A cloud computing platform for ERP applications

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ABSTRACT

Cloud computing enables many applications of Web services and rekindles the interest of providing ERP services via the Internet. It has the potentials to reshape the way IT services are consumed. Recent research indicates that ERP delivered thru SaaS will outperform the traditional IT offers. However, distributing a service compared to distributing a product is more complicated because of the immateriality, the integration and the one-shot-principle referring to services. This paper defines a CloudERP platform on which enterprise customers can select web services and customize a unique ERP system to meet their specific needs. The CloudERP aims to provide enterprise users with the flexibility of renting an entire ERP service through multiple vendors. This paper also addresses the challenge of composing web services and proposes a web-based solution for automating the ERP service customization process. The proposed service composition method builds on the genetic algorithm concept and incorporates with knowledge of web services extracted from the web service platform with the rough set theory. A system prototype was built on the Google App Engine platform to verify the proposed composition process. Based on experimental results from running the prototype, the composition method works effectively and has great potential for supporting a fully functional CloudERP platform.

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1. Introduction

Traditional business applications such as computer aided design (CAD), product data management (PDM), Computer aided manufacturing (CAM), enterprise resources planning (ERP) and manufacturing execution systems (MES) all rely on a central server and procedural software. These systems are not autonomous or flexible enough to support a dynamic business environment [34]. With the advance of Internet technology and globalization, these enterprise applications, especially ERP systems have been web-enabled, providing access to information and communications via the Internet as a part of global business strategy [16]. Along with the emerging demand for mobility and on-demand services, the development of web-based ERP systems becomes an urgent research and development issue [64].

The subscription to web services for ERP applications has two essential advantages: ease of integration and reduction in costs through the hosted application model [57]. Wu et al. [67] presented a framework for measuring the scalability of service based applications in a Cloud Computing environment and propose an assignment strategy to improve the scalability of composite Web services in terms of services productivity. Recent research indicates that ERP delivered thru SaaS will outperform the traditional IT offers as a consequence of the current economic crisis and will helps the economies to recover [21]. Although ERP is lagging behind other applications in terms of SaaS based applications there seems to be a general consensus that ERP in SaaS is gaining momentum. To grab this momentum, the four big players in the ERP systems market SAP, Oracle, Sage and Microsoft are positioning their ERP offers in SaaS model [24]. However, distributing a service compared to distributing a product is more complicated because of the immateriality, the integration and the one-shot-principle referring to services [23]. Also, the process of analyzing and selecting services in the Web services composition process is more complex than the one of analyzing and selecting parts for a product design [37]. It is further complicated by the customer's request in terms of the scope of application. One specific need is the development of efficient composition methods which evaluate and optimally integrate these possibly heterogeneous services on the Web, especially in the ERP application domain, in response to an enterprise customer's request.

Therefore, this paper proposes a CloudERP platform on which enterprise customers can select web services and customize a unique ERP system to meet their specific needs. The CloudERP aims to provide enterprise users with the flexibility of renting an entire ERP service through multiple vendors. This paper also addresses the

challenge of composing web services and proposes a web-based solution for automating the ERP service customization process. This study proposes a method that makes use of the genetic algorithm (GA) concept and the rough set theory to solve the Web services composition problem. The genetic algorithm incorporates with rough set theory to solve the web services composition problem has been discussed and applied [5,36,37]. However, these all focus on how to use rough set theory to extract rules and ignore the feature of the application domain. The novelty of the proposed method lies in the application domain (Cloud ERP).

This remainder of this paper is organized as follows: Section 2 reviews the concepts of Web-based ERP and Web services composition. In Section 3, a novel ERP platform called CloudERP is proposed. In Section 4, the proposed composition method for Web ERP services is presented. In Section 5, a system prototype is presented along with experimental data analysis and then followed by Section 6 which provides concluding remarks and summary of future research directions.

2. Literature review

2.1. Web-based ERP

ERP systems are one of the most adopted information technology (IT) solutions in organizations [2]. Because of their scale and substantial resources consumption, it is not surprising that ERP systems have been a center of focus by both researchers and practitioners [11]. The key competitive edge for every enterprise in the 21st century is in its ability to prescribe, standardize, and adapt its business activities and collaborations with customers, suppliers, partners and competitors [34]. Most ERP vendors today recognize this interoperability issue as significant and have built up Internet-enabled supply chain/logistics modules to facilitate integration with the back-end systems of supply chain partners relying on a diverse set of legacy databases, IT infrastructure and applications [52]. For example, Gollakota [15] reported a company which created kiosks with Internet and computer access and operated a web portal serving the needs of the farming industry. The portal provided information relating to farming techniques, farm business information, and general information such as weather and climate, and access to the firm's ERP system. Separately, Tarantilis et al. [57] presented a Web-based ERP system developed to address business problems and manage real-world business processes ranging from a simple office automation procedure to complex supply chain planning. Zhang et al. [75] explored the IT service innovation in textile industrial clusters from a service system perspective. They argued that the IT enabled producer service could be used to ensure the structural upgrading of the textile industrial clusters. Mital et al. [44] also developed an integrative framework to identify the determinants of choice of SaaS in the specific context of SaaS based e-procurement and ERP.

In summary, one of the most important trends in the recent years is cloud computing. It has the potentials to reshape the way IT services are consumed. More recently, some ERP vendors have moved some of their offerings to the cloud e.g., SAP By Design. However, there is still a lot to be done in order for the customers to see more and more services and suites moving to the cloud. Therefore, more research efforts are still needed in order to elucidate knowledge on the marriage of the two [11].

2.2. Web services composition

The capability of composition is an important strength of any Web services provider. Rather than accessing a single service, composing services is essential as it adds better benefits to its users [13]. By ensuring high-level interoperability, Web services offer have the capability of composing compatible processes referred to as composite Web services, independent of specific platforms and computing paradigms [42]. While elementary Web services do not rely on other Web services to fulfil external requests, composite services integrate multiple service components to fulfil a customer's request [43].

Several approaches and applications have been proposed to exploit the concept of Web services composition. One research looked into the role of policies and context for framing the composition of Web services. Policies are to govern the behavior of Web services engaged in composition; and context is to support the development of adaptable Web services [42]. Yu et al. [73] designed a broker-based architecture for selecting Quality of Service (QoS)-based services. The objective of service selection is to maximize an application-specific utility function under the end-to-end QoS constraints. Park [46] presented a decentralized protocol design called the Web services co-allocation protocol, aiming to facilitate the execution of composite Web services, while Lee et al. [32] proposed a Web services-based Multidisciplinary Design Optimization (MDO) framework that synthesizes both disciplinary and cross-disciplinary resources available for MDO. Taking advantage of Web services, Zhao et al. [77] built a biomedical digital library infrastructure called the Living Human Digital Library (LHDL) that allows clinicians and researchers to preserve, trace, and share data resources, as well as to collaborate at the data-processing level. Recently, Yahyaoui et al. [70] proposed a novel matchmaking approach between fuzzy user queries and real world Web services. The matchmaking spans over a domain dependent classification step that produces fuzzy classification rules for Web services. Furthermore, these rules are leveraged to classify Web services into categories, which allow reducing the matchmaking space. One study developed an efficient approach for automatic composition of Web services using the state-of-the-art Artificial Intelligence (AI) planners [79].

Rajeswari et al. [51] revealed various challenges in the QoS parameter for Web service composition because it is difficult to recognize. In summary, Web services composition is a complex issue. The complexity initially arises from the diversity and compatibility of the composition components of Web services. It is further complicated by the customer's request in terms of the scope of application. In theory, service components are developed by different organizations and offered by different providers at different rates. There is a general need for developing principles and methodologies for managing composite Web services. One specific need is the development of efficient composition methods which evaluate and optimally integrate these possibly heterogeneous services on the Web, especially in the Cloud ERP application domain, in response to an enterprise customer's request.

3. CloudERP

Cloud computing is defined as both the applications delivered as services and the hardware and systems software in the data centers that provide those services [3]. Kim [29] anticipated that Cloud computing would become a key computing paradigm for the next 5–10 years. Cloud services can be viewed as a cluster of service solutions based on cloud computing, which involves making computing, data storage, and software services available via the Internet. Generally, cloud services can be divided into three categories [69]:

(1) Software as a service (SaaS): Applications services delivered over the network. SaaS simplifies the utilization of a large