

Developing Logistics Optimization Software for Manufactory Using Computer Modeling Methods

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Abstract

The paper describes development of computer model for manufactory logistic and creating client application for semi-automatic logistics management. Object of this study is metal processing company. PHP programming language, MySQL database, and Apache web server were used to create client application. The interface developed using HTML5, CSS and javascript.

1 Introduction

Nowadays, small manufactories work with large order amounts from different customers, and their transport resources are often limited. One of the possible ways to reduce expenses and increase the transport usage utility for manufactories is the creation of client software, which takes part of the work in loads distribution and creating optimal routes.

Creating such a solution in form of a web application [1] will provide access to the system for both operators in the field, and for company management, and if necessary, directly for drivers involved in delivery.

2 Theory

The manufactory works with processing and manufacturing of metal products for orders, which may include a large number of positions from the same customer or similar items from different customers. The experience of enterprise software development was representing in [7-12]. In the first version of the created application, each product unit has set of attributes.

Table 1. Attributes of «Product unit»

| No | Attributes | Description |
|----|-----------------------|---|
| 1 | Name | Full name of the product unit |
| 2 | Weight | Kg. (1 pc.) |
| 3 | Count | pc. |
| 4 | Amount in one package | pc. |
| 5 | Size of a package (W) | mm. |
| 6 | Size of a package (L) | mm. |
| 7 | Size of a package (H) | mm. |
| 8 | Fragility | Y/N. This attribute is used in the product's card for record at packing and loading the product |

| | | |
|----|-----------|---|
| 9 | Status | <ol style="list-style-type: none"> 1. Accepted - This is default value. The product's card is available for the Manager, Master and Administrator. At this stage Manager sets order priority. 2. Making in progress - Master sets this value to show changed status of the order. 3. Preparing for delivery - Master sets this value to show changed status of the order. 4. Ready for delivery - Manager sets this value to show changed status of the order. 5. Sent. 6. Delivered. |
| 10 | Transport | Linked transport id from transports list is set for products that got status "Ready for delivery" |
| 11 | Order | Order's number in case of multiple orders from one customer |
| 12 | Priority | Determines the order of production |

Table 2. Attributes of «Customer»

| № | Attributes | Description |
|---|------------|-------------------------------------|
| 1 | Name | Customer's or his organization name |
| 2 | Contacts | Phone number or e-mail |
| 3 | Payment | Customer's payment info |
| 4 | Comment | Additional information |

Table 3. Application roles:

| № | Role | Description |
|---|---------------|-----------------------------------|
| 1 | Master | Access to edit statuses of orders |
| 2 | Manager | Access to edit all data of orders |
| 3 | Driver | Access to view all data of orders |
| 4 | Administrator | Full Access |

Table 4. Attributes of «Transport»

| № | Attributes | Description |
|---|-------------------|--|
| 1 | Transport | Car model, identification number |
| 2 | Carrying capacity | The maximum load weight, t. |
| 4 | Maximum height | mm. |
| 5 | Maximum length | mm. |
| 6 | Maximum width | mm. |
| 7 | Fuel efficiency | Liters per 100 km. |
| 8 | Status | <ol style="list-style-type: none"> 1. Not available 2. Active 3. Busy |
| 9 | Driver | Linked user id from users list (1 driver – 1 transport) |
| № | Attributes | Description |

Table 5. Attributes of «Order»

| № | Attributes | Description |
|---|----------------|--|
| 1 | Number | Identification number |
| 2 | Address | Full address for delivery |
| 3 | Delivery order | <ol style="list-style-type: none"> 1. In pieces 2. Only full batch |
| 4 | Payment status | <ol style="list-style-type: none"> 1. Waitng for payment (after delivery) 2. Waitng for payment (before delivery) 3. Paid |
| 5 | Customer | Linked customer id from customers list |

The role model of application implies restrict of access to view orders statuses for various users. An example of such a restriction can be "Driver" role - these users have access to view only those product units that they are linked to.

When order is received, a product unit card is generated. Access to it is received by master from manager. All product unit records in the database that have status "Ready for delivery" are automatically processed by application at the moment of products batch preparation. Based on information about their mass and size, products are automatically linked to transport units [2] that have status "Active" and their drivers receive access to these products' cards.

Next step is create routes for all loaded transport units using interaction with GIS API [3]. Main criteria for distribution and construction of routes:

1. No fragmentation of the order by one customer to different transport units (if possible);
2. Minimize total fuel expenses for loaded transport units (fuel expenses are determined by data from database and distance of route).

The result should be a set of routes for minimum number of required transport units, which will be used to deliver all products that are ready to delivery to customers. Product units of orders with "Delivery order" set as "Only full batch" are not loaded if there are pending product units from the same batch for the customer.

3 Realization

3.1 Resources

For creating prototype version, it was decided to use the PHP programming language and the BoltCMS content management system. This choice has been taken because PHP is optimal for the development and support the project, and also there are many ready-made solutions in free access that used PHP. And the CMS is based on the convenient Symfony framework and tools such an administrative interface, standard functionality for restrict access rights and built-in templates.

At first step, integration with the Google Maps GIS API was used to test functionality, make a list of necessary improvements and get feedback from potential users. In future versions there will be used a selection of optimal routes from different systems, instead of using a single GIS. Ant algorithms [4] will be used for the analysis of these optimal routes.

The server part of the system required to use PHP version above 7.0 and MySQL database version 5 or higher [5]. It can be placed both at customer's or external server by an individual arrangement with customer. Access to the client part is realized via the web interface and through SSL encryption protocols (if it's possible) to ensure the security of the transmitted information.

3.2 Structure of working process and database

The process of changing orders statuses and checking conditions is shown in Figure 1. Models that described in par.1 was put in form of a database using DBMS MySQL. Scheme of this database is shown in Figure 2.

Access to modify data in database is limited according to role model presented in Figure 1. Only administrators and director of the company have full access.

3.3 Output data for logistic part of application

Data is generated in database in application working process. It contains information about incoming orders, ordered products, customers and transport. This data is used to calculate the summary values for GIS API. These values include data about transport units, products and customers' addresses.

Linking product units to transport units is automated process in the system with two conditions to be fulfilled: status of product unit must be set to "Ready for delivery"; delivery order of order must be set to "In pieces". If delivery order is set to "Only full batch" then product unit is not taken to linking process to transport units, until all other product units from this order will be ready.

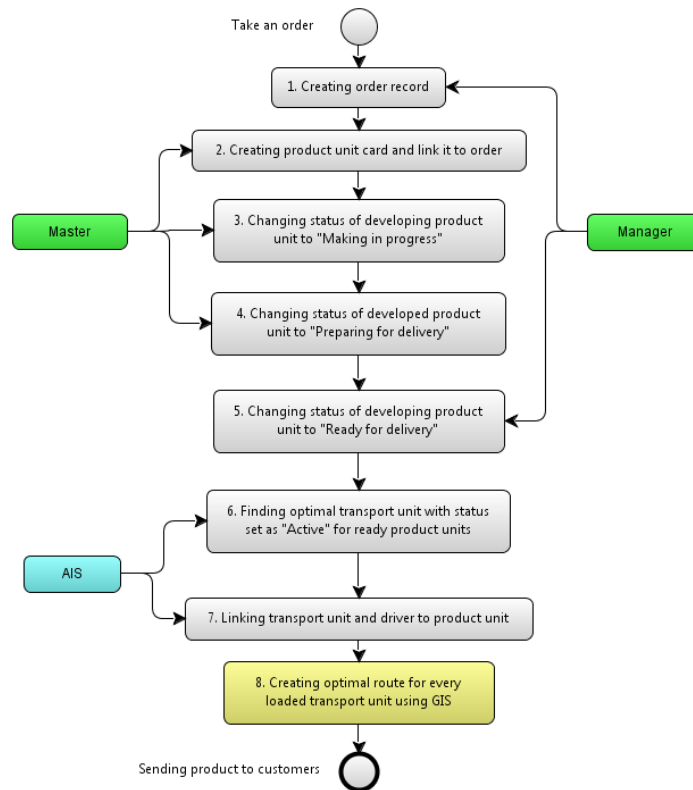


Figure 1. Scheme of working process in application

Linking transport unit to a product unit is carried out according to conditions: to load transport unit maximally according to its carrying capacity and to minimize number of transport units per order [6]. Limits for this process are carrying capacity and size of transport unit, as well as weight, quantity and size of product units. As a result, we obtain parameters of each loaded transport units (final weight, fuel expenses).

Customer's address is delivery point. Linking address to a product unit was carried out through an order card, which contains links to all products ordered by customer. Information about departure point was set by default from the place of production.

GIS uses received data to create optimal routes for all loaded transport units, according to all addresses (arrival points), fuel expenses (in case of need to add refueling points to the route) and total weight of transport units with cargo (it's important for traffic weight restrictions).

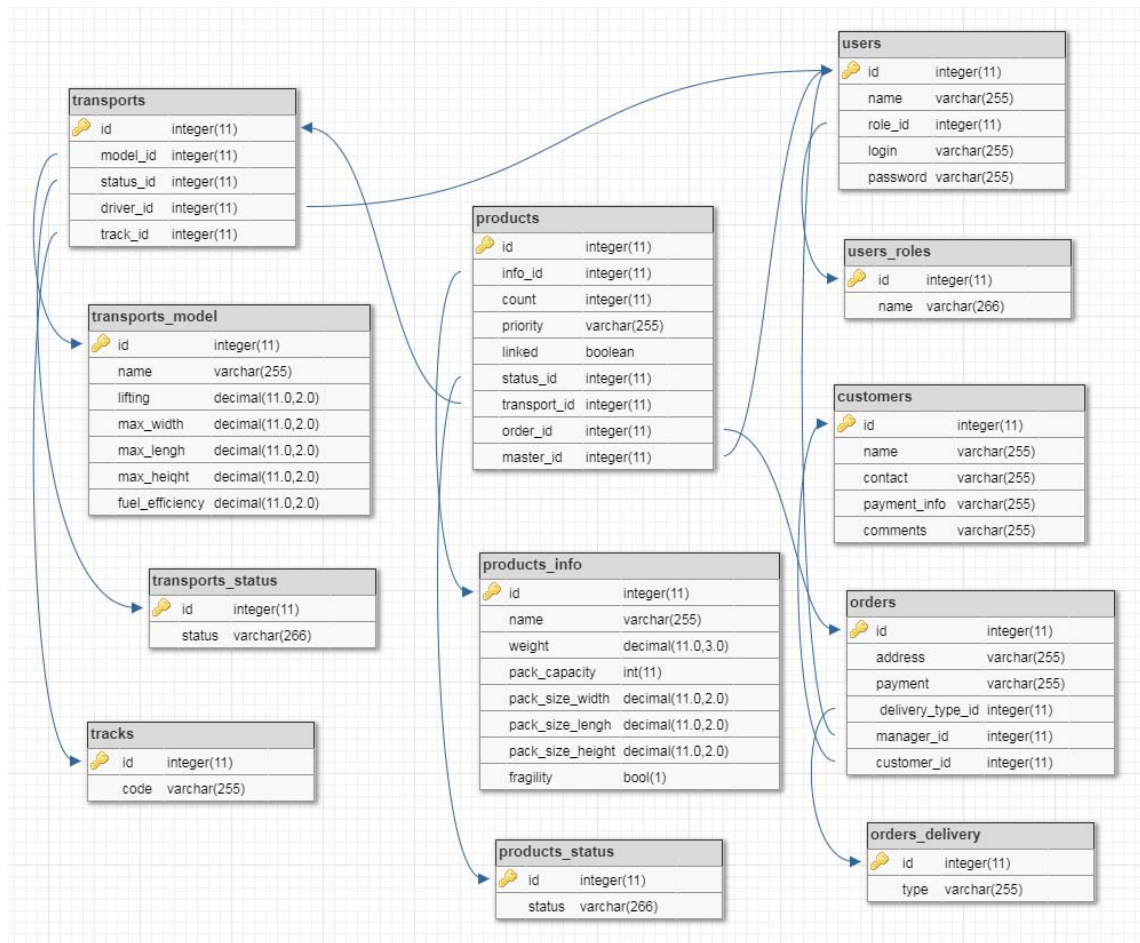


Figure 2. Scheme of application database

4 Conclusion

Presented system allows to optimize logistics of the company using automated distribution of products and creating routes with minimizing probability of operator errors. Implementation in form of a web application provided minimal requirements to hardware solutions and allowed us to consider in future development new options by creating mobile applications or integrating with external services and systems.

Further improvement of developed solution was planned through implementation of searching for optimal routes by using data from multiple GIS and addition of an internal system for orders distribution with new attributes and checks based on feedback after testing.

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