UDC **338.48-32:656.02(045)**

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**Routing of travel itinerary of tourist and excursion offices based on parametric network models**

**1. Introduction.** The study relates to optimizing the excursion design process. Namely, it relates to the field of the introduction of automatic route identification and features of service of tourist groups on the route network, especially when the route is intended to provide full disclosure of a certain topic (excursion). The need to move to network-based routing models in tour design arises from the fact that, at the moment, the activities of tour operators are quite specific and bound up with a set of network routes that interact with each other. This is because, under conditions of digitization, such economic entities are being restructured from the static organization of various tours (when tourist routes are unchanged) to a dynamic organization. Dynamic routes are adjusted to the needs, clients' needs, and tour group topics. The main problem of tourist and excursion offices is that they cater to unorganized tourists living in hotels, sanatoriums, or on company-organized tours. At the same time, although the economic unit itself establishes the nomenclature of the guided tours, they are not always conducted according to a clearly defined program and under the same conditions for all participants. In the course of providing such services, the requirements and features of customer service are not known in advance. Age (including child participation), state of health, size of tourist groups, and requests of tourists may lead to an adjustment of the priorities of visits to historical, natural, and other places; length of service of the tourist itinerary (tourist route).

According to PricewaterhouseCoopers, 25% of modern reviews and thematic transport tours provided by tour operators deviate from the original travel program. Approaches to excursion design are therefore changing.

For example, agencies «Tours at Alik» (providing guided tours and trips in Antalya travel market) and Questtour (providing non-standard guided tours and trips in Czech Republic travel market), instead of clear paths of travel of tourist groups (from one location to another with predefined roads, streets, and other communication arteries), since 2017 use route networks for travel.

Since 2018, Denmarktour- Your guide (providing guided tours in Denmark travel market) and Italy with Us providing guided tours in Vatican, Rome, Venice, Florence travel markets) not only use route networks for travel but group them according to the cost of participation in the tour program, features of service of tour groups.

These innovations are based on the fact that tour operators have to plan their costs and all possible routes for the tours before the introduction of the tour services. It is necessary to conclude in advance contracts for the rental of vehicles, with catering establishments, theatres, and other facilities for further use on excursions. In doing so even when costs have already been incurred, it is extremely difficult to design all possible variations in the organization of the tour, including travel on the route network and additional costs associated with the immediate cost of the service.

To earn money on the tour route, specialists of and excursion offices draw attention to the importance of the clear definition of basic parameters of network models (early, late terms of each tour event, time reserves, critical path (largest path in the network), availability of urgent cost of services), which swing on operational metrics (prices) and tour duration.

It is the basic parameters that should form the basis for the routing of the tourist route, i.e. to provide a process for automatically determining the optimal excursion route, taking into account the parameters of the overall route network and the current location of the excursion group in real-time.

**2.** **Brief Literature Review.**

There are many studies on the importance of meeting the challenges of optimizing the guided tour design process for different types of guided tours. However, specialists in this field describe in an abstract way the features of splitting the excursion project into route operations (determining the number of nodes in the route network) needed to move to the objects of inspection. It is proposed to use typed closed, open, homogeneous (defined by the number of routes in the network), as well as non-typed network models (assuming that the number of routes in the network cannot be typed). In this way, Various statistical, probabilistic (not alternative and alternative) methods of analysis of selected network models of routing operations identify possible improvements in the movement of tour guides on a particular route (or optimal route) before or during its implementation.

In particular, we have selected authors (Dorigo, M. and Stutzle, Th, 2009, Bonavear, E. and Dorigo, M., 1999). They propose to use closed network models of routing operations, accompanying excursions (with a constant number of routes in the network) and analyze them using the model of the behavior of the ant colony, which gravitates to a source of food. Open network models (where any numbers of routes are possible) are not considered by the authors, although it is suggested that such models could be developed in a high season (Bonavear, E. and Dorigo, M., 1999). Possible improvements in the movement of tour guides along the route are identified within the framework of metaheuristic optimization. The ant colony can be seen 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 of the colony. The disadvantage of the approach is that a common calendar is built that defines the fixed start and end of each route operation as well as its relationship to other operations in the network of routes. However, within the framework of metaheuristic optimization, the definition of parameters such as early, late completion of the excursion event, reserve time, the critical way is not provided (Dorigo, M, 1992). It is therefore difficult to route a tourist destination through metaheuristic optimization.

According to studies (Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 2009, etc.) there are closed, open (determined by high and low seasons) or homogeneous (if the number of routes circulating in the network is conditionally constant) network models of route operations and excursions. These models are analyzed using various graph alternative models that represent the relationships between random values defined by the location of the excursion group and the type of network. Possible improvements in the movement of tour guides along the route are identified by various methods. Specifically, with the help of Control Graph (T. Filatova, J.G. Polhill, S. van Ewijk, 2015); Directed Tree (I. Lorscheid, B-O. Heine, M. Meyer, 2012); Syntactic Trees or Sorting Trees (Y. Li, 2017); Petri Networks and others (Jovanović V., Njeguš A., 2008). According to this approach, a calendar is established that defines the start and end of each routing operation as well as its relationship to other network operations (including those where it is possible to move guides between individual sections of the path or to adjust the path). The optimization result only identifies critical operations that require special attention to complete the tour service within the standard time. As for the parameters of the network model that form the basis of routing (such as the completion date of each excursion event; time reserves for route operations) they are not defined.

Some researchers (Xiaochen Chou, Luca Maria Gambardella, Roberto Montemanni, 2019; Papapanagiotou, V., Montemanni, R., & Gambardella, L. M., 2015, etc.) suggest that network models should not be typed, but rather than excursions on the route network should be divided into families of network routing sub-models. According to the authors, the type of route network does not affect the possibility of deviation from the set of planned works on tour routes (Schwartz, Z.; Uysal, M.; Webb, T.; Altin, M., 2016; Caicedo-Torres, W.; Payare, F. A, 2016). At the same time, it is proposed that the possible deviations and improvements in the movement of tour guides for each sub-model be determined based on a statistical test method (namely, the Monte-Carlo method). Naturally, the search for the optimal path is provided by a numerical model using random-magnitude generators. The optimal route is played repeatedly based on parameters of each family of network submodels - the distance between objects (Papapanagiotou, V., Montemanni, R., & Gambardella, L. M., 2015). A drawback of the approach is its labor-intensive nature, which creates problems for routing.

For example, to determine the average distance between two random points of a route in the network:: 1) to take into account the coordinates of a large number of random pairs of points within the periphery of the object of inspection (Li, X.; Pan, B.; Law, R.; Huang, X., 2017; Bangwayo-Skeete, P.F.; Skeete, R.W., 2015); 2) calculate the distance for each pair of points within the boundaries of a given circle of the object of examination (Li, G.; Song, H.; Witt, S.F., 2016; Gunter, U.; Önder, I., 2015). Only such calculations, in the opinion of the representatives of the approach, will allow calculating the average arithmetic distance for the journey to the place of the event (Zhang, G.; Wu, J.; Pan, B.; Li, J.; Ma, M.; Zhang, M.; Wang, J., 2017).In addition, values of parameters such as early, late completion dates of each excursion event, time reserves in optimization are not important (Vansteenwegen, P., Souffriau, W., Vanden Berghe, G., & Van Oudheusden, D., 2009; Chou, X., Gambardella, L. M., & Montemanni, R., 2018).

The selected approaches provide a generalized picture of the tour operations and their features routing operation on the network, as they do not allow for 1) finding basic parameters of the network model;2)modifying the excursion path on the network to improve it; 3) analysis of the location of the tour group. That is, it is necessary, not abstract, but parametric network models of tour route operations. They form the substantive basis for a quick definition of a tour route in networks, involving a 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, 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 typing and separating network model families lead to duplication of parameters and unnecessarily complicate the tour network plan (Montes y Gómez, M., Escalante, H., Segura, A., Murillo, J., Eds., 2016). Therefore, most modelers are focused on intelligent model simplification (Vdovenko N.M., 2015; Muzi Zhang, Junyi Li, Bing Pan, Gaojun Zhang,2018), due to a combination of simplicity and maximum precision. Naturally, in the routing of the tourist destination, the type and sub-model families 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 offices, based on parametric network models based on the characteristics of dynamically adaptable tables containing the best routes.

**4. Methodology and Data.**

It is intended to present the content of the routing of tourist and excursion offices in parametric network models. The classical network model with parameterized routing operations is used, which, together with self-regulating technical means, are the main attributes of excursion work. It is assumed that the configuration is based on the travel patterns of tourists within the itineraries and excursion reserves. To identify and illustrate the peculiarities of the solutions to this problem used network planning methods (in particular network analysis), **namely analytic** (including formula calculations), **tabular (**including the transmission of the attributes of the arguments in the route network as identifiers for a specific route**),cloud computing in Any Logic Claud environment**. Based on the applied methods in network models, the data is set by a table and the whole process of presenting the content basis of routing is described through their analysis in the Any Logic Claud environment (it has a free tariff on computational functions, among which the construction of network parametric models).

The tourist and excursion office of DenmarkTour-Your Guide, created by Russian, Ukrainian and Danish representatives, providing excursion services in the tourist market of Denmark, is chosen as the base for the study. This office was chosen, considering that it not only has about 20 representative offices in Denmark (a Aarhus, in the cities of Jursland peninsula and in Aalborg), but has already adapted route networks to the practice of excursion design.

DenmarkTour-Your Guide is actively working on the parameterization of such networks, in particular, the focus is shifted from the kilometer of excursion(namely, the reduction of the total distance that is crossed by the excursionists) to the minimization of movements between objects. The office has already purchased locator devices with the aim of starting automatic routing in real time.The focus is on the excursion path which includes various attractions, including shrines, castles and other structures.

Therefore, the subject has already formed a basis for parameterizing the complex of works and moving between these objects (the nomenclature of all works on the path has been compiled and their indicative sequence has been established). However, that is not enough. To provide a substantive basis for the routing of tourists and excursions office the parameters of the route networks should be determined not only based on the list of actions (works) to be carried out, their sequences (i.e. previous), but also on the minimum and the maximum possible duration. This is important because the lack of attention to the time taken to service the tour groups (in particular, the timing of the start and end of each work) leads to the disruption of tour schedules. Thus, in 2020, as a result of inefficient parameterization, DenmarkTour-Your Guide has monthly canceled 5-6 tours on Aalborg and Surroundings. Taking into account that the amount of profit of the Office for 1 such excursion about 550 euros, the monthly lost profit is estimated at 2,250 thousand euros (DenmarkTour-Your Guide, 2020). Also, DenmarkTour-Your Guide suffers monthly losses within 15% of the profit on 4-6 guided tours with a fixed cost (direction Aarhus and Surroundings, Jursland peninsula, Aalborg and Surroundings). Losses arising as a result of payment of a fixed cost for selected excursions (among which, ordering individual excursions in the objects of inspection, excursions between sessions of the objects of inspection, etc.). Taking into account that the profit for such an excursion is up to 800 euros per 20 tours, the monthly loss is estimated at 0.72 thousand euros (DenmarkTour-Your Guide, 2020). The total annual loss and loss of profit of DenmarkTour-Your Guide exceeds 35,64 thousand euros. A similar situation prevails at tourist and excursion offices in various countries of the world, including Ukraine (Ernst & Young Global Limited, 2020).Because of this problem, it is proposed to calculate the cost of the tour based on the maximum mileage and process of displacement identifying in the route network defined through a normal or accelerated sequence of individual excursions 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 plural set of ij, consisting of possible events j (by showing combinations of excursion objects) and planned works i (works or planned activities of the guide in the routing space set by the tour program) with flexible time and operational markers. The combinatory of objects in such a route network is provided by their grinding on collections of excursion objects, combining museums, monuments, possible places for organizing food, and free time. It was understandable, that Basic parameters of route network models for the routing of tourist destinations are: critical path in the network; reserves of event time, taking into account combinatory of excursion objects, works, and paths to them (or maximum allowable amount of time to delay the event, works, and tracks without extending the tour schedule). The study complements such basic indicators with several supporting indicators, which allow their sequencing to be taken into account for the analysis of possible and actual travel of travelers 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.

Table 1:

List of parameters, which became the basis of routing DenmarkTour-Your Guide

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter groups | Detailed data argument | Algorithms | Characteristics of parameter |
| Time reserves of events, works and ways | total travel reserve LпилиR(LR) B\* | tjR -tiP-tij | The maximum time for which it is possible to postpone or extend the work ttj without adjusting the overall time for completion of the work package. If R(ij) =0 the work is critical |
| time reserve for event j-or Rj A*\** | tjn - tjp | A time-frame within which an event j can be postponed without exceeding the time-limit for the completion of all excursions |
| free reserve of working time (i,j)rijC.B A*\** | tjP- tiP-tij | Maximum time to delay or extend the work time provided that all network events occur early |
| full reserve of time work (i,j)or rijR A*\** | t(LKP)-t(LП)=TKP-TП | Allowable extensions of all excursion work as a sum of journey Ln relative to LK |
| private reserve of time of the first type or R1 A*\** | R(i,j)= RR(i,j) - R(i) | A portion of the full time reserve by which the duration of work can be extended without changing the time of the start-up event |
| private reserve of second type of time, or free reserve of working time (i,j) Rc or R(i,j) A\* | RR(i,j) - R(j) | Part of the full time reserve by which the duration of work can be extended without changing the early date of the final event |
| Critical path | duration of the critical path Lcor Tcor R(i,j) *B\** | RR(i,j)- R(i) - R(j)  | Abstract series of tasks that determine the design date for the start or end of excursions |
| Early and Late Events, Works and Ways | early tjp / late due date of the j-th event or tjn  ***B\**** | - | t m³ 3 for a given excursion period / t m³ 3 for a tour of the excursion object (which will not violate the normative time for execution of subsequent works) |
| early term of start work (i,j) tijP.H ***/***end termof work (i,j)or tijP.O ***B\**** | tjp | mіnm4start work with the given duration of excursion work /mіnm4the end of this excursion for a given period of work |
| tiP+tij |
| lateterm of start work(i,j)ortijП.H A***\**** | tjR-tij | maxmstart concrete work, when further excursions are still possible within the scheduled time  |
| late term of end work (i,j) or tijП.О  A***\**** | tjR | maxmend concrete, when further excursions are still possible within the scheduled time |
| running time LRA***\**** | t(LR); | deadline for completion of all works |
| runningworkor tож(i,j) A***\**** | (3 tmin(i,j)+2 tmax(i,j))/5 | random value can take any value within a given range |
| dispersion or S2(i,j) A***\**** | 0,04(tmax(i,j)-tmin(i,j))2 | Range of possible values around the expected level |
| Work intensity | coefficient of intensity of work (i,j)or kijH ***B\**** | (t(Lmax) - t'(Lkp)/(Tkp - t'(Lkp)) | Time pressure for work (i,j), that determines the likelihood / admissibility expectancy excursion |
| coefficient of complexity Cc***B\**** | npab 2 / ncob1 | Determines the complexity of route network. Networks with Cc1.0 to 1.5 are simple, 1.51 to 2.0 are medium complexity, and more than 2.1 are complex. |
| t(Lmax) A***\**** | - | Duration of the maximum non-critical path through work |
| Lmax or t'(Lkp) A***\**** | Duration of part of the critical work inunder path |

Notes

1 npab – the amount of work, units;; 2 ncob – the number of events, units; 3 the minimum possible duration ofj (t mіn); 4 minimum/maximum possible time (mіn/max m);

\*Parameter groups: basic (Б); auxiliary (A)

Presentation of such informative basis of routing DenmarkTour-Your Guide allows to take into account the importance of time metrics and to identify possible complexity of tourist destinations. Consequently, this framework creates the potential for rapid decision-making on the permissibility of extending/reducing the duration of all excursions in the sum of each journey. Since the analysis of a parameterized routing network on t(Lmax) and t'(Lkp) is most accurate in simple routing networks, in the process of investigation the values are most important:

- Coefficient of the intensity of work. The value of the coefficient can change from 0 (for works in which the segments of the maximum of the tracks which do not coincide with the critical path consist of dummy works, zero duration) to 1 (for work of the critical path). The closer one value of the coefficient, the more difficult it is to complete the work in 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(Lmax) and t'(Lkp) is the most accurate). Routing networks with a complexity factor of 1.51 to 2.1 are complex, their analysis on t(Lmax) and t'(Lkp) are possible after simplification to structures with a complexity factor of up to 1.5.

To ensure the presentation of the content basis of routing, the events on the display of sights and the work of DenmarkTour-Your Guide are transformed into a combinatorial view in which their properties are reflected, in the form of a route network ij, in the directions of Aarhus and Surroundings, Jursland peninsula, Aalborg and Surroundings. For example, input data for the DenmarkTour-Your Guide route networkin 2021 is presented in table 2.

Table 2:

**The** input data for the DenmarkTour-Your Guide route networkin 2021

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Network / Code | Combinatory | Time characteristic, minutes | Cost parameters, euros | Expected duration te(i,j), minutes1,2,3. | Dispersion S2(i,j)1,2,3 | Nature of the excursion cluster (code decryption in column 2) | Nature of planned work (according to the tour program and codes in column 3) |
| j events | і work | normal tmin(i,j) | expedited tmax(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 inspection point;; (3) xcursion with visual reconstruction; (4) excursion with panoramic presentation; (5) lunch; (6) monument examination; (7) visit of the festival, digustatory; (8) excursion of the technologist with localization of events. |
| 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.

2Calculation 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;

3Calculation of the expected value and measure of dispersion 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:

Formed based on: Characteristics of the Daniatur-Your Tour Guide Network as of 2021https://drive.google.com/file/d/16Hs9\_l6RjezN5-CHYurcK4-KuELgDLc9/view?usp=sharing

For elements of a route network ij the concepts are introduced: 1) minimum rating tmin(i,j), which determines the duration of a given excursion work in the most favorable circumstances; 2) maximum tmax(i,j) which determines the duration of a specific excursion in the most unfavorable conditions. The values tmin(i,j) and tmax(i,j) allowed to expand the data about the DenmarkTour-Your Guide route network. The duration of the operation is also considered to be a random value that, as a result of the implementation, can accept any value within a given interval. Such estimates are called probabilistic (random) and identify their expected te(i,j) and the range of possible values around the expected level necessary to represent the content basis of a parameterized DenmarkTour-Your Guide itinerary.

**5. Results.** Considering that the resulting result should provide the content 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. This is feasible with the basic and auxiliary characteristics and properties highlighted in table 1. The results of the parameterization of the DenmarkTour-Your Guide route network are highlighted in table 3. The routing of tourist and excursion offices based on parametric network models converts the time reserves of the excursion route and their operational metrics into dynamic values, depending on the duration of the excursion work. Accordingly, important: 1) a sequence of tasks that most often determines the start time or end time of a route; 2) the combinatory of combinations i,j defining the detailed cost/time reserve ratios in the DenmarkTour-Your Guide route network.

Table 3:

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

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Net-work | i,j1 | Duration tij | Еarly-term, , minutes | Later-term, , minutes | reserve time, , minutes | Private reserve, minutes | critical path,  works. | Duration of critical path, minutes |
| start tijР.Н. | ending tijР.О | startо tijR.Н | ending е tijR.О | full RijR1 | specific RijН3 |  I type, Rij | II type, RijC |
| 1 | 1.2 | 114 | 0 | 114 | -114 | 0 | -114 | 0 | -114 | 0 | (7.3) (7.6) | 172 |
| 2.3 | 0 | 114 | 114 | 0 | 0 | -114 | 114 | 0 | 0 |
| 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) (7.8) | 104 |
| 2.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 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 |

Notes

1 combinationi,jare created automatically in AnyLogic Claud, based on expenditure/time reserve ratios

Formed based on:

RijП, RijН, I Type Rij, I Type Rijс, I Type а, Rij, duration ofcritical path– Network Settings Aarhus and Surroundings (Network 1)https://drive.google.com/file/d/1EY5QbCQnlgvPAjmVTp5\_\_yAnTDVl2UfC/view?usp=sharing, Network SettingsJursland peninsula (Network 2) https://drive.google.com/file/d/11WjqRg9Pe9TNqDQcaQpSbnvozYVZRRDZ/view?usp=sharing; Network Settings Aalborg and Surroundings (Network 3) https://drive.google.com/file/d/11WjqRg9Pe9TNqDQcaQpSbnvozYVZRRDZ/view?usp=sharing.

Table 1 **- Route network** DenmarkTour-Your Guide **input data**, 2021

In particular, the parameterization forms an opportunity not only to determine the duration of all works for each i,j route network but also to adjust it quickly. For example, according to the data received, 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 duration is 7 hours 40 minutes. The total cost of the tour will change from 1833 to 2081 euros. For Aalborg and Surroundings, the maximum duration of a tourist route is 10 hours 50 minutes and the minimum duration is 5 hours 50 minutes. The total cost of the tour will change from 1620 to 2450 euros. With the parameterized approach possible to take into account the requests of the excursion group, since possible to define how to increase

or reduce the duration of the works belonging to the given track, provided that the completion of the whole complex of works does not interrupt the general schedule of excursions (taking into account the scheduled hour load).In that way, 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 arrival of the group to the destination).It will also minimize the loss of profits, which exceeded €27,000 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 excursion services through intermediaries, on all route networks, the price is fixed. To prevent monthly losses within 15% of the profits from 4-6 tours of Aarhus and Surroundings, Jursland peninsula, Aalborg, and Surroundings, specific adjustments are needed for work on the sites, taking into account the values of time reserves on the maximum route. A set of excursions is defined: 1) with a maximum difference in early and late-term; 2) The normal and urgent price of works on the facilities.

To minimize losses on routes that increase 8000 euros per year, taking into account each location of the excursion group, it is determined that for a minimum surcharge to the operating metric (route price) it is possible to complete the complex of works in the required time, as such a supplement is not reimbursed by the excursionists. For this purpose, the routing of tourist and excursion offices, based on parametric network models, should be supplemented by the option of analyzing all possible ij paths by t(Lmax) taking into account t'(Lkp) for all i. Such analysis is most accurate in simple route networks that are formed by DenmarkTour-Your Guide. Based on the results of analysis of parameterized route network DenmarkTour-Your Guide its simplification is not required (Table 4), all possible variations of travel route on t(Lmax) are highlighted, taking into account t'(Lkp) for all works.

Table 4:

Result of analysis of route network DenmarkTour-Your Guide on t(Lmax) taking into account t'(Lkp) for all works, 2021

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i,j | path / worksthroughlocation guidedgroupandprevious guided group | t(Lmax), euro1 | Kc2 | i,j | path / works through location guided group and previous guided group | t(Lmax). euro 1 | Kc2 | i,j | path / works through location guided group and previous guided group | t(Lmax), euro1 | Kc2 |
| transaction token (total price) | network 1 for the duration of 10 hours 33 min - 1837 euros | network 2for the duration of 10 hours 40 min - 1886 euros | network 3for the duration of 10 hours 50 min -1620 euros |
| Price adjustment for t(Lmax) at t'(Lkp) (7,3) and (7,6) - 79 euros, which will provide temporary reserves of 23 minutes. | Price adjustment for t(Lmax), att'(Lkp) (1.2) – 53 euros, which will provide temporary reserves of 30 minutes. | Price adjustment for t(Lmax), att'(Lkp) (6,7)(7,8) – 400 euros, which will provide temporary reserves of 60 minutes. |
| recommended price adjustment of €79 | recommended price adjustment of 53 euros | recommended price adjustment of 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 рекомендуется ускорить(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)2recommended 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 |
| оптимальный резерв, мин. | 172 |  |  |  | 230 |  |  |  | 106 |  |

Notes

1The maximum path gave the t'(Lkp) of [work](https://context.reverso.net/%D0%BF%D0%B5%D1%80%D0%B5%D0%B2%D0%BE%D0%B4/%D0%B0%D0%BD%D0%B3%D0%BB%D0%B8%D0%B9%D1%81%D0%BA%D0%B8%D0%B9-%D1%80%D1%83%D1%81%D1%81%D0%BA%D0%B8%D0%B9/work%22%20%5Ct%20%22_blank). Defines the minimal co-payment for the operating metric (route price) that can be completed complex of works within the required timeframe; 2 network complexity through the coefficient of intensity Кс; 3 path / that recommends implementing least, to be able to use time reserve.

Formed in AnyLogic Claudbased on:

t(Lmax), Kc– Network Settings Aarhus and Surroundings (Network 1)https://drive.google.com/file/d/1EY5QbCQnlgvPAjmVTp5\_\_yAnTDVl2UfC/view?usp=sharing, Network Settings Jursland peninsula (Network 2) https://drive.google.com/file/d/11WjqRg9Pe9TNqDQcaQpSbnvozYVZRRDZ/view?usp=sharing; Network Settings Aalborg and Surroundings (Network 3) https://drive.google.com/file/d/11WjqRg9Pe9TNqDQcaQpSbnvozYVZRRDZ/view?usp=sharing.

i,j - Table 2, Table 3

Based on the results of analysis of the route network DenmarkTour-Your Guideon t(Lmax) taking into account t'(Lkp) for all works it can be stated that the time reserves of the tour route and their operational metrics aren’t constant values*.*They are determined from the location of the excursion group and all previous excursions. To be able to adjust them minimally, the sequence of tasks that most often determines the start or end of a journey should be the last one.

**6. Conclusions**

Routing the tourist route of tourist and excursion offices based on parametric network models converts their time reserves and operational metrics into dynamic values, depending on the duration of the excursion work. This makes it possible not only to ensure strict observance of the schedule of all excursions (including form an opportunity for excursion reservation and minimize the disruption of the team’s schedule of arrival at their destination) but also to minimize the monthly loss of profit estimated at 2250 thousand euros on the route Aalborg and Surroundings. There may, however, be situations where a change in the overall cost of an excursion is not possible. For example, in DenmarkTour-Your Guide, when working with mediators, the cost of excursions is fixed. To prevent a monthly loss of profit, Aarhus, and Surroundings, Jursland peninsula, Aalborg, and Surroundings tours require adjustments to the works on the sites, taking into account the values of temporary reserves on the maximum route. Namely, including a complex of excursion works:: with a maximum difference in the times (early and late) of their realization; 2) in the prices of works (normal and urgent) on the objects.

In fact, to minimize the losses on the routes (which in a year raise 8,000 euros), it is defined as how for the minimum addition to the operational metric (the price of the route) it is possible to complete the complex of works in the necessary time. As such a supplement is not reimbursed by the excursionist. For example, based on the analysis of the parameterized route network DenmarkTour-Your Guide, with a fixed price Aarhus and Surroundings guided tour in 1837 euros, lasting 10 hours 33 minutes, it is possible to adjust the dates (towards earlier) for a minimum surcharge to the operating metric of 79 euros. This will provide temporary reserves for combinatorial elements (7.3) and (7.6) in 23 minutes.Although the random variation generator shows that excursions can be made on site, each route can be adjusted from (1.1) to (7.6) by an average of 172 minutes.

At the cost of the Jursland peninsula excursion- 1,886 euros, 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 of 53 euros. This will provide temporary reserves for element1.2 of 30 minutes. However, as the generator of random values in terms of the time spent on excursions at the sites shows, it is possible to adjust each of their routes from (1.2) to (7.3) by an average of 180 mines. With the cost of an excursion of Aalborg and Surroundings of 1,620 euros of 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 of 400 euros. This will provide a temporary reserve for element(6.7)(7.8) of 60 mines. In parallel, the generator of random values in terms of the period of excursion at the sites determines possible adjustments of each of the tracks of this route from (1.2) to (7.8) by an average of 104 mines.

The routing of tourist and excursion offices requires a minimum (for a minimum fee) and an optimal time reserve for all excursions, taking into account the cost of their acceleration. Using this reserve, the results presented identify path adjustments for each route based on the actual time reserve (which is available based on the location of the excursions group and prior excursions). The specters of application of the presented content basis of routing for tourist and excursion offices consist in the possibility of forming dynamic graphic images of the whole procedure of carrying out excursions in the form of a directed graph of a route network. This will allow the introduction of detailed illustrations of the modeling processes of broad route variation, analysis, and rapid correction.

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