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Aleksandar Djordjevic [1]
Tijana Cvetic

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A BUSINESS INTELLIGENCE APPROACH FOR CHOOSING A OPTIMAL QUALITY SOLUTION

Abstract: *The diversity of business processes is very large, and in addition to this diversity between processes there are a number of tools, methods and techniques, especially from the perspective of business intelligence with prominent aspects of their development, the aspect of measurement and analysis of process performance. The purpose of this paper is that for a certain class of problems for which business process are designed to choose certain process model. Through the systematization of the existing models of business processes and methods, techniques and tools for their modeling, the analysis of one class of problems and correspondent business processes has been conducted. In that manner, basis for the new business intelligence optimization model for optimal choice of business processes model is created. To achieve this objective, numerous optimization methods were used from the fields of information engineering, modeling of processes and systems, and decision support systems. In this paper optimization model based on the application of Genetic Algorithm optimization method has been developed.*

Keywords: *optimal selection, business process, optimization model, business intelligence*

1. Introduction

Business Intelligence (BI) used a number of methods, techniques and tools to develop, measure and analyze the performance of business processes, in order to make effective business decisions. In this concept of BI, business process has the task of converting inputs (objectives, data, resources) to the desired output (Stefanovic *et al*., 2010). For these reasons, business process modeling, which is the result of a process model, has a significant impact on output (information, products, decision making suggestions).

Business processes are very diverse, and on the other hand, there are a number of methods, techniques and tools for their development. This is especially important from the perspective of a BI that is used to emphasizes the aspect of measurement and analysis of process performances (Arsovski *et al.*, 2009; Arsovski *et al.*, 2012). It is therefore important that a specific class of problems for which business process is designed, to choose the appropriate process model (Kucinar *et al.*, 2012; Arsovski *et al.*, 2011; Pavlovic *et al.*, 2011), especially in the uncertain environment (Stefanovic *et al.*, 2015). BI techniques and tools have been used in a various fields related to decision

[1] Corresponding author: Aleksandar Djordjevic
email: adjordjevic@kg.ac.rs

making in business processes. It has been used for assesment and optimization of business process quality by applicaton of fuzzy sets (Tadic *et al.*, 2012), and genetic algorithms (Nestic *et al.*, 2015). BI techniques and tools have been used in a desicion making processes for resilience improvement (Tadić *et al.*, 2014), vulnerability assessment (Aleksić *et al.*, 2014) and risk management (Gvozdenovic *et al.*, 2012) of busiess processes and organizations. Also, BI methos have been used in for quality evaluation of business processes (Tadic *et al.*, 2013; Aleksić *et al.*, 2014; Arsovski *et al.*, 2008; Tadic *et al.*, 2016) and also as support for supplier selection (Rankovic *et al.*, 2012a; Rankovic *et al.*, 2012b). By analyzing one class of problems and correspondent business processes systematization of existing models of business processes and methods, techniques and tools for their modeling is performed. This is the basis for the development of an original approach to the selection of an optimal model of business processes by appling business intelligence optimization methods, which is the subject of this paper. This approach has been converted to the methodology which is presented in the paper.

In order to achieve this goal numerous methods in the field of information engineering, modeling processes and systems, and decision support systems have been used.

The proposed approach is based on existing approaches of optimization models. The originality of this new approach is reflected in the transformation of knowledge about business process models into practice, with different levels of information, human and other resources. Based on the defined criteria and objective functions optimal business process model may be select the, in this paper, by appling the genetic algorithm (GA).

Limitations of this study are related to the characteristics of the sample in Serbia, dominated by business processes that are insufficiently supported with ICT, and as a result is dominated by the low level of business intelligence, which was found on a sample of 53 organizations.

2. Business models in terms of changes

The rapid development of science and technology in the 21st century has affected certain aspects of life, and life itself. According to Bostrom (2007) predictions of the future are tied to a specific probability and inaccuracy, through various scenarios. In order to reduce uncertainty in predicting through systemic approach different models have been developed. One group of models is related to business models (BM). By applying BM it is aimed to determine the structure, relations and success factors of an organization, especially in terms of the rapid changes in the market, which induce changes in organizations. So Powley (2013) implemented three phases of possibilities for organizations recovery:

- resources activation,
- association for resolving, and
- remodeling

This paper emphasizes the remodeling because it (a) provides greater force for change and (b) promote the long-term reproducibility of the organization. Mechanisms for recovery organizations have empathy, intervention, collective efforts and leadership.

Buyukdamagaci (2003) examined the factors that influence the definition of the problem, as a process and to the individual and organizational level. On different stages: (a) identification of problems, (b) the development of solutions to problems, (c) implementation of the new solutions and (d) redefinition of the problem. In all these stages using different methods and tools. Using literature from this field method with 8 steps for improvement of the business processes has been proposed.

On the organizational design great influence has applied ICT, through:

- availability of ICT,
- application of ICT,
- impact on changes in organizational design,
- increasment of the number of information, and
- effective decision-making.

According to Davenport (2010) business intelligence has an especially important role in organizational decision-making. Based on this paper there are 27 types of decisions, especially by analyzing the link between the decisions and information. Also, three cases were distinguishes:

- the weak link - the necessary information infrastructure,
- structured decision of experts on the basis of accurate and timely information, and application of adequate methods and techniques,
- automated decision making using ICT, most often related to specific processes and products.

The process of making connections and information takes place in four steps which are (Wixom and Watson, 2010):

- the strategic focus on key decisions,
- providing the necessary information,
- designing (design) decisions, and
- the implementation of decisions.

In this way the "classic" organization slowly becomes BI organization. BI affects the functioning of the organization, changing:

- strategic vision,
- business focus,
- level of commitment and support,
- scope,
- management,
- sponsorship,
- the necessary resources,
- impact on people and processes, and
- benefits for the organization.

Especially important are the changes introduced in the area of BI transformation of the organization, as well as fundamental changes in operations, support new strategic business models and etc.

Relations between business models (BMI model business processes (BPR) are described in Solaiman and Bouwman (2010). They defined the BM as a strategic organizational structure in terms of the logic of unfolding, as opposed to processes that are viewed on the operating level. Therefore, BP is virtually the link between business strategy and business processes (Ibid, 659). This problem is treated in the concept of EA (Enterprise Architecture). The key to successfull connection between BM and BP is the process of harmonization, based on the top-down principle, with the exchange of values, information and linkage of business processes.

Business processes are strongly associated with a model of organization based on systems theory (Becker, 2003), which includes three key aspects of the system: structure, behavior, and the system hierarchy. The scope of the model of organization includes the following types of processes:

- basic processes, such as the acquisition, development, production, sales, finance and accounting, etc.,
- management processes, and
- support processes.

Hierarchical concept is based on the transformation of the real world into an abstract model, which is governed by two principles:

- first, the hierarchy of elements (parts), on the basis of building a system, and
- second: hierarchy type, which is realized through generalization and specialization. This type of hierarchy allows building block entities.

The structure of the system is based on the principle of multiple related links between

elements of the system, and not the isolated parts of the system and it interacts with each other to achieve synergy of the system. System structure and processes within them works with a variety of graphic symbols, which have their meaning (semantics). The structure has a formal and semantic aspects. The formal aspect is connected to the other end of the graph, and the mapping of semantic elements and relationships within the organization. The organization achieves its activities at facilities using other facilities, such as products, resources and other work orders. There are two basic approaches to structuring the system:

- the first activity corresponding to the elements and the corresponding relations between objects (eg., value added process, where the output is seen as an object bonding activity - seen as an element, the input object other activities - seen as element), and
- second activities and the corresponding relations of objects that correspond to the elements (eg. the structure plan process, where the two objects, seen as elements linked through activities are considered as relations).

The behavior of the system depends on the properties of human and technical factors. Based on this an analysis of the elements that influence the behavior of the system in time are: (1) static/dynamic, (2) short-term/long-term variable, (3) sequential and other (Becker, 2003).

The organizational model, compared to the real organization, defined on the basis of different positions, which are described and integrated in various ways: (1) information, (2) functional aspect, and others. For the structuring of complex dynamic systems the concept of system architecture may be used. Architecture is defined on the basis of the reference methodology selected by the organization, whose level of the adoption or adaptation is defined by methodology and reference architecture of the organization.

The reference architectures and methodologies have been developed over the last thirty years. The international group of IFAC/IFIP proposed a solution to a generic reference architecture of an organization called GERA (Generic Company Reference Architektur), which was later standardized by the ISO 15704:2000 - Industrial automation systems - Requirements for organizations - reference architectures and methodologies (Industrial Automation System - requirements for enterprise - reference architectures and methodologies).

Basic principles of integration, which are definitive in this standard are:

- identification of the organization and the organization's mission,
- separation of functions to achieve the mission and functions of control,
- identification of process structure,
- process of identifying the content,
- identification phase of the life cycle,
- evolutionary approach to the integration of companies, and
- modularity.

Process-oriented modeling concepts are obliged to preserve the functionality of business processes and their behavior. By GERA methodology application, these requirements are achieved by (Arsovski, 2012):

- lifecycle phases of entities and organizations in the life cycle,
- entity life history,
- types of entities in the organization, and
- integrated modeling and model views.

Figure 1 shows the stages in the life cycle methodology organization GERA entity.

The paper presents the results of the development of this model for the first three stages in the life cycle of the entities, which are developed and implemented in the local telecommunication companies. The life history of a dynamic entity is the next phase

in time, realized primarily through various projects of information systems in the organization.

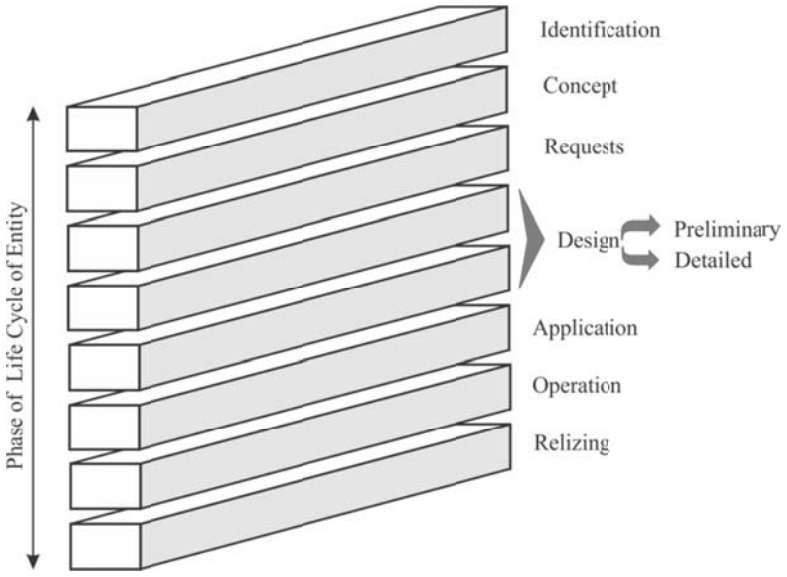


Figure 1. Stages of the life cycle of the entity according to the GERA methodology

The types of entities in the organization can be classified into two main categories:

- entity-oriented operations, and
- generic and recursive set of entity types.

Among these types of entities there are intimate relationships, because the identification of the output of one entity type is the result of operations of other types of entities.

In a study of telecommunications organizations the following entities are recognized: strategic management, organizations, products, processes and development methodologies (Figure 2).

Modeling of the process reproducts work of entities and entity types with the following aspects: functional, behavioral, informing, resource and organizational. This approach allows the creation of models for decision support, as well as more efficient monitoring and management of processes in the organizations.

In modeling, of organizations and processes, by appling the GERA methodology, it is necessary to define the following sub-models or attitudes:

- the content model entities (functions, information, resources, organization),
- purpose entities (products and services to clients, management and control),
- attitudes application persons (employees tasks, automated tasks, task management), and
- attitudes physical manifestation of an entity (software, hardware).

ISO 15704:2000 allows other views, which depend on the specific needs of the organization.

3. Modeling and Business Process Maturity

3.1. Business Process Modeling

Given that the business process is fully enclosed, timely and logically separated activity or series of activities that are

necessary for the execution of the particular business object Porter (1980) has defined a model of the value chain. The business activities were divided into primary and support activities. Within this process model process activities/processes were separated from the rest of the organization, so that for each activity there are defined: (1) inputs, (2) outputs, (3) resources, (4) the regulation process, (5) the manner and process management, and (6) a responsible process owners.

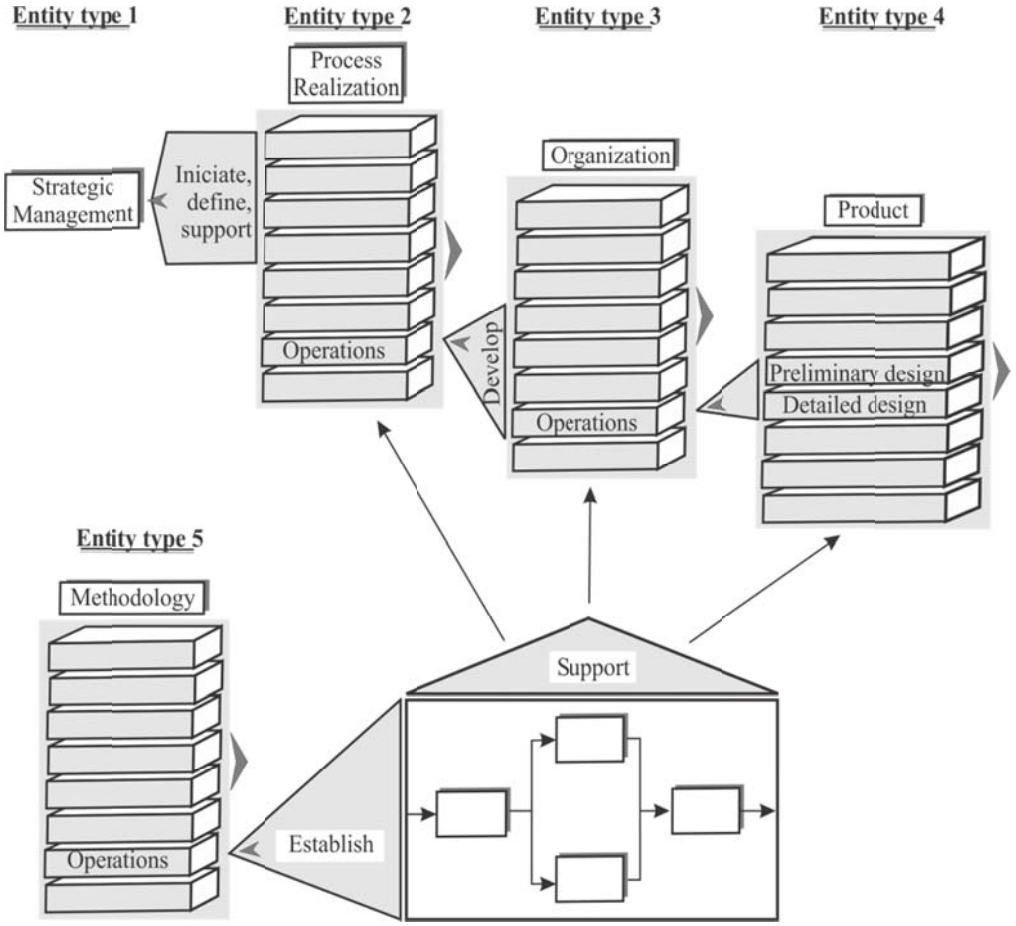


Figure 2. Example of the relationship entity types according to the GERA methodology

Selection criteria for business processes are: (1) the relevance of the market, (2) the potential for improvement and (3) the possibility of achieving. According to Becker (2003), the modeling process is carried out in seven stages as follows: (1) preparation for process modeling, (2) the development of strategies and frameworks of business processes (3) modeling and analysis of existing conditions, (4) modeling and optimization of a future state, (5) the development of process-oriented organizational structure, (6) the introduction of a new organization, and (7) the continuous improvement of process. On this basis, a number of different modeling approaches has been developed (Arsovski, 2006; Binner, 2000; Wagner, 2001) in which certain aspects of business process modeling are treated.

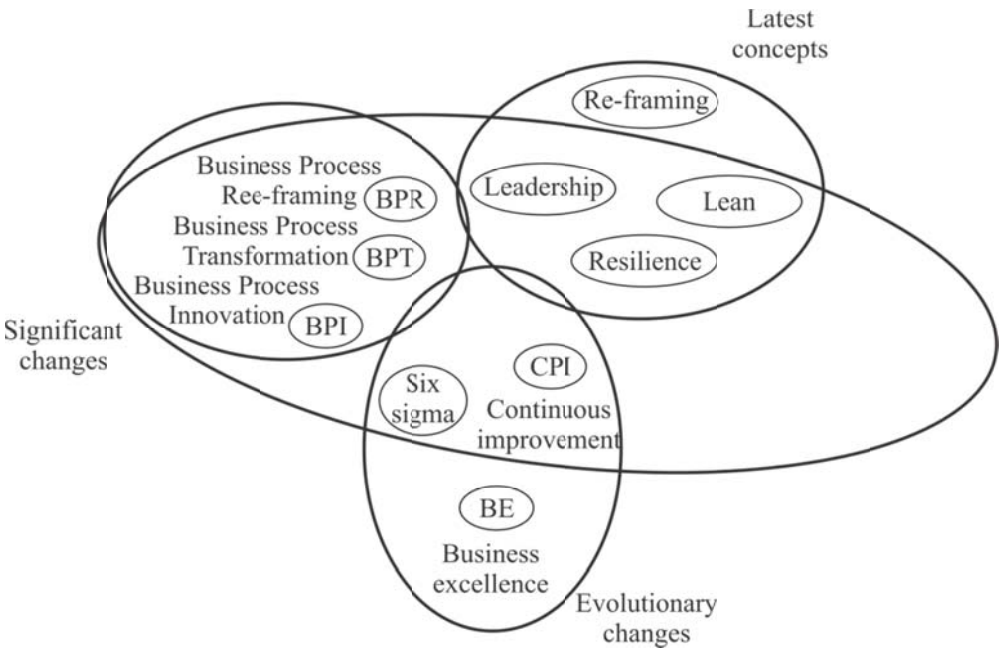


Figure 3. Central elements of the business process changes

On this basis of the concept of six sigma 1986 the concept of Business Process Management BPM is developed at the end of the 21st century. BPM basis was setted by Hammer and Champy (1990) and at the beginning of the 20th century it reached a major sweep (Smith and Fringer, 2002; Jeston and Nelis, 2006). The concept of BPM was further developed and integrated with many other concepts.

The new BPM methodology involves more stakeholders in the initiation, propagation, understanding and designing of business processes (Miers, 2006). At the same time, significantly increasing the number of iterations in terms of flows, integration, metrics, control operations, user interface, feedbacks, using simulation techniques and scenarios, adaptation and review.

In addition to the description of the process, which was the focus at the beginning of the development of the BPM, now the emphasis is on the business process change (Graver and Markus, 2008) as shown in Figure 3.

To design a business process Information and Communication Technologies (ICT) are used more and more and different analytical techniques and tools. Hofaker and Vetschera (2001) have proposed an algorithmic approach based on genetic algorithms. This problem is analyzed in Deweerdt *et al.* (2012) and found that most applied approaches are based on algorithms. Among these approaches are based on the classification and clusters, and inductive logic programming and probabilistic approaches.

The output from the process of modeling is the process model. Given the large number of different approaches and modeling facilities, there are differences in the consistency between the process models, which include: increasing the "fineness" of the process model and the identification of correspondences between them. Observed inconsistency may refer to the difference from the reference or other models. If the degree of equivalence of elements is larger, they are considered to be more consistent process.

4. Business Process Maturity

The maturity of business processes is a logical extension of the concept of BPMN. Maturity models typically include a number of levels in the form of anticipated, desired or logical way from the initial state to full maturity process (Becker *et al.*, 2009), maturity models represent theory on the progress of the organization features step-by-step in a logical way. This involves defining characteristic at each level of maturity. According to Roglinger *et al.*, (2012) framework to design maturity has three levels:

1) Basic principles of design:
   - obtaining basic information,
   - definition of the focus of maturity,
   - definition of the focus of the application domain,
   - Documentation of target groups.
2) Principles for descriptive use:
   - criteria that can be verified from multiple entities.
   - assessment methodology oriented towards target groups and
3) Design principles prescribed for use:
   - improvement measures for each level of maturity,
   - decisions and calculations for the selection of measures to improve the
   - adopting methodologies oriented towards the target group.

Roseman and Bruin (2005) distinguished five groups of properties model BPM maturity:

1) as a tool for diagrams,
2) as a tool for identifcation and relations between activities,
3) as a means for determination of priorities for decision-making,
4) as a means for measuring the performance of the process, and
5) as a tool for internal and external benchmarking.

In their paper criteria for measuring the maturity of BPM are highlighted, and they are:

- number of processes,
- involvement of staff, and
- relationship with other management tools.

Factors influencing the maturity dimensions are related to: (1) culture, (2) performance, (3) the harmonization, (4) responsibility, (5) methodology, and (6) the use of ICT.

The ISO 9004: 2009 is defined by a tool for assessing the maturity of an organization with five levels and the following key elements:

- leadership and management of sustainable success of the organization,
- policies and strategies,
- management of resources,
- management of processes, and
- improvement, innovation and learning.

Process orientation and maturity influence the process of innovation performance and business performance. According to Tang and Iijima (2013) the impact of process orientation on innovation performance is obtained through:

- process approach,
- engaging people in the process, and
- management and measurement of the processes.

and the effects of process orientation are:

- strong cross-sectoral integration,
- strong integration with customers, and
- increased employee innovation.

All of which affect the innovation performance of a larger organization.

Measuring and improving business performance is linked to BPM (Martin,

2010). In the development of performance measurement systems starting from the excellent leadership (top management level), and then over the top management and the benefits of ICT teams at the level of the business units and local teams in four phases:

- creation of a stable process,
- identification of high risk property damage,
- the development of libraries of standard and proven software solutions, and
- the creation of the organization of quality assurance on the basis of developed quality metrics process.

5. Selection of the optimal model of business processes and software to support the process modeling

5.1. Influence of ICT and Business intelligence

Characteristics of ICT solutions significantly affect the choice of business process model. In order to realize the necessary characteristics of ICT solutions must come from the IS strategy (Chen *et al.*, 2010). This work aligns the business strategy development processes with IS strategy, and through it the IS strategy and the impact of IS strategy.

Peppard and Ward (2004) analyzed the strategic role of IS in particular pointed to the IS necessary competence and did their bond with the processes, which are primarily human resources with: (1) business skills, knowledge and experience, (2) technical skills, knowledge and experience, and (3) behavior and attitudes. Competitiveness in the future is crucial knowledge and rezilient ICT infrastructure.

Caldeira and Ward (2002) have pointed out the conditions for the successful adoption of ICT in small and medium-sized enterprises. The authors pointed to the problem of measuring the performance of ICT applications, in particular the concept of customer satisfaction information as a set of positive and negative reactions from users. For the 12 industrial sectors they are defined clusters in two-dimensional fields:

1) The level of ICT adoption:
   - only administrative processes,
   - plus key production processes,
   - plus integrated key processes, and
   - plus external integration, and
2) The relative level of success of the application of ICT:
   - unsuccessful,
   - less satisfied,
   - satisfied, and
   - successful.

They concluded that on the success of the adoption of ICT a major influence has top management and attitudes in terms of ICT adoption, as well as internal ICT competence of employees.

Mans *et al.* (2013) analyzed the impact of IT in healthcare by applying process-oriented methodologies. In doing so, they use approaches "process mining", and discrete event simulation, for "as-is" and "to-be" analysis phase. The entrance to the "process mining" for "as-is" analysis is to identify the events in the current situation, and the "to-be" analysis identifying the event for the application of new digital technologies. For developed ProM framework emphasized the possibility of applying the CPN (Coloured Petri Nets) and other techniques and tools. Through the proposed simulation model indicated a possible realization showed performance measures for patients, dentists and dental technicians.

Figures 4 and 5 show the results, from figure 4 it that can be seen that in the sample dominat are the organizations with 5 - 50 employees, and from figure 5 that the dominant grades are in the range of 6 - 7 (on a scale 1 - 10), where a lower score indicates on the lower level, and the higher the score the higher the level of implementation of BI.

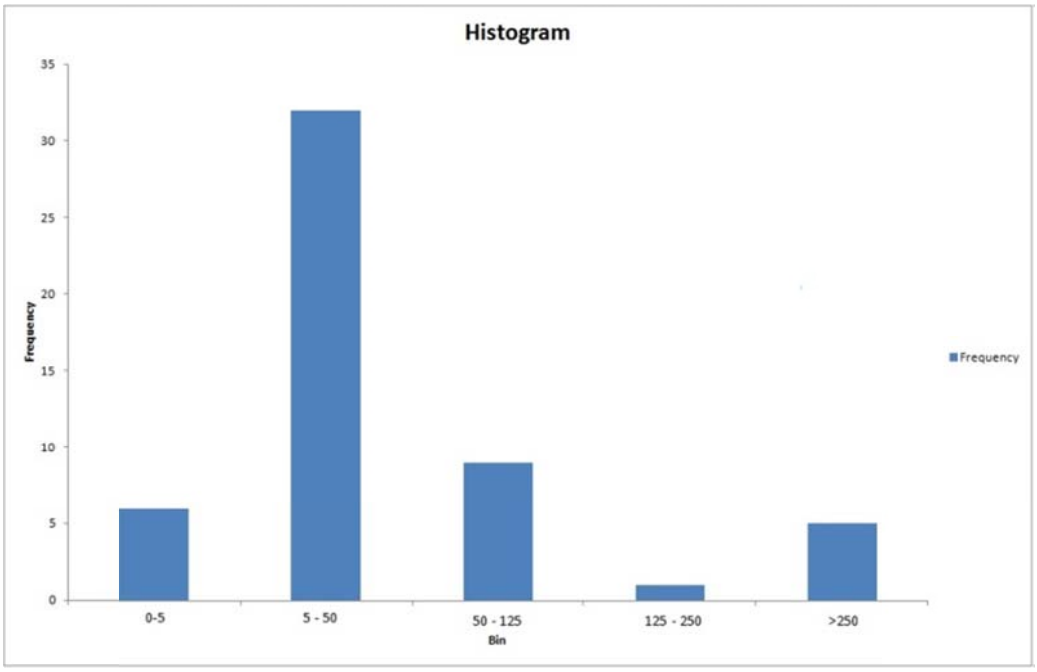


Figure 4. Distribution of employees in the measuring sample of 53 organizations in Serbia

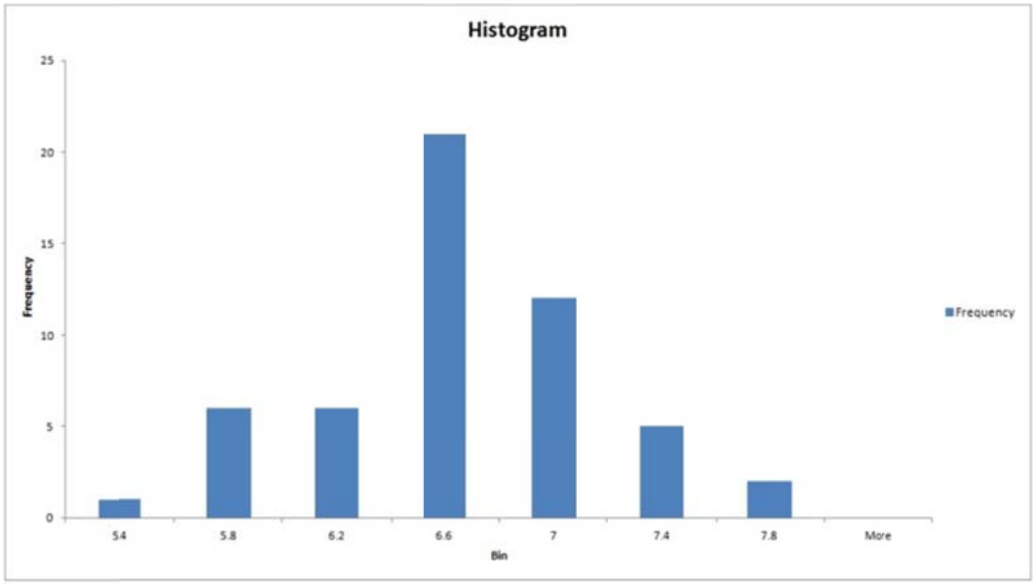


Figure 5. Distribution of the frequency of BI application score

BI application Rating level is based on the conceptual assessment of:

- BI products,
- BI solutions,
- BI performances, and
- BI tool.

Impact of quality of information exchanged in use of the inter-organizational information

systems has been investigated by a group of authors Harton *et al.* (2010).

They proved that properties of IT infrastructure and the level of support of top management have a positive impact on the quality of distributed information, and those in turn on the general performance of the company and the supply chain.

Choe (2008) has researched the impact of relationships within the organization using the IS and information through value chains. For transactional and management information in a variety of industry sectors he has analyzed a clinical impact of these types of information on the quality and reliability of delivery, flexibility and cost reduction. This made it possible to analyze the cluster in order to form strategic alliances and virtual organizations.

Alliance of BPM and SOA (Service Oriented Architecture) as a strategic alliance was investigated by Behara (2006).

In doing so he observed relation between levels of:

- business processes
- services
- aplications and
- technologies.

In relation model performance monitoring at the exit of service-oriented architecture is defined, which is the entrance to the BPM (the stages of modeling, simulation and process redesign).

Looy *et al.* (2013) discussed the selection problem of model maturity process starting from the conceptual model BPMM (Business Process Maturity Model). Based on the analysis of the theory of project design in terms of product and process design, they have identified the key requirements and defined the appropriate model of decision-making. By applying Delphi method they have determined the significance of the characteristics of the model in the fields of: (1) modeling, (2) diffusion, (3) optimization, (4) management, (5) a culture and (6) structures.

For the selection of the optimal model they used multiple criteria decision making. The final list of selection criteria BPMM included the:

- possibility of evaluating and improving the properties of business processes,
- number of business processes,
- Type of business processes (internal and external),
- function of user toward the organization,
- model purpose,
- method validation model,
- architecture type of model,
- details of model architecture, which affect the maturity,
- data collection techniques,
- scale for evaluating the collected data,
- plain availability of elements for the assessment,
- direct costs,
- number of questions for assessing the maturity,
- assessment of maturity duration.

In this paper, April *et al.* (2005) analyzed the problem of improving BPM application simulation. The authors, starting from the process map in health care, pointed to the modern concepts of simulation using the simulation and metaheuristical optimizer, that can be used in practice to add metamodel and decision filter.

The problem of decision-making increasingly includes knowledge, any knowledge of such facts or tacit knowledge (experience, attitudes, etc.). If the decision problem is complex, each case must be separately analyzed and approach applied to the management cases involving:

- intensive use of knowledge,
- variability,
- long-termness,
- cooperation and coordination,
- increased number of participants with multiple roles

- connection between the cases,
- critical timeline,
- presence of external dangers,
- hardly noticeable progress in the present case,
- ultimate reporting requirements,
- historical retrospective case,
- safety,
- isolated "islands" of automation.

Relation problem of BPM and BI has been analysed in paper Vukšić *et al.* (2013) for telecommunications and banking companies, The authors found regarding:

- relation between BI i BPM:
  - BPM give entry to BI,
  - BPM and BI are treated special,
  - There is a specific structure of management BPM and BI,
  - specialties for BPM and BI are cooperating.
- impact of BI on BPM:
  - BI indicates on the problematic aspects of BPM,
  - BI gives entry to BPM in relation to the standard and continuous process improvement,
  - BI provides input for project redesign for BP.
- BI is used for the measurement, analysis and management of business processes, which use the following techniques:
  - data warehousing and and OLAP,
  - *dashboards*,
  - analytical tools,
  - optimization tools,
  - Process performance data obtained from MIS (eg, ERP),
  - manually collected data about business processes.

Turner *et al.* (2012) suggests on three perspectives business processes search (BP *mining*):

- process perspective,
- organizational perspective and
- case perspective.

and the search process types are:

- process review,
- verification of conformity (compliance) and
- extension process.

Authors have grouped the techniques for drawing business processes in the following way:

- transitional systems and regions,
- claster technique,
- evolutionary techniques (e.g., GA), and
- declarative techniques.

They then analyzed the available software tools from the aspect of business processes search type, process models, problem searching process, algorithms and additional properties.

Starting from the goals / criteria analysis and the application of ICT, process owners carry out the selection of process model and then team leader for the process performes business process modeling. In the next phase, the process owner determines the effectiveness of the modeling process. Depending on the process change, they are accessing choice of methods, techniques and tools. Which affects the level of implementation of ICT. On the basis on foregoing analysis the authors define the general algorithm of choice of optimal methods and software for model selection process (figure 6). With lower changes approach is to amend the targets/criteria.

6. Using genetic algorithms for finding the optimal software for business process modeling

Genetic algorithms have been proposed by John H. Holland in the early seventies. Holand, along with his students developed them at the University of Michigan during the seventies and eighties. The book that was published in 1975 by Holand "Neuronal

Adaptation and artificial system" represents the genetic algorithms as an abstraction of biological evolution and provides a theoretical framework for the application of genetic algorithms. During more than two decades, and especially in recent years, they proved to be very powerful and at the same time general tool for solving a whole range of problems from engineering practice (Đorđević *et al.*, 2013). This can be explained by their simplicity; how the very idea of on which they are established, and their application; and the contribution of a range of scientists and engineers on their adaptation of it to a large number of problems and increased efficiency. In parallel with the increase in application increases the scope of the research work and the properties of genetic algorithms and attempt to reduced their elements on some theoretical theories.

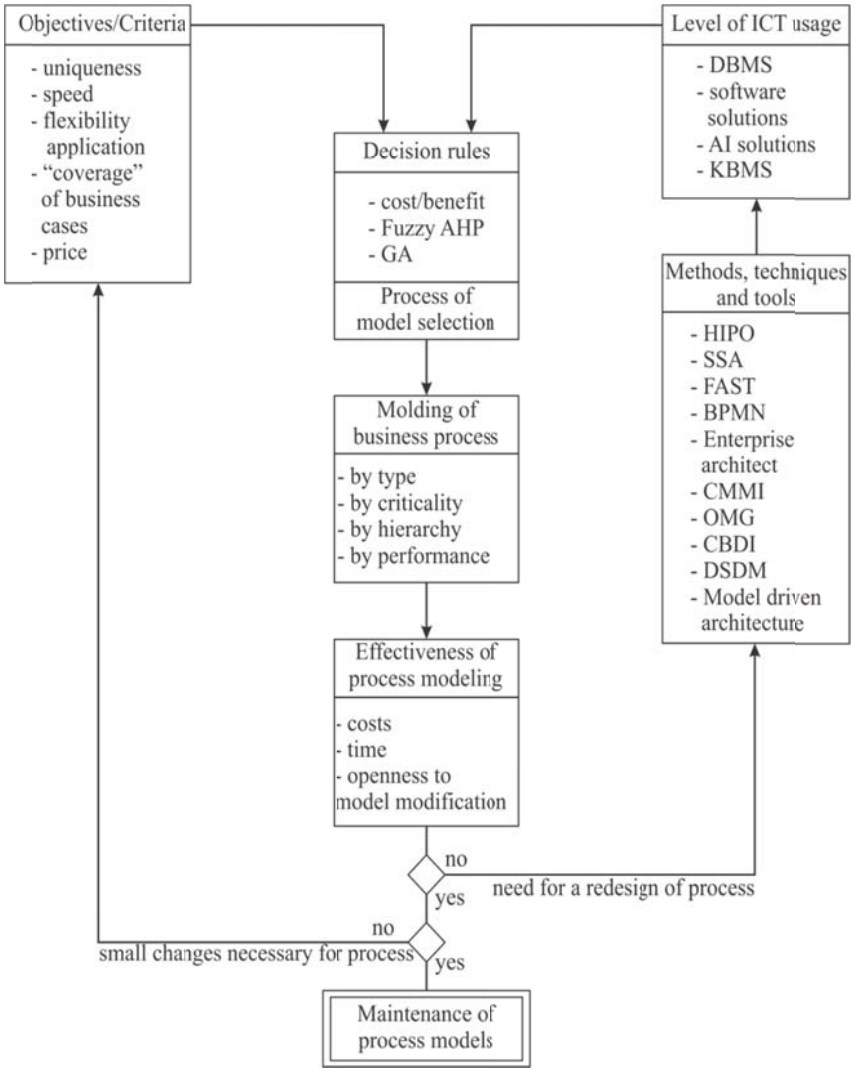


Figure 6. General algorithm for selection of methods and tools for process modeling

Genetic Algorithm (GA) represents one of the techniques of optimization and search based on genetics and natural selection. Optimization alone represents the process of finding the most appropriate solutions. When someone comes up with some new ideas he uses optimization to improve this idea. Optimization consists of trying out variations of the initial concept and use of the information obtained in order to improve the idea. The computer is an ideal tool to optimize until the idea or variables that influence the idea can be entered in an electronic format. Optimization is used to adjust the input of a mathematical process, experiment or characteristics of some device, so that minimum or maximum solution or outpu may be gained. Input data consist of variables, processes or functions and are known as cost function (cost function), the objective function (objective function) and functions of adaptation (fitness function), and outputs ie. solutions are cost or fitness. If the process is an experiment, then the variables are physical size of that experiment (Haupt and Haupt, 2004).

The importance of genetic algorithms lies in their ability to determine the position of the global optimum in a space with more local extremes, the so-called. multiple- modal space. Classical deterministic methods will always move toward a local minimum or maximum, whereby he may be global, but it can not be determined from the results. Stochastic methods and genetic algorithms, are not dependent on some possible starting points and can provide its search process with a probability of locating the global optimum of a specific target function. The main difference between the classical and the application of stochastic methods is that the result of some, let's say, the gradient methods we can say with certainty that there has been local extrem within the desired accuracy. For the result of a genetic algorithm, however, we can not say with absolute certainty whether he represents a global or a local optimum, and whether the same is determined with the desired precision. As much as stochastic methods improve our performance, they will never be able to give any result with absolute certainty. Safety of results obtained significantly increases by the repetition of process solving, which in classical method does not make sense. Since the genetic algorithms incurred great attention is given to research related to increasing the efficiency of execution.

In recent years, genetic algorithms are one of the most interesting topics in the context of computer technology and AI (artificial intelligence), because the technology has found a way to commercialize their application Application of genetic algorithms gives good results in combination with neural networks (Chow *et al.*, 2002). Genetic algorithms are used in the search for the shortest path (Mulyana and Killat, 2002), some of them have used the algorithm for finding the shortest path to the Internet from source to destination in compliance with the protocol (Buriol, 2005), while others are used for finding optimal path in the supply chain, and in problems similar to the transport problem, in order to select the optimal number, locations and capacity of manufacturing plants and warehouses, which should be opened in order to meet all user requirements with minimal costs of distribution network (Amiri, 2004; Ganeshan, 1999; Gen *et al.*, 2006). One of the most interesting is an optimization problem which the authors deal with when it comes to genetic algorithm, the traveling salesman problem (Zhao *et al.*, 2009; Hernández-Pérez and Salazar González, 2007; Hernández-Pérez *et al.*, 2008) with the aim of finding the shortest possible way such that each city is being visited exactly once and returned to the prime city.

A similar example of the application of genetic algorithms is the problem of finding the optimal software for business process modeling. The results obtained by this method in quality can be compared with the results obtained using the most popular algorithms, which are based on Tabu search

(Pezzellaa *et al.*, 2008). Arrange Activities are arranged and designed using rules of priority in which the priorities are defined using a genetic algorithm. Schedules are constructed using the procedures that generate active parameterized schedules (Goncalves *et al.*, 2005).

Many real problems, which include finding the optimal parameters, may prove to be very difficult for traditional methods, and very easy to genetic algorithms. In this article are some examples of the application of genetic algorithms. However, the field of application of genetic algorithms is a lot wider and growing daily.

7. Multi-objective methodology for finding the optimal choice of software for business process model

Most real optimization problems, such as the selection of the optimal model of business processes requires simultaneous optimization of more than one objective function. Often, important goals can be in conflict. For example, the software for business process modeling with the lowest price, can have poor quality. Therefore, the customer must carry out an analysis and find a compromise solution to more relevant criteria. Bi or multi-criterion approach enables evaluation of multiple criteria. This paper proposes a multi-criterion model for optimal software for model business processes. The paper proposes the use of a genetic algorithm (GA) to find the optimal model of business processes with the appropriate solutions which are obtained in the form of Pareto Front.

The most commonly used criteria in the literature, when it comes to multi-criterion selection of software are maximizing the functions of positive characteristics (eg. Quality) and minimization of negative characteristics (eg, prices). This paper analyzed on the basis of the most essential characteristics for which software is to decide. We considered 20 types of software for business process modeling, with 9 main features to determine the individual qualities of each of the softwares for business process modeling.

Software characteristics, on the respective weighted value, are the following:

- K1 (0,05) – the required level of knowledge about the processes (-)
- K2 (0,10) – the required level of knowledge of IT (-)
- K3 (0,05) – visualization of process flows (+)
- K4 (0,10) – ease of implementation of changes (+)
- K5 (0,05) – level of designers collaboration process (+)
- K6 (0,20) – price (-)
- K7 (0,20) – model quality (+)
- K8 (0,10) – level of special requirements (-) in terms of hardware and software
- K9 (0,15) – Number of methods, techniques and tools (+).

Software tools are shown in Table 1, while the scores relating to the nine main features are shown in Figure 3.

Optimization was performed using MATLAB tools for multi-objective optimization using the GA (gamultiobj). In MATLAB are defined both target functions separately. Thus, the formal definition of optimization problem read as follows:

$$\text{Min } f_{1(K1,\,K2,K6,K8)} = \sum_{i=1}^{N} x_i * K1 + \sum_{i=1}^{N} x_i * K2 + \sum_{i=1}^{N} x_i * K6 + \sum_{i=1}^{N} x_i * K8$$

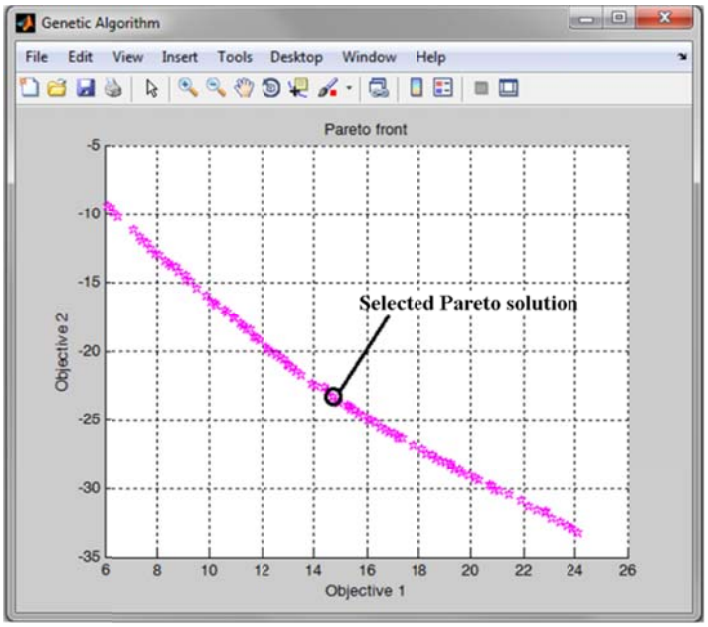
$$\text{Max } f_{2(K3,K4,K5,K7,K9)} = \sum_{i=1}^{N} x_i * K3 + \sum_{i=1}^{N} x_i * K4 + \sum_{i=1}^{N} x_i * K5 + \sum_{i=1}^{N} x_i * K7 + + \sum_{i=1}^{N} x_i * K9$$

Table 1. Software tools

No.	Software title	Supplier	www address
1	ARIS Express	Software AG	www.ariscommunity.com
2	Cacoo	Nulab	www.cacoo.com
3	Calligra Flow (formerly Kivio)	KDE	www.calligra.org
4	Creately	Cinergix	www.creately.com
5	Dia	Dia developers	wiki.gnome.org
6	Diagram Designer	MeeSoft	meesoft.logicnet.dk
7	Edraw Max	EdrawSoft	www.edrawsoft.com
8	grafShare	grafShare collaborate graphically	www.grafshare.com
9	Inspiration	Inspiration Software	www.inspiration.com
10	LibreOffice Draw	StarDivision	www.libreoffice.org
11	LucidChart	Lucid Software	www.lucidchart.com
12	Microsoft Visio	Microsoft	visio.microsoft.com
13	Modelus Suite	Modelus	vektiva.com/modelus
14	OmniGraffle	The Omni Group	www.omnigroup.com
15	OpenOffice.org Draw	Oracle Corporation	www.openoffice.org
16	ProcesOn	The ProcessOn Team	www.processon.com
17	Schematic	Dot Software Ltd	www.dotsoftware.co.uk
18	SmartDraw	SmartDraw, LLC	www.smartdraw.com
19	Signavio editor	Signavio	www.signavio.com
20	Software Ideas Modeler	Dusan Rodina	softwareideas.net

The results of optimization using MATLAB tools are shown in Figure 7. Pareto optimal solutions are displayed via stars. Using this method, there are up to 105 different optimal solutions, which are mutually non-dominant.

Based on the obtained Pareto solutions one solution is chosen which is in the middle of Pareto front, which gives rang of softwares for modeling the process as shown in Figure 8.



Fugure 7. Optimal Pareto solutions

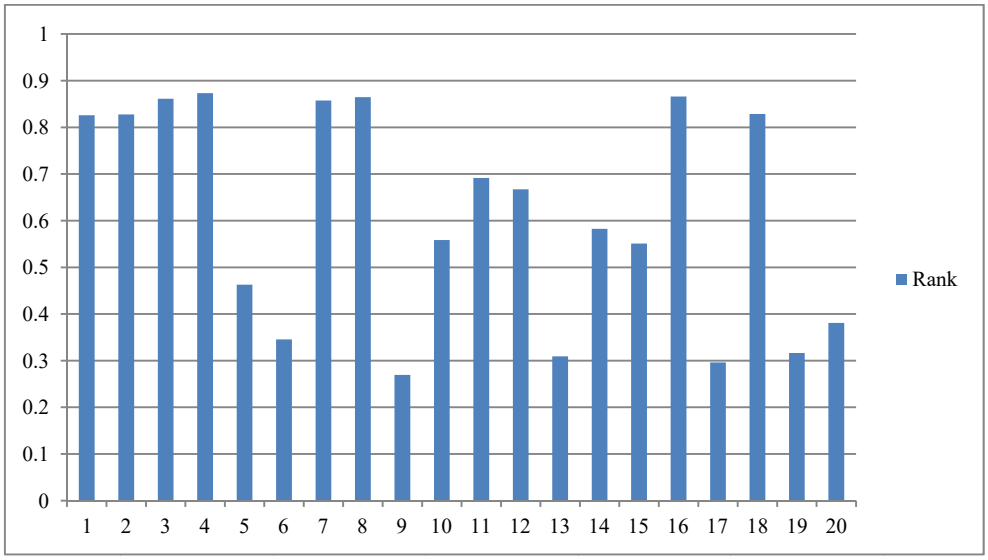


Figure 8. Rank of enterprises for centralized solution of Pareto front

The choice of software is significant because it affects the increase of efficiency of process modeling. The most commonly used models for optimization based on data from the literature are AHP and MIP methods, which carry with them a certain level of subjectivity. GA method is interesting because it is new and easy to modify. It can be concluded that the software tool under number 4 is the best choice, as it offers the best ratio of favorable and negative characteristics.

The paper presents the optimization of the multi-criteria software selection based on the given characteristics.Optimization is made with consideration of each individual objective function, wherein is Pareto-optimal solution obtained. The user can decide which solution is best suited to him. The advantage of this method is that only one optimization search provides a collection of different solutions. The application of the presented approach depends on the affinity and domain knowledge of decision-makers.

8. Conclusions

Methods and tools for modeling business processes were developed intensively in the last 50 years, first in the context of software engineering, and later BPM and BI. On that way were numerous problems existed, dilemmas and many solutions offered. Each of the offered solutions related to the specific context of the application, including the level of ICT infrastructure, knowledge about the processes, BI applications. For these reasons, a survey was conducted in the field of application of BI modeling processes in Serbia. In a sample of 53 organizations was found:

- in organization sample identified was the median level of application of BI, which is a higher level than expected. After analysis of the samples was determined that this is due to the fact that in all organizations is implemented quality management system and conducted process modeling using any of the tools,
- the list of software solutions from 20 software products including BI tools for process modeling has been selected,
- on the basis of previously established 9 criteria of goals the application of GA was carried,

pursuant to which the software solution under number 4 is chosen.

Further research in the future will be related to:

- sample increase,
- inclusion of statistical methods for the evaluation of the importance of influential variables in the model for the application of BI,
- inclusion of more criteria in GA,
- connection of GA with other methods, especially Fuzzy AHP and neural networks.

Limitation of the research is the sample of companies is Serbia, where ICT does not provide sufficient support for business processes, resulting in a very low level of business intelligence application.

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Aleksandar Djordjevic
University of Kragujevac,
Faculty of Engineering
Kragujevac
Serbia
adjordjevic@kg.ac.rs

Tijana Cvetic
University of Kragujevac,
Faculty of Engineering
Kragujevac
Serbia
t.cvetic@kg.ac.rs