# Towards Cloud Service Customization: A State of the Art

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Abstract: Cloud computing is becoming an important tool that is offering multiple opportunities to organizations. However, cloud providers can not always offer personalized services that fully match customers' needs. This occurs for several reasons, the most important is the level of investment required to design and operate personalized services considering the great number of customers and the diversity of their needs. In this context, this work presents a literature review to identify what are the main contributions made in the research literature to carry out such assessment. This review is made by defining three context and five customization research questions, making an analysis of each one of them in a filtered set of customization papers and finding families or categories that can answer the research questions proposed. The objective is to provide an overview of this research area and help researchers to develop new contributions for cloud service customization.

## 1 INTRODUCTION

Cloud computing is becoming an important tool capable of providing multiple financial, social and technological opportunities to institutions in all industrial sectors (Armbrust et al., 2010; Zhang et al., 2010). The possibility of taking such advantage of this model depends directly on the customization capabilities that cloud services provide to clients. Such capabilities are essential in order to adapt the service characteristics to customer needs. Customization needs can range from changes on the graphical user interface (GUI) to workflow and business process logic modification, creating a large range of options when we refer to cloud customization. However, providers can not always offer personalized services that fully match the needs of their clients. This occurs for several reasons, among which are: (i) the investment level required to design personalized services taking into account the number of clients and the diversity of their needs and (ii) the investment level required to manage personalized services during the operation taking into account the differences in its design and the differences in the request for change raised by customers (Khan and Jiang, 2017).

In this context, this research presents a literature review to identify and analyze research contributions to cloud service customization. The main objective of this review is to provide an updated overview of the main existing works in the area by identifying their main characteristics, like customization aspects, methods, techniques, and so on. Other objectives of the review are: on the one hand, this review will ease researchers search for relevant studies in the area and help them to constitute a base for further research. On the other hand, structuring the literature in a detailed and systematic manner also clarifies which issues are not well covered.

This work is organized as follows: Section two describes the review method and the applications of its two first steps (planning, and conducting and material collection). Section three presents the application of the last step of the method, which consists in a synthesis for each of the evaluation categories used. Finally, section four presents the conclusions and a discussion of the results, future work and limitations of the study.

## 2 STUDY METHOD AND DESCRIPTION OF SELECTED WORKS

The literature review process includes the following steps: (i) planning, (ii) conducting and material collection and (iii) reporting (Bosse et al., 2014; Seuring and Müller, 2008). (i) *Planning*. It consists on the definition of the criteria to conduct the search and validate the selected works. It aims at identifying the relevant contributions in the research field. (ii) *Conducting* and Material Collection. This step is related



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to perform an exhaustive search for primary approaches and validates and assesses the found approaches with respect to the research questions. The goal of this step is to select a final set of works. (iii) *Reporting phase*. This step presents a synthesis of the answers for each research question, besides a material analysis and interpretation is also presented.

## 2.1 Planning

The review is aimed at finding out the main techniques and methods used for cloud customization. To perform this analysis, two evaluation categories are defined: (i) Context to analyze the domain in which the reviewed works were originally intended to, as well as their goal and scope and (ii) customizing method to identify the characteristics of their customization process, as well as the customizable aspects, methods for customizing, models for customizing, type of architecture and customization strategy. Every category includes evaluation criteria that in turn have related questions to analyze the contribution of each work to the criteria. The elements previously described are shown in Table 1.

## 2.2 Conducting and Material Collection

With the purpose of finding potential research works answering the research questions preciously announced, the Scopus database was used by introducing the following criteria:

- Cloud Services Search Terms: (IT Service) or (ICT service) or (Cloud Service) (Cloud Computing) or (Cloud Management) or (Cloud Sourcing) or (Software as a Service) or (Platform as a Service) or (Infrastructure as a Service).
- User Customization Terms: Customizing or Personalize or Customized or Adapted or Adjusted or Custom-build or Custom-made or Tailor-made or Made-to-order or Tailored or Configurable or Configuration
- Search Area: Computer Science.
- Document type: Conference paper or Journal paper.
- Search field type: Title.

Thus, the query introduced in the database is:

TITLE ( ( ”information and comunication technology service” OR ”information technology service” OR ”IT service” OR ”ICT service” OR ”cloud service” OR ”saas” OR ”paas” OR ”iaas” OR ”cloud computing” OR ”cloud management” OR ”cloud sourcing” OR ”software as a service” OR ”platform as a service” OR ”infrastructure as a service” OR ”software-as-a-service” OR ”platform-as-a-service” OR ”infrastructure-as-a-service” ) AND ( ”multi tenant” OR multitenant OR multi-tenant OR customizing OR customising OR personalize OR personalise OR customized OR personalised OR adapted OR adjusted OR custom-build OR custom-made OR tailor-made OR made-to-order OR ”made to order” OR tailored OR configurable OR configuration ) )

With this criteria, the Scopus search engine returned 279 candidate articles. To reduce the number of articles included in the analysis, firstly, a review of the article titles was carried out. This filter reduced the number to 89. Secondly, a reading of articles abstracts was undertaken to filter those works that do not present evidence of answering any of the analysis questions. This filter limited the number of articles to 31. Thirdly, a complete reading of the articles was performed to select the final works set, made up of 25 articles which were identified and included in the analysis. The article set includes relevant information about cloud customization and how different techniques were used to achieve it.

# 3 REPORTING

After the 25 papers that were more closely related to cloud customization were selected, we realized an analysis of each and every one of them under the research questions presented in Table 1. After an individual analysis, we performed a group analysis of all papers under each research question in order to find relationships between the papers that could lead into conclusions for each research question.

## 3.1 Context

### 3.1.1 To Which Domain is the Research Work Applied?

During our analysis of the knowledge in cloud customization, we divided the papers into domain categories to analyze the context of the work done in this field. Of the 25 papers analyzed, we found that 21 of them were oriented to the academia, while the remaining 4 were oriented to the development of the industry. References to these papers can be found in table 2, under the ”Papers Domain Classification” section.

### 3.1.2 What is the Main Objective of the Research Work?

After the analysis of Cloud Customization related papers, we found three categories of objectives that

Table 1: Categories, criteria and research questions.

| Category | Criteria | Question |
|---|---|---|
| Context | Domain | To which domain is the research work applied? |
| | Goal | What is the main objective of the research work? |
| | Scope | For what service (SaaS, PaaS, IaaS) and deployment (private, public, community, hybrid) models is the research work intended? |
| Customizing Method | Customizable Aspects | Which aspects of the service can be customized? How is the customization addressed ? |
| | Method for customizing | Which are the methods employed to customize the service? |
| | Models for Customizing | Which are the models, languages or notations employed to customize the service? |
| | Type of Architecture | What Architecture style was used? |
| | Customization Strategy | In which degree the customization is made in an automatic, semiautomatic or manual way? |

could cover the core goals of all of them. First, we identified the "Architectures based on Customization" category. In this category we can found papers whose goal is to propose or define architectures with customization in mind, using different techniques like (i) the development of new architectures that have customizable modules that can be selected by the tenant (Tizzei et al., 2017; Kriouile et al., 2015; Wang and Zheng, 2010; Jumagaliyev et al., 2016; Walraven et al., 2014), (ii) the development of a framework to create applications with run time customizations of user interfaces and business logic using inheritance and polymorphism (Lee and Choi, 2012) or architectures built with configurable options (Zhou et al., 2016; Cao et al., 2015; Kumara et al., 2013; Khalil et al., 2013; Tsai and Sun, 2013; Schroeter et al., 2012a; Kang et al., 2011; Mietzner et al., 2008; Khan et al., 2015; Correia et al., 2013; Jamshidi and Pahl, 2015; Schroeter et al., 2012b)

Second, we found the "Optimization of Customization Features" category, which covers papers that address the performance of configuration processes and implement techniques to increase their efficiency. In this group we can find papers that address the area of tension between cost efficiency and customizability (Müller et al., 2009) or that develop a framework to identify the proper amount of customization needed by a cloud application (Walraven et al., 2015).

Finally, in the context of cloud application with already developed features that can be implemented to a base application by the tenant, we identified the "Connection of Features" category. This category contains papers that help the connection and configuration of these features with the core application. In this category we found papers that address this issue using primarily two techniques:

- Develop matching techniques that find the features selected by the tenant, merge their core application with the services selected and help to customize them (Hajlaoui et al., 2017).
- Develop a platform that allow tenants to switch configurations of the features selected in a quick and easy way (Bobák et al., 2015).

In our analysis, we could find that 18 papers fell in the "Architectures based on Customization" category, of which 5 of them where papers that implemented their architectures in the industry (Tizzei et al., 2017; Cao et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Walraven et al., 2014) and the rest 13 of them in this category made their proposals in an academic environment. We also found that 3 papers fell into the "Optimization of Customization Features" category and the remaining 4 papers where assigned to the "Connection and Configuration of Features" category. References to papers from all categories of this question can be found in table 2, under the "Papers goals classification" section.

#### 3.1.3 For What Service and Deployment Models is the Research Work Intended?

Our research found that, from our final set of 25 papers related to cloud customization, we found that only one of them was oriented to Iaas and PaaS applications (Bobák et al., 2015) and another one was oriented only to Iaas platforms (Zhou et al., 2016). The rest of the papers were all focused on SaaS applications, while one of them was a SaaS variation based on customized instances for each tenant (Khan and Jiang, 2017). References to all papers focused on SaaS applications can be found in table 2, under the "Papers Scope Classification" section.

Since the majority of work found was dedicated to the academia and their proposals were usually oriented towards SaaS, PaaS or IaaS in general, not all the papers had an specific deployment model (private, public, community or hybrid). We found that only 5 articles that were focused in SaaS services were oriented to a specific deployment model, of which 4 were oriented to private SaaS (Tizzei et al., 2017; Cao et al.,

2015; Kriouile et al., 2015; Kumara et al., 2013) and 1 was oriented to public SaaS (Walraven et al., 2014).

## 3.2 Customizing Method

### 3.2.1 Which Aspects of the Service can be Customized? How is the Customization Addressed?

First, we defined a group called "Selectable Modules" category. This group has all the papers that try to achieve customization by creating different, independent and functional modules that can be integrated to the main application according to user's needs. This process is usually made in a manual manner, by developing new functional modules that can be added to the main application as the client requests them, usually using modules made in the past for efficiency (Tizzei et al., 2017; Schroeter et al., 2012a; Mietzner et al., 2008; Müller et al., 2009; Jumagaliyev et al., 2016; Correia et al., 2013; Walraven et al., 2014; Schroeter et al., 2012b), but other papers use an approach that allows the tenant to pick from a predefined list of already developed modules to use in his application, making the assembling of modules in real time (Liu et al., 2012; Wang and Zheng, 2010; Jamshidi and Pahl, 2015). We found that the Selectable Modules category is the most common, with 11 papers related to it. References to all papers in this category can be found in table 2, under the "Papers Customizing Aspects Classification" section.

Second, we identified the "Customization of Files" category. In this category we found techniques to customize cloud applications by the modification of style files that define the aspect of the application, allowing user to personalize logos and colors, and specific functionality methods, which allows to personalize some specific functionalities. We found 2 papers associated with this category in our study, references to all papers in this category can be found in table 2, under the "Papers Customizing Aspects Classification" section.

Third, we defined the "System Structure" category, in which the articles that allow to personalize the workflow and the structure of the application through an interface are included. Such interface allows user to select their preferences and reconfigure their single instance according to their needs. In this category we classified 2 papers which implement these techniques, references to all papers in this category can be found in table 2, under the "Papers Customizing Aspects Classification" section.

Finally, we defined the "Feature Selection Aid" category. In this category, cloud services help users choose the features they need to get their desired service, mapping those requirements with the services needed. Some of these papers use matching algorithms that search the features or hardware preferences and configure them to work with the tenant instanced application without much more input for the user (Hajlaoui et al., 2017; Zhou et al., 2016; Cao et al., 2015), while others focus on the assistance of user in the moment of selecting their desired service (Bobák et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Walraven et al., 2015; Sun et al., 2008). This category has 8 papers that talk about different ways to build the application that the user needs, references to all papers in this category can be found in table 2, under the "Papers Customizing Aspects Classification" section.

### 3.2.2 Which are the Methods Employed to Customize the Service?

We manage to organize the different methods of customization in three main categories. The first group was called "Software Product Line (SPL) related methods and their variations", in which all the methods related to SPL or that use SPL techniques are grouped. These techniques include the domain analysis of the product, a development of assets that can be connected to a base application and a set of rules for the development and assembling of assets for new configurations.

The second group we distinguished was the "Development of new Architecture", in which the methods that develop a new architecture with customization in mind can be found. This process usually defines all the major components of the architecture proposed depending on the focus of each architecture, defining their architectural components and general workflow. This category is characterized by having techniques that do not relly on independent modules, since it is for the papers that focus on new architectural structures self made by the authors. These techniques vary, but they usually define aspects like instances, data organization and user management for customization.

Third, we defined the "Function customization" group, which locates the methods that modificate or help the modification of functions to customize user experience. These techniques focus on the customization of short pieces of code (usually functions) that allow them to customize specific functionalities for the tenants.

Finally, we defined the "Implementation of Algorithms" category, that locates all the methods that run algorithms that automate or aid users with their customization process. The functionality of these algo-

rithms vary between papers, but they usually help the user with the configuration of desired features (Zhou et al., 2016), connection with specific functionalities (Hajlaoui et al., 2017; Kriouile et al., 2015) or automatization (Tsai and Sun, 2013).

From the 25 papers analyzed, we found that the "Software Product Line (SPL) related methods and their variations" category had 10 papers related to it, the "Development of new Architecture" category had 6, the "Function customization" category had 5 and the "Implementation of Algorithms" category had 4. References to these papers can be found in table 2, under the "Papers Customizing Method Classification" section.

#### 3.2.3 Which are the Models, Languages or Notations Employed to Customize the Service?

In our analysis we found that 9 papers used Flow Charts, 9 papers used Feature Models, 7 papers used the UML standard, 6 papers used Architectural models, 3 papers used tree models, 3 papers used Components Models and 2 used new models designed by the authors, the reference of which can be found in table 2 under the "Papers Customizing Models Classification" section. Feature Models were usually used to represent variability in applications with independent modules or that implemented SPL techniques, Tree models were used to represent components or inheritance relationships, Component Models were used in architectures based in components and the new models were used to represent characteristics of new architectures that were not supported by traditional models.

Since most papers used more than one model or language, we could find some relationships in our analysis. We found that Feature models are used with almost all the other type of models (Tizzei et al., 2017; Hajlaoui et al., 2017; Cao et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Jumagaliyev et al., 2016; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b), Tree models are usually used with feature models (Hajlaoui et al., 2017; Tsai and Sun, 2013) and Flow Charts usually are used alone (Zhou et al., 2016; Bobák et al., 2015; Kriouile et al., 2015; Khan et al., 2015) to describe the customization methods in papers.

This analysis shows that Feature Models and Flow Charts are the most commonly used to describe Customization in cloud services (Tizzei et al., 2017; Hajlaoui et al., 2017; Zhou et al., 2016; Bobák et al., 2015; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Liu et al., 2012; Kang et al., 2011; Mietzner et al., 2008; Jumagaliyev et al., 2016; Khan et al., 2015; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b). However, since many of the papers focus in new architectures, the Architectural models and UML techniques are also used in many papers to describe their proposals (Tizzei et al., 2017; Khan and Jiang, 2017; Khalil et al., 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Kang et al., 2011; Wang and Zheng, 2010; Jumagaliyev et al., 2016; Walraven et al., 2015; Correia et al., 2013; Walraven et al., 2014). We can also see that Tree and Component Models are common (Hajlaoui et al., 2017; Tsai and Sun, 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Sun et al., 2008; Correia et al., 2013), which is not rare taking into account the amount of papers that focus in modular architectures. Finally, we found that some papers developed new models (Müller et al., 2009; Schroeter et al., 2012b), showing the necessity to explore new ways to represent the concepts of cloud features in some cases.

#### 3.2.4 What Architecture Style was used?

Over the 25 papers analyzed, we identified four groups that could represent the different types of techniques used for architecture. First, we identified the Components and Software Product Line related techniques, which covers all the papers that use architectures based on components or techniques similar to the ones used in SPL engineering, since SPL techniques heavily rely on connection between component models. Second, we defined the Integrated Architectures category, which covers the papers that focus on architectures that do not use functional modules, and instead use different type of techniques like layers, meta data or services to provide the customization. Third, we found the Architectures Based on tree category, that defines architectures that change their functions following a tree structure. Finally, we defined the Techniques for Customization category, which covers the papers that do not define an architecture scheme but use different techniques to facilitate the customization for tenants.

In our analysis, we found that the Components and Software Product Line related techniques had 11 papers related to it, the Integrated Architectures category had 8 papers, the Architectures Based on Trees had 3 papers and the Techniques for Customization category had also 3 papers related to it. References to these papers can be found in table 2, under the "Papers Type of Architecture Classification" section.

Table 2: Analysis of papers related to Cloud Customization.

| Category | Total | Papers |
|---|---|---|
| **Papers Domain Classification** | | |
| Academia | 20 | (Khan and Jiang, 2017; Hajlaoui et al., 2017; Zhou et al., 2016; Bobák et al., 2015; Kriouile et al., 2015; Khalil et al., 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Liu et al., 2012; Kang et al., 2011; Wang and Zheng, 2010; Mietzner et al., 2008; Müller et al., 2009; Jumagaliyev et al., 2016; Walraven et al., 2015; Khan et al., 2015; Sun et al., 2008; Correia et al., 2013; Jamshidi and Pahl, 2015; Schroeter et al., 2012b) |
| Industry | 5 | (Tizzei et al., 2017; Cao et al., 2015; Tsai and Sun, 2013; Walraven et al., 2014) |
| **Papers Goals Classification** | | |
| Architectures based on Customization | 18 | (Tizzei et al., 2017; Zhou et al., 2016; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Khalil et al., 2013; Tsai and Sun, 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Kang et al., 2011; Wang and Zheng, 2010; Mietzner et al., 2008; Jumagaliyev et al., 2016; Khan et al., 2015; Correia et al., 2013; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Optimization of Customization Features | 3 | (Müller et al., 2009; Walraven et al., 2015; Sun et al., 2008) |
| Connection and Configuration of Features | 4 | (Khan and Jiang, 2017; Hajlaoui et al., 2017; Bobák et al., 2015; Liu et al., 2012) |
| **Papers Scope Classification** | | |
| SaaS | 24 | (Tizzei et al., 2017; Hajlaoui et al., 2017; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Khalil et al., 2013; Tsai and Sun, 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Liu et al., 2012; Kang et al., 2011; Wang and Zheng, 2010; Mietzner et al., 2008; Müller et al., 2009; Jumagaliyev et al., 2016; Walraven et al., 2015; Khan et al., 2015; Sun et al., 2008; Correia et al., 2013; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Iaas | 2 | (Zhou et al., 2016; Bobák et al., 2015) |
| Paas | 1 | (Bobák et al., 2015) |
| Private | 4 | (Tizzei et al., 2017; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013) |
| Public | 1 | (Walraven et al., 2014) |
| **Papers Customizing Aspects Classification** | | |
| Selectable Modules | 11 | (Tizzei et al., 2017; Schroeter et al., 2012a; Liu et al., 2012; Wang and Zheng, 2010; Mietzner et al., 2008; Müller et al., 2009; Jumagaliyev et al., 2016; Correia et al., 2013; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Customization of Files | 2 | (Khan and Jiang, 2017; Lee and Choi, 2012; Khan et al., 2015) |
| System Structure | 2 | (Khalil et al., 2013; Kang et al., 2011) |
| Feature Selection Aid | 8 | (Hajlaoui et al., 2017; Zhou et al., 2016; Bobák et al., 2015; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Walraven et al., 2015; Sun et al., 2008) |
| **Papers Customizing Method Classification** | | |
| Software Product Line (SPL) related methods and their variations | 10 | (Tizzei et al., 2017; Cao et al., 2015; Kumara et al., 2013; Schroeter et al., 2012a; Mietzner et al., 2008; Jumagaliyev et al., 2016; Correia et al., 2013; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Development of new Architecture | 6 | (Bobák et al., 2015; Khalil et al., 2013; Lee and Choi, 2012; Kang et al., 2011; Walraven et al., 2015; Sun et al., 2008) |
| Function customization | 5 | (Khan and Jiang, 2017; Liu et al., 2012; Wang and Zheng, 2010; Müller et al., 2009; Khan et al., 2015) |
| Implementation of Algorithms | 4 | (Hajlaoui et al., 2017; Zhou et al., 2016; Kriouile et al., 2015; Tsai and Sun, 2013) |
| **Papers Customizing Models Classification** | | |
| Flow Charts | 9 | (Zhou et al., 2016; Bobák et al., 2015; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Liu et al., 2012; Kang et al., 2011; Mietzner et al., 2008; Khan et al., 2015) |
| Feature Models | 9 | (Tizzei et al., 2017; Hajlaoui et al., 2017; Cao et al., 2015; Kumara et al., 2013; Tsai and Sun, 2013; Jumagaliyev et al., 2016; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Component Models | 3 | (Schroeter et al., 2012a; Sun et al., 2008; Correia et al., 2013) |
| UML | 7 | (Tizzei et al., 2017; Khan and Jiang, 2017; Schroeter et al., 2012a; Wang and Zheng, 2010; Jumagaliyev et al., 2016; Correia et al., 2013; Walraven et al., 2014) |
| Architectural Models | 6 | (Khalil et al., 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Kang et al., 2011; Wang and Zheng, 2010; Walraven et al., 2015) |
| Trees Models | 3 | (Hajlaoui et al., 2017; Tsai and Sun, 2013; Lee and Choi, 2012) |
| New Models | 2 | (Müller et al., 2009; Schroeter et al., 2012b) |
| **Papers Type of Architecture Classification** | | |
| Components and Software Product Line related techniques | 11 | (Tizzei et al., 2017; Kumara et al., 2013; Khalil et al., 2013; Schroeter et al., 2012a; Mietzner et al., 2008; Jumagaliyev et al., 2016; Walraven et al., 2015; Correia et al., 2013; Jamshidi and Pahl, 2015; Walraven et al., 2014; Schroeter et al., 2012b) |
| Integrated Architectures | 8 | (Zhou et al., 2016; Bobák et al., 2015; Kriouile et al., 2015; Lee and Choi, 2012; Liu et al., 2012; Kang et al., 2011; Wang and Zheng, 2010; Müller et al., 2009) |
| Architectures Based on Trees | 3 | (Hajlaoui et al., 2017; Cao et al., 2015; Tsai and Sun, 2013) |
| Techniques for Customization | 3 | (Khan and Jiang, 2017; Khan et al., 2015; Sun et al., 2008) |
| **Papers Customizing Strategy Classification** | | |
| Manual | 17 | (Tizzei et al., 2017; Khan and Jiang, 2017; Hajlaoui et al., 2017; Cao et al., 2015; Kriouile et al., 2015; Kumara et al., 2013; Khalil et al., 2013; Lee and Choi, 2012; Schroeter et al., 2012a; Mietzner et al., 2008; Müller et al., 2009; Jumagaliyev et al., 2016; Walraven et al., 2015; Khan et al., 2015; Correia et al., 2013; Walraven et al., 2014; Schroeter et al., 2012b) |
| Semiautomatic | 5 | (Liu et al., 2012; Kang et al., 2011; Wang and Zheng, 2010; Sun et al., 2008; Jamshidi and Pahl, 2015) |
| Automatic | 3 | (Zhou et al., 2016; Bobák et al., 2015; Tsai and Sun, 2013) |

#### 3.2.5 In Which Degree the Customization is Made is an Automatic, Semiautomatic or Manual Way?

In our study, we analyzed 25 papers and found that 17 of them used manual, 5 used Semi-automatic and 3 used Automatic customization methods. When related with the Methods for Customization category, the Manual strategy is mostly related to the "Software Product Line (SPL) related methods and their variations" category (Tizzei et al., 2017; Cao et al., 2015; Kumara et al., 2013; Schroeter et al., 2012a; Mietzner et al., 2008; Jumagaliyev et al., 2016; Correia et al., 2013; Walraven et al., 2014; Schroeter et al., 2012b), the Semiautomatic strategy is mostly related to the "Development of new Architecture" (Liu et al., 2012; Wang and Zheng, 2010) and "Function customization" (Kang et al., 2011; Sun et al., 2008) in the same amount, and the automatic strategy is mostly related to the "Implementation of Algorithms" (Zhou et al., 2016; Tsai and Sun, 2013). References to all papers can be found in table 2, under the "Papers Type of Architecture Classification" section.

## 4 CONCLUSIONS AND FUTURE WORK

The conclusions regarding the first category is described as follows. The domain category shows an inclination towards the academia that could imply that many research made in cloud customization has not been implemented in the industry yet, and there is field for more research about the techniques implemented in the industry. Regarding the goal category, the Architectures based on Customization category was the most popular, in which papers proposed new architectures to this end. This inclination could indicate that customization has to be a core requirement during the construction of the architecture of a cloud application. Regarding the scope, we found that a vast majority of the work analyzed was oriented to SaaS applications, and only two papers dedicated to IaaS and PaaS service models. We believe that this inclination is due to the difficulty that SaaS customization represents.

The conclusions regarding the second category is described as follows. Regarding the customizable aspects, we believe that the popularity of the Selectable Modules category relays on the amount of different services that an application with different selectable modules can offer. Regarding the Methods for Customizing, we found that the works in each of the identified categories show that techniques to achieve the above described customizable aspects can vary between authors. However, we saw a clear inclination to create architectures from scratch, by using SPL techniques or new architectural styles. Regarding the models for Customizing, a clear majority was focused in the proposal of new architectures with different modelling techniques. Since the majority of work is done in architectural proposals, models such as Flow charts are the most used. Also, we found papers who created new modelling techniques either by modifying already existing ones or creating their own ones. Regarding the Type of Architecture, we found that SPL and SPL derived techniques were popular in cloud customization, but architectures that do not use modular components are almost equally used. Finally, regarding the Customization Strategy, we found that the majority of the work analyzed made Manual Customization. These results indicate that further work is necessary for amortization. As future work, additional research is necessary to propose and structure a maturity model for cloud service customization based on the literature review carried out in this work. Such model could provide elements to practitioners allowing them to understand the maturity level in which their organizations currently are and the path to move towards higher maturity levels. In addition, further research work is necessary in order to understand the benefits that cloud service customization can provide to customers in several areas such as Business and IT alignment, which is one of the today top priorities for IT managers (Avila and Garcés, 2014).

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