Application of AHP method in development of Information Systems

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Abstract. *Change of paradigms, development and improvement of tools used for that purpose are just two sensitive factors applied in development of Information Systems. Besides the possibility of using the tools or applying the final solutions also emerge. Business management has been put in a sensitive position in which it has to carefully evaluate specific circumstances and choose optimal and efficient solution. Very often this applies to situations when a group of parameters has to be carefully defined since their values, mutual influences and dependencies help to eliminate all the unnecessary activities. Application of AHP method is one of the possibilities for solving the occurred situations. This paper analyses the possibilities of applying AHP method in making decisions concerned with development and application of Information Systems and its connectivity with methods and tools used for the same purposes.*

Keywords. Information System, AHP method, Decision making, Case tools, Implementation

1. Introduction

Founding and building of a concrete business system requires careful planning on several different levels. The customary thing is to plan on three basic levels: the operative level, the tactics level and strategic level. Besides, the development of ICT and globalization of business dealings, as well as the need for constant adapting to the market, requires a finer and more flexible planning level – the level of business transactions. Preparing of high quality plans is linked with collecting and processing relevant information that will be used as the basis for planning and making decisions. An information system does not exist by itself, but it is necessarily linked with a business system it serves as backup for good overall realization of business processes and full business function.

In recent literature one may encounter the viewpoint how an information system is the data image of a process from a business system realized through data models, process models and user models. The relation between these two phenomenon has first of all symbiotic characteristics. This is why an information system must be defined as a higher projection of a business system, where the information processes reflect the information dimension of the business processes. Where the quantity of information is extensive and its processing is complex, ICT is a necessity.

It is evident that similar to the business system the information system requires careful, if not even more careful planning on the mentioned levels. It is of exceptional importance for both the management and working teams which and what kind of methods to apply when planning, especially when making certain decisions. Methods should provide efficient and effective

plan realization, meeting of terms and elimination of possible risks.

2. Strategic planning of information system development

In strategic planning we can have two situations: the initial position is to create a completely new system or to have strategic planning for developing of the existing system. In both situations, especially the latter one, it is necessary to carry out the analysis of ICT influence when making the strategic plan, make the design and information system development plan, and the analysis of the existing situation. However, there are certain differences in defining the information system development strategic planning. Strategic planning is defined as the process of defining a group of applications that provide competitiveness for the business system through reaching business goals or as a process of business dealings planning and analysis with the goal of making an informatics plan on basis of the business system organization [1] or as the making of the informatics strategic plan, the realization of which, based on the best use of all resources, would lead to meeting all the business system goals. By synthesizing various definitions and approaches, the informatics system strategic planning was defined as the process of the information system development that will provide reaching of strategic business goals for the business system [2].

2.1. The strategic plan for developing the information system

A strategic plan for developing a business system must be supported by a strategic plan for developing the information system. When mentioning further down the strategic plan we shall also have in mind the strategic plan for developing the information system. It is usual that a strategic plan should contain strategic elements: mission description, vision, goals, directions, possible problems and success critical factors.

It is also necessary to have a model of the organization system on a global level on basis of which it is possible the get the necessary information on: the function model, information model, business process model, user model. A strategic plan is a basic document and all further activities in carrying out the plan are based on it. Making of a strategic plan depends first of all on the business system size, but as to the time period – it should not be longer than half a year. The synergic relationship between the business systems – information system is hereby stressed, based on the fact that the information system strategic plan is derived from the strategic plan for the business system. On the other hand, synergy is necessary for reaching the goals as to business dealings and a competitive position in the market. It is presumed that there will be careful bringing into coordination of the system's business and information domains. While the organizational infrastructure includes the business system structure, business processes and personnel, informational infrastructure includes all technological and human resources necessary for the development, implementation and maintenance of the information system.

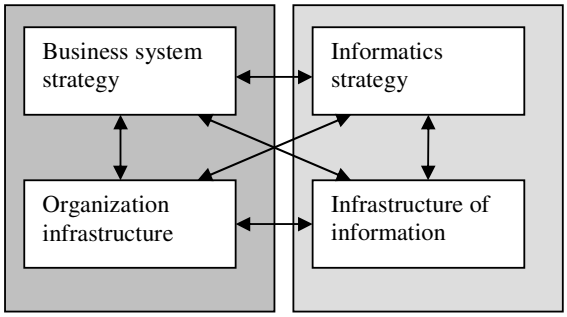

Figure 1: Strategic bringing into coordination of the business and information domain [3]

Various strategy models and methodology for bringing into coordination elements belonging to the information and organizational domains can be found in literature. Fig.1. shows directions of the element influence between themselves. In this manner eight basic approaches may be defined of strategic bringing into coordination of the mentioned elements and four derived ones that are a combination of two basic ones [3].

Each of the approaches includes three to four elements and one of the elements is the main one here (the so-called anchor) and it influences directly the second element and indirectly the third element. Thus the business system strategy (anchor) is realized through bringing into coordination the organizational infrastructure with information infrastructure, whereas realizing competitiveness in the market is provided by direct bringing into coordination of the business and information system strategies by indirect influence on the business infrastructure. In this case the anchor is the information system strategy that has the so-called offensive architecture because it stresses the information processes importance. There is special influence of organizational and informatics culture of elements, the importance of which is uncovered in carrying out the strategic plan of building the information system. The targeted state is the state of balance between the listed elements and this is a pre-condition for efficient carrying out of business goals and the system's competitive capabilities. In this case achieving the balance and keeping the balance between elements are two separate processes but with mutual pre-conditions.

The result of strategic planning is a strategic plan or strategic plans in case it is permissible to allow the possibility of alternatives. A strategic plan must be precise, integral but also flexible, i.e. possible to adapt to certain changes caused by the necessity of coordinating with business plans and changes in the technological environment. Preparing a strategic plan does not comprise its realization yet. However, the prepared strategic plan is the basis for estimating whether the investments into informatics will be justified and in which way, and whether they will answer to the expected business system needs.

Of course, the financial aspect for strategic planning is of exceptional importance. Strategic planning is supported by financial investments that are by no means insignificant. Therefore, it is important to justify the investments, with the displaying of time and quantity structures of the invested means return. Due to different reasons it is often the case that organizations decide to invest into ICT without preliminary estimates and strategic plans. In such cases the consequences may be catastrophic in respect to the business system. Let us list some of them: failure in investing because the developed information system does not follow the business system in an adequate manner, the possible inconsistency and poor integrated state, frequent necessity to change plans, poor information control, conflict situations between the elements in the organizational and informatics domain and the need for constant and significant modifications [4].

2.2. Methodics for strategic planning of the information system development

What and what kind of methodic should be applied for strategic development planning of information systems? Because of following up with the development and improvement of informatics technology, the approach to strategic development planning of an information system has been changed. By classifying them in time and in respect to orientation, we can discuss on classic general jobs such as IBM BSP methodology or structural such as SSADM, data oriented such as Oracle's CASE*Method, object oriented such as OMT all the way to today's predominating, combined methodologies. More recent methodologies are supported by corresponding CASE tools [5]. If we observe the information system as several projections of a business system carried out through data models, process models and user models, the use of corresponding methodologies in planning and development of each listed model is necessary. Modeling of the data includes planning and creating a database model: EVA model and relational data model in the range of relational databases and object oriented data model in object oriented databases.

Changing of paradigms in the approach to designing and programming usually requires a change or at least a modification of applied

methodology in strategic planning of information system development. Turning from the procedural approach towards the object-oriented approach is the best example. In such situations it is advisable to apply combining of tested and suitable methodologies for strategic planning of certain information system development phases. A systematic approach and the corresponding method combination (SPIS methodology) may be observed in the paper [5], where the authors propose a combination of tested methods and techniques. The proposed combination of methods and techniques fully covers all goals set by the strategic plan.

2.3. Strategic decisions making for IS development

The strategic plan is made by a team most often consisting of experts who will subsequently carry out the projects set down by the strategic plan. The team usually consists of the organization's managers, informatics experts and key users of the information system. The key users in time have the leading role in caring for the modeled processes and data. In carrying out a project it is often necessary to outsource consultants specialized for certain areas or skilled in using high level CASE tools. The load of planning and strategic plan realization should be evenly distributed between team members. In carrying out the plan the greatest load is usually on the key users because their work is doubled during certain phases. The ones in charge of methodologies are usually the informatics experts, and they usually carry the load of teaching and introducing novelties, while the others in the system usually try to avoid such novelties due to inertia.

There are specific moments in making and carrying out the strategic plan for building an information system. Those are moments of bringing the decision on the beginning of making a strategic plan, on the beginning of carrying out a strategic plan, on the choice of the corresponding equipment. The complexity of decision-making is pre-conditioned by the environment in which the decision is being made, by the number of possible alternatives and the complexity of set goals [6]. Decision-making involving multiple, sometimes conflicting, objectives and/or criteria is called Multi Criteria Decision-Making, MCDM[7]. Often the criteria include both qualitative and quantitative factors, whereas the quantitative criteria may be measured in incomparable units. One of the MCDM methods to which recently much attention is being paid is Analytic Hierarchy Process[8]. Applied methodologies for strategic planning must answer adequately to requirements for good decision-making at the right time. If, for instance, modification of the existing information system presumes the use of the corresponding methodology for which the business system does not have the adequate experts, it is necessary to outsource experts. Besides the organization being forced to spend extra means, it is placed in a situation that it must search and choose between what is offered at the moment. The application of suitable methods on basis of which the decisions will be brought in the said situations is of exceptional importance.

3. Analytic Hierarchy Process

A hierarchy is a system of ranking and organizing certain phenomenon where each element of the system, except the highest one is subjected to some other element of that system. Hierarchical diagrams most often are formed in pyramids, due to the fact that on the structure's top there is only one element. We usually use hierarchy with the goal of presenting a more complex reality: we dissemble the real world into parts; we then dissemble those parts into even smaller parts, until we are in the position to see unmistakably a certain part of the overall structure as an independent whole. In this we temporarily ignore the remaining part of the system. Thus, by going through a process we acquire a complete idea about the complex reality we are studying.

The analytical hierarchy process (AHP) is a methodological approach that helps in the

process of bringing decisions and it includes structuring of criteria for numerous options in a hierarchy, including relative values of all criteria, comparing alternatives for each criterion and setting the mean importance of the alternatives. AHP is a structured technique that is used when making complex decisions. The goal is to offer, not only «correct» decisions, but to single out one of the possible ones, for which it is evident on basis of the said technique that it is the most adequate one and most favorable one for the users. AHP provides a substantial and rational framework for problem structuring, as well as presentation and qualification of elements that make up the issue. Techniques for connecting such elements make it possible to direct everything towards the final solution, as well as techniques for ranking alternative solutions. AHP is considered as a multi-criteria decision-making method. The concept of AHP, as well as some other theories was made meaningful by Thomas Saaty, the American mathematician from the Pittsburgh University [8]. The advantages and benefits of this method are the following:

- With the help of AHP subjective and objective measurements can be covered more easily with an efficient mechanism for checking whether the measurements are true
- The possibility of checking alternatives proposed by the development team members with the possibility of reducing the differences that make decision-making more difficult
- AHP makes it possible to minimize the most frequent mistakes in the process of decision-making such as focus shortage, mistakes in the planning segment, errors in the control segment of all the participants, etc.

However, the most important advantage of AHP is independence in application. AHP is not limited to certain business functions. It may be applied in decision-making in an equal manner in all business system segments; in the account department, marketing, production or logistics (the example of application in the account department [9]). Significant is the application of the AHP method in informatics at the beginning of last century's nineties in decision-making in the area of planning and development of information systems[10].

Basic deficiencies and drawbacks of the AHP method:

- Lack of theoretical foundation when constructing a hierarchy may bring to developing different models describing an identical situation and this may result in completely different final solutions
- AHP critics consider the ranking as unreliable because it is based on the user's subjective idea of the system
- The possibility of significant discrepancies in respect to individual values – evaluations for individual elements, as well as to composite-collective values
- AHP does not have any anchors in basic theory of statistics

3.1. Basic AHP method settings

The foundation of AHP is a set of axioms that carefully delimits the scope of the problem environment [8]. It is based on the well-defined mathematical structure of consistent matrices and their associated right-eigenvector's (non zero vector) ability to generate true or approximate weights [8]. The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pairwise mode. AHP uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales [8]. It converts individual preferences into ratio scale weights that can be combined into a linear additive weight w(a) for each alternative a. The resultant w(a) can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice. Given that the three basic steps are reasonable descriptors of how an individual comes naturally to resolving a

multicriteria decision problem, then the AHP can be considered to be both a descriptive and prescriptive model of decision making.

3.2. AHP axioms

Every theory is based on axioms, basic and implicitly included facts that make the theory applicable. AHP is based on three relatively simple axioms.
The first axiom, the reciprocal axiom, requires that, if PC(EA,EB) is a paired comparison of elements A and B with respect to their parent, element C, representing how many times more the element A possesses a property than does element B, then PC(EB,EA) = 1/PC(EA,EB).
The second, or homogeneity axiom, states that the elements being compared should not differ by too much, else there will tend to be larger errors in judgment. When constructing a hierarchy of objectives, one should attempt to arrange elements in clusters so that they do not differ by more than an order of magnitude in any cluster. (The AHP verbal scale ranges from 1 to 9).

The fundamental scale for pairwise comparisons		
Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
2	Equally to moderately	*
3	Moderate importance	Experience and judgment slightly favor one element over another
4	Moderately to strongly	*
5	Strong importance	Experience and judgment strongly favor one element over another
6	Strongly to very strongly	*
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
8	Very strongly to extremely	*
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
Intensities of 2, 4, 6, and 8 can be used to express intermediate values. Intensities 1.1, 1.2, 1.3 (at sub layer level) can be used for elements that are very close in importance. [6]		

Table 1. Judgments scale for Pairwise Comparisons

The third axiom states that judgments about, or the priorities of, the elements in a hierarchy do not depend on lower level elements. This axiom is required for the principle of hierarchic composition to apply.

4. Practical carrying out of the AHP method

Practical carrying out of the AHP method means application of the mentioned AHP principles and realizing AHP functionality in a concrete case. Graphic display of the hierarchical structure is used while processing with the AHP method; i.e., the tree structure. Simple AHP hierarchy includes the goal at the highest level, criteria that are subordinated to the goal and are positioned at a lower level and alternatives on the lowest level (Picture 2). Each alternative is linked with the superordinated criterion level and is covered with certain criteria. Concrete situations are usually more complex, so the middle level – criteria level is decomposed into so-called layers or hierarchy sub-criteria. Once the hierarchy has been constructed, the participants use AHP to establish **priorities** for all its nodes. In doing so, information is elicited from the participants and processed mathematically. This activity is somewhat complex, and the participants have many options on the road to completing it. This and the following sections describe a simple, straightforward example of establishing priorities. According to [6] Analytic Hierarchy Process (AHP) can be divided into nine phases(Table 2):

Title	Mean	Activity description
Problem	Start	Select information system project
List alternatives Importance of criteria	Parallel	The goal in this phase is to select one particular alternative from a set of known options. The first step in AHP is to list all alternatives.
Define threshold levels	Parallel	The threshold levels are defined; these are the minimum requirements which an alternative has to fulfill. Possible requirements are a minimum level for the ROI and the pay-back period. Sometimes there is a logical sequence between proposed systems.
Determine acceptable alternatives		All alternatives listed in step 1 are reviewed with respect to the threshold levels. Alternatives which do not meet these requirements are dismissed.
Define criteria	Sequentially	The management defines the criteria that will be used to judge the alternatives (the projects). [2] suggest three methods to select criteria, a pro/con analysis of the alternatives, using 'off-the-shelf' norms, and the critical success factors technique.
Develop decision hierarchy	Sequentially	The manager develops a decision hierarchy. This hierarchy consists of at least three levels, a goal, criteria and alternatives. These elements are represented in a tree structure. The hierarchy represents the structure of the decision problem.
Compare alternatives pairwise (Relative priorities of projects)	Sequentially	For each criterion, the decision maker evaluates all alternatives pairwise. For each criterion, every possible combination of two alternatives is judged in this way. The other criteria or characteristics of an alternative should not be considered in making the pairwise comparisons with respect to one particular criterion. Managers can make numerical or verbal judgements.
Compare criteria pairwise (important of criteria)	Parallel	AHP determines the relative importance of each criterion. This is done by means of the same process which was used in the previous step to derive the relative priorities of the alternatives. The decision maker compares all criteria pairwise. The manager indicates which criterion is more important, and to what extent.
Calculate overall priorities of alternatives		The overall priorities are determined by means of a linear additive function, in which the relative priorities for an alternative are multiplied by the importance of the corresponding criteria and summed over all criteria. The AHP analysis shows which project has the highest priority.
Sensitivity analysis	Sequentially	Before the manager chooses the project with the highest overall priority, a sensitivity analysis can show the robustness of the overall priority rating. Sensitivity analysis shows, for example, to what extent the overall priorities are sensitive to changes in the importance of criteria. The more stable the ranking of the alternatives, the more confident the manager will be in the proposed choice.
Advice: select project with highest priority	End	Prepare project for realization

Table 2. AHP process

5. Conclusion

ICT development and improvement has caused significant changes in approach to building of an information system. The changes are significant in the area of all information system parts. The period of hardware and software as the basic means of a business system is past history. The Internet and extensive communication possibilities allow informatics type job

outsourcing such as the development of one's own software, decreasing as a result hardware expenses as well as other expenses necessary in order to organize and maintain a system. This opens other questions and other issues, but the issues remain in respect to strategic planning of business and information system development. The supplementary quality of the information and business systems requires the same attention as with planning on all levels, especially on the strategic level.

The importance of bringing decisions requires from the management and other participants knowledge and skills in bringing the strategic plan. The AHP method as the tool or methodology is of exceptional importance, namely at the time of bringing crucial decisions in carrying out set plans. This method's independence is a strong quality making it topical in such a sensitive area as the information system. It is evident that the AHP method by itself is not of such importance, but in combination with information system development techniques it represents a reliable tool for bringing good and timely decisions. The relative simplicity of the AHP method mathematical transformations is also a reason for its application in a wide range of business systems.

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