

## DEVELOPMENT OF THE STOCK EXCHANGE INFORMATION SYSTEM

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**Abstract:** The stock exchange represents the key institution for the development of capital market of any country. Thus the information system of every stock exchange must satisfy very strict international standards. The development of these systems is particularly difficult in countries in transition, due to intense economic and legal changes, lack of technical and financial resources, lack of experience and knowledge in the area of the capital market business, etc. Therefore the special software project management methodology for their realization must be clearly defined. In the development process of the Belgrade Stock Exchange (BSE) information system a new software project management methodology for its realization has been defined, the application of which is illustrated through a series of different development stages of the Belgrade Stock Exchange information system. In order to make all the problems more comprehensive, only the continuous trading method is described, being the most frequently used trading method in the world.

**Keywords:** Stock exchange, trading engine, market, board, order, continuous trading method, project management methodology, object oriented development.

### 1. INTRODUCTION

Development and implementation of the stock exchange information system represents a responsible and difficult task, the realization of which require substantial financial resources, as well as human and technical resources. Limited material, staff and technical resources were the main factors that influenced many countries that were undergoing a period of transition to take over the stock exchange information systems of countries with developed market economies. However, there are examples of countries that have chosen an independent development path of their own stock exchange information system. This decision represents a professional challenge for experts that

have been selected to help in the realization of this system. The construction of this trading system demands an interdisciplinary approach for the projection of the whole system, which must be compatible with the surroundings in which it operates. The realization of these types of systems is usually done in phases, where you first have to deal with the functions of the stock exchange that represent a priority and then with the remainder of the functions, which are also very important for the development of the capital market.

The first step in the process of creating a stock exchange information system is defining the general user requirements that will be set to the information systems, where extra attention is given to the particularities that appear while creating such a system in a country that is undergoing transition. Beside the standard technical and technological aspects that are given attention during the development of the stock exchange information system, it is essential that other important problems that IT managers encounter during the realization of the system be solved too. This refers to the project orientated organization for the development of an extremely complex system that has the following elements:

- Strategic, operational and tactical planning for the further development of the stock exchange;
- Defining the rules by which the stock exchange will operate in accordance with the law regulations;
- Organization of the development of the information system and its exploitation;
- Defining the organizational structure of the stock exchange, organizational behaviour, staff administration, working relations and the creation of a project team;
- Controlling your own time and activities.

During the research phase, with the aim to find the best ways to create the stock exchange information system, information is gathered and sorted regarding relevant solutions, analyses of already existing methods of development, putting in place your own development methodology by putting together reliable and verified elements with your own original ones, comparative analyses of suggested methods and already existing ones, experimental checks of suggested methods done by creating test versions of the solution and through practical checks of the set hypotheses done by testing the trial versions and by testing under production circumstances.

Research done regarding development had very strict demands and standards set by the European Union (EU) in the domain of stock exchange information systems that should make possible trading with all types of market materials, using different methods, trading from the location of the broker (remote trading), the distribution of information regarding trade and control over how the stock exchange functions. It talks about very complex technical and technological systems that comprise a high performance communications and computer infrastructure, sophisticated computer protection mechanisms, transmission lines and rights and access to work, good system support, a well projected and maintained informational base that guarantees that all business transactions run smoothly, and reliable applicative back-up.

Here are some conditions under which the project had to be carried out in Serbia:

- Complete lack of some legal solutions important for proper functioning of electronic business (e-business regulations, etc.), incomplete legal solutions to existing laws and constant changes in legal legislature and regulations due to many different reforms taking place in the country.
- Many business requirements are unclear and do not arrive on time due to the country's unclear strategy regarding the development of the capital market.
- Difficult financial and economic situation in the country, which has left many of those involved with the stock exchange with no motivation to further develop their informational systems.
- Technical requirements for these systems, as far as performance and security are concerned, are very rigorous and entirely defined by international standards.
- The lack of technical resources has meant that substantial financial resources have had to be employed for their acquisition.
- Lack of trained staff (in most departments; financial, legal, IT, etc.) with enough experience to set up and develop such a system for the stock exchange.

Despite all these circumstances, the Belgrade Stock Exchange (BSE) decided to start developing new trading system (BELEX) due to the fact that there simply was no other way to satisfy the requirements of the National Bank for automatic electronic trading with old saving bonds and other securities in a very short period of time.

The first step in development of any stock exchange is careful analysis of the conditions under which it will function, i.e. making the analysis of the capital market that depends on a series of different republic and state laws. This analysis should clearly show the links between the stock exchange and all other institutions that affect it in any way, and its information system.

In June 2001, the institutions that had a certain role in the capital market were the Ministry of Finance of the Republic of Serbia, the Securities Exchange Commission (SEC), National Bank of Serbia, Temporary Depository Register, Central Depository Register, brokerage firms, and Belgrade Stock Exchange (BSE). At that moment two registries existed with the same primary functions, but their responsibilities were kinds of different securities. Note that the Temporary Depository Register was planned to last only during the period of privatizing and that all the securities would be transferred to the Central Depository Register after this period.

The Ministry of Finance is responsible for the legal framework concerning the market (for securities), i.e. it is responsible for the harmonization of the different laws that apply to the stock exchange and the laws regarding securities. The Securities Exchange Commission is a regulative state organ that supervises and controls the different instruments, participants and institutions in the capital market. In accordance to law, the SEC regulates the quality of the securities, maintains discipline in the financial market, regulates all the acts concerning stock exchange and its mediators, administrates most important activities that go on at the capital market, sets the rules by which trade with securities can be done, etc.

The responsibilities of the National Bank of Yugoslavia (Serbia) are: the control over the organization and functioning of the capital market and short term bonds, the

regulation of banks and their activities in the financial market, giving out treasury bills of the National Bank that are mainly sold through stock exchange, organizing and supervising the work of the central depository register that was, at the time, a special organizational unit of the National Bank, etc.

The Temporary Depository Register formed a part of the agency responsible for the privatization of Serbia. This institution was responsible for registering and pre-registering actions that were the result of privatization. The Temporary Depository Register had its own information system with which shares were registered, whilst clearing and settlements were carried by the broker. The Temporary Depository Register had several functions, such as regulating privatization, giving support to the shares fund, keeping track of all the securities on the issuer's account, noting the rights of the third party on the securities, clearing and settling obligations and finding business that was connected to securities in the securities themselves.

The Central Depository Register was a part of the National Bank of Yugoslavia. Therefore it used its infrastructure in order to function properly. It managed all the registering, depositing and settlement of bonds that were given out by the Republic of Serbia to repay old savings, as it did with the other securities that were given out by the National Bank and Republic of Serbia. As the Central Depository Register, which was a specific part of the National Bank, did not have its own information system in the early stages of its development, it was vital that alongside the development of the informational system of the stock exchange, the Central Depository Register information system was developed. The Central Depository Register carried out all the usual functions normally performed by such an institution, such as adding CFI codes and ISIN numbers, keeping track of different securities on issuer's accounts, etc.

The Belgrade Stock Exchange is the only organized market for securities and bonds currently existing in Serbia. Trading is done using all types of financial instruments. At the time it had its own system for trading short term financial instruments which depended on legacy technology available at the time. The system is constructed in such a way that it acts as a semi-automated support system for floor trading.. This system could not keep up with the newly formed demands of the market. The BSE carried out all the usual jobs one would expect of such an institution, such as registering all market materials and goods that are being sold and bought at the stock exchange, clearly stating and carrying out all the actions that are necessary for the trading of securities, all the activities related to the stock exchange, keeping track and noting any transactions taking place outside of the organized market materials traded at the BSE were short and long-term debtors book shares.

In June 2001, there were 80 brokerage firms in Serbia that could legally work as brokers or brokers-dealers at the stock exchange. The market materials they mainly traded in were mainly money, short-term bonds and shares. Typical of all the mediators was that they had, on average, 5 to 7 employees and poor quality information systems mainly comprised of MS Windows with several computers connected together and, depending on what type of market materials they were dealing with, several independent applications for carrying out various jobs. The technological infrastructure they had to work with was inadequate and simply could not measure up to the world standards.

When the BSE information system (BELEX) was completed in June 2004, the new situation in the capital market greatly varied from the situation in June 2001. The main difference was that the Temporary Depository Register was closed and everything

was transferred to the Central Depository Register which became an independent institution on January 1, 2004. The Central Depository Register carried on using a part of the National bank infrastructure as well as its own equipment. The register also has its own application, which is very effective as far as trading with securities is concerned. It has also been adapted in such way as to allow the trading of shares.

As a result of passing new laws, as well as the changing of work conditions on the market, brokerage firms have witnessed a number of changes such as rise in the capital and better technical and staff support which has in turn meant that better computer and telecommunications equipment has been obtained. Brokerage firms also provided a sufficient number of communication lines (ISDN, Frame Relay, rented lines) and back office applications capable of processing all types of market materials in call auction and continuous trading, and which also enable for information to be exchanged electronically with the stock exchange and register.

## **2. THE STOCK EXCHANGE INFORMATION SYSTEMS SURVEY**

The stock exchange represents one of the key institutions responsible for proper functioning of economy as a whole. This fact is true for all countries and helps explain why so much attention is given to regulation, monitoring and advancement of the exchanges. In order to gain the trust of all the participants in the capital market, the stock exchange is made completely transparent, so to speak, yet completely secure. It means that the trading rules on the stock exchange are known to the public, but the way in which the actual stock exchange works and the way in which these rules are implemented remains a well kept secret. Therefore no specific information can be obtained about the information systems of the stock exchange, only some general specifications of technical infrastructure.

The Belgrade Stock Exchange is the only stock exchange that currently exists in Serbia, although there have been attempts to create new ones such as the Commodity Exchange in Novi Sad. There are two stock exchanges in Montenegro - the Montenegro Stock Exchange and the NEX Stock Exchange. Montenegro Stock Exchange has created its very own information system, but since they have released no information about this system we cannot discuss it. The NEX Stock Exchange received Ljubljana's information system as a donation from the Republic of Slovenia.

Information systems can be classified in a variety of ways depending on what criteria are being used. The solutions applied for some big exchange systems throughout the world cannot be applied for the development of BSE information system due to their complexity. The largest stock exchanges in the world, such as the London Stock Exchange, Frankfurt Stock Exchange and EuroNext, use complex trading systems. For example, EuroNext's system is developed and maintained by their company Atos Euronext, with about 2000 employees, mostly business analysts and computer experts.

That is why this analysis incorporates only the systems of small and medium stock exchanges, the structure of which may be used for the development of stock exchange in Serbia. These stock exchanges can be split into two distinct groups. On one hand, there are those belonging to economically developed capitalist countries with long tradition, created many years ago (Athens Stock Exchange, Luxemburg Stock Exchange, etc.). Their main characteristic is that their information systems, developed during

1990's, were based on traditional concepts of huge central computers (they have, in the past few years, adapted their systems so that they can take advantage of the Internet as well). On the other hand, there are those that belong to the countries undergoing a period of transition, founded during the 1990's, whose systems were based both on some of the already mentioned solutions from the first group and the web of personal computers.

When comparing the results of the analysis of the systems used by these companies, we will use the criteria these systems were graded by, that is to say, the characteristics that can be reported. These criteria are made up according to what types of market materials are being traded, what type of market it is, trading methods, order types, system security, control over how the market works, client's work stations, the possibility of routing an order, etc. We will now present the analysis of a few systems that we analyzed while making our own system.

**The Ljubljana Stock Exchange** was founded in 1989. They received their first information system in 1993 as a donation from the Canadian government. The system belonged to the Canadian company EFA Horizon. From 1993 until 1999 they developed their own systems named BTS (Borzin Trgovalni Sistem), later donated to Macedonia, Montenegro, Croatia (Varazdin) and Bosnia and Hercegnova (Sarajevo and Banja Luka). This is a typical example of a system perfectly suited to a small market. The modules of this system are trading, administration, trade supervision, technical supervision, data distribution and communication module. The system was developed using Windows, the development surroundings were MS Visual C, MS SQL 7.0 formed the base, the net protocol was TCP/IP, the maximum amount of trade that could be carried out was 8000 and the maximum number of work-stations was 200.

The standard characteristics of a trading system are that market is divided into regular exchange market and over the counter market, block trade is allowed, trading of shares and bonds, where special orders are used (all or none, block, minimal quantity and hidden quantity), it is possible for the broker to halt or to carry on (resume) with an order, four order books exist (active order, inactive, stopped and cancelled) and it is possible to change already finalized trade manually.

The **Efa company** was responsible for creating software used in different financial market institutions, including stock exchanges. Their system *Horizon*, has been installed at many stock exchanges such as Boston SE, Jamaica, Barbados, West Africa, Romania, Egypt, Iran, Qatar, Bahrain, etc. The company went bankrupt in 1999 and its software was bought by the Australian company, ComputerShare, which also specialized in this type of software. The system was created with the help of C++. MPL is the database, and the operational systems are Unix and Windows.

*Horizon* is a system designed for automatic trade and specially created for new markets that are being automated for the first time, or the markets in the early stages of development. The main characteristic of this system is that it supports trading with any type of shares, it supports the workload of a number of specific markets, the usage of all types of orders, an integrated ordering book, call auction and continuous trading, trading with all types of material (shares, bonds, futures, options, etc.). All these operations take place in the RAM (memory based system). The system is entirely based on being able to deal with messages (message driven), flexibility, expendability, reliability, ratatability. The system is fault tolerant.

*Horizon* is based on a client server structure with a centralized message distribution principle. All messages are exchanged via a system that handles messages.

To maximize the speed at which the system operates, the system uses an embedded base. Orders and quotas are recognized as messages in a very fast machine that stores all the information regarding the market and book of orders in its memory. The parameters of the system can easily be changed so that it can perform a vast number of functions depending on the needs of a user. Using the API technology (Application Program Interface) it can easily be integrated with any external system such as risk management, limit control, distribution of facts order management systems.

**The OM** is a Swedish company that specializes in software used in stock exchange, brokerage firms, banks and other financial institutions. It started developing in the 1970's and built systems that were used by medium and large stock exchanges. These were mainly based on large computers (mainframe) such as Tandem and Alpha. Later, it adapted its systems to fit the needs of countries undergoing transition by building them with the help of PCs. These systems can be found all over the world; America, Athens, Australia, Italia (Borsa Italiana), Hong Kong, Stockholm, etc. The company has created several different types of systems such as the SAXESS, TYZER and CLICK XT.

The SAXESS system is multifunctional and is intended for medium to large stock exchanges. It is crated using the already mentioned Tandem or Alpha computers. These systems enable you to trade with all types of market materials including derivates, continuous and call auction trade, all types of orders, you can completely adjust the parameters, or the ratability of the system; its capacity is up to 2000 orders a second, it has a Unix platform and Oracle base. TYZER, on the other hand, is intended for smaller markets. It is very similar to the SAXESS and therefore uses the same technology, has the same characteristics, but with the poorer performance. CLICK X is another system that is primarily based on the SAXESS system, but uses cheaper PC platforms. It enables the trading of shares and derivates. It is cheaper to operate, with smaller hardware demands. It is easier to connect independent programs to it with the help of API; the application is the same for all members; it's been simplified for trading with shares and derivate; there is centralized administration for members and materials; it has lower demands for communication; infrastructure and installing the system is relatively straight forward.

### 3. PROJECT MANAGEMENT METHODOLOGY

Project management is mainly defined as being able to apply skills, knowledge and techniques in such a way as to finish all the necessary work and jobs that the project itself demands, or, in other words, that are vital to the successful completion of the project. Therefore the analysis was made of all previously existing project management methodologies. The conclusion drawn from this analysis was that the chosen methodology must always be clearly defined and applicable to most IT projects. Following this conclusion we can see that heading a project is an activity made up of many different processes that can be grouped together into groups of processes. These groups of processes are operating the project integration (the correct coordination of different elements), operating the project range (only carrying out activities that need to be carried out), handling time efficiently, realization, handling money (making sure that you do not exceed the given budget), controlling the level of quality, being able to

manage human resources, managing communications, dealing effectively with risks and with security measures for the goods and services outside the company.

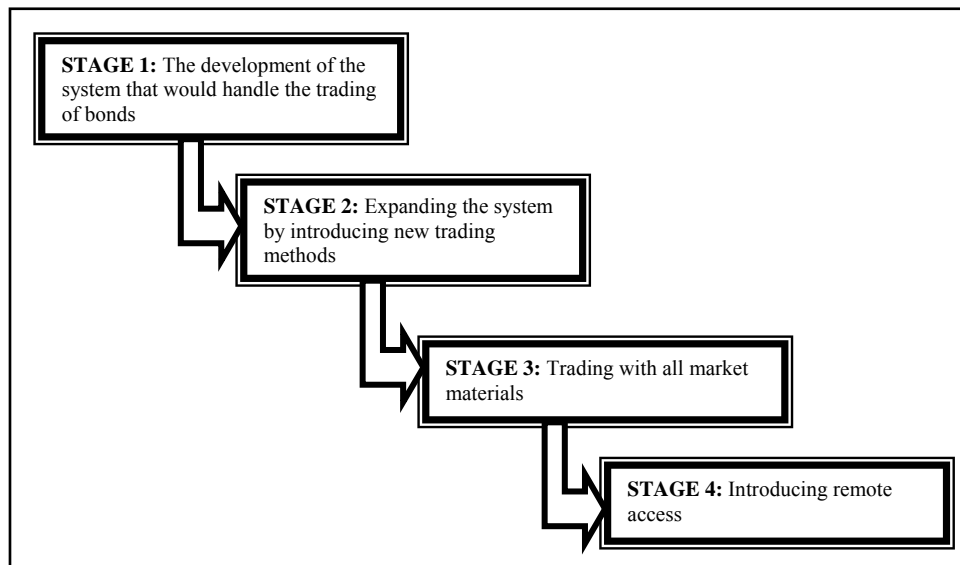
Through the analysis made of different project management methodologies and the already mentioned facts, we decided to define our methodology, BELEX PMM (BELEX Project Management Methodology). It would be used for project management, which had to be adjusted to EU standards. This methodology had to be capable of enabling the development of this project in difficult circumstances such as receiving business requirements too late or the requirements contradictory in nature, adapting activities to the demands of the European Union donators, adapting to frequent changes of the conditions in which the project is to be carried out (changes in legislature, closing of the Temporary Depository Register, etc.) and being able to easily redirect staff and resources from one assignment to another.

Considering these demands we chose a concept of realization in which the development of the whole system would be carried out in four main stages, divided in such a way that each stage represented an individual project. Bearing this strategy in mind, four versions of the system were planned, so that the final version would comprise all the characteristics of a modern stock exchange system. These are the four stages:

- Development of the primary system that would allow trading with some market materials;
- Expansion of the system by adding new trading methods (continuous trade);
- Improving the system again by trading with all market materials;
- Making remote access possible.

We decided to let some software companies handle the development of the project so that they, along with the staff employed in the stock exchange, might form a single team, whilst the IT department of the BSE would be expanded gradually, taking on more and more of the workload as it grew. The pace of the project development we planned by always keeping in mind the current situation in the capital market, the financial possibilities and human resources that could be offered by the stock exchange, as well as the fact that everything required for this project would be bought either by using the income received from the stock exchange or by using donations.





**Figure 1:** The system development life cycle

**The Belex PM methodology** represents a group of modules and principles for developing the stock exchange information system, with the help of which all the different elements of the project, such as human resources, tools and different processes can be organized much better, thus increasing their overall efficiency. It was already mentioned that this system represents a modification of standard methodologies for heading an IT project adapted to the needs of the BSE and its information system. This methodology is similar in many respects to the methodology suggested by Microsoft (MSF-Microsoft Solution Framework) and it represents a combination of the waterfall and spiral model.

A model is a collection of the different processes and shows the way in which the project will be managed, something similar to a schedule that shows when different activities will be carried out. In the last few decades two models separated from the rest, the waterfall model (made up of a series of dots that signify the end of a certain phase; only when one phase is finished may the next one start; this model is useful in projects that have been planned ahead carefully and where no modifications to the plan are expected) and the spiral model (based on continuous modifications and adaptations to new demands; as the project develops new solutions are constantly being found, each time growing in complexity, where each step brings it closer to the final one; the main drawback of this model is the lack of any clear planning, control points).

The Belex PMM represents the combination of these two modules. The project life cycle represents the spiral of versions. Each version is a whole in its own right divided into a number of phases with respective milestones. At each milestone certain approved parts of the project are delivered. The beginning of a new phase is not strictly linked to the finishing of the previous one; it merely depends on whether or not enough data has been collected to enable the start of the next phase. If any changes occur, it is always possible to redefine parts of the previous phase. This model gives the user

complete control over all of the individual phases, whilst offering a certain degree in flexibility. It means that if there is a change in plan he will be able to adapt to it, which is of vital importance for a project that is being carried out in Serbia. Finally, large projects are subdivided into smaller projects that are simpler to organize and control, which in turn means that efficiency is brought up and so is the overall motivation of the team.

The life cycle of a project can be divided into five phases: analysis, planning, development, stabilization and delivery. At the end of each phase there is a main milestone, whilst internal milestones do exist inside the different phases. The main characteristics of the different phases are:

- In the first phase, **analysis**, a project team is gathered as well as the initial project documents. These documents represent a consensus between those making the orders and the project team saying what will be done during the development of this project and in what way.
- In the second phase, **planning**, the technological concepts are formed, the functional specifications of the project (conceptual, logical and physical design) on the basis of which plans for the realization of the project can be made.
- In the third phase, **development**, the realization of the project begins. It is important to carefully check the suggested solution and start by building simple prototypes (proof of concept) giving no doubt to the workability of the solution.
- In the fourth phase, **stabilization**, the project team puts together the concepts of implementation, preparing the solution for delivery. This is when the final documentation is put together and tested alongside the final result.
- The fifth and final phase is the **delivery** of the solution (start of production). After the completion of the final analysis, the system is installed. If any errors appear during installation they are corrected. This phase also incorporates the responsibility for the system maintenance and the correction of any possible errors that may occur.

It should be mentioned that from a technological and technical point of view this project is realized according to the principles of modern software realization (Unified Process). On the other hand, it is also adapted to suite our needs and this is done in four stages:

- Defining the demands (creation of a logical model of the functions and a physical model of the business processes);
- Object orientated analysis (forming the conceptual model);
- Object orientated design (putting together the diagram of cooperation, complete class diagrams, state diagrams and defining the cooperation package);
- Implementation (creating the necessary applications, defining the technology, applicative and net architecture and testing).

This process of object orientated development is partly modified so that it can handle the needs and conditions of work in the Belgrade Stock Exchange. For example, when we were defining the demands we used a technique of function modeling IDEF0 (Integration Definition Function Modeling), which uses both graphics and text. This

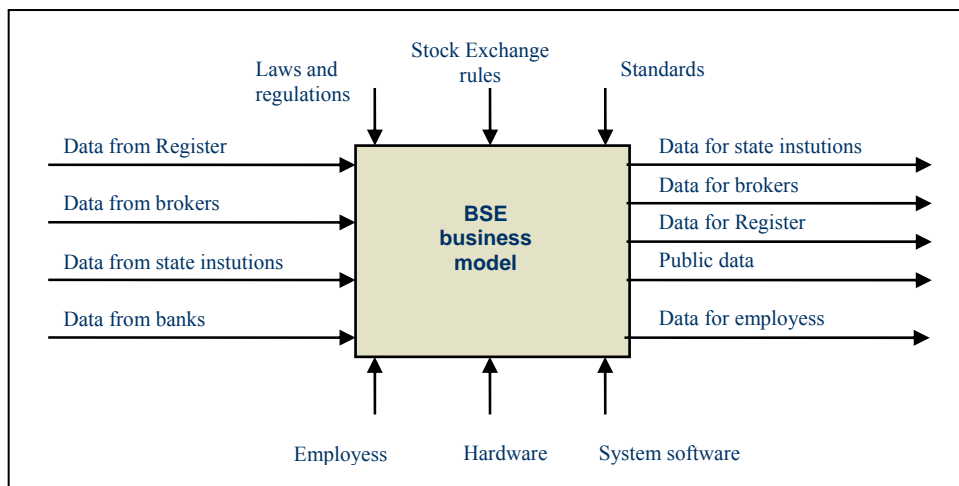
technique was chosen over the objectively orientated approach, because it was impossible to create a precise textual description of the objective model, as is usually done in that process.

The IDEF0 technique was first used in the ICAM (Integrated Computer Aided Manufacturing) project in the USA. The reasons for its usage were that it was capable of graphically illustrating a huge number of company operations in as much detail as it was required, it provided rigorous and precise expressions, it improved communications among system analysts, development team and the user. This method has been well tested and it can be generated with the help of a large number of computer tools.

IDEF0 describes a method of functional decomposition through a group of diagrams, where each one represents a limited amount of detail that is defined by a corresponding syntax. The diagrams are connected in such a way that they form a hierarchy. The diagrams are made up of squares that represent parts of a whole and that are connected with arrows. Squares, lines and rules form the syntax of this graphical language. Functional modeling is described with the help of the contexts of the diagrams, tree of activities and decomposition diagrams.

#### 4. DEFINING THE SYSTEM REQUIEREMENTS

We started the development of the stock exchange information system by building a logical model of the functions, that is to say with the IDEF0 methodology the functional specifications of the system were obtained, which should say what the system is supposed to do, as opposed to how it should do it. The answer to the question how the system should work is given for a concrete example, for the technology and organization in which the system has been implemented. The logical model defines the essential characteristics of the activities being carried out, independent of the job that will be carried out.



**Figure 2:** Model of the Belgrade Stock Exchange's business

In accordance to these principles this logical model is divided into two parts. The first represents the functional demands which describe what the system should do and the non-functional demands that describe what conditions the system must satisfy so that the realization of the functional demands can be carried out. Generally, non-functional demands are implementation limits and limits to the system surroundings, such as performance, platform dependence and maintenance.

**Functional requirements** describe all the jobs that information system has to carry out when it comes to trading with bonds and securities. These jobs are divided into trading, market surveillance, data distribution and accounting. This paper only deals with the business side of trading. Figure 2 shows the highest level of specified jobs. The functional requirements for trading are defined by the characteristics of the market, which are market materials, market participants, trading methods, phases, orders and calendars.

**The market** is characterized by the trading method on the main board and other special boards, if they exist. The market can be found in many different states. These are initialization (setting the parameters of the market), pre-opening (when the orders are taken in), opening (orders are accepted and trading begins), closed (the market closes) and verification (establishing the trading results and carrying out a check of all trade that has been carried out before announcing the results). The state of the closed market arises when the administrator stops trade so that a check can be made, after which the market can be opened again or closed. The movement from one phase to another can be done automatically in accordance with the trading schedule or after the administrator's intervention.

**Market materials** traded at the stock exchange are defined by the laws and acts of the stock exchange and these materials may only be given out with the authorization of the Securities Exchange Commission and a record of them must be made in the SEC. Securities used by BELEX are shares, short and long term bonds, treasury and commercial notes.

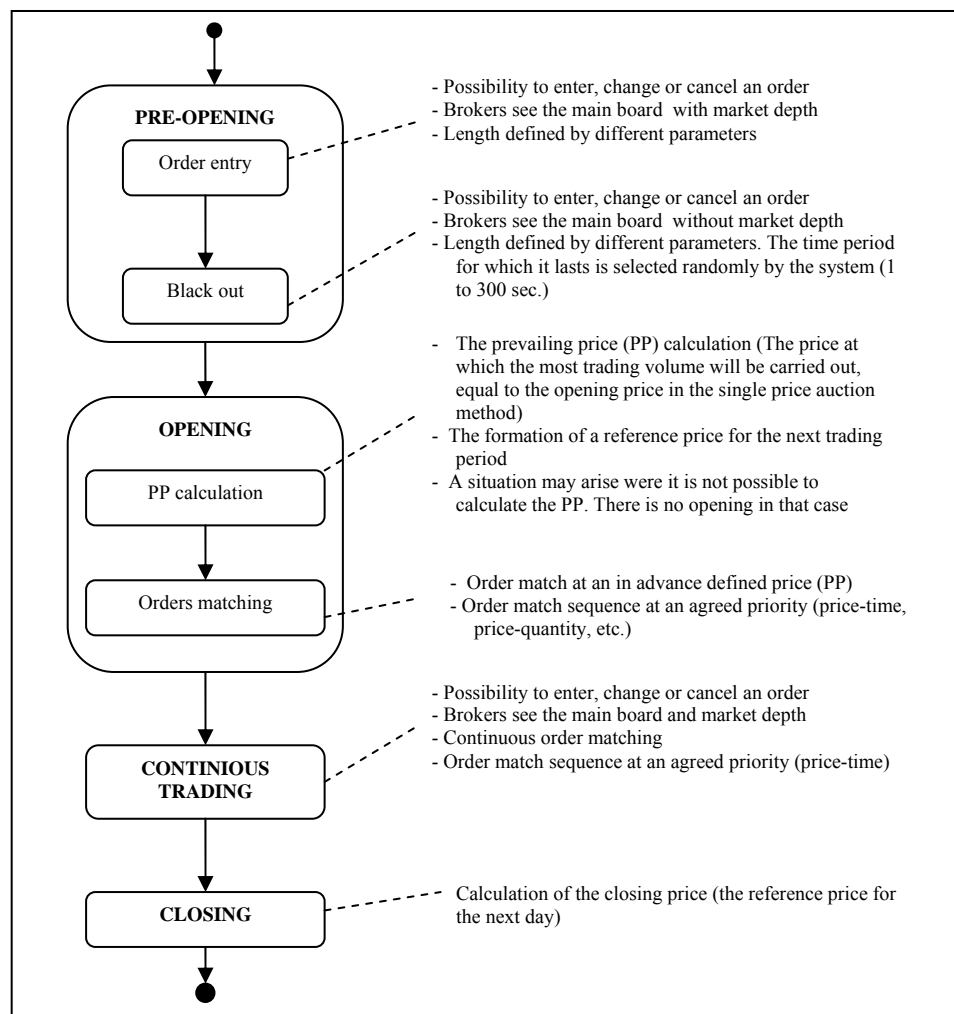
Every security that is traded on the information system of the stock exchange has its own symbol, ISIN number and CFI code. Each symbol is unique and is used to identify different securities. They are marked by the stock exchange itself and there is no security that is without its own identification. The ISIN number and CFI code are handed out by the central securities depository and are universal. Every security has its own characteristics that define the type of paper, expiry date, price, etc. All securities are noted before trading into the stock exchange system and this generally referred to as listing.

**Market participants** who are involved with the market can generally be placed into one of two groups - internal users (employees of the stock exchange) and external users (brokers, members of the stock exchange, the Central Depository Register, and the SEC). Every user should have the appropriate authorization if he is to carry out any job. For example, a broker, as a user of the system, is authorized to deal with orders (enter, change and cancel orders), trades, messages, news, etc.

In both theory and practice, there is a series of **trading methods** that can be divided on the basis of different criteria. Only one method will be explained in detail and this method is the continuous trading method, the most frequently used one in the world. This is the standard stock exchange method for trading with liquid securities and it is carried out during an already agreed upon period of time during the day in which trading orders are received. Trading prices vary and are identified on the basis of individual orders. This method consists of a number of phases, as is shown in figure 3. Types of

orders that are allowed for this method are: “buy”\ “sell” (depending on the type of transaction); “good for day”\ “good till date”\ “good till cancel” (depending on time duration); “limit”\ “market” (depending on the price) and there are also special types of orders such as “stop order”, “stop limit order”, “all or none order” etc.

The continuous trading method is made up of the following phases; pre-opening (sub phase: order entry and black out) whose length is decided by a set of parameters, opening phase (sub phases: calculation of the prevailing price and order matching) which is being done immediately (depending on the capabilities of the system), the continuous trading phase and the closing phase. Changes from one phase to another are done automatically and follow a time schedule.



**Figure 3:** Continuous trading method

Boards are special logical entities inside a market where trading is done according to the predefined trading method. The system supports two types of boards and they are the main board and special board. The main board is intended for receiving orders which are automatically matched. It represents the central trading place for any market where the price discovery and order matching processes are handled. Depending on the trading method, we can differentiate between two types of main boards and these are auction board (prevailing price method) and continuous board (continuous trading method). There are a number of different types of special boards and in this system only one is mentioned and this is pre-agreed trading (block), as this construction completely satisfies the needs of our market.

The **trading phases and trading calendar** decide the time schedule for all activities in the system whose parameters can be adjusted to suite the needs of the stock exchange. With the help of the trading calendar the days during which trading will be carried out can be clearly defined. Limitations do exist and trading can be carried out only during week days, the order expiry date can also only be on a week day and the period for the statistical analysis can only be on week days.

Different types of **trading orders** are clearly defined using standardized markings as to avoid mistakes that could be costly for anyone involved. Every order, aside from its own name and description, has its own special mark which makes trading procedures much simpler and avoids any unnecessary confusion. Orders can be divided depending on what type of transactions take place (buy and sell), depending on the price (market and limit orders), depending on quantity (lot), time (good for day, good till date, good till cancel) and orders with special conditions (stop order, stop limit order, all or none order, etc.).

All orders that can be found in the order book of the stock exchange can be found in one of four states. They are active orders (those that have not been realized yet and whose time has not yet expired, but are found inside the zone of fluctuation), inactive orders (orders that can be found outside the zone of fluctuation and their time has still not expired nor have they been realized yet), stopped orders (those that have been halted either by the broker or stock exchange controller and can only be reactivated by the broker) and removed orders (orders that have been realized, orders whose time has run out and that have been removed by the broker or stock exchange administrator during the de-listing of the security).

**Nonfunctional requirements** are those requirements that do not say what the system should do, but rather how it should do it and what level of quality it should aim to achieve. By realizing these demands the system can function, from an operative point of view. The system performances and general security requirements belong to this group of requirements.

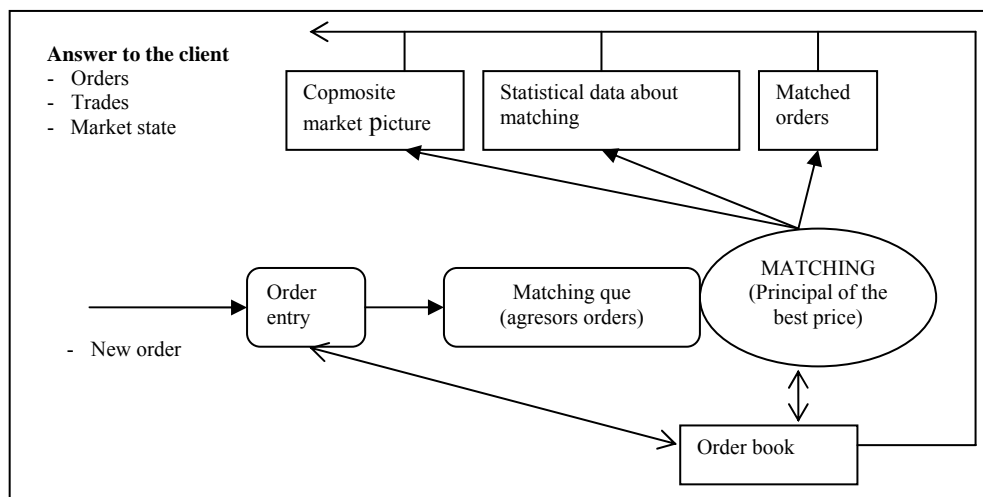
The system performances are measured by the maximum and average number of orders per second (100, that is 10), the maximum and average number of transactions per second (200), etc. The defining of the demands for the global security of the information system is done on the basis of a number of different criteria that have been set by different international standards. Security standards should be defined and applied in areas such as general legal act, organizational structure, physical protection, software protection, data protection, protection of the infrastructure, access security and protection against fires.

## 5. BSE INFORMATION SYSTEM IMPLEMENTATION

As the continuous trading method represents the primary trading method that is used in stock exchanges around the world, the realization of the Belgrade Stock Exchange system of trading will be illustrated using this method as an example. We shall only deal with a new order which has a limited price, it can be good for day or good till cancel and it has no special limitations (all or none, hidden quantity, etc.)

New orders that are brought into the system are called aggressors, whilst those that can already be found in the system (in the order book) are called providers. Any new orders can be turned down if they contain any errors. An accepted order can immediately be partially or completely matched, in which case a trade is concluded and private information regarding the order is sent to the client, whilst all other participants are informed of the matching (a public message is sent). If the order is not matched, it is noted into the order book and everybody who is involved in the trade is notified. Figure 4 shows the principal of continuous order matching.

As can be seen in fig. 4, demands connected to the entering of the order are accepted into the system and the order is written into the order book. Accepted orders can go to the matching queue, which is processed by the sub-system for matching and which tries to match those orders with the ones that have already been entered into the order book (providers). As a result of making a match, the system creates transactions that, similar to the process of accepting orders, affects individual statistics and summaries.



**Figure 4:** The concept of the system for continuous order matching

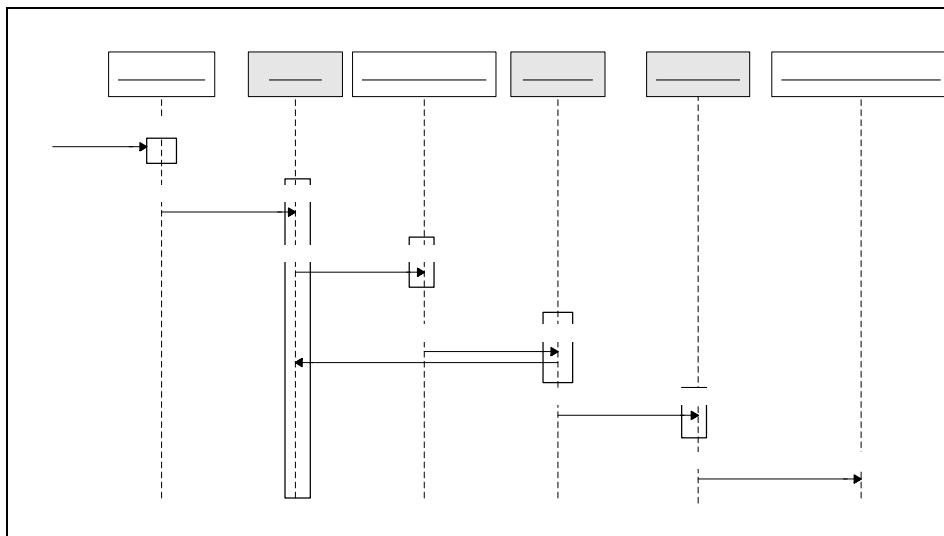
Orders that have been accepted by the system have to go through different phases of processing and they are as follows; checking if the order is unique, that is to say whether or not it has been in the system before, the potential translation of the external format of the order into the internal format, to verify whether or not the user is authorized to apply the order, validation and verification of the information contained in

the order, the processing of the order and returning of the results obtained to the system's user.

When adding a new order it is important to secure a unique identification for the order. Securing a unique number for the order is important for the precise processing of the order. Several solutions have been found, but the most commonly used one is where all orders that arrive from a client have their unique number with the help of which the client can identify the order, whilst the stock exchange generates its own unique number for the order for internal use. Therefore every order receives its own unique number once inside the system.

It is important to keep in mind that operations regarding the processing of a new order must be atomic, i.e. transactionally protected. That means that if an error does occur during processing (whilst the order is being accepted), the system has a mechanism that can either carry out all of the needed operations or none at all, as otherwise the system would remain in an inconsistent state or would crash if such an error was to occur. This is true for all new demands being brought into the system. Independent of this, if an error does occur so that the system cannot receive the demand it is important to note the number of the demand that has created the error.

The principle by which new orders are received and processed is shown in figure 5. The task of processing a new order is made up of the following steps; creating a unique number for the order, noting down the order with its new number in the order book, registering orders for matching (if the order is active) and composite market picture which depends on whether or not the order is active.



**Figure 5.** The sequence diagram for new order entry

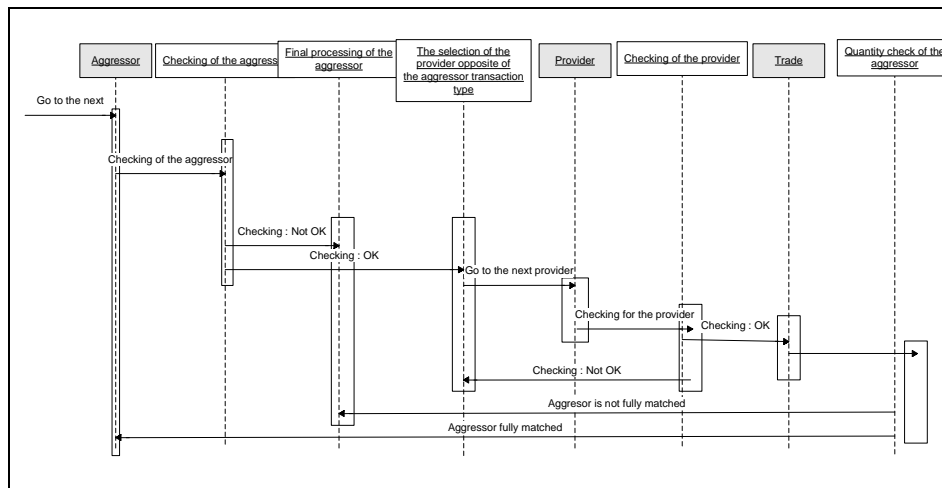
The composite market picture represents the sum totals of the symbol belonging to a security for both buy and sell side. All orders that are active and, of course, have the price of their own and quantity that can participate in matching are presented as a sum



total in the composite market picture. The symbols are placed in order depending on the buy and sell price from best to worst price. When it comes to sell prices the order is from highest to lowest, where all the orders with the same price are grouped together. It's a similar situation with the buy price, except that the order is changed from lowest to highest.

Continuous order matching is a process with the help of which orders that are in the matching queue are matched with those that are active and ready to be matched and that have been recorded in the order book and these orders are called providers. The sub-system for continuous matching constantly checks whether or not there is an order waiting in the matching order and of so, how many. When it finds such an order it takes this order and tries to match it with an order that has been listed in the order book. The criteria by which candidates for matching are selected is explained in the algorithm, and is based on the selection that is based on the sorting of the prices so that the best price is first and then depending on the time needed to receive the order for the provider. The principle by which continuous order matching is done is shown in figure 6.

As result of an attempt at making a match, the aggressor can be left unmatched, that is to say unchanged, it can be unmatched, but of a different status or it can be matched with one or more providers whose remaining quantity is equal to none and therefore cannot further participate in the matching process. With every match that is made between a provider and aggressor, the composite market picture is changed for the symbol in question, side (buy and sell), price and quantity. Matching also affects statistics that deal with symbols.



**Figure 6:** The sequence diagram for continuous order matching

Every time the system tries to match an aggressor and it isn't completely matched and if the type of aggressor allows it, then that aggressor turns into a provider and it will be possible to match it with other aggressors that arrive. When an aggressor

becomes a provider, its price can cause a change to the best purchasing and selling prices for the symbol and this needs to be changed.

Aggressors are taken one by one from the matching queue and each one is tested, to see if it can be matched, on the basis of the best price and whether the aggressor is still an active order, and if the test is positive then all providers that fulfill certain matching conditions are chosen (same part of the market, symbol, type of transaction and active state of the provider). Continuous order matching is done by picking out one provider by one from the selected group and matching it with an aggressor. If the provider is matched, completely or partially, statistics regarding that symbol are altered and so is information concerning the state of the market, after which information about the changes is sent to the users. When the processing of one provider is carried out, the next provider is taken and this is done as long as there are more providers or until all of the aggressors have been matched.

It is important to keep in mind the importance of testing the system when building the stock exchange information system. As the stock exchange trading system is very sensitive due to the function it carries out in the national economy, the testing of an application is approached with caution, as any mistake can have very harmful consequences if we take into account that trading is a process that happens in real time (continuous method), brokers that trade are located all over Serbia and the trading results are announced in real time with the use of special applications for the distribution of information. This is why a special test book has been written that precisely defines the test procedures that are to be carried out, when they are to be carried out, test teams, etc.

## 6. CONCLUSION

During the development of all four stages of this extremely complex system, that is to say all four versions of the system, the set goals have been fully achieved. It should be noted that our new project management methodology (Belex PMM) proved itself to be very successful in conditions such as the ones found in Serbia, mainly because it made possible the overcoming of very critical situations like the lack of clearly defined requirements, resources and skilled staff needed for such a project. It can also be said that the object orientated approach for the realization of the project, with the modifications that we made, gave exceptionally successful results.

As far as comparing the realized system to the information systems of other stock exchanges in the world, it can be done using standard criteria that are used for measuring the quality of different stock exchange systems. A complete analysis of the Belgrade Stock Exchange system was done in comparison to the Ljubljana Stock Exchange because Slovenia has now reached a level of development that is equal to the level of western countries, whilst the Ljubljana Stock Exchange has been classified as being a developed European stock exchange. As well as this, the trading system used by the Ljubljana Stock Exchange has been implemented in most of the former Yugoslavian republics, so that the author is more familiar with them and can therefore carry out a more thorough comparison.

The analysis and results show that the Belgrade Stock Exchange has reached the level of the Ljubljana Stock Exchange, and, as far as the appliance of technological solutions is concerned, especially in the field of system security, it is much better. It

should be stressed one more time that BELEX was developed to suit the needs of the Serbian capital market and to, at the same time, satisfy the world standards for stock exchange information systems.

It should be mentioned that the results obtained by the realization of this project are for more detailed than is required for the building of another information system, although that system is complex in every aspect. Leading such a project as this one has resulted in the following:

- The formation of the software management methodology required to develop a complex information system, supported by a group of development tools and relevant information-communications implementation technologies that takes into account the specific conditions which are somewhat limited in comparison to those of the developed world. It is a new, practical methodology for development of complex information systems that takes into account that at the start of the development process not all of the user requirements and nonfunctional limitations are known, or in other words allows the supplementation or alteration of those requirements or limitations that appear during the development process.
- The building of an effective, efficient, robust and reliable stock exchange information system in developed parts of the world. This system enables the trading with different market materials, different stock exchange trading methods, trading from the brokers' location and distributing information about trade immediately after a trading event occurs and that gives the system a high degree of transparency.
- Keeping in mind that every trading system is based on the working rules of the stock exchange to which it belongs, and keeping in view that these rules establish equality, transparency and regularity of the market, one of its main contributions is that it has caught the attention of many foreign and domestic investors and has, as a result, meant that more money is being invested in our country. This has in turn resulted in the development of share holding, provided a wide spectrum of opportunities for investing and has resulted in the creation of surroundings that many big world players have gotten used to.
- As far as security and protection of information is concerned the system satisfies world standards. The fact that during the past three years there has not once been a 'break in' into the system or a 'leakage' of information shows that system is technologically well protected.
- During the realization of the system cooperation with many different organizations belonging to the European Union was established. This primarily refers to the Luxemburg Stock Exchange that had greatly helped in the realization of remote access trading, the European stock exchange society, etc.
- The system is very reliable, so that for now there has been no stoppage of trade nor have any errors occurred as a result of technical problems.
- The heading of such a project under the conditions that were mentioned earlier was not only difficult for the team to whom this responsibility was given to, but valuable experience has been gained as a result of which a

well organized and well-trained working force has emerged. During the realization of this project a strong development team has been formed, that is made of many different specialists and is well disciplined, both of which are very important for the realization of such a complex project.

- The system that was created by the Belgrade Stock Exchange has been put through two international and one domestic inspection and it has shown to be of good quality and that it satisfies all of the set world standards. These test inspections were carried out by City Consultants Limited from London in September 2001, by a specialized team that was hired by the Luxemburg stock exchange in 2003 and by the Institute for applied mathematics form Belgrade in December 2003 which is the only institute in the country that has the authorization to set up communication securities and to control it.

The positive results received from the various inspections that were carried out on the system are conformation that the project team had carried out its job well, its conformation that the system is of good quality, but the most important indicator of the value and quality have been the three years that it has been running for. During these three years, as has already been mentioned, there have been no errors nor have there been any major system failures that could have disrupted the trade of securities or could have caused it to stop.

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