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RIKS AND RELIABILITY IN THE MANAGEMENT

CLASSIFICATION OF MAINTENANCE DECISIONS, MODELLING OF THEIR PREDICTION WITH SOFT DECISION TREES

Theses of Phd dissertation

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1. Foreword

People have been searching the stone of wisdom since the time beyond all memory. Almost all tools have been used in different ages from occultism to scientifically established theories. In technical meaning a long road has gone to utilisation of the methods of artificial intelligence in the practice. Now you can forecast the changes of weather (unfortunately only for some days, for a longer period you are still on the level of shamans) more safely and well established than ever before, but it is still very far from finding the stone of wisdom. While studying economical-social systems it has been realised that these systems are difficultly organised having non-linear features, operate chaotically and even – which is extremely confusing – they capable to modify and change their inside structures. Approaching with the logic of Aristotle (in which facts are true or false) it is impossible to discover and understand their operations. So you are forced to acknowledge that you have no tools, methods or techniques in your hands, by which you enable to exactly determine the expected behaviour of such a complex system.

You have hopes in methods that are included in the artificial intelligence, fuzzy logic, neural and genetic systems. Now the significant part of scientists think that the "big" nature perhaps discloses something when the same road is followed as it has followed for billions of years. You do not know how the road you are going on is good. Although each of them has been existed since the 50s, each of them is young science.

You will know whether your expectations are right, if you acquire experiences, which can be realised mainly with experiments. They may lead to opposite, amazing or unexpected results.

I think these experimental results – which can be even small crumbs – will stone the way with many errors, on which your children will reach new boundaries in 100 or 200 years, but will walk safely on the road being under construction now.

With my work I would like to put a small stone into the foundation that is now under construction. There are two amazing and simple consequences in the result of the research, which can be easily realised by some thinking. No such things come to your mind spontaneously.

Even at first sight it is difficult to believe it because it is not a usual thing to describe the behaviour of a very difficult organisation with some simple and heuristic rules and to come to approaching consequences for the future.

Another consequence is that the basic and unsaid expectations of a maintenance organisation can be expressed with three features. They are safety, the authority and quality for mainte-

nance of a nuclear power plant. For a classic maintenance organisation, where safety and the authority features are also rigorous, everything else can be conceptualised in the categories of quality, time and money.

I was astonished when realised that this result played a key role in the basic principles of TQM and customer centric thinking. When an organisation produces a value, customers can obtain a product/service in a faster/better/cheaper way. Also these results can be read from the researches.

2. Background of the research

Herbert Simon states in his theory of "limited rationality" that in life of a company the rules of behaviour, customs and decisions evolve during a long process and they are modified to a small extent by actual decision situations. In human decisions much more effects are accumulated than the profit in the simple sense of economics.

Actuality of the topic

The current research topic is more relevant in our age than ever before. When the social-economical events have been accelerated in our environment, you should make more decisions during a unit of time. It comes to the same thing that it serves for survival of a private life or a company. It complicates the matter that a decision will be implemented in the future, but the information – which is incomplete, "noisy" and rarely false - is available in the present. It means a trouble that the final result is given by the joint decision of not one but several people. It is true in a family in the case of buying a car or a house, and also when future investment or financing issues of a large company should be decided. It is the same also concerning the result of the recent parliamentarian elections. The latter one is an interesting area, because the result has been affected by a very large number of decision-makers (the society) and according to a large number of decision aspects. Each area is difficult having strong nonlinear elements and memories. Its behaviour depends on the momentary environmental condition. In such situations, where there are no clear and transparent conditions: it is risky to make decisions, because everybody is uncertain. Uncertainty is rarely tolerated by nonlinear systems. It would be good to know when a system reacts sensibly upon something, when behaves tolerantly and when we can expect very quick and stormy changes.

Decision-makers in an organisation make their decisions in a similar way with uncertainty, in an environment with lack of information and for performance having different preferences.

Decisions are often acceptable or well completed, but it happens that everything should be rethought and occasionally excellent performances occur. It would be good to know how a decision will be unacceptable, good or even excellent. If we were familiar with the influential facts, dependence of an effect upon a cause – even in a large way -, effectiveness and operation of an organisation would be better or the limits of its performance would extend. Thereto it should be realised by what and how an organisation is operated.

Compiling the research program

I should have found a good area for analysing complex decisions, where several decision-makers affect solution of difficult situations and problems. The Maintenance Division of Paks Nuclear Power Plant Ltd. seemed a good opportunity for me to analyse and examine the results concerning maintenance decisions, and to publish research results. It is considered a rare moment in the world of decision research, because – as I experienced – you usually hide your decisions and their results, even then they are good, rather than disclose them.

When compiling the research program first I concentrated on discovering the weak and strong signs, which play a definitive role in organisational decisions. Five large decision areas represent decisions of the maintenance organisation. The areas of decisions are differently affected by the strong and weak signs. My research focused on the decisions concerning technological issues of the organisation. It was assumable on the current area that mainly the strong signs affect the outcomes of decisions. It was difficult to collect decision cases, since it seemed to be the private matters of the organisation. It was more difficult to evaluate the quality of decisions with the decision-makers. For example, there was no case observed where the decision made was unacceptable. It is obviously impossible, since each decision cannot end positively. I assume that they can be resolved in a wider sample collection.

The set of decision cases contain estimable knowledge relating to decisions of an organisation in the form of "data patterns". In order to discover knowledge I used so-called **conceptual primitives**, which were determined from decision cases of the decision-makers.

I founded knowledge to be discovered in the set of decision cases on the **conceptual hierarchies** based on background knowledge. By the conceptual hierarchies knowledge is organised into **a tree graph built in inductive way**, in which the conceptual primitive is illustrated as an inner junction point. The tree graph is one of the compact forms of knowledge illustration. At the ends of tree branches the result of the qualified decision can be found. It is difficult to express the experienced knowledge existing inside an organisation; it is not displayed or can-

not be described in explicit way. In the activities and concrete cases of an organisation you can find also unsaid and latent knowledge, which can be discovered and read out of the decision trees in the form of rules. These rules are not precise ones, but they have some reliability and well-foundedness.

I worked with extremely few, only with some dozens of samples. I also wanted to examine whether it was possible to learn the behaviour of an organisation from such number of the samples. In addition I wanted to have an answer to the question whether some dozens of the samples and decision cases would contain the unsaid basic expectations of the decision-makers, which they would always have in their minds independently of the nature of a problem.

The rules, which can be read out of the decision trees, embodied in some heuristic rules. Some well-founded rules, which seemed to be reliable, adequately described the decisions of the maintenance organisation.

In heuristic rules the reliability is in connection with **certainty**, while foundeness with **usefulness**. **Simplicity** of the rules is determined by the number of "data pattern" attributes.

Reducing and simplifying the number of rules is important for decision-makers from the aspect of usability of the rules. The **minimal reliability** and **foundedness** limit numbers for the categories describing decisions and for the attributes were established on the basis of discussions with the decision-makers. The rules, which meet the limits relating to the minimal expectations, have been incorporated into the base of knowledge concerning decisions of the organisation. I considered the rules below the limits noisy; perhaps they demonstrate individual cases.

My main objective was to develop a forecasting model based on the collection of rules supporting technological decisions of the organisation, which will serve for estimating outcomes of expected decisions of the organisation concerning technological issues.

One of the problems in connection with the rules is that they provide sharp boundaries for the conclusion. Heuristics can be used in more advantageous way, if the reality is taken in accordance with everyday practice. This approach breaks with the sharp boundaries. By **fuzzy logic** I defined intervals on a joint qualification scale for premises and conclusions. The composed numeral/linguistic values provide their messages with different language truth values for the relevant premises and conclusions. You can read out heuristic rules of the cut back decision trees, which display the expected results of decisions in more fine and realistic way by fuzzy logic.

3. Established research tasks

In my **first** and **second hypotheses** I try to prove the subjective sense of the decision-makers and their acceptable, "good enough" decisions made on the basis of defective information. The solutions (heuristics, thumb rules) are illustrated by the rules, which meet a minimal foundedness and reliability limit. My objective was to demonstrate that decision-makers reduce their decisions to some decision variables considered relevant by them, which are still transparent and understandable for them. I prepared the less shaped use of the heuristic rules and consideration of the environment according to the momentary condition by the fuzzy logic (a soft, multi-valued logic).

This topic was analysed with different true functions of similar behaviour of each maintenance area, in which each decision-maker referred to the same set of decision aspects.

Studying the truth functions focused on readiness of decision-makers to compromise.

Each organisation uses information for founding its decisions. In the decision-making practice of maintenance organisations – especially for decisions concerning technological issues – you are disposed to believe that almost the all necessary information is available as prescribed. Since a very large number of concrete rules were elaborated for planning and performing maintenance of technological equipment, you tend to implement instructions precisely and in a programmed way. In the **third hypothesis** this thought is proved. I assume that the maintenance organisation evaluates and implement the rules fluidly with very few deviations when managing problems of the technological areas. In my research I examined that to which extent the weak and strong signs are present in evaluation of the rules. Maintenance of equipment is implemented as a result of the man-machine interaction. Consequently, it is not enough to examine and consider only the environmental signs relating to the technology.

The environmental signs are in close relationship with the expectations relating to the decision-making aspects. The expectation of a decision-making aspect can be set reasonably according to the origin of the affecting environmental signs. If a decision-maker is not familiar with the relation between the signs and expectations (desires and opportunities), the quality and outcome of the decision will be unacceptable. A decision-maker can learn it after some decisions made, if the same problem (data sample) is repeated. If it rarely occurs and/or decision-makers have no background knowledge about the attribute describing the concerned

problem (having no knowledge of a language and/or another knowledge), their decisions will be unacceptable. They will be such agents with reflex action.

In the **forth hypothesis** I attempted to prove that when customs, values, convictions, that is the social coefficients of the maintenance organisation change, usefulness sense of decision-makers, consequently their extended preference functions and risk evaluation will change. In the organisation the single truth functions superimpose onto each other. The resultant truth function cannot satisfy all decision-makers' expectations, so it is accepted by decision-makers to a certain extent. This "certain extent" is called as disposition to agree.

You are not only a simple data-information processing unit, but a human being acting with mostly non-numeric data, even with concepts and ideas. In your conclusions you think not only with ANDs and ORs, but use their combination together your intuition. Consequently, the truth often can be subjective and a multi-valued decision. You follow along with soft logic toward the solutions and – if necessary – concede "sacrificing" a precise solution in order to keep the issue in hands, realise and finally find a solution.

Using the results of the hypotheses I established the model of the system classifying the decisions of the organisation.

I had no more time to try more ideas, which are demonstrated among the possibilities for further development, such as adaptive learning, "recoding" of truth functions of decision variable resulted from environment changes, changing their sensibility and tolerance band, or learning of new concerns and eliminating the old ones from the forecasting system.

4. Methods and results of the completes analyses

The theses of the current study were compiled for an intelligent organisation, to which the investigated maintenance organisation approaches. In general it can be declared that the activities of the intelligent organisation compare to the operation of an agent[1] having inner state, which is purposive and considers usefulness of his/her activities. The maintenance organisation operates under limited accessible[2], some deterministic[3], quasi-static[4] and discrete[5] envi-

[1] The agent is an intelligence, who senses and acts in order to achieve the given aims.
[2] For the organisation the operating environment is limited accessible. Information is limited accessible in space and time. In most cases it is not known exactly, which can be achieved anyway. The cause is behind defectiveness and subjective spirit of human activities.
[3] The environment is deterministic concerning the strong signs. Since not only the strong signs affect the outcome of an activity, so " "
[4] The environment is never permanent, it always changes and shower a large number of stimuli onto decision-makers. However during the examined period (6 months) it can be considered permanent, since no significant changes happened.
[5] You perceive the changes of the environment not in its process. For you this change is discrete and it can be well identified and consists of the sequence of perceivable displacements. Enough displacements are required so that you can perceive that the world has been changed. E.g. it means a set of decisions concerning the discrete condition of the examined period.

ronmental circumstances. It was necessary to border the environment because organisations of different structure can manage different environments. The examined organisation acquires the information required to decision-making (considering the operating conditions determined above), updates and modifies its knowledge. Accordingly, knowledge of the organisation creates a harmonic relationship between organisational perceives and activities. This is only a quasi-static state, because, if the environment changes in the next period, the new balance between perceives and activities can be realised by updating and modifying knowledge.

Knowledge plays an outstanding role in the decision (activity) program of the organisation, since it can be considered static under changing circumstances. New problems cannot be solved by old knowledge. The decision-making process based on conclusions derived from knowledge stands in the centre of the estimation of organisational decisions. It is important to represent knowledge.

In my study I strongly build on William James's and Helmholtz's work. Both insisted on the fact that a subconscious logic conclusion has a role in human perceive. In my model the subconscious logic is embodied by fuzzy functions of the decision-makers. The soft fuzzy functions in mathematical meaning transforms the difficult miscellany of maximising, psychological, social and cultural attitudes of decision-makers. Their origin is a resultant fuzzy function, which is called as the truth function of decision-makers.

My idea is supported by Kenneth Craik's work titled as *The Nature of Explanation* and published in 1943. Craik established the missing mental image between the environmental stimuli and decision-makers' activities. He stated that belief, aims and concluding steps could be useful parts of the theory of human behaviour, and they are so scientific terms as pressure or temperature, when you speak about gases (even gases consist of molecules, and they have neither pressure nor temperature. By this ingenious wording Craik referred to the representation of knowledge. He tried to demonstrate that you used the abstract terms to perceive the relation between different things, which do not exist independently and without which the relationships between different things cannot be expressed. Craik established the operation of a knowledge-based agent onto three points: (1) stimuli coming from an external environment are transformed to an internal representation[6], (2) this representation is manipulated by an internal cognitive process, and a new representation can be resulted, (3) accordingly, the ac-

[6] According to the current information human knowledge is a lattice structure organised difficultly and serveral times embedded into each other. It is called as cognitive schema in psychology and the reality is perceived by each person in a different way (but maybe similarly, especially in the case of a same school) (László Mérő, Új észjárások, 2001)

tivity occurs. Finally he provided an interpretation for knowledge-based approach of human activities, which forms a base of almost all algorithms representing knowledge. He wrote that: „If an organisation includes the "small-sized model" of the external reality and own possible activities, it enables to try different alternatives, to decide on the one, which is the best for it, to react on future conditions before their occurrence, to use past events in order to manage present and future situations, and to respond to emergency cases in more exhaustive, safer and competent manner" (Craik, 1943).

Craik's agent is similar to the behaviour of modern organisations. Such an intelligent organisation is enable to preliminary plan its own activities, such as planned preventive maintenance, capable to eliminate unexpected failures, e.g. failures resulted from emergency situations. That is, it is capable to foreseen and consider alternatives based on experiences learnt from past events and knowledge.

Representing knowledge (which studies how knowledge can be worded in the form so that computerised conclusion can be made possible) connects to a language. In this case the language is the technical terminology of maintenance, one kind of "jargon", which is enable to express briefly and detailed the subject of speaking and relation at the same time. The language itself is not definitive and a lot of things remain unsaid. It means that you should understand the subject and context of an event so that you can understand the event itself. It does not mean only registration of an event.

I did not perform the examination for the whole operating cross-section of the organisation, but I focused only on the area of technological decisions.

Identifying the strong and weak signs of an operating environment

The first task was to discover the operating environment. I divided the environmental signs affecting technological decisions into strong and weak groups of signs. The strong signs – I recorded up to 80 pieces – included the instructions, prescriptions and regulations relating to the programmed operation of the organisation. These signs can be well identified; they are the signs considered important by decision-makers. For the weak signs – I found up to 150 pieces – their importance changed individually. The weak signs are stimuli originated by events, which shrunk below the surface, they are not adequately considered, but they can be the precursors of big changes. They are ignored in most evaluations, because evaluations usually proceed from strong trends. The weak signs are not weak due to their unimportance, but they are weak enough to suppress other irrelevant facts or disappear in strong environmental noise.

They have enough causes for you to ignore them. In business life, in organisational decision-making these signs are of higher importance, since their recognition can mean success or collapse of an organisation. Potential identification (importance) of weak signs is not easy; highlighting them is possible only inside a complex adaptive system.
I worded my hypotheses based on the information acquired from the environment.

Hypothesis 1: Organisational decisions are slightly affected by weak signs when clear, definite rules and instructions exist. Information is limited accessible for decision-making, so decisions are made by incompletely informed decision-makers. Decision-makers should manage uncertainty. Decision-makers eliminate uncertainty resulted from the lack of information by using weak signs, but for decisions concerning technology they can be used only moderately.

Soft logic of human conclusion

The difference between the natural language and the language that is suitable for representing knowledge meant the problem my model should have tackled. Natural languages satisfy communication needs instead. Coded information miscellany appears in sounds, movements and circumstances, which cannot be described with simple words. They are not suitable for explicit demonstration of knowledge, but knowledge in practical life is often transferred without explicit representation. Another problem of natural languages is due to their ambiguity. If you say that something "goes not too fast", everybody can translate and imagine it under the given cultural circumstances. However it is not easy to express the same with the representation language. The "jargon" of a profession mixes the natural and representation language. It is demonstrative and brief in the meaning that using it you can express everything you need. I would note that the language of a profession should be developed, if you want to use it to describe events having no example in knowledge basis. In this situation you should create new terms and you acquire new knowledge. This language seemed to be definitive enough and independent of an environment for describing events. It actually means that what you word something it will be true also tomorrow. However, I was not able to express all knowledge, because the cases I processed included much more knowledge, on the other hand the decision-makers used not only professional jargon for describing events, but also their own natural languages. Harsányi's thoughts, which have been cited several times, have been proved here,

so that you know much more than you can express. It is a scientifically proved fact that a significant part of human knowledge is stored non-verbally (Anderson and Wanner, 1986), but you remember the essence of events, rather than exact words. According to the famous hypothesis of Sapir-Whorf the language has a very strong influence on human thinking and decisions, especially on the categories, by which the world is divided into different objects. In summary it can be stated that using the representation language I could prepare only a schema about knowledge of the organisation, consequently uncertainty entered the group of problems to be solved.

Hypothesis 2: Beyond the traditional economic assumptions (decision-makers are always rational, profit-maximising, completely informed) cultural effects originated from personal conviction and driven by social environment of the maintenance organisation, and professional-specific cultural affects of maintenance are superimposed onto the organisational decisions. This extended usefulness controls decision-makers in decision-making. If customs, values, conviction and social-cultural facts change at the maintenance organisation, sense of usefulness by decision-makers, consequently the extended preference functions will also change.

Identifying important decision aspects

Due to existing information noise level the information concerning the problems can be difficult. Then decision-makers attempt to make decisions on the basis of "**important features**". The group of relevant features relating to the problems – if the information noise level is not kept artificially highly – will be cleaned off in the process of time.

The significant decision variables and attributes could be determined from decision cases. The attributes, which were well founded and seemed to be "useful enough" – such as *safety, quality, authority and performance time* – became unsaid and basic expectations from decision aspects. Fondness was given by occurrence in the sample and frequency, and I set a limit number for frequency after a consultation hold with the decision-makers. It resulted that if an examined attribute has 30 % of occurrence in the sample, it will be founded.

A decision aspect was classified as useful, if it was informative. The original set of samples was divided into definitive groups in the way, so conclusions could be drawn. In other words, the distribution of the restructured set of samples had small dispersion and strong coherence.

This kind of usefulness was expressed by informative feature of the attribute and rate of profit of the information.

Hypothesis 3: The decision-makers make their decisions according to subjective sense of the risks and search originally acceptable, "good enough" solutions (based on heuristics and thumb rules). Thumb rules are reduced to some decision variables, which are considered relevant, and still clear and transparent.

In decisions of the maintenance organisation some relevant decision variables can be measured, which significantly influence the outcome of decisions.

Heuristic rules, long-term memory of the organisation

In most cases social-economical and biological phenomena can be replaced by a black box, the inside of which is unfamiliar. Substance of these systems is given by their complexity. What you can observe is the exact relationship between their inputs and outputs. In order to reach adequate complexity joint occurrence of sufficient number of samples (events) or cells in biological meaning is necessary. Sufficient number of samples meant some dozens for decisions, in biology the same one was represented by DNA of a glossina. It is not too big, but adequately difficult to represent operating and behaviour features of the whole and conclusions can be drawn for the whole system.

Each of the decision cases could be considered as a "micro" rule, which interpreted the situation together with its concrete environment and actual expectations. 30 as a number of samples seemed to be sufficient to structure these "micro" rules into a structured decision tree in inductive way. Accordingly, the decision tree demonstrated knowledge in compact form. I started to construct the decision tree using the attribute, which had the largest rate of profit and foundedness. Then I completed the final tree according to the rules for building an inductive tree. Subsequently the tree was cut back to the stem, that is only one premise was left in the rule, which contributed to my aims and enabled to read out complex rules later.

Since it seemed only a slight difference among the significant decision variables and the number of samples was low, a decision tree was built up similarly with other significant decision variables.

Finally four cut back decision trees gave the rules, each of which contributed to the final result to "any degree".

Hypothesis 4: In an organisation the relationship between the significant decision variables (premises) and classes qualifying a decision (conclusion) is adequately described by some heuristic rules. These rules reflect the basis expectations of the decision-makers in an organisation. Absence of them makes a decision unacceptable.

5. New scientific results and theses

Using the research results **my hypothesis determined for strong and weak signs** (hypothesis 1) did not seem to be true. The organisation in the decisions of concerning the technology uses extremely large amount of soft information. The ratio of strong and weak signs is three to two, which contradicts the assumption that elaboration and usability of the maintenance operating procedures, and the rules elaborated and used for managing and eliminating different emergency situations show strong coherence. It is known from experiences that Maintenance Operating Procedures (MOP)[7] are suitable, since occurrence of failures after PPM[8] does not exceed the percentage of failures resulted by maintenance and occurring in nuclear power plant of similar type. Emergency situations are managed according to different logic. In the beginning there is large uncertainty due to the lack of information. After the problem is identified, also information, which is in connection with human factors rather than some kind of scenarios, is also used in difficult and hidden cases. It would be an explanation for the occurrence of weak signs in about 1/3 ratio. During the analyses I concluded that weak signs even disturbed repair of the failures resulted from emergency situations, because specialists should have considered unexpected effects, which were irrational concerning technological decisions. For example, formal observation of the quality instructions or relative few time for elimination, absence of the exchange of knowledge or the behaviour of a manager.

[7] Maintenance operating procedures, the collection of rules, which specify in details how a machine or equipment should be maintained step by step.
[8] Planned Preventive Maintenance

They are against the fact that they will be used in solving a given problem.

I realised that the solutions found for solving maintenance problems could not be simply determined on the basis of a collection of rules. There are thumb rules for simple and easily manageable situations, and relatively few strong signs are needed. In difficult situations much more signs are taken into consideration (but most of them are thrown away while searching a solution). Uncertainty is always high on the road to solution. The weak signs help decision-makers to reduce uncertainty and to develop new solution variations. Due to their changeability the weak signs combined with strong signs enable to develop a large number of solution variations. The organisation knows from its experiences that which solutions should be considered for a concrete problem. If rules and instructions were specified too inflexibly, only a well-defined and narrow group of the solutions could be considered. In extreme situations the rules would prefer only one solution. The organisation would state that it is familiar with all possible problems, instructions required to elimination and scenarios. It has the information needed to elimination, which is impossible for a difficult and non-linear system. The weight of weak signs is so large (1:3), because the rules (strong signs), which are worded not too precisely, enable to develop an acceptable solution only combined with weak signs. The strong signs can ensure a playfield only in this situation for the decision-makers so that they can incorporate their own ideas, hopes and belief into a solution. For this the decision-makers use all secondary signs existing in the environment, which can support or reject their belief and conviction.

Based on my research I can state that the ratio of weak signs influences the solution variations with unbalanced pressure and it changes dynamically in time. In the beginning it can be much larger than 1:3. Later, as the solution starts to be defined, its ratio quickly reduces. Finally, when the solution is reached: only the weak signs, which influence the given solution and the effect of which should be considered during an action, remain in the “basket” of signs.

This interpretation gives an explanation to the fact that the implementing organisation relies only partially on the content of MOPs, and adds own experiences to MOPs. Concerning the solutions it considers that compromise is necessary also on higher levels of the technical management, which would be impossible in the case of inflexible rules.

It can be stated that who is searching solutions for maintenance problems should consider a large number of influential aspects affecting the time of searching and the solution. The ratio of weak signs, which is considered high, focuses on complexity of the technology and human

calculability that is special and even partial. The weak signs are to compensate for lack of information reducing uncertainty of the road to the solution.

The hypothesis of logic conclusion concerning human sense (hypothesis 2) was according to my expectations. Beyond the traditional economic assumptions cultural effects originated from personal conviction and driven by social environment of the maintenance organisation, and professional-specific cultural affects of maintenance are also incorporated into organisational decisions. This statement, which is also supported by measurements, sufficiently shakes the traditional economical conception. It means that human decisions are not controlled only by financially expressed profit maximization, but even economical externalies, such as cultural effect of maintenance as a profession and belief resulted from individual conviction of decision-makers. All of these can be jointly described by an extended fuzzy truth function. If each decision-maker's costs devoted to solution of problems equal, and it can be financially expressed, each set of fuzzy functions will completely overlap each other. It can be logically proved, since everybody would follow the principle of the lowest cost in this case. Assuming that everybody has enough time and information, everybody should come to the same conclusion in financial meaning. The tests performed during the research prove the opposite one. The decision-makers felt the statements composed in the same reference system (scale) for the relevant decision variables true to different extent. Behaviour of the functions of each fuzzy set family was similar, but they never overlapped each other. Accordingly, the decision-makers' the sense of truth (consequently also perceive of costs) was different. The measure of the difference focuses on the facts, which influence the sense of truth not on rational bases. Behaviour of the set function families was not too different. It enabled to replace them by an average function of truth later. I called it sense of truth of the organisation referenced to a given decision variable. The effect of culture could be demonstrated for the decision variables where the work areas inside the organisation were similar. For example, the decision-makers of the organisational units performing designing and organising activities conceived in the similar way concerning the decision variables of Quality and Safety. The sense of truth for implementation had behaviour farther from them. But not too far, because in the case of common decision-making of a group each leader should be disposed to agree with the solution to any extent, so behaviour of set functions cannot be too different from each other.
I was able to identify only one case, when a large difference occurred concerning a "not too useful" decision variable (Control). In this case the conflict could also be demonstrated. In

fact, it was difficult for this decision-maker to take a position to come to an agreement. It is unreasonable to establish conclusions onto this only one case, but it can be concluded that if behaviours had been far from each other in semantic meaning, the organisation would have made its decisions under the conditions that are full of conflicts, which would reduce the effect of the organisational cohesion.

Using the fuzzy function family for modelling the sense of truth of an organisation is a new idea, because this approach has not been used in the meaning of economic externalies, by which decision-makers' sense of truth can be well modelled. The operation of the model could be considered quasi-stationary. The reasons of its incompleteness cannot be explained rationally for human nature, but they can be originated from behaviour that is acceptable by good sense. Accordingly, if expectations are not fulfilled, you will be able to concede (Harsányi), which will change the sense of truth. Semantic elements of the fuzzy set and corresponding truth values will be also changed. It will be the same when you will acquire new experiences, which will modify the schema, consequently will change also the sense of truth. Another consequence will be that the balance of knowledge will start within the organisation. If it does not occur or it is very slow, behaviour of the fuzzy functions will step out of the cohesion band, inside of which decision-making under low-level conflicts can be still maintained. In this situation life of the organisation becomes "noisy". Obviously – realising lawfulness – the organisation itself contributes to this process.

The hypothesis concerning the important attributes (hypothesis 3) was proved in the experiment. In a sample of 30 decisions they were based on 27 decisions variables. Further increase of the number of samples may have not caused such a great increase of the aspects. Only a few (altogether 4) of 27 decisions variables – there are some dozens of samples – had acceptable foundedness and usefulness. You usually establish automatically your decision aspects according to the categories, which often exist in your environment and your decisions built on them in the past seemed to be successful enough, so you will be selective towards them. *These important aspects for the organisation were safety, quality and time of performance.* Each linguistic variable may have several (2-5) values, but not each of them had an example. Consequently, rules were established for only the aspect-expectation pairs, for which enough situations were collected. The aspect found in the root of the decision tree is one that is ahead of the others in preferences, foundedness and useless. Consequently, this aspect significantly affects the outcome of a decision. In this case it was completely true. If a decision was not acceptable from the aspect of *safety*, it led automatically to an unacceptable decision.

However not each decision had safety aspect (17 of 30 cases had no significant safety aspect), so it was logic and reasonable to establish a decision tree according to the other significant aspects. They gave another kind of structure to the set, so they contributed to the outcome from a different aspect.

My hypothesis relating to some heuristic rules (hypothesis 4) seemed to be true, since it could be stated that the variations between the decision aspect-expectation and outcome of a decision jointly determine the possible heuristic rules. However, such a rule could be worded only for the pairs that had enough examples of cases in the set. The others should have been precluded from the analysis, because I had no experiences about them (the decision-action sequence of the organisation gave no information about the relationships between the pairs not examined). In life of the organisation the event density existed would have not established further establishment of these rules.

6. Model of the forecasting system and opportunities for further development

Relying on the results achieved you can establish an intelligent agent, the operation of which is based on the given heuristic rules, the conclusions on measured significant decision variables and proposal for decision on their common result.

This system cannot learn independently, because the decision tree (which constitutes the basis of knowledge) should be rebuilt after a certain number of events; knowledge should be maintained. Of course, it means no problem for a computer, only results in a technical breakdown, i.e. the tree is rebuilt and the concerns are discovered in offline way.

Conclusions of an agent can be improved regarding the expected decision, if the background is continuously monitored and significant changes shall be learnt using a neural lattice for relevant decision aspects. Consequently, the result can be explained in a much better way and the reason of forecast will be clearer.

The next idea of development is maintenance of fuzzy functions. Decision makers may be changed; new decision makers will have different expanded functions of preferences as their predecessors. However the functions of preferences of an existing decision maker can be even

changed by learning something new. Although this latter one is a slow change, it will modify the run of truth functions describing the expectations of a decision maker, and even the output of an expected decision.

Finally, it is reasonable to establish a neural network for the event-base process system, which learns the concerns of an aspect meanwhile. During that time an agent can indicate that the conclusions may be far from the reality, because the concerns appearing in the set of examples have not been used in the conclusions.

On the other hand, if an agent cannot find meaningful correlations between the set of the neural lattice of background events and significant decision variables, the examples are not from the reality or the decision tree of an agent has not been maintained. Consequently, forecasting suitability of the expected decisions will decrease.

Of course, in development also the techniques of evolution-biology can be used. Due to lack of time I only touched on this topic, but I feel that the largest development ideas may be out in this field.

If several decision trees are built (e.g. using information profit for the first one, rate of profit for the second one and concerns of the far past for the third one as a control), even there will be several forecasts for decision making. They are – less or more – different from each other. If an agent learns that which tree gives the forecast fitting to the reality the best, later this type of tree can become dominant for further forecasts.

The relevant decision variables for each decision tree (even slightly) differ from each other. If they are managed as genes that constitute decisions, so called mixed trees can be built, since the agent will choose them in random way, on which the tree will be built. Since chances have an important role in building the tree, it can be established after several hundreds of iteration, at which the agent can feel that the reality and forecast are close enough to each other. The same phenomenon is taking place here as in evolution. Deficient or less operable variables are discarded by the agent establishing a new combination for building a new one.

7. Field of use

Chances have an immeasurable role in your everyday decisions. Chances are resulted from unpredictable feature of the environment on the one hand, and inconsistency of your human reactions on the other hand. You as human beings are not inconsistent because you react on the same phenomenon in different way, but only in a similar way, never in the same way.
This realization itself justifies that such kind of agent should be established in the way, so that chances have a role in its operation, even on several places. You should let operable versions be selected by the environment itself.

In Chapter 6 and according to the above-mentioned ideas such a system is able to operate effectively in all areas where the output of the operation of a non-linear system is controlled by chances. (Obviously, the system should be able to clarify the coherences from the events.) If an agent has no realizable coherences, its forecast will not be better than of a dicer. In most cases you can find such relations between the events.

Below some concrete fields are listed where I think such a system can be used effectively:

- Ageing management of components, status control in any industrial plant
- Forecast of stock exchange rates
- Cancer diagnostics
- Preparation of decisions
- Marketing
- War industry
- Astronomy

Common feature of the above fields is that they are subject to chances, but they include systems.

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