Andrii KUZNICHENKO [1]

Supervisor: Pavlo TESLENKO[2]

# PROJEKTOWANIE SYSTEMU PLANOWANIA TRASY TRANSPORTU Z WYKORZYSTANIEM GOOGLE MAPS API I ALGORYTMU CLARKE'A-WRIGHT'A

**Streszczenie:** W artykule przedstawione są etapy rozwoju zintegrowanego systemu planowania tras ruchu pojazdów, który jest zintegrowany z systemem ERP przedsiębiorstwa i pozwala zoptymalizować przepływy transportowe i logistyczne w celu obniżenia kosztów transportu ładunków. System umożliwia podłączenie do usługi mapowania Google Maps API oraz obliczenie najkrótszej trasy z jednego punktu trasy do drugiego, z uwzględnieniem współrzędnych GPS pojazdu i miejsca przeznaczenia towaru. Aby rozwiązać problem trasowania ruchu towarowego, zastosowano algorytm Clarka-Wrighta.

**Słowa kluczowe:** optymalizacja tras transportu, logistyka, system ERP, Google Maps API, algorytm Clarka-Wrighta

# DESIGN OF A VEHICLE ROUTING PLANNING SYSTEM USING GOOGLE MAPS API AND CLARKE-WRIGHT ALGORITHM

**Summary:** The article presents development stages of the integrated vehicle routes planning system already being integrated into the ERP system «1C Enterprise 8x: Accounting for Ukraine» of the enterprise and enabling to optimize transport-warehouse logistical flows aimed at decreasing the enterprise's costs. The system includes working a link with Google mapping services and calculation of the shortest way from one route point to another, taking into account the GPS coordinates of the vehicle and destination of the goods. Clarke-Wright algorithm (CW) is applied to solve the task of cargo transportation routing.

**Keywords:** Distribution Route Optimization, ERP system, Google Maps API, Clarke-Wright algorithm

## 1. Introduction

traffic. The region of Odessa, with three the largest ports in the Black Sea, is a particularly large and branched transportation infrastructure. That is why there is a

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[1] Odessa National Polytechnic University, Odessa, Ukraine, Student, email:andriikuznichenko@gmail.com

[2] Odessa National Polytechnic University, Odessa, Ukraine, Ph.D., email: p_a_t@ukr.net

large number of enterprises, the major activity of which is forwarding cargo both on the territory of Ukraine and beyond its borders.

In the nearest future the key direction for development of logistics branch shall be the introduction of decisions and technologies linked with IoT. The introduction of IoT may be conditionally divided into 4 levels:

- Sensors and detectors meant to support the chosen connection technology. In the cargo tracking geoposition and other vehicle's parameters (fuel level, movement mode, load on assemblies and sets, audiovisual data, etc.) are up to date.
- Means of connection, presence of network, for example, sensors connection using 2G, 3G or 4G network.
- Platform to manage data. Its designation is getting significant information, having processed a large amount of data.
- Visualization be means of a program or integration with other management systems – for example, ERP, that on the grounds of this information can perform further actions.

The purpose of this work is developing a software integrated into the enterprise's ERP system and enabling optimization of transport-warehouse logistics flows. The system provides cartographic information on the enterprise's logistical flows and also enables to automate its document flow.

The developed program module is an add-on for the ERP system "1C Enterprise 8x: Accounting for Ukraine", as the integration of modules being developed by developers, and the configuration of this module is possible within the scope of standard configurations of this system [1]. The system includes a working link with Google mapping services and calculation of the shortest way from one route point to another, taking into account the GPS coordinates of the vehicle and destination of the goods.

Clarke-Wright algorithm (CW) [2] is used to solve the tasks of transportations routing. This algorithm due to its simplicity, reliability and flexibility enables to take into account a wide range of additional factors influencing the final solution of the task and is often used by researchers in their works, for example, in works [3,4] the possibilities of the CW algorithm are used to solve the task of vehicles' routing, and in [5,6] it is used together with Google maps. But there are almost no works where the algorithm is integrated into the ERP system «1C Enterprise 8". That is why we consider research and development in this direction as relevant.

## 2. Materials and methods

### 2.1 General architecture of the integrated system

Nowadays, Ukrainian enterprises engaged in logistics, warehousing and forwarding mostly use the software of the 1C Enterprise family. That is why development of the software in the form of add-on to this ERP system is relevant. In Fig. 1 the architecture of the developed program add-on is shown. The solution architecture 1C is divided into a "platform" that contains a core, a platform component library and development tools, that is, a configurator [1].

Another part is an applicable decision for final users. Developers often change ready decisions in accordance with a consumer's necessities and duplicate replicated

configurations. That is why if an enterprise needs to complete such replicated decision or ready configuration, it may involve a developer for that purpose. The proposed work presents the completion of configuration adopted for the needs of a certain enterprise, and it is also possible to create a replicated configuration.
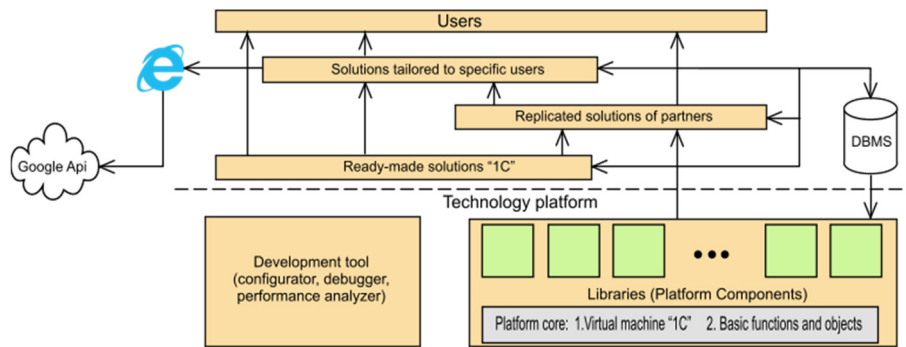


*Figure 1. General architecture of the integrated system*

## 2.2 Business-processes UML modeling

Fig. 2 shows a diagram of variants of using the developed system that is represented as innumerable essences and actors interacting with the system with the help of so-called use cases. In this case, any essence contacting with the system from the beyond is called an actor. The use case serves to describe the services that the system provides to the actor.

Fig. 3 shows the sequence diagram. "Buyer" makes an order for a commodity needed by him at the "Sales Department". The "Sales Department" Manager analyses the buyer's history. If the buyer was not referred to the "black list", the manager makes a new entry ("Card") in the reference book. The information on addresses of all buyer's trade points where cargo may be delivered is entered in the data register "Contact Information". The Manager creates a Document: "goods and services sales" where he/she enters the contractor, delivery address, goods list (all these are taken from appropriate reference books and registers), as well as the number of released cargo. At the end of the work day, the cargo is loaded in the warehouse on the basis of the information provided and the reports of "load list", "route tracing", "route printing" generated and handed in with all the required set of documents to the driver-forwarder. Fig. 4 shows the ER-diagram of classes for software add-on.
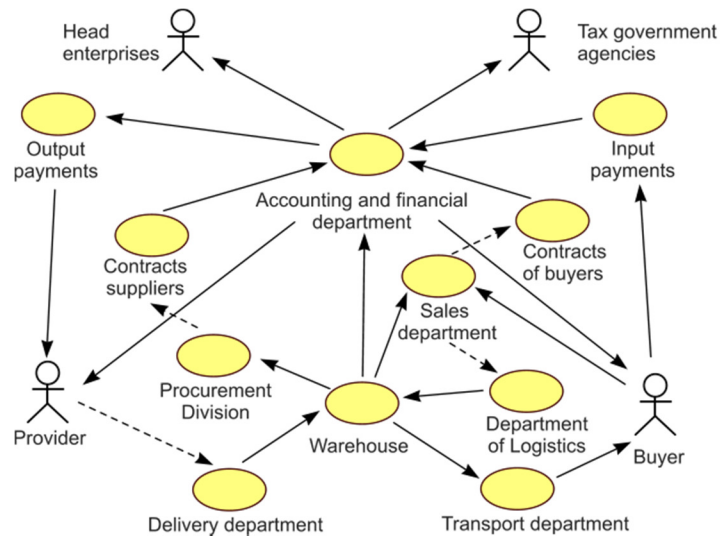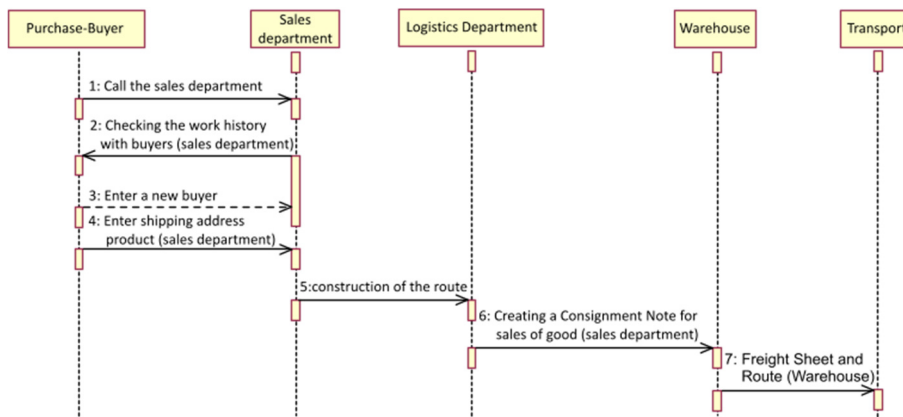
*Figure 2. Use case diagram*



*Figure 3. Sequence diagram*

### 2.3 Clarke-Wright algorithm

Upon the arrangement of car circular routes, meaning a situation when the car moves from the same point to which it returns after having delivered all cargo, it is necessary to determine reasonable consequences of movement between points to complete a delivery with a minimal run.

Having performed the analysis of different ways to solve the task, it was decided to use Clarke-Wright algorithm. This algorithm uses the concept of benefits to determine the routes merger operations. The benefit is the amount of cost reduction earned by way of combining two small routes into a large one. That means routes starting from one sending point are grouped by pairs into circular routes under the principle of

getting the maximum benefit from this merger. The benefit from merging points i and j is calculated, using the formula:

$$\Delta ij = l_{i,0} + l_{0,j} - l_{i,j}, \tag{1}$$

where $l_{i,0}$ – is the shortest distance from the point i to the sender,
$l_{0,j}$ – is the shortest distance from the sender to the point j,
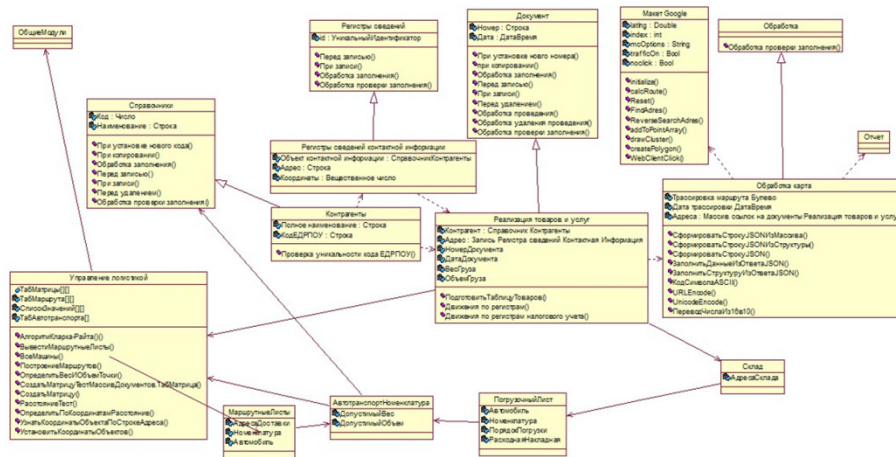$l_{i,j}$ – is the shortest distance from the point i to the point j.

*Figure 4. ER-diagram of classes*

According to the estimation of all possible combinations of point i and j into pairs (in the table of distances and benefit), a couple of first points have a maximum benefit value. In the following step the inclusion is carried out either at the route start (at point i) or at its end (at point j). In this case the maximum benefit in the column i and in line j in the table of distances and the benefit are calculated, depending on which another point to the formed route section is included.

Upon formation of the route the check for satisfaction of limitation (by vehicle's cargo capacity, journey time, period of cargo delivery, etc.). Formation of route ends when the list of points ends or upon absence of possibility to include a point without exceeding the set limitations. In the last case a new route is arranged. Procedure is repeated until the whole route plan is received.

Decisions inaccuracy in average does not exceed 5-10%. However, taking into account the greedy character of Clarke-Wright algorithm, the decisions made are often of insufficient quality in comparison to more complicated approaches. It should also be taken into account that after the first several iterations in tasks with many limitations the possibility of routes mergers can also sufficiently decrease and cannot control the number of routes.

## 2.4 Connection of maps

Javascript requests to Google service databases were created to work with Google scripts. Data extracted from Google maps are used to get a distances matrix. Using

this matirix the shortest way shown of the Google map is calculated. Own methods were developed to work with the Google maps, their short list is given below.

- initialize() – map initialization method, places marker on the map by clicking the mouse.
- addMarker(location) – method adds marker appeared on the map to the array, namely passes its location (latitude and longitude).
- calcRoute(options) – method contains algorithm of arranging the route by control points.
- Reset() – method resets markers on the map.
- FindAdres(Adres) – method performs address searching by name.
- ReverseSearchAdres(CoordX, CoordY, Adres) – method performs address searching by coordinates.
- addToPointArray(CoordX, CoordY, ID, Text) – method adds points to the points array. Required for linking of whichever point to each cluster.
- – drawCluster() – method adds cluster to the points array. After the point is added to each cluster, polygon is formed.

## 3. Results and Discussion

Work with the software component based on adding and editing database control points (points of sale). To add or edit an enterprise's address it is enough to go the bookmark "Contact Information" at the contractor's (buyer's) card and to enter address in a certain format (see Fig. 5)



*Figure 5. Entering of an enterprise's address*

When the sales department manager issues additional document (expenditure invoice), he/she selects the point of sales where the goods must be delivered from the data register "Contact Information" (see Fig. 6).



*Figure 6. Adding delivery address*

In such a way, the DB is filled with expenditures invoices for the current day. Upon pressing the button "Route Tracing", the data are transferred by SQL request to the form with map and the route is drawn with the shortest way between the control points (enterprises) on the ground of the calculated matrix of distances and kilometers benefit (see Fig. 7). After that the manager that works with the program module is able to issue a report on the route and also the report on the loading list.
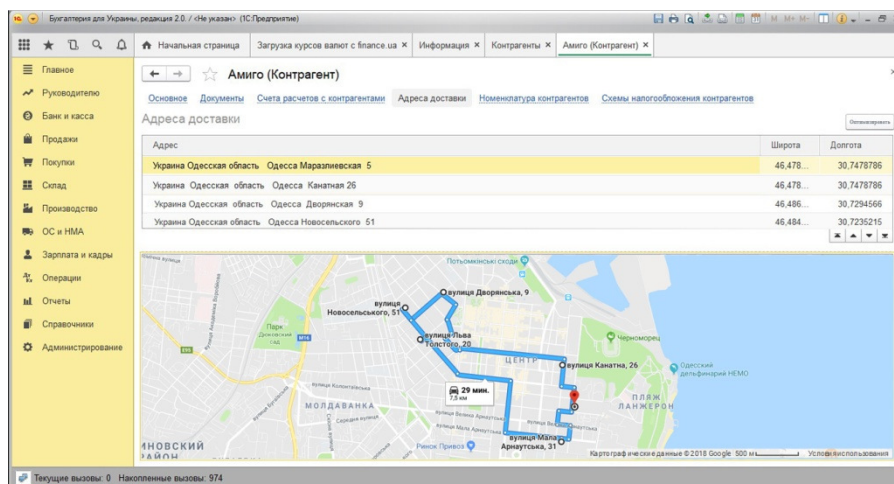


*Figure 7. Route with the shortest way between the control points*

## 4. Conclusions

The developed system enables to perform automation of cargo transportation planning taking into account limitations, calculation of the optimal way of transportation using the Clarke-Wright algorithm, visualization of logistical approaches with the help of the mapping service, automatic formation of analytical reports under various criteria. It is worth noting that there are some problems for the development of dispatching and planning automatic systems that linked with absence of accurate and detailed mapping services taking into account the IoT requirements and, however, transport. There are problems with coverage and operation of 3G/4G networks on the territory of Ukraine. But, despite of that, use of technologies connected with IoT is a promising direction of further development of the logistics branch in Ukraine.

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