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PaaS - Black or White: An Investigation into Software Development Model for Building Retail Industry SaaS

Vu Viet Hoang Pham[1], Xiao Liu[1], Xi Zheng[1], Min Fu[2, 3], Sahil Vikas Deshpande[1], Weidong Xia[1], Roger Zhou[1], Mohamed Abdelrazek[1]

[1]School of Information Technology, Deakin University, Melbourne, Australia
[2]Department of Computing, Faculty of Science and Engineering, Macquarie University, Sydney, Australia
[3]Data61, Commonwealth Scientific and Industrial Research Organization (CSIRO), Sydney, Australia
{vvpham, xiao.liu, xi.zheng, svdeshpa, xiaw, rogerz, mohamed.abdelrazek}@deakin.edu.au, min.fu@mq.edu.au

***Abstract*— One of the most important goals for Software Engineering is that end users or those people who understand software requirements but without too much programming experience can build their software products or prototypes easily. The recent success of cloud computing has made a big step towards this goal where Platform as a Service (PaaS) can provide general and comprehensive software development services within an integrated online environment for building Software as a Service (SaaS). However, currently, most PaaS are in a "white-box" which still requires significant learning efforts for software developers and lets alone inexperienced project managers or end users. Therefore, it is high time that we should comprehensively investigate the challenges for PaaS and provide a suitable development model. In this paper, we firstly identify and analyze the challenges for current White-PaaS through literature review. Afterwards, employing the retail industry as a typical application domain, a novel "Black-Box" PaaS framework is proposed which requires much less learning time and supports much more flexible and speedy SaaS design and development.**

Keywords- Cloud Computing; Software Development; Software as a Service; Platform as a Service

I. INTRODUCTION

One of the oldest and maybe the biggest challenges in Software Engineering is the precise delivery of software requirements from the customers to the software developers. In the recent decades, Component Based Software Engineering (CBSE) and Service Oriented Architecture (SOA), especially the recent success of cloud computing have made a big step towards this goal [1]. In cloud computing, Software as a Service (SaaS) is a model in which software products are delivered to clients through the Internet and charged based on their usage [2]. Platform as a Service (PaaS) is the software development model for SaaS. Currently most PaaS providers adopt "White-PaaS" model which tries to provide a set of general and comprehensive services for software development within an integrated online environment [3, 4]. However, current White-PaaS software development model still has many challenges as will be discussed in Section II. Therefore, it is the high time we should comprehensively investigate the requirements and challenges for PaaS. The authors in [5] discussed both the challenges and opportunities of PaaS. However, the challenges identified in this paper are mostly from project management instead of technical perspectives. In addition, there is no concrete framework to support such a process.

In this paper, we focus on some of challenges which are typical in the application domain of retail industry SaaS. We firstly identify and analyze the challenges for current White-PaaS through literature review. Afterwards, to cope with these challenges, we propose a "Black-Box" PaaS framework. Our Black-PaaS framework can be employed to develop general SaaS applications but it is designed to particularly meet the requirements of retail industry SaaS which is a typical business application domain with very strong market demand from a large number of small and medium enterprises. Since the software requirements and business processes for these enterprises are very dynamic and complicated, the software development platform needs to be very flexible and efficient. With our Black-PaaS framework, end users or project managers who fully understand the software requirements can easily build (mainly in the form of drag-and-drop) their own software or the software prototypes which can be used by professional developers for further development. In such a case, the efforts for developing SaaS applications can be significant reduced while their quality can be effectively improved.

II. PROBLEM INVESTIGATION

In this section, we will present our investigation into current White-PaaS. However, instead of trying to cover all aspects of PaaS, we start our research focusing on a typical application domain which is the retail industry SaaS.

Cost Models: With PaaS, software organizations can focus on the software development itself without investing in the infrastructure as well as services for development, testing, deployment, and hosting. As a result, they can reduce the costs for developing applications, especially with start-up companies [6, 7, 8]. Moreover, with the pay-as-you-go pricing model of PaaS providers, the organizations just

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need to pay for what they use, PaaS is likely to offer them cost advantages for their business [9]. However, whether the cost models of PaaS are really beneficial for practitioners is controversial. As a matter of fact, the practitioners usually underestimate the costs of using PaaS [6, 10].

Complexity of Development: Similar to the controversy over the cost model, there are some people thinking that using cloud computing reduces the time for development and testing, but there are also many people stating that cloud computing is complicated and requires much expertise to successfully develop SaaS [11, 12]. According to the market research company Red-Monk, many developers have to spend non-trivial time to learn how PaaS works as well as the programming languages supported by PaaS [4].

Online/Offline Mode: One of the essential requirements for SaaS application to run is having sufficient and reliable network connectivity. However, the quality of Internet connection may vary from place to place and time to time. The instability of the network connectivity is one of the major problems in using SaaS [13, 14]. Moreover, cloud servers can also have unpredictable downtime. For example, the Google App Engine experienced an outage about 5 hours because of a program error [15]. Another example of interrupted services is the failure of EC2 [16]. Moreover, in many application domains such as Point Of Sale (POS) system in the retail industry, the application cannot be interrupted during the business time due to the nature of the business. These applications are required to work even when there is no network connection. Therefore, SaaS applications should be able to work in both online and offline mode. However, this is still an open question for PaaS to support the running of SaaS in both online and offline mode.

Hybrid Cloud: Generally speaking there are four resource models for cloud computing which are public cloud, private cloud, community cloud and hybrid cloud. Currently, public cloud plays an important role in the cloud market and it is regarded as the key enabling technology for IT industry. However, many enterprises do not want to put their important data on the public cloud as they will lose the control of the data [17]. To resolve this problem, hybrid cloud can be a suitable choice. With the hybrid model, customers can put important data in their internal private cloud and use other services on the public cloud. In addition, there are many other benefits for organizations when using hybrid cloud such as reducing infrastructure cost, flexibility in acquiring resources for development and testing, and better level of control [18]. Ideally, PaaS should ensure that the edges between public and private clouds are transparent. However, how to support the building of SaaS based on hybrid cloud is still an open issue for PaaS.

Security and Privacy: Many surveys indicated that security and privacy is the major issue which hindered the adoption of cloud by potential customers [20, 21, 22]. For example, in a survey conducted by International Data Corporation (IDC) for Chief Information Officers (CIO) and IT Executives, nearly 75 percent of participants shared the opinion that security is the major issue for cloud computing [19]. However, so far how to solve the issue of security and privacy is still a big challenge for PaaS.

III. PROPOSED SOLUTION

In this section we will propose a novel software development model for building SaaS. The solution can be seen as a Black-Box PaaS (Black-PaaS for short) as it tries to cover all internal mechanisms of PaaS and provide a set of development services so that developers can focus on building SaaS applications itself.

Our Black-PaaS framework has three tiers from top to bottom. The top developer services tier faces Cloud/SaaS solution developers, product managers, and UX engineers. The UX Engine provides UX engineers visual prototype and experimental tool sets to accelerate the UX design process. At deployment time, machine learning algorithms can be helped to learn the user behaviors (e.g., by recording user's mouse movement and actions on the SaaS user interface and reports) to tailor UX experience for a specific tenant or a group of customers for a tenant. The Report Engine provides highly customized templates and data items for product manager to create/change tenant's reports. The Application Engine provides drag-and-drop experience for developers and product managers to customize each tenant's application user interfaces and processing logics for the input information. The Workflow Engine integrates report and application engine to provide product managers drag-and-drop experience to customize complicated business processes which can interact with reports and web forms.

The middle tier consists of the Security and Privacy engines. In the security engine, we provide security operation office [23] and real time traffic classifier to detect and prevent attacks [24]. In the privacy engine, we provide differential privacy algorithm to hide each user's sensitive data. The security and privacy officer can define SaaS service level and Tenant's level of security and privacy policies through the engines. Since the engines are tightly integrated inside the Black-PaaS, it has unprecedented access to internal real time application logs thus more effective and efficient.

The bottom kernel services tier consists of the Dynamic Provisioning Engine and Database Engine. Like the second tier, it requires minimum configuration from the developers as all the processes are automatic. The Dynamic Provisioning Engine manages all virtual resources and can dynamically provision resources according to the system performance requirement. The Database Engine provides an intuitive data model which integrates relational databases service and NOSQL database service through an intelligent middleware which wraps these two types of database services to provide a unified API for developers.

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REFERENCES

[1] I. Sommerville, *Software Engineering (10th Edition)*: Addison-Wesley, 2015.

[2] S. Lange, M. Margraf, S. T. Ruehl, and S. A. Verclas, "On Valid and Optimal Deployments for Mixed-Tenancy Problems in SaaS-Applications", *Proc. 2014 IEEE World Congress on Services*, pp. 287-294, 2014.

[3] R. F. Roggio, T. Bilyayeva, and J. R. Comer. "Everyday Cloud Computing with SaaS", *Proc. International Conference on Software Engineering Research and Practice*, pp. 1-7, 2012.

[4] G. Lawton, "Developing Software Online with Platform-as-a-Service Technology", *Computer*, 41(6):13-15, 2008.

[5] M. Benedict, "Coming to (Your) Terms with Platform-as-a-Service (PaaS)", *Progress Software*, Bedford, MA, pages 1-11, 2013.

[6] B. Martens, M. Walterbusch, and F. Teuteberg, "Costing of Cloud Computing Services: A Total Cost of Ownership Approach", *Proc. Hawaii Conference on System Science*, pp. 1563–1572, 2012.

[7] Y. Mehmood, M. A. Shibli, U. Habiba, and R. Masood, "Intrusion Detection System in Cloud Computing: Challenges and Opportunities", *Proc. 2nd National Conference on Information Assurance*, pp. 59-66, 2013.

[8] Y. Jadeja and K. Modi, "Cloud Computing - Concepts, Architecture and Challenges", *Proc. International Conference on Computing, Electronics and Electrical Technologies*, pp. 877–880, 2012.

[9] S. Sahni and V. Varma, "MultiPaaS - PaaS on Multiple Clouds", *Proc. 2014 IEEE International Conference on Cloud Computing in Emerging Markets*, pp.1-6, 2014.

[10] M. Al-Roomi, S. Al-Ebrahim, S. Buqrais, and I. Ahmad, "Cloud Computing Pricing Models: A Survey", *International Journal of Grid and Distributed Computing*, 6(5):93-106, 2013.

[11] A. Shahzad, A. G. Golamdin, and N. A. Ismail, "Opportunity and Challenges using the Cloud Computing in the Case of Malaysian Higher Education Institutions", *International Journal of Management Science and Technology Information*, (20):1–18, 2016.

[12] B. P. Rimal, E. Choi, and I. Lumb, "A Taxonomy and Survey of Cloud Computing Systems", *Proc. Interntional Joint Conference on INC, IMS and IDC*, pp. 44-51, 2009.

[13] O. Ali, J. Soar, and J. Yong. "An Investigation of the Challenges and Issues Influencing the Adoption of Cloud Computing in Australian Regional Municipal Governments", *Journal of Information Security and Applications*, 27-28:19-34, 2016.

[14] C. Kalloniatis, H. Mouratidis, M. Vassilis and et.al, "Towards the Design of Secure and Privacy-Oriented Information Systems in the Cloud: Identifying the Major Concepts", *Computer Standards and Interfaces*, 36:759--775, 2014.

[15] M. Armbrust, A. Fox, R. Griffith, and et.al, "A View of Cloud Computing", *Communications of ACM*, 53(4):50–58, 2010.

[16] J. Joshi, H. Takabi, G. Ahn, "Security and Privacy Challenges in Cloud Computing Environments", *IEEE Security & Privacy*, vol. 8, pp. 24-31, 2010.

[17] S. Marston, Z. Li, S. Bandyopadhyay, J. Zhang, and A. Ghalsasi, "Cloud Computing - the Business Perspective", *Decision Support Systems*, 51(1):176–189, 2011.

[18] S. Goyal, "Public vs Private vs Hybrid vs. Community Cloud Computing: A Critical Review", *International Journal of Computer Network and Information Security,* 6(3):20, 2014.

[19] N. Sultan, "Cloud Computing for Education: A New Dawn?", *International Journal of Information Management*, 30(2):109-116, 2010.

[20] A. Verma and S. Kaushal, "Cloud Computing Security Issues and Challenges: A Survey", *Proc. International Conference on Advances in Computing and Communications*, pp. 445-454. 2011.

[21] J. Yang and Z. Chen, "Cloud Computing Research and Security Issues", *Proc. International Conference on Computational Intelligence and Software Engineering*, pp. 1-3, 2010.

[22] D. Nascimento and M. Correia, "Shuttle: Intrusion Recovery for PaaS," *Proc. 35th IEEE International Conference on Distributed Computing Systems*, pp. 653-663, 2015.

[23] B. Rothke, "Building a Security Operations Center," https://www.rsaconference.com/writable/presentations/file_upload/tech-203.pdf, accessed on 26th Oct. 2016.

[24] S. Wen, W. Zhou, Y. Xiang and W. Zhou, "CAFS: a Novel Lightweight Cache-Based Scheme for Large-Scale Intrusion Alert Fusion," *Concurrency and Computation: Practice and Experience*, 24(10): 1137-1153, 2011.