *Accommodation*: An attributive entity containing the accommodation enterprises (referred to as POIs) and their relevant data. Table [B.2](#) provides the attributes used for this entity.
- *Accommodation Niche*: The primary entity that represents the different niches that further classify the accommodation. This is included to enable a more personalised selection of options that fits the type of ambience the user enjoys. The list of possible niches are:
 1. Modern
 2. Boutique
 3. Franchise
 4. Luxury

5.6.2 Meal-related entities

There are three entities that store the information needed to provide FB options to the user. These are:

- *Food and Beverage Type*: The primary entity that stores the different *types* that the FB POIs can be categorised as. The options are:
 1. Restaurant
 2. Café
 3. Takeaways
 4. Fine dining
 5. Bar
 6. Market

5.6 Database implementation

- *Food and Beverage POIs*: An attributive entity containing the FB enterprises (referred to as POIs) and their relevant data. Table B.5 provides the attributes used for this entity.
- *Mealtimes*: The primary entity that stores the time blocks that a day can be divided into. Each FB POI is assigned the mealtimes that correspond to their opening and closing times. The mealtimes are:
 1. Breakfast
 2. Lunch
 3. Dinner
 4. Brunch
 5. Lunch and dinner

5.6.3 Activity entities

There are many categories of POIs for the activities to be tailored more specifically to the user's personal preferences. The POIs that can be visited during the morning, afternoon and evening sessions are categorised according to the *type* of activities they can be described as. The following entities, except the evening POIs, have attributes as described in Table B.8. The activity entities are:

- *Adventure and Nature POIs*: The attributive entity containing all POIs that are considered adventurous activities or that take place within nature.
- *Arts POIs*: The attributive entity that contains the POIs that are parts of the arts scene, such as art museums and galleries.
- *Culture POIs*: The attributive entity that provides the cultural POIs, including museums, historical sites and theatre performances.
- *Entertainment POIs*: The attributive entity containing POIs that are part of the entertainment industry. These are the enterprises that provide any entertainment service, such as movie theatres, casinos and live shows.
- *Relax POIs*: An attributive entity that includes POIs the user can use to relax on their trips, such as spas, beaches and parks.
- *Sightseeing POIs*: The attributive entity containing places or activities that are considered "must-see" or "must-do" in their respective cities. This entity also includes any POIs that do not fit into any other category since *sightseeing* is a very broad term.

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- *Sports POIs*: The attributive entity that stores all POIs related to a sport, for example stadiums and sport museums.
- *Evening POIs*: An attributive entity that includes *all* POIs that can be attended during the evening session, including POIs from the adventure and nature, arts, culture, entertainment, relaxation, sightseeing and sports categories. This entity is similar to the others in this list, except that it focuses on establishments and activities available at night (according to their closing time). Table [B.9](#) describes the attributes used for this entity.

5.6.4 Shopping entities

The alternative option the user can choose to do during their morning or afternoon session is *shopping*. There are two entities created to provide the shopping recommendations, and these are:

- *Shopping POIs*: The attributive entity that contains the stores and shopping malls that can be visited during the available time in the morning or afternoon. The attributes used in this entity are listed in Table [B.10](#).
- *Shopping Categories*: The primary entity that stores the categories that all shopping establishments can be classified as, with attributes as described in Table [B.11](#). The options are:
 1. Shopping mall
 2. Tourist shops
 3. Groceries
 4. Luxury stores
 5. Hobbies

5.6.5 Other entities

The remaining entities required to perform the TIP process are discussed next.

- *Cities*: The primary entity that stores the different cities in which each POI can be found. The choices provided in this demonstrator are:
 1. Cape Town
 2. Johannesburg
 3. Amsterdam
 4. Paris
 5. New York

5.6 Database implementation

6. London
 7. Sydney
- *Interests*: The primary entity that provides the categories that the evening POIs can be classified into. These *interests* correlate to the individual POI categories listed in Subsection 5.6.3 and are:
 1. Adventure and nature
 2. Arts
 3. Culture
 4. Entertainment
 5. Relax
 6. Sightseeing
 7. Sports
 - *POI Type*: The primary entity that stores the different *types* that the accommodation and POIs can be categorised as. This classification is included to personalise the user's itinerary further and provide more specific options. The two POI types are:
 1. Popular
 2. Hidden gem: a term used to describe an activity or establishment that is less “well-known”, new in the area, or generally has fewer visitors per day and its more popular competitors.
 - *Transport*: The primary entity that provides the available transportation options for the user to travel to and from their accommodation and the POIs. These include:
 1. Car
 2. Bus
 3. [Uber \(2020\)](#)
 4. Train/Metro

The TIP database is the third and final component of the TIP demonstrator, together with the BUI and algorithm described in Sections 5.3 and 5.4. This concludes the section on the database implementation performed in this study. The subsequent section will present the resulting itinerary that the TIP demonstrator will produce.

5.7 Display of resulting itinerary

This section explains how the outputs from the TIP algorithm are displayed as results on the web page (on the front-end). As described in Sections 5.4 and 5.5, the Python algorithm produces a set of POIs for each “session” of the day and presents it to the user. These TIP demonstrator outputs are:

- A set of accommodation recommendations.
- A set of POIs for the: breakfast, morning session, lunch, afternoon session, dinner and evening session.
- The cost of each morning, afternoon and evening POI.
- The best transportation available for getting to the POI.
- The combinations of POIs that fit within the specified budget.
- All available options for the day.
- The lowest cost possible for the trip (that still allows for an enjoyable and activity-filled trip).
- If the trip can be completed within the specified budget or not, and if *not*, a notification to the user prompting them to restart the process on the web page.

Since the **accommodation** is handled separately before the planning of the individual days, the results are displayed directly after the user enters their accommodations preferences on the web page.

Then, the sets of POI results are displayed individually throughout the process of the user navigating through the web page. Each result is displayed at the end of the Svelte component that it relates to; for example, the lunch options are displayed directly after the questions about the user’s lunch preferences (as illustrated in Figure 5.5) are asked, and the afternoon POI results are displayed directly after the afternoon questions (as illustrated in Figure 5.6). This creates a flow of questions and answers from the first component of the day, Breakfast, to the last component, Evening.

The TIP demonstrator is created to be very *user-focused*; therefore, the results are displayed *throughout* the user’s navigation on the web page, creating a more interactive process. This keeps the user involved and holds their attention so that they will complete all the necessary questions up to the end of the web page.

5.8 Conclusion: System implementation

This chapter documented the implementation of the system architecture built in the previous chapter. This involved the development of the three main components of the demonstrator, as discussed in Section 4.5.

Firstly, the technology, tools and programming languages used in this study were listed, as well as an overview of the web application explaining the front- and back-end development. The BUI and its components were then discussed, which included the inputs obtained from the user. Next, the algorithm structure was presented with an in-depth description of the programming and functions of each component, including the calculations and code performed to create the final itinerary. Lastly, a discussion of how the demonstrator results are displayed to the user was presented. The subsequent chapter will describe and discuss the verification and validation of the TIP demonstrator.

Chapter 6

Verification and validation of the demonstrator

The previous chapter described the implementation of the system and how the tourist itinerary planning (TIP) demonstrator was built. To verify and validate that the browser user interface (BUI), algorithm, and database are integrated and operate correctly and that the incorporation of *personalisation* and *budget* is satisfactory, functional tests must be performed. Scenarios with different variables must be tested using the TIP demonstrator and the results evaluated, which fulfils Objectives VI and VII.

This chapter starts with an overview of verification and validation, after which the functional tests performed to address those will be presented. Each test will include a description of the scenario, a report of the results, and a discussion of the evaluation of these results.

6.1 Overview of verification and validation

Verification and validation are essential to the successful development of the TIP demonstrator since they display and confirm the functionality, performance and usefulness of the demonstrator. Law & Kelton (2014) states that *verification* is used to determine if the “model is built right” whereas *validation* confirms that “the right model is built”.

In this study, *continuous* verification and validation were performed as desk-level testing. This also agrees with the methodology of the Waterfall and Agile models described in Subsection 4.2.2, which enables the developer to identify any errors and immediately make the necessary improvements and changes.

Bekker (2019) states that the main action performed to *verify* that the model or demonstrator is “built right” is *debugging*. This was performed throughout the entire system development process, from concept development to design and implementation. Other actions involved checking logic and correcting syntax, compiling and run-time errors. This was done throughout the coding and execution of each component and the complete algorithm.

As for *validating* the TIP demonstrator, Law & Kelton (2014) states that a system must be tested and evaluated to confirm conceptual validity, credibility and operational validity. To do this, tests were performed to confirm that the resulting itinerary is correct according to the user preferences (**conceptual validity**) and that it recommends points-of-interest (POIs) that the user would visit in real-life (**operational validity**). This will also increase the user’s confidence in the TIP demonstrator and its recommended itinerary (**credibility**).

6.2 Introduction to functional testing

To facilitate the verification and validation described in this section, the TIP demonstrator was used to create itineraries for five different scenarios, which were:

1. A one-day business trip to Johannesburg.
2. A weekend (three-day) trip around Amsterdam with a balance of busy and relaxed days.
3. A day trip in New York City including shopping, popular attractions and the city's nightlife scene.
4. A two-day trip in Amsterdam with visits to a variety of different *types* of attractions and restaurants.
5. A weekend (two-day) trip in Paris packed with activities and luxury shopping excursions.

A discussion of the tests performed using these scenarios will be presented in the subsequent sections, together with the evaluation of the resulting itineraries. These descriptions mention the “user” as the person entering the preferences via the BUI and in this study the researcher acted as the user.

6.2 Introduction to functional testing

The subsequent chapters provide the testing performed to verify the functionality of the TIP demonstrator. The three main components, *i.e.* the (BUI), TIP algorithm and demonstrator database, are evaluated using different tests to demonstrate that each component performs its required functions and that they operate cohesively to form the complete TIP demonstrator. Note that all costs and budgets are in ZAR since the demonstrator is developed in South Africa and also to ensure continuity in the database.

6.3 Functional test 1

This section presents the first functional test executed with the accompanying discussion of the results.

Objective: To demonstrate that the front- and back-end of the TIP demonstrator are connected and can communicate data correctly.

This test addresses the functional requirement of *Intersection 1* in Figure 4.5 in Subsection 4.2.5.

To test the connection between the front- and back-end of the demonstrator, a set of user inputs is entered via the BUI. It is evaluated if the correct data is obtained by the Python algorithm and then also if the BUI receives the correct data in return. This is tested using the accommodation component

of the demonstrator, and a scenario is created with the following *general* and *accommodation-specific* information:

- **Destination:** Johannesburg
- **Length of trip:** 1 day
- **Total budget:** R12 000
- **Mode of transport preferred:** Car
- **Accommodation type:** Hotel
- **Popular or hidden gem:** Popular
- **Niche:** Luxury
- **Minimum rating:** 4 (out of 5)
- **Minimum price per person (p.p.) per night:** R1 500
- **Maximum price per person (p.p.) per night:** R10 000

The request for the accommodation recommendations received by the algorithm (for testing) is manually retrieved from the Python terminal:

```
Receive message {'inputAccType': 'Hotel', 'inputAccPOI': 'Popular', 'inputAccNiche': 'Luxury', 'inputMinRating': '4', 'inputMinPrice': '2000', 'inputMaxPrice': '15000', 'cityID': '2'}
```

The data in this request received by the Python algorithm agrees with the information the user entered via the BUI, for example, the user specified that they want a *popular* place to stay and the algorithm received *popular* as the value for the *inputAccPOI* variable in the request. Since the value of each variable was correctly transferred from the web page to the algorithm, it is clear that the **front-end to back-end** connection performs correctly.

After the algorithm received this request, the relevant section of code was executed. The three accommodation options identified by the algorithm (according to the user preference constraints) are the 54 on Bath hotel, the Residence Boutique Hotel and the Clico Boutique Hotel.

The front-end then received the following response:

```
Sent message ['54 on Bath', 'The Residence Boutique Hotel', 'Clico Boutique Hotel'] on event channel responseAcc
```

The three options identified by the algorithm and the options received by the web page in the front-end, as shown above, are the same. This confirms that the information was correctly transferred from the algorithm to the web page and that the **back-end to front-end** connection performs correctly.

Similar tests with other options were conducted but not reported, and they all yielded correct data transfers.

6.4 Functional test 2

This section discusses the second functional test performed in this study.

Objective: To confirm that the calculations, coding functions, queries and programming loops operate correctly in all scenarios, even under extreme data selections.

This test addresses the functional requirements of *Intersections 1, 2 and 6* in Figure 4.5 in Subsection 4.2.5.

For this functional test, the TIP demonstrator is used to plan a three-day trip and the resulting POI options and combinations are then evaluated and discussed. The scenario created for this test includes the following initial user inputs:

- **Destination:** Amsterdam
- **Length of trip:** 3 days
- **Total budget:** R1 200
- **Mode of transport preferred:** Train/Metro

The user preferences for each individual day were chosen to exhibit an itinerary with a *tight* budget and a *relaxed* schedule for Day 1, a *large* budget and *busy* schedule for Day 2 and an *average* budget with a *moderately busy* schedule for Day 3. It is to be verified that the TIP demonstrator can perform sufficiently when *extreme* data selections are made.

The remaining user inputs for each individual day are given in Table 6.1. The TIP demonstrator captured these inputs and executed the algorithm.

6.4 Functional test 2

Table 6.1: Functional test 2: User inputs

User input	Day 1	Day 2	Day 3
Budget for the day	R100	R700	R400
Start of day	10:00	09:00	09:30
End of day	20:00	22:00	21:00
Breakfast included	No	Yes	No
Activity/Shopping for the morning session	Shopping	Activity	Activity
Lunch included	No	Yes	Yes
Activity/Shopping for the afternoon session	Activity	Activity	Activity
Dinner included	Yes	Yes	Yes
Evening POI wanted	No	Yes	Yes
Enough time for the evening POI?	N/A	Yes	No
Breakfast duration		02:00	
Type of breakfast place	N/A	Café	N/A
Popular/Hidden gem		Hidden gem	
Morning interest type(s)		Adventure/Nature, Relax	Adventure/Nature
Popular/Hidden gem	N/A	Popular	Hidden gem
Morning shopping category	Groceries	N/A	N/A
Lunch duration		02:00	01:00
Type of lunch place	N/A	Fine dining	Takeaways
Popular/Hidden gem		Popular	Hidden gem
Afternoon interest type(s)	Arts, Culture	Arts, Sightseeing, Entertainment	Arts, Entertainment
Popular/Hidden gem	Popular	Hidden gem	Popular
Afternoon shopping category	N/A	N/A	N/A
Dinner duration	01:30	01:30	02:00
Type of dinner place	Restaurant	Takeaways	Fine dining
Popular/Hidden gem	Hidden gem	Popular	Popular
Activity/Nightlife for evening session	N/A	Activity	N/A
Evening interest type(s)		Entertainment, Relax	
Popular/Hidden gem	N/A	Popular	N/A

6.4.1 Functional test 2: Results for Day 1

Table 6.2 presents the resulting POIs that fit the user preferences and are within the budget specified for Day 1.

Table 6.2: Functional test 2: Results for Day 1

Session	POI options identified for Day 1
Breakfast	N/A
Morning	Mirna Supermarkt Spar International B.V. Jumbo City
Lunch	N/A
Afternoon	Moco Museum @ R270 Van Gogh Museum @ R325 Rijksmuseum @ R240 Anne Frank House @ R240 Royal Palace Amsterdam @ R10 Cannabis Museum Amsterdam @ R171 TROPENMUSEUM @ R172 Rembrandt House Museum @ R221
Dinner	De Vergulden Eenhoorn Oma Letje
Evening	N/A

The user preferences specified for Day 1, as described in Table 6.1, indicate that the user did not want to spend a lot of money on activities and wanted a relaxed schedule. The itinerary displayed on the BUI only included recommendations for shops to visit in the morning, activities for the afternoon and two dinner options, with the rest of the day given as free time.

The process of creating combinations of activities for the day (as described in Subsection 5.5.1) was also executed, and the results were displayed on the BUI. A list of combinations of one morning activity, one afternoon activity and one evening activity each was created. This did *not* include any shopping or food and beverage (FB) POIs. Since Day 1 has a relaxed schedule, the user only specified “activity” for the afternoon session, and consequently no activities were identified for the morning or evening for this day. Therefore, the budget of R100 had to cover only the afternoon activity.

The only option for the afternoon activity was the *Royal Palace Amsterdam* at R10 p.p. The options for this session are limited because of the tight budget and the personalisation constraints. The POIs that are classified as “Culture” are generally more expensive than some of the other available interests, such as Adventure/Nature or Relax, which have more POIs that are free or low

cost. Therefore, if one of those interests were also selected on the BUI when asked for the afternoon activity preference, more POI options could have been identified. This shows the TIP demonstrator's ability to incorporate both *personalisation* and *budget*, as well as its behaviour when confronted with stringent constraints.

6.4.2 Functional test 2: Results for Day 2

For Day 2, the user chose “activity” for the morning, afternoon *and* evening sessions and all meals included for the day, which will provide a very busy schedule. A budget of R700, as it was chosen for Day 2, is considered a *large* budget for this TIP demonstrator since it still allows for a *personalised* itinerary. If, for example, the budget was R500 for a single day, the set of available POI options would be too large to be considered “personalised”. The balance between *personalisation* and *budget* is a vital characteristic of the demonstrator developed in this study, and a trade-off must be made to ensure that both are always obeyed. Therefore, the R700 budget for Day 2 was chosen to allow for a realistic set of POI combinations.

The resulting POIs that fit the user preferences specified for Day 2 are presented in Table 6.3.

The user preferences specified for Day 2, as described in Table 6.1, indicate that the user has a large budget for Day 2 that must cover their *busy* schedule for the day.

Combinations of the activity POIs listed in Table 6.3 were created, and the combinations that were *not* within the budget were eliminated. The remaining combinations were then presented to the user on the web page. Since the user selected *three* interests for the afternoon session, there are many POI options for the afternoon and consequently many different combinations for the day. Two examples of these are:

- **Combination 1:** Westerpark in the morning from 11:00 to 12:00, the NXT Museum between 14:00 and 18:00 in the afternoon and an Amsterdam Canal Ring Cruise between 19:30 and 22:00 in the evening (for a total of R640).
- **Combination 2:** Rembrandtplein in the morning from 11:00 to 12:00, the Electric Ladyland between 14:00 and 18:00 in the afternoon and BIMHUIS between 19:30 and 22:00 in the evening (for a total of R425).

The morning, afternoon and evening POIs were correctly added together to create the combinations displayed on the BUI, since they correlate with the POI options identified in the independent sessions presented in Table 6.3.

A narrowed-down list of combinations was then presented on the BUI as the “cheapest” itinerary for the day, at a total cost of R230:

- **Morning session:** Westerpark or Rembrandtplein (both R0).

Table 6.3: Functional test 2: Results for Day 2

Session	POI options identified for Day 2
Breakfast	Ree 7 De Koffieschenkerij Bakhuys Lebkov & Sons Bijlmer Arena Greenwoods Singel
Morning	Westerpark @ R0 Rembrandtplein @ R0
Lunch	Sinne Restaurant Moon
Afternoon	NXT Museum @ R410 Willet-Holthuysen Museum @ R170 NDSM @ R311 The yawner gable stone @ R0 The statue of the little woodcutter @ R0 Sculptures under the Vondelpark viaduct @ R0 Electric Ladyland @ R85 The Upside Down @ R25 Royal cinema Pathé Tuschinsk @ R10 The Milkmaid Project @ R1 700 Sherlocked Escape Rooms @ R510 Plan B @ R212 OBA Library of Amsterdam @ R0 Molen Van Sloten @ R136 Hortus Botanicus Amsterdam @ R204 Minigolf Amstelpark @ R153 Het Pappegaaï @ R0 The Proverbs of the Oude Kerk @ R120 Karthuizerhofje @ R0 Westerstraat 54 Hidden Miniature Houses @ R0
Dinner	Wok To Walk Sugo Manneken Pis Damrak Dutch Dabbawala
Evening	BIMHUIS @ R340 Amsterdam Canal Ring Cruises @ R230 Amsterdam Icebar Experience @ R462

- **Afternoon session:** The yawner gable stone, the statue of the little woodcutter, the sculptures under the Vondlepark viaduct, OBA Library of Amsterdam, Het Pappegaai, Karthuizerhofje or Westerstraat 54 Hidden Miniature Houses (all R0).
- **Evening session:** Amsterdam Canal Ring Cruises (R230).

As mentioned in Subsection 6.4.1, some interests have multiple POIs that are free to visit; therefore, a *single* combination cannot be identified as the “cheapest”. Consequently, a combination of one POI from each session listed above is considered the “cheapest” option.

The TIP demonstrator’s functionality in terms of time and the duration of activities and meals are also verified in this test. The day begins at 09:00, as the user specified and the itinerary starts with a breakfast of two hours. The user also wanted lunch included, and therefore the time available for the morning session is one hour between 11:00 and 12:00. Westerpark and Rembrandtplein, both with a duration of one hour, were the only available options since most of the “Adventure/Nature” and “Relax” activities take longer than an hour to complete or visit. For example, the ARTIS Amsterdam Royal Zoo would have been an option since it is also a popular adventure/nature POI that opens before 11:00, but it has a duration of three hours and is therefore eliminated because of the time constraint.

The BUI notified the user that a calculation was performed to determine if there is enough time between the end of dinner and the end of the day for an evening session. For this day, the BUI displayed that there *was* enough time for an evening session, and it prompted the user for their preferences. Since dinner starts at 18:00 (which is the fixed dinner start time used in the algorithm) and the user wanted an hour and 30 minutes for the meal, the time at which dinner ends and the evening session starts is 19:30. The user specified 22:00 as the end of their day, which leaves two hours and 30 minutes for an evening POI. The activities listed in Table 6.3 for the evening have durations of one or two hours, which agrees with the time available for the evening session.

6.4.3 Functional test 2: Results for Day 3

For Day 3, the user chose an average budget of R400 and a moderate schedule with preferences as described in Table 6.1. The resulting POIs that accommodate the user preferences specified for Day 3 are presented in Table 6.4.

Table 6.4: Functional test 2: Results for Day 3

Session	POI options identified for Day 3
Breakfast	N/A
Morning	Oosterpark @ R0 Rembrandtpark @ R0 Beatrixpark @ R0
Lunch	Fat Phill's Diner
Afternoon	Moco Museum Amsterdam @ R270 Van Gogh Museum @ R325 Anne Frank House @ R240 Amaze Amsterdam @ R460 A'dam Lookout @ R240 A'dam Lookout (Swing incl.) @ R375 Heineken experience @ R340 Ripley's Believe It or Not! Amsterdam @ R375 The Amsterdam Dungeon @ R450 VRGH ARENA @ R680 Lightning VR Amsterdam @ R620
Dinner	De Silveren Spiegel Spectrum Sinne Restaurant Vermeer Restaurant Daalder The Duchess Restaurant Moon
Evening	N/A

The same process of creating combinations as described for Days 1 and 2 was then executed by the algorithm. However, the combinations for Day 3 only include morning and afternoon activities which agrees with the user preferences. Many POI combinations were identified, including the following two examples:

- **Combination 1:** Rembrandtpark in the morning from 09:30 to 12:00 and the Van Gogh Museum between 13:00 and 18:00 in the afternoon (for a total of R325).
- **Combination 2:** Beatrixpark in the morning from 09:30 to 12:00 and Ripley's Believe It or Not! Amsterdam between 13:00 and 18:00 in the afternoon (for a total of R375).

The morning and afternoon POIs were correctly formed to create the combinations displayed on the BUI, since they correlate with the POI options identified in the individual sessions presented in

Table 6.4.

A narrowed-down list of combinations was then presented on the BUI as the “cheapest” itinerary for the day, at a total cost of R240:

- **Morning session:** Oosterpark, Rembrandtpark or Beatrixpark (all R0).
- **Afternoon session:** Anne Frank House or A’dam Lookout (both R240).

The itinerary for Day 3 also contains multiple POIs that are free to visit/enter. Therefore, there is also not a single “cheapest” combination, but rather four possibilities that each included one morning POI and one afternoon POI from the list above.

A notable observation regarding the total costs of Days 2 and 3 is that the “cheapest” option for Day 2 costs less than that of Day 3, even though Day 2 has a larger budget. This is as a result of the interests specified for each day. For Day 2, two interests were selected for the morning session and three for the afternoon, whereas Day 3 only included POIs from one interest for the morning session and two for the afternoon. Therefore, the TIP demonstrator identified a larger set of POIs for Day 2 than for Day 3, as presented in Tables 6.3 and 6.4, which increases the possibility of cheaper combinations. Another difference between Days 2 and 3 is that the user selected “Hidden gem” for Day 2 and “Popular” for Day 3. On average, the POIs classified as “Popular” are more expensive than those classified as “Hidden gem”, which also has an impact on the overall cost of activities.

When comparing the POIs identified for Days 2 and 3, it is noted that the lunch POIs for Day 2 and the dinner POIs for Day 3 are different, even though the preferences of two hours, “Fine dining” and “Popular” were the same for both days. This is as a result of the lunch being from 12:00 to 14:00 and the dinner from 18:00 to 20:00 and there being different FB establishments open at those times.

Another observation made upon comparison of the two days is that there is no evening session included for Day 3, even though the user specified that they would like it included (the same as for Day 2). The dinner on Day 3 ends at 20:00 and since the user wanted to end their day at 21:00, there was not enough time to include an evening session because most evening activities have a duration of more than one hour.

Both of these observations verify the *time* functionality of the TIP demonstrator. The opening and closing times of the FB establishments were correctly compared to the mealtimes in the user’s schedule and the time left between dinner and the end of the day was correctly calculated and evaluated to make the conclusion that there is not enough time for an evening session.

After the planning of each day via the BUI, the “cheapest” total cost of activities for the trip was displayed, which was R470. This is well within the total budget, which verifies the TIP demonstrator’s successful cost calculation functionality.

6.5 Functional test 3

This section provides a discussion of the third scenario that was tested using the TIP demonstrator.

Objective: To demonstrate that the database contains *sufficient* records with accurate and consistent data.

This test addresses the functional requirements of *Intersections 3, 4 and 5* in Figure 4.5 in Subsection 4.2.5.

In order for the algorithm to create suitable combinations of POI options according to the user preferences, the data in the SQL database must be *accurate* and *consistent*. The algorithm contains SQL queries that extract records from the database that are then presented in user view format. These records must contain the information of real-life POIs that the user would take the time to visit, and in doing so it eliminates the process of the user manually searching for activities themselves using a plethora of websites.

The attributes of each record were chosen to provide all relevant information regarding that specific POI. Each table has different attributes since it represents a unique entity, and these are given in the data dictionary (DD) in Appendix B. For example, for the algorithm to identify the correct FB establishments, each record in the *tbl_FoodandBevPOIs* table must contain a *City_ID* representing the city it is in, a *Mealtime_ID* that describes the time of day that it receives the most customers, the *type* of establishment it is (for example a restaurant or a market), the opening and closing times, the *POIType_ID* labelling the POI as “Popular” or “Hidden gem” and the *Transport_ID* that relates to the type of transportation most accessible for the establishment.

This can be seen in Table 6.5, which presents five records from the *tbl_FoodandBevPOIs* table, and Table 6.6, which presents 5 records from the *tbl_AdventureNaturePOIs* table. The *ID* columns in the SQL tables contain numbers relating to other tables, but the descriptions of those IDs are given here.

The records from Tables 6.5 and 6.6 were searched online and the data in the tables was compared to the information found on the websites of the POIs. The data matched the information of the POIs, which confirms that the records in the SQL database are *accurate*.

To test if the SQL database is *consistent*, the demonstrator is used to plan two separate one-day trips with the same user preferences. The first trip is planned normally, after which records were added to the relevant tables, and the same trip is planned again for a second time. The POI options identified by the algorithm for both trips are then compared to evaluate if the newly added records are included or not.

Table 6.5: Records in *tbl_FoodandBevPOIs*

Food-Bev_ID	Name	City_ID	Mealtime_ID	FoodBev-Type_ID	Opening time	Closing time	POI-Type_ID	Transport_ID
2	La Parada V&A Waterfront	Cape Town	Lunch and dinner	Fine dining	11:00	00:00	Popular	Car
46	Café Kuijper	Amsterdam	Lunch	Café	09:00	16:00	Popular	Bus
62	Prison Break Market	Johannesburg	Brunch	Market	09:00	21:00	Hidden gem	Car
184	The Lighthouse Bar and Club	London	Dinner	Nightclub	17:00	00:00	Popular	Uber
195	Golden Diner	New York City	Lunch and dinner	Takeaway	10:00	22:00	Popular	Uber

Table 6.6: Records in *tbl_AdventureNaturePOIs*

Activity_ID	Activity name	Entry price	City_ID	Opening time	Closing time	Duration	POI-Type_ID	Transport_ID
1	Kirstenbosch National Botanical Garden	R200	Cape Town	08:30	17:30	02:00	Popular	Car
10	Vondelpark	Free	Amsterdam	05:00	00:00	03:00	Popular	Uber
20	Parc de Baratelle	Free	Paris	09:30	20:00	02:00	Hidden gem	Uber
24	Central Park	Free	New York City	05:00	00:00	03:00	Popular	Uber
25	Acrobranch Melrose	R500	Johannesburg	09:00	17:00	03:00	Popular	Car

The scenario created for this test includes the following initial user inputs:

- **Destination:** New York City
- **Length of trip:** 1 day
- **Total budget:** R500
- **Mode of transport preferred:** Uber

The remaining user inputs are given in Table 6.7.

Table 6.7: Functional test 3: User inputs

User input	Day 1
Budget for the day	R500
Start of day	09:30
End of day	21:00
Breakfast included	No
Activity/Shopping for the morning session	Shopping
Lunch included	Yes
Activity/Shopping for the afternoon session	Activity
Dinner included	No
Evening included	Yes
Morning shopping category	Tourist
Lunch duration	02:00
Type of lunch place	Market
Popular/Hidden gem	Popular
Afternoon interest type(s)	Arts
Popular/Hidden gem	Popular
Activity/Nightlife for the evening session	Nightlife

The TIP demonstrator captured these inputs and executed the algorithm. The following POIs were then added to the relevant tables in the SQL database:

1. **Grand Bazaar NYC:**

- Table: *tbl_ShoppingPOIs*
- City: New York City
- Opening time: 10:00
- Closing time: 17:00
- Shopping category: Tourist
- Transport: Uber

2. Essex Street Market:

- Table: *tbl_FoodandBevPOIs*
- City: New York City
- Mealtime: Lunch and dinner
- Food and beverage type: Market
- Opening time: 08:00
- Closing time: 20:00
- POI type: Popular
- Transport: Uber

3. Brooklyn Museum:

- Table: *tbl_ArtsPOIs*
- City: New York City
- Entry price: R270
- Opening time: 11:00
- Closing time: 18:00
- Duration: 02:00
- POI type: Popular
- Transport: Uber

4. Karasu:

- Table: *tbl_FoodandBevPOIs*
- City: New York City
- Mealtime: Lunch and dinner
- Food and beverage type: Restaurant
- Opening time: 11:00
- Closing time: 00:00
- POI type: Hidden Gem
- Transport: Uber

5. The Campbell:

- Table: *tbl_FoodandBevPOIs*
- City: New York City
- Mealtime: Lunch and dinner
- Food and beverage type: Bar
- Opening time: 12:00
- Closing time: 00:00
- POI type: Hidden gem
- Transport: Uber

Table 6.8 presents the resulting POI options that were identified by the SQL queries *before* and *after* the addition of new POIs.

Table 6.8: Functional test 3: Results

Session	POI options identified	POI options identified (after adding records)
Morning	Chelsea Flea Market Canal Street Market The Seaport Dover Street Market NY Artists & Fleas Chelsea Housing Works thrift shops - Soho	Chelsea Flea Market Canal Street Market The Seaport Dover Street Market NY Artists & Fleas Chelsea Housing Works thrift shops - Soho Grand Bazaar NYC
Lunch	Grand Central Market Union Square Green Market Urbanspace Chelsea Market	Grand Central Market Union Square Green Market Urbanspace Chelsea Market Essex Street Market
Afternoon	The Museum of Modern Art The Metropolitan Museum of Modern Art American Museum of Natural History	The Museum of Modern Art The Metropolitan Museum of Modern Art American Museum of Natural History Brooklyn Museum
Evening	Fraunces Tavern McSorley's La Noxe Bar Centrale	Fraunces Tavern McSorley's La Noxe Bar Centrale The Campbell

As seen in Table 6.8, the algorithm correctly included the applicable *newly added* POIs in the itinerary. For example, the Essex Street Market is one of the recommendations for the lunch session, since it is in the specified city, and all its attributes are aligned with the user preferences (as described in Table 6.7). The remaining *new* POIs were included in the itinerary where they conform to the user preference constraints. Therefore, Grand Bazaar NYC, Brooklyn Museum and The Campbell were included, but the Karasu restaurant was not since it is categorised as a *restaurant* and *hidden gem* which do not match the user inputs. It follows from the results for this test that the SQL database *consistently* stores, updates, and presents the data records.

6.6 Functional test 4

This section presents the fourth functional test executed with the accompanying discussion of the results.

Objective: To confirm that the options identified by the algorithm *do* conform to the specified user preferences.

This test addresses the functional requirements of *Intersections 2 and 6* in Figure 4.5 in Subsection 4.2.5.

For this functional test, the TIP demonstrator is used to plan a two-day trip and the resulting point-of-interest (POI) options are then compared to the specified user preferences. The scenario created for this test includes the following initial user inputs:

- **Destination:** Amsterdam
- **Length of trip:** 2 days
- **Total budget:** R2 300
- **Mode of transport preferred:** Bus

The remaining user inputs for each individual day are given in Table 6.9.

Table 6.9: Functional test 4: User inputs

User input	Day 1	Day 2
Budget for the day	R800	R1 500
Start of day	09:00	10:00
End of day	20:00	23:00
Breakfast included	Yes	No
Activity/Shopping for morning session	Shopping	Activity
Lunch included	No	Yes
Activity/Shopping for afternoon session	Activity	Shopping
Dinner included	Yes	Yes
Evening POI included	No	Yes
Breakfast duration	01:30	
Type of breakfast place	Cafe	N/A
Popular/Hidden gem	Popular	
Morning interest type(s)		Art, Culture and Sightseeing
Popular/Hidden gem	N/A	Hidden gem
Morning shopping category	Shopping mall	N/A
Lunch duration		01:30
Type of lunch place	N/A	Restaurant
Popular/Hidden gem		Popular
Afternoon interest type(s)	Relax, Sightseeing	
Popular/Hidden gem	Popular	N/A
Afternoon shopping category	N/A	Tourist
Dinner duration	02:00	02:00
Type of dinner place	Restaurant	Fine dining
Popular/Hidden gem	Popular	Popular
Activity/Nightlife for evening session	N/A	Activity
Evening interest type(s)		Entertainment
Popular/Hidden gem	N/A	Hidden gem

The TIP demonstrator captured these inputs and executed the algorithm. Table 6.10 presents the resulting POI options that were identified by the algorithm.

Table 6.10: Functional test 4: Results

Session	POI options identified for Day 1	POI options identified for Day 2
Breakfast	Sango Specialty Coffee	N/A
Morning	De Hallen Amsterdam The Kalvertoren Magna Plaza Gelderlandplein De Bijenkorf Amsterdam De Beurspassage De 9 Straatjes Amsterdamse Poort Winkelcentrum Rooswijk	NXT Museum @ R24 Het Scheepvaartmuseum @ R17 OBA Library of Amsterdam @ R0
Lunch	N/A	Esther's Cookery Boaz Amsterdam Ta Toru
Afternoon	The Amstel @ R0 Rembrandtplein @ R0 Centraal Station @ R0 NEMO Science Museum @ R305 Dam Square @ R0 Amsterdam Canal Ring @ R0 Museum Quarter @ R0 Herengracht @ R0 Red Light District @ R0	The Jordaan Albert Cuyp Market Noordermarkt I Amsterdam store Dam Square Souvenirs Dutch Souvenirs Shop
Dinner	Midtown Grill Esther's Cookery Guru Restaurant Mr. Meat Ta Toru Lumbini Indian & Nepalese Restaurant	De Silveren Spiegel Spectrum Sinne Restaurant Vermeer Restaurant Daalder The Duchess Restaurant Moon
Evening	N/A	Roller Dreams @ R338

Combinations of the results presented in Table 6.10 were then created and filtered to present those within the budget. However, this will not be discussed here since is not relevant to the objective of this test. Each POI given in Table 6.10 was manually retrieved from the SQL database and the attributes compared to the user preferences in Table 6.9. Two examples are presented to illustrate this evaluation process:

- **Magna Plaza:** The record for Magna Plaza is located in table *tbl_ShoppingPOIs* and has a *City_ID* that represents *Amsterdam*. It is open from 10:00 until 21:00 and is categorised as a *shopping mall*. Following the start time of the day and breakfast duration, the morning session is from 10:30 until 12:00; therefore, visiting the Magna Plaza is available during this time. All attributes of this record match the user preferences captured on the web page (and displayed in Table 6.9).
- **Boaz Amsterdam:** The record for Magna Plaza is located in table *tbl_FoodandBevPOIs* and has a *City_ID* that represents *Amsterdam*. It is categorised as a *restaurant* with a *Meal-time_ID* corresponding to *brunch* (which indicates that it is visited most during breakfast- and lunchtime). Boaz Amsterdam’s trading hours are 10:00 to 20:00, and it is, therefore, open during the user’s lunchtime for Day 1 (12:00 to 13:30). It is also classified as a *popular* establishment, which is what the user specified for lunch.

The attributes for each record in Table 6.10 were evaluated in the same manner as described in these two examples. *All* records identified by the algorithm for this scenario satisfy the user preferences captured via the BUI.

The outcome of this test demonstrates the TIP demonstrator’s ability to provide personalised results that satisfy the user preferences. The algorithm, therefore, correctly filters the options to eliminate any POIs the user does not want and only provides options that they would pursue in real life.

6.7 Functional test 5

This section provides a discussion of the final scenario that was tested using the TIP demonstrator.

Objective: To demonstrate that the BUI is dynamic, easy to use and shows the correct components according to the user inputs.

This test addresses the functional requirement of *Intersection 7* in Figure 4.5 in Subsection 4.2.5.

To test the behaviour of the BUI, a two-day trip is planned using the TIP demonstrator and the selection of HTML elements and components that are shown, as well as the navigation through the web page are then evaluated. These must all operate sufficiently for the BUI to be *dynamic* and easy to use.

The first component that the user interacts with on the web page is the “initial user inputs” component. Figure 6.1 shows the initial user inputs used in the scenario created for this test.

INITIAL USER INPUTS

DESTINATION

LENGTH OF TRIP

days

TOTAL BUDGET

R

MODE OF TRANSPORT PREFERRED:

Figure 6.1: Display of the initial user inputs for functional test 5

Figure 6.1 also shows the *HTML input types* used to obtain the user preferences. Since the user must choose an option from a predetermined list of destinations and transport types, these inputs are obtained using **drop-down menus**. For the length of trip and total budget preferences, the user must enter any amount they would like, and therefore **number** inputs are used to obtain that information. Finally, there is a **submit** input used to capture the user preferences and send them to the back-end of the TIP demonstrator.

Each input type is chosen according to the type of information that must be obtained from the user for that *specific* user preference. The elements used are also familiar to most users, which would make them feel comfortable while using the BUI, and add to a positive overall user experience. This consideration in the selection of elements is followed for the user preferences in all the components following the “initial user inputs” component as well. Section 6.3 provides a test that confirms the successful connection between the front- and back-end connection and this also verifies that the HTML elements correctly capture the user information.

Additionally, Figure 6.1 also displays the prompts and language used to question the user. These instructions are clear and concise, which attempt to avoid any confusion while not including any unnecessary words.

The descriptions of the components and inputs from Days 1 and 2 are discussed side by side in order to compare the results from the two separate days. However, on the BUI, the user completes *all* inputs for Day 1 first, and the process is then repeated for Day 2. The user preferences captured via the “general daily inputs” component for both days are given in Table 6.11.

Table 6.11: Functional test 5: Day 1 general input

User input	Day 1	Day 2
Budget for the day	R400	R600
Start of day	09:30	08:30
End of day	20:30	22:00
Breakfast included	Yes	Yes
Activity/Shopping for the morning session	Shopping	Activity
Lunch included	No	Yes
Activity/Shopping for the afternoon session	Activity	Activity
Dinner included	Yes	No
Evening included	No	Yes

The inputs in Table 6.11 were submitted via the “general daily inputs” component of the BUI. Since the user wanted breakfast included for both days, the components illustrated in Figure 6.2 were displayed next (the breakfast component for Day 1 on the left and for Day 2 on the right).

BREAKFAST PREFERENCES

HOW LONG WOULD YOU LIKE FOR BREAKFAST?

01:30 hours

TYPE OF BREAKFAST PLACE:

Cafe

POPULAR/HIDDEN GEM:

Popular Hidden gem

Submit

RECOMMENDATIONS FOR BREAKFAST:

Café de Flore available via Train/Metro
La Fontaine de Belleville available via Train/Metro
Republique of Coffee available via Train/Metro

BREAKFAST PREFERENCES

HOW LONG WOULD YOU LIKE FOR BREAKFAST?

01:30 hours

TYPE OF BREAKFAST PLACE:

Cafe

POPULAR/HIDDEN GEM:

Popular Hidden gem

Submit

RECOMMENDATIONS FOR BREAKFAST:

Coutume available via bus
Les Deux Magots available via Uber
Ten Belles available via Train/Metro

Figure 6.2: Display of breakfast components for test 5 (Days 1 and 2)

Next, the component for the morning session of each day was displayed. Figure 6.3 presents the individual morning session components with the component for Day 1 on the left and Day 2 on the right.

6.7 Functional test 5

MORNING SESSION:

SHOP CATEGORY RECOMMENDATIONS WANTED:

Luxury

SHOPPING RECOMMENDATIONS:

CHAMPS-ÉLYSÉES
GALLERIE VIVIENNE
GALERIE LAFAYETTES
PIERRE HERMÉ
CENTRE COMMERCIAL BEAUGRENELLE
WESTFIELD FORUM DES HALLES

MORNING SESSION:

INTEREST TYPE:

Adventure & Nature
 Art
 Culture
 Entertainment
 Relax
 Sightseeing
 Sports

POPULAR OR HIDDEN GEM:

Popular Hidden gem

Musee de l'Armee des Invalides : R16 p.p. available via bus
Arc de Triomphe : R220 p.p. available via Train/Metro
Jarden des Tuileries : R0 p.p. available via Train/Metro
Pont Neuf : R0 p.p. available via Train/Metro

Figure 6.3: Display of morning session components for test 5 (Days 1 and 2)

The morning session component presented on the left of Figure 6.3 shows the BUI component displayed when the user chooses “Shopping” for the morning session. Table 6.11 indicates that the user selected “Shopping” for the morning of Day 1, and therefore the correct component was displayed. For Day 2, however, the user selected “Activity” for the morning session, as seen in Table 6.11. The right side of Figure 6.3 presents the component displayed for Day 2, which also agrees with what the user specified. This demonstrates that the BUI presents the correct follow-up questions that agree with what the user specified.

Since the user wanted lunch included only for Day 2, the component illustrated in Figure 6.4 was displayed next. This component was *not* displayed for Day 1 which indicates that the BUI correctly captured this user preference from the daily inputs component and only displayed the lunch questions when required.

LUNCH PREFERENCES

HOW LONG WOULD YOU LIKE FOR LUNCH?

01:00 hours

TYPE OF LUNCH PLACE:

Takeaway

POPULAR/HIDDEN GEM:

Popular Hidden gem

RECOMMENDATIONS FOR LUNCH:

Il était un square available via bus
Baan Boran available via Uber
New Sanna available via bus
Bayan available via bus
KEHRIBAR available via bus

Figure 6.4: Display of the lunch component for functional test 5 (Day 2)

6.7 Functional test 5

The next component displayed was that of the afternoon session of each day. Figure 6.5 presents the individual afternoon session components with the component for Day 1 on the left and Day 2 on the right.

AFTERNOON SESSION:

INTEREST TYPE:

Adventure & Nature
 Art
 Culture
 Entertainment
 Relax
 Sightseeing
 Sports

POPULAR OR HIDDEN GEM:

Popular Hidden gem

Display afternoon activity options:

Parc des Buttes-Chaumont : R0 p.p. available via Train/Metro
Parc Monceau : R0 p.p. available via Train/Metro
Parc de Bagatelle : R0 p.p. available via Train/Metro
Parc Montsouris : R0 p.p. available via Train/Metro

AFTERNOON SESSION:

INTEREST TYPE:

Adventure & Nature
 Art
 Culture
 Entertainment
 Relax
 Sightseeing
 Sports

POPULAR OR HIDDEN GEM:

Popular Hidden gem

Display afternoon activity options:

Musee de l'Orangerie : R155 p.p. available via Train/Metro
Louvre Museum : R290 p.p. available via Train/Metro
Musée d'Orsay : R440 p.p. available via Train/Metro
Musee de l'Armee des Invalides : R16 p.p. available via bus

Figure 6.5: Display of afternoon session components for test 5 (Days 1 and 2)

The two afternoon session components presented in Figure 6.5 agree with the choice of “Activity” for the afternoon of **both** days in Table 6.11. Consequently, the questions were also the same, but the user specified different interest types for Day 1 and Day 2. The individual sets of recommendations were then also displayed.

Next, Figure 6.6 presents the dinner component displayed during the planning of Day 1. There was no dinner component displayed for Day 2, which agrees with the user’s selection of “No” for dinner in the general daily inputs component.

DINNER PREFERENCES

HOW LONG WOULD YOU LIKE FOR DINNER?

02:00 hours

TYPE OF DINNER PLACE:

Fine dining

POPULAR/HIDDEN GEM:

Popular Hidden gem

RECOMMENDATIONS FOR DINNER:

La Scene Theleme available via bus
ACCENTS table bourse available via Train/Metro
Restaurant Guy Savoy available via Train/Metro
FrenchYaste available via Train/Metro
Le Sergent Recruteur. available via Train/Metro

Figure 6.6: Display of the dinner component for functional test 5 (Day 1)

6.7 Functional test 5

No other components were displayed after the dinner component of Day 1, and the cost calculations section was then displayed. For Day 2, the *evening* component was displayed after the afternoon session, followed by the cost calculations section. This agrees with the user's choice to include *only* dinner and no evening session for Day 1, and *only* an evening session with no dinner for Day 2 (as presented in Table 6.11). Figure 6.7 presents the evening component displayed during the planning of Day 2.

EVENING SESSION:

Calculate if there is enough time for an evening POI

There is enough time for an evening POI.

ACTIVITY OR NIGHTLIFE FOR EVENING SESSION:

Nightlife ▾

Submit

Display nightlife options:

NIGHTLIFE RECOMMENDATIONS:

CHARLOTTE CLUB PARIS
CRYSTAL

Figure 6.7: Display of the evening component for functional test 5 (Day 2)

As seen in Figure 6.7, the user chose **Nightlife** for the evening session and that recommendations of bars/nightclubs were then given. The correct set of recommendations were therefore displayed, since questions about the evening activity would alternatively have been asked via the BUI if the user had chosen “Activity”.

At the end of the planning for both days the cost calculation section was shown on the BUI, as illustrated in Figure 6.8. This component must be displayed after every day, and was therefore also executed correctly in this scenario. The cost calculations section displayed the list of activity combinations, and an example of the first combination for Day 2 can be found in Figure 6.8. Combinations were created for Day 2 since the user selected “Activity” for both the morning and afternoon sessions. No combinations were created for Day 1, however, since an activity was only included during the afternoon (and shopping in the morning).

6.8 Discussion of functional tests results

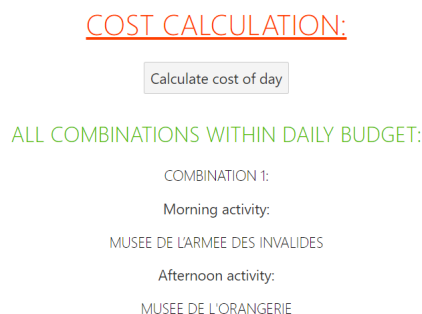


Figure 6.8: Display of the cost calculations component for functional test 5 (Day 2)

This test confirmed that the BUI correctly displays the components as requested by the user. The BUI guided the user from one component to the next with the correct follow-up questions and a logical display of each successive component. This created a continuous TIP process that allowed for successful user-BUI interactions. Therefore, the TIP demonstrator has a dynamic and working BUI.

[Kendall & Kendall \(2014\)](#) provides four principles that define a good design of the display of inputs and outputs on a web page:

1. Keep the display simple.
2. Keep the presentation consistent.
3. Facilitate user movement among display screens and pages, and the displayed output.
4. Create an attractive and pleasing display.

The test performed in this subsection showed that the TIP demonstrator exhibits these qualities. Figures 6.1 to 6.8 present the simple and logical nature of each section of the BUI and all components have the same appearance, which creates a consistent presentation. The navigation of the user through the BUI was supported by the subsequent display of components on the web page. Finally, the web page showcased different fonts, colours and font sizes, which attracts the user's attention and adds to the aesthetic appearance of the web page.

6.8 Discussion of functional tests results

The results for functional tests 1 to 5 confirmed that the TIP algorithm operates satisfactorily and that the correct information is displayed on the BUI. All POIs identified accommodated the user preferences entered via the BUI and the budget was incorporated correctly. The scenarios tested in this chapter consisted of shorter trips (one to three days) but a longer trip of seven days was also tested and described in Appendix C. This test yielded an itinerary that was acceptable and

6.9 Conclusion: Verification and validation of the demonstrator

agreed with the user preferences, but was not described in this chapter since it is lengthy and to avoid repetition. The results for the seven-day scenario test confirmed that the TIP demonstrator can be used for longer trips as well. The structure of the TIP process allows the user to decide how far in advance they would like to plan their trip days. For example, they can plan all seven days *before* starting the trip or they can plan the itinerary for two or three days at a time, which would give them the opportunity to take the POIs they pursued on the previous days into account before planning the itinerary for the remaining days. This emphasises the descriptive nature of the TIP process and the focus on user interactions.

The itineraries produced for each test provided personalised options that offered structure to the user's travel days while still allowing for flexibility in the planning of activities. The TIP demonstrator's POI selection ability amply replaced the process of the user having to *manually* determine available POIs, which would require plenty of time spent researching and communicating with travel agents. Additionally, the TIP demonstrator offers a variety of recommendations and activity combinations, so the user is not forced to choose the cheapest option if they do not want to. They are given adequate choices to guarantee their satisfaction with the itinerary. This is also useful when a trip day has a longer session, for example when no lunch is wanted and there are many hours available for the afternoon session. Given the variety of POI recommendations, the user is then able to pursue more than one activity during that session.

This concludes the tests performed to verify and validate the TIP demonstrator. This section presented an evaluation and interpretation of the test results and therein proved the satisfactory operation of the algorithm, database and BUI. Therefore, the TIP demonstrator performed correctly and is considered a working prototype.

6.9 Conclusion: Verification and validation of the demonstrator

Several tests were designed and executed to verify and validate the working of the TIP demonstrator and they were presented and discussed in detail in this chapter. The tests consisted of creating itineraries for five scenarios with different variables, such as the city, number of days and activity preferences, and the results were evaluated.

Firstly, this chapter provided an overview of verification and validation as an introduction to *how* and *why* the functional tests were performed. Next, a discussion of each test was given, which included the objective of the test, a description of the scenario and the results, and its evaluation. Finally, a comprehensive review of the test results were presented.

All tests yielded the correct results, but the researcher understands that latent errors may still be present in the system since no system can be claimed to be completely error-free. A real-life development and deployment of the TIP demonstrator should be subjected to the rigorous testing

6.9 Conclusion: Verification and validation of the demonstrator

required by software engineering principles. The conclusions will be provided next, in the final chapter of this study.

Chapter 7

Conclusion and recommendations

The previous chapters described the complete process followed to create the working tourist itinerary planning (TIP) demonstrator, which includes the research completed, concept development and system architecture, design, testing and evaluation of the demonstrator. This chapter will conclude this study by providing a project summary and recommendations for future work as well as arguments for a potential business opportunity. Finally, an appraisal of the study will be provided.

7.1 Research summary

This section presents a summary of this study by means of a discussion of the research objectives (listed in Section 1.3) and the work done to fulfil them.

Firstly, Chapter 1 was presented as an introduction to this study. It provided background information on the global Travel and Tourism (T&T) sector and the incorporation of technology within the field. This revealed the opportunity that there currently is in T&T for new developments, and consequently, the gap in the market for a new and improved tourist itinerary planner was identified. The resulting problem statement was then formed, and thesis objectives were laid out to guide the development process of the TIP demonstrator. Chapter 1 also provided the project scope and research methodology followed to obtain the knowledge required to address the research objectives. Finally, the structure of the thesis was described.

The first objective (I) was to acquire knowledge of information systems in the travel industry and existing tourist itinerary planners. To fulfil this objective, a literature study was conducted and presented in Chapters 2 and 3. Chapter 2 investigated the T&T sector by researching the growth of the industry, trends in T&T, typical tourist behaviour and the general process of trip planning. Next, Chapter 3 presented the study of the role information systems have in the field of itinerary planning. This included popular concepts in itinerary planning literature, such as decision support systems and activity-based modelling for trip planning, as well as a discussion of existing online itinerary planners. [TripHobo \(2020\)](#) and [Inspirock \(2020\)](#) were identified as the two most popular of these, and the process that each planner follows to provide an itinerary to its user was examined. This highlighted possible areas of improvement in current online itinerary planners and valuable features that must be incorporated.

The next objective (Objective II) stated that the study required the development of a system architecture. This was completed and documented in Chapter 4. A software architecture was developed by identifying stakeholders, creating an architectural definition and establishing the applicable viewpoints and perspectives. The TIP concept was described from the *functional*, *information* and

development viewpoints, and the *availability*, *performance* and *usability* perspectives were then applied. An Object-Process Methodology (OPM) model was also developed, followed by a discussion of the three main components of the TIP demonstrator, which concluded in Chapter 4.

Objectives III, IV and V were addressed in Chapter 5, where the implementation of the TIP concept was completed. During this stage of development, various programming languages and software tools were studied to determine what would best support the satisfactory performance and functionality of the TIP demonstrator of this study. As a result, a combination of HyperText Markup Language (HTML), Python, Microsoft SQL Server and Svelte were used to build the TIP demonstrator. Chapter 5 describes the front- and back-end development, the browser user interface, algorithm and database, detailing all functions, coding and entities involved.

Next, Chapter 6 presented the verification and validation of the TIP demonstrator which consisted of five functional tests performed with different scenarios. This fulfilled Objectives VI, VII and VIII, and exhibits the TIP demonstrator's competency as a working prototype. Compared to existing systems like TripHobo and Inspirock, the capabilities of the TIP demonstrator eliminated the limitations of these systems as outlined in Subsections 3.3.1 and 3.3.2.

This concludes the summary of the research and development completed in this study. Since all objectives were realised and a working TIP demonstrator was developed, the researcher achieved the purpose of this study. The next section will provide recommendations for future work that can be done to further the research and development of this study.

7.2 Future work

This section presents some recommendations for future work that can be done following the research and development performed in this study:

- The points-of-interest (POIs) included in the database were described and categorised according to the specifications listed in Subsection 4.5.2.2, which were evaluated when finding options that fit the user preferences. The POIs can be given additional attributes, for example, whether they are child-friendly or not, and the user can be queried for more preferences. This will then cause a more focused set of relevant options to be identified by the algorithm.
- A function can be added, allowing third parties to submit their activities or establishments for inclusion in the database as POIs. The system administrator can then be responsible for evaluating the legitimacy of the submissions and allowing for the POIs to be added to the database. A policy for the inclusion and exclusion of applicants should be developed for this process. As more third parties get involved, the database expands, and more options can be presented to the user. In this study, the POIs were added manually for testing and demonstration purposes.

7.3 Potential business opportunity

- The TIP demonstrator can be implemented as a real-life website, and with further work, it can provide the user with the option of making bookings or buying tickets directly from the website.
- The programming and calculations can be modified to incorporate the specific currency used in the different cities and do the correct conversions where necessary.
- A recommender system can be developed and incorporated to further enhance the personalisation capability of the TIP demonstrator. The user can be given the possibility of creating an account on the website to store every itinerary they plan and also save incomplete itineraries to be completed later. The recommender system can then use the past itineraries and preferences to identify more customised POI options.

This concludes the recommendations for future work opportunities. The following section will present a business opportunity for the TIP demonstrator.

7.3 Potential business opportunity

The TIP demonstrator presents a potential business opportunity because it could be developed into a fully deployed web-based commercial system. The website can be monetised via some of the current strategies used by many entrepreneurs and businesses, namely:

1. Forming partnerships with businesses in the T&T industry.
2. Selling advertisement space.
3. Generating leads.
4. Selling a premium itinerary planning service (the basic service is free).

The input cost for such a service includes web development, marketing and a service provider to host the web service. Low risk is involved in developing and offering such a service, and the owner can use a disclaimer to avoid legal consequences when customers use this service.

7.4 Appraisal

This section provides the self-assessment of the research and work that this thesis entailed. The researcher thoroughly enjoyed the different aspects of development in this study, including the research, architecture definition, programming and web development. The task of developing a working web-based demonstrator using industrial engineering concepts as well as topics and software that the researcher had not worked with before proved to be a great challenge with an even greater reward.

7.5 Chapter conclusion

An important step during the initial development stage included researching existing online trip planners, with TripHobo and Inspirock being the most prevalent, and identifying whether or not there is a need for an alternative that provides more **personalised** and **budget-focused** itineraries. The research revealed there *is* a gap in the market for such a product, as well as an alternative that is more *descriptive* than *prescriptive*. After evaluating the TIP demonstrator developed in this study and comparing it to these existing trip planners, the researcher is proud of the innovative and improved itinerary planning capabilities that it offers, as well as the strong competitor it can be developed to be a public, commercial website (as part of the future work discussed in Section 7.2).

The design and development of the TIP demonstrator required the use of software that the researcher had a lack of knowledge and experience with since they are outside the general scope of industrial engineering students' knowledge, including Python and Svelte. Therefore, the researcher spent a considerable amount of time and effort studying these programming languages and frameworks. The researcher then used this knowledge to produce a working algorithm and web page that fulfilled the research objectives and contributes to the final operational TIP demonstrator. This also provided the researcher with knowledge of topics outside the industrial engineering field, which is considered a valuable takeaway of this research.

The researcher enjoyed combining information systems concepts, programming, system modelling, research, web development and database design to form a fully functioning system. Since the TIP demonstrator was verified and validated as a working prototype of a web-based itinerary planner, the research question was answered, namely that it is possible to develop a personalised budget-constrained tourist itinerary planner.

7.5 Chapter conclusion

This chapter provided a summary of this thesis, recommendations for future work, a business case for the TIP demonstrator developed and a self-assessment of the work completed. It concludes the study in which the development of a web-based demonstrator for tourist itinerary planning was accomplished.

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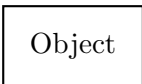
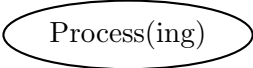






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Appendix A

Object-Process Methodology (OPM) conventions

This appendix provides the symbols and their descriptions used in the Object-Process Modelling (OPM) performed and discussed in Section 4.4.

Table A.1: Object-Process Diagram legend (Dori, 2002)

Symbol	Name	Description
	Object	A static object that has the potential of mental, physical, unconditional or stable existence.
	Process	The transformation that objects undergo by affecting, consuming, or generating them.
	Aggregation	Relates a whole to its parts.
	Generalisation	A general thing is related to its specialisations.
	Instrument Link	A non-human that act as enabler in order for the process to occur.
	Agent Link	A human that act as enabler in order for the process to occur.
	Structural Link	It represents a meaningful association between two objects.
	Input/Output Link	It represent the connection between an object and a process to show how the object undergoes transformation or enables a process.

Appendix B


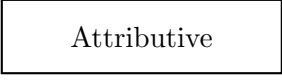
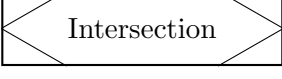
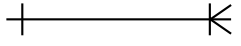
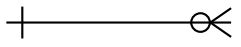
Semantics and data dictionary of the TIP demonstrator’s database

This appendix includes an explanation of the conventions used in the Extended Entity-Relationship Diagram (EERD) and the data dictionary (DD) that describes the entities in Section 5.6 are given.

B.1 Demonstrator database semantics

There are different conventions available in literature for the design of an EERD, but in this study, the *crow’s foot notation* is used. Table B.1 describes the symbols and conventions used in the EERD of this study (Figure 5.10).

Table B.1: Extended Entity-Relationship Diagram legend (Kendall & Kendall, 2014)

Symbol	Name	Description
	Primary Entity	An entity that can exist on its own.
	Attributive Entity	An entity that requires information from a primary entity.
	Intersection Entity	An entity used to join two primary and/or attributive entities.
	One-to-many relationship (<i>mandatory</i>)	An instance on the one side must be related to at least one instance on the many side.
	One-to-many relationship (<i>optional</i>)	An instance on the one side may be related to no instance on the many side.

B.2 Database dictionary

The DD of the tourist itinerary planning (TIP) demonstrator database is presented in this section. It consists of tables, their attributes and data type descriptions.

Tables B.2, B.3 and B.4 are the accommodation entities: the “niche” that the accommodation can be classified as, the accommodation points-of-interest (POIs) and the types of accommodation available.

B.2 Database dictionary

Table B.2: Entity: *tbl_Accommodation*

	Attribute	Data Type	Description
1	Acc_ID	int	The primary key linked to each accommodation record.
2	Name	varchar(50)	The name of the accommodation record.
3	City_ID	int	The foreign key that links back to the Cities table.
4	AccType_ID	int	The foreign key that links back to the Accommodation Type table.
5	Average rating	float	The accommodation record's average rating on Google.
6	Average price per person (p.p.) per night	varchar(50)	The average price of the accommodation record per person per night.
7	POIType_ID	int	The foreign key that links back to the POI type table.
8	Niche_ID	int	The foreign key that links back to the Niche table.
9	Transport_ID	int	The foreign key that links back to the Transport table.

Table B.3: Entity: *tbl_AccommodationType*

	Attribute	Data Type	Description
1	AccType_ID	int	The primary key linked to each "accommodation type" record.
2	Accommodation type	varchar(50)	The name of the "accommodation type" record.

Table B.4: Entity: *tbl_AccNiches*

	Attribute	Data Type	Description
1	Niche_ID	int	The primary key linked to each niche record.
2	Niche name	varchar(50)	The name of the niche record.

Tables B.5, B.6 and B.7 present the entities related to meal sessions: the food and beverage (FB) POIs, the FB type and the meal times.

B.2 Database dictionaryTable B.5: Entity: *tbl_FoodandBevPOIs*

	Attribute	Data Type	Description
1	FoodBev_ID	int	The primary key linked to each food and beverage POI (FB_POI) record.
2	Name	varchar(50)	The name of the FB_POI record.
3	City_ID	int	The foreign key that links back to the Cities table.
4	Mealtime_ID	int	The foreign key that links back to the Mealtimes table.
5	FoodBevType_ID	ID	The foreign key that links back to the Food and Beverage Type table.
6	Opening time	time(7)	The time that the FB_POI opens.
7	Closing time	time(7)	The time that the FB_POI closes.
8	POIType_ID	int	The foreign key that links back to the Point-of-interest (POI) type table.
9	Transport_ID	int	The foreign key that links back to the Transport table.

Table B.6: Entity: *tbl_FoodBevType*

	Attribute	Data Type	Description
1	FoodBevType_ID	int	The primary key linked to each “food and beverage type” record.
2	Food and beverage type	varchar(50)	The name of the “food and beverage type” record.

Table B.7: Entity: *tbl_Mealtimes*

	Attribute	Data Type	Description
1	Mealtime_ID	int	The primary key linked to each meal time record.
2	Meal time	varchar(50)	The name of the meal time record.

Table B.8 presents the entities related to the categories of POIs: adventure and nature, arts, culture, entertainment, sightseeing and sports. Only description is included for all these tables since they all possess the same attributes. Table B.9 then describes the evening POIs since it has an extra attribute.

B.2 Database dictionary

Table B.8: Activity entities

	Attribute	Data Type	Description
1	Activity_ID	int	The primary key linked to each POI record.
2	Activity name	varchar(50)	The name of the POI record.
3	Entry price	int	The entry price of the POI.
4	City_ID	int	The foreign key that links back to the Cities table.
5	Opening time	time(7)	The time that the POI opens.
6	Closing time	time(7)	The time that the POI closes.
7	Duration	time(7)	The estimated time it will take to complete the activity.
8	POIType_ID	int	The foreign key that links back to the Point-of-interest (POI) type table.
9	Transport_ID	int	The foreign key that links back to the Transport table.

Table B.9: Entity: *tbl_eveningPOIs*

	Attribute	Data Type	Description
1	EveningPOI_ID	int	The primary key linked to each POI record.
2	Activity name	varchar(50)	The name of the POI record.
3	Entry price	int	The entry price of the POI.
4	City_ID	int	The foreign key that links back to the Cities table.
5	Opening time	time(7)	The time that the POI opens.
6	Closing time	time(7)	The time that the POI closes.
7	Duration	time(7)	The estimated time it will take to complete the activity.
8	POIType_ID	int	The foreign key that links back to the Point-of-interest (POI) type table.
9	Transport_ID	int	The foreign key that links back to the Transport table.
10	Interest_ID	int	The foreign key that links back to the Interests table.

Tables [B.10](#) and [B.11](#) are entities related to shopping.

B.2 Database dictionaryTable B.10: Entity: *tbl_ShoppingPOIs*

	Attribute	Data Type	Description
1	ShoppingPOI_ID	int	The primary key linked to each shop record.
2	Name	varchar(50)	The name of the store record.
3	City_ID	int	The foreign key that links back to the Cities table.
4	Opening time	time(7)	The time that the store opens.
5	Closing time	time(7)	The time that the store closes.
6	ShopCategory_Type	int	The foreign key that links back to the Shop Categories table.
7	Transport_ID	int	The foreign key that links back to the Transport table.

Table B.11: Entity: *tbl_ShopCategories*

	Attribute	Data Type	Description
1	ShopCategory_ID	int	The primary key linked to each shopping category record.
2	Category	varchar(50)	The name of the Category record.

The entities representing the cities, POI type, interests and transport types all have the same attributes, as shown in Table [B.12](#).

Table B.12: “Other” entities

	Attribute	Data Type	Description
1	ID	int	The primary key linked to each record.
2	Name	varchar(50)	The name of the record.

Appendix C

Seven-day scenario test

This appendix presents the results for a seven-day scenario test used for further verification and validation of the tourist itinerary planning (TIP) demonstrator. It includes a description of the scenario, the user inputs for the seven days and the resulting itinerary determined by the TIP algorithm.

In this test, a seven-day trip to Cape Town is planned for an individual that wants a combination of activities and shopping, with a focus on nature, sightseeing and relaxing. Since the trip is for a whole week, the traveller would like to include some early nights as well as one or two evenings exploring the city's nightlife scene.

Since the TIP demonstrator lets the user plan each day individually, the user can decide how many days they would like to plan at a time. They can either plan all seven days before or at the start of the trip, or they can split the planning into groups of two or three days to give themselves time to re-evaluate what they would like to include in the upcoming days following what POIs they decided to pursue the days before.

The following initial user inputs were entered via the browser user interface (BUI):

- **Destination:** Cape Town
- **Length of trip:** 7 days
- **Total budget:** R1 300
- **Mode of transport preferred:** Car

Tables C.1 and C.2 include the remaining user inputs for Days 1 to 7. Note that the “Adventure/Nature” option for the activity interest preference will be referred to as “Nature” due to limited space in the tables.

Table C.1: Seven-day scenario user inputs (Days 1 to 4)

User input	Day 1	Day 2	Day 3	Day 4
Budget for the day	R200	R350	R600	R150
Start of the day	08:00	09:00	09:00	10:00
End of the day	18:00	20:00	21:00	21:00
Breakfast included	No	Yes	Yes	No
Activity/Shopping for morning session	Activity	Shopping	Activity	Activity
Lunch included	Yes	No	No	Yes
Activity/Shopping for afternoon session	Shopping	Activity	Activity	Shopping
Dinner included	No	Yes	No	No
Evening POI wanted	No	No	Yes	Yes
Enough time for the evening POI?	N/A	N/A	Yes	Yes
Breakfast duration		01:30	01:00	
Type of breakfast place	N/A	Café	Café	N/A
Popular/Hidden gem		Hidden gem	Popular	
Morning interest type(s)	Nature	N/A	Sightseeing	Relax
Popular/Hidden gem	Popular		Hidden gem	Hidden gem
Morning shopping category	N/A	Tourist	N/A	N/A
Lunch duration	02:00			02:00
Type of lunch place	Restaurant	N/A	N/A	Fine dining
Popular/Hidden gem	Hidden gem			Hidden gem
Afternoon interest type(s)	N/A	Entertainment, Relax	Nature, Relax	N/A
Popular/Hidden gem		Popular	Popular	
Afternoon shopping category	Groceries	N/A	N/A	Hobbies
Dinner duration		02:00		
Type of dinner place	N/A	Restaurant	N/A	N/A
Popular/Hidden gem		Popular		
Activity/Nightlife for evening session	N/A	N/A	Nightlife	Activity
Evening interest type(s)	N/A	N/A	N/A	Entertainment
Popular/Hidden gem				Hidden gem

Table C.2: Seven-day scenario user inputs (Days 5 to 7)

User input	Day 5	Day 6	Day 7
Budget for the day	R400	R250	R0
Start of the day	08:00	09:30	10:00
End of the day	22:00	19:30	22:00
Breakfast included	Yes	No	Yes
Activity/Shopping for morning session	Activity	Activity	Shopping
Lunch included	No	Yes	Yes
Activity/Shopping for afternoon session	Activity	Activity	Shopping
Dinner included	Yes	Yes	Yes
Evening POI wanted	Yes	Yes	Yes
Enough time for the evening POI?	Yes	No	Yes
Breakfast duration	01:30		01:30
Type of breakfast place	Restaurant	N/A	Market
Popular/Hidden gem	Popular		Popular
Morning interest type(s)	Nature	Art, Culture	N/A
Popular/Hidden gem	Popular	Hidden gem	
Morning shopping category	N/A	N/A	Luxury
Lunch duration		01:30	01:00
Type of lunch place	N/A	Market	Takeaways
Popular/Hidden gem		Hidden gem	Hidden gem
Afternoon interest type(s)	Nature, Relax	Sightseeing, Culture	N/A
Popular/Hidden gem	Popular	Popular	
Afternoon shopping category	N/A	N/A	Shopping mall
Dinner duration	01:30	01:30	02:00
Type of dinner place	Restaurant	Restaurant	Fine dining
Popular/Hidden gem	Hidden gem	Popular	Popular
Activity/Nightlife for evening session	Activity	N/A	Nightlife
Evening interest type(s)	Entertainment	N/A	N/A
Popular/Hidden gem	Popular		

The user was navigated through the questions for each day on the web page. After the preferences for each session, for example the morning session, lunch or dinner, were submitted, the available POI

options for the specific session were displayed on the web page.

C.1 Results for Day 1

This section presents the POI options that conform to the user preferences for Day 1 which are displayed in Table C.3.

Table C.3: Results for Day 1

Session	POI options identified
Morning	Cape Town Tandem Paragliding @ R1 300 Climb Lion's Head @ R0 Company Gardens @ R0 Twelve Apostles @ R0
Lunch	Belly of the Beast The Strangers Club A Taste of Africa
Afternoon	Blue Bird Garage Food and Goods Market The Point Mall Shopping Centre Woolworths Green Point SPAR Cape Quarter

No combinations were displayed for Day 1, but the “cheapest” option was given: to climb **Lion's Head**, explore the **Company Gardens** or visit the **Twelve Apostles**. This correctly correlates to the user specifying that they only wanted one session (the morning session) to include an activity.

C.2 Results for Day 2

The results obtained from the TIP demonstrator for Day 2 are presented and discussed in this section.

Table C.4: Results for Day 2

Session	POI options identified
Breakfast	Harvest Café
Morning	Cape Quarter Greenmarket Square Milnerton Flea Market Neighbourgoods Market
Afternoon	GrandWest Casino @ R0 Rush @ R150 Mouille Point Putt Putt Course @ R36 Clay Café Houtbay @ R100 City Rock @ R180 Clifton Beaches @ R0 Camps Bay Beaches @ R0 Tidal Pools at St James @ R0 Bloubergstrand Beach @ R0 Muizenberg Beach @ R0 Fish Hoek Beach @ R0
Dinner	The Pot Luck Club Chefs Warehouse SeaBreeze Fish & Shell Between Us Kapstadt Brauhaus V&A Waterfront Quay Four Restaurant Tjing Tjing Torii

Table C.4 displays the POI options identified for Day 2. No combinations were displayed at the end of Day 2, the “cheapest” option was only indicated as any of the POIs with a cost of R0: **GrandWest Casino**, any of the **beaches** or the **Tidal Pools at St James** In Table C.1 it is indicated that the user also included only one activity session for this day, with the morning session to be used for shopping. Therefore, the results agree with the user preferences.

C.3 Results for Day 3

This section presents the results and accompanying discussion for Day 3 of the scenario.

Table C.5: Results for Day 3

Session	POI options identified
Breakfast	Jason's Bakery Nourish'd Café & Juicery
Morning	Boulders Penguin Colony @ R0
Afternoon	Kirstenbosch National Botanical Garden @ R200 Cape Town Tandem Paragliding @ R1 300 Climb Lion's Head @ R0 Climb Table Mountain @ R0 Company Gardens @ R0 Twelve Apostles @ R0 World of Birds @ R130 Camp's Bay Beaches @ R0 Clifton Beaches @ R0 Tidal Pools at St James @ R0 Bloubergstrand Beach @ R0 Muizenberg Beach @ R0 Fish Hoek Beach @ R0
Evening	Darling Bob's Bar District Six Shimmy Beach Club

Table C.5 presents the POIs identified after each consecutive session of Day 3 was planned on the web page. After the planning of Day 3 was completed, the available combinations that were within budget for the day were displayed. Many POI combinations were identified, including the following two examples:

- **Combination 1:** Boulders Penguin Colony in the morning from 10:00 to 12:00 and World of Birds between 12:00 and 18:00 in the afternoon (for a total of R130).
- **Combination 2:** Boulders Penguin Colony in the morning from 10:00 to 12:00 and Muizenberg Beach between 12:00 and 18:00 in the afternoon (for a total of R0).

A narrowed-down list of combinations was then presented on the BUI as the “cheapest” itinerary for the day, with a number of free options for Day 3:

- **Morning session:** Boulders Penguin Colony for R0.
- **Afternoon session:** Climb Lion's Head, climb Table Mountain, Company Gardens, Twelve Apostles, Camp's Bay Beaches, Clifton Beaches, Tidal Pools at St James, Bloubergstrand Beach, Muizenberg Beach, Fish Hoek Beach (all R0).

C.4 Results for Day 4

The results presented in this section verifies the operation of the TIP algorithm and the correct displaying of information on the BUI. The tables containing the POIs for the *Sightseeing* and *Adventure/Nature* interests contain many records that are free to visit. This agrees with the fact that there are many “cheapest” POI combinations identified for the Day 3.

C.4 Results for Day 4

The results obtained from the test performed for Day 4 of this scenario are presented in this section.

Table C.6: Results for Day 4

Session	POI options identified
Morning	Picnic at Llandudno Beach @ R0
Lunch	Pier Chef’s Warehouse Beau Constantia La Colombe
Afternoon	Pier Clark’s Bookshop Bargain Books Tygervalley Sportsmans Warehouse Canal Walk The Pro Shop Exclusive Books V&A Observatory Thrifting
Evening	The Galileo Open Air Cinema @ R130

Table C.6 presents the results for Day 4, which indicates that there is only one POI identified for both the morning and evening sessions. After these results were displayed, only one combination of activities was given for Day 4: a **picnic at Llandudno Beach** from 10:00 to 12:00 and a film at **The Galileo Open Air Cinema** between 18:00 and 21:00 (for a total of).

C.5 Results for Day 5

Table C.7 presents the POIs identified for Day 5.

Table C.7: Results for Day 5

Session	POI options identified
Breakfast	JARRYDS Eatery
Morning	Kirstenbosch National Botanical Garden @ R200 Cape Town Tandem Paragliding @ R1 300 Company Gardens @ R0 Twelve Apostles @ R0 World of Birds @ R130
Afternoon	Kirstenbosch National Botanical Garden @ R200 Cape Town Tandem Paragliding @ R1 300 Climb Lion's Head @ R0 Climb Table Mountain @ R0 Company Gardens @ R0 Twelve Apostles @ R0 World of Birds @ R130 Camp's Bay Beaches @ R0 Clifton Beaches @ R0 Tidal Pools at St James @ R0 Bloubergstrand Beach @ R0 Muizenberg Beach @ R0 Fish Hoek Beach @ R0
Dinner	Belly of the Beast A Taste of Africa
Evening	Barleycorn Music Club @ R50

Following the individual display of results for each session, the POI combinations that fit within the budget for the day were presented. Many POI combinations were identified, including the following two examples:

- **Combination 1:** Visiting the World of Birds in the morning from 09:30 to 12:00, swimming and relaxing at Muizenberg Beach between 12:00 and 18:00 in the afternoon and visiting the Barleycorn Music Club between 19:30 and 22:00 in the evening (for a total of R180).
- **Combination 2:** Exploring the Company Gardens in the morning from 09:30 to 12:00, visiting Kirstenbosch National Botanical Garden between 12:00 and 18:00 and going to the Barleycorn Music Club between 19:30 and 22:00 in the evening (for a total of R250).

The combinations identified agrees with the preferences specified for Day 5. The user selected the *Adventure/Nature* and *Relax* interests for the morning and afternoon sessions, which produced POI options which are all free to visit. Therefore, there were multiple “cheapest” combinations displayed, for a total cost of R50, and they were:

- **Morning session:** Company Gardens or Twelve Apostles (both for R0).
- **Afternoon session:** Climb Lion’s Head or Table Mountain, the Company gardens, Twelve Apostles, Camp’s Bay Beaches, Clifton Beaches, Tidal Pools at St James, Bloubergstrand Beach, Muizenberg Beach or Fish Hoek Beach (all for R0).
- **Evening session:** Barleycorn Music Club for R50.

None of the displayed “cheapest” combinations (with POIs as listed above) included the same activity for the morning session *and* the afternoon session, even though five POIs were provided in the individual recommendations for morning and afternoon. This occurred because the user selected *Adventure/Nature* for both the morning and afternoon sessions. This verifies that the TIP algorithm correctly removes duplicates when creating the POI combinations.

Since the afternoon session is from 12:00 to 18:00 and many of the *Relaxing* POIs are beaches that are free to visit, the user can also go to more than one if they would like.

C.6 Results for Day 6

This section presents the POIs identified after the information for Day 6 was submitted.

Table C.8: Results for Day 6

Session	POI options identified
Morning	Southern Guild Collectable Design Gallery @ R0 Eyewitness - A Private Collection @ R0 The Heart of Cape Town Museum @ R327
Lunch	Oranjezicht City Farm Market The Neighbourgoods Market
Afternoon	The Castle of Good Hope @ R60 District Six Museum @ R20 South African Jewish Museum @ R109 Cape Wheel @ R220 Chapman's Peak @ R50 Table Mountain @ R390 Two Oceans Aquarium @ R225 Hout Bay @ R0 Cape Town Khayelitsha Township Tour @ R465
Dinner	The Pot Luck Club Chef's Warehouse Winebar & Pinchos SeaBreeze Fish & Shell Between Us Kapstadt Brauhaus V&A Waterfront Quay Four Restaurant Tjing Tjing Torii

Table C.8 presents the results for Day 6. After these POIs were displayed on the BUI, the combinations that are within the R250 budget for the day were presented. Two examples of these are:

- **Combination 1:** Southern Guild Collectable Design Gallery in the morning from 09:30 to 12:00 and visiting Chapman's Peak between 13:30 and 18:00 in the afternoon (for a total of R50).
- **Combination 2:** Explore the "Eyewitness - A Private Collection" in the morning from 09:30 to 12:00 and visit the Two Oceans Aquarium between 13:30 and 18:00 in the afternoon (for a total of R225).

There were two "cheapest options" displayed for Day 6, which were:

- **Morning session:** Southern Guild Collectable Design Gallery or the Eyewitness - A Private Collection (for R0).

- **Afternoon session:** Hout Bay for R0.

The results presented in this section verifies the operation of the TIP algorithm and the correct displaying of information on the BUI.

C.7 Results for Day 7

The results for the final day of this scenario are presented in this section.

Table C.9: Results for Day 7

Session	POI options identified
Breakfast	V&A Food Market
Morning	The Old Biscuit Mill Afraid of Mice Merchants on Long Mungo & Jemima Kat Van Duinen Anpa Jewellery Kluk CGDT Just Cruizin Stefania Morland
Lunch	Love Is Monks Chinese The Poke Co.
Afternoon	V&A Waterfront Tygervalley Cavendish Square Canal Walk Shopping Centre Access Park Kenilworth Table Bay Mall
Dinner	La Parada V&A Waterfront The Test Kitchen Grub & Vine Thali
Evening	Darling Bob's Bar District Six Shimmy Beach Club Julep Bar Decodance Nightclub

C.8 Seven-day itinerary with the lowest cost

No combinations were displayed for after the planning of Day 7. This agrees with the user who specified that they wanted only shopping and nightlife POIs for this day. Because of this, no activities were identified and therefore no combinations were created.

C.8 Seven-day itinerary with the lowest cost

After the planning of each individual day via the BUI, the final itinerary with the lowest cost is identified. Table C.10 presents the combination of activities for each day that will provide this lowest cost after the seven days. Note that Table C.10 is only used to display the *activities* and therefore does not include the shopping and meal-related POIs of the trip.

Table C.10: Activities of final itinerary

Day	Activity session time	POIs
One	08:00 - 12:00	Lion's Head, Company Gardens or Twelve Apostles
Two	12:00 - 18:00	GrandWest Casino, City Rock, Clifton Beaches, Camp's Bay Beach, Tidal Pools at St James, Bloubergstrand Beach, Muizenberg Beach or Fish Hoek Beach
Three	10:00 - 12:00	Boulders Penguin Colony
	12:00 - 18:00	Lion's Head, climb Table Mountain, Company Gardens, Twelve Apostles, GrandWest Casino, City Rock, Clifton Beaches, Camp's Bay Beach, Tidal Pools at St James, Bloubergstrand Beach, Muizenberg Beach or Fish Hoek Beach
Four	10:00 - 12:00	Picnic at Llandudno Beach
	20:00 - 21:00	The Galileo Open Air Cinema
Five	09:30 - 12:00	Company Gardens or Twelve Apostles
	12:00 - 18:00	Lion's Head, climb Table Mountain, Company Gardens, Twelve Apostles, GrandWest Casino, City Rock, Clifton Beaches, Camp's Bay Beach, Tidal Pools at St James, Bloubergstrand Beach, Muizenberg Beach or Fish Hoek Beach
	19:30 - 22:00	Barleycorn Music Club
Six	09:30 - 12:00	Southern Guild Collectable Design Gallery or Eyewitness - A Private Collection
	13:30 - 18:00	Hout Bay

The results presented in this appendix verifies the operation of the TIP algorithm and the correct displaying of information on the BUI. All POIs identified for Days 1 to 7 conformed to the user preferences entered via the BUI and the budget was incorporated correctly.