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DEVELOPMENT OF THE APPLICATION FOR THE INFORMATION SUPPORT OF LOGISTIC BUSINESS PROCESSES OF THE CONSTRUCTION SERVICES ON BUILDINGS INSULATION

The **subject** of the research is the methods and technologies of information support of logistic business processes of buildings facades insulation. The **goal** of the paper is to provide the information support to the companies that provide services for the buildings facades insulation. The following **problems** were solved: analysis of functionality the sites of the companies providing insulation services; formation of business process diagrams; database development; web application development for business processes informational support for buildings facades insulation. To solve these problems, **methods** of system analysis, set theory, database and web applications development technologies were used. The following **results** were obtained. Sites of companies providing the facades insulation services were analyzed and identified as for their advantages and disadvantages. The advantages of developing web applications compared to sites are considered. The model of logistic business processes for facade insulation is formed, which consists of three stages: preparatory, main and final. The set-theoretical description of the business process model components is given, which allows to determine the main components of the insulation process logistic support and to apply the calculation formulas for the corresponding information support module. The information support architecture for insulation business processes is developed, which consists of a database, a calculation module and a web application interface. The database structure is developed, which contains information about the company, the contractors for insulation, the necessary materials in stock, order and customer parameters. The web application development allows automating the information processing for the organization of work and providing the user with the ability to quickly place an order. **Conclusions**: information support of insulation logistic business processes ensures their maintenance at all stages of work through the timely preparation of an individual services list and checking the availability of necessary materials. The main result of the web application is the ability to automatically calculate the warming area and the order cost, taking into account the availability or purchase of the necessary materials, and the formation of an agreement between the customer and the company-performer on the basis of the selected parameters of the insulation service.

Keywords: business processes; building insulation; set-theoretical description; precedent diagram; system architecture; database; web application.

Introduction

The issue of insulation of facades becomes an important in connection with the increase in the cost of heating houses in winter. This reduces heat loss and therefore reduces heating costs. Today there are many companies providing such services that do not always meet all requirements for the execution of orders: no preliminary work to eliminate defects in the walls is carried out, cheap low-quality materials are used, etc. These disadvantages lead to the gradual destruction and deformation of the structure, as well as contribute to the appearance of fungal formations, which ultimately can cause collapse. To avoid such situations, it is necessary to form an individual list of works and materials that will be used for work in a timely manner, which requires considerable time. Information automated support of this process will reduce the time for material support [1].

Analysis of recent research and publications

When performing works on construction services, special attention should be paid to their timely implementation [2], which is impossible without logistic control methods [3]. This requires the development of an information support system using modern technology [3, 4].

Today, each company has its own website from which the user can obtain the information he needs. But the growing popularity of using web applications is due to their benefits, the main of which are the following [5−7]:

- flexible data access;
- the guarantee of a safe user registration;
- support for all devices;
- faster user access to the necessary data in comparison with the site;
- quick user registration;
- applications run through the URL;
- support for all devices;
- web application development is more simple than website.

Thus, for convenient use, it is proposed to develop a mobile application that supports the logistics process of insulation of the facades of buildings.

Table 1 shows the comparative characteristics of the sites of firms providing services for insulation of houses exclusively in the city of Kharkov [8 − 11].

Based on the analysis, functional requirements for the web application were developed [1]:

1) review information about:
- list of materials necessary for performance of installation works;
- additional services (with possibility of demonstration of finished objects);
- general information about the crew of climbers and their tolerances to high-altitude works;
2) the choice of the working components of insulation of the facade of the building;
3) the calculation of the cost of the order for the selected parameters.

Table 1. *Comparative analysis of the sites of companies for insulation of walls*

Name of the Company	Possibilities	Disadvantages
"VESTA"	- the price is set per square meter; - the choice of material; - drawing up a contract with a representative of the firm; - insulation of walls by the standard technology.	- absence of the choice of auxiliary material and coating; - the length of the order processing; - exceeding the time of execution of works; - lack of access to the material; - the contract is not complete.
"Albatros"	- the possibility of choosing the technology of insulation of walls; - drawing up a contract with a representative of the firm; - insulation of walls by the standard technology; - the possibility of performing work on a lifting machine.	- no billing; - lack of insulation of individual apartments.
"W-teple"	- drawing up a contract with a representative of the firm; - insulation of walls by standard technology; - provision of services for the purchase of foamed insulating plates.	- lack of the choice of material; - no tariffs set; - lack of access to the material. - the contract is not complete.
"TeploHata"	- the possibility of ordering different types of work; - insulation of walls by standard technology; - fixed price for services; - the scheme of work with the customer is shown.	- absence of the choice of auxiliary material; - absence of review of the performed works; - the lack of the ability to calculate the price of the order.

Materials and methods

Fig. 1 shows the scheme of logistics business processes providing services for the insulation of facades of houses in the form of a sequence of works, which can be divided into three stages:

- stage of preparation, that is, discussion of the details of the order, which begins with the receipt of the order;

- the main stage, that is, carrying out the necessary calculations;

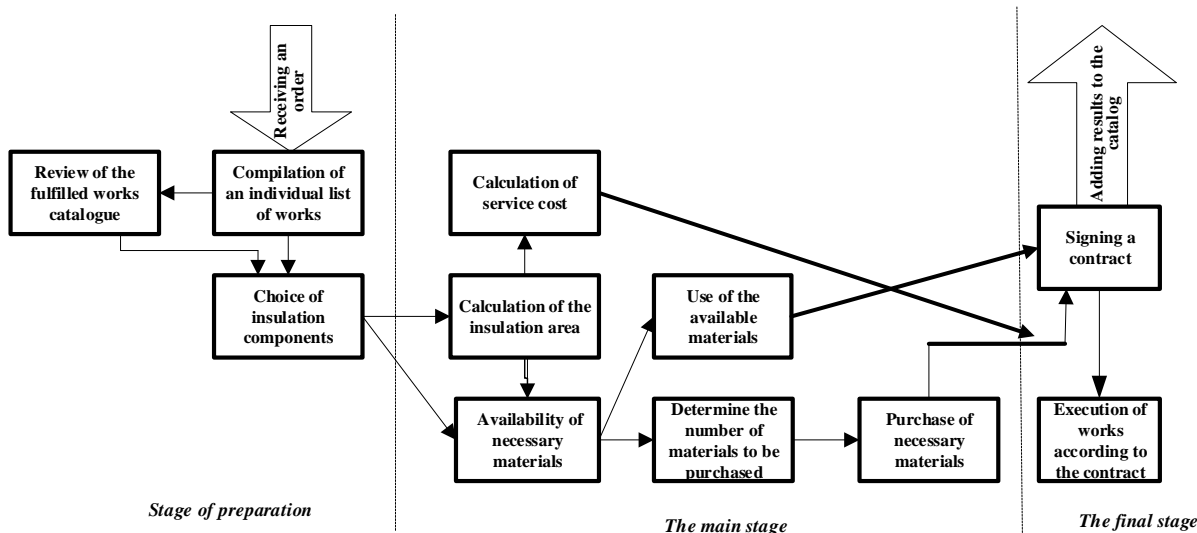- the final stage, that is, the conclusion of the contract and the conduct of insulation.

Fig. 1. Scheme of logistic business processes providing insulation services to the facade of the building

We give the set-theoretic representation of the model of business processes of providing the insulation services [1, 3, 4]:

$$Posl = (Pidgot, Osn, Zakl),   (1)$$

where *Pidgot* – preparation stage;

Osn – main stage;

Zakl – final stage.

We will decompose the processes of these stages into sub processes and separate works.

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After receiving the order, the representative of the company goes to the object and agrees with the customer the details that correspond to the stage of preparation. Let's imagine this process as a set of sub processes:

$$Pidgot = (per\_rob, vib\_komp, per\_inf) , \quad (2)$$

where *per_rob* – preparation of an individual list of works;

vib_komp – selection of insulation components;

per_inf – the ability to view information about the work done, the brigade of masters, etc.

In turn, the choice of insulation components provides for the definition [12, 13]:

- type of insulation;
- type of dowels for mounting, which corresponds to the selected type of insulation;
- adhesive for reinforcing layer;
- facade mesh (fiberglass);
- reinforcing primer;
- decorative plaster;
- facade paint.

$$rozr\_ob\_komp = (rozr\_ob\_mat, rozr\_ob\_ut, rozr\_ob\_dm) , \quad (5)$$

where *rozr_ob_mat* – determination of the materials amount *mat* to be purchased to complete the order;

rozr_ob_ut – determination of insulation material volume;

rozr_ob_dm – determination of the volume of additional materials (dowels, paint, etc.).

The result of the sub process of calculating components is a set of volumes of materials:

$$rozr\_zam \Rightarrow zam = (pl + S_2) \cdot (\text{var}\_mat + \text{var}\_ut + \text{var}\_rob) \cdot (\text{var}\_mat + \text{var}\_ut) + \sum_{i=1}^{n_3} \text{var}_i \cdot ob\_dm_i , \quad (7)$$

where *var_mat* – the cost of the selected material for insulation;

var_ut – the cost of the selected insulation;

vari – cost of the i-st additional material,

n_3 – quantity of additional materials;

kil_dmi – quantity of the i-st additional material;

var_rob – the cost of carrying out the work by a team of climbers;

pl – square of the insulated area;

S_2 – square of zones that are insulated by other materials (window slopes).

The sub process of checking the presence of material is decomposed into a set of such works:

$$nayav = (vik, viz\_ob\_komp\_zak) , \quad (8)$$

where *vik* – determination of materials that are present in the warehouse in full;

Thus, the result of the process of determining the required materials is the value:

$$nayav \Rightarrow ob\_mat = \sum_{i=1}^{n2'} ob\_mat_i + \sum_{i=1}^{n2''} ob\_mat\_zak_i. \quad (11)$$

Thus we have the third level – the decomposition of the sub process into separate work of the selection of materials:

$$vib\_komp = (v_1, v_2, \dots v_{n1}) . \quad (3)$$

The main stage can be represented as a set of calculated sub processes:

$$Osn = (rozr\_pl, rozr\_ob\_komp, rozr\_zam, nayav) , \quad (4)$$

where *rozr_pl* – calculation of the square of the insulated aream *pl*;

rozr_ob_komp – calculation of the volume of components required for insulation;

rozr_zam – calculation of the cost of the order *zam*;

nayav – checking the availability of material in stock.

The sub process of calculating the components for insulation, in its turn, consists of the calculation of three components:

$$rozr\_ob\_komp \Rightarrow mat = (m_1, m_2, \dots m_{n2}). \quad (6)$$

The result of the sub process of calculating the cost of the order is the price, which contains the cost of all the necessary components and the costs of performing the volumes of the corresponding high-rise and installation works by the team. Thus,

viz_ob_komp_zak – determination of the amount of components that must be purchased to complete the order.

Determining the availability of necessary materials is as follows. If the condition is fulfilled

$$ob\_mat\_skl_i \ge ob\_mat_i, i = \overline{1, n_{2'}} , \quad (9)$$

where $ob\_mat_i\_skl$ – the amount of the *i*-th material at the firm's warehouse;

ob_mat_i – the amount of the *i*-th material for insulation,

than for insulation the material from the warehouse is used.

If the condition (10) is not met, the volume of the i-th material for purchase ob_mati_zak is determined in the following way:

$$ob\_mat\_zak_i = ob\_mat_i - ob\_mat\_skl_i, i = \overline{1, n_{2''}}, n_{2'} + n_{2''} = n_2 . \quad (10)$$

The final stage will be presented in the form of three sub processes:

$$Zakl = (ukl\_dogov, zak, prov\_rob) , \quad (12)$$

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where ukl_dogov – conclusion of the contract between the customer and the contractor;

zak – purchase of necessary materials and components,

$prov\_rob$ – work on the facade insulation.

After the work is finished, the result is saved in the catalog of completed orders.

Let's form a hierarchical structure of business processes according to the given sets (fig. 2.).
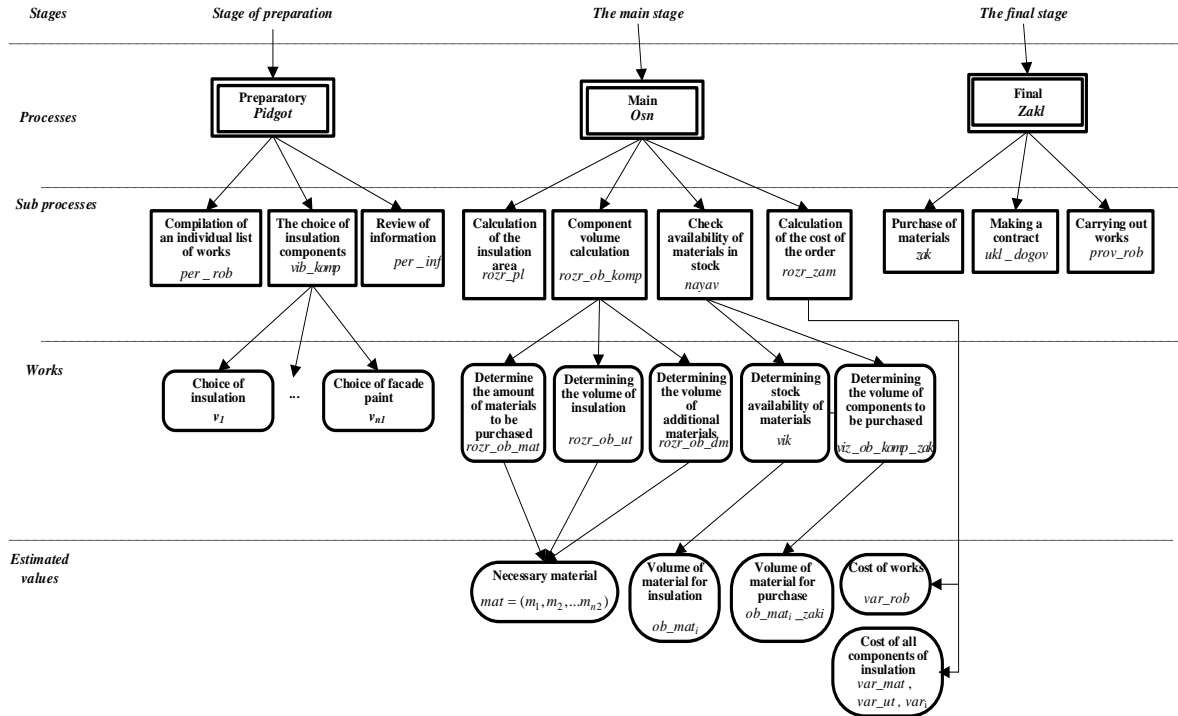

Fig. 2. Hierarchical structure of business processes providing services of insulation of the facade of the house

The presentation of these elements in the form of a set-theoretic description allows us to determine the main components of the logistics business processes of insulation of facades of houses, which are the basis for the development of the functional structure of the web application. The formalized representation of the calculated values allows to develop an algorithm of the calculation module and take into account the storage of these values in the database.

Research results

For automated maintenance of logistic business processes of insulation, information support is required for each of the steps, set out in fig. 2. Based on this, we will form the architecture of the web application [14] (fig. 3).
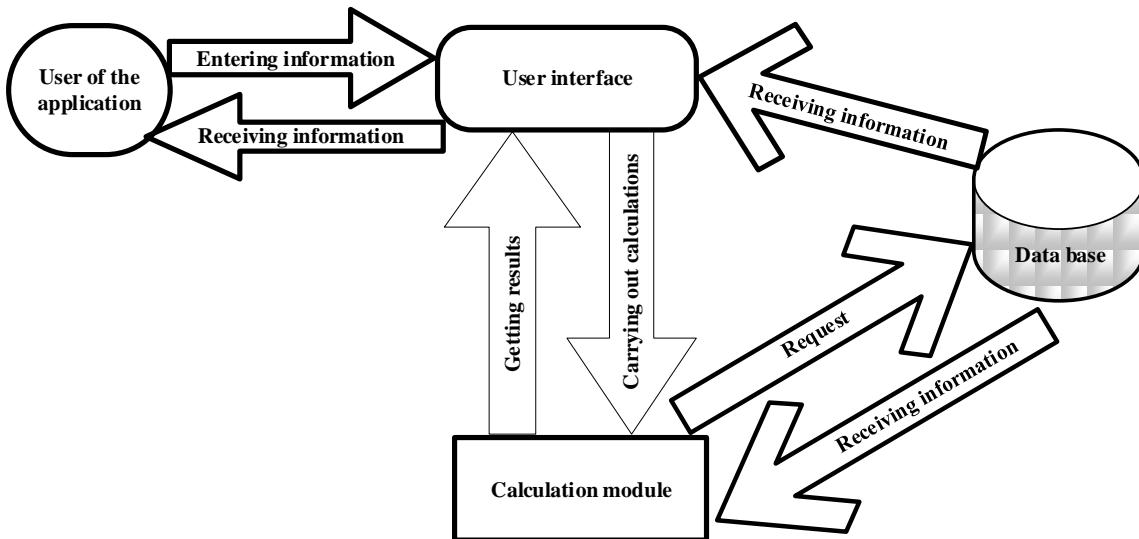

Fig. 3. Generalized architecture of web application for information support of logistics business processes

So, the architecture consists of such modules as:

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- web application interface for automating the work of the company's employees;
- data base;
- calculation module for basic calculations and the formation of the invoice and the contract.

To develop a web application for information support, a client-server architecture was chosen, that is, a separate, sufficiently powerful and reliable server is allocated for the database (DB), network access to which is carried out by several users (employees and clients) [15]. This gives you the quick access to viewing the necessary data thanks to the user interface, which speeds up the work of the employee of the company and eliminates the need to return to the office with the necessary documents

Due to the simple architecture of the web application, the representative of the company without much effort is able to obtain information about the list of items stored in the DB, as well as to analyze and calculate the necessary costs for insulation, as well as to arrange a contract for the implementation of installation work by the team of climbers [14].

Fig. 4 shows the structure of the DB, which consists of nine tables that contain information about the following:
- general information about the firm providing services (table Firma);
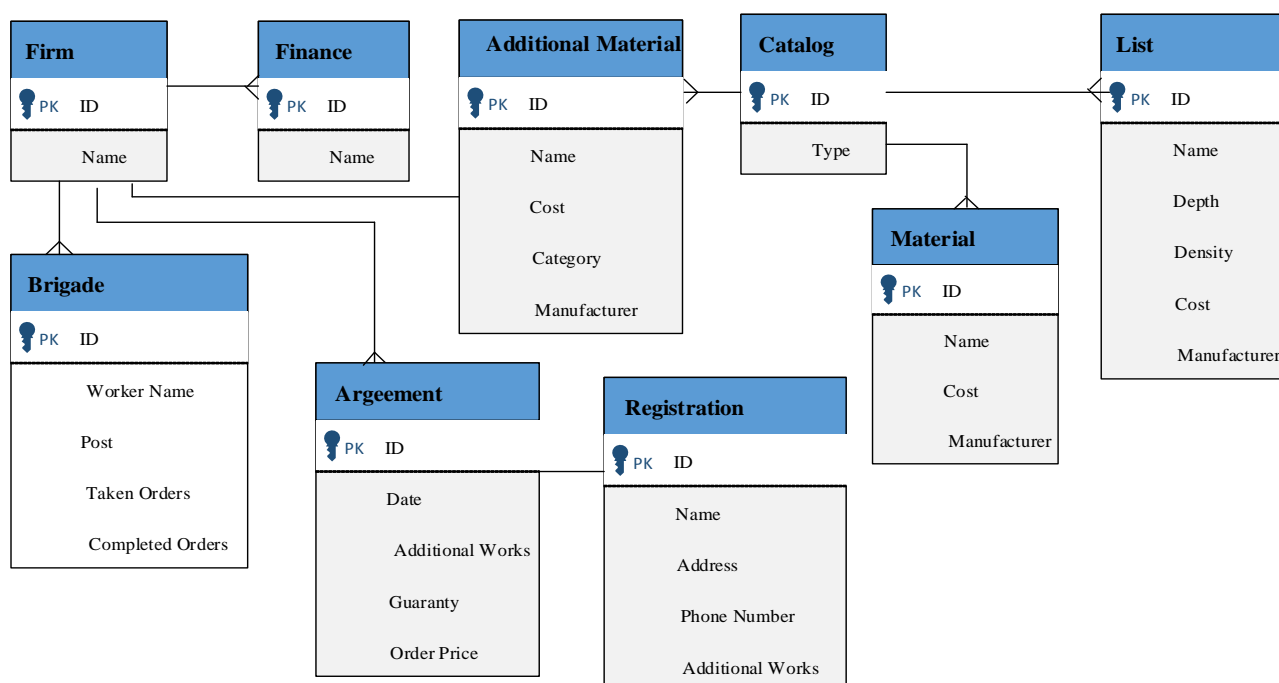- membership of the teams of craftsmen (table Brigada);

list of the main material (sheets for insulation) (table List);
- basic materials for insulation (table Material);
- list of additional materials for insulation (table Dop.Material);
- contracts (table Dogovor);
- the presence of materials in the warehouse (table Katalog);
- customer data (table Regestracia);
- financial statements of the company (table Finans)-contracts (table Dogovor).

Microsoft SQL Server DBMS was chosen to implement the database because it provides high performance, productivity and sufficient functionality, and is compatible with the Windows operating system and web application development technologies [16, 17].

To calculate the cost of materials in the application interface provides a special dialog form in the form of a table. The table shows all the necessary components for the insulation of the facade of the building, their units of measurement, the necessary volumes and cost. The required fields indicate the insulated facade area and the cost of the insulation chosen by the customer. After that, the total cost of all necessary materials for insulation is calculated. It should be noted that the table plays the role of an invoice, that is, on its basis will be purchased all the necessary material, and the result of the calculations is stored in the financial statements of the company and serves as the basis for the conclusion of the contract between the company and the customer.

Fig. 4. Database structure

Fig. 5 shows a precedent diagram that reflects the basic functionality of the web application for the three categories of users: administrator, employee and customer.

The application includes the separation of powers: the customer has the opportunity to register

and view information about the company, its news and events; the administrator can view information in the database and edit it, i.e. to make changes about the company and contribute data to the catalog of available materials for insulation.
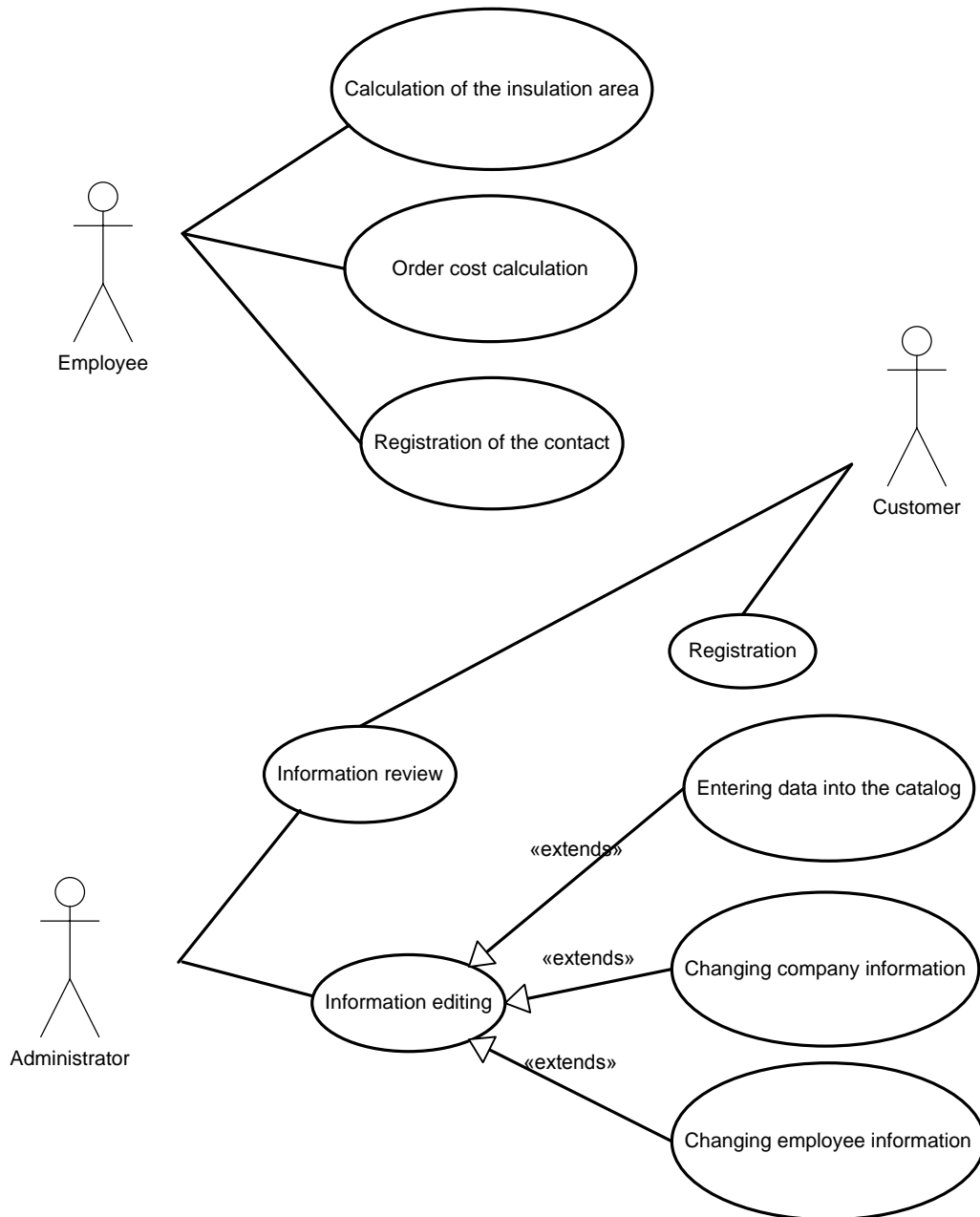
Fig. 5. Diagram of precedents

The employee has the ability to:

- carry out the calculations of the area of the insulation;

- carry out calculations of the order value;

- demonstrate to the customer the following information: list of insulation sheets available in the warehouse, using the built-in catalog; about the company, its news and events; about the team of climbers; about the catalog of finished projects.

To support the calculation function, a web-based application "Calculation of the cost of insulation" menu has been developed in which the company representative has the opportunity (fig. 6):

- to enter the output to calculate the area of insulation;

- to select the parameters of the base material (sheets for insulation of a certain thickness);

- to choose the additional services, i.e. order specific coating parameters (antifungal, anti-corrosion and water repellent).

The interface of the web application also provides the ability to select from a list of additional services for the better execution of the order.

After calculating the cost and approval by both parties, the representative of the company draws up a contract in which all the parameters are recorded: the list of individual works, the amount of the pre-payment, the cost of the order, taking into account the price of materials and performance of work, the term of execution of works, contact details of the customer, etc.

Web application development was carried out using HTML technologies (HyperText Markup Language), CSS (Cascading Style Sheets) i Java Script [18].

Fig. 6. Web application menu "Calculation of the insulation cost"

It should be noted that this application reduces the cost of storing paper documents, since the main contract is stored electronically. In case of contradictory moments, the employee can open the necessary agreement on the surname of the customer on his number, together to review and clarify the details of the contract. Each object is attached to a certain climber team, which bears material liability for it, and must fulfill all the terms of the contract and finish the work in the assigned term.

Conclusions

In the article the scheme of logistic business processes of insulation of facades of buildings is formed. According to this scheme, the technology of information support of processes at all stages of the work is developed by timely drawing up an individual list of services and providing the necessary materials. Automatically conducted calculations of the heated area of the facade and the cost of the order, which form the basis of the corresponding module of information support. Due to this it is possible to calculate several variants of insulation, after which the customer can choose the most preferable for himself.

The scientific novelty of the article is the formalized hierarchical model of logistics business processes, which can be used to reflect the business processes of providing services in any field of activity.

Practical value is the possibility of using the developed web-application for informational support of the firm's employee when concluding a contract with the customer with the ability to automatically calculate the area of insulation and cost of the order, as well as the formation of an electronic contract between the customer and the firm-performer on the basis of selected parameters of the insulation service.

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РОЗРОБКА ДОДАТКУ З ІНФОРМАЦІЙНОЇ ПІДТРИМКИ ЛОГІСТИЧНИХ БІЗНЕС-ПРОЦЕСІВ БУДІВЕЛЬНИХ ПОСЛУГ УТЕПЛЕННЯ БУДИНКІВ

Предметом дослідження є методи й технології інформаційної підтримки логістичних бізнес-процесів утеплення фасадів будинків. **Метою** роботи є забезпечення інформаційної підтримки діяльності фірм, що надають послуги з утеплення фасадів будівель. В роботі вирішені наступні **задачі**: проведення аналізу функціональності сайтів компаній, що надають послуги з утеплення; формування схеми бізнес-процесів; розроблення бази даних; розроблення веб-додатку інформаційної підтримки бізнес-процесів утеплення фасадів будівель. Для вирішення вказаних задач були використані **методи** системного аналізу, теорії множин, технології розробки баз даних та веб-додатків. Отримані такі **результати**. Проаналізовані сайти фірм з надання послуг утеплення фасадів та виявлені їх переваги й недоліки. Розглянуто переваги розробки веб-додатків порівняно

з сайтами. Сформована модель логістичних бізнес-процесів утеплення фасадів, яка складається з трьох етапів: підготовчого, основного й заключного. Наведено теоретико-множинний опис компонентів моделі бізнес-процесів, що дозволяє визначити основні складові логістичного забезпечення процесу утеплення, а також застосувати формули розрахунків для відповідного модуля інформаційної підтримки. Розроблена архітектура інформаційної підтримки бізнес-процесів утеплення, яка складається з бази даних, розрахункового модулю та інтерфейсу веб-додатку. Розроблена структура бази даних, яка містить інформацію про фірму, виконавців робіт з утеплення, необхідні матеріали на складі, параметри замовлення й замовника. Розробка веб-додатку дозволяє автоматизувати обробку інформації для організації виконання робіт й надати користувачеві можливість швидкого оформлення замовлення. **Висновки**: інформаційна підтримка логістичних бізнес-процесів утеплення забезпечує їх супровід на всіх етапах проведення робіт за рахунок своєчасного складання індивідуального переліку послуг та перевірці наявності необхідних матеріалів. Основним результатом роботи веб-додатку є можливість автоматичного розрахунку площі утеплення й вартості замовлення з урахуванням наявності або закупівлі необхідних матеріалів, а також формування договору між замовником і фірмою-виконавцем на основі вибраних параметрів послуги утеплення.

Ключові слова: бізнес-процеси; утеплення будинків; теоретико-множинне подання; діаграма прецедентів; архітектура системи; база даних; веб-додаток.

РАЗРАБОТКА ПРИЛОЖЕНИЯ ПО ИНФОРМАЦИОННОЙ ПОДДЕРЖКЕ ЛОГИСТИЧЕСКИХ БИЗНЕС-ПРОЦЕССОВ СТРОИТЕЛЬНЫХ УСЛУГ УТЕПЛЕНИЯ ЗДАНИЙ

Предметом исследования являются методы и технологии информационной поддержки логистических бизнес-процессов утепления фасадов зданий. **Целью** работы является обеспечение информационной поддержки деятельности фирм, предоставляющих услуги по утеплению фасадов зданий. В работе решены следующие **задачи**: проведение анализа функциональности сайтов компаний, предоставляющих услуги по утеплению; формирование схемы бизнес-процессов; разработка базы данных; разработка веб-приложения информационной поддержки бизнес-процессов утепления фасадов зданий. Для решения указанных задач были использованы **методы** системного анализа, теории множеств, технологии разработки баз данных и веб-приложений. Получены следующие **результаты**. Проанализированы сайты фирм по предоставлению услуг утепления фасадов и выявлены их преимущества и недостатки. Рассмотрены преимущества разработки веб-приложений по сравнению с сайтами. Сформирована модель логистических бизнес-процессов утепления фасадов, которая состоит из трех этапов: подготовительного, основного и заключительного. Приведено теоретико-множественное описание компонентов модели бизнес-процессов, позволяющее определить основные составляющие логистического обеспечения процесса утепления, а также применить формулы расчетов для соответствующего модуля информационной поддержки. Разработана архитектура информационной поддержки бизнес-процессов утепления, которая состоит из базы данных, расчетного модуля и интерфейса веб-приложения. Разработана структура базы данных, содержащей информацию о фирме, исполнителях работ по утеплению, необходимых материалах на складе, параметрах заказа и заказчика. Разработка веб-приложения позволяет автоматизировать обработку информации для организации выполнения работ и предоставить пользователю возможность быстрого оформления заказа. **Выводы**: информационная поддержка логистических бизнес-процессов утепления обеспечивает их сопровождение на всех этапах проведения работ за счет своевременного составления индивидуального перечня услуг и проверки наличия необходимых материалов. Основным результатом работы веб-приложения является возможность автоматического расчета площади утепления и стоимости заказа с учетом наличия или закупки необходимых материалов, а также формирование договора между заказчиком и фирмой-исполнителем на основе выбранных параметров услуги утепления.

Ключевые слова: бизнес-процессы; утепление зданий; теоретико-множественное представление; диаграмма прецедентов; архитектура системы; база данных; веб-приложение.