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Sustainable service and energy provision based on agile rule induction

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ABSTRACT

Providing sustainable service and energy has been becoming a trend due to environmental concerns. One of the academic challenges in sustainable service and energy is identified as follows: In the complex service sector, survey data may be complicated, qualitative in nature and in large scale. Numerous attributes which are un-structured in nature and have the impact on service performance are involved. One of the promised solution approaches is the Rough Set (RS) based approach that can deal with qualitative information and provide computational results through an individual object model without any statistical assumption. To date, the traditional RS based approaches still contain a few disadvantages: (i) The decision attribute is only in one level which it could contain or reflect the concept hierarchy if well defined, (ii) Using a two stage process to generate reducts and induct decision rules. In this paper, an extended RS based rule induction approach is proposed while the associated decision tables are not in traditional format. This study contributes implementation of the solution model development to sustainable service and energy provision.

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1. Introduction

The concept of sustainable product-service systems is emerging and becomes more and more critical recently (Roy, 2000). Sustainable service refers to the service offering the tasks embedded with economic, social and environmental protection elements that are so far still non-existence especially to the existing traditional, conventional and competing offers in the market. Sustainable service is envisaged as a service that is capable to adapt to its environment, to dynamically integrate the ever-changing conditions of this environment, and as such to be sustainably coherent with its evolving challenges (Dyllick and Hockerts, 2002).

Providing sustainable service and energy has been becoming a trend due to environmental concerns. It is also because the service concept of sustainable development, not only can generate demand, and guide green consumption, but also can create the green benefits (Pan and Ren, 2011). In recent years, despite expansive literature could be found, contributions to its implementation are currently limited not yet emerging. One of the academic challenges is: Obtaining pertinent, consistent and up-to-date information across different aspects is a complex and time consuming process since data are dynamically changed from time to time. Due to such situation, rule induction to support decision making is required to be agile and effective. In addition, in the complex service sector, those data (e.g., from questionnaires) may be complicated, qualitative and in large scale. Moreover, numerous attributes which have the impact on service performance are involved. A sustainable service and energy must take many attributes into account and evaluate how maximum benefits could be provided through the use of different indicators. Numerous indicators of sustainability have been studied for many years and have been identified as desirable instruments and/or measuring rods to assess and monitor progress towards sustainable development (Selman, 1999). Decision making may redundantly utilize these indicators. Consequently, a rule induction approach to reduce the number of attributes which is derived from indicators and amount of data is required.

In data mining, rule induction approaches are numerous (Han and Kamber, 2001). The main difference between the rough set based induction and other methods is that these approaches are not suitable in selection of "sustainable attribute" because they are with population based approaches which may require several statistical assumptions and view the solution approach as a black box, and they have limitation to handle qualitative type of data (Kusiak, 2001). Rough Set (RS) based approach can deal with qualitative information and provide an individual object based approach (Kusiak, 2001) which the relationship between each object and the rule can be recognized. The RS theory has been

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applied to sustainable service and energy are numerous (Goh *et al.*, 2008; Liao et al., 2010).

However, the traditional RS approaches have the following disadvantages: (1) Most of previous studies on rough sets focused on finding certain rules and possible rules that a decision attribute is in "one level" only. However, hierarchical attributes including "condition" and "decision" features are usually predefined in real-world applications (Hong et al., 2009). In practice, each attribute could be conceptually hierarchical in nature. It is required to take into account the overall hierarchy of attributes, both condition or decision attributes. (2) Previous RS approaches used two stages to generate reducts and induct decision rules, respectively. Large computing space is required to store the reducts from the first stage, and solution searching is complex. Moreover, comparison of the reducts is limited to the same decision attribute and to the same number of attributes selected in the reducts. When the number of attributes is more, the strength index, which is introduced to identify meaningful reducts, is larger. This conflicts with the definition of a reduct, a minimal subset of attributes that provides the same descriptive ability as the entire set of attributes. In this paper, an exntended RS based rule induction is proposed to extract decision rules and handle the aforementioned four disadvantages.

Section 2 surveys the literature according to suitable service and energy. In Section 3, the hierarchical rough set problem is defined. To resolve this problem, the extended solution approach is proposed in Section 4 and Section 5 presents a case study to validate the proposed solution approach. Section 6 concludes this paper.

2. Literature review

In this section, sustainable service and energy, rough set approach are introduced and surveyed. Based on the literature survey, motivation and subject relevant to this paper is described at the end of this section.

2.1. Sustainable service and energy provision

Environmental issue has become one of the major concerns by many developed countries and regions. Sustainable services are vital to any organizations that are continuously seeking operations that are socially, economically and environmentally friendly (Shaharudin and Zailani, 2011). Sustainable service refers to the service offering embedded with economic, social and environmental protection elements that are so far still non-existence especially to the existing traditional, conventional and competing offers in the market. Sustainable service is envisaged as a service that is capable to adapt to its environment, to dynamically integrate the ever-changing conditions of this environment, and as such to be sustainably coherent with its evolving challenges (Dyllick and Hockerts, 2002). Kimita et al. (2009) recognizes sustainable service as services that create value without abandoning materials, and therefore can continuously create value throughout the entire life cycle of a service. Service like supply chain has attracted lots of attention in sustainable and green focus (Wu et al., 2015). Nowadays tremendous growth of tourism as a field of study, coupled with increasing demand for tourism education has led to a heightened focus on research and publications (Jogaratnam et al., 2005). Providing sustainable service in tourism has been becoming a trend due to environmental concern (Pan and Ren, 2011). It is also because the service concept of sustainable development, not only can affect tourism demand and guide green consumption, but also can create of the green benefits (Pan and Ren, 2011).

In this study, provision of sustainable service is main focus, rather than broadly to enhance local development, protect natural environment, and conserve cultural heritage in international resolutions. Literatures in sustainable service have been investigated and studied. Two current issues and challenges for sustainable service and energy provision are concluded.

(1) Agile decision making based on data that are dynamically changed

In recent years, the motivation toward providing a more sustainable service has led to the realization that greening product designs and production processes alone are not sufficient. Sustainable solutions that encourage more holistic thinking and strategic design planning are now receiving increased research activities (Low et al., 2001). Despite an extensive sustainable service literature, for example in tourism, contributions to its implementation are currently limited yet emerging. As such, implementing sustainable tourism is challenging with theoretical best practices not necessarily translating into practical outcomes (Sharpley, 2009; Weaver, 2000). This situation has encouraged researchers to focus attention on the implementation stage to better understand the application of sustainable development principles to tourism practices (Waligo et al., 2013).

To date, from perspective of best practices in service, evolution and alteration of the current environment are relatively swift than before. The new paradigm known as "agility" is being promoted as the solution for maintaining competitive leadership in this new environment (Goldman and Nagel, 1993; Kidd, 1994).

Agility means using market knowledge and a virtual corporation to exploit profitable changes in a volatile marketplace (Naylor et al., 1999).

Current service is undergoing a major paradigm shift that is taking it from traditional management into a world of agility. An agile business should be able to rapidly respond to the market changes and solution approaches to quickly supporting decision making are crucial. Managers make informed decisions based upon a combination of judgments and data from marketing, sales, research, development, manufacturing and finance departments (Huang, 1999). Frequently, such judgments are often made through heuristic rules inducted from collected data over time. However, obtaining pertinent, consistent and up-to-date information across a large company is a complex and time consuming process since data are dynamically changed from time to time. For this key reason, rule induction to support decision making is required to be agile and effective because data are dynamically in-cremental or de-cremental during the implementation stage.

(2) Attributes and data space to be reduced in agile rule induction

A service sector receives objects that are tangible or intangible from a service supplier through a service channel in order to provide a high & sustainable-quality (Shimomura and Tomiyama, 2005). Those data in the service process, for example from questionnaires, files, transaction, etc, may be complicated, qualitative and in large scale. Numerous attributes related to the service performance are presented in Fig. 1, where three crucial sustainability aspects at the bottom. A customer as a receiver has the attributes including income level, customer-provider interaction, background and expectation level. A travel agent as a supplier has the attributes like responsiveness, accuracy and promptness. A travel destination as a service object has attributes timeliness, uniqueness and friendliness. Since these attributes are un-structured in nature and have the impact on service performance, a sustainable service must take many attributes into account and evaluate how maximum benefits could be provided through the use of different indicators.

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