

# CONCEPT OF INTELLIGENT SYSTEM FOR OPERATIONAL PLANNING AND OPTIMISATION OF INTRA-CITY SUPPLY CHAINS

*Alexander Grakovski, Igor Kabashkin, Anatoly Ressin*

*Transport and Telecommunication Institute  
Lomonosova str.1, Riga, LV-1019, Latvia  
Ph: +371 67100654, e-mail: avg@tsi.lv*

Currently in the city of Riga there are several parallel, independent of each other, networks for delivery goods. It is noteworthy that, unlike the major networks, companies doing outsourcing cannot provide the routes full load vehicles and the best routes. In the central part of the city near the same streets perform different trucks delivering goods to customers of neighbouring addresses. The movement, parking and downloading of vehicles produced during the working day and during peak hours, sometimes without taking a single lane road. This creates additional problems for urban traffic, pedestrians and the urban environment. The situation could be improved by creation of a virtual segment of intellectual transport system, planning the work of small transport companies (SME) that work on outsourcing of logistics centres. The concept of such a system is in creation of the Internet-portal for linking customers and freight transport companies.

**Keywords:** intelligent transport systems, supply chains, optimisation, vehicle routing problem

## 1. Introduction

The situation in major cities of Europe, particularly in new EU member-countries, in the sphere of intensity of urban traffic becomes heavier every year because of the increasing number of vehicles in city streets, while maintaining an outdated infrastructure and archaic system of traffic management. For example, according to the department of traffic management (CSDD), in recent years in Riga and Riga region each year adds approximately 25-26 thousands of newly registered vehicles [1]. Moreover, there are growing volumes of freight transportation related to the development of industry and services sector. Usually the preference is given to road freight transport, which has a great degree of mobility and minimum additional links in the chain "supplier - customer".

The entry of heavy vehicles in the central part of the city (historic center) in major cities of Europe is fully or partially banned for stabilizing the tension of urban traffic. Therefore, the idea of logistics centers in the border city where a storage and transshipment of goods from large trucks (long-distance and international traffic) for delivery networks is becoming increasingly popular and other modes of transport (multimodal logistics centers) to medium and small cargo transport is performed for the delivery of goods to end-recipients. Thus, organized logistics supply network, linking between the places of storage of goods (logistics centers, warehouses of final products of the enterprises, etc.) with the clients, the customers of the goods.

At present, there are many independent supply chains of goods to supermarkets and shops located in the central part of Riga city: "Maxima", "RIMI", "Elvi", "Nelda", "RD Electronics", "Elis" and others. Some enterprises like "Dzintars", "Latvijas Balzāms", "Aldaris", "Hanzas maiznīca" also have own supply chains. The largest of them, such as "Maxima" and "RIMI", have their own distribution centers (logistic centers) located in the outskirts of the city and have the necessary space and equipment for transshipment of goods from heavy trucks on middle class freight cars (5 - 7.5 tons) to deliver goods to customers in the central part of the city.

Companies "Maxima" and "RIMI" have their own fleet to carry out the bulk of the deliveries within their supply chains. In addition, through these distribution and transportation centers the occasional delivery of goods to other customers is performed. If their own transport capacity is not powerful enough to carry out all the supplies, part of orders is transmitted to small transport enterprises (SME), specializing in the field of transport and has the fleet of necessary class of trucks (mostly, 3-5 tons of payload capacity). Such additional transport capacity "from the side" is known as "outsourcing" in the global business practice. On average, the proportion of deliveries in Riga can reach up to 20% of the total intra-transport operations through the logistics center (see Figure 1).

Thus, several parallel, independent of each other, supply chains of goods delivery operates in Riga. It is noteworthy that, unlike the major supply chains, the companies that work in outsourcing cannot provide their trips of fully loaded vehicles and with the best driving route. It is possible that in the central zone of the city practically at the same streets and at the same time some different trucks are in delivering goods to customers comply with neighboring addresses. Since the time of delivery is usually determined on the basis of personal arrangements between the carrier and the final recipient of goods, the general movement of goods vehicles in the central part of the city can be regarded as haphazard and ungovernable. On the other hand, the movement, parking and downloading of these machines is done during working hours, including peak hours of the city traffic, sometimes while taking a one-lane road. This circumstance creates additional problems for urban traffic, pedestrians and urban environment.

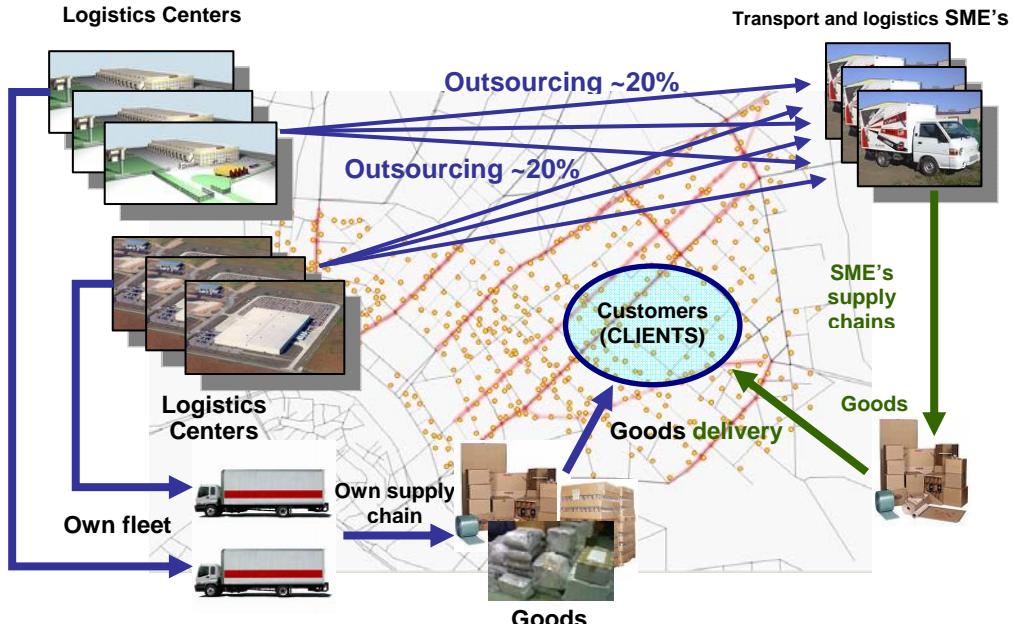


Figure 1. The scheme of inner-delivery logistics networks currently in Riga

The situation could be improved by establishment of www-portal (electronic exchange) as a virtual segment of intelligent transport system, planning the work of small transport companies (SME), that are engaged in outsourcing for logistics centers. The concept of such a system is to create sustainable and mutually beneficial cooperation between the logistics centers and companies-carriers through providing them with transport planning services.

## 2. The Concept of Internet Portal (Electronic Stock Exchange) for Intra-City Supply Chain of Goods

The activity of small transport companies involved in outsourcing for major logistics centers can be streamlined, if they are able to unite in a common network, managed by a joint information and analytical resources (Internet portal) and providing for it members more profitable operations, on a voluntary basis. In this way, by managing of significant part of the flow of intra-city freights delivery, one can coordinate their interests of the city, residents, the environment, for example, by using time planning to deliver cargo outside of peak hours or minimization of the freight cars in the most problematic streets in terms of traffic volume (see Figure 2).

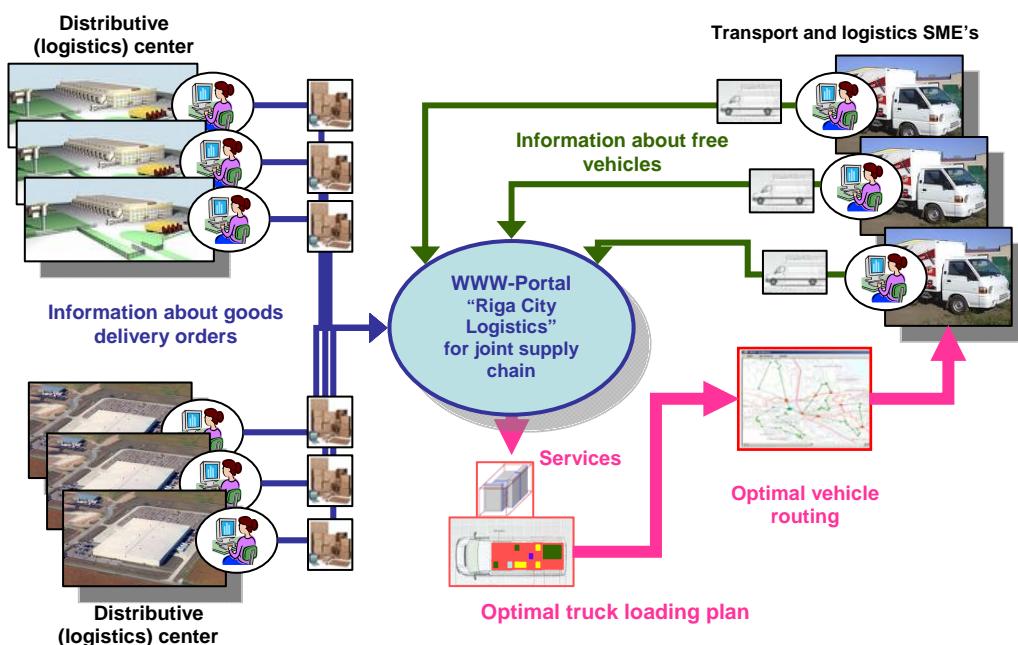


Figure 2. The conceptual scheme of organizing an Internet portal (electronic stock exchange) to manage the joint intra-city supply chain of goods

Logistics centers offer to portal the information in on-line mode about the availability of goods to be delivered to customers (address, kind of cargo, volume, the type of packaging, etc.). Transport companies provide the information about the availability of free vehicles and their characteristics (volume of cargo compartment, etc.). Then all the necessary information to determine the minimum required number of vehicles to ensure the supply of goods for a certain period of operational planning (for example, on the following day) meets in the information service portal (see Figure 3).

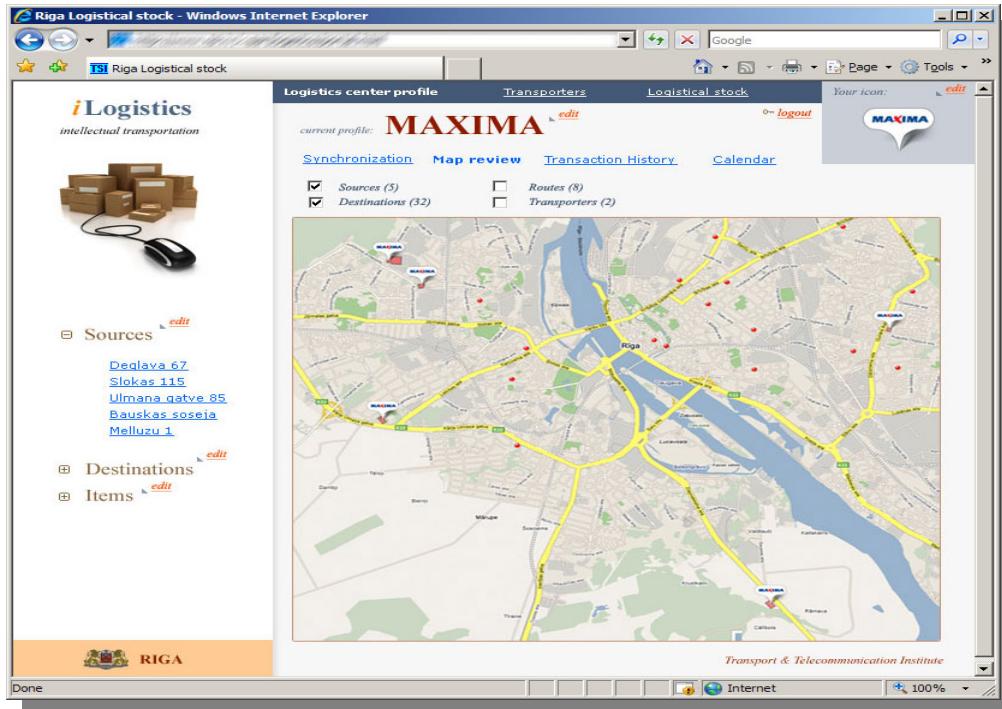


Figure 3. The interface prototype of Internet portal "Riga City Logistics" (electronic stock exchange) to manage the joint intra-city supply chain

Combining the volume of shipments for all available orders can maximize the use of vehicles for carriers (a car full load and an optimal time or distance of traffic route). To do this, optimization (heuristic and combined) algorithms can be used [2-6]. The existence of a unified information system data on orders for transportation of various goods and information about free vehicles effectively meet the challenge of planning the optimal load vehicles and the task of planning the best routes in the face of external constraints (time, travel bans on certain streets at certain times and so on) [5-6]. The result of optimizing software of www-portal can be operational plans and schemes of allocated vehicles' routes (the next day routes) that meet the above criteria. An example of such a route is shown in Figure 7.

### 3. Functional and Informational Model of “City Logistics” Internet-Portal

As presented above, the aim of a portal “Riga City Logistics” is a creation of the joint electronic communication and collaboration space of three types of market players: transport companies, logistics centers, and retailers.

The concept provides that the portal software will include *planning kernel* - a specialized software module that is capable of applications received under the plan quickly transport routes for the entire system, minimizing the overall cost of the system as a whole. The algorithms used to build this kernel-based transport system, are oriented to the achievement of the condition, known as the “social equilibrium” or Pareto optimum [7]. With their use, routes are planned so that the total costs throughout the system earn less than if each player was forced to choose its own best strategy itself (*synergy effect*).

The main interface is a Web-portal site through which authorized visitors can keep applications for transportation, offer vehicles for transportation to receive assignments, monitor the status of orders and stuff. All these actions are recorded in a single database portal.

The draft provides for the integration of customer information systems with the database via the portal XML Web-services, which are an alternative business-to-business portal interface. Figure 4 shows the general scheme of interaction between the components of the portal and the external environment.

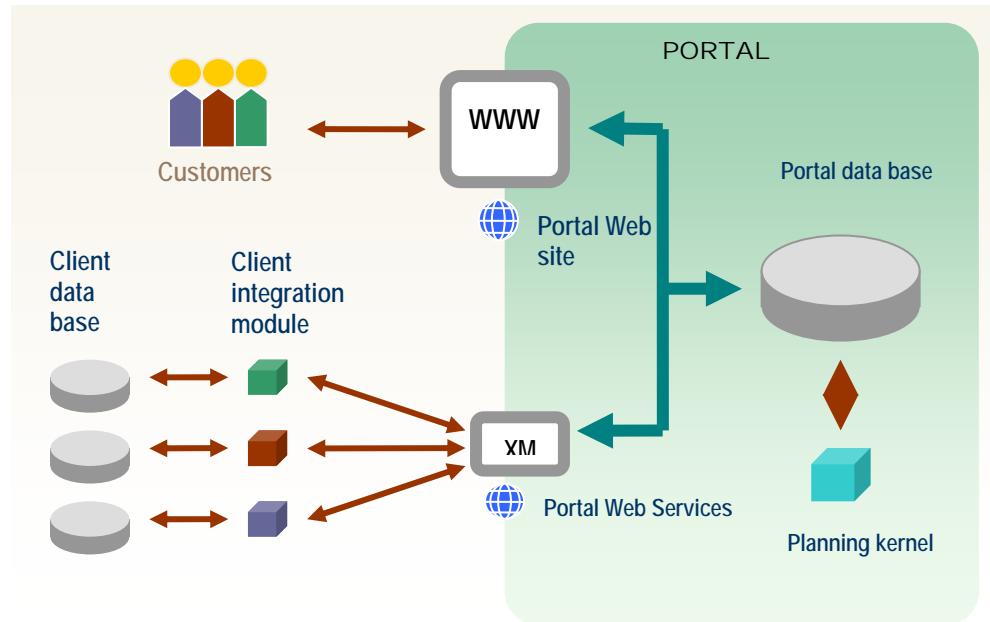


Figure 4. The scheme of interaction between the portal components and the external environment

Then the operation provides a portal in terms of its users, their roles and functions. It also provides the main scenario; use the portal (financial relations aspect of the players at this stage is not considered).

### 3.1. Users of the portal, their rights and duties

The draft scheme of the portal provides for a minimum five categories of users:

- *Representatives of logistics centres;*
- *Representatives of transport companies;*
- *Representatives of shops (trade centres);*
- *Operators;*
- *Administrator.*

In Figure 5 it represents a hierarchical classification of users, collecting all users listed above in two categories:

- *Clients;*
- *Technical staff.*

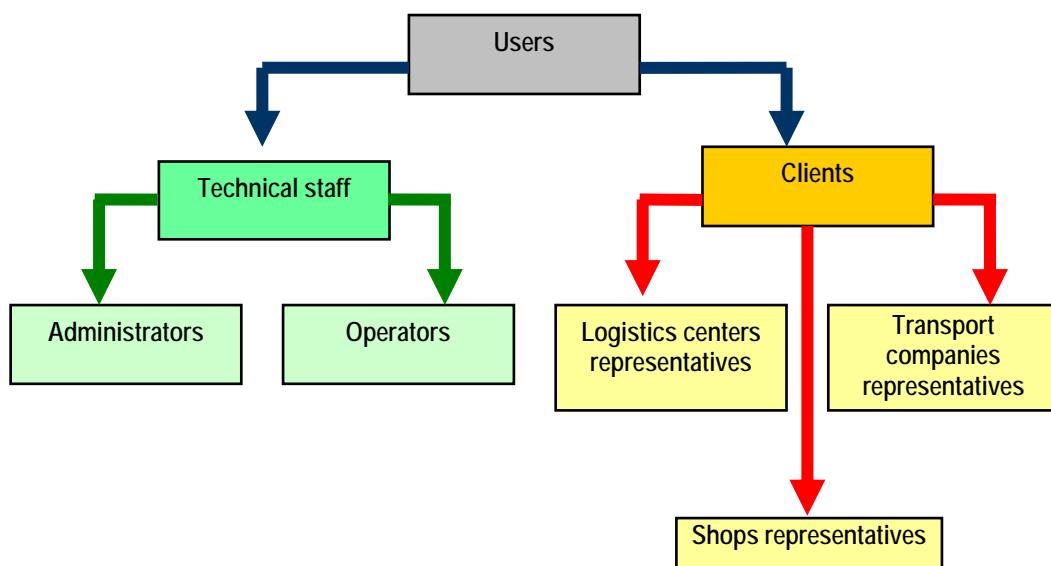


Figure 5. Users classification

All of the above categories of users are roles. This means that in principle the same individual could combine several roles.

Formally, the portal is designed for cooperation between the enterprises, but in fact the access to portal is personalized. This means that each user is identified by the system individually and he shall be individually responsible for his acts committed while using the portal.

### 3.2. Portal's functional map

The functional map of the portal is presented in Figure 6. It schematically displays the screen forms (pages), available for different types of the users, as well as navigational links between them.

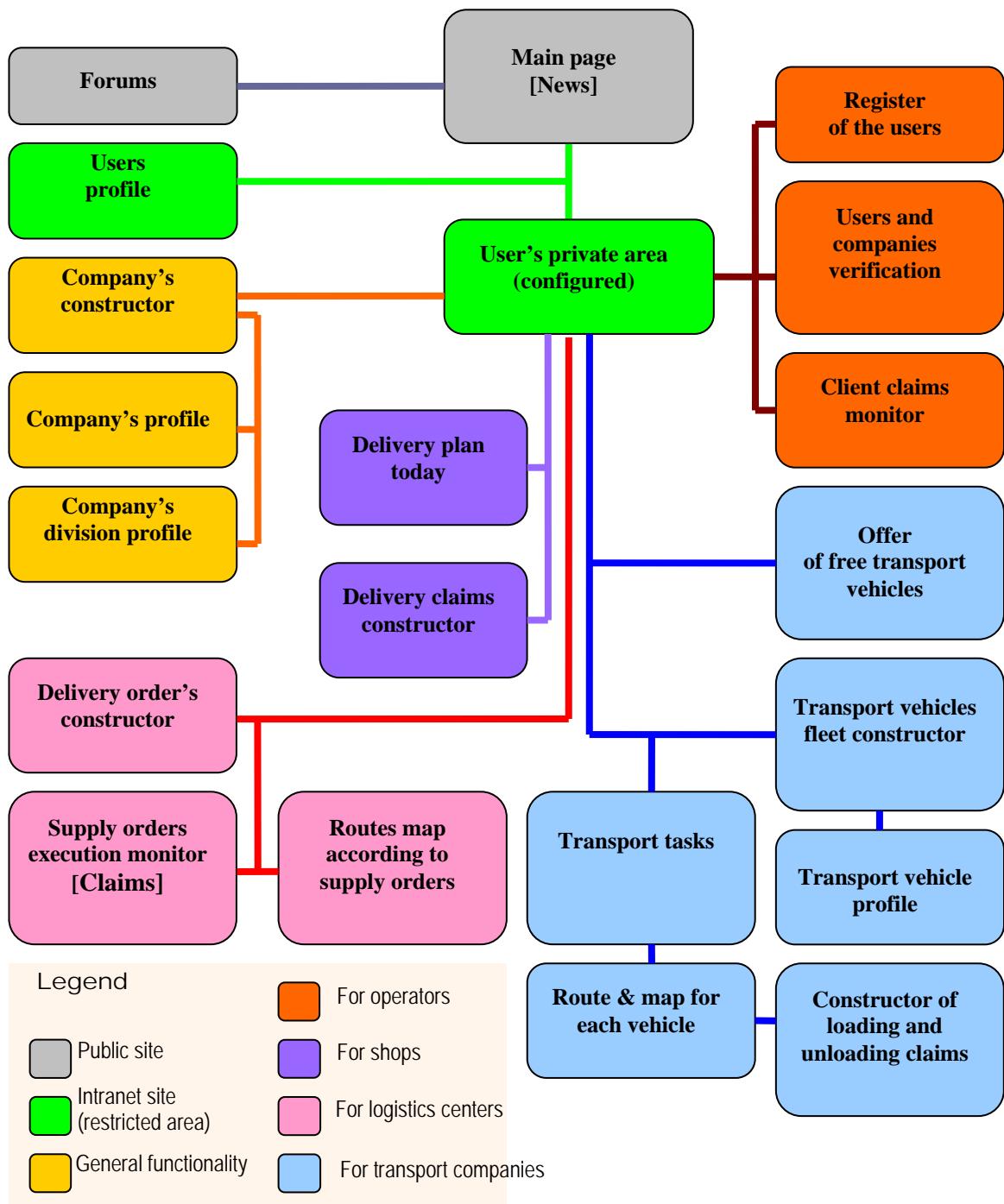


Figure 6. Portal's functional map

### 3.3. The mechanism of registration of users and companies

Each user, regardless of its provisions in the system, should provide at least the following characteristics (elements of the user profile):

- *Name;*
- *Surname;*
- *Personal code;*
- *E-mail;*
- *Telephone.*

The system in this case also proposes to select a unique user name and password, which together with the date of registration are saved as a user's options. The remaining elements of the user's profile are already dependent on user's role.

#### ***The status***

One of the possible statuses is being defined for a user account:

- |                              |   |
|------------------------------|---|
| • <i>Unclear</i>             | <i>- the user can only enter his data,</i>                      |
| • <i>Guest (training)</i>    | <i>- the user can do almost everything, but without fixing,</i> |
| • <i>Working (read-only)</i> | <i>- the user can browse working data,</i>                      |
| • <i>Working full power</i>  | <i>- the user can pass core activities,</i>                     |
| • <i>Blocked</i>             | <i>- the user can do nothing.</i>                               |

The system allows users to register themselves on the portal site, specifying the minimum elements of mentioned profile, as well as passing the test CAPTCHA (preventing the automatic registration). In this case the user has obtained an account with the status "Unclear". Such an account has a minimum of rights, while the user is seen as a client: he is suggested to choose by whom it considers itself: *the representative of ...*

- ... *Logistics center,*
- ... *Transport company,*
- ... *Shop (the recipient of goods).*

The user can also either create a profile of the company he works in or seek to connect to the company already registered in the system. Profile is created in the mode of company constructor and includes the following attributes:

- *Title,*
- *Registration Number,*
- *Legal notices,*
- *Bank account,*
- *The official telephone and fax,*
- *Responsible person.*

For one company one can also create multiple units of the physical address where the units are located. Among the units there are:

- *Logistic Centers (point of embarkation),*
- *Shops (the point of discharge),*
- *Transport fleet.*

For each unit it must be signed:

- *Conditional title,*
- *Physical address,*
- *Contact person, who is responsible for this unit.*

A person, who requested the inclusion of firms in the database portal, automatically becomes a responsible and a contact person (i.e. the user). The user with the status "unclear" cannot do anything more. It is necessary that someone from administrators or operators would change his status to continue normal work in the system.



#### ***The administrator***

Initially in the system there is only one user with pre-established properties and rights - *administrator*, he is a super-user. The administrator has all the available rights, including the right to register new users and give them (or take off) the rights, which deems fit. Including them an administrator can give the user administrative rights. The support of technical integrity of the system, as well as registration of *operators*, is the main responsibility of the administrator.



### **The operator**

The operator's account can be created only by administrator and handed over personally (or through the privacy channel) to the appropriate user. The main responsibility of the operators is the verification of information provided by customers themselves (see above), as well as registration of claims and fulfilling appropriate actions.

The operator is responsible for regularly reviewing the list of user accounts with the status of "unclear" and implementation the *off-line* verification of information about the user and firm. On the base of the results of verification the operator changes the account status. If the result is negative, the verified account can be blocked.

In addition, the operator can change the status of the company based on the history of interaction with the company. Once the operator has verified the user and data of the company, the user officially becomes the representative of any unit of any company. The user reserves the right to update his profile and the profile of his company, but in case of any modifications he must undergo re-verification. Therefore, before editing profile, the user is warned about this.



### **The representative of transport company**

The representative of transport companies performs the following steps:

- Fill and maintain relevant information on their fleet (must be registered on all vehicles that could potentially participate in the process of transport);
- Daily providing information on the availability of vehicles for tomorrow (accurate lead time to plan is to be determined by experience);
- Daily from morning (exact time is to be determined by experience) receive job to the transportation of goods, which are obliged to refer to drivers for fulfillment;
- Timely report the failure of transportation task (force major, etc.).

Profile of vehicle, which should be filled by the representative of the transport company, is as follows:

- *The internal accounting identifier (can be generated by the system or introduced for easier identification of the vehicle);*
- *State number;*
- *Carrying capacity (automatically determines the type of vehicle);*
- *Type of the vehicle (Passenger, minibus, truck);*
- *The height, length and width of the cargo compartment;*
- *The company - owner.*

The information about free vehicles must be stored every day by an authorized representative of the transport company manually or exported from the schedule employment vehicles from the transport company's information system (if it exists in the company).

Every morning for each offered free transport vehicle, the job in the form of working route, that consists of a sequence of loads and discharges addresses, is issued to transport company. Each loading and downloading is accompanied by a full list of supply orders. The ability to carry out loading and downloading for the vehicle is guaranteed by optimisation algorithm [6] of *planning kernel*.

If, having received the assignment, the representative of the transport company discovers that it cannot be complied for some reason; he should immediately reject the assignment. Non-rejected during a certain time, the assignment is considered as approved for execution. During the route, carrying out loading and downloading, the driver notes in a special routing his actual time, as well as various claims.



### **The representative of the shop (the recipient of goods)**

Daily the representative of the shop receives a list of downloading, which will be made in his address that day. For each downloading, the list of orders is indicated as well as planned time interval of delivery. In general, several vehicles may make all discharges at different times (although the algorithm try to minimize such cases). It is the responsibility of the representative of the shop to fix the facts of downloading, as well as any claims against supplier and carrier.



### **The representative of logistics center**

Daily, the representative of logistics center places orders for delivery in the database portal (or this will happen automatically, based on XML Web-services). The order for delivery includes the following characteristics:

- *Location (logistics center's address);*
- *Where (delivery address);*
- *The interval of time, which should take the goods;*
- *The interval of time, which should deliver the goods;*
- *Type of goods (food / industrial);*
- *Packaging type;*
- *The width, length and height of the cargo unit in terms of the type of packaging;*
- *Number of units of cargo;*
- *Number of invoice;*
- *Who prepares the order;*
- *When issued.*

The type of packaging is one of the preliminary arranged types, which determine the linear dimensions of cargo units. The width, length and height are specified in the order - a monolithic size of one unit of cargo (it cannot be decomposed down into component parts and regrouped in another form).

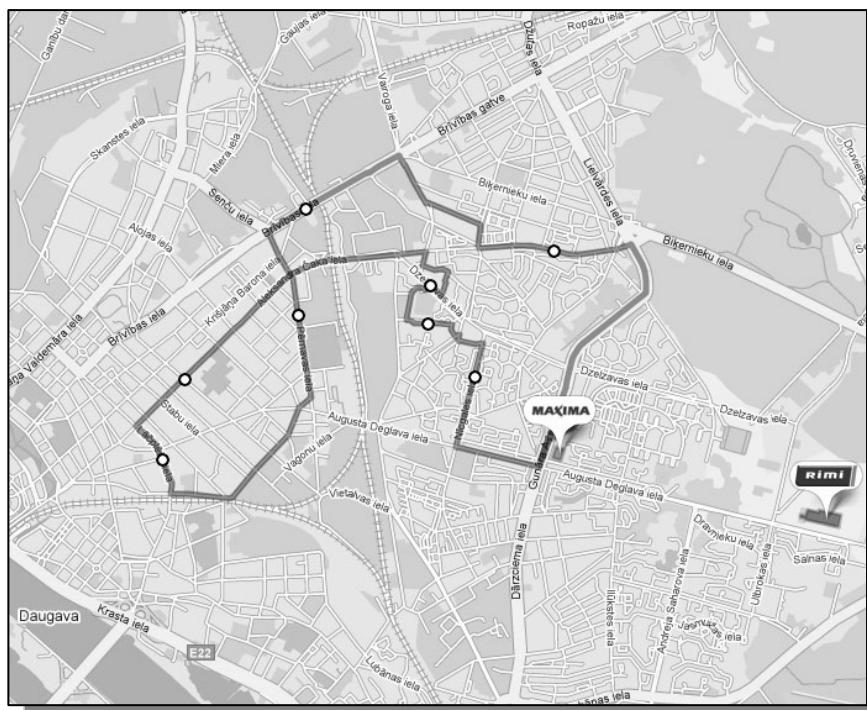
The representative of logistics center can view the routes of vehicles involved in the execution of his orders. Additionally, he can view the state of execution of his orders in real time on the site (the recipients of goods are obliged to promptly provide such information).

### **3.4. Organizational aspects of the Internet portal "Riga City Logistics"**

The portal can provide services of planning a unified network of supply chains on a commercial basis for licensed users under the auspices of city government. For the functioning of the portal minimal administrative staff and technical support service will be required. In the first phase of the portal, the city government will oblige all companies involved in transport within the city, including logistics centers, to register with the on-line mode. With those companies who wish to participate in the work a special license agreement will be concluded, and they become a power (licensed) user of the system.

To attract the users in the first stage it might need some incentives, such as preferential taxation within the purview of municipal authorities or other measures. Additionally, taking into account all the legal aspects mechanism of financial and legal relationships between all participants in transport operations, including the electronic stock exchanges (portal) personnel, in full accordance with existing legislation should be elaborated.

In case of success in the planning and visible results of implementation it may join the newly independent carriers and transport units to the system in future as well as their own divisions of main companies-owners of the logistics centres.



*Figure 7. An example of planned optimal route for one vehicle in a single delivery network interface prototype of Internet portal "Riga City Logistics"*

## Discussion

Functioning portal “City Logistics” is interesting for all involved in the supply of goods participants on the principles of Private Public Partnership (PPP):

- Transportation companies and SME will receive the largest gains from the introduction of such a system, as they will be provided guaranteed volumes of work on the delivery of goods with maximum efficiency use of vehicles without losses (a car full load and the optimal time or distance route). Furthermore, the companies will be able to manage their own maintenance and repair of the vehicle fleet as well as the work of drivers and service personnel more effectively, which should positively impact on road safety.
- Major companies, the owners of logistic centers, will exclude the need of a continual search of the perpetrators of small irregular orders (outsourcing), and more, they will be able to increase the number of orders for small irregular international traffic if supported by WWW portal service in the final phase of delivery.
- It will be possible to talk about joint network supply as a part of the city logistics system, which, using the optimal planning, gives an opportunity to minimize the number of vehicles that carry out the delivery of goods available in the central part of the city. Moreover, there is an opportunity to exclude implementation of routes during peak hours in the busiest urban streets and in the historical center of the city. This, in turn, will affect the intensity of the urban traffic and environmental situation in the city, which is desirable for the State, municipal services and all residents.

**Acknowledgements.** The presented research was accomplished with the support and partial funding under the European project „START – Short-term tasks for cargo transport traffic reorganization”, European Commission Intelligent Energy Executive Agency project (2006-2008), grant contract EIE/05/169/SI2.419609.

## References

1. <http://www.csdd.lv> (Road Traffic Safety Department web site)
2. Lenstra, J. K., Rinnooy Kan, A.H.G. Complexity of vehicle routing and scheduling problems, *Networks*, 11, 1981, pp. 221-227.
3. Helsgaun, K. An Effective Implementation of the Lin-Kernighan Travelling Salesman Heuristic, *European Journal of Operational Research* 126 (1), 2000, 106-130.
4. Holland, J. H. *Adaptation in Natural and Artificial Systems*. University of Michigan Press, Ann Arbor. 1975
5. Grakovski, A., Ressin, A., Medvedev, A. Optimisation of operational routing for supply chain on basis of genetic algorithms. In: *Proceedings of the 6th International Conference “Reliability and Statistics in Transportation and Communication (RelStat'06)*, 25–28 October 2006, Riga, Latvia”, Riga: Transport and Telecommunication Institute, 2006, pp. 125-137.
6. Grakovski, A., Ressin, A., Medvedev, A. Vehicle routing problem for city services solution by hybrid genetic algorithm. In: *Proceedings of the 7th International Conference “Reliability and Statistics in Transportation and Communication (RelStat'07)*, 24–27 October 2007, Riga, Latvia”, Riga: Transport and Telecommunication Institute, 2006, pp. 246-254.
7. Allard, M., Bronsard, C., Richelle, Y. Temporary Pareto Optimum Theory, *Journal of Public Economics*. 1989, pp. 343-368.