Knowledge Acquisition and Management
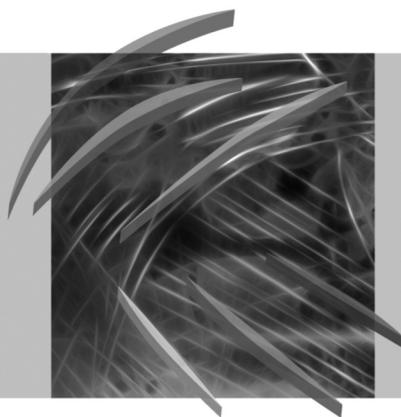
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CASE-BASED STRATEGIC DECISION-MAKING

Summary: It seems that the level of strategic decisions, taking into account their complex nature and intuitive character, falls outside the actual scope of decision support systems. The research on case-based simulations brought promising results in the context of rationalizing the strategic decisions-making. This paper mainly focuses on the problems and solutions related to a strategy support system, which would refer to the crucial role of analogical reasoning. We have chosen case-based reasoning as a suitable decision-making paradigm. Then the Strategos case-based reasoning system for supporting strategic decision-making by the small and medium enterprises (SME) management board is presented, followed by a presentation of experimental results and concluded with a possibility of further research in this field.

Keywords: strategic decisions, analogical reasoning, knowledge representation, Strategos.

1. Supporting strategy decision-making

Managerial strategic decisions relate to actions with long-term consequences which help build competitive advantage on the market and exploit successfully company's primary resources and capacities. For these reasons, they are poorly structured, intuitive, and made under conditions of great uncertainty. It is obvious that one of the biggest challenges in management information systems development is to create an information system for supporting unstructured managerial decisions [Simon 1991]. Such problems have been the focus of intensive works within the framework of the research on artificial intelligence. Until today there has been no satisfactory solution in this field. We support the realistic approach that the real managerial decisions are so complex that a human being might be supported in decision-making process by computer systems but not replaced.

2. Strategy planning and reasoning by analogy

Developing and formulating the strategy of an enterprise is one of the most important managerial issues. It is related to the fundamental questions concerning experience, knowledge, and intuition of managers, initial conditions and market context of company's activity, potential and limitations of a company, the need to respond

quickly to changes in the environment, etc. In the case of any new problem, when deductive reasoning is limited, it turns out that appealing to experience is by all means a rational behaviour. As Thagard [1996] points out, "Analogies can be computational powerful in situations when conceptual and rule-based knowledge is not available". As regards strategic management, a research team of Harvard Business School [Gavetti, Levinthal, Rivkin 2005] made similar statement: "Reasoning by analogy is a common form of logic among business strategists. Facing a novel opportunity or predicament, strategists think back to some similar situation they have faced or heard about, and they apply the lessons from that previous experience". In this context the following questions are crucial: "Is it possible to form the company's strategy adapting an existing strategy prepared for a similar company?". The positive answer leads to two further questions: "What does it mean that two companies are similar and how can this similarity be measured?", and "What adaptations (modifications) should be made for the adopted strategy to be acceptable?". Using analogies helps to escape the unrealistic assumptions concerning the rationality of managerial decisions, while in the contrary it helps introduce rational elements in the "reactionary" and *ad hoc* actions of managers. This issue has been thoroughly discussed by Gavetti, Rivkin [2006], who refer to the concepts of company's plasticity and rationality in its search for the right strategic decisions.

3. Theoretical framework. Case-based reasoning

The mentioned research problem might be solved partially by means of applying the case-based reasoning (CBR) approach. Case-based decision process is formally described as follows [Gilboa, Schmeidler 2001]. Let P be a set of decisions problems (case description), A – a set of acts that may be chosen at the current problem, R – a set of possible outcomes. Then a case is a triple: (q,a,r), where: q (problem) ϵ P, a (act) ϵ A, r (outcome) ϵ R. The theoretical set of conceivable cases is the set of all such triples: $C \equiv P \times A \times R$. Obviously, the set of cases that are known to have to occurred will thus be a subset of C. The similarity function:

$$s: P \times P \to [0, 1]$$

is assumed to provide a quantification of similarity judgments between decision problems. The utility function:

$$u: R \to [-1, 1]$$

measures the desirability of outcomes. Positive utility values can be associated with positive experience, which a decision-maker would like to repeat, whereas negative utility values correspond to negative experience, which a decision-maker would rather avoid. A decision-maker is facing problem $p \epsilon P$, and we assume that he or she knows the possible courses of action he or she might take, which are denoted by A. A decision-maker can base his or her decision on the cases he or she knows. Formally,

decision-maker's memory is a subset of cases: M is a subset C. M represents those cases that actually occurred and which a decision maker was informed of. Finally, decision-makers would rank available acts according to the similarity weighted sum of utilities that have resulted in the past. Formally, a decision-maker with memory M, similarity function s, and utility function u, who now faces a new decision problem p, will rank each act $a \in A$ according to:

$$U_{p,M}(a) = \sum_{(q,a,r) \in M} s(p,q)u(r)$$

and will chose an act a^* that maximises that sum over all the cases in which it was chosen in the past:

$$a^* = \max\{U_{p,M}(a)\}.$$

4. The Strategos architecture

Basing on the case-based reasoning framework presented in Section 3 and strategic problems described in Section 2, we proposed the idea of Strategos systems for supporting strategic decision-making. We start with the knowledge representation issue and then we follow with the implementation of the whole case-based reasoning cycle.

4.1. Knowledge representation

Case-based reasoning framework for its functionality requires three main components: case representation, general knowledge representation, and similarity measure. The case representation should reflect the company itself (company description), its market environment (context description), and one or more strategic decision taken in this particular situation. In order to establish it properly, we conducted some surveys with CEOs of the selected SMEs. Based on those interviews and the empirical research on the case representation for SMEs [Surma2008], the following problem (case) description (P) was established as the set of the attributes that are taken into account:

Company description: market share, location, products/services, number of employees, sales volume (trends in at least two years period), sales volume (export), EBITDA (trends in at least two years period), B2B/B2C, etc.

Context description: industry, industry life cycle phase, Porter five forces analysis (threat of substitute products, threat of the entry of new competitors, intensity of competitive rivalry, bargaining power of customers, bargaining power of suppliers).

The act which is chosen as a solution for the current problem (A) is the list of all the combinations of product/market decision based on the Ansoff matrix (product × market) [Ansoff 1965], and positioning decision based on the Porter's generic strategies [Porter 1980]. The case outcome (r) is included in the case as a statement

given by a CEO. We were not able to enumerate formally the set of the possible case outcomes (R). The desirability of outcomes (the utility) is given by a CEO as his or her personal and subjective judgment. Additionally, every information included in the case representation might be enhanced with text, images, files, hyperlinks, etc. [Surma 2009]. One of the critical issues is connected with general knowledge (domain ontology) representation. This knowledge is important during the re-use phase of the case-based reasoning cycle. Thanks to this knowledge, it is possible to adapt the proposed solution from the retrieved case to the new case. Unfortunately, the strategic decision process is too complex, and it is impossible to represent the ontology properly. Despite this, we decided to use general knowledge in our approach as a warning system in situations when the solution proposed is unrealistic for formal reasons, for instance: **If** life cycle (input case) = birth and ansoff strategy(retrieved case) = market penetration, **then** warning message is " the propose strategy in not adequate". It is also important to define an appropriate similarity function (s) for the retrieval phase. Most of the case-based systems, including Strategos, retrieve a previous case based on superficial syntactical similarities. It is important to underline that Strategos similarity measure takes into account the whole problem (company and context) description (p). Nevertheless, the complete approach in strategy decision making requires deeper semantic similarities based on the object-oriented similarity [Bergman, Stahl 1998].

4.2. The CBR cycle

Based on the CBR cycle (see Figure 1) and the formal description, the whole Strategos decision-making functionality will be described. We assume that the specific input problem is given by a CEO. The task is to establish a proper strategic decision (act) for a given problem. A company (problem) is described by a set of attributes as it was described in Section 4.1. The Strategos problem solving cycle consist of four phases [Aamodt, Plaza 1994; Surma 2010]:

1. Retrieve: The solution is retrieved from the case base, basing on the similarity between a new case and cases already stored in the case base and utilities that have resulted in the past. The retrieved cases are shown to a user ranked based on the U value. Every choice is verified through the general knowledge in order to avoid unrealistic proposals.

2. Reuse: After the retrieve phase, it is possible to establish an act for a new case, after that anew case is called a solved case. The main goal of this phase is to give inspiration and/or verification and to propose rational choices based on the retrieved cases to amanagement board. Finally, every proposed solution is verified by general knowledge.

3. Revise: The solved case that was established in the previous phase has a planned strategic decision (act). This is a kind of proposal for a strategic actions plan. The most important goal of the revision phase is to recognise what has actually

happened with that company after a strategic decision was taken. It is crucial to take into consideration the case utility value (*u*) and user remarks concerning the reasons why the proposed approach was successful or unsuccessful. In reality, there are several factors of different type such as economic trend, customers' behaviour, organisational atmosphere in a company, etc., which have impact on the final result.

4. Retain: Finally the tested/repaired case is placed into the case base as a lesson learned for the future re-use – a learned case. The quality of learned cases is a crucial problem in the whole CBR cycle, because quality of suggested solution directly depends on this. It should be emphasised that lessons learned might be negative as well (the case utility < 0).

5. Empirical evaluation

The empirical evaluation was made in two phases. During Phase 1 (see Section 5.1) the results of the examination of the Strategos system will be shown at the technical level (correctness and quality of recommendations generated based on real test cases and pattern cases) in order to verify system technically. The functional correctness will be enhanced in Section 5.2 with users comments. A specially selected target group of CEOs of some SMEs assessed the Strategos functionality. The domain field in our approach is SME mainly in the IT/TELCOsector. SMEs in this area are mainly governed by creative CEOs, who do not have a deep knowledge and experience in strategy creation. They operate in an uncertain environment.

5.1. Empirical tests

Empirical tests of Strategos system were conducted based on pattern cases and real cases. Case base of the system was completed with 454 pattern cases prepared on the basis of standard knowledge in the field of strategic management, i.a., Michael Porter's book [Porter 1980]. Those cases reflect the correlation between the phase of development, competitive position, product/market strategy, and one of the three competitive Porter strategies, see an example in Figure 1. Real cases have been prepared basing on 13 IT companies listed on the Warsaw Stock Exchange. The fundamental objective of the tests was to evaluate the quality of recommendations proposed by the system by using a quality measure reflecting similarities between test (real) case and pattern case. In order to perform tests, we created the quality measure based on expertise that was calculated according to the formula:

Quality (test_case, pattern_case) = 0.75 · Ansoff_quality(test_case, pattern_case)[1] + 0.25 · Porter_quality(test_case, pattern_case).[2]

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[1] Ansoff_quality =1 if there is the same strategy between test and pattern case, else 0.5 if there is market development and product development strategy, else 0.

[2] Porter_quality =1 if there is the same strategy between test and pattern case, else 0.5 if there is focus/niche and product differentiation strategy, else 0.

Case description	Proposed strategy
Company life cycle = birth, Theintensity of competitive rivalry = low	Ansoff strategy: product development Porter competitive strategy: focus-niche

Figure 1. Example of the pattern case

Source: author's own study.

Basing on this formula, we were able to compute the quality of the proposed solution. Thus, firstly the system retrieved (based on the similarity measure) the pattern case from the case base, and secondly the quality of the proposed solution is evaluated. In Table 1 the results are presented for the cases with the utility value bigger than zero. On average, the quality for the most similar case was 0.13, which is statistically not different from the quality for the randomly selected cases 0.14 ($p < 0.05$). Nevertheless, the system is more useful when a user overviews the list of the most similar cases, and in fact for five the most similar cases (5-NN) the average quality increases to 0.26 (see Table 1), which is statistically different from random search ($p < 0.05$). In general, the quality was technically accepted but not very impressive. It was crucial that during the test the general knowledge module was behaving properly. Based on the domain knowledge (if-then rules), the right warning messages were generated.

As shown in Section 3, each case is evaluated by utility function. Let us take as an example the ADV.PL case. The comparison between this and pattern case is shown

Table 1. The tests results test cases with the utility ≥ 0

Test case	Similarity(1-NN)[*]	Qualilty (1-NN)	Quality (5-NN)
Bankier	0.94	0.25	0.35
TravelPlanet	0.88	0.13	0.18
Macrologic	0.94	0.00	0.15
K2 Internet	0.88	0.25	0.45
PointGroup	1.00	0.00	0.15
Perfect Line	0.79	0.00	0.00
LSI Software	0.94	0.13	0.33
Procad	0.92	0.25	0.20
Power Media	0.94	0.00	0.00
Quantum Software	1.00	0.13	0.33
DGA	0.85	0.25	0.45
Average:	**0.92**	**0.13**	**0.26**

*1-NN: nearest naighbour, 5-NN: average on the five the most similar cases.

Source: author's own study.

Table 2. Comparing the test and learning case

Attributes	Test (real) case (input case)	Learning (pattern) case (retrieved case)
Name	ADV.PL	Pattern_case_157
Phase	Development	Development
Porter force (2, 4, 5)	(4, 4, 4)	(4, 3, 4)
Strategy (Ansoff)	Diversification	Product extension and/or product development
Strategy (Porter)	Not clear	Focus/niche

Source: author's own study.

in Table 2. The pattern_case_157 is the most similar case (with the similarity = 0.88) and the quality measure is equal to zero. It means that proposal from the case base is completely different from the strategy taken in reality by ADV.PL company. The diversification strategy which was really taken by ADV.PL was not proper for the company in development phase, and as we can see Strategos proposed an adequate "product extension/development" strategy proposal. ADV.PL case with utility value lower than zero meaning negative experience (in fact the company achieved a bad financial position after implementing the diversification strategy), so it is a very useful case.

5.2. Evaluation by CEOs

The evaluation of the Strategos system was supplemented with quality research. The target user of the system is a CEO of a SME. In this context a survey among some CEOs was conducted. They were shown how the Strategos system prototype works. The test group was selected by the target selection of critical cases and it is composed of 33 CEOs from SMEs operating in IT and telecomm sectors. The sectors were selected so that the CEOs functioned in a strongly competitive and innovative market, posing significant strategic challenges. It is important to underline that 11 out of 33 CEOs analysed head listed companies, which in turn involves a great level of transparency of that company and the ongoing verification of CEOs' activities by the market. All analysed CEOs were male, average age 42 years, of which 11 years as CEO. All of them (with six exceptions) were engineers. Almost everyone admitted lack of formal education in the basics of strategic management. Each of the CEOs was interviewed individually in the form of astructured interview, where answers to questions were recorded according to Likert's scale.[3] Each CEO was asked to evaluate the system after the presentation of the entire work cycle for a given demonstrative case. The evaluation was done based on the questions that interpret Strategos as

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[3] From (1) "definitely not" to (5) – "definitely yes".

a support decision tool (support), educational tool (education), or an expert system that gives direct advice what to do (decision making) – see Table 3. In Table 4 a summary of answers is presented.

Table 3. List of variables

Variable	Explanation
Support	Strategos supports me in the real strategy decision problems
Education	Strategos trains me in strategy management
Decision making	Strategos generates a final solution for my strategy problems

Source: author's own study.

Table 4. Results of the Strategos system evaluation by CEOs

	Support (%)	Education (%)	Decision making (%)
Definitely no (1)	0.0	0.0	42.7
No (2)	3.1	2.8	54.8
I do not know (3)	10.3	6.6	2.5
Yes (4)	42.4	51.5	0.0
Definitely yes (5)	44.2	39.1	0.0
Summary	**100**	**100**	**100**

Source: author's own study.

It transpires that the evaluation results are very positive, the system was met with a very good reception. The results reflect the realistic approach of CEOs, where Strategos is used as a system supporting strategic decisions, and not a system bossing around. Strategos is interpreted as an outstanding decision support tool, which is able to increase the strategy knowledge of a CEO as well. They very enthusiastically commented on functioning of the system, they also underlined their willingness to use it in real life, once the condition of adequate quality and capacity of data base is met. All of the evaluated CEOs rejected statement that this approach may give them direct solution for their strategic problems. The CEOs analysed combined acceptance of Strategos with a strong feeling of limitation of reasoning appealing solely to analogies and experience. The analysed treated the system as an inspiration or a verification for their actions, being fully aware that every decision-making situation is unique and unrepeatable. It seems that this awareness will not be the same for the entire population of CEOs of SMEs. It also seems probable that CEOs of SMEs would reject Strategos as a theoretical tool or fall for the opposite tendency, namely accept its suggestions almost automatically. Such automatic acceptance of the system and lack of the formal strategic knowledge may lead to critical decision-making errors and to huge problems for a company.

6. Final remarks

The empirical research discussed in Section 5 confirms the thesis about the usefulness of the Strategos system in strategic decision-making. It is important to underline several observations. A very strong link connecting experience and intuition in making strategic decisions was established. The analysed CEOs displayed humbleness towards experiences of other companies and many times they interpreted the case base as a sort of their own memory extension. It seems rational that the behavioural characteristics of decision-making process at the analysed CEOs would constitute a path to follow in relation to the entire population of CEOs of SMEs.

Making correct strategic decisions by CEOs of SMEs is one of the greatest challenges of management. The use of case-based reasoning and its implementation in the presented system seem to be a credible attempt to support this complex issue. Currently, the work is in progress on implementing the final version of the system and development of the case base. The main effort is focused on the proper ontology, where a company can be represented in the case base by a set of cases ordered in time (episode) so that we can have the whole life-time history of a company led by a strategic decision. This is a problem of building dynamics memories called in the literature "episodic-based reasoning" [Sanchez et al., 2005], and is currently under development. Updated info about the project and the most recent build of the system can be retrieved at www.strategos.pl.

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PODEJMOWANIE STRATEGICZNYCH DECYZJI W OPARCIU O ANALIZĘ PRZYPADKÓW

Streszczenie: Wydaje się, że poziom strategicznych decyzji, biorąc pod uwagę ich złożoną naturę i intuicyjny charakter, wykracza poza zakres systemów wspomagania decyzji. Badania oparte na analizie przypadków przyniosły obiecujące wyniki w kontekście racjonalizacji strategicznego podejmowania decyzji. Ten artykuł skupia się głównie na problemach i rozwiązaniach związanych z systemami wsparcia strategii, które odnoszą się do kluczowej roli wnioskowania przez analogię. Wybraliśmy wnioskowanie oparte na analizie przypadków jako odpowiedni paradygmat podejmowania decyzji. Następnie zaprezentowany został system Strategos oparty o wnioskowanie na podstawie przypadków na potrzeby wspierania podejmowania decyzji strategicznych przez zarządy małych i średnich przedsiębiorstw (MŚP). Następnie zaprezentowane są wyniki doświadczeń i podsumowane możliwościami dalszych badań w tej dziedzinie.

Słowa kluczowe: decyzje strategiczne, wnioskowanie przez analogię, reprezentacja wiedzy, Strategos.