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The Information Technology for Determining Vehicle Route Based on Ant Colony Algorithms

Hennadii Khudov[1], Oleksii Baranik[2], Oleksandr Kovalenko[3], Yevhen Yakovenko[4], Yurii Chahan[5]
[1,2]Ivan Kozhedub Kharkiv National Air Force University, Ukraine, Kharkiv, 61023
[3]Central Ukrainian National Technical University, Ukraine, Kropyvnytskyi, 25006
[4]National Academy of the National Guard of Ukraine, Ukraine, Kharkiv, 61001
[5]Hetman Petro Sahaidachnyi National Army Academy, Ukraine, Lviv, 79026

Abstract— **The article proposes on the information technology for determining vehicle route based on ant colony algorithms. The analysis of specialized software and information technologies for determining vehicle route was carried out. Existing information technologies for determining the route of vehicles are not able to find an accurate solution or require an unreasonably long time to find effective solutions. The relevance of the article is due to the great complexity and dimension of routing problems, as well as the emergence of its new verifications. In this regard, there is a need to develop new information technologies for solving problems of this class. The proposed information technology is based on ant colony algorithms. This information technology allows to reduce the time of searching for solutions in problems of large dimensions, and at the same time improve the quality of the solutions obtained. Information technology for determining the route of the vehicle will be considered in the form of a set of functions. This set of functions are related to each other in a certain way. This set of functions implement techniques, methods and methods that ensure the receipt, storage, processing, transmission and use of information regarding the route of the vehicle. In the paper, we will use the IDEF0. This is required for visualization and further formal representation of the structure and composition of the information technology for determining the route of the vehicle. We will present the Determining Route Information Technology in its entirety: the tuple and the sets. The top-level context diagram and. the upper child diagram top-level context diagram are presented. When determining the route of the vehicle, we will use ant algorithms. The main modifications of the classic ant colony algorithm are presented: Max-Min Ant System, Elitist Ant System, Q-ant system, Rank ant system, Ant Colony System, Fast Ant System, Antabu.**

Keywords— **information technology, determining vehicle route, ant colony, IDEF0**

I. INTRODUCTION

At present, the development of transport logistics is associated with an increase in the role and number of tasks to be solved by information and automated systems and complexes. The use of automated systems is associated with the use of appropriate information technologies [1]. Information technologies are being introduced directly into technological and social processes. The information technologies are used for the decision of the problem of countering terrorism is expanding, the importance of timely detection of defects in transport infrastructure, remote and continuous monitoring and control of traffic flows, remote control and unmanned operation of transport and technological complexes [2].

One way to save resources when determining vehicle routes is to use decision support systems for transport logistics. The development of software packages that solve the problems of this industry requires serious scientific research in order to obtain effective algorithms suitable for use in daily practice. One of the functions of decision support systems for transport logistics is the ability to calculate and build cost-effective bypass routes for various purposes on the transport network. This may be, for example, the task of determining routes for visiting a given set of addresses by a certain number of vehicle units. In this case, there is a mandatory return of vehicles to the initial location after the end of the trip [3, 4]. This problem is most common among companies transporting goods from a warehouse to points of consumption or retail [5]. Also at present, especially in Ukraine, the task of determining safe routes for the supply of military equipment is relevant [6, 7].

Existing information technologies for determining the route of vehicles are not able to find an accurate solution or require an unreasonably long time to find effective solutions. The relevance of the article is due to the great complexity and dimension of routing problems, as well as the emergence of its new verifications. In this regard, there is a need to develop new information technologies for solving problems of this class.

The information technology considered in the paper based on ant colony algorithms. The information technology allows to reduce the time of searching for solutions in problems of large dimensions, and at the same time improve the quality of the solutions obtained.

Ant algorithms are currently used to solve various problems:

– segmentation and interpretation of images [8–10];
– calculation of an unmanned aerial vehicle flight [11, 12];
– search and detection of objects [13];
– making managerial decisions [14–16], etc.

The proposed information technology based on ant colony algorithms for solving the problem of determining the routes of vehicles allows you to find a lot of "good" solutions and issue recommendation decisions for the person receiving solution.

The object of research is transport and logistics processes. The main content of the work is theoretical studies of transport problems and their solutions, focused on improving the efficiency of managing them, making decisions using modern methods of information processing.

II. Literature Review And Problem Statement

In [17], a service for building pedestrian, car and bicycle routes, Meganavigator, is proposed. However, there is no choice of means of transport on the site. The route is laid by default and corresponds to the movement on a motor vehicle. This service includes building optimal routes, visualizing GPS tracks and a map constructor. Meganavigator is a site with a built-in Yandex.Map [18]. The advantage of [17] is the understanding voice commands; takes into account traffic jams and traffic events, shows parking places. The disadvantages of [17] include the limited list of countries in which routes are built; building a route only for motor vehicles; no prompts when entering an address; inability to set the address as the first one by default; when selecting points on the interactive map of the service without entering addresses, the route is not built.

In paper [19] it is proposed to plot a route on Google Maps. The advantages of Google Maps are the ability to get directions for a trip in your own car or a shared trip, for a trip by public transport, a bicycle or a motorcycle, as well as for walking and even flying by plane. Several routes will be suggested, which are marked in gray. The best route will be marked in blue on the map (Fig. 1).

The main disadvantage of [19] is the possibility of incorrect path construction. However, it is possible to report incorrect routes on Google Maps that apply to any mode of transportation other than public transport. However, a route error can only be reported from a computer, and not in all countries or regions.

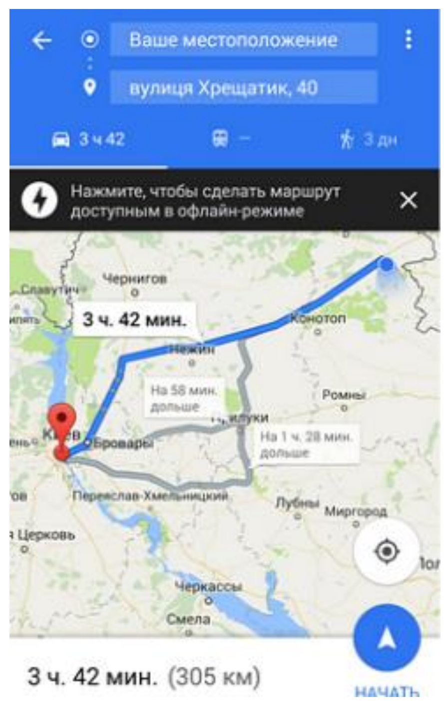

Fig. 1. Mapped routes on Google Maps: the best route is marked in blue [19]

However, services such as Yandex.Maps and Google Maps do not provide the user with the ability to search for the optimal route. When entering multiple points, the service builds the route in the order in which they were entered. The choice of means of transportation affects only the options for building a route between the entered waypoints.

The [20] proposes 2GIS (Fig. 2). 2GIS is a geoservice with maps of cities in Russia and Ukraine, as well as some foreign countries – Italy, Cyprus, Czech Republic, Chile, United Arab Emirates UAE, etc.

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The main advantages of [20] are: free registration; location of any organization in the served cities and their contact details, which allows you to call this organization before the trip and clarify all the necessary questions; the ability to use without an Internet connection. The disadvantage of [20] is that it plots specific and sub-opt imal routes.

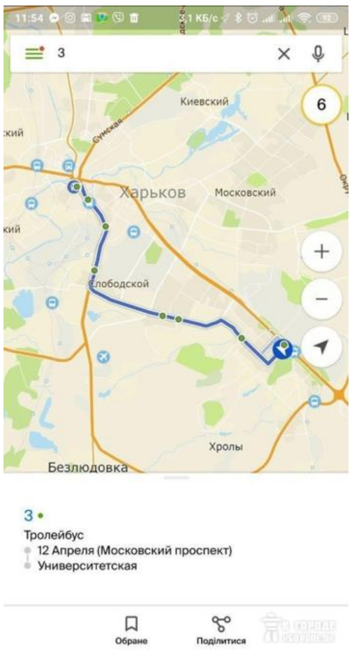

Fig. 2. Screenshot of the 2GIS [20]

The main disadvantage of the most common services (Navigator, Yandex Maps and 2-GIS) is their control by the government of the Russian Federation. These softwares can collect personal data of drivers, transmit real-time information to the aggressor state about obstacle-free routes, traffic congestion on the roads, obstacles (including roadblocks), etc.

In [21], a logistic program was proposed for the optimal construction of routes on the map. There is Logist Uno. Advantages of [21] is to increase the efficiency of transport delivery due to the possibility of maximizing the number of points to visit; calculation and minimization of fuel costs and wages of employees. The main disadvantages of [21] are the choice of only two modes of transport. There are motor transport (building a route along the roads) and helicopter (direct route between selected route points) and the necessary payment for its use.

In [22], the VeeRoute service was proposed to perform transportation and deliveries in the presence of various problems associated with logistics. The main advantages of [22] are the ability to rebuild routes in real time due to unexpected traffic jams, route failures, and the appearance of additional tasks and availability of SMS informing about the planned arrival time and delays. The disadvantage of [22] is the possible errors in the construction of the path when it is rebuilt.

The Speedy Route [23] is the most popular for building of the optimal route among foreign mapping services with the construction function. The advantage of [23] is the calculation of the most fuel-efficient route between several points. The condition for laying the route is one point, both initial and final (Fig. 3).

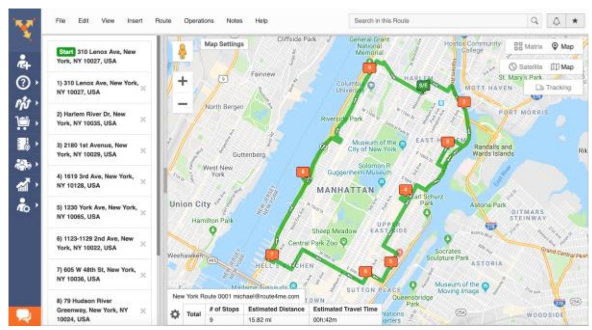

Fig. 3. Screenshot of the Speedy Route service [23]

The disadvantages of [23] are route calculation only for road transport and the presence of a minimum number of route points – 5 (that is, it is impossible to build routes from 4 points).

In [24], the Waze software is proposed. This is a social free navigation software for mobile devices (Fig. 4). The Waze software allows to plot the best routes and monitor the situation on the roads in real time.

The main advantages of [24] are the ability to learn about the location of speed radars, warn other users about changes in road conditions, the presence of obstacles, the police and receive information from other users. In the Waze software, maps are created by users themselves. The main disadvantages of [24] are that it works only on the Android and iOS hardware platform, all routes are built without taking into account traffic jams, the presence of errors in the calculation of the arrival time. But the main disadvantage is that the maps are created by the users themselves and this application is popular and filled in a limited number of countries.

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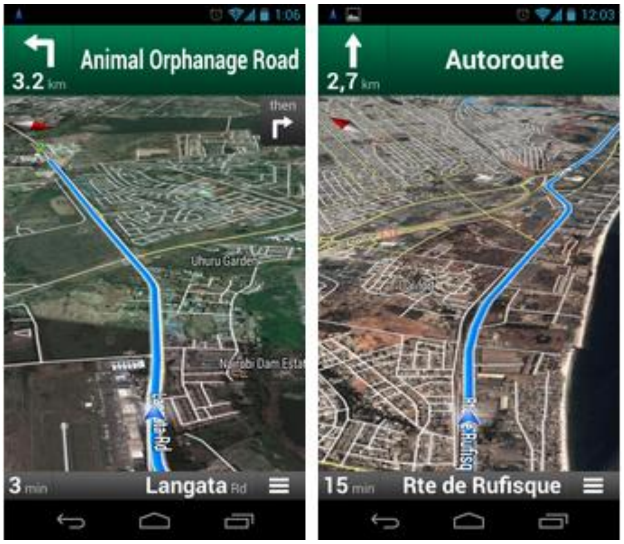

Fig. 4. Screenshot of the Waze software [24]

In [25] it features the HERE WeGo app (Fig. 5). This is a free navigation app that makes it easy to travel and get directions on foot or by car. The main advantages of [25] is the ability to lay routes around the world; the ability to add points on the route; the ability to use the app offline. The main disadvantage of [25] is the impossibility of switching among the laid automobile routes. The main route is the blue route and it is not possible to select another gray route.

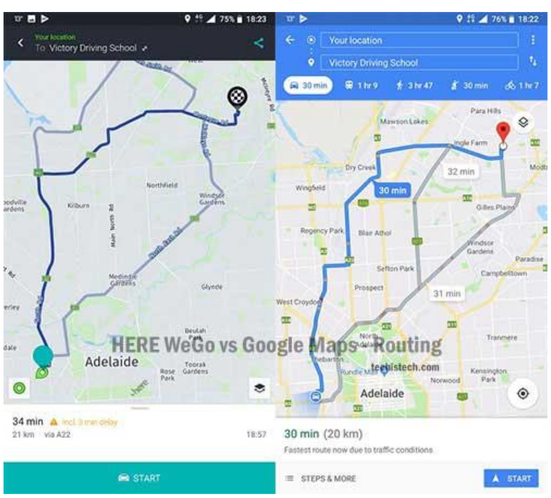

Fig. 5. Screenshot of the HERE WeGo app [25]

In [26], a model for finding the optimal route for a vehicle is proposed. The model is based on the use of information from various databases. Advantage of [26] is the use of information from many sources.

Disadvantage of [26] is the use of a priori information, which may not be available in practice.

In [27], the task of the determining the route of vehicles is proposed. In this case, a priori information about the time of the route, the duration of the route, the number and capacity of vehicles is used. Advantage of [27] is the use of several final destinations, a small number of random errors in determining the route of movement. Disadvantage of [27] is the restrictions on a specific type of vehicle.

Paper [28] presents a method for managing vehicle flows based on the Internet of things. The method [28] allows you to determine the state of the vehicle, the state of the road in real time. Advantage of [28] is the ability to calculate the speed of movement and determine the route of movement. Disadvantage of [28] is its focus on the ideal driving situation.

III. MATERIALS AND RESEARCH METHODS

Information technology for determining the route of the vehicle will be considered in the form of a set of functions. This set of functions are related to each other in a certain way. This set of functions implement methods and techniques to ensure the receipt, storage, processing, transmission and use of information regarding the route of the vehicle. In the work, we will use the IDEF0 (ICAM (Integrated Computer Aided Manufacturing) Definition) system modeling methodology [29].

This is required for formal representation and visualization of the structure and composition of the information technology for determining the route of the vehicle (Determining Route Information Technology (DRIT)). IDEF0 methodology is based on the method of structural analysis and design SADT (Structured Analysis & Design Technique) [29].

We will present the DRIT in its entirety:

– the tuple T^{DRIT} – expression (1);

– the set $\left\{D_l^{DRIT}\right\}$ – expression (2);

– the set $\left\{L_j^l\right\}$ – expression (3).

$$T^{DRIT}=\left\langle In^{DRIT},\left\{D_l^{DRIT}\right\}\right\rangle; \qquad (1)$$

$$\left\{D_l^{DRIT}\right\}=\left\{\left\{F_i^l\right\},\left\{L_j^l\right\}\right\}; \qquad (2)$$

$$L_j^l=\left\{\left\{V_j^l\right\},\left\{C_s^l\right\},\left\{I_m^l\right\},\left\{O_n^l\right\},\left\{M_r^l\right\}\right\}, \qquad (3)$$

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where In^{DRIT} – the formulation of the goal. The goal is the development of a system of related functions. These functions implement methods and techniques of collecting, storing, processing, transmitting and using data regarding the route of the vehicle as an information technology;

$\{D_l^{DRIT}\}$ – set of detail levels of DRIT presentation;

$\{F_i^l\}$ – a set of functions that implement methods and techniques of working with data to determine the route of the vehicle at the level of detail of the DRIT presentation;

$\{L_j^l\}$ – set of interactions of system elements (internal and boundary interactions are taken into account);

$\{V_j^l\} \subseteq \{L_j^l\}$ – set of interactions between functions from the set $\{F_i^l\}$ (internal interactions are taken into account);

$\{C_j^l\} \subseteq \{L_j^l\}$ – set of interactions of software and technical means implementing DRIT (controlling boundary interactions are taken into account);

$\{I_j^l\} \subseteq \{L_j^l\}$ – a set of input interactions (controlling boundary interactions are considered (transformed by a function);

$\{O_j^l\} \subseteq \{L_j^l\}$ – a set of output interactions (display the data produced by the function);

$\{M_j^l\} \subseteq \{L_j^l\}$ – a set of interactions (mathematical apparatus used to formalize knowledge about vehicle routing).

The top-level context diagram is presented in Fig. 6 (expression (4). Fig. 6 and expression (4) show the area and boundaries of the DRIT presentation.

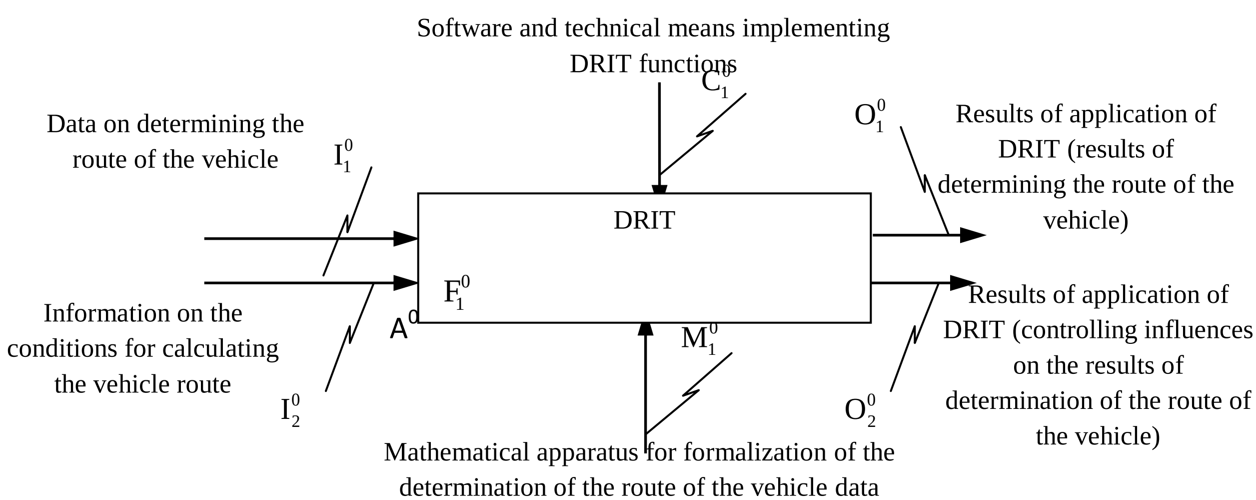

Fig. 6. The top-level context diagram

DRIT determines that l=0,...,3, where at l=0 the context diagram of the upper level is formed, at l=1 – the upper child diagram, at l=2, l=3 – child diagrams.

Fig. 7 shows the upper child diagram (functions-processes of DRIT (expression (4)):

$$D_1^{IPIT} = \{\{F_i^1\},\{C_1^0, I_1^0, I_2^0, O_1^0, O_2^0, M_1^0, \{V_t^1\}\}\}, \qquad (4)$$

where t=1,2,…,7.

Process functions that implement techniques, methods and methods are considered as functions from the set $\{F_i^1\}$ of the upper child diagram D_1^{DRIT} of the level D_0^{DRIT}:

– collection of data on the determination of the route of the vehicle $F_1^1 \in \{F_i^1\}$;

– storage of data on determining the route of the vehicle $F_2^1 \in \{F_i^1\}$;
– calculating the route of the vehicle $F_3^1 \in \{F_i^1\}$;
– transmission of data on the route of the vehicle $F_4^1 \in \{F_i^1\}$;
– use of vehicle route data $F_5^1 \in \{F_i^1\}$.

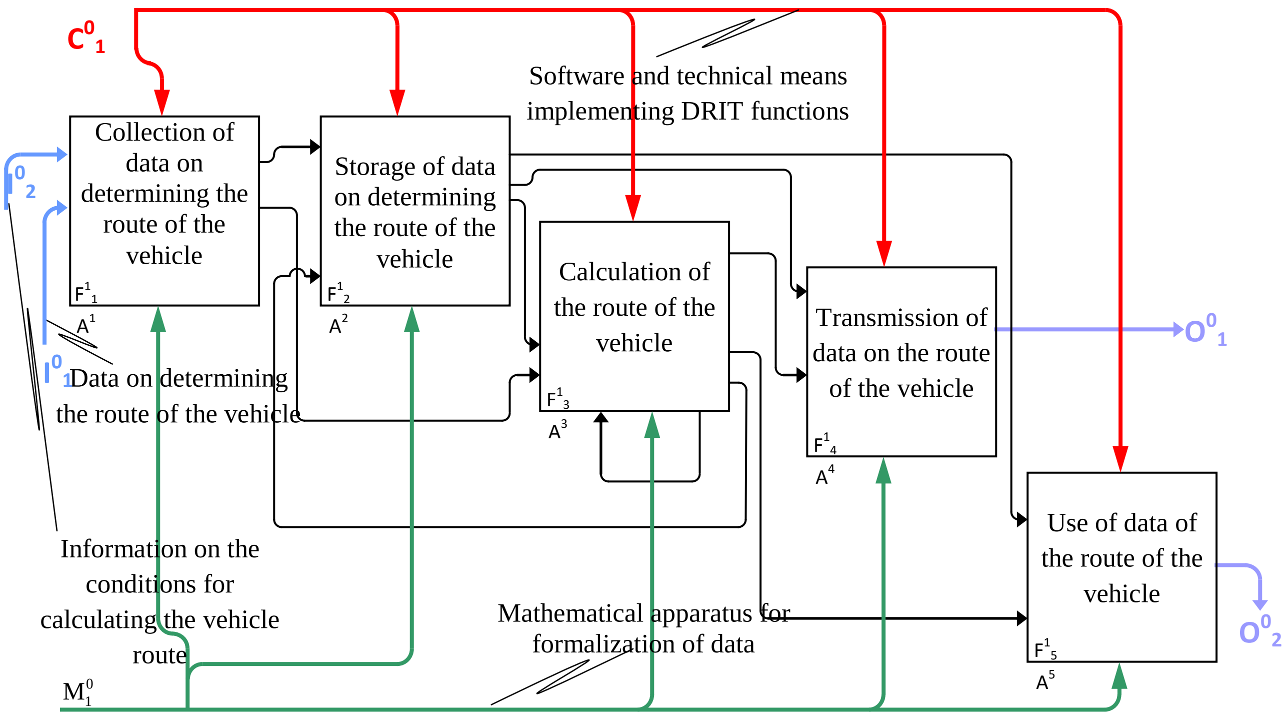

Fig. 7. The upper child diagram top-level context diagram

The function-process of data collection regarding the determination of the route of the vehicle $F_1^1 \in \{F_i^1\}$ is implemented by performing the following functions-sub-processes:

– the data collection sub-process function $F_{11}^2 \in F_1^1$ for determining the route of the vehicle, which is implemented during the development of the software-algorithmic complex for determining the route of the vehicle;

– function-sub-process $F_{12}^2 \in F_1^1$ of data collection regarding the determination of the route of the vehicle, which is implemented during the operation of the software-algorithmic complex for determining the route of the vehicle.

During the implementation of the sub-process function F_{11}^2, the composition of the data regarding the determination of the route of the vehicle (including, from the point of view of allocation of procedural and declarative knowledge) is determined.

If necessary, during the implementation of the sub-process function F_{12}^2, the composition of the data regarding the determination of the route of the vehicle is adjusted (for example, regarding weather conditions, traffic area, time of day, season, etc.).

The function-process $F_2^1 \in \{F_i^1\}$ of storing data regarding the route of the vehicle is implemented by performing the following functions-subprocesses:

- function-sub-process $F^2_{21} \in F^1_2$ of developing a database on traffic routes;
- function-sub-process $F^2_{22} \in F^1_2$ of implementing the process of direct storage of data regarding the route of the vehicle.

The sub-process function F^2_{21} is implemented by performing the following functions-operations:

- the architecture of the software-hardware complex for determining the route of the vehicle is being developed (which determines the structure, functions and interconnection of the components of the software-hardware complex);
- the composition of the technical means of the software and hardware complex for determining the route of the vehicle is determined;
- the composition of the software tools of the software and hardware complex for determining the route of the vehicle is determined (operating system, programming language, tools, etc.);
- the software implementation of the components of the hardware and software complex is carried out based on the selected technical and software means of implementation;
- the rule base of the hardware and software complex is filled.

During the implementation of the sub-process function, the rules entered or adjusted at the previous stage are stored in the rule base of the software-algorithmic complex for determining the route of the vehicle, and the data about the conditions of the route, the terrain, and the results of the calculation of the route are stored in the fact base.

The function-process $F^1_3 \in \{F^1_i\}$ of determining the route of the vehicle is implemented by performing the following functions-subprocesses (Fig. 8):

- the sub-process function $F^2_{31} \in F^1_3$ of developing methods for determining the route of the vehicle (implemented at the stage of creating the hardware and software complex);
- function-sub-process $F^2_{32} \in F^1_3$ of implementation of the process of direct automated calculation of the vehicle's route during the operation of the software and hardware complexes.

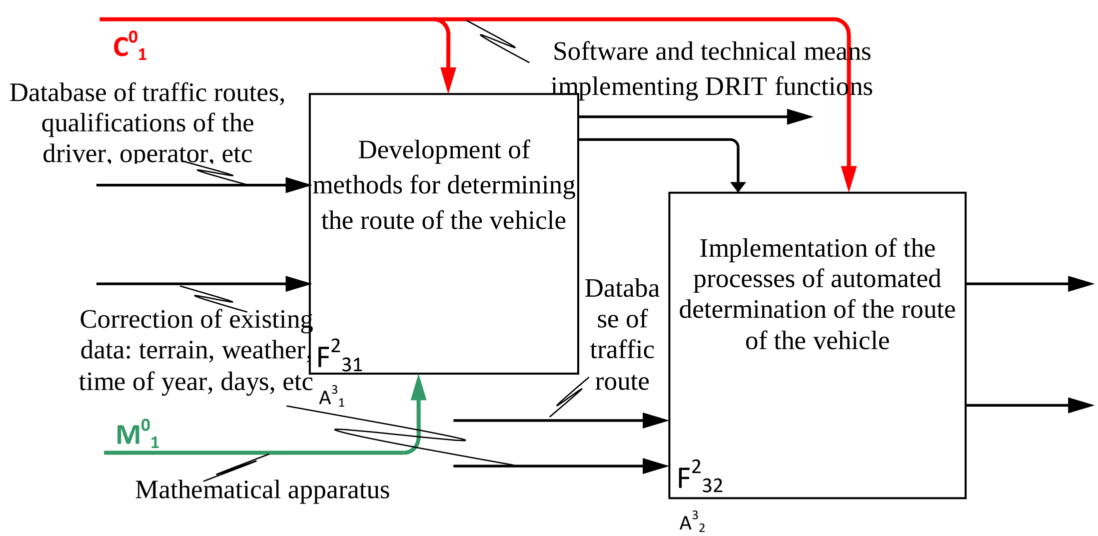

Fig. 8. The child diagram describing IPIT sub-process functions for implementing the vehicle routing function-process

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The sub-process function F_{31}^{2} is implemented by performing the following functions-operations:

- the task of formalizing the process of determining the route of the vehicle is being set;
- the methods of data presentation are determined (the mathematical apparatus choice (data presentation model) is justified) regarding the determination of the route of the vehicle;
- a formal presentation of the processes of determining the route of the vehicle is made.

When determining the route of the vehicle, we will use ant algorithms.

Ant algorithms are based on the idea of modeling the behavior of an ant colony (multi-agent system), which is associated with the ability of ants (agents) to quickly pave the shortest path from an anthill to a food source, while constantly adapting to changing conditions [30]. The ability to find a new path, if the already laid one has become inaccessible, is solved through the exchange of information between the individuals of the ant colony (agents) due to the deposition of a special enzyme – pheromone. That is, modeling the process of stigmergy [31].

Ant colony algorithms, like most swarm intelligence algorithms, are based on the use of a population of potential solutions and are designed to solve complex combinatorial optimization problems, primarily finding the shortest path on graphs. Ant colony algorithms are used to solve problems of the TSP (Traveling Salesman Problem) [32] and QAP (Quadratic Assignment Problem) [33]. Quite a large number of different practical problems are reduced to these types of problems. These are the problems:

- routing (primarily in telecommunications networks (networkrooting) and transport logistics (transport logistics);
- assignment (frequently assignment, graph coloring, generalized assignment, quadratic assignment problem);
- scheduling and scheduling (Total Terdiness, job shop, Flow Shop, Group Shop, Project Sheduling, Open shop);
- data clustering;
- robotics (vehiclerouting, etc.);
- machine learning (fuzzy systems, Bayesian networks, classification rules);
- bioinformatics;
- covering the set, knapsack problem (set covering, multi-knapsack, maximum clique, reduncy allocation, bin packing, max independent set, weight constrained graph tree partition);
- word processing, etc.

Consider the classical ant colony algorithm ("ant colony").

The general procedure is as follows [30, 31]:

1. Definition on the edges of the graph:
   - the number of agents;
   - initial position of agents;
   - the initial amount of pheromone.
2. Laying the route by agents. Each of the agents paves the route independently of the others.
3. Calculation of the objective function for each laid route.
4. Update the amount of pheromone on the edges.
5. Verification of compliance with the conditions of the stop. Stop conditions can be the following: execution of a certain number of iterations, found an acceptable solution; passage of all agents in the same route for a certain number of iterations.

If the condition is met, then the end of the algorithm. If the condition is not met, go to step 2.

The main disadvantages of the classic ant colony algorithm are [34-36]:

- low rate of convergence to the optimum. This is due to the equal contribution to the renewal of pheromones from different areas of space of the solutions;
- the need to store obviously unpromising solutions in memory;
- the possibility of losing the best solution already found.
- Conducting experiments [37-39] using classical ant colony algorithm showed that:
- classic ant colony algorithm works well on low-dimensional graphs;
- on complex graphs of large dimensions, the algorithm becomes less stable and more sensitive to the choice of algorithm parameters;
- convergence to the shortest route of good with a small number of agents. A large number of agents, on the contrary, often leads to the fact that the search does not converge;

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- the process of pheromone evaporation is more significant for complex graphs and in the case where there is no evaporation – the algorithm may not convergence. But if the pheromone evaporates too quickly, the algorithm converges to suboptimal solutions.

The mentioned disadvantages, the results of experiments and the simplicity of classical ant colony algorithm provided a large number of opportunities for improving the algorithm. Let's consider the main modifications of the classic ant colony algorithm.

1. Max-Min Ant System (MMAS). This modification of the algorithm allows solving the problem of rapid convergence of the algorithm to the local optimum, that is, the problem of premature stagnation. The main differences from classical ant colony algorithm are [40, 41]:
   - limitation in some given interval of the minimum and maximum amount of pheromone on the edges;
   - the concentration of pheromone on all edges of the graph is set to the maximum allowable on the first iteration;
   - a smoothing mechanism is used for pheromone concentration;
   - changing the pheromone concentration is allowed only for the best solutions found in this iteration.
2. Elitist Ant System. This modification of the classic algorithm is related to the introduction of so-called "elite ants" into the algorithm for a more thorough study of the areas around already found successful solutions and the fastest convergence to the optimum. The main feature of this algorithm is that "elite" agents deposit pheromones only on the edges of the best route found at the beginning of the algorithm [42]. Increasing the number of elite agents to a certain level is quite effective, which allows to significantly reduce the number of iterations of the algorithm. However, if the number of elite ants is too large, the algorithm quickly finds a suboptimal solution.
3. Q-ant system (Ant-Q). This modification is related to the rule of local change of pheromone concentration, which is implemented taking into account the Q-learning method. The peculiarity of the modification is that the algorithm stores a Q-table, which assigns to each of the edges of the graph a value that determines the "usefulness" of the transition along this edge. This table changes during the operation of the algorithm, that is, the system is trained.

   The value of the "usefulness" value of the transition along the edge of the graph is influenced by the value of the "usefulness" of the transition along the next edges as a result of the preliminary determination of the next possible states. These values are updated after each iteration, based on the lengths of the routes that included the corresponding edges [43].
4. Rank ant system (AS-rank). This modification is related to the ranking of agents at the end of each iteration in accordance with the lengths of the paths they have traveled. The main modifications are [44]:
   - only the best agent on the edges of the globally best route is allowed to change the pheromone concentration;
   - "elite" agents are used for the most thorough study of the neighborhoods of already found successful solutions;
   - the change in pheromone concentration is proportional to the position of the agent, i.e. according to its rank.

This strategy of elitism differs from the Elitist Ant System in that the elite agent's contribution to the deposited pheromone concentration is directly proportional to its rank.

5. Ant Colony System (ACS). To increase the efficiency of the classic algorithm, the following modifications were introduced [45, 46]:
   - the level of pheromone concentration on edges is updated not only at the end of each iteration, but also at each transition from vertex to vertex;
   - at the end of each iteration, the pheromone level increases only on the shortest of all found routes;
   - the algorithm uses a modified vertex-to-vertex transition rule.
6. Fast Ant System (Fast Ant System). The main features of this modification are the use of a population consisting of one agent and changed rules for pheromone correction without evaporation [45]. The use of only one agent significantly reduces the computational complexity of the algorithm.
7. Antabu. This modification consists in a local search using a tabu list to improve the solutions obtained at each iteration of the ant system algorithm. The difference is the following global rule for calculating the concentration of pheromone, in which all agents deposit pheromone on each edge of the graph in proportion to the quality of the traveled route [47].

During the implementation of the sub-process function F_{32}^{2} direct implementation of the methods of determining the route of the vehicle based on the ant algorithm is performed during the operation of the hardware and software complex.

Functions-processes of transferring $F_4^1 \in \{F_i^1\}$ and using $F_5^1 \in \{F_i^1\}$ data related to the determination of the route of the vehicle are implemented by performing a generalized algorithm for manipulating formalized data during the operation of the software and hardware complexes for determining the route of the vehicle.

IV. CONCLUSIONS

Thus, the article focuses on the information technology for determining vehicle route based on ant colony algorithms. The analysis of specialized software for determining vehicle route was carried out.

The proposed information technology based on ant colony algorithms for solving the problem of determining the routes of vehicles allows you to find a lot of "good" solutions and issue recommendation decisions for the person receiving solution.

Information technology for determining the route of the vehicle will be considered in the form of a set of functions. This set of functions are related to each other in a certain way. This set of functions implement techniques, methods and methods that ensure the receipt, storage, processing, transmission and use of information regarding the route of the vehicle. In the work, we will use the IDEF0 This is required for visualization and further formal representation of the structure and composition of the information technology for determining the route of the vehicle.

We will present the Determining Route Information Technology in its entirety: the tuple and the sets. –

The top-level context diagram and. the upper child diagram top-level context diagram are presented.

When determining the route of the vehicle, we will use ant algorithms.

Ant algorithms are based on the idea of modeling the behavior of an ant colony (multi-agent system), which is associated with the ability of ants (agents) to quickly pave the shortest path from an anthill to a food source, while constantly adapting to changing conditions.

The ability to find a new path, if the already laid one has become inaccessible, is solved through the exchange of information between the individuals of the ant colony (agents) due to the deposition of a special enzyme – pheromone. That is, modeling the process of stigmergy.

The main disadvantages of the classical ant colony algorithm are presented.

The main modifications of the classic ant colony algorithm are presented: Max-Min Ant System, Elitist Ant System, Q-ant system, Rank ant system, Ant Colony System, Fast Ant System, Antabu.

In further research, it is necessary to compare the quality of the calculation of the route of the vehicle using the proposed information technology and known information technologies (for example, based on a genetic algorithm [48]).

REFERENCES

[1] Kherbach O., Kaboul R., Deghir Y. Information Technology and Systems in Transport Supply Chains. European Journal of Formal Sciences and Engineering. Vol. 5, Iss. 1, 2022. pp. 61–72. ISSN 2601-8675.

[2] Bean J., Slack M. Benefits of Information Technology in Transportation and Logistics. 2022. Available at: https://www.avioconsulting.com/blog/benefits-information-technology-transportation-logistics.

[3] The importance of Information Technology applied in Logistics. 2022. Available at: https://blog.portalvmi.com.br/en/a-importancia-da-tecnologia-da-informacao-aplicada-na-logistica/.

[4] Khudov, H., Koval V., Khizhnyak I., Bridnia Y., Chepurnyi V., Prykhodko S., Oleksenko O., Glukhov S., Savran V. The Method of Transport Logistics Problem Solving by the MAX-MIN ACO Algorithm. International Journal of Emerging Technology and Advanced Engineering. 2022. Vol. 12. Issue 7, pp. 23–32. DOI: https://doi.org/10.46338/ijetae0722_12 .

[5] Zhao T., Huang J., Cheng G., Chen C., Shi J. Maneuvering Route Safety Planning for Military Vehicles during Wartime. MATEC Web of Conferences 81, 02005. (2016) ICTTE 2016. DOI: http://doi.org/10.1051/matecconf/2012016810200.

[6] Tan Z., Huang J, Shi J., Chen C. Route Planning for Military Ground Vehicles in Road Networks under Uncertain Battlefield Environment. Journal of Advanced Transportation. 2018. Vol. 2018. DOI: https://doi.org/10.1155/2018/2865149.

[7] How weapons get to Ukraine and what's needed to protect vulnerable supply chains. 2022. Available at: https://theconversation.com/how-weapons-get-to-ukraine-and-whats-needed-to-protect-vulnerable-supply-chains-179285.

[8] Khudov H., Ruban I., Makoveichuk O., Pevtsov H. et. al. Development of methods for determining the contours of objects for a complex structured color image based on the ant colony optimization algorithm. Eureka: Physics and Engineering. № 1. 2020. pp. 34–47. DOI: https://doi.org/10.21303/2461-4262.2020.001108.

[9] Ruban I., Khudov H. Advances in Spatio-Temporal Segmentation of Visual Data, Chapter 2. Swarm Method of Image Segmentation. Series Studies in Computational Intelligence (SCI), 876. Publisher Springer, Cham, 2020. 53-99. DOI https://doi.org/10.1007/978-3-030-35480-0.

[10] Ruban I., Khudov H., Makoveichk O., Khizhnyak I. et al. Method for determining elements of urban infrastructure objects based on the results from air monitoring. Eastern-European Journal of Enterprise Technologies. 2019. № 4/9 (100). pp. 52–61. DOI: https://doi.org/10.15587/1729-4061.2019.174576.

[11] Khudov H., Oleksenko O., Lukianchuk V., Herasymenko V., Yaroshenko Y., Ishchenko O., Ikaiev D., Golovchenko O., Volobuiev A., Drob Y., Solomonenko Y., Khizhnyak I. The Determining the Flight Routes of Unmanned Aerial Vehicles Based on Swarm Methods. International Journal of Emerging Technology and Advanced Engineering. 2021. Vol. 11. Issue 09, pp. 23–32. DOI: 10.46338/ijetae0921_03.

[12] Oleksenko O., Khudov H., Petrenko K., Horobets Y., Kolianda V., Kuchuk N., Konstantinov A., Kireienko V., Serdiuk O., Yuzova I., Solomonenko Y. The Development of the Method of Radar Observation System Construction of the Airspace on the Basis of Genetic Algorithm. International Journal of Emerging Technology and Advanced Engineering. 2021. 11, 8, 23-30. DOI: https://doi.org/10.46338/ijetae0821_04.

[13] Khudov G.V. Features of optimization of two-alternative decisions by joint search and detection of objects. Problemy Upravleniya I Informatiki (Avtomatika). 2003. 5. 51-59.

[14] Ruban I., Khudov H., Makoveichuk O., Khizhnyak I., Khudov V. et al. The Development of a Forecasting Model for the Situation Based on Space Images. In: 2021 IEEE XVI Intern. scient.-techn. Conference on Computer Science and Information Technologies (CSIT-2021). pp. 763–774. DOI: https://doi.org/10.1109/CSIT52700.2021.9648685.

[15] Khudov H., Butko I., Makoveichuk O., Khizhnyak I., Khudov V. et al. An Improved Model for Clarification of Geospatial Information. Lecture Notes in Networks and Systems. Vol. 336. 2022. pp. 827–837.

[16] Khudov H., Ruban I., Butko I., Makoveichuk O., Khizhnyak I. et al. The Improved Mathematical Model for Interpretation of Satellite Imagery. In: 2021 IEEE 8 Intern. scient.-pract. Conference on Problems of Infocommunications. Science and technology (PIC S&T). pp. 384–388. DOI: https://doi.org/10.1109/PICST54195.2021.9772162.

[17] Meganavigator. URL: http://meganavigator.com/

[18] Yandex Maps - transport, navigation, search for places – Yandex. 2022. Available at: https://yandex.ru/maps/

[19] Lebezova E., Semichastny I., Wolodtschenko A. Mini-Bildatlanten in Google Maps oder Yandex Maps. Journal for Theoretical Cartography. Vol. 6. 2013.

[20] 2Gis. 2022. Available at: https://info.2gis.ua/kiev/products/

[21] Logist. Uno. 2022. Available at: https://logist.uno/logisticheskaya-programma-dlya-postroeniya-marshrutov

[22] Automation, optimization, planning. 2022. – Veeroute. Available at: https://veeroute.tech/materials_and_titles/planning-automation-optimization-routing/

[23] Speedy Route. 2022. Available at: https://www.speedyroute.com/

[24] Vasserman S., Feidman M., Hassidim A. Implementing the Wisdom of Waze. In Proceedings of the 24th International Joint Conference on Artificial Intelligence July, 2015; Vol. 24.

[25] HERE WeGo | Maps & Navigation | Applications. 2022. Available at: https://www.here.com/products/wego

[26] Davoodi, M. and Mesgari, M. S.: GIS-based route finding using ant colony optimization and urban traffic data from different sources, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XL-1/W5, 129–133, https://doi.org/10.5194/isprsarchives-XL-1-W5-129-2015, 2015.

[27] Agárdi A, Kovács L, Bányai T. Ant Colony Algorithms For The Vehicle Routing Problem With Time Window, Period And Multiple Depots. Manufacturing Technology. 2021;21(4):422-433. doi: 10.21062/mft.2021.054.

[28] Kumar P. M., Usha Devi G, Manogaran G., Sundarasekar R., Chilamkurti N., Varatharajan R. Ant colony optimization algorithm with Internet of Vehicles for intelligent traffic control system, Computer Networks, Vol. 144, 2018, P. 154-162, ISSN 1389-1286, https://doi.org/10.1016/j.comnet.2018.07.001.

[29] New IDEF0 [classic]. 2022. Available at: https://creately.com/diagram/example/i8r0q06q1/new-idef0-classic?gclid=EAIaIQobChMIgbTtityw-wIV8kaRBR3wMQ_IEAMYAiAAEgL91_D_BwE

[30] Dorigo M. "Ottimizzazione, apprendimento automatico, ed algoritmi basati su metafora naturale (Optimization, Learning, and Natural Algorithms)", dissertation for a degree "Doctorate in Systems and Information Electronic Engineering", Politecnico di Milano, 1992 г.

[31] Colorni A., Dorigo M., Maniezzo V. Distributed Optimization by Ant Colonies. Proceedings of the First European Conference on Artificial Life, Paris, France, Elsevier Publishing. 1991. P. 134-142.

[32] Jadczak R. Traveling salesman problem: approach to optimality. Przedsiebiorczosc i Zarzadzanie. Entrepreneurship and Management. 2014. Vol. 15 (2). P. 157-169. DOI: https://doi.org/10.2478/eam-2014-0024.

[33] Zaied A. N. H., Metwally M. A., El-Fatah L. A. Quadratic Assignment Problem: A survey and Applications. International Journal of Digital Content Technology and its Applications. 2015. Vol. 9(2):90.

[34] Dorigo M., Stützle T. Ant Colony Optimization. A Bradford Book. Massachusetts London, England. 2004. 305 p.

[35] Adubi S., Misra S. A Comparative Study on the Ant Colony Optimization Algorithms. In: 11th International Conference on Electronics, Computer and Computation (ICECCO). 2014. DOI: https://doi.org/10.1109/ICECCO.2014.6997567.

[36] Gupta A., Srivastava S. Comparative Analysis of Ant Colony and Particle Swarm Optimization Algorithms for Distance Optimization. In: International Conference on Smart Sustainable Intelligent Computing and Applications (ICITETM2020). 2020. Vol. 173. P. 245-253. DOI: https://doi.org/10.1016/j.procs.2020.06.029.

[37] Ruban I., Khudov H., Makoveichuk O., Khizhnyak I. et. al. Segmentation of optical-electronic images from on-board systems of remote sensing of the Earth by the artifical bee colony method. Eastern-European Journal of Enterprise Technologies. № 2/9 (98). 2019. pp. 37-45. DOI: https://doi.org/10.15587/1729-4061.2019.161860.

[38] Khudov H., Makoveichuk O., Khizhnyak I., Oleksenko O., et al. Devising a method for segmenting complex structured images acquired from space observation systems based on the particle swarm algorithm. Eastern-European Journal of Enterprise Technologies. 2022. № 2/9 (116). pp. 6–13. DOI: https://doi.org/10.15587/1729-4061.2022.255203.

[39] Stützle T., Linke S. Experiments with variants of ant algorithms. Mathware & Soft Computing. 2000. Vol. 7.

[40] Stützle T., Hoos H. H. MAX-MIN Ant System. Future Generation Computer Systems. 2000. Vol. 16 (8). P. 889-914.

[41] Ruban I., Khudov H., Makoveichuk O., Chomik M., Khudov V., Khizhnyak I., Podlipaiev V., Sheviakov Y., Baranik O., Irkha A. Construction of methods for determining the contours of objects on tonal aerospace images based on the ant algorithms. Eastern-European Journal of Enterprise Technologies. 2019. 5 (9(101)). pp. 25-34. doi: https://doi.org/10.15587/1729-4061.2019.177817.

[42] Abuhamdah A. F. Adaptive elitist-ant system for medical clustering problem. Journal of King Saud University – Computer and Information Sciences. 2020. Vol. 32 (10). P. 709-717. DOI: https://doi.org/10.1016/j.jksuci.2018.08.007.

[43] Dorigo M., Gambardella L. M. A study of some properties of Ant-Q. Parallel Problem Solving from Nature – PPSN IV, Lecture Notes in Computer Science. 1996. Vol. 1141. P. 656-665.

[44] Bullnheimer B., Hartl R. F., Strauß, C. A new rank based version of the Ant System. A computational study. Working Papers SFB "Adaptive Information Systems and Modelling in Economics and Management Science", WU Vienna University of Economics and Business. 1997.

[45] Dorigo M., Maniezzo V., Colorni A. The Ant System: Optimization by a colony of cooperating agents. In: IEEE Transactions on Systems, Man, and Cybernetics-Part B. 1996. Vol. 26 (1). P. 29-41.

[46] Ruban I., Khudov V., Makoveichuk O., Khizhnyak I., Khudov H. Swarm Method for Segmentation of Images Obtained from On-Board Optoelectronic Surveillance System. In: 2018 IEEE 5 Intern. scient.-pract. Conference on Problems of Infocommunications. Science and technology (PIC S&T). pp. 613-618.

[47] Dorigo M. Swarm Intelligence, Ant Algorithms and Ant Colony Optimization. Reader for CEU Summer University Course "Complex System", Budapest, Central European University. 2001. P. 1-38.

[48] Khudov H., Makoveichk O., Butko I., Gyrenko I., Stryhun V., et al. Devising a method for segmenting camouflaged military equipment on images from space surveillance systems using a genetic algorithm. Eastern-European Journal of Enterprise Technologies. 2022. № 3/9 (117). pp. 6–14. DOI: https://doi.org/10.15587/1729-4061.2022.259759.