REQUIREMENTS ENGINEERING AS A TECHNIQUE FOR DEFINING SCALE PAIR WISE COMPARISON IN THE APPLICATION OF AHP METHOD IN THE PLANNING OF TRAFFIC

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Abstract

The analytic hierarchy process (AHP) as multiple criteria decision making method can be effectively used in planning transport and logistics processes within the business system. The most sensitive part of the application of AHP method is setting up the most relevant set of criteria which are the base for comparison the alternative solutions. Score structural complexity through the decomposition is the first phase, which results with the matrix of parameters - measuring on a ratio scale. If there are n alternative solutions it is necessary to define the n (n-1) pair wise comparisons. Team approach to solving these problems allows combine techniques for resolving them. The paper proposes requirements validation as a technique for defining Saaty's scale pair wise comparisons. Beside this, by this technique, definition of business processes through the description of the use cases is achieved. Those definitions can be also used for other purposes.

Keywords

AHP, Requirements validation, business processes, planning, traffic

INTRODUCTION

Functioning of concrete business system from the idea of its establishment, establishment itself, construction and latter maintenance requires adequate planning. Two activities are especially important in the beginning of construction: qualitative planning and creation of qualitative project. Planning is more lasting process in comparison to planning that lasts shorter and results in common product – desirable project. Planning is usually performed on three to four levels. These are, starting from the lowest to the highest: transactional, operative, tactical and strategic. Qualitative planning, regardless to the level of its realisation, requires qualitative information system. Solely qualitative information system can ensure information necessary for adoption of appropriate plan. Relationship between business system and related information system make a whole and is synergy-supplemented. At the same time information system doesn't exist on its own and it can exist only together with business system. Elimination of business activities also causes elimination of information processes and related information system consequently looses its purpose.

Planning, creation and construction of business system as business system, which function is to satisfy needs within logistics and transportation of persons and goods, is specific by its nature and determined speciality. Creation and application of different methods, methodologies and techniques primarily in making the systems and later in planning all business activities demands attentive and serious approach. This paper tries to argument need for simultaneous combining of different techniques and methods from aspect of their mutual supplementation respectively lack of one method supported by the other with purpose of choosing the most favourable projects and making safe and reliable business plans. The first part is elaboration view of some methods of choosing and evaluating the project. The second part considers basic data about AHP method and UML application, as well as the combination of these two techniques. The third part is proposition of combining the concrete activities in planning the choice and evaluation of projects.

PLANNING, DESIGNING AND DEVELOPMENT

Connection between planning and designing business system and related information system allows combination of different techniques. Every plan consequently results in something that can be named as model of future system. Model is simultaneously instrument and tool for simulating the behaviour of future system in natural environment. In this occasion especially useful are different techniques and methods supported by computers. Development of ICT and especially the reorganisation of paradigms in approaching design of primarily information systems provide great opportunities in planning, designing and development of business systems. Paradigms of objectively oriented approach to creation of information systems resulted in tools such as

UML. Application of UML as tool is not restricted by specificities of system that is being planned and designed especially if individual parts of this tool can easily accept specificities of a concrete system.

However, UML as tool can be more effectively used in later phases of system design. Information system is data picture of process derived from business system realised through models of data, processes and users. Therefore information system should be defined as higher projection of business system where information processes reflect information dimension of business processes. Which method to apply in planning and especially making the concrete decisions is exceptionally important for management and for teams that realize made plans. Methods should provide effective and efficient execution of plans, respect of deadlines and exclusion of possible risk.

Engineering economics, or engineering economy, are terms that represent application of different economic methods for evaluation of projects and support in choosing the solutions if there are no alternatives. Engineering economics is evaluation of relevance of plan or project, evaluation of their value and justification of investment. Main goal is to determine the best project or projects. Several papers discuss issues of evaluation and choosing the projects by using one method or combination of two and more methods. Different authors approach the problem from different aspects. Some start from strategic purpose of projects, factor of their choosing as well different qualitative and quantitative methods of choosing the project [1], while others are directed towards choosing design methodology [2] or choosing tools for working on plans and projects. Different papers discuss application of tools by using mathematical methods of design such as linear programming [3], tools like utility function [4], application of Goal programming [5] and portfolio methods [6].

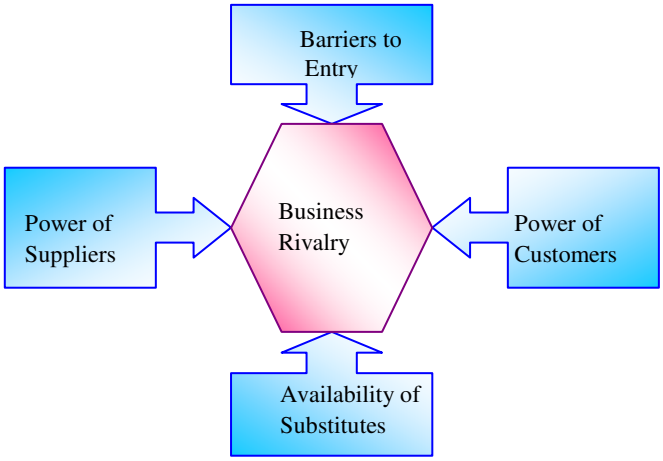
Most of authors apply AHP methods for solving the issue of decision making about choice of projects [7], [8]. Choice of project from aspect of quality management is well presented in paper [9]. Regardless to method or technique that will be applied, basic problem comes down to ensuring communication between system elements, analysis of procedures, synthesizing and appropriate application of the same in ensuring solution for problems that could occur in project.

Application and choice of mentioned methods in planning can depend upon specificities of business system itself as well its environment. Choice of techniques and methods of planning in choosing the planned project and mode of its evaluation will greatly depend upon competence, education and capability of members of team that will perform mentioned activities. Choice and acceptance of plan is a milestone and beginning of its realisation and realisation of business function of system respectively beginning of its market existence.

Traffic of persons, goods and services has an essential importance for society. Business systems which function is providing these kinds of services try to provide constant offer of variety of products and services from this scope. Their quality depends upon several factors but mostly upon rightful evaluation of characteristics of system's environment.

Realisation system's business function is being planned at different levels, for different time periods and detailed accordingly. Strategic plan of business is nevertheless ground for all other plans. Plan is usually made according to so-called 5P model – model of five forces (picture 1) [10]. These are:

1. Barriers to market entry – barriers are determined by different constraints of environment or market rivalry.
2. Position and power of suppliers respectively direct dependency upon suppliers – volume and quality of business depends upon providing the required materials, raw materials and services
3. Position and power of product buyers or service users – determination of financial frames in negotiations with buyers



Picture 1. 5P model in strategic planning [10]

4. Capability and willingness for substituting production and/or innovations in manufacture – capability of fast adjustment to new business conditions through adoption of new products and services
5. Rivalry in activities. Rivalry frames are determined according to evaluation of own strengths and weaknesses. According to evaluation of relationships, own strengths and weaknesses, rivalry can be defined as competitive and aggressive with intention of overtaking the market but can also be co-existential or cooperative within frames of wider associations and clusters.

It is obvious that this methodology can be used for reaching the balance between four forces that determine the fifth force – rivalry ability important for business rivalry. If we examine model in more details, we will spot its orientation towards environment and evaluation of relationships in environment used for planning the internal system organisation and arrangements of strengths in individual positions. It is normal that business as whole depends upon

mode and quality of collected information. Besides method 5P – 5 forces equally good can be applied SWOT analysis that treats system through specific strengths and weaknesses of internal system components while environment is being treated through specific opportunities and potential threats within which the system will act [11].

We should mention The Core Business Model as newer method [12]. As opposed to tradition pure-play models this method considers possibility of developing a sustainable competitive advantage in the Internet economy in making strategic plans. Starting phase of this method is Understand Customer Requirements. Possibilities offered by Internet and web make this phase dynamic. Web allows interaction with user without constraints in time and space. Continuous collecting and evaluation of user requirements demand creation of data base as grounds for making adequate decisions and forming the adequate business plans.

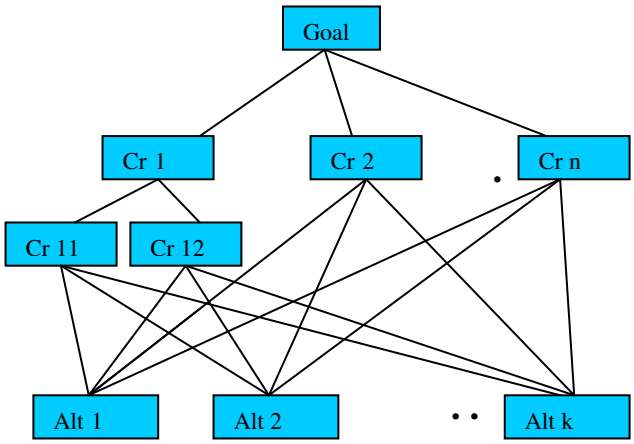
Possibility of combining the methods and techniques for planning used in other area such as designing and development of information system opens bigger possibilities and allows simultaneous usage of results in both areas. It is clear that in present globalisation frames information systems should be developed together with business system. Life cycle of both systems is structured in the same manner from the beginning of including and evaluating user requirements to implementation and installation respectively moment popularly called "go-live". Further on, application of objectively oriented paradigms provides possibility for applying tools created as combination of former development and design tools. Objectively oriented approach begins with so-called inception phase. This is usually a phase that includes smaller part of requirements involved in phase of requirements determination. Starting activities encompass determination of activities and deadlines for projects, identification of business cases – cases of usage, basic risks and evaluation of frames within which the business will develop. [13] The following part describes proposition of combining AHP method, method of requirements engineering and some techniques used within UML frame during the system's designing and development.

3. AHP + REQUIREMENTS ENGINEERING

3.1. AHP (Analytic Hierarchy Process)

Among many methods used in multiple criteria decision problems, AHP (Analytic Hierarchy method), introduced by Saaty in 1980's is the most popular one. The popularity of the method is based mostly on the fact that the method could be used in different business situations, is easy to use and acceptable by the users because of the approach which is similar to human thinking. To resolve the complex problem one try to decompose it to a number of less complex problems. The same does AHP. Three main components of the decision problem: the goal, criteria (sub-criteria) and alternatives are put together into the hierarchical structure model. On the top is the goal, on the first lower level are criteria which can be further decomposed into sub-criteria on the lower levels. On the bottom level are alternatives. Picture 2. is the graphical representation of the model.

The output of the decision process should be the priority list of the alternatives. Based on advantages of one alternative over others and its shortcomings, the number which represents priority position should be assigned to alternative. If the criteria are not of the same importance, their weights should also be taken into account. The importance (priority) is always examined regarding the element on the higher level i.e. importance of criteria are relative to the goal and the priority of the alternatives are relative to criterion. To calculate alternatives' priorities and criteria weights AHP starts with comparison of criteria and alternatives in pairs. The mathematical procedure (based on matrix) is developed for calculating them.



Picture 2. AHP model with goal, criteria and alternatives

The main issue is how one can measure (assign the number) the importance ratio for two criteria when their values could be expressed quantitative, qualitative and in different measured units. The same thing is with setting the relative priority number for two alternatives. Saaty's scale (Table 1) gives the metrics for both, except that for the alternatives the numbers are interpreted as how many times is one alternative in advance over other.

The fundamental scale for pair wise comparisons		
Intensity of importance	Definition	Explanation
1	Equal important	Two elements contribute equally to the objective
2	Equally to moderately important	*
3	Moderate important	Experience and judgment slightly favour one element over another

4	Moderately to strongly important	*
5	Strongly important	Experience and judgment strongly favour one element over another
6	Strongly to very strongly	*
7	Very strong (proved) importance	One element is favoured very strongly over another; its dominance is demonstrated in practice
8	Very strongly to extremely	*
9	Extreme importance	The evidence favouring 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. [15]		

Table 1. Saaty's 9 scale

Although the Saaty's scale proposes the metric, still exists the issue "Are decision makers able to judge the importance and priority in the right manner?" i.e. in which extent can we overcome the difference in individual approach or how we can improve the measuring of importance. One possible solution is to develop goal, criteria and alternatives based on well defined requirements of the problem in case. This can be done following requirement engineering process. In this case requirements mean the decision problem elements - goals, criteria, criteria weights and alternatives.

3.2. REQUIREMENT ENGINEERING PROCESS

Requirement engineering process is a six phase process. The phases are:

1. Requirements elicitation

Through the communication with the stakeholders develop the list of criteria and alternatives. The stakeholders are those who know the best the decision problem domain (goal, criteria and alternatives). Reasonable number of criteria and alternatives should be listed.

2. Requirements analysis and negotiation

During this phase the requirements are analysed for resolving the conflicts, overlaps, omissions and inconsistencies. Based on information available from the analysis the stakeholders negotiate to agree on the criteria and alternatives. Pair-wise criteria weights and alternatives priorities are also agreed. This is the most sensitive phase because the results of this phase will influence the output of decision process.

3. Describing requirements

Description of goal, criteria and alternatives should be concise, understandable and unambiguous. The resulting document from this phase is the place for introducing all the changes.

4. Requirements modelling

Develop the decision process model (hierarchical structure of goal, criteria and alternatives).

5. Requirement validation

Formal check the criteria and alternatives for omissions, conflicts and ambiguities. This ensures the quality of the input data in decision process.

6. Requirements management

All the activities regard the changing criteria and alternatives during the decision making process.

As the result of the previous described process, we can expect decision more accurate. By this approach we can also simulate the output due to the fact that some new information can be gathered during the decision process and can influence the pair-wise criteria weights and alternatives priorities set up in phase two.

4. AHP + REQUIREMENTS ENGINEERING IN PRACTICE

Starting assumption is to take into consideration a relevant number of indicators used as basis for creation of proposition or more alternative propositions of strategic plan. Relevant number of indicators presumes holistic approach to insuring required cognitions and structured data base important for decision making. In a concrete example of business system the above described deals with traffic and logistic activities that will include data structured in frames defined by 5P scheme (picture 1). Considering the importance of traffic for concrete environment we should give attention to planning of traffic and location on different levels (from local to international level) taking into consideration specificities and characteristics of space such as: physical conditions, spatial structure, demographic structure, social conditions and structures, economic determinants etc. Appreciation of spatial component is important from several points of view but primarily due to rationalisation of spatial organisation and increasing spatially important effects of social-economic development of the environment. Therefore especially important are characteristics and quality of relationship between traffic and related location and their interdependence respectively mutual connections and influences [14]. Creation of required data base is starting point for planning and preparing project of system's development. Preparation of

data can be realised through usage of different techniques that will include research of already made and implemented plans, research and summarising of good practices, consult of P2P type (peer to peer), questionnaires and interviews.

The second presumption is that above described manner will ensure all conditions for implementation of AHP method. AHP as method helps in decision making process and includes structuring of different options criteria into hierarchy, considering the relevant values of all criteria, comparison of alternatives for each criterion and defining average importance for each alternative [15] This process ensures eventful but rational frame for structuring problems, representing and quantifying elements of problems, while techniques of binding these elements and evaluating alternative solutions guide course of processes towards final solution.

Those who oppose application of AHP method emphasize their prejudice respectively dependence upon objectivity of experts who evaluate importance of specific parameter. Presumption is that two experts from same field will during the analysis of same conditions express if not the same then at least approximate evaluation. During the analysis of remarkable number of papers that consider subject of AHP method application in wide range of different business systems we can still derive common denominator. The great majority evaluate parity importance of required time, eventual risks, quality level, required services and normally required costs.

Phases of AHP application starting from decomposition to evaluation and grading then choice of most favourable plan can be anticipated by individual activities specific for requirements engineering. Elicitation or recognition is mode of collecting information related to planned system respectively future requirements and eventual problems. Simultaneously this is a good time to decompose – the first AHP phase – structuring problems and their analysis into sub-problems and forming the hierarchy tree. We could also mention this is a good moment to describe use cases that can later be used for other purposes as well. Process can be realised iteratively starting from general presumptions to extremely detailed.

Describing of use cases is situation in which concrete activities are being specified and written, collected information are being sorted and documented. These activities do not require professionals but final choice of needed material should be under their control. The truth is that this process strengthens danger of missing theoretical grounds described by AHP critics and possibility for designing different model that describe identical situation which could lead to completely different final solutions. Namely, after specifying and writing requirements it is needed to make their validation respectively check consistency between requirements and real needs of system users.

It is recommended to collect as much information possible about user expectations regarding system. This is demanding and big task but also the best way to determine mode of functioning for present system. Techniques are: interviews, questionnaires, documentation analysis, review of daily activities and analysis of similar systems of eventual computer applications if they exist. Each of these techniques is appropriate for specific situation and their choice depends upon goal that tries to be achieved.

Requirements validation is convenient moment for evaluation – the second phase of AHP method. By moving through hierarchy from top to bottom AHP method can gradually exclude goals (semantic branching and defining of modules), criteria (examination of parameters) and valuating the alternatives (measuring success of specific solution according to given criterion). Each branch is expounded into appropriate/rational level of detail analysis. At the end of this phase, line of iterations transform unstructured problem into hierarchy determined by defined criteria that is easy to manipulate both in horizontal and vertical directions. Increase of criteria number decrease their importance and equals it that finally is being compensated by allocating value to each of these criteria. Allocation of relative value to each criterion is based on relevance of modules content of associated criterion. Sum of all criteria that belong to modules indirectly determine value of "parent module" respectively it assumes value of 100% or index 1. Global importance assumes middle value of sum of all relative importance of given criteria.

Validation of requirements can be recapitulated but is not the same as validation or grading all alternative solutions and their mutual comparison. At this moment it is also recommendable to execute so-called Fagan inspection of achieved results [16]. This can be the final phase of AHP method that results in choosing the most favourable solution. Creation of matrix of favourable solutions enables evaluation and allocation of so-called consistency coefficient where value 1 means that all favourable solutions for chosen module are internally consistent.

In contrary, internal inconsistence can occur where X is more favourable then Y, Y is more favourable solution then Z and Z is more favourable solution then X and at that moment coefficient will have the lowest value. This phase of AHP process is according to most crucial for grading AHP as theoretically good approach. Validation is executed by allocating the relative grade to most specific decisions of internal hierarchy, then wider context and further on towards top where the total grade is being calculated. Comparison of alternatives help to choose the one that best suits defined criteria.

Tabular performance of individual phases in combination of AHP methods and requirements engineering can appear as in Table 2. Fagan inspection can be made at the end of Focused questionnaire survey phase.

Requirements engineering	AHP method	Key details
Elicitation	Preliminary interviewing	Determination of crucial points Preliminary interviews Choosing the expert field
Specification		

		that will be interviewed unstructured interviews
Validation	Preliminary questionnaire survey	Identifying the main objectives and their validation (using a scale of '1 to 5', with '5' being very important) collection of specific information Pilot testing of the preliminary questionnaire conducted with experts. Multiplication and performing required number of interviews Completion and collecting the answers
	Focused questionnaire survey	Obtaining pair-wise comparisons for the identified objectives and sub-objectives – to develop the Survey priority ratings in Saaty's 9-point scale for the AHP-based selection framework.
	Structured interviews	In the above-mentioned surveys and preliminary interviews, a generic scenario was assumed for making the pair-wise comparisons

Table 2. AHP and requirements engineering timing

The following activities are related to designing of hierarchy diagram respectively analysis of goals to objectives and sub-objectives.

CONCLUSIONS

Planning and designing are complex and demanding activities so they require serious and systematic approach. Preparation of a good plan, regardless to level and deadline of its realisation, refers to good analysis of environment within which business system will realise its function and its goals. Well prepared plan is only a part of business, since realisation itself will indicate the accuracy of all evaluations made during adoption of plan.

Team approach to planning, designing and later realisation of plans is one of prerequisites of qualitatively executed businesses. Team members should share assignments and obligations together with mutual supplementation of essential competencies.

ICT application and huge possibilities of making business via Internet require team members to have additional competences at least during ICT usage and different methods of planning and decision making in choosing possible solutions. What kind of methods will be applied in planning and decision making depend upon numerous factors such as function of business system, position and location in its environment, capability and professionalism of cadre that will perform these businesses etc. In order to prefer one method one should have especially strong arguments. On the other hand, more methods can lead to wrong direction especially if methods are not compatible and if some businesses are being overlapped and duplicated.

AHP method, regardless to its lacks and complaints, is effective instrument for evaluating what kind of plan should be chosen and applied if alternatives are available. On the other hand, preparation of data required for individual phases of AHP method is extremely important activity that could decrease risk of subjectivity and wrong judgment in forming pair wise comparisons. Requirements engineering is a method compatible and supplementary to some activities of AHP method. This method of data preparation is equally important in planning and developing information system that will support related business system. Requirements engineering in accordance with business system will define use cases of business system and determine its behaviour in all situations that can be caused by such behaviour. Therefore we believe that combinations of different methods, economic and un-economic can increase quality of plans, their preparation and implementation within frames of traffic companies with consideration of their specificity. Subjectivity of decision making can be moderated in different moments from beginning of requirements identification through its validation and phase of Fagan inspection of completed business. Possibility of computer backup in these businesses equally increases efficiency and effectiveness and shortens time required for realisation of the same.

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