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**G. Varlamov** Dr. Eng. Sc., Prof. ORCID 000-0002-4818-2603
**I. Segeda** Cand. Sc. (Eng.) , Assoc. Prof .ORCID 0000-0003-1958-4985
**Y. Lokotarov** MComp Science ORCID 0000-0003-0554-1968
**Jiang Jianguo**, Ph.D. student ORCID 0000-0003-2559-4071
**I. Mitchenko,** Ph.D. student, ORCID 0000-0002-6361-9471
**National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"**

# AUTOMATED SYSTEM FOR PROVIDING POWERFUL COMPUTING SYSTEMS WITH A COMPLEX OF EQUIPMENT

*With the development of the cryptocurrency market, the need for automated support for mining hardware is growing. At present, there are practically no flexible systems for selecting equipment to fully meet the complex needs of providing complex features of mining processes, and software has not been developed that could take into account all the features of cryptocurrency developers. The purpose of this work is to develop the principles and algorithm for solving the problem of organizing the provision and selection of the necessary equipment for complex and powerful computing systems in the form of an automated system for the procurement and supply of the main computing and additional related equipment, organizing its installation, monitoring the conditions and characteristics of operation and subsequent output out of operation after the resource has been depleted or in order to increase the computational characteristics of mining farms and their cooling systems. Modern powerful computing systems are a huge amount of interconnected diverse equipment, located at different sites and interacting with each other by high-speed neural connections. The success of creating such complexes depends on the level of training of a team of specialists, which must have comprehensive and deep knowledge on the issues of building the engineering infrastructure of a computing complex, reasonable equipment with the necessary equipment, calculating the maximum energy load and providing such objects with a cooling system for computing elements and the system as a whole. Computing power is realized with the help of Data-centers, mining farms with more than 5000 computing modules. The problem of ensuring the quality of power supply of mining farms, a high level of efficiency in the use of power sources, protecting expensive equipment from overheating while ensuring high computing performance is very relevant, it requires constant attention and the use of special equipment and technologies. The developed system described in this paper relates to the management and optimization of resources of large computing centers, namely, to the organization of mass purchases of equipment, its installation and effective maintenance during operation, ensuring the efficient operation of cooling systems and the decommissioning of mining farms after completion. their work. This system allows users to create their own equipment catalogs in the form of models and then effectively organize the planning and management of devices in the form of an abstract model that consolidates all devices. Such a model is easy to control, find and perform actions on related objects, scale and make changes as needed. On the practical side, this developed product is simple in terms of the graphical interface and does not require much time for staff training and use in practice.*

**Keywords:** computer systems, mining processes, efficiency, cooling, automated equipment selection system

**Introduction.** Modern powerful computing systems (CS) are a huge number of diverse resources that are located on different sites and interact with each other. They are created by a team of specialists who have comprehensive and in-depth knowledge and experience in the construction of engineering infrastructure, as well as equipping facilities with information devices and technologies. Computing capacities of large computing centers are realized with the help of Data-centers, mining farms with the number of computing modules in the range of 300-5000 units. The mining farm is equipped with technical equipment that facilitates the extraction of cryptocurrency. It includes a large number of computers that perform a complex computational task - the development of cryptocurrency. The cost of mining is determined by the cost of equipment and electricity consumption for operations. A factor hindering the development of industrial mining is the significant specific energy consumption of computing modules with the simultaneous release of significant amounts of thermal energy. The problem of ensuring the quality of power supply of mining farms in terms of efficiency of electricity consumption, protection against overheating of expensive electronic equipment, as well as the need for energy savings in creating a set of farm connections for industrial mining is very important. To solve it, you need to use special equipment and special compact and energy-efficient heat dissipation technologies.

It is known that the quality and reliability of mining farm equipment, especially power sources, are affected by transients in the power supply network, which sometimes have short-term exceedances (usually within a few milliseconds) of currents and voltages that differ from nominal (passport) values and can be due to external and (or) internal reasons during the work of the CS. As a result of transients, voltage changes can reach from a few volts to tens of kilovolts, and current jumps - tens of kiloamperes [1].

Heating and energy consumption of mining farms largely depend on the presence of higher harmonic components in the curves of currents and voltages in the power supply networks.

Appropriate filters must be used to reduce them. In addition, there may be short-term power outages, defined as the complete absence of mains voltage or current due to loads lasting up to 1 ... 2s, which may be due primarily to the operation of the safety equipment of the mains. Such short breaks in work can lead to failures in the work of the CS and even to the failure of costly equipment.

The efficiency and operability of mining farms directly depend on the quality of electricity they receive. Another important aspect of the productivity of mining farms is the efficiency of heat dissipation from fuel elements into the environment. Currently, there are various ways to implement this process.

**1.The purpose and objectives of the study.** The analysis showed that in the construction of farms consisting of 100-300 computing modules (CM), preference is given to air cooling with the principle of cold and hot corridors.

If this amount of CM is exceeded, it is advisable to use liquid cooling of farms (liquid immersion cooling) with the predominant use of equipment with such capabilities.

Immersion cooling systems are considered to be the most efficient for megafarms [2]. There are two types of immersion systems (two-phase and single-phase): with modules immersed in a liquid with low temperatures and "boiling" systems using liquids with low (30… 50 K) boiling points. After heating, the liquid evaporates, taking with it excess heat, then due to heat dissipation condenses and flows back into the tank. Such cooling technologies are very efficient, can significantly reduce operating costs by 70… 95%. It is important that this technology allows you to create energy-intensive heat dissipation systems and create new directions and approaches to the configuration and capacity of cooling systems based on prefabricated immersion cooling systems.

The most efficient cooling system for computing components in CS is a closed system, in which both computing and cooling components are concentrated [3]. Such closed cooling systems [3] with immersion of computing components in a cooled low-boiling liquid (more than 100 computing boards with a size of 300x400 mm can be placed in one Data block (Fig.1,a) are easily assembled into powerful mobile Data Centers (Fig.1,b). Data Centers can be mounted in easily transportable containers, capable of providing high cooling efficiency with ambient air in the temperature range of +40°C ... -40°C with the achievement of PUE (Power Utilization Efficiency) [4] at the level of 1.015…1.02.


a) b)

*Figure 1 - General view of the computing Data-block (a) and the layout of 20 Data-blocks into a powerful computing Data-Centre (b)*

Based on modeling studies, it has been shown that CSs in the form of Data Centers can be flexible in installation and not tied to a specific socket, case or type of computing components, can be installed in hard-to-reach places and provide efficient heat removal from heated components [5-8].

At the moment, there is no flexible software that can fully satisfy the complex requirements of mining processes while ensuring the optimal selection of equipment according to computing characteristics and the required thermal power of its cooling system. Therefore, the development of such systems seems expedient for realizing the possibility of implementing innovative solutions within the framework of this subject area.

Therefore, the relevance of this work is that with the development of the cryptocurrency market, the need for automated hardware support for mining processes is growing. This is necessary in order to be able to easily run mining software on tens, hundreds and thousands of farms, which in turn reduces the time to set up infrastructure and speeds up the profits from the sale of developed cryptocurrencies.

The purpose of this work is the task of organizing and using resources, creating an automated system that will serve for the organization of mass procurement of equipment, installation, further maintenance and decommissioning of mining farms and cooling systems. This system can be used for public or private network, as well as for an exclusive blockchain or blockchain consortium.

Tasks to be solved:

- develop and propose new effective methods of orchestration of processes;
- design and implement a server application for planning and management of computing nodes of blockchain networks, which is able to work with a large amount of data and has the ability to further expand and implement;
- to design a client system for planning and use of blockchain networks by computer nodes;
- develop architecture, encode business logic, design and encode the interface with the server part of the CS.

**Strategy, algorithm and research results.** The system is proposed to be implemented according to the "Client-server" architecture using Java, server-side ecosystem, and JavaScript language using the React.js library on the client side. The system being designed requires ACID principles. This requirement can be met by using the PostgreSQL relational database, Java programming language, Spring Framework for creating web applications and working with the database. The choice of these technologies is justified by the need to ensure the speed of development of the system and the architecture of its applications, the constant development of the above technologies.

The system provides for the organization of processes of accounting for computing resources, resource configuration management, maintenance management and procurement of equipment. To select the necessary hardware, a detailed catalog is available, which allows for effective rapid urgent planning. This concept of the catalog, or in other words, the dictionary of devices, allows a group of users who are knowledgeable in their field, to effectively manage the accounting of devices in the system: mining farms, cooling systems for mining farms, exhaust systems, air conditioners, fans [9]. The processes are described in the form of orders. Operations that can be performed on orders include creating, editing, changing the status of a user with certain rights and access. Each status is compared to a certain phase of the life cycle. Lifecycle techniques allow you to run specific code with actions at different stages of the component lifecycle. For example: componentDidMount is executed after the initial check of components. This method is often used to retrieve data from a remote source via the API. The componentDidMount lifecycle method is shown in Fig.2.

The user can perform certain actions according to the order status and his rights in the system to change the order status. An order is an aggregate structure that is created from a catalog of devices and with the ability to perform further actions on it.

The system was developed using the Client-Server architectural approach based on the Java implementation for the server part and the corresponding ecosystem on the server side, Typescript (JavaScript) using the React.js library and functional approaches on the client side. The choice of technologies is justified according to the possibilities of modular development, the availability of all necessary libraries and modules. The constant development of the above technologies allows you to quickly find all the necessary solutions.

It should be noted that existing systems that can solve the problem of optimized use of resources for blockchain networks exist in the form of proprietary systems (such systems are usually created for specific subject areas and sold at a high price). ERP is an information system that allows you to store and process most of the critical data for the company's work, to record and maintain all necessary resources. As a close alternative to ERP systems, it is possible to cite BPM solutions that allow you to model processes instead of connecting them to real entities. Examples of BPM solutions are: ELMA BPM Suite and Bizagi BPM Suite, which are currently popular and in demand.

```
const refetchOrders = () => {
  setError(null);

  return fetchOnPremiseDevices({
    deviceType: DeviceRequestMap[activeDevice],
    devicePurpose: activePurpose,
    sortBy: 'amount',
  })
    .then(setDevices)
    .catch(setError);
};

useEffect(() => {
  refetchOrders();
}, [activePurpose, activeDevice]);
```

*Figure 2 - Example of life cycle use*

In addition, these solutions are largely functionally similar. This situation requires independent research, modeling of processes and further implementation in an automated system. ERP systems can be characterized by certain common features. Only a technician or developer can make changes to the platform code, and this system is closed to users and they do not have access to the code. The data that users are working on is stored in a database or other remote storage. Components are connected to the platform as needed. They all work with a single database and use basic functionality (if necessary). In another module, the components work independently of each other and can be connected and turned off without problems if the need for them has disappeared.

The disadvantages of ERP systems are, first of all, the difficulty of building the right architecture to ensure the lack of connectivity of modules. In practice, this leads to a large number of abstractions, which greatly increases the time to add new functionality and refactoring existing ones. More qualified specialists are needed to maintain such a code base.

The advantage of ERP-systems is the ability to scale, connect additional modules if necessary, to implement the approach of creating a system in the form of "designer".

**3.Description of the automated system database.** For the data warehouse, it is proposed to use a relational database PostgreSQL, which contains 17 normalized tables. Tables store information about users and their roles; equipment in the form of dictionaries and entities that link equipment data to each other. The physical model of the database is presented in a condensed form in Fig.3.

**4.Description of system architecture.** The server system is presented in the form of a monolithic server with a three-layer architecture. Each layer is divided into Java packages, which include the classes responsible for accessing packages at the client level, business logic, and database, respectively. The project was divided into packages so as to ensure maximum structuring of classes. In the project, a package called "controller" includes classes that process incoming HTTP requests and pass them for further management to classes that are contained in a package called "service" and in which business logic is already directly implemented.

Repository classes that work with a Java-level database are injected into service classes. In addition, the existing configuration package includes classes that are adapters, factories, and configuration classes and essentially run at server startup. They "conPicture" dependency inversion container objects, "conPicture Swagger", and class that handles exceptions and generates a processed response to an HTTP request.

The security package includes classes responsible for setting up authentication and authorization, processing JWT tokens, configuring servlets and filters when executing HTTP requests.

The "consts" package aggregates all the constants used in the service.

The utils package also includes utility helper classes for pagination and processing of JWT tokens, object converters, and a test data loader on a test environment.

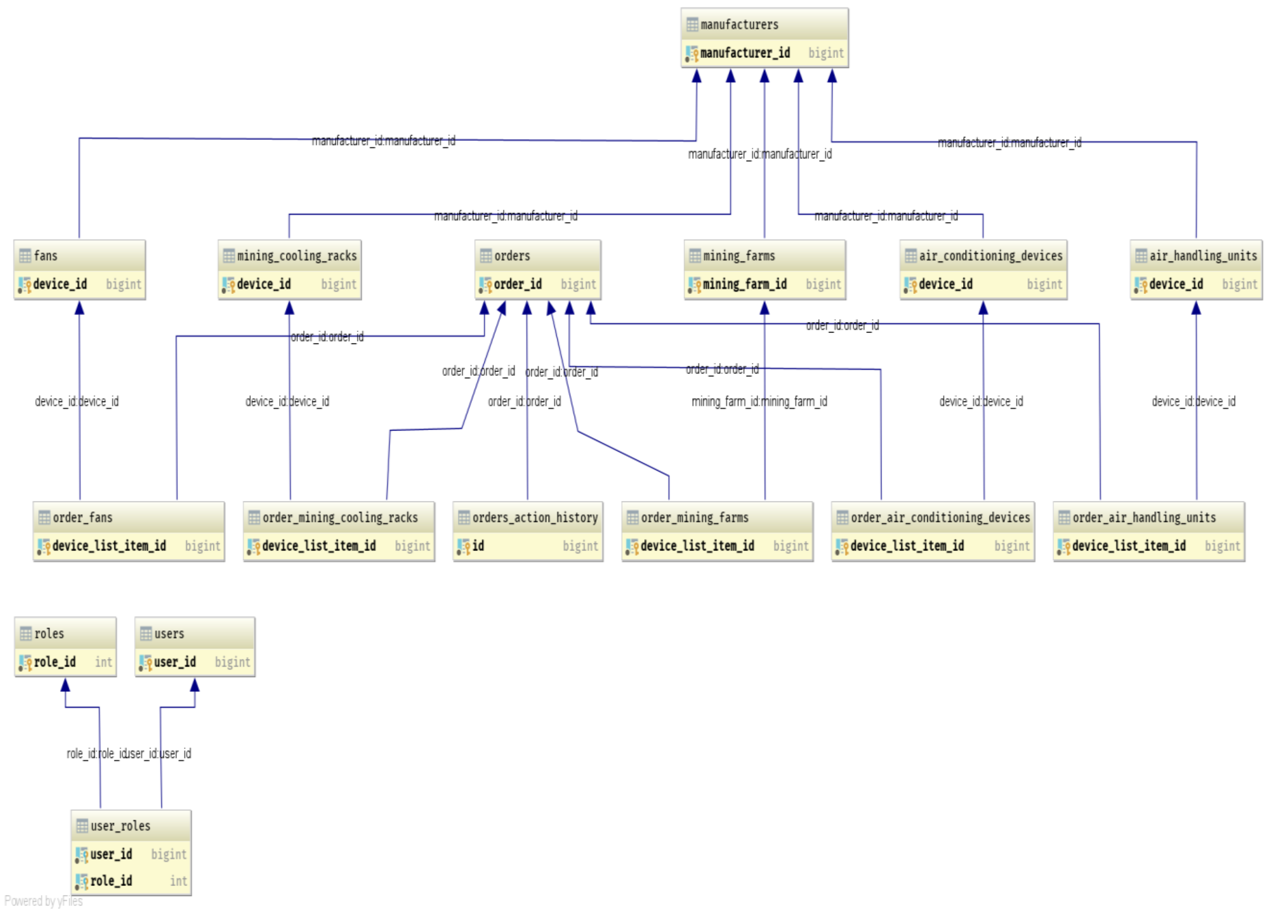



*Figure 3 - Condensed physical database model*

The model package includes classes that display database tables and allow you to operate on Hibernate information at the object level, not tables.

Model classes describe classes that display: dictionary tables, user-related tables, and order-related tables.

The "dto" package contains HTTP request and response templates.

The "target" folder contains an executable .jar archive that allows you to run the server locally. In addition, there is also a file to start the server as a Docker container and a Docker Compose file in conjunction with the PostgreSQL container.

The structure of the project (service) is shown in Fig.4.

Authentication and authorization in the system is implemented using JWT-tokens based on tables users, roles, user_roles.

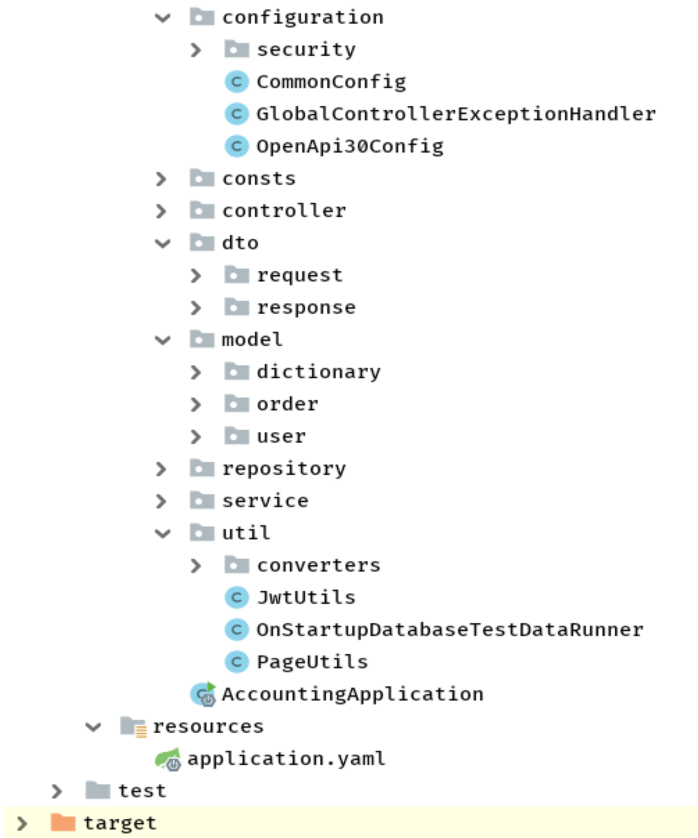



*Figure 4 - Service structure*

The "SecurityConfiguration" class is "conPictured" to work with JWT tokens, the "AuthTokenFilter" class accepts HTTP requests and as a filter performs token processing, recognizes the user and gives him access rights to the API server.

Swagger was used for API documentation. It allows you to test the API, find examples of queries and answers. Examples of the Swagger API are shown in Fig.5. and Fig.6.

The client system is presented in the form of an application that uses a component approach, the so-called atomic design (English atomic design) [10]. The level of services which includes abstraction for work with API-authorization is taken out separately. The component approach is to reuse components in terms of their complexity, as shown in Fig.7.

In general, atomic design contains 5 levels:

- "atom": this is the smallest component that can be reused in the application. An example of an atom is a button that contains a certain stylization, text, a description of how to act on certain events, such as clicking. It is appropriate to bring to the atom those buttons that contain the same stylization and behavior;

- "molecule": a combination of atoms, or atoms with some more complex or complex logic. An example of a molecule is input (search box) with a button to "clear" the field;

- "organism": it is a composition of atoms, molecules with a certain complex logic. The drop-down menu, which contains a search box molecule, a checkbox atom, and its own logic with the ability to select all flags or clear all flags, is an example of an organism;

- "template": this is a certain stylization of some components, which describes their relative position. It is appropriate to separate the header deviations from the page fill in the template. Only the page can use templates. Templates do not contain any logic, except for the position of the components;

- "page": this is a container that contains all other levels. Almost always the page contains all the necessary logic to obtain data and the functions that lead this data to those interfaces that use other level.


*Figure 5 - Example of a query in the Swagger API*

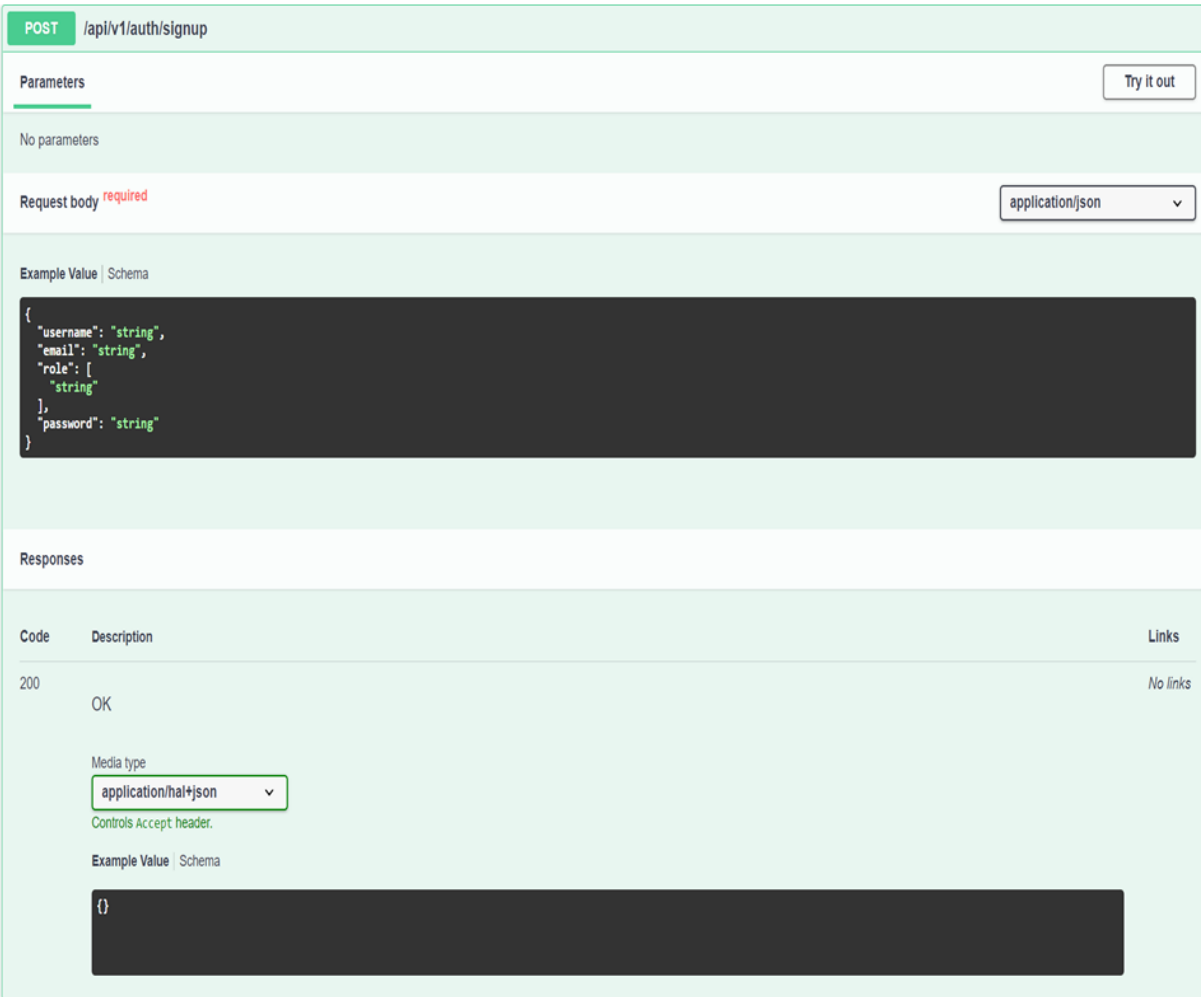



*Figure 6 - Example of query testing via the Swagger API*

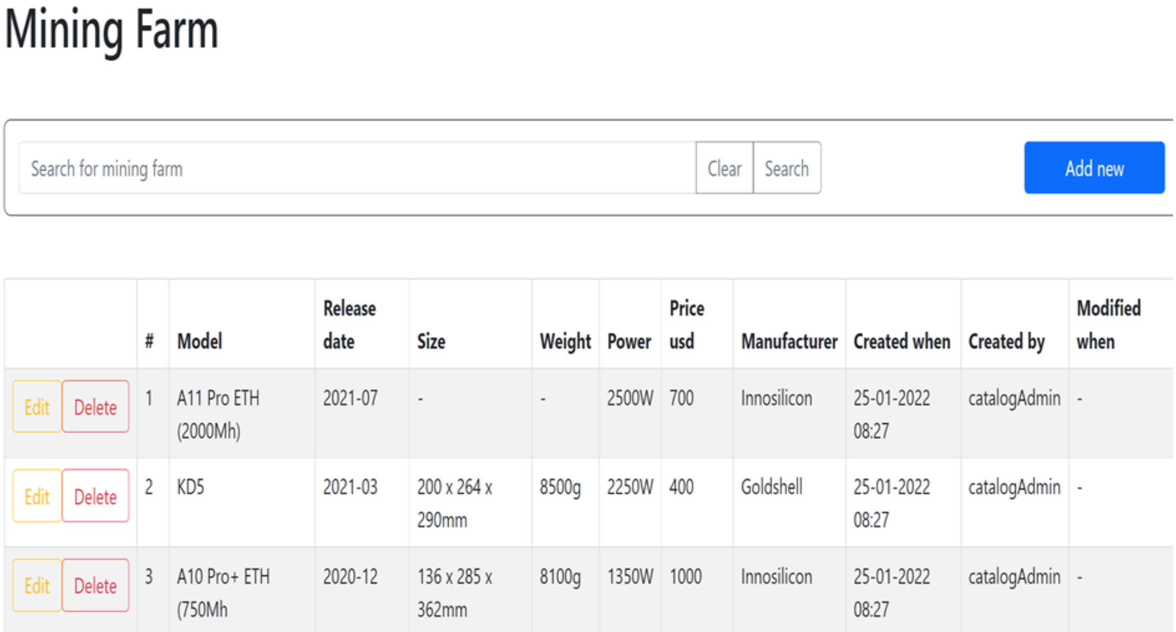

*Figure 7 - Example of the concept of atomic design*

The application is built using an architectural approach to atomic design, it allows you to easily modify any level of abstraction of components and reuse them to create new pages, or expand existing ones.

**5.System catalog description**

Hardware catalog is a list of specific equipment used in cryptocurrency mining. The user is able to add new equipment to the catalog or update information as needed. All equipment available in the catalog can be used for further accounting or planning. Each order is closely related to the catalog. Because the directory is a so-called "dictionary", orders are able to retrieve information from the catalog and already create specific objects based on catalog data. The catalog includes the operation of such devices as: fans, air conditioners, hoods, mining farms, cooling systems for mining farms, etc. Any equipment can be added to the order. The order has its own life cycle and can go to different depending on what actions the user performs.

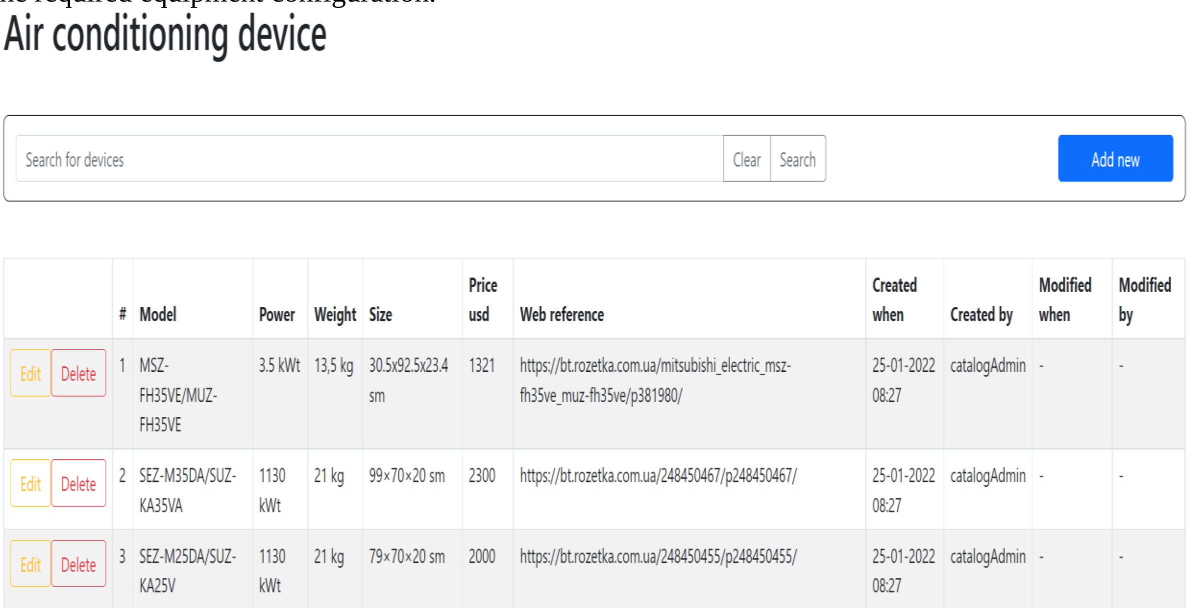
***Methods of user work*** with the software system demonstrates examples of program work simultaneously at the level of the graphical user interface and the server system. The example in Fig.8. shows a table of mining farms where the user can create new objects, search for them, delete and edit objects.




| | # | Model | Release date | Size | Weight | Power | Price usd | Manufacturer | Created when | Created by | Modified when |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Edit Delete | 1 | A11 Pro ETH (2000Mh) | 2021-07 | - | - | 2500W | 700 | Innosilicon | 25-01-2022 08:27 | catalogAdmin | - |
| Edit Delete | 2 | KD5 | 2021-03 | 200 x 264 x 290mm | 8500g | 2250W | 400 | Goldshell | 25-01-2022 08:27 | catalogAdmin | - |
| Edit Delete | 3 | A10 Pro+ ETH (750Mh | 2020-12 | 136 x 285 x 362mm | 8100g | 1350W | 1000 | Innosilicon | 25-01-2022 08:27 | catalogAdmin | - |

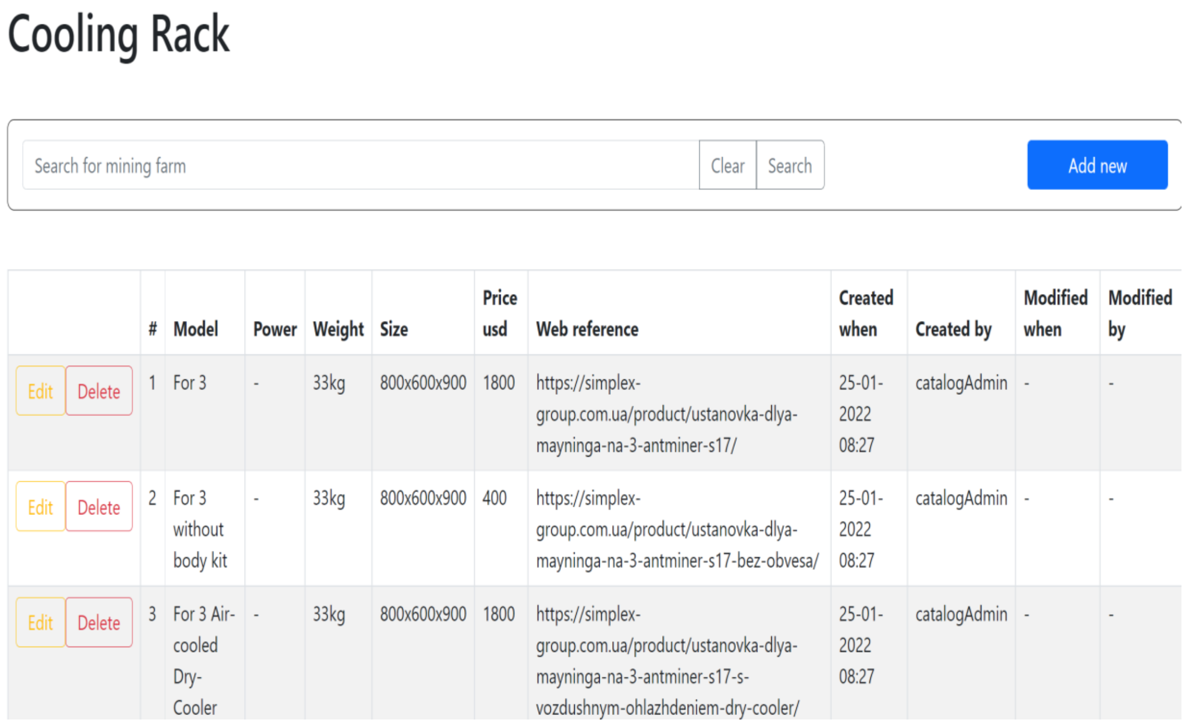
*Figure 8 - Mining farms page*

Fig.9 and Fig.10 show tables of air conditioners and cooling systems where the user can search for the required equipment configuration.




| | # | Model | Power | Weight | Size | Price usd | Web reference | Created when | Created by | Modified when | Modified by |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Edit Delete | 1 | MSZ-FH35VE/MUZ-FH35VE | 3.5 kWt | 13,5 kg | 30.5x92.5x23.4 sm | 1321 | https://bt.rozetka.com.ua/mitsubishi_electric_msz-fh35ve_muz-fh35ve/p381980/ | 25-01-2022 08:27 | catalogAdmin | - | - |
| Edit Delete | 2 | SEZ-M35DA/SUZ-KA35VA | 1130 kWt | 21 kg | 99×70×20 sm | 2300 | https://bt.rozetka.com.ua/248450467/p248450467/ | 25-01-2022 08:27 | catalogAdmin | - | - |
| Edit Delete | 3 | SEZ-M25DA/SUZ-KA25V | 1130 kWt | 21 kg | 79×70×20 sm | 2000 | https://bt.rozetka.com.ua/248450455/p248450455/ | 25-01-2022 08:27 | catalogAdmin | - | - |

*Figure 9 - Air conditioners page*



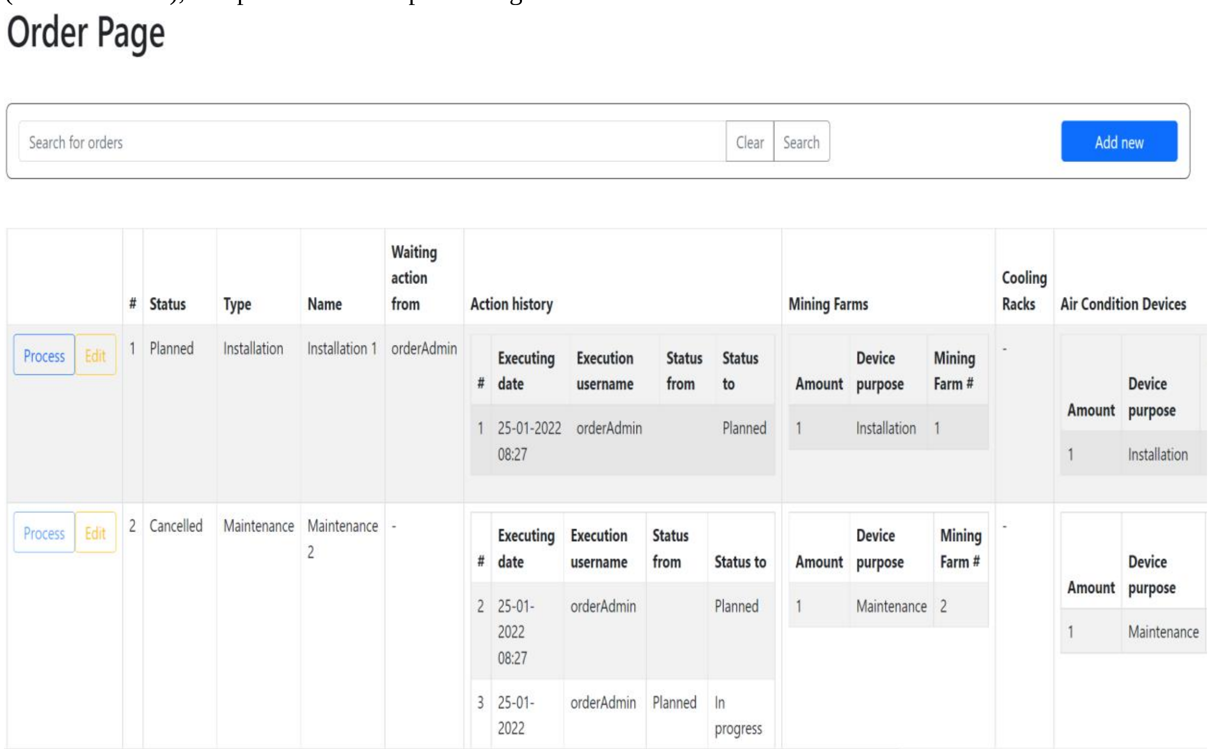
Cooling Rack

Search for mining farm | Clear | Search | Add new

| | # | Model | Power | Weight | Size | Price usd | Web reference | Created when | Created by | Modified when | Modified by |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Edit Delete | 1 | For 3 | - | 33kg | 800x600x900 | 1800 | https://simplex-group.com.ua/product/ustanovka-dlya-mayninga-na-3-antminer-s17/ | 25-01-2022 08:27 | catalogAdmin | - | - |
| Edit Delete | 2 | For 3 without body kit | - | 33kg | 800x600x900 | 400 | https://simplex-group.com.ua/product/ustanovka-dlya-mayninga-na-3-antminer-s17-bez-obvesa/ | 25-01-2022 08:27 | catalogAdmin | - | - |
| Edit Delete | 3 | For 3 Air-cooled Dry-Cooler | - | 33kg | 800x600x900 | 1800 | https://simplex-group.com.ua/product/ustanovka-dlya-mayninga-na-3-antminer-s17-s-vozdushnym-ohlazhdeniem-dry-cooler/ | 25-01-2022 08:27 | catalogAdmin | - | - |

*Figure 10 - Cooling systems page*

Fig.11 shows the order page, where the user can search for specific equipment, create a new order, edit (where allowed), and perform further processing.



Order Page

Search for orders | Clear | Search | Add new

<table>
<tr><th></th><th>#</th><th>Status</th><th>Type</th><th>Name</th><th>Waiting action from</th><th>Action history</th><th>Mining Farms</th><th>Cooling Racks</th><th>Air Condition Devices</th></tr>
<tr><td>Process Edit</td><td>1</td><td>Planned</td><td>Installation</td><td>Installation 1</td><td>orderAdmin</td><td><table><tr><th>#</th><th>Executing date</th><th>Execution username</th><th>Status from</th><th>Status to</th></tr><tr><td>1</td><td>25-01-2022 08:27</td><td>orderAdmin</td><td></td><td>Planned</td></tr></table></td><td><table><tr><th>Amount</th><th>Device purpose</th><th>Mining Farm #</th></tr><tr><td>1</td><td>Installation</td><td>1</td></tr></table></td><td>-</td><td><table><tr><th>Amount</th><th>Device purpose</th></tr><tr><td>1</td><td>Installation</td></tr></table></td></tr>
<tr><td>Process Edit</td><td>2</td><td>Cancelled</td><td>Maintenance</td><td>Maintenance 2</td><td>-</td><td><table><tr><th>#</th><th>Executing date</th><th>Execution username</th><th>Status from</th><th>Status to</th></tr><tr><td>2</td><td>25-01-2022 08:27</td><td>orderAdmin</td><td></td><td>Planned</td></tr><tr><td>3</td><td>25-01-2022</td><td>orderAdmin</td><td>Planned</td><td>In progress</td></tr></table></td><td><table><tr><th>Amount</th><th>Device purpose</th><th>Mining Farm #</th></tr><tr><td>1</td><td>Maintenance</td><td>2</td></tr></table></td><td>-</td><td><table><tr><th>Amount</th><th>Device purpose</th></tr><tr><td>1</td><td>Maintenance</td></tr></table></td></tr>
</table>

*Figure 11 - Order page*

**Conclusions**

During the implementation of this work, a thorough analysis of the subject area was conducted. Industrial mining farms consume a lot of electricity. Today, on average, the cost of mining electricity is about 30% of the available currency. The productivity of mining farms depends on the efficiency of heat dissipation from fuel elements.

It should be noted that existing systems that are able to solve the problem of optimized use of resources for blockchain networks and could fully meet the requirements of mining processes, are proprietary systems that may not be specific to the specific subject area and have a high cost. Therefore, the requirements were analyzed, technologies were selected, the system architecture was developed, precedents and internal processes of the software product were modeled, and the program code was written.

The developed system belongs to the sphere of management and optimization of resources of large computer centers, namely - to the organization of mass purchases of equipment, its installation and maintenance during operation, decommissioning of mining farms and cooling systems.

This system allows users to create their own catalogs of equipment in the form of models and then effectively organize the planning and management of devices in the form of orders for an abstract model that consolidates devices. This model makes it easy to control, locate, and perform actions on related objects.

From a practical point of view, this product is simple in terms of graphical interface and does not require much time to train staff to use it.

It should also be noted that the models in the system scale quickly and it is quite easy to make changes to them as needed (for example, as needed by users).

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**Г.Б. Варламов,** докт. техн. наук, професор, ORCID 0000-0002-4818-2603
**І.В. Сегеда,** канд. екон. наук, доцент,ORCID 0000-0003-1958-4985
**Є.О. Локоторьов,** магістр комп. наук, ORCID 0000-0003-0554-1968
**Цзян Цзяньго,** аспірант, ORCID 0000-0003-2559-4071
**І. Мітченко,** аспірант, ORCID 0000-0002-6361-9471
**Національний технічний університет України «КПІ ім. Ігоря Сікорського»**

## АВТОМАТИЗОВАНА СИСТЕМА АПАРАТНОГО ЗАБЕЗПЕЧЕННЯ ЗБОРУ ОБЛАДНАННЯ ДЛЯ ПОТУЖНИХ ОБЧИСЛЮВАЛЬНИХ КОМПЛЕКСІВ

*Проаналізовано предметну область з урахуванням проблеми забезпечення надійності енергоживлення майнінгових ферм криптовалют та ефективності використання систем охолодження важливих джерел*

*виділення теплоти з урахуванням необхідності захисту їх від перегріву під час роботи. Досліджено важливий аспект продуктивності майнінг-ферм, який залежить від ефективності відведення теплоти від тепловиділяючих елементів обчислювальних комплексів в процесі високошвідкісних обчислень. Актуальність роботи полягає у необхідності створення надійних обчислювальних системних комплексів з автоматизованим підтриманням теплового режиму потужного майнінгу комп'ютерних систем, нарощування потужності яких пов'язане зі зростанням попиту на ринку криптовалют. Успішне впровадження таких умов роботи забезпечить надійний запуск програмного забезпечення для майнінгу на десятках, сотнях і тисячах ферм, що в свою чергу зменшить час на налагодження інфраструктури та прискорить отримання прибутку від продажу криптовалюти. Запропоновано та описано функціонування автоматизованої системи контролю та оптимізації підбору апаратного забезпечення для великих обчислювальних центрів. Впровадження цієї системи в компанії, що виробляють криптовалюту, дозволить успішно вирішити проблему вибору необхідного обчислювального обладнання для майнінг-ферм та їх систем охолодження, його швидкого компонування та встановлення на об'єкті, простоти обслуговування як під час монтажу та введення в експлуатацію, так і під час обслуговування із досягнення мінімальних значень P.U.E.*
***Ключові слова:*** *комп'ютерні системи, майнінг-процеси, ефективність, охолодження, автоматизована система підбору обладнання*

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