

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering



Bachelor Thesis

Inventory Management Application

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Inventory Management Application

Objectives of thesis

This thesis investigates the field of Enterprise Resource Planning (ERP) systems. The thesis aims to analyze the impact of ERP system of business processes and to create a program which will show how an ERP system affect on them. The partial goals of the thesis are:

- to characterize an ERP system,
- to analyze the similarities and differences of the certain ERP system,
- to characterize Java DataBase Connectivity (JDBC) in ERP system,
- to identify possibilities of JDBC.

Methodology

The methodology of the thesis is based on the study and analysis of information resources. The data collected from information resources was obtained from digital scientific sources or printed literature published by established authors. The practical part is focused on creating an ERP system, analyze its functions and features and compare them with other ERP systems. Based on the experience gained and the material studied, a conclusion will be formulated.

The proposed extent of the thesis

30 – 40 pages

Keywords

Database programming, Enterprise Resource Planning, Inventory Management Application, JDBC

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Declaration

I declare that I have worked on my bachelor thesis titled "Inventory Management Application" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 14.03.2022

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Inventory Management Application

Abstract

During the planning and writing of the thesis, two goals were set. The first goal was a detailed study of the operation of ERP systems, analysis of their capabilities and impact on enterprises, not only from a business, but also from a technical point of view. The author assumes that this work could be useful for people who are starting their acquaintance with ERP systems (in addition to the above information, this work also contains information about the types of ERP systems, costs, and the most famous vendors) or for developers who want to see the process of creating an ERP system from a technical point of view. The second goal was to create an ERP system that can perform basic interactions with the database. To achieve the first goal, the author studied a lot of not only digital, but also paper sources of information. While to achieve the second goal, several programming languages (JAVA and SQL) were used, as well as platforms for working with them (Apache NetBeans and Microsoft SQL server management studio). As a result, both goals were achieved. Ultimately, the author collected the most relevant and useful information and created a program that performs the basic functions of the ERP system.

Keywords: Database programming, Enterprise Resource Planning, Inventory Management Application, JDBC

Aplikace pro správu zásob

Abstrakt

Během plánování a psaní bakalářské práce byly stanoveny dva cíle. Prvním cílem byla podrobná studie fungování ERP systémů, analýza jejich schopností a dopadu na podniky nejen z obchodního, ale i technického hlediska. Autor předpokládá, že tato práce by mohla být užitečná pro lidi, kteří se začínají seznamovat s ERP systémy (kromě výše uvedených informací obsahuje tato práce také informace o typech ERP systémů, nákladech a nejznámějších prodejcích) nebo pro programátory kteří chtějí vidět proces tvorby ERP systému z technického hlediska. Druhým cílem bylo vytvořit ERP systém, který dokáže provádět základní interakce s databází. K dosažení prvního cíle autor prostudoval mnoho nejen digitálních, ale i papírových zdrojů informací. Zatímco k dosažení druhého cíle bylo použito několik programovacích jazyků (JAVA a SQL) a platforem pro práci s nimi (Apache NetBeans a Microsoft SQL server management studio). Ve výsledku byly oba cíle splněny. Nakonec autor shromáždil nejrelevantnější a nejužitečnější informace a vytvořil program, který provádí základní funkce ERP systému.

Klíčová slova: Databázové programování, plánování podnikových zdrojů, aplikace pro správu zásob, JDBC

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Introduction

Recent years have greatly influenced the views of companies regarding digital technologies. Organizations that have previously used digital technologies in their enterprises continue to implement them even more actively than before. Even those that have never used modern technologies have already begun to think about their implementation. That is why having an automated platform for managing organization can be considered a prerequisite. A modern enterprise resource planning (ERP) system with an interactive user interface and built-in data analysis allows to constantly improve and innovate business strategies. The ERP system is already one of the main advantages of companies. Considering all the above, can be confidently state that the vast majority of companies now use ERP systems. This is also evidenced by the statistics cited by Justin Biel [1]:

- Manufacturers represented the largest portion at 47% of companies looking to purchase ERP software.
- Following manufacturers, distributors (18%), services (12%) and construction (4%) are the other industries most likely to use ERP software.
- In a survey of companies looking to purchase ERP software, 89% identified accounting as the most critical ERP function. Other responses included inventory and distribution (67%), CRM and sales (33%) and technology (21%).
- 84% of ERP users had an expected ERP spend of less than 2% of annual income.
- 40% of companies identified better functionality as their primary reason for implementing an ERP system.
- The biggest influencers in purchasing ERP software were finance and accounting (23%) and IT department employees (23%).
- ERP systems are an important investment and should be a top priority, according to 53% of IT decision makers in a recent survey.
- On average, 26% of workers use their company's ERP software.

Looking at the statistics, can be confidently assumed that the development and implementation of ERP systems is now the number 1 priority for most companies and that the number of companies using ERP will only grow in the coming years. And this is not surprising, because the contribution that the ERP system makes to business processes is very tangible.

Objectives and Methodology

2.1 Objectives

This thesis investigates the field of Enterprise Resource Planning (ERP) systems. The thesis aims to analyze the impact of ERP system of business processes and to create a program which will show how an ERP system affect on them. The partial goals of the thesis are:

- to characterize an ERP system,
- to analyze the similarities and differences of the certain ERP system,
- to characterize Java DataBase Connectivity (JDBC) in ERP system,
- to identify possibilities of JDBC.

2.2 Methodology

The methodology of the thesis is based on the study and analysis of information resources. The data collected from information resources was obtained from digital scientific sources or printed literature published by established authors. The practical part is focused on creating an ERP system, analyze its functions and features and compare them with other ERP systems. The program development process consisted of creating a database, creating a program for the user to interact with the database, and establishing a connection between the database and the application. The database was created using SQL Server 2019 and SQL Maintenance Studio 2018. First we need to explain what SQL is. SQL stands for Structured Query Language. SQL allows you to access and manage databases. With SQL, you can run queries, retrieve data, update and delete data, and perform many more operations on data in a database.[6] SQL Server 2019 brings enhancements to the core SQL engine, offers a scalable and scalable system with built-in support for big data, state-of-the-art data virtualization technology, and an embedded learning machine.[7] SQL Server Management Studio (SSMS) is an integrated environment for managing any SQL infrastructure, from SQL Server. SSMS provides tools for configuring, monitoring, and administering SQL Server instances and databases, and is also used to create queries and scripts.[8] The Apache NetBeans IDE 12.6 was used to create the database management program and create the GUI program. Apache NetBeans is an open-source integrated development environment (IDE) that provides tools for Java, JavaScript, HTML5, and many other languages. It

provides intelligent editing tools and allows users to easily refactor code.[9] Java was used as the programming language. Java is a programming language and computing platform. Java is a general-purpose, class-based, object-oriented programming language that is less implementation dependent.[10] And as the last component, JDBC was used to connect the database and the program. JDBC or Java Database Connectivity is a standard application programming interface (API) that provides Java programs with access to a database management system.

Based on the experience gained and the material studied, a conclusion was formulated.

Literature Review

3.1 Enterprise resource planning systems

In the Introduction, author of the work said that the ERP system makes a great contribution to the development of business processes of enterprises. Many companies want to implement it. But what is the ERP system and why is it so in demand today? ERP term can be described in different ways. However, the simplest and most correct definition given by Deloitte Consulting, "an ERP system is a comprehensive business software system that allows a company to automate and integrate most of its business processes; share common data and practices across the enterprise; as well as to create and access information in real time mode." [2] The ERP system links a large number of business processes and establishes a data flow between them. By collecting ERP data, the system ensures the integrity of the data and eliminates their duplication. The first impression that ERP systems make is that today they are the most in demand and are almost decisive for the management of enterprises. All this gives rise to the idea of introducing the ERP system into enterprise. However, doubts and questions remain why it is necessary to implement ERP systems and how they will affect the operation of the enterprise, what will be the costs and how to implement this system in your enterprise in general. All those questions already have reasonable answers.

3.1.1 Reasons for implementing ERP systems

The first question that entrepreneurs ask is why it is necessary to implement the ERP system and how it will affect the business. The ERP system today solves many tasks of companies such as: personnel management, inventory management, accounting, production planning, data analysis and building business strategies based on this data and others.[2] A big advantage is also the reduction of the cash cycle. Prior to the use of ERP systems, companies faced a large load and a large loss of time when processing an order and receiving payment for it (previously, in order to receive funds from a client, a company was forced to manually extract data into various programs to upload them from one system to another, which significantly affected at the time of payment).[12] However, in addition to all the reasons for the implementation, there is one thing that makes potential customers doubt that the implementation is worth it. Enterprise resource planning represents the "best way to get the process done" and to do this, businesses must share information with their business partners. For some enterprises, this is an undesirable condition. Although the statistics cited by Justin Biel suggests that companies are ready to share information with partners to improve performance and income [1]:

- In a 2019 survey of distributors and manufacturers, 67% described their implementations as successful or very successful.
- Companies that had very successful ERP implementations noted internal organizational elements like support from management, good change management programs and due diligence as primary reasons for success.
- When asked what went wrong during implementation, only 12% of respondents noted poor quality of software.
- The top two problems noted during implementation were inadequate testing and inadequate business process reengineering.
- After ERP implementation, 49% of companies said they improved all business processes. Only 5% of business said they did not improve business processes.
- In a survey on ERP implementation, midsize companies with \$100 million to \$250 million in revenue had the fastest implementations at 6.7 months. Very large companies, over \$25 billion in revenue, took the longest at 12.35 months.

After analyzing these statistics, can be inferred that most of the enterprises that have implemented ERP systems for themselves were satisfied with the result and even consider the result very successful. It is also worth noting that half of the surveyed companies said that the implementation of the ERP system improved ALL business processes of the company. From this we can conclude that the “ERP system overcomes the inefficiency of independent systems and non-integrated data by providing integrated data to support multiple business functions”. [2] Figure no. 1 elucidate how ERP transforms the enterprise from a systems perspective

TABLE 2 Before and After ERP: Systems Standpoint		
	<i>Before ERP</i>	<i>After ERP</i>
Information systems	Stand-alone systems	Integrated systems
Coordination	Lack of coordination among business functions (e.g., manufacturing and sales)	Supports coordination across business functions
Databases	Non-integrated data; data have different meanings (e.g., customer); inconsistent data definitions	Integrated data; data have the same meaning across multiple functions
Maintenance	Systems are maintained on a piecemeal basis; inconsistencies result; it is costly to maintain separate legacy systems	Uniform maintenance; changes affect multiple systems
Interfaces	Difficult to manage interfaces between systems	Common interfaces across systems
Information	Redundant, inconsistent information	Consistent real-time information (e.g., about customers, vendors)
System architecture	May not be state of the art	Relies on a client-server model
Processes	Incompatible processes	Consistent business processes which are based upon an information model
Applications	Disparate applications (e.g., many different purchasing systems)	Single applications (e.g., a common purchasing system)

Figure no. 1 – Before and After ERP: Systems Standpoint [2]

Looking at this figure, can be noticed that the ERP system improves and integrates all the main system components. More important changes that the ERP system makes are integrated data, relies on the client-server model, an interface across systems and a single application. The integrated system architecture allows companies to use the same network in different regions, which in turn eliminates the need to store redundant data in multiple

locations because the same data is displayed regardless of geographic location.[12] This and all other improvements allow to collect, store, analyze data and keep it in one place, which provides the ability to build various business strategies and implement them. In turn, this kind of improvement will have a positive effect on improving the work of the enterprise as a whole and will help save time. It will also positively affect the company's business processes and allow them to earn additional income through time savings and improve customer service, financial management, increase enterprise productivity and improve other business processes. The impact of ERP systems on an enterprise from a business point of view can be seen on Figure no. 2.

	<i>Before ERP</i>	<i>With ERP</i>
Cycle time	Costly bottlenecks	Time and cost reduction of business processes
Transactions processing	Multiple transactions use multiple data files	Faster transactions, using common data. Reduces the time and cost of multiple updates
Financial management	Increased cost of excess inventory, cost of overdue accounts receivable	Improves operational performance (e.g., less excess inventory, reduction in accounts receivable)
Business processes	Proliferation of fragmented processes with duplication of effort	Re-engineering around a business model that conforms with “best practices”
Productivity	Lack of responsiveness to customers and suppliers	Improvements in financial management and customer service
Supply chain management	Lack of integration	Linkages with suppliers and customers
eBusiness	Web-based interfaces support isolated systems and their components	Web-based interfaces are front-end to integrated systems
Information	Lack of tactical information for effective monitoring and control of organizational resources	Allows cross-functional access to the same data for planning and control. Provides widely available information
Communications	Lack of effective communications with customers and suppliers	Facilitates organizational communications with customers and suppliers

Figure no. 2 – Before and After ERP: Business Standpoint [2]

Improving productivity, increasing information throughput, reducing costs, minimum response time to customers, suppliers, and partners, simplifying and accelerating the process of transferring information to decision makers, and, accordingly, improving the decision-making system (decisions are made faster and more efficiently by accelerating the

receipt of information). All these improvements are made by the ERP system due to the integrated data. Improvements are taking place both in terms of sales and production. Efficiency gains enable lower rates, faster lead times, and improved request processing. The ERP system also has a positive effect on the production process, improving the speed of design and production of products. Relationships with customers and suppliers are also changing. Customer requests are processed faster and due to this, the quality of service also improves, suppliers receive payments faster. Processes throughout the business are optimized.[2]

After a detailed look at the changes that the ERP brings to the system and business components of the enterprise, it becomes clear why implementation of the ERP system is necessary for enterprise. However, the following question also arises how much time and money will be spent on the implementation of the ERP system.

3.1.2 Implementation costs

The issue of price is very sensitive, because after studying the ERP system and its impact on the processes of the enterprise, it becomes clear that the implementation of such a large-scale system that combines many functions will be very costly both in terms of finance and in terms of time. The size of the company also directly affects the amount that will be spent on implementation (the larger the company, the more costs will be required and the more time it will take to implement). It also plays an important role and what kind of system are implementing. For example, implementing a Vanilla ERP with all the modules attached to it. This obviously will be more expensive, but it will give more guarantees that the system will work properly. System can be implemented not entirely, but only certain modules that are required by the company. This, in turn, will be less costly both in terms of money and time. Even own ERP system can be created, although this will require a huge amount of time and money, and by creating ERP system, entrepreneur is putting himself into a serious risk. The last option is to simply not use the ERP system, this way can avoid high costs, but will not give any benefit from using it. More detailed information about the pros and cons of a particular option with approximate costs in terms of time and money are shown in Figure no. 3

TABLE 8 Menu of ERP Alternatives

<i>Option</i>	<i>Cost and Time</i>	<i>Advantages</i>	<i>Disadvantages</i>
Vanilla ERP implementation	\$150 million over 5 years	Complete standardization of business processes based upon vendor's "best practices"	Competitors have access to the same system Disruption of operations over 3–5 years
Partial ERP implementation (e.g., selected modules)	\$108 million over 2–3 years	Partial changes in business processes	Disruption of operations over 2–3 years
In-house development	\$240 million over 7–10 years	Custom-designed ERP system—unique from competitors	Long-term analysis and design process; high expense
Status quo	No cost but no gain	No business process change; little disruption of operations	May provide a competitive disadvantage because competitors have an ERP system

Figure no. 3 – Menu of ERP Alternatives [2]

These costs are well justified. The amount of time and work spent on the implementation of the system is comparable to the costs. It should be added that the ERP system is implemented in a modular way, which is a huge plus because the organization can afford to implement it in stages. Businesses can select and implement modules as needed, which is an advantage.

Speaking about the phased implementation of the ERP system, people who are thinking about its implementation ask the question of what these stages are and what happens during these stages.

3.1.3 ERP System design process

For a complete understanding of the process of designing ERP systems, for a start, it is better to look at Figure no. 4, which describes the stages, the actions that occur during these stages and the tools and methods that are used to implement these stages.

TABLE 2 ERP Systems Design Process

<i>Step</i>	<i>Activities</i>	<i>Tools and Techniques</i>
Planning	Conduct a needs assessment; provide a business justification, based upon the difference between the existing system and the proposed system	Interviewing; cost justification
Requirements analysis	Analyze current business processes and specify the processes to be supported; select the ERP system	Use best practices models to see what the company can gain by implementing the new system
Design	Re-engineer business processes around the best practices model of the ERP system or customize the software	Use the ERP methodology's best practices or customize
Detailed design	Choose standard models, processes, inputs, and outputs (e.g., customer lists, vendor lists)	Interactive prototyping
Implementation	Configure the system; migrate data from the old system to the new system; develop interfaces; implement reporting systems; conduct testing; implement controls, security; train end-users	Work with vendors to correct any "bugs" in the software; clean processes and data Use reporting tools
Maintenance and continuous improvement	Provide technical support; provide upgrades and enhancements	Add enhanced functionality to existing modules

Figure no. 4 – ERP System Design Process [2]

Looking at this Figure no. 4 the main stages of creation such as Planning, requirements analysis, design, detailed design, implementation and maintenance and further improvements can be distinguished. The planning process is characterized by an assessment of the needs and, the determination of the benefits (whether financial or operational) that enterprises wishing to implement the ERP system plan to receive. All of this will provide the business case for purchasing the software and set the bar that the company plans to achieve by implementing the system. The analysis stage includes determining which business processes should be supported by the ERP package. The development phase includes the reengineering of business processes to better interact with the software. The detailed design phase is a more in-depth version of the design phase. It takes a closer look at a particular business process and considers ways to reengineer it.[2]

Particular attention should be paid to the implementation stage. Previously was discussed the implementation of ERP systems in terms of costs, benefits, and impact. However, the implementation process itself was not given worthy attention. For a complete understanding of the implementation process, it is worth taking a look at Figure 5 first.

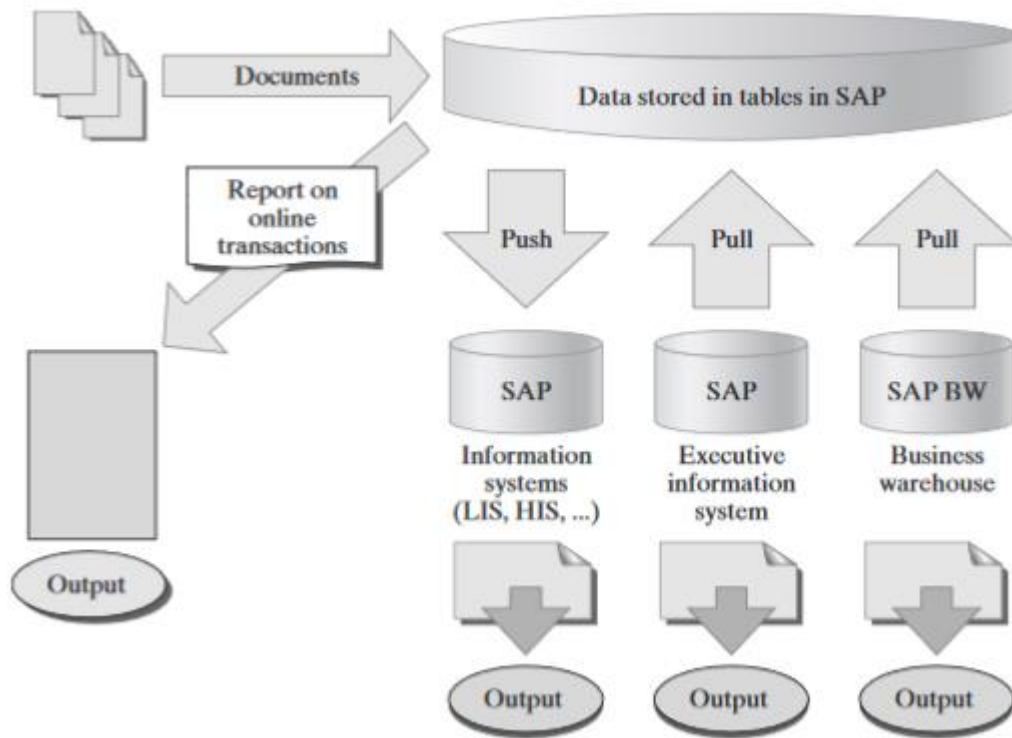


Figure no. 5 – Implementation of ERP system [2]

The implementation process includes the entire technical part of the ERP systems.

Transferring data from their old systems to the new one, fixing bugs, resolving configuration issues, implementing test results and pilot testing. To carry out this kind of action, companies need the help of technical support specialists who work and develop the vendor's software. System tuning requires a detailed look and verification of many factors related to data management and not only.[2]

After analyzing all the above information about the reasons, costs, and implementation of the ERP system, can decided whether to implement the ERP system or not. However, the last question arises which ERP system should be implemented for enterprise. To begin with, it is worth mentioning that ERP systems are divided into 3 types (2 of them are basic and 1 is a hybrid that contains functions of both types). The main types are Cloud ERP systems and Traditional ERP systems. There is also a Web-based ERP system that contains the functions of both a Cloud-based ERP system and a traditional one.[3]

3.1.4 Cloud ERP

Cloud ERPs are systems that work with a set of technologies connected by high-speed Internet networks where users have access to any information, no matter where they are.[11] To fully understand the operation of the cloud ERP system, it is worth clarifying how the cloud system works. The cloud system comes in three models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).[3] Infrastructure as a Service (IaaS) gives the customer control over the application, database, security, and runtime. However, hardware controlled by the service provider. In this case, the responsibility for all hardware lies with the service provider. Platform as a Service (PaaS) is a service with a set of additional intermediate services that will allow the client to create and implement the application according to the client wishes. Software as a Service (SaaS) is an off-the-shelf software, applications and computing infrastructure are fully managed by the cloud service provider. This model provides the client with the ability to use an application created by a cloud provider.[3]

The main advantage of the Cloud ERP system is the cost of implementation. Compared to the Traditional ERP system, the implementation of the Cloud ERP system is noticeably cheaper since the implementation takes place via the Internet and there is no need to install additional hardware and configure it. It also reduces costs (energy, setup, and support costs). Second big advantage of the cloud ERP system is the optimized performance that adapts to the needs of the client (for example, during a heavy load on the system associated with, for example, an influx of users, the cloud ERP automatically adjusts and allocates additional resources to stabilize the system).[13] Another advantage is the speed of software implementation. Any wishes of the client for change or improvement can be implemented very quickly and easily. Also, company can focus on doing business and improving without thinking about maintenance and implementation. One more significant plus is the ability to use the cloud-based ERP system on mobile devices, which includes a large selection of business applications for the efficient operation of the enterprise.[11] After all, the responsibility for this lies with the provider. Despite all the advantages, the Cloud ERP system also has disadvantages. The main disadvantage is security and privacy. Not surprisingly, using the Cloud ERP system means sharing information with the provider that provides the service. Businesses take risks and become dependent on providers.

3.1.5 Traditional ERP

The Traditional ERP system or (On-Premises system) is a product that takes time to implement. Whereas the Cloud ERP system does not require any additional hardware. The traditional ERP system requires the installation, configuration and testing of hardware and software that is required for the correct operation of the hardware. Also, the installation of computer hardware takes place at the place of work of the client. Hardware, data, and application are under the control of the client. In addition to the fact that local ERP systems require a lot of time and large investments, they also require well-trained personnel who can manage this system (update the system, maintain stable operation, maintain equipment, server rooms, eliminate errors, etc.).[13] Can be assumed that the implementation of the Traditional ERP system is more suitable for large companies, government agencies or enterprises that directly interact with the personal data of their customers (healthcare institutions, insurance companies and others).

Considering the positive and negative aspects of the Traditional ERP system, can be noticed that its advantages eradicate the disadvantages of the Cloud ERP system. At the same time, the disadvantages of the traditional ERP system can be corrected by the Cloud ERP system. For example, the main advantage of the Traditional ERP system is confidentiality and full control of the system by the client (including hardware). And the main disadvantage is the time spent on installing the system and the lack of free support from the provider. It is also important to pay a little attention to the third type of ERP systems (Web based ERP). This type of ERP system includes some parts of the Cloud ERP system and the Traditional ERP system. "It contains some features of type Cloud ERP, such as User interface, which is use the Internet browser, but does not need a huge infrastructure such as Cloud ERP, but it uses the architecture of three Tiers and this type Of architecture is different from Traditional ERP where it is more than one layer".[3] Looking in detail at Traditional and Cloud ERP systems, you can summarize all the advantages and disadvantages and compare these two types of ERP systems. Figure no. 5 reflects the key differences between these two types of systems.

Categories of differences	SaaS-ERP(Cloud ERP)	On-Premise-ERP (Traditional ERP)
ERP system total cost	Monthly Subscription Fee for ERP system No maintenance cost	Cost of license Maintenance cost is often annual
Cost of ERP Installation	No installation cost because the system is already installed on the server provider	Costs to set up the hardware and install ERP software
Updated	Included in the subscription fees	Included in the maintenance fees, but needs extra fees for updating hardware and software
Implementation time	Short time for implementation	No quick implementation
Flexibility in the ERP modules	Additional modules can be added in a short time if required	New modules may need to be added to the installation of a new package from the ERP system and removed from the old package
Selection of modules	Packages can be subscribed from modules by offers so they cannot subscribe to one module only, which reduces the flexibility of choice	Only required modules will be purchased
Mobility	Accessed from anywhere	Accessed from the location of ERP system servers, the system can be accessed via the web from anywhere, but special packages must be purchased, which leads to extra cost to the customer

Figure no. 6 – Comparison between Cloud and Traditional ERP. [3]

Looking at this picture and comparing all the points, can be concluded that the main difference between the Cloud and the Traditional ERP system is a different amount of time and money spent. Traditional ERP requires more time and investment while Cloud ERP is more affordable but less secure. Saving time and taking a little risk, or Higher costs and greater reliability, it is up to the entrepreneur who decides to implement the ERP system in the company, which one to choose from. After choosing the type of ERP system, entrepreneur should pay special attention to the vendors that provide ERP systems. At the moment, can be identified 2 companies providing ERP systems that stand out in the market: SAP and Oracle.

3.1.6 SAP vs Oracle

The choice fell on these 2 companies, as they are leaders in the field of ERP systems. During the research, gained experience working with SAP and Oracle and some conclusions can be drawn.

As two of the largest and most well-known ERP systems vendors, both companies provide an extensive list of how their software can improve business performance. However, there are some differences. So, for example, many users note more variable assistance in matters relating to company finances from Oracle. There is a lot of attention to the financial movement of data. The software allows you to manipulate and analyze data depending on the needs of the client. It can be assumed that in matters of finance and accounting, Oracle is ahead of its competitors. However, in terms of HR, SAP is far ahead of Oracle. SAP is engaged in a deeper study of personnel. Collecting all information about employees in one place. Change employee data in real time, payroll, e-recruitment function, employee data analysis, staff drain options. All this is done by SAP. It is also worth noting that the implementation of SAP will cost the company a little more and take more time. However, in all other aspects, Oracle and SAP are more or less equal, only marginally inferior to the competitor in this or that issue.[4]

After drawing up a plan, calculating all costs, choosing the type of ERP system, and choosing a vendor, you can start implementing the ERP system and start receiving all the benefits as soon as possible. However, there are those who want to implement an ERP system for themselves, but do not want to deal with an ERP system vendor but want to make their own ERP system that will fully satisfy their requirements. As mentioned earlier, it is possible to create own ERP system, but this is a very long process associated with high risks and costs, which will not give a one hundred percent guarantee of success. However, if the risk is not terrible and there is sufficient capital, then the creation of the ERP system can be carried out and implemented. The process of creating an ERP system is almost the same as the process of its implementation. As mentioned in the chapter on the implementation of the ERP system, the process of creating and implementing is approximately the same. It also requires planning, analysis, design, detailed design, implementation, and testing. However, between the detailed design and implementation processes, there must be a process for creating an ERP system. What steps need to be taken

to create own ERP system that will satisfy the wishes of the client is a question that arises for those who decide to create their own ERP system.

3.2 Creation of ERP system

Since the ERP system is one large database, in my opinion, special attention should be paid to the creation of a database and the transfer of all old data to the new system. Also, it is necessary to have an interface that will allow the user to interact with this database and change it. However, the database and the programs that will interact with it are not always located and developed in the same environment. The database can be created in a different environment in a different programming language. In such cases, something else is required to establish communication between the database and the program. There are different ways to establish this connection, but only JDBC will be explained because there has been a lot of interest in this method.

3.2.1 JDBC

JDBC or Java Database Connectivity is a standard application programming interface (API) that give Java programs access to database management system. Mainly it is based on set of interfaces.[14]

Figure no.7 represents class diagram that shows basic JDBC interfaces.

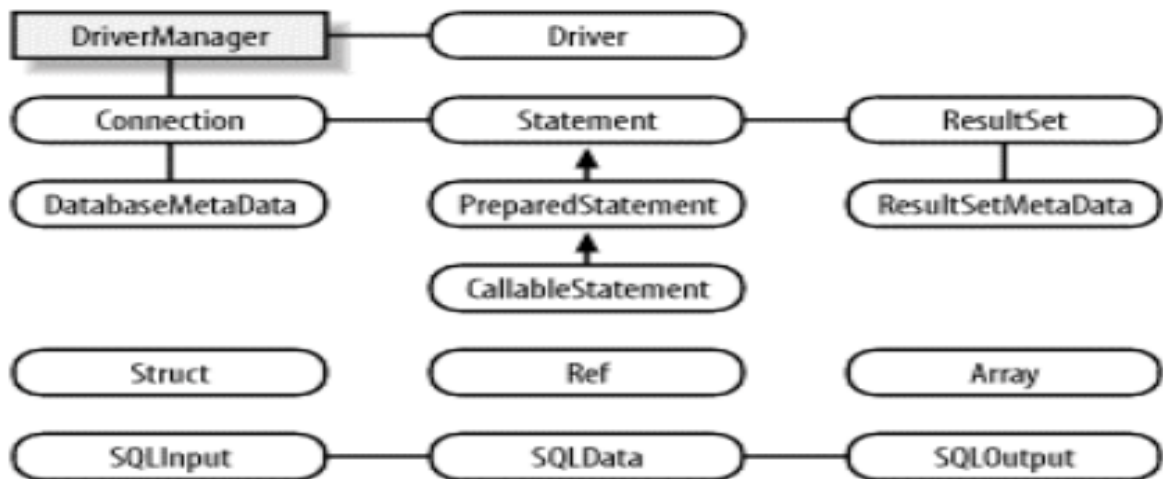


Figure no. 7 – Basic JDBC interfaces [5]

This diagram clearly shows exactly how JDBC works. The DriverManager is used to load the driver, and after it is loaded, it is used to get the connection. Connections are used to create and prepare a PreparedStatement or CallableStatement, or to create a statement. PreparedStatement is used to execute SQL statements while CallableStatement is used to execute stored procedures. Connection can also be used to get a DatabaseMetaData object that describes the functionality of the database. After executing an SQL statement using a PreparedStatement, the results are returned as a ResultSet. ResultSet can also be used to get the actual data returned, or on a ResultSetMetaData object which is used to define the data types returned in the ResultSet. You should also describe the six interfaces from the bottom of Figures no .7 which are used with object-relational technology. Object-relational mapping is a method for converting data types that are incompatible between systems using object-oriented programming languages. Struct is an object representing a database object as a record. Ref - as is clear from the abbreviation, this is a reference to an object in the database. Can be used to access a database object. An array is a database collection object in the form of an array. The SQLData interface is implemented by custom classes that are used to represent database objects as Java objects in an application. SQLInput and SQLOutput are used by the driver when creating custom classes during retrieval and storage.[5]

JDBC in the ERP system is a thread that connects a database and a database management program. One of the features of JDBC is that it can combine a database not only with an application, but also with applets, servlets, and internal objects. However, for the ERP system, only interest was in using JDBC to connect the Java application to the database. And it cannot be done without using the JDBC driver. “The JDBC driver implements interfaces and classes for a specific DBMS provider.”[14] It is also worth noting that there are 4 types of drivers for different situations, but only one of them is of interest.[15] The application of this driver, the creation of a database and an application for managing this database will be described in detail in the practical part of the bachelor thesis.

Practical Part

4.1 Program Creation Process

The practical part will show the process of creating a program that will allow the user to manage the database and perform simple operations with the data (save, change, delete). The program will also be compared with ERP systems. Functionality comparison. Pros and cons. First of all, a database was created using SQL Maintenance Studio 2018.

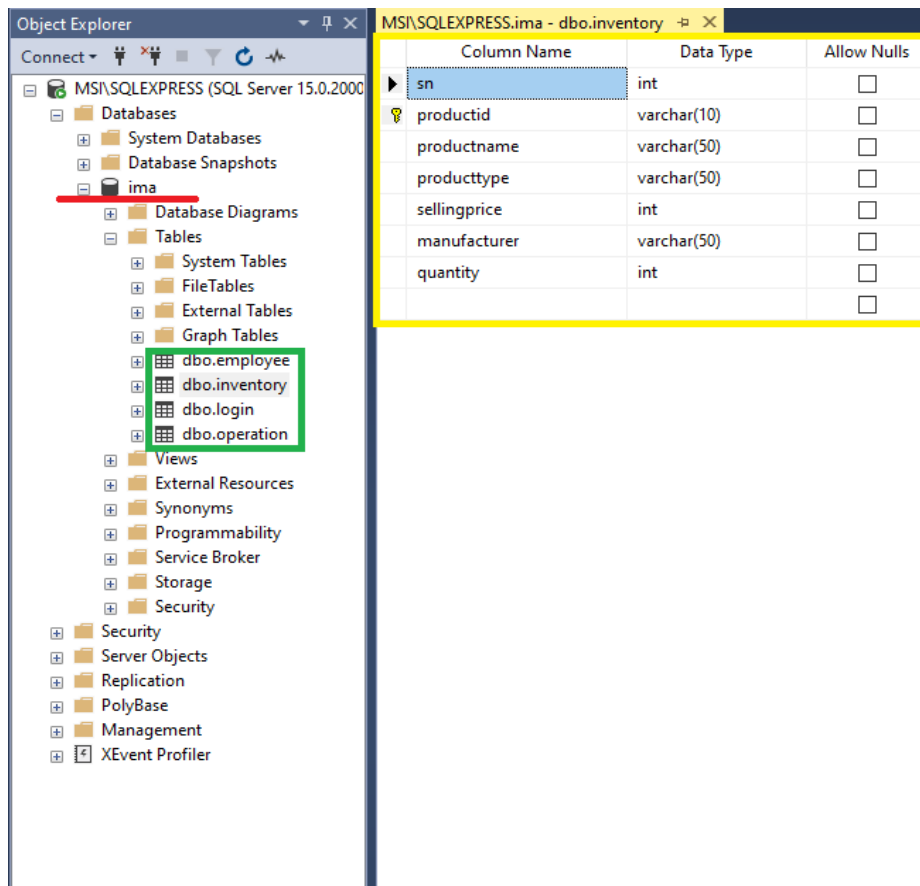


Figure no. 8 – Database Creation

Figure no 8 shows SQL Maintenance Studio. At the top left of the list, can be seen the name of the server where the database is stored (MSI\SQLEXPRESS). Also, the database (ima) is marked with a red bar, which was created by means of interacting with the interface without using code. The entire process of creating a database consisted of interaction between the user and the interface. In the green box, 4 tables that make up the database (databaseobject. employee, inventory, login, and operation) can be identified. The user of the program will interact with the data in these 3 tables. The login table is used for

logging in. Finally, the yellow box shows the process of creating the structure of one of the tables. By clicking and entering data, the user enters the name of the columns that he / she wants to see in the table, as well as the type of data and their length. For example, the quantity column can only display the data type (int - integer), which means that the data in the quantity column can only be numeric. Its length is (-2,147,483,648 to 2,147,483,647). The data in all my 3 tables are of the following types (int, varchar and date). The varchar data type allows the user to enter both numeric and alphabetic values. Maximum length (1 to 255 bytes). The date data type allows the user to enter data as a date.

Next, a graphical interface was created using the Apache NetBeans IDE. One of the advantages is that the process of creating an interface does not include a coding process. This saves a huge amount of time. The process itself consists of drag and drop objects from the pallet. The final appearance of the program is shown in Figures no. 9, 10, 11

The screenshot shows a Java Swing window with three tabs: 'Inventory', 'Employee', and 'Operations'. The 'Inventory' tab is active and displays a table with the following data:

sn	ProductID	Product Name	Type	Selling Price (K€)	Manufacturer	Quantity
35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
36	CAMCR00001	Canon XA11 Profi	Camcorders	32990	Canon	1
37	CAMNI00011	Nikon Z50	Cameras	28490	Nikon	20
39	GMCP500012	PlayStation 5	Game Consoles	13490	Sony	30
40	GMXB00005	Xbox Series S	Game Consoles	7990	Microsoft	22
52	HDPAP00009	Apple AirPods 2019	Headphones	3790	Apple	50
51	HDPSM00035	Samsung Galaxy Buds Pro Black	Headphones	5999	Samsung	30
41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40

Below the table is a form with the following fields and buttons:

- ProductID:
- Selling Price:
- Add:
- Product Name:
- Manufacturer:
- Edit:
- Type:
- Quantity:
- Delete:

Figure no. 9 – Inventory tab

sn	Employee ID	Personal ID	First Name	Last Name	Gender	Date of Birth	Position	Date of Emplo...	Salary (Kč)	Insurance Nu...	Email	Phone Number
10	EMP0000001	PIDUK000945	Olivia	Davies	Female	1999-11-14	Manager	2013-05-09	49000	INSNUMBUK4...	olidavies@gm...	771645789
7	EMP0001111	PIDCZ0000548	Kamil	Tobiška	Male	1992-07-12	Packer	2020-02-02	39000	INSNUMBCZ4...	kamitobis@s...	778945146
8	EMP0001154	PIDSK0000784	Martin	Cermák	Male	1968-10-31	Storekeeper	2018-04-01	18500	INSNUMBSK1...	cermakmartin...	771451325
12	EMP0004142	PIDMK0000444	Timandros	Stojanovski	Male	1971-05-11	Loader	2008-01-05	11500	INSNUMBMK4...	timandros@g...	775451235
11	EMP0004511	PIDCZ0000161	Vratislav	Kovár	Male	1980-08-17	Packer	2019-10-06	35500	INSNUMBCZ0...	vratislavkov@s...	779451332
15	EMP0005661	PIDCZ0000884	Matej	Kubicek	Male	1992-11-16	Packer	2021-01-03	39000	INSNUMBCZ7...	matejkub@se...	778748777
14	EMP0007078	PIDCZ0000451	Kvetoslava	Matejková	Female	2003-11-12	Loader	2021-12-29	13500	INSNUMB	matejkovakvet...	775415444
16	EMP0007941	PIDCZ0000112	Lukáš	Bednár	Male	1995-06-05	Packer	2019-01-31	42500	INSNUMBCZ7...	lukasbedna@...	777999847
13	EMP0008749	PIDCZ0000444	Zaneta	Müllerová	Female	1985-03-06	Loader	2016-07-06	13500	INSNUMBCZ1...	zanetamul@g...	775555164

Employee ID	<input type="text"/>	Date of Birth	<input type="text"/>	<input type="button" value="📅"/>	Insurance Number	<input type="text"/>	<input type="button" value="Add"/>
Personal ID	<input type="text"/>	Date of Employment	<input type="text"/>	<input type="button" value="📅"/>	Email	<input type="text"/>	
First Name	<input type="text"/>	Position	<input type="text"/>	Phone Number	<input type="text"/>	<input type="button" value="Edit"/>	
Last Name	<input type="text"/>	Salary	<input type="text"/>				<input type="button" value="Delete"/>
Gender	<input type="radio"/> Male <input type="radio"/> Female						

Figure no. 10 – Employee tab

sn	Operation ID	Product	Type of Work	Employee	Date of operation
11	OPRID0000041401	Apple AirPods 2019	Receipt of goods	EMP0008749	2022-01-25
12	OPRID0000041402	75" Samsung QE75QN800A	Receipt of goods	EMP0008749	2022-01-25
13	OPRID0000041403	Xbox Series S	Receipt of goods	EMP0007078	2022-01-24
14	OPRID0000041408	iPad Air 256GB	Receipt of goods	EMP0004142	2022-01-28
15	OPRID0000041409	Canon EOS R	Inspection of goods	EMP0000001	2022-01-12
19	OPRID0000041414	BenQ EX2780Q	Product disposal	EMP0004511	2022-01-17
18	OPRID000004142	75" Samsung QE75QN800A	Inspection of goods	EMP0000001	2022-01-29
7	OPRID000004783	Nikon Z50	Preparing goods for sale	EMP0001111	2021-01-25
4	OPRID0000047875	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-28
1	OPRID0000047881	ASUS TUF VG27AQ	Receipt of goods	EMP0004511	2022-01-05
2	OPRID0000047883	BenQ EX2780Q	Receipt of goods	EMP0004511	2022-01-05
8	OPRID0000047886	Nikon Z50	Inspection of goods	EMP0001111	2021-01-25
5	OPRID0000047887	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-25

Operation ID	<input type="text"/>	Product	<input type="text" value="Sonos SUB 3rd Gen."/>	<input type="button" value="Add"/>
Type of work	<input type="text" value="-"/>	Employee	<input type="text" value="EMP0000001"/>	<input type="button" value="Delete"/>
Date of operation	<input type="text"/>			

Figure no. 11 – Operations tab

Figure no. 9, 10, 11 show the appearance of the program which is a Tabbed Pane (which consists of three tabs) on each of which there is another Pane and several labels, datechoosers, radiobuttons and comboboxes. 3 tables also can be noticed, each of which displays data from 3 tables of the ima database. The attached code that will show the process of displaying SQL table data in the program will be shown a little later with the functions and features of the program. Before that, should be explained how the connection between the SQL table and the main program is set up. To establish a connection between the database and the program, first need to download and install the JDBC driver into the program. “A JDBC driver is a software component that allows a Java application to

interact with a database.”[15] After installing the driver, connection between them can be configured. The code to establish this connection looks like this:

```
Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");  
String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=1666";  
Connection con = DriverManager.getConnection(url);
```

Figure no. 12 – JDBC Connection

Figure 12 shows the connection establishment process. The URL uses the server port (1433 is the default as well as 3306). Then the name of the database to which access is needed, as well as the login and password for SQL authorization. This code is used every time program need to interact with database.

4.2 Functions and features of the program

After setting up the database, the program and establishing the connection, the functionality of the program can be developed. The IMA application has several functions and features: (Add data, Edit data, Delete data, Login function). All these functions allow user to make changes, display, or interact with the database by pressing buttons in the application. Below is an illustrative example of the use and operation of these functions.

4.2.1 Add Function

The Add function allows the user to add new data to the database by entering information in text fields, selecting a check box, selecting a JDateChooser, and clicking the add button. The code for the Add button is listed below in Figure no. 13.

```

private void addbtnoprActionPerformed(java.awt.event.ActionEvent evt) {
    try {
        //Connecting to sql table using JDBC
        Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
        String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=1666"; // link to sql table with the n
        Connection con = DriverManager.getConnection(url);
        String query = "insert into operation(operationid, productidop, typeofwork, employeeidop, dateofopr)values(?, ?, ?, ?, ?)"
        PreparedStatement pst = con.prepareStatement(query);
        pst.setString(1, oprid.getText()); // Take text from user interface and put it into the sql table
        productidop=prdidcb.getSelectedItem().toString();
        pst.setString(2, productidop);
        typeofwork=oprtype.getSelectedItem().toString();
        pst.setString(3, typeofwork);
        employeeidop=empidcb.getSelectedItem().toString();
        pst.setString(4, employeeidop);
        SimpleDateFormat sdf2 = new SimpleDateFormat("yyyy-MM-dd"); // Take text from user interface and put it into the
        String dateopr = sdf2.format(dateofopr.getDate());
        pst.setString(5, dateopr);
        pst.executeUpdate();
        // Following code Update recently added data and show it in the time user press "Add" button. user no more need to rest.
        DefaultTableModel model = (DefaultTableModel)oprtable.getModel();
        model.setRowCount(0);
        show operation();
        JOptionPane.showMessageDialog(null, "Data Successfully Added"); // Show message and clear all input of input fields
        oprid.setText("");
        prdidcb.setSelectedIndex(0);
        oprtype.setSelectedIndex(0);
        empidcb.setSelectedIndex(0);
        dateofopr.setDate(null);
    }
    catch(Exception e) {
        JOptionPane.showMessageDialog(null, e);
    }
}

```

Figure no. 13 – Add button code

As an example, the code of the Add button was taken to add data to the Operations table, since in it shown how the process of adding data takes place not only from text fields, but also from date and check box. On the Figure, the 4 parts of the code are marked with different colors. The red part of the code is responsible for establishing a connection between the program and the SQL database using JDBC as shown earlier. the green part of the code contains the main part of the program. The first line sends a query to the database (the data in quotes is written in SQL). Next, each text field, checkbox and JDatechooser is programmed to send data to a specific column in the SQL table. For example, the line of code `pst.setString(1, oprid.getText());` takes the data that the user entered into the text field and puts it in the SQL table. In addition to text fields, checkboxes and JDateChoosers are also programmed. The principle is the same, the data that is entered (in the case of checkboxes and JDateChoosers the user selects one of the proposed options) and added to the SQL table. So for example `productidop=prdidcb.getSelectedItem().toString();` instead of the text written by the user, sends the data that was selected by the user to the table. Further, the part of the code highlighted in blue is responsible for displaying the newly entered data by the user (the user does not need to restart the program in order to see the newly entered data. The last part of the code highlighted in yellow is responsible for informing the user about the successful completion of the operation and clearing all fields.

It is worth note that the successful completion of the operation means that all the data complies with the requirements of the SQL table. As it was said earlier, all data in the SQL table has its own type and its length. Therefore, if the data entered by the user does not meet the requirements of the table, the program will report an error. For example, productid has a data type varchar(10) which means that the user can enter both alphabetic and numerical values, but if the number of characters exceeds 10, the program will report an error. Also, if alphabetic values are entered in the quantity column, the program will also report an error, since the data type for this column is integer (only numeric). Below are Figures no. 14 and 15 which show that data has been added to the table.

The screenshot displays a software interface with a data entry form and a table. The form is titled 'Operations' and contains the following fields:

- Operation ID: OPRID000077899
- Product: ASUS TUF VG27AQ
- Type of work: Receipt of goods
- Employee: EMP0007078
- Date of operation: Dec 30, 2021

Buttons for 'Add' and 'Delete' are visible next to the form fields. Below the form is a table with the following data:

sn	operationid	productidop	typeofwork	employeeidop	dateofopr	
1	11	OPRID0000041401	Apple AirPods 2019	Receipt of goods	EMP0008749	2022-01-25
2	12	OPRID0000041402	75" Samsung QE75QN800A	Receipt of goods	EMP0008749	2022-01-25
3	13	OPRID0000041403	Xbox Series S	Receipt of goods	EMP0007078	2022-01-24
4	14	OPRID0000041408	iPad Air 256GB	Receipt of goods	EMP0004142	2022-01-28
5	15	OPRID0000041409	Canon EOS R	Inspection of goods	EMP0000001	2022-01-12
6	19	OPRID0000041414	BenQ EX2780Q	Product disposal	EMP0004511	2022-01-17
7	18	OPRID000004142	75" Samsung QE75QN800A	Inspection of goods	EMP0000001	2022-01-29
8	7	OPRID000004783	Nikon Z50	Preparing goods for sale	EMP0001111	2021-01-25
9	4	OPRID0000047875	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-28
10	1	OPRID0000047881	ASUS TUF VG27AQ	Receipt of goods	EMP0004511	2022-01-05
11	2	OPRID0000047883	BenQ EX2780Q	Receipt of goods	EMP0004511	2022-01-05
12	8	OPRID0000047886	Nikon Z50	Inspection of goods	EMP0001111	2021-01-25
13	5	OPRID0000047887	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-25
14	9	OPRID0000047889	Canon EOS R	Inspection of goods	EMP0001111	2022-01-24
15	3	OPRID0000047986	BOSE Bass module 700	Preparing goods for sale	EMP0001111	2022-01-02
16	10	OPRID0000049881	PlayStation 5	Product disposal	EMP0007941	2022-01-29

Figure no. 14 – Before Add

sn	Operation ID	Product	Type of Work	Employee	Date of operation
15	OPRID0000041409	Canon EOS R	Inspection of goods	EMP0000001	2022-01-12
19	OPRID0000041414	BenQ EX2780Q	Product disposal	EMP0004511	2022-01-17
18	OPRID000004142	75" Samsung QE75QN800A	Inspection of goods	EMP0000001	2022-01-29
7	OPRID000004783	Nikon Z50	Preparing goods for sale	EMP0001111	2021-01-25
4	OPRID0000047875	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-28
1	OPRID0000047881	ASUS TUF VG27AQ	Receipt of goods	EMP0004511	2022-01-05
2	OPRID0000047883	BenQ EX2780Q	Receipt of goods	EMP0004511	2022-01-05
8	OPRID0000047886	Nikon Z50	Inspection of goods	EMP0001111	2021-01-25
5	OPRID0000047887	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-25
9	OPRID0000047889	Canon EOS R	Inspection of goods	EMP0001111	2022-01-24
3	OPRID0000047986	BOSE Bass module 700	Preparing goods for sale	EMP0001111	2022-01-02
10	OPRID0000049881	PlayStation 5	Product disposal	EMP0007941	2022-01-29
20	OPRID0000077899	ASUS TUF VG27AQ	Receipt of goods	EMP0007078	2021-12-30

sn	operatidop	productidop	typeofwork	employeeidop	dateofopr	
1	11	OPRID0000041401	Apple AirPods 2019	Receipt of goods	EMP0008749	2022-01-25
2	12	OPRID0000041402	75" Samsung QE75QN800A	Receipt of goods	EMP0008749	2022-01-25
3	13	OPRID0000041403	Xbox Series S	Receipt of goods	EMP0007078	2022-01-24
4	14	OPRID0000041408	iPad Air 256GB	Receipt of goods	EMP0004142	2022-01-28
5	15	OPRID0000041409	Canon EOS R	Inspection of goods	EMP0000001	2022-01-12
6	19	OPRID0000041414	BenQ EX2780Q	Product disposal	EMP0004511	2022-01-17
7	18	OPRID000004142	75" Samsung QE75QN800A	Inspection of goods	EMP0000001	2022-01-29
8	7	OPRID000004783	Nikon Z50	Preparing goods for sale	EMP0001111	2021-01-25
9	4	OPRID0000047875	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-28
10	1	OPRID0000047881	ASUS TUF VG27AQ	Receipt of goods	EMP0004511	2022-01-05
11	2	OPRID0000047883	BenQ EX2780Q	Receipt of goods	EMP0004511	2022-01-05
12	8	OPRID0000047886	Nikon Z50	Inspection of goods	EMP0001111	2021-01-25
13	5	OPRID0000047887	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-25
14	9	OPRID0000047889	Canon EOS R	Inspection of goods	EMP0001111	2022-01-24
15	3	OPRID0000047986	BOSE Bass module 700	Preparing goods for sale	EMP0001111	2022-01-02
16	10	OPRID0000049881	PlayStation 5	Product disposal	EMP0007941	2022-01-29
17	20	OPRID0000077899	ASUS TUF VG27AQ	Receipt of goods	EMP0007078	2021-12-30

Figure no. 15 – After Add

You can see that adding data to the SQL table was successful and the data is immediately displayed in the program.

4.2.2 Edit Function

In addition to adding data, the program can also modify existing data. After establishing a connection to the table, the program can make changes. Before showing the code of the Edit button, it is worth talking about one more feature of the program. When clicking on any row in the Inventory and Employee tabs, all fields (text fields, checkbox fields and date) will be automatically filled with data from the table (the data will be taken from the row that the user has selected.)


```

private void emptableMouseClicked(java.awt.event.MouseEvent evt) {
    int s = emptable.getSelectedRow();
    TableModel model = emptable.getModel();
    empid.setText(model.getValueAt(s,1).toString());
    persid.setText(model.getValueAt(s,2).toString());
    firstname.setText(model.getValueAt(s,3).toString());
    lastname.setText(model.getValueAt(s,4).toString());
    String sex = model.getValueAt(s,5).toString();
    if(sex.equals("Male")){
        malebtn.setSelected(true);
    }
    if(sex.equals("Female")){
        femalebtn.setSelected(true);
    }
    try{
        int selrow = emptable.getSelectedRow();
        Date date = new SimpleDateFormat("yyyy-MM-dd").parse((String)model.getValueAt(selrow,6));
        dateofbirth.setDate(date);
    }
    catch(Exception e){
        JOptionPane.showMessageDialog(null,e);
    }
    position.setText(model.getValueAt(s,7).toString());
    try{
        int selrow = emptable.getSelectedRow();
        Date date = new SimpleDateFormat("yyyy-MM-dd").parse((String)model.getValueAt(selrow,8));
        dateofemp.setDate(date);
    }
    catch(Exception e){
        JOptionPane.showMessageDialog(null,e);
    }
    salary.setText(model.getValueAt(s,9).toString());
    insnumb.setText(model.getValueAt(s,10).toString());
    email.setText(model.getValueAt(s,11).toString());
    phnumb.setText(model.getValueAt(s,12).toString());
}

```

Figure no. 16 - Selecting data after mouse click.

Figure no. 16 shows the code that allows the user to click on the line of interest to display the data in the fields. After clicking, the program accesses one of the tables within which the row was selected and receives data from this table and displays the received data in the appropriate fields. This feature saves a lot of time and improves the Edit function.

```

private void editbtninvActionPerformed(java.awt.event.ActionEvent evt) {
    try {
        //Connecting to sql table using JDBC
        Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
        String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=1666" // link to sql table with the name of DB and login
        Connection con = DriverManager.getConnection(url);
        int rowinv = invtable.getSelectedRow();
        String value = (invtable.getModel().getValueAt(rowinv, 0).toString());
        String query ="UPDATE inventory SET productid=?, productname=?, producttype=?, sellingprice=?, manufacturer=?, quantity=? where sn="+value;
        PreparedStatement pst = con.prepareStatement(query);
        pst.setString(1, productid.getText()); // Take text from user interface and put it into the sql table
        pst.setString(2, productname.getText()); // Take text from user interface and put it into the sql table
        producttype=typelist.getSelectedItem().toString(); // Take selected item from list from user interface and put it into the sql table
        pst.setString(3, producttype);
        pst.setString(4, sellingprice.getText()); // Take text from user interface and put it into the sql table
        pst.setString(5, manufacturer.getText()); // Take text from user interface and put it into the sql table
        pst.setString(6, quantity.getText()); // Take text from user interface and put it into the sql table
        pst.executeUpdate();
        // Following code show recently changed data. user no more need to restart program to see recently added information
        DefaultTableModel model = (DefaultTableModel)invtable.getModel();
        model.setRowCount(0);
        show_inventory();
        JOptionPane.showMessageDialog(null, "Data Successfully Changed"); // Show message and clear all input of input fields
        productid.setText("");
        productname.setText("");
        typelist.setSelectedIndex(0);
        sellingprice.setText("");
        manufacturer.setText("");
        quantity.setText("");
    }
    catch(Exception e) {
        JOptionPane.showMessageDialog(null, e);
    }
}

```

Figure no. 17 – Edit button code

In this code, can be noticed already familiar lines of code for establishing communication using JDBC highlighted in red. The main part of the code is highlighted in green. Program as in the case of Add function. Sends a query to the table to update data in columns with new values. Next comes the same code as in Add Function, the program takes the new values entered by the user and saves them in a table, after that the table changes immediately and the user can see these changes without restarting the program. After the successful completion of the operation, a success message is also displayed on the user's screen and the fields are cleared. Figures no. 18 and 19 show how the Edit function works.

sn	ProductID	Product Name	Type	Selling Price (Kč)	Manufacturer	Quantity
35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
36	CAMCB00001	Canon XA11 Profi	Camcorders	32990	Canon	1
37	CAMN100011	Nikon Z50	Cameras	28490	Nikon	20
39	GMCPS00012	PlayStation 5	Game Consoles	13490	Sony	30
40	GMCXB00005	Xbox Series S	Game Consoles	7990	Microsoft	22
52	HDPAP00009	Apple AirPods 2019	Headphones	3790	Apple	50
51	HDPSP00035	Samsung Galaxy Buds Pro Black	Headphones	5999	Samsung	30
41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40

sn	productid	productname	producttype	sellingprice	manufacturer	quantity
1	35	AUDEQ00041	Sonos SUB 3rd Gen.	21990	Sonos	3
2	34	AUDEQ00077	BOSE Bass module 700	21990	BOSE	2
3	38	CAMCA00022	Canon EOS R	49990	Canon	5
4	36	CAMCB00001	Canon XA11 Profi	32990	Canon	1
5	37	CAMN100011	Nikon Z50	28490	Nikon	20
6	39	GMCPS00012	PlayStation 5	13490	Sony	30

Figure no. 18 – Before Edit

On Figure no. 18 can be seen that the function of displaying data on click is working. The selected data are identical both in the program and in the database, which also confirms the established connection and functionality of the program. Next, let's imagine a situation where 20 Nikon cameras are stored in a warehouse at a price of 28,490 CZK. During their inspection, 5 of them turned out to be defective, so they were disposed of and in connection with this, the price of the goods fell, and the new price is 26,000 CZK. The Edit function makes it very easy to make changes to the database. The result of the changes is shown in Figure no. 19.

sn	ProductID	Product Name	Type	Selling Price (Kč)	Manufacturer	Quantity
35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
36	CAMCR00001	Canon XA11 Profi	Camcorders	32990	Canon	1
37	CAMNI00011	Nikon Z50	Cameras	26000	Nikon	15
39	GMCP500012	PlayStation 5	Game Consoles	13490	Sony	30
40	GMCXB00005	Xbox Series S	Game Consoles	7990	Microsoft	22
52	HDPAP00009	Apple AirPods 2019	Headphones	3790	Apple	50
51	HDP5M00035	Samsung Galaxy Buds Pro Black	Headphones	5999	Samsung	30
41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40

ProductID	CAMNI00011	Selling Price	26000	Add
Product Name	Nikon Z50	Manufacturer	Nikon	Edit
Type	Cameras	Quantity	15	Delete

sn	productid	productname	producttype	sellingprice	manufacturer	quantity	
1	35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
2	34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
3	38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
4	36	CAMCR00001	Canon XA11 Profi	Camcorders	32990	Canon	1
5	37	CAMNI00011	Nikon Z50	Cameras	26000	Nikon	15
6	39	GMCP500012	PlayStation 5	Game Consoles	13490	Sony	30

Figure no. 19 – After Edit

4.2.3 Delete Function

There are also situations when the product is completely sold out, the batch turned out to be defective or the product is completely discontinued. That is why the data deletion function is necessary. This function allows you to completely remove data from the table. Below is the code for the Delete button, which is responsible for deleting the selected data.

```
private void deletebtnActionPerformed(java.awt.event.ActionEvent evt) {
    try {
        //Connecting to sql table using JDBC
        Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
        String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=1666";
        Connection con = DriverManager.getConnection(url);

        int rowinv = invtable.getSelectedRow();
        String value = (invtable.getModel().getValueAt(rowinv, 0).toString());
        String query="DELETE FROM inventory where sn="+value;
        PreparedStatement pst = con.prepareStatement(query);
        pst.executeUpdate();
        // Following code Update recently added data and show it in the time user press "Add" bu
        DefaultTableModel model = (DefaultTableModel)invtable.getModel();
        model.setRowCount(0);
        show_inventory();
        JOptionPane.showMessageDialog(null, "Item removed");
        productid.setText("");
        productname.setText("");
        typelist.setSelectedIndex(0);
        sellingprice.setText("");
        manufacturer.setText("");
        quantity.setText("");
    }
    catch(Exception e) {
        JOptionPane.showMessageDialog(null, e);
    }
}
```

Figure no. 20 – Delete button code

The code is simple. After establishing a connection with the table and getting data about the selected row. The row is removed, and the data is erased. The table data is instantly updated, and the fields are cleared. Below is an illustrative example of using the Delete function.

sn	ProductID	Product Name	Type	Selling Price (Kč)	Manufacturer	Quantity
41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40
45	HDWMB00046	ASUS TUF GAMING B560M	Hardware [Motherboard]	3099	Asus	19
46	HDWMB00087	MSI MPG X570	Hardware [Motherboard]	3999	MSI	18
48	HDWPR00016	Intel Core i9-12900K	Hardware [Processors]	14990	Intel	14
47	HDWPR00033	AMD Ryzen 5 5600G	Hardware [Processors]	5790	AMD	20
50	HDWRM00014	Corsair 32GB KIT DDR4 3200M	Hardware [RAM]	3590	Corsair	14
49	HDWRM00099	Crucial SO-DIMM 16GB DDR4 3	-	1579	Crucial	40
54	LPMAC00021	Macbook Air 13	Laptops	27990	Apple	30
53	LPMISI00022	MSI Katana GF66 11UG	Laptops	39990	MSI	6
32	MONAC00005	Acer Nitro XV272UP	Monitors	7990	Acer	5

ProductID	HDWRM00099	Selling Price	1579	Add
Product Name	Crucial SO-DIMM 16GB DDR4 3200MHz	Manufacturer	Crucial	Edit
Type	-	Quantity	40	Delete

sn	productid	productname	producttype	sellingprice	manufacturer	quantity	
10	41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
11	42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
12	43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
13	44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40
14	45	HDWMB00046	ASUS TUF GAMING B560M	Hardware [Motherboard]	3099	Asus	19
15	46	HDWMB00087	MSI MPG X570	Hardware [Motherboard]	3999	MSI	18
16	48	HDWPR00016	Intel Core i9-12900K	Hardware [Processors]	14990	Intel	14
17	47	HDWPR00033	AMD Ryzen 5 5600G	Hardware [Processors]	5790	AMD	20
18	50	HDWRM00014	Corsair 32GB KIT DDR4 3200	Hardware [RAM]	3590	Corsair	14
19	49	HDWRM00099	Crucial SO-DIMM 16GB DDR4...	-	1579	Crucial	40
20	54	LPMAC00021	Macbook Air 13	Laptops	27990	Apple	30

Figure no. 21 – Before Delete

sn	ProductID	Product Name	Type	Selling Price (Kč)	Manufacturer	Quantity
35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
36	CAMCR00001	Canon XA11 Profi	Camcorders	32990	Canon	1
37	CAMNI00011	Nikon Z50	Cameras	26000	Nikon	15
39	GMCP500012	PlayStation 5	Game Consoles	13490	Sony	30
40	GMCXB00005	Xbox Series S	Game Consoles	7990	Microsoft	22
52	HDPAP00009	Apple AirPods 2019	Headphones	3790	Apple	50
51	HDP5M00035	Samsung Galaxy Buds Pro Black	Headphones	5999	Samsung	30
41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8
43	HDWHD00070	WD Blue SN570 1TB	Hardware [HDD]	2599	Western Digital	60
44	HDWHD00078	WD Red Plus 8TB	Hardware [HDD]	5619	Western Digital	40

ProductID		Selling Price		Add
Product Name		Manufacturer		Edit
Type	-	Quantity		Delete

sn	productid	productname	producttype	sellingprice	manufacturer	quantity	
1	35	AUDEQ00041	Sonos SUB 3rd Gen.	Audio Equipment	21990	Sonos	3
2	34	AUDEQ00077	BOSE Bass module 700	Audio Equipment	21990	BOSE	2
3	38	CAMCA00022	Canon EOS R	Cameras	49990	Canon	5
4	36	CAMCR00001	Canon XA11 Profi	Camcorders	32990	Canon	1
5	37	CAMNI00011	Nikon Z50	Cameras	26000	Nikon	15
6	39	GMCP500012	PlayStation 5	Game Consoles	13490	Sony	30
7	40	GMCXB00005	Xbox Series S	Game Consoles	7990	Microsoft	22
8	52	HDPAP00009	Apple AirPods 2019	Headphones	3790	Apple	50
9	51	HDP5M00035	Samsung Galaxy Buds Pro Black	Headphones	5999	Samsung	30
10	41	HDWGC03060	MSI GeForce RTX 3060 Ti	Hardware [Graphical Cards]	27990	NVIDIA	4
11	42	HDWGC03090	EVGA GeForce RTX 3090	Hardware [Graphical Cards]	72990	NVIDIA	8

Figure no. 22 – After Delete

Figures 21 and 22 demonstrate that the data deletion was successful and that this one is functioning as it should. It is also worth showing one more feature of this program, this is the checkbox function in the operations table, which takes data from two other tables.

4.2.4 Operation checkboxes

Since the main topic is the ERP system. In addition to the interface and one large database, Integrated data feature was added. Data from one table is shown in another table.

sn	Operation ID	Product	Type of Work	Employee	Date of operation
11	OPRID0000041401	Apple AirPods 2019	Receipt of goods	EMP0008749	2022-01-25
12	OPRID0000041402	75" Samsung QE75QN800A	Receipt of goods	EMP0008749	2022-01-25
13	OPRID0000041403	Xbox Series S	Receipt of goods	EMP0007078	2022-01-24
14	OPRID0000041408	iPad Air 256GB	Receipt of goods	EMP0004142	2022-01-28
15	OPRID0000041409	Canon EOS R	Inspection of goods	EMP0000001	2022-01-12
19	OPRID0000041414	BenQ EX2780Q	Product disposal	EMP0004511	2022-01-17
18	OPRID000004142	75" Samsung QE75QN800A	Inspection of goods	EMP0000001	2022-01-29
7	OPRID000004783	Nikon Z50	Preparing goods for sale	EMP0001111	2021-01-25
4	OPRID0000047875	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-28
1	OPRID0000047881	ASUS TUF VG27AQ	Receipt of goods	EMP0004511	2022-01-05
2	OPRID0000047883	BenQ EX2780Q	Receipt of goods	EMP0004511	2022-01-05
8	OPRID0000047886	Nikon Z50	Inspection of goods	EMP0001111	2021-01-25
5	OPRID0000047887	Canon EOS R	Preparing goods for sale	EMP0001111	2021-01-25

Figure no. 23 – Operation Checkboxes

On Figure no. 23 you can see 2 highlighted checkboxes. Inside them are data from two other tables. From tables (Inventory and Employee). Figure shows that the Employee checkbox contains a list of employee IDs from the employee table. This simplifies the process of saving operations. Now you do not need to switch between tables to find the needed data. The required data is already displayed in the checkbox.

```

public void productCBFillData() {
    try{
        Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
        String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=l666";
        Connection con = DriverManager.getConnection(url);
        Statement stat = con.createStatement();
        String selectQuery1="SELECT productname FROM inventory";
        ResultSet rs=stat.executeQuery(selectQuery1);
        while(rs.next())
        {
            prdidcb.addItem(rs.getString("productname"));
        }
    }
    catch(Exception e) {
        JOptionPane.showMessageDialog(null, e);
    }
}

public void employeeCBFillData() {
    try{
        Class.forName("com.microsoft.sqlserver.jdbc.SQLServerDriver");
        String url="jdbc:sqlserver://localhost:1433;databaseName=ima;user=xnaza;password=l666";
        Connection con = DriverManager.getConnection(url);
        Statement stat = con.createStatement();
        String selectQuery2="SELECT employeeid FROM employee";
        ResultSet rs=stat.executeQuery(selectQuery2);
        while(rs.next())
        {
            empidcb.addItem(rs.getString("employeeid"));
        }
    }
    catch(Exception e) {
        JOptionPane.showMessageDialog(null, e);
    }
}
}

```

Figure no. 24 – Operation Checkboxes code

On Figure no. 24 shows the code that transfers data from the Inventory and Employee tables to the Operation table. Also can be noticed that the program first establishes a connection to the database and then sends a query to get specific data from certain columns from tables with further addition of this data to checkboxes. All functions and features shown above are part of the current version of the program. As a final part, it is worth comparing Inventory Management Application (IMA) with other ERP systems and looking at their similarities and differences.

4.3 Comparing IMA with ERP systems

Comparing this program created by one student as part of a bachelor thesis and the ERP system created by companies with thousands of employees cannot be objective. However, individual parts of the programs can be compared, and some parallels can be drawn. Comparing IMA and ERP system, first of all, it is worth comparing their functionality. IMA provides the ability to add, edit, delete, and use data from other tables. In the current version, IMA provides the ability to work in three tabs, each of which displays a separate part of the enterprise. For example, the Inventory tab displays the status of goods stored in

a warehouse (their ID, name, type, quantity, price, etc.). The Employee tab allows to store data about employees (their personal data, position, salary, and contact information) and the last Operation tab allows the company to save all operations that occur with the goods in the warehouse. So, for example, each delivered product, each product sent for sale, or the product being checked is recorded. The number of tabs in the program can be increased at any time. For example, if a company wants to keep financial records. This feature can also be added. The ERP system, in turn, provides the same functions, but more elaborate and giving the user more options, but of course the number of areas in which the ERP system is used is much higher. It is also worth noting that IMA is stored on a personal computer, and not on a server like the ERP system of well-known manufacturers. That is why IMA cannot contain a large amount of data. Having made such a small comparison, we can say with confidence that the use of IMA is possible, but it will only be able to satisfy some of the needs of the enterprise. For example, IMA could be used by some small company that does not need the full functionality of ERP systems, but only needs a program to control goods and employees. However, IMA will not be able to meet the requirements of larger enterprises. Thus, having analyzed all the information about the ERP systems (their functions, the price of implementation, their types, manufacturers) and trying to recreate a small part of the ERP system, we can make a conclusion.

Results and Discussion

5.1 Results

This chapter will describe the results obtained, the difficulties that the author encountered, as well as things that can be added or improved in the future. Positive results were obtained both in the theoretical and practical part. During the study, a lot of information regarding ERP systems was studied. After analysing and working out the material, the most accessible and useful information was recorded. The successful collection and analysis of useful data can be called a positive result of the theoretical part. However, the key results were achieved precisely in the practical part. The key result of this work is the creation of an IMA - ERP system that interacts with the database. The system created by ERP successfully performs such functions as data creation, modification, and deletion. Additional features have also been successfully added. For example, the Login system in a system that checks the entered login and password with the database and, if the data matches, allows the user to start interacting with the database. Another successfully introduced feature is the so-called click-to-highlight feature. This function allows the user, when clicking on a certain line, to fill in empty fields with data from the line of interest to him. This feature simplifies and speeds up the process of interacting with the database. Also, special attention should be paid to the successful creation of a function due to which data from one database table is used in another table. It also makes a significant contribution to reducing the time spent on re-entry of data. In general, the study of the thesis can be called successful. The main key results met expectations, but the author encountered some difficulties during the work.

5.2 Difficulties

During the work, there were also some problems with the implementation of ideas due to a lack of knowledge in the field of database programming. One of the main problems that remained unresolved is the non-functionality of the Edit button in the operation tab. The key feature of the operation tab is that this table uses data from two other tables. While the Edit function makes changes to the table where the data is stored. Because of this, the

change function does not work, since to change the data, you need to access two tables at the same time. Another part of minor difficulties was solved in the course of work.

5.3 Improvements

In addition to positive results and difficulties, the author also made a plan for further improvement of the program and innovations that can be made.

The main goal is to expand the areas that IMA covers. (At this stage, IMA works with Inventory, Employment and Operations. In the future, another Finance area can be added. Data on payments for goods, accrued wages, etc. will be stored there. I would also like to add a sorting function. In addition, one of the most desired improvements is the integrated data. This feature will allow multiple users from different locations to see and change the data in real time.

After describing the results obtained, a general conclusion can be drawn.

Conclusion

On the basis of the conducted research, it was possible to solve the following tasks: to characterize the ERP system, describe the types of ERP systems and the cost of their implementation, identify leaders in the ERP systems market and compare them with each other, also managed to look at and characterize JDBC, clearly demonstrate its work in the ERP system and show its possibilities. It is also worth noting the results of the practical part of the work. During the practical part, was created a program to manage the database by user interaction with a graphical interface. The current version of the program provides the user with the opportunity to perform basic manipulations with data (adding, deleting, and changing them). Current version of the program can be used to store a small amount of information. It provides the ability to store data on several aspects of an enterprise in one program without the use of third-party software. During the development of the program, some problems were identified. For example, it was not possible to configure the Edit function for the Operation tab. Since the two checkboxes use data from other tables, the code used earlier could not be applied. To solve this problem, in my opinion, you need to study the capabilities of the Java and SQL languages more deeply. In the final part of the conclusion, plan for the future of the IMA was made. IMA program can be improved and finalized. For example, the number of areas in which IMA can be used can be increased (use of IMA in the financial area of the company). Integrated data can also be added. As the user interacts with the interface, data can be sent from one table to another and can be changed immediately. For example, a Payroll function can be created in the Employee tab that will allow the user, when selecting a specific employee and clicking the corresponding button, to create a row in another table with the generated transaction number, employee name and the amount of the accrued fee. Functions such as sorting and searching data in a table, as well as adding graphic images to each product or employee, can also be added. In author's opinion IMA can evolve into a more complex program with more features.

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Appendix