Design and Implementation of a New Intelligent Warehouse Management System Based on MySQL Database Technology

Ying Zhang *[1], Feng Pan [2]
YingZhang78@126.com, FengPan278@163.com
*Corresponding Author

[1]Changchun Polytechnic, Career Foundation Department, Jilin-Changchun, 130000, China
[2]Continental Automotive Corporation Changchun Co., LTD. Moonlake Branch, IT Department, Jilin-Changchun,130000, China

Keywords: MySQL; Database technology; Intelligent Warehouse Management; Internet of Things; Eclipse; Material Management; Real Server

Received: February 3, 2022

The handling industry of materials/goods is fundamental for companies for ensuring the warehouses smooth running. Efficiency within every aspect of the business is essential to gain a competitive advantage. In order to improve the material management level of enterprises based on MySQL database technology; this paper makes an overall design of the warehouse management system, builds a MySQL database, and realizes the design and application of a new intelligent warehouse management system. Through the operation and test of the system, the results show that the system mainly realizes the five necessary functional modules of warehouse management: basic information management, system management, procurement management, warehousing management and inventory management. In the test, the system runs normally, the unit test and integration test can meet the expected requirements, realize the functions required by the user, and get the desired results within the user's acceptable response time (within 3S). Whether the system is running on the local machine or on the real server in the network, it must use the appropriate hardware and software conditions. It can provide automatic and comprehensive records for the whole process of material management of the enterprise, and provide real-time and correct information for all warehouse activities, resources and inventory levels

Povzetek: Za MySQL je bil razvit nov inteligentni upravljalski sistem.

1 Introduction

Unnecessary labor costs and the incorrect use of storage systems and racking arrangements result are caused by the disorganized warehouse spaces in many companies and find their warehouse shelves full, with no space to receive new inventory. When inventory location is not organized and easily available, pickers will take longer to find items that need to be shipped. With the progress of the times and the continuous updating of technology, society has entered the era of big data with rapid development and informatization. High-end technologies and concepts such as big data, Internet of things and cloud storage have been applied to real life and work. Warehouse management system combines management science, computer science and other sciences [1]. With the progress of the times and the continuous renewal of technology, warehouse management system plays a very important role in the development of enterprises. It can help enterprise managers make correct decisions and predict the development direction of enterprises. The content of warehouse management is very rich. For example, it includes the layout and design of warehouse system, high-quality inventory management and efficient warehouse operation. The above-mentioned contents complement each other. The production capacity and level of most Chinese enterprises lag behind the same type of foreign enterprises. In addition to the advanced technology and excellent talents of foreign enterprises, the information integration degree of domestic enterprises is not high and the operation efficiency is generally low, resulting in low profitability and even lower ability to resist market risks than foreign enterprises. In particular, China's warehousing management level is inefficient, the utilization rate of warehousing resources is not high, the operation conditions are poor, and it lacks its own development ability [2]. Like other management, enterprises need to develop towards specialization, specialization, functionalization and personalization. Most foreign enterprises have a good level of warehouse information management, including account processing and settlement processing, and providing real-time query; Location management, making documents and reports, stock control, etc. The efficient warehouse management of foreign enterprises is based on the effective control and organization of materials. Foreign enterprises have focused on the establishment of effective information networks for warehouses, manufacturers, material managers, material demanders, material descriptions and other contents, so as to realize the sharing of warehouse

information, and realize the networked and intelligent management of warehouse information through information network control [3].

This paper mainly introduces the technical research of warehouse management system. Firstly, the business process of warehouse management is studied and designed for analysis and refinement, which involves administrator login, purchase warehousing, standby transfer and scrap warehousing, outbound and inbound statistics. The specific implementation process of the functional modules such as purchase warehousing, material warehousing, material processing and query in the system is carried out. Finally, the SQL database background and the system use eclipse are realized. The test and analysis of the warehouse management system is mainly the specific analysis and description of the function test of each system module. At the same time, according to the test results, this paper deeply analyzes and studies the functional performance of the warehouse management system, and makes improvement suggestions.

(1) Plan the functional modules of the warehouse material management system

First of all, understand the relevant work tasks of each department involved in material management in the enterprise, and plan several modules required by the system, such as purchase warehousing, material warehousing, material processing, query statistics, basic material information, system management, etc. (as shown in Figure 1).

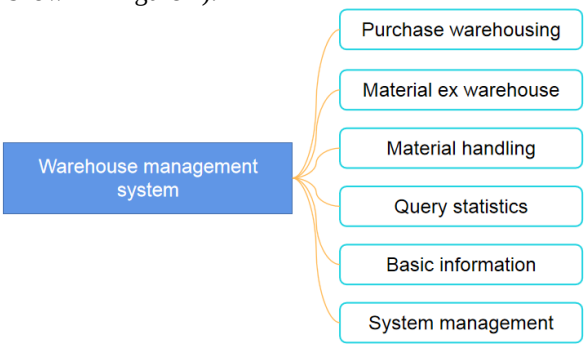

Figure 1: Schematic diagram of each module of warehouse management system

(2) Sort out the specific business and overall workflow of each module of the warehouse material management system

Based on the warehouse material management system, each module of the system has its own different business, and the business of each module also has contact and certain order. Determine the specific business of each module and the relationship between each module. Based on B / S architecture, with my SQL as the background database platform and my eclipse as the development tool, the functional design and implementation of warehouse management system are completed based on struts 2, hibernate and spring framework. At the same time, boost is used to beautify the front-end page.

Contribution: This paper makes an overall design of the warehouse management system, builds a MySQL database, and realizes the design and application of a new intelligent warehouse management system in order to improve the material management level of enterprises, based on MySQL database technology.

The organization of the paper is as follows. Section 2 provides an overview of the exhaustive literature survey followed by a methodology adopted in section 3. A detailed discussion of obtained results is in section 4. Finally, Section 5 concludes the paper.

2 Literature review

With regard to the development and application of the Internet of things, J Liang studied the construction and key points of the storage system architecture based on the Internet of things environment, and conducted simulation research [4]. Zhao, J. studied the development and application of intelligent storage information system based on Internet of things technology, expounded the technical difficulties and doubts of system development, Zhong Yuangen studied the construction and smart design of mobile electronic vending public service platform based on Internet of things technology, and simulated the construction of simulated public service platform [5]. Zhao, K. studied the construction process of digital warehouse software architecture based on Internet of things technology, highlighting the characteristics of digitization [6]. Viloria, A. studied the development process of dangerous goods intelligent logistics system based on Internet of things, so that the transportation of dangerous goods can be monitored and handled in real time [7]. Zhang, Y. studied the design process of automatic cold storage management system based on Internet of things technology [8].

With regard to the development and application of intelligent warehousing, kermani, M. studied the application of intelligent warehousing based on WLAN and RFID, and proposed a combined system using wireless RF technology and wireless LAN technology [9]. Yu, S. studied the design of intelligent storage node based on ZigBee wireless sensor network, which solved the shortcomings of strong manual dependence and low automation level of traditional warehouse management [10]. Somasundaram, M. studied RHD middleware for the h-party intelligent warehousing, expounded RFID middleware and related specifications, described the application status and problems of RFID Middleware for the h-party warehousing, and explored solutions [11]. Nastasi, G. designed the intelligent warehouse management system, expounded the key technologies of swms system, and formulated the design scheme [12]. Kumar, R. S. studied the application of intelligent warehousing in modern logistics, expounded the current

situation of warehousing management, and put forward suggestions and methods for constructing intelligent warehousing system [13]. SHARIFI, H. studied the debugging problem of intelligent storage system, fully expounded the existing reasons and gave the corresponding solutions [14].

In the development of the Internet of things in intelligent storage, Xu, Z. studied the design of RFID based storage management information system, expounded the relevant theories of storage management information system, analyzed the requirements of RFID storage management information system, carried out the overall design and detailed design of RFID storage management information system, and finally carried out the simulation implementation [15]. Mo, Z. studied the upgrading of RFID Middleware in warehouse management Internet of things system, and discussed the concept, characteristics, infrastructure and application functions of RFID Middleware in Internet of things system [16]. Ad, A. studied the warehouse management system based on RFID technology, explored and improved the RFID anti-collision algorithm, and carried out RFID optimized inventory management. On this basis, he developed and implemented the warehouse management information system [17]. Many researchers have worked in this field in the previous years, some of the relevant articles are tabulated in Table 1.

Authors	Presented Work	Key points	Benefits	References
Someah Alangari et al., 2021	This paper present and analyze system that will be intelligent enough to help the organization users to manage their inventory that will be helpful enough for providing information as well as providing various amazing heuristic methods that will be helpful enough for the system content management.	The system prediction power is useful for many inventories and the power provides the notifications in advance to manage the system's components.	Users are able to access or request a particular object from the inventory Manager handles all the entries inside the system.	[18]
R A Darajatun et al., 2017	Paper presents the design and development of Kanban of inventory storage and delivery system.	The author uses Java programming language for the application development used for building Java Web applications, while the database used is MySQL.	Goods are monitored and warehouse is divided into many locations.	[19]
Walaa hamdy et al.,	This paper proposed a framework for implementing the technology in a warehouse.	The presented work help in achieving more monitoring on the operations in the warehouse in real time.	Increased speed and efficiency. It prevents counterfeiting and inventory shortage.	[20]

Reza Pulungan et al., 2013	The state-of-the-art results are integrated in the field of intelligent systems—neural network, bee colony optimization, fuzzy control, and decision support system—together with the latest echnologies—RFID and Android-based handheld devices—in every part of business processes in WMS.	Discussions on the practical implementation of AI in the main WMS processes are provided.	Highly effective.	[21]
Jia Mao et al., 2018	Effective scheduling method is presented and initially realizes the intelligent warehouse management system based on cloud model.	To integrate the resources effectively, a variety of automation, intelligence and information technology are utilized and discussed	Better scheduling solution and the certain robustness	[22]

Table 1: Some relevant state of the art work in previous years

3 Research methods

3.1 Overall design of warehouse management system

The structure of the system adopts B / S architecture. All business processing logic is executed on the server. The client has only a browser (fire fox / Chrome / 360 / Sogou, etc.), and all interface presentation / operations send data to the server through the browser, which is processed by the corresponding module of the server, as shown in Figure 2.

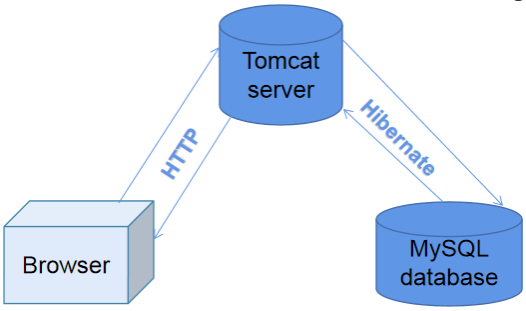

Figure 2: System B / S architecture

The system adopts a three-tier model to realize the client / server mode. The three-tier structure model of the system takes accessing the web database as the center, HTTP as the transmission protocol, and the client accesses the web server and its connected background database through the browser. The composition of its three-tier structure is shown in Figure 3.

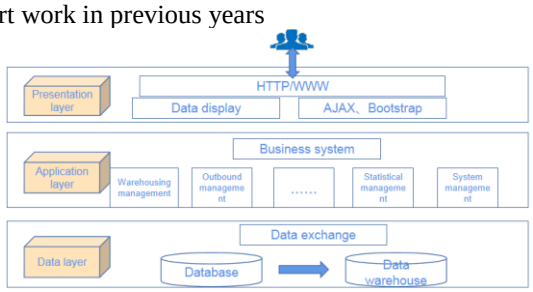

Figure 3: Three layers structure model

The first layer is the user interface layer, which is mainly responsible for user interaction processing and the interaction between the client and the background. When the user clicks a button in the page to trigger an event, the client sends a request to the background. This process may be synchronous or asynchronous through Ajax. The second layer is the business logic processing layer. When the client sends a request through a pre-defined interface, it parses the request according to the rules of the interface agreement, then processes the corresponding request, and finally returns to the client. The third layer is the data support layer, where the information records sent by the client are saved in the database through MySQL database, such as warehousing records, outbound records, etc.

3.2 MySQL database construction

My SQL is a small relational database management system. At present, my SQL is widely used in small and medium-sized websites on the Internet. Due to its small size, fast speed and low total cost of ownership, especially open source, many small and medium-sized

websites choose my SQL as the website database in order to reduce the total cost of ownership [23]. My SQL has the following features:

1. It is written in C and C + +, and tested with a variety of compilers to ensure the portability of the source code.

2. Support AIX, free BSD, HP-UX, Linux, Mac OS, Novell Netware, open BSD, OS / 2 wrap, Solaris, windows and other operating systems.

3. Provides API for multiple programming languages. These programming languages include C, C + +, python, Java, Perl, PHP, Eiffel, ruby and TCL.

4. Support multithreading and make full use of CPU resources.

5. The optimized SQL query algorithm can effectively improve the query speed.

6. It provides TCP / IP, ODBC, JDBC and other database connection channels.

7. Provides management tools for managing, checking, and optimizing database operations.

8. It can handle large databases with tens of millions of records.

First, download the appropriate version of the installation package on the official website of my SQL (we choose mysql-5.6.23-winx64). After installation, in order to use it directly under the console, you need to add the bin directory to the environment variable path. Finally, you need to add the file my.ini under the installation path and set the values of basedir and dataDir as the values corresponding to your installation directory.

This system belongs to Java website development and needs to run on a server that can run Java programs. Tomcat server is selected for the operation of this system. First, go to the official Tomcat website to download the installation package of the corresponding version. After downloading, unzip it to a path and then it can be used normally. The Tomcat version we selected is apache-tomcat-7.0.70. Go to bin / and click Startup bat to start the server directly. Click shutdown.bat to shut down the running server. The system needs to be debugged frequently during eclipse development. In order to facilitate future development and debugging, you need to configure eclipse to directly start the installed Tomcat server.

In Eclipse, click window - > preference - > server - > runtime environment, and then click Add to add. After adding, click Edit to modify the Tomcat path and the Tomcat server path.

3.3 Implementation of warehouse management system

The main purpose of the basic information management sub module is to realize the relatively static basic information management and maintenance of the logistics management system. The basic information mainly includes the information of logistics company staff, cooperative units, commodities and warehouses. The mechanism of staff information management is shown in Figure 4.

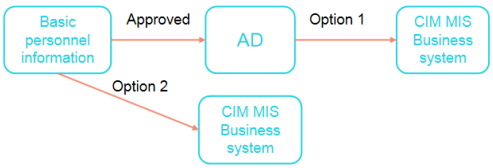

Figure 4: Mechanism of staff information management

As a warehouse management system, it is necessary to manage the necessary basic information to ensure that the subsequent operations can be met. The system can add, modify and delete materials, departments, construction groups and reservoir areas. For materials, you need to automatically generate IDs to meet your needs. Purchase order No., receipt Order No. and issue order No. in subsequent systems need to be generated automatically. The system generates ID through the database storage process. Taking the material table as an example, the database code of the storage process generate_WZID for generating material number is as follows:

```
BEGIN
 #Use WZ + year + 4-digit serial number as material number
 DECLARE current Date var CHAR (4); #current date
 #The last 5 digits of the serial number of the nearest qualified material number
 DECLARE max No INT DEFAULT 0;
 DECLARE newid VARCHAR (25);  #New item number
 SELECT DATE_FORMAT(NOW(),'%Y') INTO current Date; #4-digit year
 #Get the maximum ID number from the material list
 SELECT IFNULL(id,'') INTO old Order No FROM material
 WHERE SUBSTRING(id , 3 , 4) = current Date AND SUBSTRING(id,1,2) =
'WZ' AND LENGTH(id) = 10 ORDER BY id DESC LIMIT 1;
 IF old Order No != '' THEN
 SET max No = CONVERT(SUBSTRING(old Order No,-4),DECIMAL);
 END IF;
 #Splice the new ID number into the newid
 SELECT CONCAT('WZ',current Date,LPAD((max No+1),4,'0')) INTO newid;
 SELECT newid;
END
```

In Hibernate, the latest ID number can be generated by calling the stored procedure with the following code:

```
SQLQuery query = get Session().create SQLQuery("{call generate_WZID()}");
String id = (String) query.unique Result();
```

4 Results and discussion

4.1 System operation

Whether the system is running on the local machine or on the real server in the network, it must use the appropriate hardware and software conditions. Only the appropriate operating environment can ensure the normal operation of the system. Otherwise, problems such as bugs or poor system operation will occur due to configuration problems during testing or actual operation [24-26]. Table 2 shows the hardware and software configurations currently used by the system.

Server side		
Hardware configuration	**CPU**	**Intel i5 4750**
Software configuration	Memory	4G
	Hard disk capacity	500G mechanical hard disk
	Network card	Gigabit Ethernet
	Web server	Tomcat v9.0
	Database	My SQLv5.6.30
	JDK version	Java v8.0.7
	Client	
Hardware configuration	Traditional PC, smooth Internet access	
Software configuration	Mainstream browsers, such as chrome, Firefox, Sogou browser, etc	

Table 2: System operation hardware configuration

After the development of the system, in order to be truly put into the production environment for users to use, the system must be published to a real server in the network. Users can directly enter the address of the server in the browser to log in to the system. To deploy the project to a real server, you need to package the project into a war package and put it into the server. Right click the project name, click export - > war file, select parameters and click Finish to generate war package in corresponding directory.

The project can be run through the above two methods. Enter "http: / / server address / warehouse /" in the browser to enter the login interface, as shown in Figure 5.

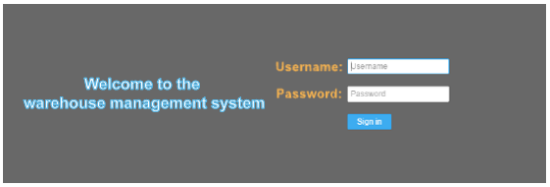

Figure 5: System login interface

4.2 System test

Unit testing is the smallest test method. This method tests a method or code block to find out whether the method or code block can complete the correct task [27, 28]. Because unit testing must fully understand the details of internal code design, it is most common for system developers rather than testers to complete this test. The system needs to conduct the corresponding unit test after the coding of a method or code segment to find problems. Due to the single similarity of the method of unit test, an example will be given below to introduce how the system uses unit test to complete the test work.

Because the system uses SSH framework and spring dependency injection to manage the creation of class objects in the system, it is difficult to use ordinary unit testing. Unit testing needs to be implemented through the unit test package provided by spring, and JUnit's jar package needs to be introduced for testing. Right click - > run as - > JUnit test to execute the test. After verification, the test is successful.

Through the unit test of this test method, the correctness of the results returned by the lower layer methods can be guaranteed to the greatest extent between the controller layer and the service layer methods [29-31]. It ensures the smooth and fast development of the system. After the unit test of the whole project, each function point has obtained the correct results. In this way, we can enter the integration test phase of the system.

Integration testing is based on unit testing to test whether each part of the work meets or realizes the corresponding technical indicators and requirements in the process of assembling all software units into modules, subsystems or systems according to the requirements of design specifications [32-34]. In other words, before integration testing, unit testing should have been completed, and the objects used in integration testing should be software units that have passed unit testing. This is very important because without unit testing, the effect of integration testing will be greatly affected, and the cost of software unit code error correction will be greatly increased.

After the design of each functional module, the system needs to test the correctness and complexity of the actual use of the module, the response speed of the website, the concurrent use of the system by multiple users, and the security of the system in actual use. Prevent the system from not working normally and poor user experience due to a large number of concurrency. Table 2 shows the description of each function point of the system and the description of the test cases of the

corresponding function points. Finally, the test results of the function points are obtained through the integration test. Table 3 shows the system function test results.

Serial number	Function description	Test case description	Test result
1	System user login	Enter the user name and password to log in to the system main interface	Realize
2	Basic information management	Add, delete, modify and query basic information such as materials and departments	Realize
3	Purchase materials	The purchaser adds a purchase order	Realize
4	Po approval	The reviewer reviews the purchase order	Can query and approve by Doc No
5	Purchase warehousing	The warehouse keeper queries the purchase order and receives it	Can query and stock in by Doc No
6	Reserve transfer / scrap receipt	The warehouse keeper adds a reserve transfer / scrap doc	Realize
7	Material ex warehouse	The warehouse keeper adds an issue document	Realize
8	Issue approval	The approver approves the issue doc	Can query and approve by Doc No
9	Inventory management	Query and statistics of receipt, issue and inventory information	The results can be queried and displayed within 3S
10	System log management	The system administrator queries the user operation log	Realize

Table 3: System function test results

In the process of system design, we need to test and improve constantly, find out the loopholes in the system through testing, and modify and improve them in time. Due to the small number of users of the system, the performance requirements are not too high, so the general requirements of the system are to realize the functions required by the user and obtain the desired results within the user's acceptable response time (the response time specified by the system is within 3S).

5 Conclusion

The system designed in this paper mainly realizes the five necessary functional modules of warehouse management: basic information management, system management, procurement management, warehousing management and inventory management. Provide automatic and comprehensive records for the whole process of material management of the enterprise, and provide real-time and correct information for all warehouse activities, resources and inventory levels. After the system running test, the system runs normally, the unit test and integration test can meet the expected requirements, realize the functions required by the user, and obtain the desired results within the user's acceptable response time (within 3S). Warehouse management system is the core of material management and an indispensable part of an enterprise. The information content it provides is very important for enterprise decision-makers and managers. The development of this system not only improves the efficiency of its own material management, but also improves the material management level of its own enterprise. The effectiveness and the efficiency of the design can be increase by adopting the approach of artificial intelligence and this work can be extended in this direction in the future.

References

[1] Velicka, J. , Pies, M. , & Hajovsky, R. . (2018). Wireless measurement of carbon dioxide by use of iqrf technology. IFAC-PapersOnLine, 51(6), 78-83, DOI: https://doi.org/10.1016/j.ifacol.2018.07.133

[2] Raju, T. , & Kim, W. S. . (2019). Mobile guidance system for evacuation based on wi-fi system and node architecture. Journal of Information Technology Applications & Management, 26, https://doi.org/10.21219/jitam.2019.26.5.041

[3] Liu, Y. X. , & Li, X. Y. . (2020). Design and implementation of a business platform system based on java. Procedia Computer ence, 166, 150-153, DOI: https://doi.org/10.1016/j.procs.2020.02.038.

[4] J Liang, Wu, Z. , Zhu, C. , & Zhang, Z. H. .

(2020). An estimation distribution algorithm for wave-picking warehouse management. Journal of Intelligent Manufacturing(1), 1-14, DOI: 10.1007/s10845-020-01688-6

[5] Zhao, J. , Xue, F. , & Li, D. A. . (2019). Intelligent management of chemical warehouses with rfid systems. Sensors, 20(1), 123, DOI: 10.3390/s20010123

[6] Zhao, K. , Zhu, M. , Xiao, B. , Yang, X. , & Wu, J. . (2020). Joint rfid and uwb technologies in intelligent warehousing management system. IEEE Internet of Things Journal, PP(99), 1-1, DOI: 10.1109/JIOT.2020.2998484

[7] Viloria, A. , Rodado, D. N. , & Lezama, O. . (2019). Recovery of scientific data using intelligent distributed data warehouse. Procedia Computer Science, 151, 1249-1254

[8] Zhang, Y. , Yao, J. , & Guan, H. . (2018). Intelligent cloud resource management with deep reinforcement learning. IEEE Cloud Computing, 4(6), 60-69, DOI: 10.1109/MCC.2018.1081063

[9] Kermani, M. , Adelmanesh, B. , Shirdare, E. , Sima, C. A. , & Martirano, L. . (2021). Intelligent energy management based on scada system in a real microgrid for smart building applications. Renewable Energy, 171.

[10] Yu, S. , X Chen, Zhou, Z. , X Gong, & Wu, D. . (2020). When deep reinforcement learning meets federated learning: intelligent multi-timescale resource management for multi-access edge computing in 5g ultra dense network. IEEE Internet of Things Journal, PP(99), 1-1, DOI: 10.1109/JIOT.2020.3026589

[11] Somasundaram, M. , Junaid, K. , & Mangadu, S. . (2020). Artificial intelligence (ai) enabled intelligent quality management system (iqms) for personalized learning path. Procedia Computer Science, 172, 438-442, https://***doi***.org/10.1016/j.procs.2020.05.

[12] Nastasi, G. , Colla, V. , Cateni, S. , & Campigli, S. . (2018). Implementation and comparison of algorithms for multi-objective optimization based on genetic algorithms applied to the management of an automated warehouse. Journal of Intelligent Manufacturing, 29, 1545-1557, DOI: 10.1007/s10845-016-1198-x.

[13] Kumar, R. S. , Raghav, L. P. , Raju, D. K. , & Singh, A. R. . (2021). Intelligent demand side management for optimal energy scheduling of grid connected microgrids. Applied Energy, 285(march), 1-14, https://doi.org/10.1016/j.apenergy.2021.116435

[14] Sharifi, H. , Roozbahani, A. , & Shahdany, S. . (2021). Evaluating the performance of agricultural water distribution systems using fis, ann and anfis intelligent models. Water Resources Management, 35(6), 1797-1816, https://doi.org/10.1007/s11269-021-02810-w.

[15] Xu, Z. , Zhang, J. , Song, Z. , Liu, Y. , Li, J. , & Zhou, J. . (2021). A scheme for intelligent blockchain-based manufacturing industry supply chain management. Computing, 103(8), 1771-1790, https://doi.org/10.1007/s00607-020-00880-z

[16] Mo, Z. , & Zhao, C. . (2021). Dynamic cost evaluation method of intelligent manufacturing enterprises based on dea model. International Journal of Manufacturing Technology and Management, 35, DOI: 10.1504/IJMTM.2021.118802.

[17] Ad, A. , Sk, A. , Pk, A. , & P B. (2020). Adaptive power management prototype employing intelligent scheduling of time and solar tracker - sciencedirect. Procedia Computer Science, 167, 1749-1760, https://doi.org/10.1016/j.procs.2020.03.385.

[18] Alangari, S., & Khan, N. A. (2021). Artificially Intelligent Warehouse Management System. *Asian Journal of Basic Science & Research*, *3*(3), 16-24, https://doi.org/10.1016/j.jbusres.2020.09.009

[19] Darajatun, R. A. (2017, December). C. In *IOP Conference Series: Materials Science and Engineering* (Vol. 277, No. 1, p. 012002). IOP Publishing.

[20] Mostafa, N., Hamdy, W., & Elawady, H. (2020). An intelligent warehouse management system using the internet of things. *The Egyptian International Journal of Engineering Sciences and Technology*, *32*(Mechanical Engineering), 59-65.

[21] Reza Pulungan. Et al., (2013). Design of an intelligent warehouse management system. *Information Systems International Conference*, 263-268, 10.1109/ISCID.2013.117

[22] Mao, J., Xing, H., & Zhang, X. (2018). Design of intelligent warehouse management system. *Wireless Personal Communications*, *102*(2), 1355-1367, https://dl.acm.org/doi/10.1007/s11277-017-5199-7

[23] Chen, M. , Wang, T. , Ota, K. , Dong, M. , & Liu, A. . (2020). Intelligent resource allocation management for vehicles network: an a3c learning approach. Computer Communications, 151, 485-494, https://doi.org/10.1016/j.comcom.2019.12.054

[24] Sharma, A., & Kumar, R. (2019). Risk-energy aware service level agreement assessment for computing quickest path in computer networks. *International Journal of Reliability and Safety*, *13*(1-2), 96-124, https://www.inderscienceonline.com/doi/abs/10.1504/IJRS.2019.097019

[25] Utracki, J. , & Boryczka, M. . (2020). A multi-agent approach to the optimization of intelligent buildings energy management. Procedia Computer Science, 176, 2665-2674, https://doi.org/10.1016/j.procs.2020.09.296

[26] RG Rodríguez, Mares, J. J. , & Christian, G. . (2020). Computational intelligent approaches for non-technical losses management of electricity. Energies, 13, https://doi.org/10.3390/en13092393

[27] Sharma, A., Cholda, P., Kumar, R., & Dhiman, G. (2021). Risk-aware optimized quickest path

computing technique for critical routing services. *Computers & Electrical Engineering*, *95*, 107436, https://doi.org/10.1016/j.compeleceng.2021.107436 .

[28] M Manbachi, & M Ordonez. (2019). Intelligent agent-based energy management system for islanded ac/dc microgrids. IEEE Transactions on Industrial Informatics, PP(99), 1-1, DOI: 10.1109/TII.2019.2945371

[29] Sharma, A., & Kumar, R. (2019). Computation of the reliable and quickest data path for healthcare services by using service-level agreements and energy constraints. *Arabian Journal for Science and Engineering*, *44*(11), 9087-9104, DOI: 10.1007/s13369-019-03836-4

[30] Sharma, A., & Kumar, R. (2019). Service-level agreement—energy cooperative quickest ambulance routing for critical healthcare services. *Arabian Journal for Science and Engineering*, *44*(4), 3831-3848. DOI: 10.1007/s13369-018-3687-z

[31] Liu, X. , Shu, S. , Yang, K. , Wang, T. , & Geng, B. . (2019). Intelligent management of secondary water supply systems in downtown shanghai. Procedia Computer Science, 154, 206-209, https://doi.org/10.1016/j.procs.2019.06.031

[32] Cui, Q. , Wang, Y. , Chen, K. C. , Wei, N. , & Ping, Z. . (2018). Big data analytics and network calculus enabling intelligent management of autonomous vehicles in a smart city. IEEE Internet of Things Journal, PP(99), 1-1, https://doi.org/10.1016/j.procs.2019.06.031

[33] Zhang, D. , Wang, L. Y. , Jiang, J. , & Zhang, W. . (2018). Optimal power management in dc microgrids with applications to dual-source trolleybus systems. IEEE Transactions on Intelligent Transportation Systems, 1-10, DOI: 10.1109/TITS.2017.2717699

[34] Chergui, H. , & Verikoukis, C. . (2020). Big data for 5g intelligent network slicing management. IEEE Network, 34(4), 56-61, DOI: 10.1109/MNET.011.1900437.