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Evaluation of new service concepts using rough set theory and group analytic hierarchy process

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ABSTRACT

One of the most crucial stages in the new service development (NSD) process is concept selection, which is characterized by newly generated alternatives and vaguely defined concept evaluation criteria. Although a number of factors have been found to be influential, a lacuna remains as to how to make a strategic decision based on influential factors. This study proposes a systematic approach to evaluation of new service concepts (NSCs) by integrating the merit of group analytic hierarchy process (AHP) in modeling multi-criteria decision making (MCDM) problems and the strength of rough set theory (RST) in handling subjectivity in concept evaluation. The suggested approach is designed to be executed in four discrete stages. First of all, a hierarchical AHP model for the evaluation of NSCs is constructed in terms of strategy, finance, market, technology, and implementation. Second, pairwise comparisons are made among criteria and sub-criteria, and preferences to NSCs with respect to the sub-criteria are obtained by domain experts. Third, the individual judgments obtained at the preceding stage are aggregated into group judgments. Finally, the NSCs are prioritized based on risk propensity of decision makers. A case study of the video game service is presented to illustrate the suggested approach. We believe that our method can promote consensus building on the promising NSCs.

1. Introduction

The strategic importance of new service development (NSD) is more apparent than ever as the market shifts rapidly and the intensity of competition in the service sector is ever intensified (Lundkvist & Yakhlef, 2004). It has become the norm for successful firms to have to consistently develop new services if they are to gain or maintain a competitive edge in such a turbulent environment (Mathieu, 2001; Meyer & Detore, 2001; Oliva & Kallenberg, 2003); consequently, there is a growing body of knowledge on NSD (Johne & Storey, 1998). In recent years, parallel to the concept of NSD that is strictly market-oriented discipline, service engineering has emerged as an engineering-centric one, and has been paid increasing attention from academia and practice alike (Lee, Kim, & Park, 2010). It is concerned with systematic development of services using suitable models, methods, and tools (Bullinger, Fahnrich, & Meiren, 2003).

One of such areas is concept selection. As is in the new product development (NPD) (Krishnan & Ulrich, 2001), the NSD process is comprised of a series of decision making. Among others, selecting new service concepts (NSCs) is regarded as one of the most crucial decisions because it directly influences the direction of remaining activities (Alam & Perry, 2002); concept evaluation is a core prerequisite activity for promoting consensus building on the most promising NSCs. Contrary to the extensive body of literature on concept evaluation in NPD, however, little attention has been paid to the evaluation of NSCs. It has been noted that methodological implications have rarely been investigated despite its importance to the overall process (Davison, Watkins, & Wright, 1989). Most firms have also been observed to use informal procedures and qualitative methods that primarily hinge on human intuition and experience (Easingwood, 1986; Edgett, 1993).

Evaluating NSCs differs from other stages in the NSD process such as concept testing and evaluation of the service quality for the following reasons. Firstly, concept testing is similar to concept evaluation in that both stages aim to further narrow down the set of service concepts, but distinct in that concept testing focuses on market potential (Meiren & Burger, 2010). A set of factors affecting the selection of NSCs should be taken into account in the concept evaluation stage to determine whether the service concept is feasible and reasonable to develop and run the business. Secondly, the evaluation of service quality is aimed at determining whether

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customers are satisfied or not based on service outcomes and customer responses while concept evaluation is performed to promote consensus building on the promising NSCs among newly generated alternatives (Goldstein, Johnston, Duffy, & Rao, 2002). There usually lacks sufficient and adequate supplementary information to aid decision making in the evaluation of NSCs (Johne & Storey, 1998).

Under such considerations, the concept evaluation problem needs to address the following two methodological issues. The first issue is how to manipulate the subjective perceptions. Concept evaluation is a vague and subjective task because it is difficult to describe the exact concepts and benefits of services (Edvardsson, Haglund, & Mattsson, 1995; Mohammed-Salleh & Easingwood, 1993). There also lack sufficient and adequate supplementary information such as prototypes (or concept sketches) and annotations of key technical features in NPD (Johne & Storey, 1998; Ulrich & Eppinger, 2003). As a consequence, the concept evaluation in NSD involves subjective judgments, instead of numerical expressions and objective decisions. In this respect, the weights of evaluation criteria and performance ratings of NSCs are often not available and have to be assessed subjectively by domain experts. The second issue is data sample size. The prototyping and simulation approach in NPD may generate voluminous and various types of data. However, due to nature of the service concepts, it is usually difficult to obtain a large amount of data in the early stage of NSD process. The suggested approach can therefore be applied when the data set is small in size, as contrary to the conventional methods that require several statistical assumptions on data sample size. Put those things together, the primary purpose of this study is to propose a systematic approach to the evaluation of NSCs that meets the issues mentioned above.

The concept evaluation in NSD is still in its infancy, but methods and tools are not brand-new but the existing ones in the more established research fields of industrial engineering, operations research, and computer science (IBM Research, 2004). In this respect, King and Sivaloganathan (1999) grouped the methods for concept evaluation into five categories: utility theory, analytic hierarchy process (AHP), graphical tools such as matrices, quality function deployment, and fuzzy set theory. Recent years have also seen a huge increase in integrated use of those methods. Among others, the fuzzy group AHP has received the most attention because of the abilities in handling the subjective human ideas and modeling multi-criteria decision making (MCDM) problems (Ayağ & Özdemir, 2009; Kuo, Tzeng, & Hwang, 2007; Saridakis & Dentsoras, 2008). However, the fuzzy group AHP is suffers the limitations that stem from pre-determined fuzzy membership function, as clarified next. First of all, the way of selecting the membership function has not yet been thoroughly established. It relies on the subjective and heuristic decisions of domain experts, and severely affects the performance of concept evaluation (Walczak & Massart, 1999). Some systematic approaches such as neural network can be utilized to tune the membership function, but they are not feasible in the evaluation of NSCs due to complexity and small data sample size. Second, the boundary interval that denotes the degree of subjectivity is fixed with respect to the types of membership functions. This is not be true in reality, because the subjective perceptions vary across decision makers (Zhai, Khoo, & Zhong, 2008).

As a remedy, this study proposes a systematic approach to the evaluation of NSCs using group AHP and rough set theory (RST). First, the group AHP is one of the most widely adopted MCDM methods that is effective in structuring group decisions and manipulating the qualitative and quantitative criteria, but ineffective when applied to an ambiguous problem (Lin, Lee, & Chen, 2009). Second, the RST is a mathematical tool capable of dealing with the imprecise and subjective judgments of domain experts by overcoming the previously noted membership function-related limitations of fuzzy set theory. It only relies on the original judgments without any assumptions on membership function and auxiliary information, and can be utilized even though the data set is small in size (Pawlak, 1982). By integrating the strength of RST in handling the subjectivity and the merit of group AHP in modeling MCDM problems, the suggested rough group AHP measures the feasibility of NSCs in terms of strategy, finance, market, technology, and implementation by taking the subjective perceptions in the concept evaluation into account. Most of the previous studies were limited to identifying factors that affect the selection of NSCs (Goldstein et al., 2002). Although a number of factors have been found to be influential, a lacuna remains in the literature as to how to make a strategic decision based on influential factors with the help of a systematic and quantitative approach. We believe that the suggested approach can promote consensus building about the promising NSCs. It is also expected that our method can be employed in various ambiguous problem, such as R&D project selection and technology selection.

The remainder of this paper is organized as follows. A general background of RST and group AHP is presented in Section 2. The suggested approach is explained in Section 3 and illustrated with a comparative case study of the video game service in Section 4. This paper ends with conclusions in Section 5.

2. Methodological background

2.1. Rough set theory (RST)

The rough set theory (RST), originally introduced by Pawlak (1982), is a mathematical tool capable of dealing with subjective and imprecise concepts. The distinct strengths of RST, *vis-à-vis* related other methods, lie in handling the subjective information without any assumptions and additional adjustments. Recent years, therefore, have seen a huge increase in the use of RST. In NPD, the RST has been employed for various problems such as concept evaluation (Zhai, Khoo, & Zhong, 2009), concept design (Shao, Chu, Qiu, Gao, & Yan, 2009; Tseng & Huang, 2008), and quality evaluation (Zhai, Khoo, & Fok, 2002).

In the RST, any vague concept can be represented as a pair of precise concepts based on the lower and upper approximations (Pawlak, 1982), as depicted in Fig. 1. The lower approximation of X is the set of all objects that can be certainly included in X while the upper approximation set of X consists of the elements which cannot be characterized with certainty as belong or not to X (Greco, Matarazzo, & Slowinski, 2001). The difference of upper and lower approximation is a boundary region of X in U, which is composed of the elements that can neither be ruled in nor ruled out as member of the target set.

According to Zhai et al. (2008), the basic concept of RST can be extended to manipulate imprecise and subjective human ideas. Assume that there is a set of n classes of human ideas, $R = \{C_1, C_2, \ldots, C_n\}$, ordered in the manner of $C_1 < C_2 < \cdots < C_n$ and Y is an arbitrary objects of U, then the lower approximation of C_i, upper approximation of C_i, and boundary region are defined as:

$$\text{Lower approximation}: \underline{PX}(C_i) = \cup\{Y \in U/R(Y) \leqslant C_i\} \tag{1}$$

$$\text{Upper approximation}: PX(C_i) = \cup\{Y \in U/R(Y) \geqslant C_i\} \tag{2}$$

$$\text{Boundary region}: BR = \cup\{Y \in U/R(Y) \neq C_i\} = \{Y \in U/R(Y) < C_i\} \cup \{Y \in U/R(Y) > C_i\} \tag{3}$$

The human ideas can be represented by rough numbers on the basis of lower ($\underline{Lim}(C_i)$) and upper limit ($Lim(C_i)$) that are referred to as the mean of elements in the lower approximation and upper approximation, respectively. In this regard, the interval of boundary region denotes the degree of preciseness; a rough