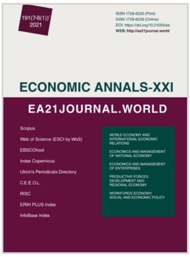

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Routing for tourist and excursion bureaus based at parametric network models

Abstract. This study is devoted to applying parametric network models for the process of defining a guided tour route within route networks on the example of Denmark. This is caused by difficulty in determining variations when organizing guided tours. Under the actual digitization conditions, tourist and excursion bureaus are being restructured from static organizations administering various excursions into dynamic ones. They are actually getting adjusted to the customers' needs and demands, taking into account the actual possibilities for covering a certain topic by the tour party within a route. The main problem encountered by tourist and excursion bureaus is the following. Although the nomenclature of presented guided tours is established by the economic entity independently, those are not always carried out according to a clearly defined itinerary and on the same conditions for all participants. When providing such services, customers' demands and service peculiarities are not known in advance. The purpose of the present study is to provide a substantive basis for routing in tourist and excursion bureaus, based on parametric network models and taking into account the peculiarities of dynamically adaptable tables containing the best routes. To achieve the research goal, network planning methods were used, such as analytical, tabular, cloud computing in the AnyLogic Cloud environment.

As a result of the study, a substantive basis of routing of the tourist route was presented for tourist and excursion bureaus, through their parametric network models. The study was implemented at the sample of the Denmark Tour -Your Guide Office, a company founded within cooperation with Russian, Ukrainian, and Denmark partners and providing travel services within the Denmark tourist market. The Office includes about 20 affiliates in Denmark, where route networks have already been adapted to designing tours in practice and parameterization of such networks is well underway, in particular by shifting the focus from the route distance rate to minimization of transfers between attraction sites. However, to provide a substantive basis for the routing in a tourist office, parameters of the routing networks should be determined not only based on the list of actions (activities) to be carried out, but also on their minimum and maximum possible duration. A lack of due attention to the servicing time for the tour groups will lead to breaking tour schedules. Thus, in 2020, as a result of the inefficient parameterization at Denmark Tour - Your Guide, about 5-6 tours around Aalborg and its vicinity were cancelled monthly. Denmark Tour- Your Guide incurs monthly profit losses at 15% in 4-6 tours around Aarhus and its surroundings, Jursland peninsula, rated at a fixed cost, as the result of payment of a fixed cost for the selected excursions. A similar situation, with breaking tour schedules and monthly losses incurred, is common with tourist and excursion bureaus in various countries around the world, including Ukraine.

According to the results of the study, it is marked that the routing of tourist itineraries designed by tourist agencies, based on parametric network models turns their static time reserves and operational metrics into dynamic values depending on the duration of the tour activities. This not only ensures following schedules properly in all tours but also minimizes monthly profit loss, at an estimated EUR 2,250 for the Aalborg and its surroundings routes. Meanwhile, there may be situations where it is not possible to change the total tour cost. For example, in the company Denmark Tour - Your Guide, when working with intermediate parties, this price is fixed. To prevent incurring monthly losses within 15% of the profits for 4-6 tours of Aarhus and its surroundings, Jursland peninsula, Aalborg and Surroundings, it is necessary to make some quite specific adjustments in some activities at the sites. These should take into account the time reserve values on the longest route. A special tour activity complex is to be completed, with a maximum difference in early and late schedule times, standard and urgent pricing for the site operations). A procedure is compiled for minimizing losses in routes (over 8K euro annually), providing for completion of the activity complex within the schedule with a minimum additional charge to the operating metric (the route price), since it is not reimbursed by the tourists. It is important that the results presented should identify the path adjustments of each route simultaneously, taking into account the actual time reserve (available based on the tour group location and the previouisly completed schedule items on the tour).

Prospects for practical implementation of the presented substantiation basis for the itinerary routing to be used in tourist and excursion bureaus, based on parametric network models, are in establishing facilities for creating dynamic graphic images of the whole tour procedure, in the form of a directed graph of the route network.

Keywords: Excursion; Bureau; Routing; Route; Network Model; Route Network; Excursion Design; Network Analysis

JEL Classification: C46; C61; C80

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Маршрутизація туристсько-екскурсійних бюро на основі параметричних мережевих моделей

Анотація

У статті відзначено високу пріоритетність використання параметричних мережевих моделей для процесу визначення екскурсійного маршруту в маршрутних мережах на прикладі Данії, що зумовлене труднощами визначення варіацій щодо організації екскурсій. В умовах цифровізації туристично-екскурсійні бюро перелаштовуються зі статичної організації на запити клієнтів з урахуванням можливостей розкриття певної теми для екскурсійної групи. Основна проблема туристично-екскурсійних бюро полягає в тому, що хоча суб'єкт господарювання самостійно встановлює номенклатуру екскурсій, вони не завжди проводяться за чітко визначеною програмою й на однакових для всіх учасників умовах. Під час надання таких послуг запити та особливості обслуговування клієнтів заздалегідь не відомі.

Мета нашого дослідження – представлення змістовної основи маршрутизації для туристсько-екскурсійних бюро на основі параметричних мережевих моделей, виходячи з особливостей динамічно адаптованих таблиць, які містять оптимальні маршрути. Для досягнення мети дослідження використано методи мережевого планування, а саме: аналітичні, табличні, хмарні обчислення в середовищі AnyLogic Claud.

Результатом дослідження стало подання змістовної основи маршрутизації туристичного маршруту для туристсько-екскурсійних бюро в вигляді їх параметричних мережевих моделей. Дослідження реалізовано на прикладі бюро «Даніятур – ваш гід», яке створене спільно з російськими, українськими, данськими представниками та надає екскурсійні послуги на туристичному ринку Данії. Бюро має близько 20 представництв у Данії, в яких маршрутні мережі вже адаптовані до практики екскурсійного проектування, й активно йде параметризація таких мереж, зокрема, увагу зміщено з кілометражу екскурсії на мінімізацію переміщень між об'єктами. Однак для подання змістовної основи маршрутизації бюро та його представництв повинні визначатися параметри маршрутних мереж не тільки виходячи зі списку дій (робіт), які треба виконати, але також їх тривалості (мінімально й максимально можливої). Відсутність належної уваги до термінів обслуговування екскурсійних груп веде до порушення графіків екскурсій. У 2020 році в результаті неефективної параметризації «Даніятур – ваш гід» щомісяця скасовувалося 5–6 екскурсій по Аалборгу та околицям. «Даніятур – ваш гід» зазнає щомісячні втрати в межах 15% від прибутку по 4–6 екскурсіям по Аалборгу, Аархусу та півострову Юрсланд із фіксованою вартістю внаслідок сплати термінової вартості за окремими екскурсійними роботами. Така ситуація характерна для туристсько-екскурсійних бюро в різних країнах світу, зокрема й в Україні.

За результатами дослідження відзначено, що маршрутизація туристичного маршруту туристсько-екскурсійних бюро на основі параметричних мережевих моделей перетворює статичні їх резерви та операційні метрики на динамічні величини, що залежать від тривалості екскурсійних робіт. Це дозволяє не просто забезпечити чітке дотримання графіку всіх екскурсій, а й мінімізувати щомісячний недоотриманий прибуток, оцінюваний приблизно в 2250 тис. євро за маршрутом Аалборг. Разом із тим можливі ситуації, коли зміна загальної вартості екскурсії неможлива. Наприклад, при роботі з посередниками. Щоб запобігти щомісячним втратам у межах 15% від прибутку необхідні досить специфічні коригування з деяких робіт на об'єктах, що враховують значення тимчасових резервів по максимальному маршрутному шляху. Необхідний комплекс екскурсійних робіт із максимальною різницею у ранніх і пізніх термінах виконання між нормальною й терміновою ціною робіт на об'єктах. Фактично, щоб мінімізувати втрати прибутку за маршрутами (які за рік перевищують 8 тис. євро), визначається, як за мінімальну доплату до операційної метрики (ціною маршруту) можна завершити комплекс робіт у необхідний термін, оскільки ця доплата екскурсантами не відшкодовується. Важливо, що представлені результати паралельно ідентифікують коригування шляху кожного окремого маршруту з урахуванням фактичного резерву часу (який доступний, виходячи з локації екскурсійної групи й попередніх екскурсійних робіт).

Перспективи застосування представленої змістовної основи маршрутизації для туристсько-екскурсійних бюро на основі параметричних мережевих моделей полягають у можливості формування динамічних графічних зображень усього порядку виконання екскурсійних робіт у вигляді орієнтовного графіка маршрутної мережі.

Ключові слова: екскурсія; маршрутизація; маршрут; мережева модель; маршрутна мережа; екскурсійне проектування; мережевий аналіз.

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Маршрутизация туристско-экскурсионных бюро на основе параметрических сетевых моделей

Аннотация

В статье отмечена высокая приоритетность использования параметрических сетевых моделей для процесса определения экскурсионного маршрута в маршрутных сетях, что обусловлено сложностями определения вариаций в отношении организации экскурсий. В условиях цифровизации туристско-экскурсионные бюро перестраиваются со статической организации различных экскурсий на динамическую, при которой они корректируются под потребности и запросы клиентов с учетом возможностей раскрытия определенной темы следования экскурсионной группы. Основная проблема туристско-экскурсионных бюро состоит в том, что хотя субъект хозяйствования самостоятельно устанавливает номенклатуру представляемых экскурсий, они не всегда проводятся по четко определенной программе и на одинаковых для всех участников условиях. В ходе представления таких услуг запросы и особенности обслуживания клиентов заранее не известны. Цель нашего исследования – представление содержательной основы маршрутизации туристско-экскурсионных бюро на основе параметрических сетевых моделей, формируемых исходя из особенностей динамически адаптируемых таблиц, содержащих наиболее оптимальные маршруты. Для достижения цели исследования использованы методы сетевого планирования, а именно аналитические, табличные, облачные вычисления в среде AnyLogic Claud.

Результатом исследования стало представление содержательной основы маршрутизации туристического маршрута для туристско-экскурсионных бюро в виде их параметрических сетевых моделей. Исследование реализовано на примере бюро «Даниятур – Ваш гид», созданного совместно российскими, украинскими и датскими представителями и предоставляющего экскурсионные услуги на туристическом рынке Дании. Бюро имеет около 20 представительств в Дании, в которых уже адаптировало маршрутные сети к практике экскурсионного проектирования, активно работает над параметризацией таких сетей, в частности, внимание переориентировано с километража экскурсии на минимизацию перемещений между объектами. Однако для представления содержательной основы маршрутизации такого бюро должны определяться параметры маршрутных сетей не только исходя из списка действий (работ), которые надо выполнить, но и их минимально и максимально возможной продолжительности. Отсутствие должного внимания к срокам обслуживания экскурсионных групп ведет к нарушению графиков экскурсий. Так, в 2020 г. в результате неэффективной параметризации «Даниятур – Ваш гид» ежемесячно отменялось 5–6 экскурсий по Аалборгу и окрестностям. «Даниятур – Ваш гид» несет ежемесячные потери в пределах 15% от прибыли по 4–6 экскурсиям в Аалборг, Аархус и на полуостров Юрсланд с фиксированной стоимостью. Аналогичная ситуация характерна для туристско-экскурсионных бюро в различных станах мира и Украине.

По результатам исследования отмечено, что маршрутизация туристического маршрута туристско-экскурсионных бюро на основе параметрических сетевых моделей превращает временные их резервы и операционные метрики в динамические величины, зависящие от продолжительности экскурсионных работ. Это позволяет не просто обеспечить четкое соблюдение графика всех экскурсий, но и минимизировать ежемесячную недополученную прибыль, оцениваемую примерно в 2250 тыс. евро по маршруту Аалборг. Вместе с тем возможны ситуации, когда изменение общей стоимости экскурсии невозможно. Например, в «Даниятур – Ваш гид» при работе с посредниками такая стоимость фиксированная. Чтобы предотвратить ежемесячные потери в пределах 15% от прибыли по 4–6 экскурсиям в Аалборг, Аархус и на полуостров Юрсланд, необходимы достаточно специфические корректировки по некоторым работам на объектах, учитывающие значения временных резервов по максимальному маршрутному пути (включающие особый комплекс экскурсионных работ с максимальной разницей ранних и поздних сроков, нормальной и срочной ценой работ на объекте). Фактически, чтобы минимизировать потери прибыли по маршрутам (которые за год превышают 8 тыс. евро), определяется, как за минимальную доплату к операционной метрике (цене маршрута) можно завершить комплекс работ в необходимый срок, поскольку она экскурсантами не возмещается. Важно, что представленные результаты параллельно идентифицируют корректировки пути каждого отдельного маршрута с учетом фактического резерва времени (который доступен исходя из локации экскурсионной группы и предшествующих экскурсионных работ).

Перспективы применения представленной содержательной основы маршрутизации для туристско-экскурсионных бюро на основе параметрических сетевых моделей состоят в возможности формирования динамических графических изображений всего порядка выполнения экскурсионных работ в виде ориентированного графа маршрутной сети.

Ключевые слова: экскурсия; маршрутизация; маршрут; сетевая модель; маршрутная сеть; экскурсионное проектирование; сетевой анализ.

1. Introduction

The study refers to the scope of optimization in the tour design procedure. Namely, it relates to the field of implementing automatic identification of itinerary and servicing peculiarities for tourist groups within the route network, especially in cases where the travelling itinerary is intended to provide full treatment of a certain topic (excursion subject). The necessity for shifting to network-based routing models in tour designing arises from the fact that currently tour agencies' activities are quite specific and associated with a selection of network routes interacting with one another. This is due to the fact that, against the background of digitization, such economic entities are being restructured in their activities, from simply static organization of various tours (with unchanged tourist routes) to a dynamic organization pattern. Dynamic routes are adjusted according to the customers' demands and requests, and topics within a tour group itinerary. The main problem for tourist and excursion bureaus is that they are targeted for servicing unorganized tourists staying in hotels and spa resorts, or those arriving on company-organized tours. At the same time, although the economic entity may itself establish a range of presented guided tours, these are not always conducted according to a clearly defined program and under the same conditions for all visitors. In the process of providing such services, the personal demands and servicing peculiarities of the customers are not known in advance. Age ranges (including children tourists), state of health, numbering of tourists in groups, and their requests may lead to making adjustments in the visiting sequence for historical, natural, and other attraction sites; servicing duration and the tourist itinerary proper.

According to data by Pricewaterhouse Coopers, 25% of modern sightseeing tours and topical coach trips provided by tourist agencies have deviations from the original traveling itinerary. Therefore, approaches to tour designing are changing.

For example, the «Alik's Tours» agency (providing guided tours and trips in Alania travel market) and Questtour (providing non-standard guided tours and trips in Czech Republic travel market), instead of clear travelling itinerary for tourist groups (from one location to another, by predefined roads, streets, and other transport corridors), have been using route networks for transferring since 2017.

Since 2018, the agency Denmark Tour - Your Guide (providing guided tours in Denmark travelling market) and the agency Italy with Us, providing guided tours in the Vatican, Rome, Venice, Florence travel markets) not only use route networks for travel but also cluster them according to the the tour program participation cost and service peculiriarities for tour groups.

These innovations derive from the fact that tourist agencies have to plan their costs and all possible routes for the tours before actually introducing the tour services. It is necessary to conclude contracts for the rental of vehicles in advance, those with catering companies, theatres, and other facilities for visiting them later during tours. In doing so, even when costs have already been incurred, it is extremely difficult to design all possible variations in the tour organization, including travelling within the route network and any probable arising of additional costs associated with the immediate service cost.

To provide for obtaining profit from the tour route, tourist agency experts draw attention to the importance of the clear definition of basic parameters in network models (completing each tour event ahead or behind of schedule, time reserves, critical track (longest within the network), availability of urgent cost of services), influencing operational metrics (prices) and tour duration.

It is the basic parameters that should form the basis for the routing of the tourist trip, i.e. ensure an automatic process for determining the optimal trip route/track, taking into account the parameters of the route network in general and the current location of the tourist group in real-time mode.

2. Brief Literature Review

There are many studies on the importance of solving issues in optimizing the guided tour design process for different types of guided tours. However, experts in this field describe, in an abstract way, the peculiarities of splitting a tour project into route operations (determining the number of nodes in the route network) required to move to the sightseeing sites. It is proposed to use specialized closed, open, homogeneous (those defined by the number of routes within the network), as well as non-specialized network models (assuming that the number of routes in the network cannot be typified). At this, by utilizing various statistical, probabilistic (alternative and not alternative) methods of analysis for the selected network models of routing operations, possible improvements are identified in the movement of tourists on a particular route (or optimal route) before or during its implementation.

In particular, we have selected these authors (Dorigo, M., and Stutzle, Th, 2009, Bonavear, E., Dorigo, M., and Theraulaz, G., 1999). They suggest utilizing closed network models of routing operations and accompanying tour activities (with a constant number of routes in the network) and analyzing them using the ant colony behavior model, which tends to a food source. Open network models (where any numbers of routes are possible) are not considered by the authors, although it is noted that such models could be developed in the peak season (Bonavear, E., Dorigo, M., and Theraulaz, G., 1999). At this possible improvements in the tourists moving along the route are identified within the framework of metaheuristic optimization. It is pointed here that an ant colony can be viewed as a network model in which each agent (ant) functions autonomously according to a very simple rule - finding the optimal path. Naturally, this behavior of agents ensures the optimum of all route operations for the colony. The disadvantage of the approach is that a common calendar schedule is compiled, defining a fixed beginning and completion for each route operation, as well as its coordination with other operations within the network of routes. However, determining parameters within the framework of metaheuristic optimization, such as early or late completion of a tour event, reserve time, the critical track is not envisaged (Dorigo, M, 1992). It is therefore difficult to complete routing of a tour itinerary via metaheuristic optimization.

According to these studies (Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, 2009, etc.) there are closed, open (determined by peak and low seasons) and homogeneous (in case the number of routes circulating in the network is conditionally constant) network models of route operations and tour activities. These models are analyzed using various graph alternative models representing relationships between random values defined by the tour group location and the network type. Possible improvements in the movement of tourists along the route are identified by various methods. Specifically, with the help of Control Graph (T. Filatova, J. G. Polhill, and S. van Ewijk, 2015); Directed Tree (I. Lorscheid, B-O. Heine, and M. Meyer, 2012); Syntactic Trees or Sorting Trees (Y. Li, 2017); Petri Networks and others (Jovanović, V. and Njeguš, A., 2008). According to this approach, a calendar schedule is compiled, defining the beginning and completion for each routing operation, as well as its coordination with other network operations (including those allowing for a transfer of the tourists between individual sections of the itinerary or a route adjustment). The optimization result will only identify critical operations requiring special attention for completing the tour servicing within the standard time. As for the parameters of the network model shaping the routing basis (such as the completion date for each excursion event; time reserves for route operations), they are not defined.

Some researchers (Xiaochen Chou, Luca Maria Gambardella, and Roberto Montemanni, 2019; Papapanagiotou, V., Montemanni, R., and Gambardella, L. M., 2015, etc.) suggest rejecting the type-design practice for network models, substituting it with subdividing tours within the route network into clusters of network routing sub-models. According to the authors, the type of route network does not affect the probability of deviation from the complex of scheduled activities during tour routes (Schwartz, Z., Uysal, M., Webb, T., and Altin, M., 2016; Caicedo-Torres, W., and Payares, F., 2016). At the same time, it is suggested that the possible deviations and improvements in the tourists' itinerary for each sub-model should be determined based on a statistical test method (namely, the Monte-Carlo method). Naturally, the search for the optimal path is ensured by a numerical model, using random-value generators. The optimal route is replayed repeatedly, based on parameters of each cluster of network submodels, i.e. distances between locations (Papapanagiotou, V., Montemanni, R., and Gambardella, L. M., 2015). A drawback of the approach is in its labor-intensive nature, which creates issues with routing.

For example, to determine the average distance between two random points in a route within the network, the following tasks are to be completed:

1) to take into account the coordinates of a large number of random pairs of points within the periphery of the attraction site (Li, X., Pan, B., Law, R., and Huang, X., 2017; Bangwayo-Skeete, P. F., and Skeete, R. W., 2015);
2) to calculate the distance for each pair of points within the boundaries of a given circle of the attraction site (Li, G., Song, H., and Witt, S. F., 2016; Gunter, U., and Önder, I., 2015).

Only such calculations, in the opinion of the approach representatives, will allow for calculating the average arithmetic distance for the transit to the event site (Zhang, G., Wu, J., Pan, B., Li, J., Ma, M., Zhang, M., and Wang, J., 2017). In addition, values of parameters, such as early, late completion dates for each tour event, time reserves are not important for optimization (Vansteenwegen, P., Souffriau, W., Vanden Berghe, G., and Van Oudheusden, D., 2009; Chou, X., Gambardella, L. M., and Montemanni, R., 2018).

The selected approaches provide a generalized picture of the tour operations and their typical routing operations on the network, as they do not provide for the following: 1) finding basic parameters for the network model; 2) modifications of the excursion itinerary in the network aimed at improving it; 3) analysis of the tour group location. In other words, it is necessary to have not abstract but parametric network models of the tour route operations. They form the substantive basis for a quick definition of a tour route in networks, as related to the process of maximizing its beneficial characteristics from the already existing tour group locations. Based on the results of the network simulation, there is a need for some dynamically adaptable table for the tour group location, in which several optimal routes are possible, rather than one (Pai, P. F., Hung, K. C., Lin, K. P., 2014). However, the optimization processes involved in typifyng and separating network model clusters, lead to parameter duplication and complicate the tour network plan unnecessarily (Montes y Gómez et al., 2016). Therefore, most modelling experts are focused on smart model simplification (Vdovenko N. M., 2015; Muzi Zhang, Junyi Li, Bing Pan, and Gaojun Zhang, 2018), by combining simplicity and maximum precision. Naturally, in the process of routing a tourist trip, the type and sub-model clusters placed in the network model can be neglected.

3. Purpose

The purpose of the study is to provide a substantive basis for the routing of tourist and excursion bureaus, based on parametric network models shaped taking into account the characteristics of dynamically adaptable tables containing the best routes.

4. Methodology and Data

It is intended to present the substantive basis of the routing for tourist and excursion bureaus in parametric network models. Actually, the classical network model featuring parameterized routing operations is used. The latter, together with self-regulating technical means, serve as a means of configuring main attributes of the tour activities. It is assumed that the configuring is performed based on the tourists' travel peculiarities within the itineraries and the trip timing reserves. To identify and illustrate the peculiarities of the solutions to this problem, we used network planning methods (in particular network analysis), namely analytic ones (including calculations with formulae), tabular ones (including the transmission of the arguments attributes in the route network serving as identifiers for a specific route), cloud computing in AnyLogic Cloud environment. Proceeding from the applied methods in network models, the data are set with a table, and the whole process of presenting the substantive basis of routing is described through their analysis in the AnyLogic Cloud environment (which has a free tariff on computational functions, among which the compilation of network parametric models).

The tourist and excursion office of DenmarkTour - Your Guide, founded by Russian, Ukrainian and Danish representatives, and providing sightseeing services in the Denmark's tourist market, is chosen as the base for the study. This office was chosen, considering that it not only has about 20 affiliates throughout Denmark (in Aarhus, in the cities of Jursland peninsula and in Aalborg), but has already adapted its route networks to the practice of tour designing.

DenmarkTour-Your Guide staff are actively working on the parameterization of such networks, in particular, the focus is shifted from the tour mileage (namely, decreasing the total distance covered by the group tourists) to the minimization of transfers between sites. The office has already purchased locator devices with the aim of launching automatic routing in the real-time mode. The focus is on the tour route including various attractions featuring shrines, castles and other buildings.

Therefore, this entity has already formed a basis for parameterizing the complex of activities and transfers between these sites (a nomenclature of all activities within the route has been compiled, and their approximate sequence has been established). However, that is not sufficient. To provide a substantive basis for the routing, tourists and sightseeing offices should determine the parameters in the route networks, not only based on the list of actions (activities) to be carried out, as well as their sequences (i.e. previous ones), but also their minimum and the maximum possible duration. This is important, since lack of attention to the time taken for servicing tour groups (in particular, the timing of the start and end for each activity) will lead to breaking tour schedules. Thus, in 2020, as a result of inefficient parameterization, DenmarkTour-Your Guide cancelled 5-6 Aalborg and Surroundings tours monthly. Taking into account that the amount of profit for the Office, per 1 such tour, makes about 550 euros, the profit lost monthly is estimated at 2,250 thousand euros (DenmarkTour-Your Guide, 2020). Also, DenmarkTour-Your Guide incurs monthly losses within 15% of the profit from 4-6 guided tours with a fixed cost (within the directions of Aarhus and Surroundings, Jursland peninsula, Aalborg and Surroundings). Losses arising as a result of payment of a fixed cost for selected tours (including ordering individual tours with sightseeing sites, tours compiled to match working schedules of the attraction sites, etc.). Taking into account that the profit from such a tour makes up to 800 euros per a group of 20 tourists, the monthly loss is estimated at 0.72 thousand euros (DenmarkTour-Your Guide, 2020). The total annual losses and profit lost by DenmarkTour-Your Guide exceeds 35,64 thousand euros. A similar situation is typical for tourist and excursion bureaus in various countries of the world, including Ukraine (Ernst & Young Global Limited, 2020). Due to this range of problems, it is suggested to calculate the tour cost based on the maximum mileage, and process of identifying transfers within the route network should be defined through a normal or accelerated sequence of completing individual tours and their entire complex (shaping based on reserves of travel time).

In the study, the route network of DenmarkTour-Your Guide is defined as a multiple set named ij, consisting of possible events j (by showing combinations of tour attractions) and scheduled works i (operations or planned activities by the guide in the routing environment, as set by the tour program) with flexible time and operational markers. The combinatorics of sites in such a route network is provided by their networkization by clusters of tour attraction sites, combining museums, monuments, possible places for organizing nutrition, and leisure time. It is not unexpected that basic parameters of route network models in routing of tourist route itineraries are the following: critical route within the network; reserves of event time, taking into account combinatorics of the tour attraction site locations, operations, and roads to them (or maximum allowable amount of time for a delay in events, activities and roads without increasing the total tour schedule timing). The study complements such basic indicators with several supporting indicators, allowing for their sequencing to be taken into account for the analysis of possible and actual transfers of the tourists on the route network. The list of parameters of the route network, which became the basis of the routing of DenmarkTour-Your Guide is highlighted in Table 1.

Presentation of such substantive basis of routing at DenmarkTour-Your Guide allows for taking into account the importance of time metrics and identifying possible complexity of tourist routes. Consequently, this framework creates the potential for rapid decision-making on the permissibility of increasing/reducing the duration of all tours in total by each way individually. Since the analysis of a parameterized routing network by $t(L_{max})$ and $t'(L_{kp})$ is most accurate in simple routing networks, the following values are most important in the process of investigation:

Table 1:
List of parameters serving as the basis of routing in DenmarkTour-Your Guide

Parameter groups	Detailed data argument	Algorithms	Characteristics of parameter
Time reserves of events, activities and ways	total travel reserve $L_П$, or $R(LR)$ **B***	$tjR - tiP - tij$	The maximum time of postponing or increasing the operation *ttj* without adjusting the overall time for completion of the set of operations. If $R(ij) = 0$ the task is critical
	time reserve for completing event *j*, or R_j **A***	$t_j^n - t_j^p$	A time-frame within which an event j can be postponed without exceeding the time-limit for the completion of all tours
	available reserve of working time *(i,j), or* $r_{ij}^{C.B}$ **A***	$t_j^P - t_i^P - t_{ij}$	Maximum time to delay the activity start or increase the operation timing, provided that all network events occur early
	full reserve of time work *(i,j)*, or r_{ij}^R **A***	$t(L_{KP}) - t(L_П) = T_{KP} - T_П$	Tolerable increasing of all tour activities, as a sum of travel *Ln* relative to L_K
	private reserve of time type 1 or R_1 **A***	$R(i,j) = R^R(i,j) - R(i)$	A part of the full time reserve by which the duration of task can be increased without changing the time of the late event start
	private time reserve of type 2, or free reserve of operational time *(i,j) Rc*, or $R(i,j)$ **A***	$R^R(i,j) - R(j)$	Part of the full time reserve by which the duration of the task can be increased without changing the early deadline of the final event
Critical way	duration of the critical way L_c or T_c , or $R(i,j)$ **B***	$R^R(i,j) - R(i) - R(j)$	An abstract sequence of tasks determining the design date for the start or end of tours
Early and Late Events, Works and Ways	early t_i^p / late due date of the *j*-th event completion, or t_j^n ***B****	-	*t m* ³ for a given trip activity duration / *t m* ³ for visiting an attraction site (which will not break the normative time for execution of subsequent works)
	early term of start work *(i,j)* $t_{ij}^{P.H}$ **/** end term of operation end *(i,j)*, or $t_{ij}^{P.O}$ ***B****	t_i^p $t_i^P + t_{ij}$	*min m* ⁴ operation start with the given duration of tour work / *min m* ⁴ end of this trip for a given period of work duration
	late term of work start *(i,j)*, or $t_{ij}^{П.H}$ **A***	$t_j^R - t_{ij}$	*max m* start for the task, when extra tour activity can be completed within the scheduled time
	late term of task end *(i,j)*, or $t_{ij}^{П.O}$ **A***	t_j^R	*max* end *m* for the task, when extra tour activity can be completed within the scheduled time
	travelling time *LR* **A***	$t(L_R)$;	deadline for completion of all works
	task duration, or $t_{exp}(i,j)$ **A***	$(3t_{min}(i,j) + 2t_{max}(i,j)) / 5$	random value can take any amount within a given range
	dispersion, or $S^2(i,j)$ **A***	$0,04(t_{max}(i,j) - t_{min}(i,j))^2$	Range of possible values around the expected level
Work intensity	coefficient of intensity of work *(i,j)*, or k_{ij}^H **B***	$(t(L_{max}) - t'(L_{kp}) /$ $/ (T_{kp} - t'(L_{kp}))$	Time pressure for the task *(i,j)*, determining the probability/tolerance of the tour duration increase
	coefficient of complexity C_c **B***	$n_{pab}{}^2 / n_{cob}{}^1$	Determines the complexity of route network. Networks with Cc1.0 to 1.5 are simple, those within 1.51 to 2.0 are of medium complexity, and those over 2.1 are complex
	$t(L_{max})$ **A***	-	Duration of the maximum non-critical way transiting through the task
	L_{max} or $t'(L_{kp})$ **A***		Duration of part of the critical activity within the way considered

Notes: ¹ - n_{cob} - the number of events, units; ² - n_{pab} - the amount of activities, units;
³ - the minimum possible occuring time, $j\ (t\ min)$; ⁴ - minimum/maximum possible time $(min/max\ m)$;
* Parameter groups: basic (**B**); auxiliary (**A**)

Source: Calculated by the authors

- Coefficient of the intensity of work. The value of the coefficient may vary from 0 (for activities where the segments of the longest track do not coincide with the critical track and consist of dummy activities with zero duration) to 1 (for tasks in the critical track). The closer a coefficient value to 1, the more difficult it is to complete the work within a given time;
- Coefficient of complexity. The value of the coefficient determines the complexity of the route network. Routing networks with a coefficient of complexity up to 1.5 - are simple (here the analysis by $t(L_{max})$ and $t'(L_{kp})$ is the most accurate). Routing networks with a complexity factor of 1.51 to 2.1 are complex, their analysis by $t(L_{max})$ and $t'(L_{kp})$ is possible after simplification down to structures with a complexity factor of up to 1.5.

To ensure the presentation of the sustentative basis for routing, the sightseeing events and the work of DenmarkTour-Your Guide are transformed into a combinatorial view displaying their attributes, in the form of a route network ij, in the directions of Aarhus and Surroundings, Jursland peninsula, Aalborg and Surroundings. Thus, input data for the DenmarkTour-Your Guide route network in 2021 are presented in Table 2.

For elements within a route network ij, the following concepts are introduced:

1) minimum rating $t_{min}(i,j)$, determining the duration of a given tour operation under most favorable circumstances;
2) maximum $t_{max}(i,j)$ determine the duration of a specific tour in the most unfavorable conditions.

The values $t_{min}(i,j)$ and $t_{max}(i,j)$ allowed enriching the data about the DenmarkTour-Your Guide route network. The duration of the operation is also considered as a random value, which, as a result of implementation, may accept any value within a given interval. Such estimates are called probabilistic (random) and allow to identify their expected $te(i,j)$ value and the range of possible values dispersion around the expected level, as required to represent the substantive basis in the parameterized DenmarkTour-Your Guide route network.

5. Results

Considering that the results obtained should provide the substantive basis of the parameterized DenmarkTour-Your Guide route network, based on input data it is important to maximize the description of their route operations and processes i,j. employing basic and auxiliary characteristics and properties highlighted in Table 1. The parameterization results for DenmarkTour-Your Guide route network are highlighted in Table 3. The routing of tourist and excursion bureaus based on parametric network models serves for converting the time reserves in a tour route and their operational metrics into dynamic values, depending on the duration of the tour operations. Respectively, the following factors are important:

1) a sequence of tasks best determining the start time or end time for a route;
2) the combinatorics of combinations i,j defining the detailed cost/time reserve ratios in the DenmarkTour-Your Guide route network.

In particular, it is evident that the parameterization forms an opportunity not only to determine the duration of all activities for each i,j route network but also to adjust it on the spot. For example, according to the data obtained, it is clear that in the Aarhus and Surroundings itinerary, the maximum duration of a tourist route is 10 hours 33 minutes, with a minimum duration of 7 hours 15 minutes. The total cost of the tour will change from 1837 to 2614 euros. For the Jursland peninsula, the maximum duration of a tourist route is 10 hours 40 minutes and the minimum one is 7 hours 40 minutes. Typically, the total cost of the tour will vary from 1833 to 2081 euros. For Aalborg and Surroundings, the maximum duration of a tourist route is 10 hours 50 minutes and the minimum one is 5 hours 50 minutes. Here the total tour cost will change vary 1620 to 2450 euros. With the parameterized approach it is possible to take into account the tour group requests, since it is possible to define on the spot the increase or reduce in the duration of the activities within the given track, provided that the total completion time for the whole scope of operations does not break the general tour schedule (taking into account the scheduled hourly load). Thus, the results of the parameterization (presented in Table 2) can be used for network analysis and identification of time reserves, if there is a need to optimize routes (for example, if the group is significantly behind the tour schedule or the site arrival time). It will also minimize the of profit loss. The latter which exceeded 27,000 euros in 2020 (DenmarkTour-Your Guide, 2020). However, there may be situations where the total cost of a guided tour cannot be changed. Thus, in DenmarkTour-Your Guide, when selling tourservices through intermediaries, on all route networks, the price is fixed. To prevent

Table 2:
The input data for the DenmarkTour-Your Guide route network in 2021

Network / Code	Combinatorics		Time characteristic, minutes		Cost parameters, euros		Expected duration $t_e(i,j)$, minutes ^{1,2,3}	Dispersion $S^2(i,j)^{1,2,3}$	Nature of the tour cluster (code decryption in column 2)	Nature of planned work (according to the tour program and codes in column 3)
	j events	i work	Normal $t_{min}(i,j)$	Expedited $t_{max}(i,j)$	Normal value	Urgent cost				
1	2	3	4	5	6	7	8	9	10	11
1	1	2	130	90	130	177	114	64	Aarhus and Surroundings: (1) Huset Carmel; (2) Vor Frue Kirke; (3 Mathilde Fibigers Have; (4) KØN - Gender Museum Denmark; (5) Sirene: (6) Springvandet Endless Connection; (7) Toldboden; Den Gamle Post & Telegrafbygnin; (8) Aarhus Theatre	1) visit to the museum; (2) excursion at the attraction site; (3) excursion with visual reconstruction; (4) excursion with panoramic presentation; (5) lunch; (6) monument viewing; (7) visit of the festival, digustatory; (8) excursion by guide with event localization technique.
	2	2	60	45	31	32	54	9		
	3	3	60	35	54	144	50	25		
	4	1	40	42	37	88	40.8	0.16		
	4	5	60	30	50	72	48	36		
	5	6	20	10	33	49	16	4		
	6	3	60	30	30	74	48	36		
	7	3	60	45	55	122	54	9		
	7	6	20	12	14	26	16.8	2.56		
	8	7	120	90	1400	1830	108	36		
2	1	3	120	90	142	195	108	36	Jursland peninsula: (1) Tved Kirke, Kirke; (2) Knebel Kirke; (3) Porskaer Stenhus; (4) Vistoft Church; (5) Molbo Stotten; (5) Molbo Stotten; (6) Mollerup Gods; (7) Kalo Hovedgaard, Bregnet Kirke, Egens Kirke, Baunhoj Molle Grenaa; (8) Vindpust og vandkunst, Ostjylland Grenaa; (9) Orum Kirk;	
	2	2	45	35	30	62	41	4		
	4	4	40	20	60	67	32	16		
	4	8	40	30	55	62	36	4		
	3	5	20	10	23	31	16	4		
	5	6	60	40	130	142	52	16		
	6	3	60	40	30	40	52	16		
	7	3	60	45	30	32	54	9		
	8	6	60	45	33	40	54	9		
	9	7	120	90	1300	1410	108	36		
3	1	1	60	30	107	212	0	0	Aalborg and Surroundings: (1) Aalborgtarnet, Gug Church; (2) Lindholm Hoeje Museum; (3) Aalborghus Castle, Utzon Center; (4) Salling Aalborg, Jens Bang's Stenhus, Apotekersamlingen; (5) Kongelig Toldkammer & Toldbodsplads; (6) Monastery of the Holy Ghost; (7) Springtudser; Jomfru Ane Gade;	
	2	2	120	45	60	100	0	0		
	3	2	60	40	54	104	0	0		
	3	5	60	20	55	100	0	0		
	4	4	30	20	50	80	0	-44		
	5	4	60	40	50	30	0	0		
	6	3	60	30	30	74	0	0		
	7	6	30	10	50	100	104	0		
	7	7	30	15	64	150	0	0		
	7	8	120	80	1100	1500	0	0		

Notes: 1 Calculation of the expected value and measure of dispersion across the network 1:
te(1.2) = (3*130+2*130)/5 = 114; te (2.2) = (3*60+2*60)/5 = 54; te(3.3)=(3*60+2*60)/5 = 50; te(4.1) = (3*40+2*40)/5 = 40.8; te(4.5)=(3*60+2*60)/5 = 48; te (5,6) = (3*20+2*20)/5 = 16; te(6.3)=(3*60+2*60)/5 =48; te(7.3) = (3*60+2*60)/5=54; te(7.6) = (3*20+2*20)/5=16.8; te (8.7) = (3*120+2*120)/5 = 108; S2(1.2) = 0.04(90-130)2 = 64; S2(2.2) = 0.04(45-60)2 = 9; S2(3.3) = 0.04 (35-60)2 = 25; S2(4.1) = 0.04 (42-40)2 = 0.16; S2(4.5) = 0.04(30-60)2 = 36; S2(5.6) = 0.04 (10-20)2 = 4; S2(6.3) = 0.04 (30-60)2 = 36; S2(7.3) = 0.04(45-60)2 = 9; S2(7.6) = 0.04 (12-20)2 = 2.56; S2(8.7) = 0.04 (90-120)2 = 36.
2 Calculation of the expected value and measure of dispersion across the network 2:
te (1.3) = (3*120+2*120)/5 = 108; te (2.2) = (3*45+2*45)/5 = 41; te(4.4) = (3*40+2*40)/5 = 32; te(4.8) = (3*40+2*40)/5 = 36; te (3.5) = (3*20+2*20) / 5 = 16; te(5.6) = (3*60+2*60)/5 = 52; te(6.3) = (3*60+2*60)/5 = 52; te(7.3) = (3*60+2*60)/5 = 54; te(8,6) = (3*60+2*60)/5 = 54; te (9.7) = (3*120+2*120)/5 = 108; S2(1.3) = 0.04(90-120)2 = 36; S2(2.2) = 0.04(35-45)2 = 4; S2(4.4) = 0.04(20-40)2 = 16; S2(4.8) = 0.04(30-40)2 = 4; S2(3.5) = 0.04(10-20)2 = 4; S2(5.6) = 0.04(40-60)2 = 16; S2(6.3) = 0.04(40-60)2 = 16; S2(7.3) = 0.04(45-60)2 = 9; S2(8.6) = 0.04(45-60)2 = 9; S2(9.7) = 0.04(90-120)2 = 36;
3 Calculation of the expected values and dispersion indicators across the network 3:
te(1.1) = (3*60+2*60)/5 = 48; te(2.2) = (3*120+2*120)/5 = 90; te(3.2) = (3*60+2*60)/5 = 52; te(3.5) = (3*60+2*60)/5 = 44; te(4.4) = (3*30+2*30)/5 = 26; te(5.4) = (3*60+2*60)/5 = 52; te(6.3) = (3*60+2*60)/5 = 48; te (7.6) = (3*60+2*60)/5 = 48; te(7.7) = (3*30+2*30)/5 = 24; te(7.8) = (3*120+2*120)/5 = 104; S2(1.1) = 0.04(30-60)2 = 36; S2(2.2) = 0.04(45-120)2 = 225; S2(3.2) = 0.04(40-60)2 = 16; S2(3.5) = 0.04(20-60)2 = 64; S2(4.4) = 0.04(20-30)2 = 4; S2(5.4) = 0.04(40-60)2 = 16; S2(6.3) = 0.04(30-60)2 = 36; S2(7.6) = 0.04(30-60)2 = 36; S2(7.7) = 0.04(15-30)2 = 9; S2(7.8) = 0.04(80-120)2 = 64.

Source:
Compiled by the authors based on: Characteristics of the Daniatur-Your Tour Guide Network as of 2021 (a full dataset is available from the authors upon request)

Table 3:
Results of the DenmarkTour-Your Guide route network parameterization, 2021

Network	i,j[1]	Duration t_{ij}	Early-term, minutes		Late-term, minutes		Reserve time, minutes		Private reserve , minutes		Critical track, tasks	Duration of critical track, minutes
			start $t_{ij}^{P.H.}$	end $t_{ij}^{P.O}$	start o $t_{ij}^{R.H}$	ending e $t_{ij}^{R.O}$	full R_{ij}^{R1}	specific R_{ij}^{H3}	I type, R_{ij}	II type, R_{ij}^{C}		
1	1.2	114	0	114	-114	0	-114	0	-114	0	(7.3)	172
	2.3	0	114	114	0	0	-114	114	0	0	(7.6)	
	3.4	0	114	114	0	0	-114	114	0	0		
	4.1	40.8	114	154.8	-40.8	0	-154.8	-40.8	-40.8	-154.8		
	4.5	48	114	162	-48	0	-162	114	-48	0		
	5.6	16	162	178	-16	0	-178	162	-16	0		
	6.3	48	178	226	-48	0	-226	66	-48	-112		
	6.7	0	178	178	194.8	194.8	16.8	194.8	194.8	16.8		
	7.3	54	178	232	-54	0	-232	-118	-232	-118		
	7.6	16.8	178	194.8	-16.8	0	-194.8	-16.8	-194.8	-16.8		
2	1.2	0	0	0	0	0	0	0	0	0	(1.3)	180
	1.3	108	0	108	-108	0	-108	0	-108	0		
	2.3	0	0	0	0	0	0	108	0	108		
	3.4	0	108	108	162	162	54	108	162	0		
	3.5	16	108	124	-16	0	-124	108	-16	0		
	4.8	36	108	144	162	198	54	0	0	54		
	5.6	52	124	176	-52	0	-176	124	-52	0		
	6.3	52	176	228	-52	0	-228	56	-52	-120		
	6.7	0	176	176	0	0	-176	176	0	0		
	7.3	54	176	230	-54	0	-230	54	-54	-122		
3	1.2	0	0	0	0	0	0	0	0	0	(6.7)	104
	2.3	0	0	0	0	0	0	0	0	0	(7.8)	
	1.3	52	0	52	-52	0	-52	-52	-52	-52		
	3.5	44	0	44	-44	0	-44	0	-44	0		
	4.5	0	0	0	0	0	0	44	0	44		
	5.4	52	44	96	-52	0	-96	-52	-52	-96		
	6.3	48	0	48	-48	0	-48	-48	-48	-48		
	6.7	0	0	0	0	0	0	0	0	0		
	7.6	48	0	48	-48	0	-48	-48	-48	-48		
	7.8	104	0	104	0	104	0	0	0	0		

Note:
[1] - combinations i,j are compiled automatically in AnyLogic Cloud, based on expenditure/time reserve ratios.

Source: Compiled by the authors based on:
RijP, RijH, I Type R_{ij}, II Type R_{ij}^{c}, duration of critical track for the Network Settings of Aarhus and Surroundings (Network 1); Jursland peninsula (Network 2); Aalborg and Surroundings (Network 3)
(a full dataset is available from the authors upon request); input data of the route network
by DenmarkTour-Your Guide, 2021 from Table 1

monthly losses within 15% of the profits in 4-6 tours of Aarhus and Surroundings, Jursland peninsula, Aalborg, and Surroundings, specific adjustments for the operations on site, taking into account the values of time reserves on the maximum route track. A set of tours is defined in the following way:

1) with a maximum difference in early and late terms;
2) with the normal and urgent price of site operations.

To minimize profit losses with routes over 8000 euros per year, taking into account each tour group location, a procedure is determined allowing for completing a scope of operations within the required time for a minimum surcharge to the operating metric (route price), since such a supplement is not reimbursed by the tourists. For this purpose, the routing in tourist and excursion bureaus, based on parametric network models, should be supplemented by the option of analyzing all possible ij tracks by $t(L_{max})$, taking into account $t'(L_{kp})$ for all i. Such analysis is most accurate in simple route networks compiled by DenmarkTour-Your Guide. Based on the analysis results of parameterized route network DenmarkTour-Your Guide, its further simplification is not required (Table 4), and all possible variations of the route passing on $t(L_{max})$ are highlighted, taking into account $t'(L_{kp})$ all tasks.

Based on the results of analysis of the route network by DenmarkTour-Your Guide at $t(L_{max})$ taking into account $t'(L_{kp})$ for all activities, it can be stated that the time reserves of the tour route and their operational metrics aren't constant values. They are determined with the tour group location and all previous tour activities. To enable for their minimal adjusting, the sequence of tasks best determining the start or end of a route should be implemented as the last one.

Table 4:
Analysis result for the route network by DenmarkTour-Your Guide on $t(L_{max})$ taking into account $t'(L_{kp})$ for all works, 2021

i,j	track /tasks by group location and previous tasks	t(Lmax), euro[1]	Kc[2]	i,j	track/tasks by group location and previous activities	t(Lmax), euro[1]	Kc[2]	i,j	track/tasks by group location and previous activities	t(Lmax), euro[1]	Kc[2]
Operation marker (total price)	network 1 for the duration of 10 hours 33 min - 1837 euros				network 2 for the duration of 10 hours 40 min - 1886 euros				network 3 for the duration of 10 hours 50 min -1620 euros		
	Price adjustment for $t(Lmax)$ at $t'(Lkp)$ (7.3) and (7.6) - 79 euros, to provide temporary reserves at 23 minutes.				Price adjustment for $t(Lmax)$, at $t'(L_{kp})$ (1.2) – 53 euros, to provide temporary reserves at 30 minutes.				Price adjustment for $t(Lmax)$, at $t'(L_{kp})$ (6.7)(7.8) – 400 euros, to provide temporary reserves at 60 minutes.		
	recommended price adjustment by 79 euros				recommended price adjustment by 53 euros				recommended price adjustment by 400 euros		
1.2	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226	simple	1.2	(1.2) recommended to accelerate[3]	0	simple	1.2	(1.2)(2.3)(3.2)	52	simple
2.3	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226		1.3	(1.3)(3.5)(5.6)(6.3)	228		2.3	(1.2)(2.3)(3.2)	52	
3.4	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226		2.3	(2.3)(3.5)(5.6)(6.3)	120		3.2	(1.2)(2.3)(3.2)	52	
4.1	(1.2)(2.3)(3.4)(4.1)	154.8		3.4	(1.3)(3.4)	108		3.5	(1.2)(2.3)(3.5)(5.4)	96	
4.5	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226		3.5	(1.3)(3.5)(5.6)(6.3)	228		4.5	(4.5)(5.4)	52	
5.6	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226		4.8	(4.8)(8.6)	90		5.4	(1.2)(2.3)(3.5)(5.4)	96	
6.3	(1.2)(2.3)(3.4)(4.5)(5.6)(6.3)	226		5.6	(1.3)(3.5)(5.6)(6.3)	228		6.3	(6.3)	48	
6.7	(1.2)(2.3)(3.4)(4.5)(5.6)(6.7)(7.3)	232		6.3	(1.3)(3.5)(5.6)(6.3)	228		6.7	(6.7)[2] recommended to accelerate (7.6)	48	
7.3	(7.3) recommended to accelerate[3]	54		6.7	(1.3)(3.5)(5.6)(6.7)(7.3)	230		7.6	(6.7)[2] recommended to accelerate (7.6)[3]	48	
7.6	(7.6) recommended to accelerate[3]	16.8		7.3	(1.3)(3.5)(5.6)(6.7)(7.3)	230		7.8	(6.7)(7.8) recommended to accelerate[3]	104	
Optimal reserve, minutes		172				230				106	

Notes:
[1] The maximum track considering $t'(L_{kp})$ by tasks. It defines the minimal extra payment to the operating metric (route price) the scope of work can be completed within the required timeframe;
[2] network complexity through the intensity coefficient Kc;
[3] track / activities are recommended for implementing last, to enable the time reserve.

Source: Compiled by the authors in AnyLogic Cloud, based on:
$t(L_{max})$, Kc - Network Settings Aarhus and Surroundings (Network 1); Network Settings Jursland peninsula (Network 2); Network Settings Aalborg and Surroundings (Network 3) (a full dataset is available from the authors upon request);
i,j - Table 2, Table 3

6. Conclusions

Routing a tourist route in tourist and excursion bureaus based on parametric network models serves for converting their time reserves and operational metrics into dynamic values, depending on the duration of the tour activities. It allows for not only ensuring accurate following of the schedule of in all tours (giving an opportunity for a tour booking and minimizing breaking the group arrival schedule to their destination points) but also for minimizing the monthly profit loss, estimated at 2250 thousand euros for the route Aalborg and Surroundings. However, there may be situations where a change in the overall tour cost is not possible. For example, in DenmarkTour-Your Guide, when working with intermediate parties, the cost of tours is fixed. To prevent a monthly profit loss in Aarhus, and Surroundings, Jursland peninsula, Aalborg, and Surroundings directions, tours require adjustments in the site activities, taking into account the values of temporary reserves on the longest route track. Namely, those including a complex of tour activities:

1) with a maximum difference in the timings (early and late) of their completion;
2) in the task pricings (normal and urgent) at the sites.

In fact, to minimize the profit losses on the routes (over 8,000 euros annually), a procedure is defined for completing the scope of activities within the required time range with a minimum extra charge to the operational metric (the route price), since these extra payments are not reimbursed by the tourists. For example, based on the analysis of the parameterized route network designed by DenmarkTour-Your Guide, with a fixed price for Aarhus and Surroundings guided tour at 1837 euros, and a duration of 10 hours 33 minutes, it is possible to adjust the dates (towards an earlier one) for a minimum extra charge to the operating metric at 79 euros. This will ensure temporary reserves of 23 minutes for combinatorial elements (7.3) and (7.6). Although, as the dispersion generator of random value for site activities shows, each route track can be adjusted within (1.1) to (7.6) by an average of 172 minutes.

With the cost of the Jursland peninsula tour at 1,886 euros, and a duration of 10 hours 40 mines, it is possible to adjust the dates (to the earlier ones) for a minimum additional charge to the operational metric at 53 euros. This will provide for temporary reserves of 30 minutes in the element 1.2. However, as the dispersion generator of random value for site activities shows, it is possible to adjust each of the route tracks within (1.2) to (7.3) by an average of 180 minutes. With the cost of a tour of Aalborg and Surroundings at 1,620 euros and the duration at 10 hours and 50 min, it is possible to adjust the dates (to the earlier ones) for a minimum additional fee to the operating metric at 400 euros. This will provide a temporary reserve of 60 minutes for the element (6.7)(7.8). At the same time, the dispersion generator of random value for site activities shows possible adjustments in each of the route tracks within (1.2) to (7.8) by an average of 104 minutes.

Routing in tourist and excursion bureaus requires availability of a minimum (for a minimum extra fee) and an optimal time reserve for all tours, taking into account their acceleration cost. Using this reserve, the results presented will identify the track adjustments for each route, based on the actual time reserve (available based on the actual tour group location and prior tour activities).

The implementing perspectives of the presented substantive basis for routing in tourist and excursion bureaus lie in the possibility of forming dynamic graphic images of the whole procedure of carrying out tour activities in the form of a directed graph of a route network. This will allow for introducing detailed illustrations of the modeling processes for a wide route variety, their further analysis, and immediate adjustment.

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