UNIVERSITI PUTRA MALAYSIA

CUSTOMIZATION APPROACH AND SOFTWARE QUALITY MAPPING MODEL TO IMPROVE SAAS CUSTOMIZATION

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CUSTOMIZATION APPROACH AND SOFTWARE QUALITY MAPPING MODEL TO IMPROVE SAAS CUSTOMIZATION

By

ABDULRAZZAQ QASEM ALI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

This thesis is dedicated to my ever caring parents, my beloved wife, my wonderful kids, and my dear brother Abdullah

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

CUSTOMIZATION APPROACH AND SOFTWARE QUALITY MAPPING MODEL TO IMPROVE SAAS CUSTOMIZATION

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Chairman: Abu Bakar Md Sultan, PhD
Faculty: Computer Science and Information Technology

Software as a Service (SaaS) is widely used for a wide range of applications development. Therefore, the SaaS should capacitate itself to offer services to many customers having their own specific requirements, without encountering software quality problems. Hence, understanding SaaS customization's impact on the software quality will mitigate the risk. However, studies on the effects of software customization on the quality of SaaS application are still lacking. Furthermore, it is essential to record the customization category to ascertain the impact and risks linked to specific types of customization. Any form of SaaS customization is likely to influence the software quality. Accordingly, customization types and customization practices in the context of multi-tenant SaaS should be identified prior to assessing the impact of customization.

Although several researchers have clearly stated the need for emphasis on SaaS application customization, there remains a dearth of knowledge on software customization types and practices in the SaaS multi-tenant context. Hence, the aim of this research is to propose a customization approach and software quality mapping model that provides three main information: 1) software customization types and a list of common practices for each customization type in the SaaS Multi-Tenant context, 2) key quality attributes of SaaS applications associated with customization, and 3) empirical evidence on the impact of each customization type over SaaS quality. The proposed model was initially constructed from 46 customization practices and 13 quality attributes in the SaaS multi-tenant context. Each investigated customization practice was deductively assigned to one of the customization approaches (personalization, configuration, composition, modification, integration, and extension).

The model was content validated in two rounds and necessary changes were made as suggested by the content experts. Subsequently, the internal consistency reliability study among 34 software engineers was conducted and showed that all constructs are reliable. The model then had undergone further investigation to empirically assess construct reliability, construct validity, and the effect of each customization approach on the SaaS quality by surveying 244 software professionals who have been involved in SaaS development life cycle. The collected data was then analyzed using factor analysis and Structural Equation Modeling (SEM).

The model was modified based on the results of factor analysis. The test for reliability and validity revealed that the model is acceptable. The findings of the structural model assessment show that all customization approaches significantly influence the quality of SaaS application except integration. Furthermore, it revealed that the impact of configuration and composition approaches on SaaS quality is positive, while the impact of other approaches is negative. The results of model validation showed experts positive feedback on the usefulness of the model. As a conclusion, this research provides a wider view of the impact of software customization on SaaS quality from different aspects (e.g., customization types, quality attributes, and potential impacts). This is a useful guidelines and references for both SaaS researchers and SaaS practitioners.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENDEKATAN PENYESUAIAN DAN MODEL PEMETAAN KUALITI PERISIAN UNTUK MENAMBAH BAIK PENYESUAIAN SAAS

Oleh

ABDULRAZZAQ QASEM ALI

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Perisian sebagai perkhidmatan (SaaS) digunakan secara meluas untuk pelbagai bentuk pembangunan aplikasi. Oleh itu, SaaS seharusnya mempunyai kapasiti tersendiri untuk menawarkan servis kepada ramai pelanggan dengan keperluan spesifik masing-masing, tanpa menghadapi masalah kualiti perisian. Dengan itu kefahaman tentang impak penyesuaian ke atas kualiti boleh mengurangkan risikonya. Bagaimanapun, masih kurang kajian efek dijalankan ke atas penyesuaian perisian terhadap kualiti aplikasi SaaS. Seterusnya, adalah perlu untuk merekodkan kategori penyesuaian untuk memastikan kaitan impak dan risiko terhadap jenis-jenis spesifik penyesuaian. Sebarang bentuk penyesuaian SaaS berkemungkinan mempengaruhi kualiti perisian. Sewajarnya jenis penyesuaian dan praktis penyesuaian dalam konteks SaaS pelbagai-penyewa dikenal pasti dahulu sebelum penilaian impak penyesuaian.

Sungguhpun beberapa penyelidik dengan jelas menyatakan keperluan untuk memberi penekanan ke atas penyesuaian aplikasi SaaS, masih terdapat kekurangan pengetahuan terhadap jenis-jenis penyesuaian dan praktis dalam konteks SaaS pelbagai-penyewa. Oleh itu, matlamat kajian ini adalah untuk mencadangkan pendekatan penyesuaian dan model pemetaan kualiti perisian yang bagi menghasilkan tiga maklumat utama: 1) jenis-jenis penyesuaian perisian dan senarai praktis yang biasa bagi setiap jenis dalam konteks SaaS pelbagai-penyewa, 2) atribut-atribut kualiti utama aplikasi SaaS yang berkaitan dengan penyesuaian, dan 3) bukti empirikal keatas impak setiap jenis penyesuaian terhadap kualiti SaaS. Model cadangan ini asalnya dibangunkan dari 46 praktis pennyesuaian dan 13 atribut kualiti dalam konteks SaaS pelbagai-penyewa. Setiap penelitian praktis penyesuaian telah agihkan secara deduktif kepada salah satu pendekatan-pendekatan penyesuaian (pemperibadian, konfigurasi, komp-

osisi, modifikasi, integrasi, dan sambungan).

Kandugan model ini disahkan dua pusingan dan perubahan yang perlu dilakukan mengikut cadangan oleh pakar kandungan. Seterusnya, kajian kebolehpercayaan ketekalan dalaman dikalangan jurutera perisian dilaksanakan dan menunjukkan semua binaan model validasi-kandungan adalah dipercayai. Model ini kemudiannya melalui kajian lanjutan untuk menilai kebolehpercayaan binaan secara empirical, pengesahan binaan, dan efek setiap pendekatan penyesuaian keatas kualiti SaaS dengan mensurvei 244 profesional perisian yang terlibat dalam kitar pembangunan SaaS. Data yang dipungut daripada survei dianalisa menggunakan analisis faktor dan Permodelan Persamaan Struktur (SEM).

Model ini diubahsuai berasaskan keputusan analisis faktor. Ujian kebolehpercayaan dan kesahan mendedahkan model ini boleh diterima. Dapatan penilaian model struktur menunjukkan dengan jelas semua pendekatan-pendekatan penyesuaian memberikan kesan ke atas kualiti aplikasi SaaS kecuali pendekatan integrasi. Seterusnya, ia juga mendedahkan bahawa impak pendekatan-pendekatan konfigurasi dan komposisi ke atas kualiti SaaS adalah positif, sementara impak pendekatan-pendekatan lain adalah negatif. Keputusan model kesahan oleh pakar menunjukkan maklumbalas positif terhadap kebolehgunaan model. Kesimpulannya, penyelidikan ini menghasilkan pandangan lebih meluas terhadap impak penyesuaian perisian terhadap kualiti SaaS daripada aspek-aspek yang berbeza (contoh: jenis penyesuaian, kualiti atribut-atribut, dan potensi-potensi impak). Ini merupakan panduan berguna dan sebagai rujukan untuk kedua-dua penyelidik SaaS dan pengamal SaaS.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Declaration by graduate student

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This is to confirm that:

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- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

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LIST OF ABBREVIATIONS

AMOS	Analysis of Moment Structure
AVE	Average variance extracted
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CMB	Common method bias
CLF	Common latent factor
C.R.	Critical ratio
CR	Construct reliability
CRM	Customer relationship management
CS	CiteSeer
CVI	Content validity index
DL	Digital library
EAI	Enterprise application integration
EAM	Enterprise asset management
EI	Ei Compendex and Inspec
ERP	Enterprise Resource Planning
ES	Empirical study
EFA	Exploratory factor analysis
GoF	Goodness of Fit
GS	Google Scholar
GUI	Graphical user interfaces
I-CVI	Item content validity index
KMO	Kaiser-Meyer-Olkin
MLE	Maximum likelihood estimation
OLS	Ordinary least square
PLS	Partial least squares
PS	Primary study
PAF	Principal axis factoring

PCA	Principal components analysis
RMSEA	Root mean square error of approximation
SaaS	Software as a Service
SAP	Systems, Applications, and Products
S-CVI	Scale content validity index
SD	ScienceDirect
SEM	Structural Equation Modeling
SCM	Supply chain management
SJR	SCImago Journal Rank
SL	SpringerLink
SMI	Service measurement index
SMS	Systematic mapping study
SPS	Selected primary study
SPSS	Statistical Package for Social Sciences
SC	Software customization
SQ	Software quality
SQA	Software quality assurance
SRS	software requirements specification
TLI	Tucker-Lewis index
WIS	Wiley InterScience
WoS	ISI Web of Science

CHAPTER 1

INTRODUCTION

1.1 Background

In Software as a service (SaaS), the software and its related data are centrally hosted in the cloud computing environment. Users usually access this data using a web browser and a thin client (Mell and Grance, 2009; Arrieta, 2012). The high regard for SaaS in the business domain can be attributed to its multi-tenancy design structure. Multi-tenancy is defined as the case when a single instance of software running on a server, services numerous customers (Arrieta, 2012; Kwok et al., 2008). Multi-tenancy is a vital feature of cloud computing (Kwok et al., 2008). The need for an effective SaaS model has become imperative because it has the potential to lower the expenditures related to hardware, software, maintenance, and management (Lee et al., 2013; Yang et al., 2010; Walraven, 2014; Walraven et al., 2014; Shen et al., 2011).

The design of SaaS is mainly aimed at servicing numerous clients through a single software application instead of developing many software versions for each client (Fiaidhi et al., 2012). The ultimate goal of SaaS application providers is the provision of an easy to use, fully coordinated option. However, the management of highly complex software that may entail extremely complicated adaptations may go beyond the capacity of delivery model in a multi-tenancy setting (Salih and Zang, 2012).

The economically viable method of developing SaaS application is to make a generic application which is relevant to a large number of customers (Shahin et al., 2014). In this instance, the SaaS provider is unable to provide a unique SaaS application for each customer, and so this is where a change needs to be made. To address the distinctive needs of each customer in terms of function and quality, a SaaS application must be customizable. The effectiveness of SaaS is highly dependent on its capacity for customization (Tsai and Sun, 2013; Mietzner and Leymann, 2008). To accommodate the model of SaaS, providers of SaaS applications need a well-structured strategy for SaaS customization and quality. The lack of such a strategy will hamper the development and maintenance of SaaS applications.

The mounting interest in SaaS customization prompted the researcher to propose a model that provides a more comprehensive understanding of the software customization approaches and practices in the SaaS multi-tenant context and identifies the key quality attributes of SaaS applications associated with customization. Furthermore, this model supposes to provide empirical evidence on the impact of the customization over SaaS Quality.

1.2 Problem Statement

Customization plays a significant role in the provision of an application to different tenants (Walraven, 2014; Araujo and Vazquez, 2013); however, it can present threats to the quality of SaaS application that need to be considered by the hosts of SaaS (Al-Shardan and Ziani, 2015). This is because the software source code alterations essential to meet most customization requirements are rendered increasingly complicated in the context of multi-tenant SaaS applications (Walraven et al., 2014; Guo et al., 2011; Sun et al., 2008) by the need to separately maintain each tenant's customization code (Guo et al., 2011). Therefore, frequent customization leads to the continuous maintenance and evolution of the SaaS application that threatens the crucial scalability and cost-efficiency of the application (Van Landuyt et al., 2015; Walraven et al., 2014).

Additionally, a tenant's requirement changes often emerge after the applications and services are developed; therefore, the run-time customization scoped to a specific tenant has to be supported within the same application instance (Van Landuyt et al., 2015; Walraven et al., 2014; Shahin, 2014b), and it should not affect tenant isolation and application availability (Van Landuyt et al., 2015; Walraven, 2014). It is likely that the rather small initial investment and monthly subscription fees received from tenants may not cover the overall expenditure for complicated customization (Guo et al., 2011; Sun et al., 2008). Therefore, SaaS application providers need to cautiously evaluate their customization proficiency (Samir and Darwish, 2016; Guo et al., 2011) and assess the impact of software customization on the crucial features of SaaS (Walraven et al., 2014; Espadas et al., 2013; Joha and Janssen, 2012).

The impact of customization on software quality has often been one of the major challenges faced by software engineers and project managers (Parthasarathy and Sharma, 2017), and there are some empirical evidences on this issue (Parthasarathy and Sharma, 2017; Ng, 2013; Light, 2001). However, the available empirical evidences have not given a pivotal focus on the effects of software customization on the quality of software delivered in a multi-tenancy environment[1], where customization is gaining more consideration (Walraven, 2014; Araujo and Vazquez, 2013).

Furthermore, it is essential to record the customization category to ascertain the impact and risks linked to specific types of changes (Chaumun et al., 2002), where any form of customization is likely to influence the software quality (Parthasarathy and Sharma, 2017). Accordingly, customization types and customization practices in the context of multi-tenant SaaS should be identified prior to assessing the impact of customization on the quality features of SaaS. Although several researchers have clearly stated the need for emphasis on SaaS application customization, there remains a dearth of knowledge on software customization types and practices in the SaaS multitenant context[2].

[1] For instance, see Chapter 2, Section 2.6.
[2] For instance, see Chapter 2, Section 2.5.

In view of the importance of software customization and its impact on SaaS quality, it is needful for researchers and practitioners to understand the customization practices pertaining every customization type in the context of multi-tenant SaaS, the essential quality attributes of SaaS from customization perspective, and the potential impact of each customization type on SaaS quality. Hence, developing and evaluating a well-defined customization approach and software quality mapping model, that provides this set of information, is in demand to be researched.

1.3 Research Objectives

With respect to the problem statement of this research, there is a need to understand the relationship between software customization and SaaS quality. Hence, the primary objective of this research is to propose customization approach and software quality mapping model to improve SaaS customization. In order to achieve the main objective, the following are the sub-objectives of this research:

- To identify the software customization approaches that impact SaaS quality. With this identification, a set of common practices pertaining to every customization approach in the context of multi-tenant SaaS should be identified as well.
- To investigate which quality attributes of SaaS applications are associated with software customization. These attributes best represent the key quality attributes of SaaS application that might be impacted by software customization.
- To empirically assess the impact of the customization on SaaS quality by investigating the effects of each customization approach on SaaS quality. This will involve the identification of the degree of the impact between each customization approach and SaaS quality.

1.4 Research Scope

The scope of this research is summarized as follows:

- This research is restricted to customization types, practices, and quality attributes of SaaS applications that are the results of systematic mapping study and experts' opinion. However, this research does not intend to claim that these are the only customization types, practices of SaaS customization, and SaaS quality attributes.
- Though this research will empirically report the impact of each customization approach on SaaS quality defined by a list of quality attributes of SaaS associated with software customization, this research does not consider the impact of each customization approach on each quality attribute of SaaS application.

- This research mainly focuses on SaaS provider respondents. This can include SaaS architect, SaaS developer and SaaS operator who are employees of the SaaS provider (Walraven et al., 2014). Thus, persons who have been involved in any step of SaaS development life cycle (e.g., Requirements analysis, design, development, testing, maintenance, and support) can be as respondents of this research.

1.5 Research Contribution

Theoretically, this research contributes to the body of knowledge for software engineering and information systems in many ways, but the main contribution is the construction and evaluation of customization approach and software quality mapping model to improve SaaS customization, especially not many studies had been conducted relating software customization to SaaS quality. Furthermore, the developed model provides a set of information that can be used for assessing different types of software customization and their impact on SaaS quality. The information lists provided by this model, and the significance of each, are detailed below.

- Different customization types and a list of common practices for each customization type in the SaaS multi-tenant context. Having this list can aid in the understanding of SaaS customization aspects, as well as in the assessment of the software and SaaS customization's impact in several contexts.
- The key quality attributes of SaaS applications associated with customization. This list is important in understanding the relationship between customization and specific quality attributes of SaaS considered crucial factors for the success of SaaS applications.
- The potential impact of each customization type on SaaS quality. Prior to any decisions about customizing a SaaS application, understanding customization's impact on the quality of SaaS will mitigate the risk of reduced quality.

Creating this model based on academic-related literature, with academic-related experts, and then empirically evaluating it using software engineering and cloud computing professionals enables this model to provide considerable benefits to both researchers and practitioners. Moreover, the development of valid and reliable questionnaire to measure the impact of different customization types on SaaS quality can be used as useful guidelines or references for prospective researchers with similar research intentions.

1.6 Organization of the Thesis

This thesis is divided into six chapters as follows:

- **Chapter 1** is the introduction of the thesis. It describes the problem background and statement, research objectives, scope of the research, and contributions of the research.
- **Chapter 2** is the literature review. It presents software and SaaS background from customization and quality aspects, and a detailed study of existing customization solutions for SaaS application. This Chapter also highlights gaps in the literature and report related empirical studies on customization impact over software quality.
- **Chapter 3** discusses the research methodology as well as justifies the research methodology design used in conducting this research. In addition, the research process, design, development of the instrument, pilot study, population, sample and data collection, and data analysis methods are presented. More specific details describe how each objective was accomplished are presented in the respective Chapter.
- **Chapter 4** presents the conceptualization of the model, the iterative analysis of its content validity, and evaluation of its reliability by submitting it to an internal consistency reliability test.
- **Chapter 5** explains the findings of the empirical assessment of proposed model which includes the results of the construct reliability, construct validity, and research hypotheses test.
- **Chapter 6** presents the conclusions, limitations, implications, and potential future works on this research.

REFERENCES

Afthanorhan, W., Ahmad, S., Mamat, I., et al. (2014). Pooled confirmatory factor analysis (pcfa) using structural equation modeling on volunteerism program: A step by step approach. *International Journal of Asian Social Science*, 4(5):642–653.

Akojwar, M. R. A., Kothari, M. R. V., Kahate, M. S. A., and Ganvir, M. R. D. (2012). Software as a service with cloud computing. *IJECCE*, 3(1):149–155.

Al-Shardan, M. M. and Ziani, D. (2015). Configuration as a service in multi-tenant enterprise resource planning system. *Lect. Notes Softw. Eng*.

Alhamad, M., Dillon, T., and Chang, E. (2010). Conceptual sla framework for cloud computing. In *4th IEEE International Conference on Digital Ecosystems and Technologies*, pp. 606–610.

Alkawsi, G. A., ALI, N. B., and Alghushami, A. (2018). Toward understanding individuals' acceptance of internet of things-based services: Developing an instrument to measure the acceptance of smart meters. *Journal of Theoretical & Applied Information Technology*, 96(13):4265–4281.

Almorsy, M., Grundy, J., and Ibrahim, A. S. (2012). Tossma: A tenant-oriented saas security management architecture. In *2012 IEEE Fifth International Conference on Cloud Computing*, pp. 981–988.

Aouzal, K., Hafiddi, H., and Dahchour, M. (2015). An overview of variability management in cloud services. In *2015 International Conference on Cloud Technologies and Applications (CloudTech)*, pp. 1–5.

Araujo, V. M. and Vazquez, J. A. (2013). Business and technical requirements of software-as-a-service: Implications in portuguese enterprise business context. *International Journal in Foundations of Computer Science & Technology (IJFCST)*, 3(6).

Arrieta, L. O. (2012). From software as a good to software as a service: Preparing the evolution of software products into the cloud. In *2012 IEEE 6th International Workshop on the Maintenance and Evolution of Service-Oriented and Cloud-Based Systems (MESOCA)*, pp. 58–59.

Ary, D., Jacobs, L. C., Irvine, C. K. S., and Walker, D. (2018). *Introduction to research in education*. Cengage Learning.

Askarinejadamiri, Z., Zulzallil, H., Ghani, A. A. A., and Wei, K. T. (2017). Impact propagation of human errors on software requirements volatility. *Int. J. Adv. Comput. Sci. Appl.*, 8(2):227–237.

Aulbach, S. (2011). *Schema flexibility and data sharing in multi-Tenant databases*. PhD thesis, Technische Universität München.

Aulbach, S., Seibold, M., Jacobs, D., and Kemper, A. (2011). Extensibility and data sharing in evolving multi-tenant databases. In *2011 IEEE 27th International Conference on Data Engineering*, pp. 99–110.

Aulkemeier, F., Paramartha, M. A., Iacob, M.-E., and van Hillegersberg, J. (2016). A pluggable service platform architecture for e-commerce. *Information Systems and e-Business Management*, 14(3):469–489.

Awang, Z. (2012). *Structural equation modeling using AMOS graphic*. Penerbit Universiti Teknologi MARA.

Awang, Z., Afthanorhan, A., Mohamad, M., and Asri, M. (2015). An evaluation of measurement model for medical tourism research: the confirmatory factor analysis approach. *International Journal of Tourism Policy*, 6(1):29–45.

Badidi, E. (2013). A framework for software-as-a-service selection and provisioning. *ArXiv*, abs/1306.1888.

Bell, E., Bryman, A., and Harley, B. (2015). *Business Research Methods*. Oxford University Press, 4 edition.

Ben-Gal, I. (2005). Outlier detection : Data mining and knowledge discovery handbook: A complete guide for practitioners and researchers, red. o. maimon, l. rokach.

Bezemer, C. and Zaidman, A. (2010). Challenges of reengineering into multi-tenant saas applications. Technical report, Delft University of Technology, Delft,The Netherlands.

Bhatti, M. W. and Ahsan, A. (2017). Global monitoring and control: A process improvement framework for globally distributed software development teams. *Journal of Global Information Technology Management*, 20(1):43–63.

Boehm, B. W. (1978). *Characteristics of Software Qualitys*. STRW Softw. Technol. Amsterdam: NorthHolland.

Brehm, L., Heinzl, A., and Markus, M. L. (2001). Tailoring erp systems: a spectrum of choices and their implications. In *Proceedings of the 34th Annual Hawaii International Conference on System Sciences*, pp. 9 pp.–.

Brown, T. A. (2015). *Confirmatory factor analysis for applied research*. Guilford publications.

Byrne, B. M. (2010). Structural equation modeling with amos: basic concepts, applications, and programming (multivariate applications series). *New York: Taylor & Francis Group*, 396:7384.

Cancian, M. H., Hauck, J. C. R., von Wangenheim, C. G., and Rabelo, R. J. (2010). Discovering software process and product quality criteria in software as a service. In Ali Babar, M., Vierimaa, M., and Oivo, M., editors, *Product-Focused Software Process Improvement*, pp. 234–247, Berlin, Heidelberg. Springer Berlin Heidelberg.

Cao, Y., Lung, C., and Ajila, S. A. (2015). Constraint-based multi-tenant saas deployment using feature modeling and xml filtering techniques. In *2015 IEEE 39th Annual Computer Software and Applications Conference*, volume 3, pp. 454–459.

Chaumun, M., Kabaili, H., Keller, R. K., and Lustman, F. (2002). A change impact model for changeability assessment in object-oriented software systems. *Science of Computer Programming*, 45(2):155 – 174. Special Issue on Software Maintenance and Reengineering (CSMR 99).

Chen, D., Li, Q., and Kong, L. (2013). Process customization framework in saas applications. In *2013 10th Web Information System and Application Conference*, pp. 471–474.

Chen, L., Babar, M. A., and Zhang, H. (2010a). Towards an evidence-based understanding of electronic data sources. In *Proceedings of the 14th International Conference on Evaluation and Assessment in Software Engineering*, EASE'10, pp. 135–138, Swindon, UK. BCS Learning & Development Ltd.

Chen, W., Shen, B., and Qi, Z. (2010b). Template-based business logic customization for saas applications. In *2010 IEEE International Conference on Progress in Informatics and Computing*, volume 1, pp. 584–588.

Churchill, G. A. and Iacobucci, D. (2006). *Marketing research: methodological foundations*. Dryden Press New York.

Coallier, F. (2001). Software engineering–product quality–part 1: Quality model. *International Organization for Standardization: Geneva, Switzerland*.

Cohen, L., Manion, L., and Morrison, K. (2002). *Research methods in education*. Routledge.

Cooper, D. and Schindler, P. (2003). *Business Research Methods*. McGraw-Hill Irwin, Boston.

Corner, S. (2009). Choosing the right type of rotation in pca and efa. *JALT testing & evaluation SIG newsletter*, 13(3):20–25.

Correia, A., Penha, J. R., and da Cruz, A. M. R. (2013). An architectural model for customizing the business logic of saas applications. In *ICSOFT*.

Costello, A. B. and Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical assessment, research, and evaluation*, 10(1):7.

CSMIC (2014). Service measurement index framework version 2.1.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Bus. Rev.*, 76(4):121–131.

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied Nursing Research*, 5(4):194 – 197.

Denis, D. J. (2015). *Applied univariate, bivariate, and multivariate statistics*. John Wiley & Sons.

Dong, J., Zhang, S., Shi, Y., Xu, X., and Guo, W. (2010). Process customization based on dependent topology in software as a service model. In *The 2nd International Conference on Software Engineering and Data Mining*, pp. 295–298.

Dromey, R. G. (1996). Cornering the chimera [software quality]. *IEEE Software*, 13(1):33–43.

Duarte Filho, N. F., de Souza Bermejo, P. H., Zambalde, A. L., de Barros, U. S., et al. (2013). Saasquality-a method for quality evaluation of software as a service (saas). *International Journal of Computer Science & Information Technology*, 5(3):101.

Dutta, M. and Gupta, P. (2014). Customization issues in cloud based multi tenant saas applications. *International Journal Of Engineering And Computer Science*, 3(4):5447–5452.

Espadas, J., Concha, D., and Molina, A. (2008). Application development over software-as-a-service platforms. In *2008 The Third International Conference on Software Engineering Advances*, pp. 97–104. IEEE.

Espadas, J., Molina, A., Jiménez, G., Molina, M., Ramírez, R., and Concha, D. (2013). A tenant-based resource allocation model for scaling software-as-a-service applications over cloud computing infrastructures. *Future Generation Computer Systems*, 29(1):273–286.

Etame, F. and Atsa, R. (2018). Survey on erp's customization-driven requirements engineering. In *Applied Informatics*, volume 5, p. 2. Springer.

Etedali, A., Lung, C., Ajila, S., and Veselinovic, I. (2017). Automated constraint-based multi-tenant saas configuration support using xml filtering techniques. In *2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)*, volume 2, pp. 413–418.

Falk, R. F. and Miller, N. B. (1992). *A primer for soft modeling*. University of Akron Press.

Fan, H., Hussain, F. K., Younas, M., and Hussain, O. K. (2015). An integrated personalization framework for saas-based cloud services. *Future Generation Computer Systems*, 53:157 – 173.

Fiaidhi, J., Bojanova, I., Zhang, J., and Zhang, L. (2012). Enforcing multitenancy for cloud computing environments. *IT Professional*, 14(1):16–18.

Fornell, C. and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, 18(1):39–50.

Franke, N., Keinz, P., and Steger, C. J. (2009). Testing the value of customization: when do customers really prefer products tailored to their preferences? *Journal of marketing*, 73(5):103–121.

Gey, F., Landuyt, D., Walraven, S., and Joosen, W. (2014). Feature models at run time: Feature middleware for multi-tenant saas applications. In *CEUR Workshop Proceedings*, volume 1270.

Gey, F., Landuyt, D. V., and Joosen, W. (2015). Middleware for customizable multi-staged dynamic upgrades of multi-tenant saas applications. In *2015 IEEE/ACM 8th International Conference on Utility and Cloud Computing (UCC)*, pp. 102–111.

Gilmore, J. H., Pine, B. J., et al. (1997). The four faces of mass customization. *Harvard business review*, 75(1):91–102.

Guerra-García, C., Perez-Gonzalez, H. G., Ramírez-Torres, M., Juárez-Ramírez, R., and González, H. (2020). Moscaf–specifying data quality requirements according web functionalities. In *2020 8th International Conference in Software Engineering Research and Innovation (CONISOFT)*, pp. 46–56. IEEE.

Guo, C.-J., Sun, W., Jiang, Z.-B., Huang, Y., Gao, B., and Wang, Z.-H. (2011). Study of software as a service support platform for small and medium businesses. In Agrawal, D., Candan, K. S., and Li, W.-S., editors, *New Frontiers in Information and Software as Services*, pp. 1–30, Berlin, Heidelberg. Springer Berlin Heidelberg.

Haines, M. N. (2009). Understanding enterprise system customization: An exploration of implementation realities and the key influence factors. *Information Systems Management*, 26(2):182–198.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., Tatham, R. L., and other (2013). *Multivariate Data Analysis*. Pearson Education Limited.

Hair, Jr., J. F., Anderson, R. E., Tatham, R. L., and Black, W. C. (2015). *Multivariate Data Analysis*. New Jersey: Pearson education.

Harris, C. L. and Holloway, S. (2012). Development of an evidence-based protocol for care of pilonidal sinus wounds healing by secondary intent using a modified reactive delphi procedure. part one: the literature review. *International wound journal*, 9(2):156–172.

He, Q., Han, J., Yang, Y., Grundy, J., and Jin, H. (2012). Qos-driven service selection for multi-tenant saas. In *2012 IEEE Fifth International Conference on Cloud Computing*, pp. 566–573.

Helmich, M., Müller, J., Krüger, J., Zeier, A., Enderlein, S., and Plattner, H. (2009). Mappermania: A framework for native multi-tenancy business object mapping to a persistent data source. In *AMCIS*.

Hinton, P. R., McMurray, I., and Brownlow, C. (2014). *SPSS explained*. Routledge.

Hoogland, J. J. and Boomsma, A. (1998). Robustness studies in covariance structure modeling: An overview and a meta-analysis. *Sociological Methods & Research*, 26(3):329–367.

Hosono, S. and Shimomura, Y. (2013). Towards establishing mass customization methods for cloud-compliant services. In Shimomura, Y. and Kimita, K., editors, *The Philosopher's Stone for Sustainability*, pp. 447–452, Berlin, Heidelberg. Springer Berlin Heidelberg.

Hosseinian, S., Abdollahi, A., Zamanshoar, E., Beh-Pajooh, A., and Carlbring, P. (2018). The moderating effect of hardiness on the relationships between problem-solving skills and perceived stress with suicidal ideation in nursing students. *Studia Psychologica*, 60(1):30–41.

Hu, B., Ma, Y., Zhang, L., Xing, C., Zou, J., and Xu, P. (2013). A ccra based mass customization development for cloud services. In *2013 IEEE International Conference on Services Computing*, pp. 705–712.

ISO, I. (2011). Iec25010: 2011 systems and software engineering–systems and software quality requirements and evaluation (square)–system and software quality models. *International Organization for Standardization*, 34:2910.

ISO, Standard, I. (2001). 9126 software product evaluation–quality characteristics and guidelines for their use. *ISO/IEC Standard*, 9126.

Israel, G. D. (1992). Determining sample size. *Program Evaluation and Organizational Development, Fact Sheet PEOD-6*.

Jadhav, C., Bandgar, V. V., Fattepurkar, G. A., and Bhandare, P. S. (2014). An approach for development of multitenant application as saas cloud. *International Journal of Computer Applications*, 106:15–18.

Jihyun Lee, Sungju Kang, and Sung Jin Hur (2012). Web-based development framework for customizing java-based business logic of saas application. In *2012 14th International Conference on Advanced Communication Technology (ICACT)*, pp. 1310–1313.

Joha, A. and Janssen, M. (2012). Design choices underlying the software as a service (saas) business model from the user perspective: Exploring the fourth wave of outsourcing. *Journal of Universal Computer Science, 18 (11), 2012*.

Jumagaliyev, A., Whittle, J. N. D., and Elkhatib, Y. S. S. A. (2016). Evolving multitenant saas cloud applications using model-driven engineering. In *10th International Workshop on Models and Evolution*, volume 1706. CEUR-WS. org.

Jung, H.-W. (2007). Validating the external quality subcharacteristics of software products according to iso/iec 9126. *Computer Standards & Interfaces*, 29(6):653–661.

Kabbedijk, J. (2014). *Variability in Multi-Tenant Enterprise Software*. PhD thesis, Utrecht University, Department of Information and Computing Sciences.

Kabbedijk, J., Bezemer, C.-P., Jansen, S., and Zaidman, A. (2015). Defining multitenancy: A systematic mapping study on the academic and the industrial perspective. *Journal of Systems and Software*, 100:139 – 148.

Kabbedijk, J. and Jansen, S. (2011). Variability in multi-tenant environments: Architectural design patterns from industry. In *Proceedings of the 30th International Conference on Advances in Conceptual Modeling: Recent Developments and New Directions*, ER'11, pp. 151–160, Berlin, Heidelberg. Springer-Verlag.

Kapuruge, M., Colman, A., and Han, J. (2011). Achieving multi-tenanted business processes in saas applications. In *Proceedings of the 12th International Conference on Web Information System Engineering*, WISE'11, pp. 143–157, Berlin, Heidelberg. Springer-Verlag.

Keeney, S., Hasson, F., and McKenna, H. P. (2001). A critical review of the delphi technique as a research methodology for nursing. *International Journal of Nursing Studies*, 38(2):195 – 200.

Khanjani, A. (2015). *Quality of service model for software as a service in cloud computing from users' and providers' perspectives*. PhD thesis, Universiti Putra Malaysia.

Khanjani, A., Rahman, W. N. W. A., Ghani, A. A. A., and Sultan, A. B. M. (2014). Saas quality of service attributes. *Journal of Applied Sciences*, 14(24):3613–3619.

Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., and Linkman, S. (2009). Systematic literature reviews in software engineering - a systematic literature review. *Information and Software Technology*, 51(1):7 – 15. Special Section - Most Cited Articles in 2002 and Regular Research Papers.

Kitchenham, B. and Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering. Technical report, Keele University and University of Durham.

Kitchenham, B. A., Budgen, D., and Brereton, O. P. (2010). The value of mapping studies: A participantobserver case study. In *Proceedings of the 14th International Conference on Evaluation and Assessment in Software Engineering*, EASE'10, pp. 25–33, Swindon, UK. BCS Learning & Development Ltd.

Kitchenham, B. A., Mendes, E., and Travassos, G. H. (2007). Cross versus within-company cost estimation studies: A systematic review. *IEEE Transactions on Software Engineering*, 33(5):316–329.

Kitchenham, B. A., Mendes, E., and Travassos, G. H. (2007). Cross versus within-company cost estimation studies: A systematic review. *IEEE Transactions on Software Engineering*, 33(5):316–329.

Kline, R. B. (2015). *Principles and practice of structural equation modeling*. Guilford publications.

Kong, L., Li, Q., and Zheng, X. (2010). A novel model supporting customization sharing in saas applications. In *2010 International Conference on Multimedia Information Networking and Security*, pp. 225–229.

Kriouile, H., El Asri, B., and EL Haloui, M. (2014). Towards flexible and reusable saas for multi-tenancy to design, implement and bind multi-functional variability for rich-variant services. In *2014 Second World Conference on Complex Systems (WCCS)*, pp. 164–170.

Kumara, I., Han, J., Colman, A., and Kapuruge, M. (2015). Software-defined service networking: Runtime sharing with performance differentiation in multi-tenant saas applications. In *2015 IEEE International Conference on Services Computing*, pp. 210–217.

Kumara, I., Han, J., Colman, A., Nguyen, T., and Kapuruge, M. (2013). Sharing with a difference: Realizing service-based saas applications with runtime sharing and variation in dynamic software product lines. In *2013 IEEE International Conference on Services Computing*, pp. 567–574.

Kurbel, K. E. (2013). *Enterprise Resource Planning and Supply Chain Management: Functions, Business Processes and Software for Manufacturing Companies*. Springer Publishing Company, Incorporated.

Kwok, T., Nguyen, T., and Lam, L. (2008). A software as a service with multi-tenancy support for an electronic contract management application. In *2008 IEEE International Conference on Services Computing*, volume 2, pp. 179–186.

La, H. J. and Kim, S. D. (2009). A systematic process for developing high quality saas cloud services. In Jaatun, M. G., Zhao, G., and Rong, C., editors, *Cloud Computing*, pp. 278–289, Berlin, Heidelberg. Springer Berlin Heidelberg.

Landeta, J. (2006). Current validity of the delphi method in social sciences. *Technological Forecasting and Social Change*, 73(5):467 – 482.

Lee, J. Y., Lee, J. W., Cheun, D. W., and Kim, S. D. (2009). A quality model for evaluating software-as-a-service in cloud computing. In *2009 Seventh ACIS International Conference on Software Engineering Research, Management and Applications*, pp. 261–266.

Lee, S., Park, S. B., and Lim, G. G. (2013). Using balanced scorecards for the evaluation of software-as-a-service. *Information & Management*, 50(7):553 – 561.

Lee, W. and Choi, M. (2012). A multi-tenant web application framework for saas. In *2012 IEEE Fifth International Conference on Cloud Computing*, pp. 970–971.

Lee, W. and Choi, M. (2012). Supporting multi-tenancy in saas environments. In Park, J. J. J. H., Leung, V. C., Wang, C.-L., and Shon, T., editors, *Future Information Technology, Application, and Service*, pp. 187–191, Dordrecht. Springer Netherlands.

Lei, P.-W. and Wu, Q. (2007). Introduction to structural equation modeling: Issues and practical considerations. *Educational Measurement: issues and practice*, 26(3):33–43.

Leite, P., Gonçalves, J., Teixeira, P., and Rocha, Á. (2014). Towards a model for the measurement of data quality in websites. *New Review of Hypermedia and Multimedia*, 20(4):301–316.

Li, H., Shi, Y., and Li, Q. (2009). A multi-granularity customization relationship model for saas. In *2009 International Conference on Web Information Systems and Mining*, pp. 611–615.

Liao, C.-F., Chen, K., and Chen, J.-J. (2013). Modularizing tenant-specific schema customization in saas applications. In *Proceedings of the 8th International Workshop on Advanced Modularization Techniques*, AOAsia '13, pp. 9–12, New York, NY, USA. ACM.

Liao, C.-F., Chen, K., Tan, D. H., and Chen, J.-J. (2016). Automatic query rewriting schemes for multitenant saas applications. *Automated Software Engg.*, 23(4):535–568.

Light, B. (2001). The maintenance implications of the customization of erp software. *Journal of software maintenance and evolution: research and practice*, 13(6):415–429.

Liu, W., Zhang, B., Liu, Y., Wang, D., and Zhang, Y. (2010). New model of saas: Saas with tenancy agency. In *2010 2nd International Conference on Advanced Computer Control*, volume 2, pp. 463–466.

Lizhen, C., Haiyang, W., Lin, J., and Pu, H. (2010). Customization modeling based on metagraph for multi-tenant applications. In *5th International Conference on Pervasive Computing and Applications*, pp. 255–260.

Luo, W. and Strong, D. M. (2004). A framework for evaluating erp implementation choices. *IEEE transactions on Engineering Management*, 51(3):322–333.

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing research*, 35(6):382–385.

Ma, K., Yang, B., and Abraham, A. (2012). A template-based model transformation approach for deriving multi-tenant saas applications. *Acta Polytechnica Hungarica*, 9:25–41.

Makki, M., Van Landuyt, D., Walraven, S., and Joosen, W. (2016). Scalable and manageable customization of workflows in multi-tenant saas offerings. In *Proceedings of the 31st Annual ACM Symposium on Applied Computing*, SAC '16, pp. 432–439, New York, NY, USA. ACM.

Management, P. S. (2008). *Information Technology Infrastructure Library (ITIL v3)*. Publications Service Management.

Manford, C. (2008). The impact of the saas model of software delivery. In *Proceedings of the 21st Annual NACCQ Conference, NACCQ, Auckland, New Zealand*, pp. 283–286.

Matemba, E. D., Li, G., and Maiseli, B. J. (2018). Consumers' stickiness to mobile payment applications: An empirical study of wechat wallet. *Journal of Database Management (JDM)*, 29(3):43–66.

Mathiassen, L. and Sandberg, A. B. (2014). Process mass customization in a global software firm. *IEEE Software*, 31(6):62–69.

McCall, J. A. (1977). Factors in software quality. *US Rome Air development center reports*.

Mell, P. and Grance, T. (2009). The nist definition of cloud computing. *National Institute of Standards and Technology*, 53(6).

Mietzner, R. and Leymann, F. (2008). Generation of bpel customization processes for saas applications from variability descriptors. In *2008 IEEE International Conference on Services Computing*, volume 2, pp. 359–366.

Mietzner, R., Leymann, F., and Papazoglou, M. P. (2008). Defining composite configurable saas application packages using sca, variability descriptors and multi-tenancy patterns. In *2008 Third International Conference on Internet and Web Applications and Services*, pp. 156–161.

Mietzner, R., Metzger, A., Leymann, F., and Pohl, K. (2009). Variability modeling to support customization and deployment of multi-tenant-aware software as a service applications. In *2009 ICSE Workshop on Principles of Engineering Service Oriented Systems*, pp. 18–25.

Miguel, J. P., Mauricio, D., and Rodríguez, G. (2014). A review of software quality models for the evaluation of software products. *International Journal of Software Engineering & Applications*, 5(6):31.

Mijač, M., Picek, R., and Stapić, Z. (2013). Cloud erp system customization challenges. In *Proceedings of the Central European Conference on Information and Intelligence Systems*, pp. 132–140.

Moens, H. and De Turck, F. (2014). Feature-based application development and management of multi-tenant applications in clouds. In *Proceedings of the 18th International Software Product Line Conference - Volume 1*, SPLC '14, pp. 72–81, New York, NY, USA. ACM.

Moens, H., Dhoedt, B., and De Turck, F. (2015). Allocating resources for customizable multi-tenant applications in clouds using dynamic feature placement. *Future Gener. Comput. Syst.*, 53(C):63–76.

Moens, H., Truyen, E., Walraven, S., Joosen, W., Dhoedt, B., and De Turck, F. (2012). Developing and managing customizable software as a service using feature model conversion. In *2012 IEEE Network Operations and Management Symposium*, pp. 1295–1302.

Mohamed, F., Abu-Matar, M., Mizouni, R., Al-Qutayri, M., and Mahmoud, Z. A. (2014). Saas dynamic evolution based on model-driven software product lines. In *2014 IEEE 6th International Conference on Cloud Computing Technology and Science*, pp. 292–299.

Moses, J. (2009). Should we try to measure software quality attributes directly? *Software Quality Journal*, 17(2):203–213.

Mourão, E., Kalinowski, M., Murta, L., Mendes, E., and Wohlin, C. (2017). Investigating the use of a hybrid search strategy for systematic reviews. In *2017 ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, pp. 193–198.

Müller, J., Krüger, J., Enderlein, S., Helmich, M., and Zeier, A. (2009). Customizing enterprise software as a service applications: Back-end extension in a multi-tenancy environment. In Filipe, J. and Cordeiro, J., editors, *Enterprise Information Systems*, pp. 66–77, Berlin, Heidelberg. Springer Berlin Heidelberg.

Munkelt, T. and Völker, S. (2013). Erp systems: aspects of selection, implementation and sustainable operations. *International Journal of Information Systems and Project Management*, 1(2):25–39.

Nadanam, P. and Rajmohan, R. (2012). Qos evaluation for web services in cloud computing. In *2012 Third International Conference on Computing, Communication and Networking Technologies (ICCCNT'12)*, pp. 1–8.

Ng, C. S.-P. (2013). A case study on the impact of customization, fitness, and operational characteristics on enterprise-wide system success, user satisfaction, and system use. *Journal of Global Information Management (JGIM)*, 21(1):19–41.

Nguyen, P. H., Kramer, M., Klein, J., and Traon, Y. L. (2015). An extensive systematic review on the model-driven development of secure systems. *Information and Software Technology*, 68:62 – 81.

Nguyen, T., Colman, A., and Han, J. (2016). A feature-based framework for developing and provisioning customizable web services. *IEEE Transactions on Services Computing*, 9(4):496–510.

Nunnally, J. C. (1994). *Psychometric theory 3E*. Tata McGraw-Hill Education.

Oh, B., Jun, S., and Hur, S. (2012). Customizable online application development environment and online marketplace system. In *2012 14th International Conference on Advanced Communication Technology (ICACT)*, pp. 1220–1225.

Oh, B., Won, H., and Hur, S. (2011). Multi-tenant supporting online application service system based on metadata model. In *13th International Conference on Advanced Communication Technology (ICACT2011)*, pp. 1173–1176.

Parhizkar, M. (2016). *Impact analysis of enterprise resource planning post-implementation modifications*. PhD thesis, City, University of London.

Park, K., Won, H., and Hur, S. (2012). Saaspia platform: Integrating and customizing on-demand applications supporting multi-tenancy. In *2012 14th International Conference on Advanced Communication Technology (ICACT)*, pp. 961–964.

Parratt, J. A., Fahy, K. M., Hutchinson, M., Lohmann, G., Hastie, C. R., Chaseling, M., and O'Brien, K. (2016). Expert validation of a teamwork assessment rubric: A modified delphi study. *Nurse education today*, 36:77–85.

Parthasarathy, S. and Sharma, S. (2017). Impact of customization over software quality in erp projects: an empirical study. *Software Quality Journal*, 25(2):581–598.

Pathirage, M., Perera, S., Kumara, I., and Weerawarana, S. (2011). A multi-tenant architecture for business process executions. In *2011 IEEE International Conference on Web Services*, pp. 121–128.

Petersen, K., Feldt, R., Mujtaba, S., and Mattsson, M. (2008). Systematic mapping studies in software engineering. In *Proceedings of the 12th International Conference on Evaluation and Assessment in Software Engineering*, EASE'08, pp. 68–77, Swindon, UK. BCS Learning & Development Ltd.

Pinto, V. H., Luz, H. J., Oliveira, R. R., Souza, P. S., and Souza, S. R. (2016). A systematic mapping study on the multi-tenant architecture of saas systems. In *Twenty-Eighth International Conference on Software Engineering and Knowledge Engineering (SEKE 2016)*, pp. 396–401.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., and Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of applied psychology*, 88(5):879.

Polit, D. F. and Beck, C. T. (2006). The content validity index: Are you sure you know what's being reported? critique and recommendations. *Research in Nursing & Health*, 29(5):489–497.

Qiu, H. S., Nolte, A., Brown, A., Serebrenik, A., and Vasilescu, B. (2019). Going farther together: The impact of social capital on sustained participation in open source. In *2019 IEEE/ACM 41st International Conference on Software Engineering (ICSE)*, pp. 688–699. IEEE.

Rafique, A., Landuyt, D. V., Lagaisse, B., and Joosen, W. (2015). Policy-driven data management middleware for multi-cloud storage in multi-tenant saas. In *2015 IEEE/ACM 2nd International Symposium on Big Data Computing (BDC)*, pp. 78–84.

Ralph, M. (2008). Using variability descriptors to describe customizable saas application templates. *Institute of Architecture of Application Systems*, pp. 1–27.

Rico, A., Noguera, M., Garrido, J. L., Benghazi, K., and Barjis, J. (2016). Extending multi-tenant architectures: A database model for a multi-target support in saas applications. *Enterp. Inf. Syst.*, 10(4):400–421.

Rothenberger, M. A. and Srite, M. (2009). An investigation of customization in erp system implementations. *IEEE Transactions on Engineering Management*, 56(4):663–676.

Ruehl, S. T. and Andelfinger, U. (2011). Applying software product lines to create customizable software-as-a-service applications. In *Proceedings of the 15th International Software Product Line Conference, Volume 2*, SPLC '11, pp. 16:1–16:4, New York, NY, USA. ACM.

Ruehl, S. T., Wache, H., and Verclas, S. A. W. (2013). Capturing customers' requirements towards mixed-tenancy deployments of saas-applications. In *2013 IEEE Sixth International Conference on Cloud Computing*, pp. 462–469.

Russo, D. and Stol, K.-J. (2020). Gender differences in personality traits of software engineers. *IEEE Transactions on Software Engineering*.

Salama, M., Shawish, A., Zeid, A., and Kouta, M. (2012). Integrated qos utility-based model for cloud computing service provider selection. In *2012 IEEE 36th Annual Computer Software and Applications Conference Workshops*, pp. 45–50.

Saleh, A. I., Fouad, M. A., and Abu-Elkheir, M. (2014). Classifying requirements for variability optimization in multitenant applications. In *2014 IEEE 6th International Conference on Cloud Computing Technology and Science*, pp. 32–37.

Salih, N. K. and Zang, T. (2012). Variable service process by feature meta-model for saas application. In *2012 International Conference on Green and Ubiquitous Technology*, pp. 102–105.

Salih, N. K. and Zang, T. (2016). Modeling and self-configuring saas application. *CoRR*, abs/1606.05991.

Samah, B. (2016). Enhancing extension education research using structural equation modelling.

Samir, A. and Darwish, N. R. (2016). Reusability quality attributes and metrics of saas from perspective of business and provider. *International Journal of Computer Science and Information Security*, 14(3):295–312.

Samir, A. and Salah, A. (2015). Challenges and research questions of saas applications customization. In *The 50 Annual International Conference on Statistics, Computer Science and Operations Research*, p. 19.

Scheibler, T., Mietzner, R., and Leymann, F. (2008). Eai as a service - combining the power of executable eai patterns and saas. In *2008 12th International IEEE Enterprise Distributed Object Computing Conference*, pp. 107–116.

Schniederjans, D. G. and Hales, D. N. (2016). Cloud computing and its impact on economic and environmental performance: A transaction cost economics perspective. *Decision Support Systems*, 86:73–82.

Schroeter, J., Cech, S., Götz, S., Wilke, C., and Aßmann, U. (2012a). Towards modeling a variable architecture for multi-tenant saas-applications. In *Proceedings of the Sixth International Workshop on Variability Modeling of Software-Intensive Systems*, VaMoS '12, pp. 111–120, New York, NY, USA. ACM.

Schroeter, J., Mucha, P., Muth, M., Jugel, K., and Lochau, M. (2012b). Dynamic configuration management of cloud-based applications. In *Proceedings of the 16th International Software Product Line Conference - Volume 2*, volume 6 of *SPLC '12*, pp. 171–178, New York, NY, USA. ACM.

SCImago, n. S. (2017). *SCImago Journal and Country Rank*.

Sekaran, U. and Bougie, R. (2016). *Research Methods For Business: A Skill Building*. John Wiley & Sons, 7 edition.

Shahin, A. A. (2014a). Multi-dimensional customization modelling based on metagraph for saas multi-tenant applications. *CoRR*, abs/1402.6045.

Shahin, A. A. (2014b). Variability modeling for customizable saas applications. *International Journal of Computer Science & Information Technology*, 6(5):39–49.

Shahin, A. A., Samir, A., and Khamis, A. (2014). An aspect-oriented approach for saas application customization. *CoRR*, abs/1409.1656.

Shangguang Wang, Zheng, Z., Qibo Sun, Hua Zou, and Fangchun Yang (2011). Cloud model for service selection. In *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, pp. 666–671.

Shao, Q. (2011). *Towards effective and intelligent multi-tenancy SaaS*. Arizona State University.

Sharma, S., Mukherjee, S., Kumar, A., and Dillon, W. R. (2005). A simulation study to investigate the use of cutoff values for assessing model fit in covariance structure models. *Journal of Business Research*, 58(7):935–943.

Shen, Y., Cui, W., Li, Q., and Shi, Y. (2011). Hybrid fragmentation to preserve data privacy for saas. In *2011 Eighth Web Information Systems and Applications Conference*, pp. 3–6.

Shi, Y., Luan, S., Li, Q., and Wang, H. (2009). A multi-tenant oriented business process customization system. In *2009 International Conference on New Trends in Information and Service Science*, pp. 319–324.

Song, J., Zhang, S., Gong, Y., and Dai, B. (2012). A qos evaluation model for test-bed in the cloud computing environment. In *2012 IEEE Ninth International Conference on e-Business Engineering*, pp. 292–295.

Sun, W., Zhang, K., Chen, S.-K., Zhang, X., and Liang, H. (2007). Software as a service: An integration perspective. In *Service-Oriented Computing – ICSOC 2007*, pp. 558–569, Berlin, Heidelberg. Springer Berlin Heidelberg.

Sun, W., Zhang, X., Guo, C. J., Sun, P., and Su, H. (2008). Software as a service: Configuration and customization perspectives. In *2008 IEEE Congress on Services Part II (services-2 2008)*, pp. 18–25.

Sun, X. (2016). *Toward Customizable Multi-tenant SaaS Applications*. PhD thesis, Arizona State University.

Sunikka, A. and Bragge, J. (2008). What, who and where: Insights into personalization. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008)*, pp. 283–283.

Tabachnick, B. G. and Fidell, L. S. (2007). Multivariate analysis of variance and covariance. *Using multivariate statistics*, 3:402–407.

Tabachnick, B. G., Fidell, L. S., and Ullman, J. B. (2007). *Using multivariate statistics*, volume 5. Pearson Boston, MA.

TGI (2007). *Information technology governance institute. COBIT 4.1: Control objectives, Management guidelines, Maturity models*. Rolling Meadows: ITGI.

Thompson, B. (2004). Exploratory and confirmatory factor analysis: Understanding concepts and applications. *Washington, DC*, pp. 10694–000.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and applications*, 5:147–158.

Truyen, E., Cardozo, N., Walraven, S., Vallejos, J., Bainomugisha, E., Günther, S., D'Hondt, T., and Joosen, W. (2012). Context-oriented programming for customizable saas applications. In *Proceedings of the 27th Annual ACM Symposium on Applied Computing*, SAC '12, pp. 418–425, New York, NY, USA. ACM.

Tsai, W., Huang, Y., and Shao, Q. (2011). Easysaas: A saas development framework. In *2011 IEEE International Conference on Service-Oriented Computing and Applications (SOCA)*, pp. 1–4.

Tsai, W., Shao, Q., and Li, W. (2010a). Oic: Ontology-based intelligent customization framework for saas. In *2010 IEEE International Conference on Service-Oriented Computing and Applications (SOCA)*, pp. 1–8.

Tsai, W., Shao, Q., and Li, W. (2010b). Oic: Ontology-based intelligent customization framework for saas. In *2010 IEEE International Conference on Service-Oriented Computing and Applications (SOCA)*, pp. 1–8.

Tsai, W. and Sun, X. (2013). Saas multi-tenant application customization. In *2013 IEEE Seventh International Symposium on Service-Oriented System Engineering*, pp. 1–12.

Tsai, W.-T., Shao, Q., Huang, Y., and Bai, X. (2010). Towards a scalable and robust multi-tenancy saas. In *Proceedings of the Second Asia-Pacific Symposium on Internetware*, Internetware '10, pp. 8:1–8:15, New York, NY, USA. ACM.

Tsai, W.-T., Zhong, P., and Chen, Y. (2016). Tenant-centric sub-tenancy architecture in software-as-a-service. *CAAI Transactions on Intelligence Technology*, 1(2):150 – 161.

Van Landuyt, D., Walraven, S., and Joosen, W. (2015). Variability middleware for multi-tenant saas applications: A research roadmap for service lines. In *Proceedings of the 19th International Conference on Software Product Line*, SPLC '15, pp. 211–215, New York, NY, USA. ACM.

Parthasarathy, S. and Sharma, S. (2016). Efficiency analysis of erp packages-a customization perspective. *Computers in Industry*, 82:19 – 27.

Walraven, S. (2014). *Middleware and Methods for Customizable SaaS*. PhD thesis, KU Leuven - Faculty of Engineering.

Walraven, S., Landuyt, D. V., Truyen, E., Handekyn, K., and Joosen, W. (2014). Efficient customization of multi-tenant software-as-a-service applications with service lines. *Journal of Systems and Software*, 91:48 – 62.

Walsh, J., Roche, D., and Foping, F. (2012). Nitroscript: A php template engine for customizing of e-commerce applications. In *2012 International Conference for Internet Technology and Secured Transactions*, pp. 459–464.

Wang, Y., Mäntylä, M., Eldh, S., Markkula, J., Wiklund, K., Kairi, T., Raulamo-Jurvanen, P., and Haukinen, A. (2019). A self-assessment instrument for assessing test automation maturity. In *Proceedings of the Evaluation and Assessment on Software Engineering*, pp. 145–154. ACM.

Wang, Y. and Redmiles, D. (2019). Implicit gender biases in professional software development: An empirical study. In *2019 IEEE/ACM 41st International Conference on Software Engineering: Software Engineering in Society (ICSE-SEIS)*, pp. 1–10. IEEE.

Wang, Z., Xu, X., and Wang, X. (2013). Mass customization oriented and cost-effective service network. In van Sinderen, M., Oude Luttighuis, P., Folmer, E., and Bosems, S., editors, *Enterprise Interoperability*, pp. 172–185, Berlin, Heidelberg. Springer Berlin Heidelberg.

Weiliang, C., Shidong, Z., and Lanju, K. (2010). A multiple sparse tables approach for multi-tenant data storage in saas. In *2010 2nd International Conference on Industrial and Information Systems*, volume 1, pp. 413–416.

Werts, C. E., Linn, R. L., and Jöreskog, K. G. (1974). Intraclass reliability estimates: Testing structural assumptions. *Educational and Psychological measurement*, 34(1):25–33.

Williams, B., Onsman, A., and Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, 8(3).

Wohlin, C. and Prikladnicki, R. (2013). Systematic literature reviews in software engineering. *Information and Software Technology*, 55(6):919 – 920.

Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., and Wesslén, A. (2012). *Experimentation in software engineering*. Springer Science & Business Media.

Wynd, C. A., Schmidt, B., and Schaefer, M. A. (2003). Two quantitative approaches for estimating content validity. *Western Journal of Nursing Research*, 25(5):508–518.

Xiaojun, R., Yongqing, Z., and Lanju, K. (2013). Saas template evolution model based on tenancy history. In *2013 Third International Conference on Intelligent System Design and Engineering Applications*, pp. 1242–1247.

Yamada, J., Stevens, B., Sidani, S., Watt-Watson, J., and De Silva, N. (2010). Content validity of a process evaluation checklist to measure intervention implementation fidelity of the epic intervention. *Worldviews on Evidence-Based Nursing*, 7(3):158–164.

Yang, S., Yoo, B., and Jahng, J. (2010). Does the saas model really increase customer benefits. *Asia Pac J Inf Syst*, 20:87–101.

Yao, P., Wen, H., and Dai, Q. (2011). Study on presentation layer structure of multi-tenant e-business systems. In *2011 IEEE 18th International Conference on Industrial Engineering and Engineering Management*, volume Part 1, pp. 352–354.

Yilmaz, M., O'Connor, R. V., Colomo-Palacios, R., and Clarke, P. (2017). An examination of personality traits and how they impact on software development teams. *Information and Software Technology*, 86:101–122.

Ying, L., Bin, Z., Guoqi, L., Deshuai, W., and Yan, G. (2010). Personalized modeling for saas based on extended wscl. In *2010 IEEE Asia-Pacific Services Computing Conference*, pp. 355–362.

Yong, A. G., Pearce, S., et al. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, 9(2):79–94.

Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H., and Nikanfar, A.-R. (2015). Design and implementation content validity study: Development of an instrument for measuring patient-centered communication. *J Caring Sci*, 4(2):165–178.

Zhang, H., Babar, M. A., and Tell, P. (2011). Identifying relevant studies in software engineering. *Information and Software Technology*, 53(6):625–637.

Zhang, K., Zhang, X., Wei, S., Liang, H., Huang, Y., Liangzhao, Z., and Xuanzhe, L. (2007). A policy-driven approach for software-as-services customization. In *The 9th IEEE International Conference on E-Commerce Technology and The 4th IEEE International Conference on Enterprise Computing, E-Commerce and E-Services (CEC-EEE 2007)*, pp. 123–130.

Zhang, X., He, K., Wang, J., Wang, C., and Li, Z. (2013). On-demand business rule management framework for saas application. In Ivanov, I. I., van Sinderen, M., Leymann, F., and Shan, T., editors, *Cloud Computing and Services Science*, pp. 135–150, Cham. Springer International Publishing.

Zhang, Y., Liu, S., and Meng, X. (2009). Towards high level saas maturity model: Methods and case study. In *2009 IEEE Asia-Pacific Services Computing Conference (APSCC)*, pp. 273–278.

Zhao, S., Zhang, Y., Shen, B., Shen, X., and Chen, R. (2014). Mass data processing and personalized services in shanghai e-commerce credit evaluation platform. In *2014 IEEE International Conference on Progress in Informatics and Computing*, pp. 481–485.

Zheng, X., Li, Q., and Kong, L. (2010). A data storage architecture supporting multi-level customization for saas. In *2010 Seventh Web Information Systems and Applications Conference*, pp. 106–109.

Zhou, X., Yi, L., and Liu, Y. (2011). A collaborative requirement elicitation technique for saas applications. In *Proceedings of 2011 IEEE International Conference on Service Operations, Logistics and Informatics*, pp. 83–88.

Zhu, X. and Wang, S. (2009). Software customization based on model-driven architecture over saas platforms. In *2009 International Conference on Management and Service Science*, pp. 1–4.

Zia, A. and Khan, M. N. A. (2012). Identifying key challenges in performance issues in cloud computing. *International Journal of Modern Education and Computer Science*, 4(10):59.

Ziani, D. and AlShehri, A. (2015). A new framework for customizing erp systems in a multi tenant saas environment. In *2015 2nd World Symposium on Web Applications and Networking (WSWAN)*, pp. 1–7.

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LIST OF PUBLICATIONS

Ali, A. Q., Sultan, A. B. M., Abd Ghani, A. A. and Zulzalil, H. (2021). An empirical investigation of software customization and its impact on the quality of Software as a Service: perspectives from software professionals. *Applied Sciences*, 11, no. 4: 1677.

Ali, A. Q., Sultan, A. B. M., Abd Ghani, A. A. and Zulzalil, H. (2020). Development of a valid and reliable software customization model for SaaS quality through iterative method. *PeerJ Computer Science*, 6, e294.

Ali, A. Q., Sultan, A. B. M., Abd Ghani, A. A. and Zulzalil, H. (2019). A Systematic Mapping Study on the Customization Solutions of Software as a Service Applications. *IEEE Access*, 7: 88196-88217.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H. (2019). Empirical studies on the impact of software customization on quality attributes: A system-atic review. *Journal of Theoretical and Applied Information Technology*, 97 (6):1747-1763.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H. (2018). Customization of Software as a Service Application: Problems and Objectives.*Journal of Computer Science & Computational Mathematics*,8 (3): 27-32.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H. (2018). The Five Ws Taxonomy on Customization of Software as a Service Applications.*Journal of Computer Science & Computational Mathematics*,8 (3): 43-48.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H. (2017). Critical Issues across SaaS Development: Learning from Experience. *International Journal of Advances in Electronics and Computer Science4*, (9):69-74.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H. (2017). Defining Problems and Objectives Toward Low Complexity in SaaS Customization.*Proceedings of the 6th International Conference on Computer Science and Computational Mathematics*,4-5 May 2017, Langkawi, Malaysia, 19-23.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H.(2017). A Taxonomy on Customization of Software as a Service Applications by utilizing 5Ws Method. *Proceedings of the 6th International Conference on Computer Science and Computational Mathematics*,4-5 May 2017, Langkawi, Malaysia, 24-29.

Ali, A. Q., Sultan, A. B. M., Ghani, A. A. A. and Zulzalil, H.(2017). Critical Issues across SaaS Development: Learning from Experience. *Proceedings of 75th ISERD International Conference*, 1-2 July 2017 ,Dublin, Ireland, 4-9.

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