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A Systematic Mapping Studies of Cloud Testing Ecosystem

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Abstract— Cloud computing gave birth to a new IT resource service stack. It has led to a surge of software services designed and hosted via cloud infrastructures that are accessible by millions of users across the globe. The services include Infrastructure as a service (IaaS), Platform as a service (PaaS), Software as a service (SaaS) and other emerging ones such as Testing as a service (TaaS). TaaS allows developers and vendors to provide an environment for testing services across the layers of the cloud service ecosystem or test the cloud platform itself. The approaches to cloud testing are of a wide variety and focus on aspects of cloud layers or performance characteristics. In this paper, we present the results of a systematic mapping study (SMS) of cloud testing ecosystem that aims to characterize and categorize how empirical studies have been used to investigate cloud testing area. The objective of the mapping was to understand how researchers study cloud testing at each of the service layers, types of testing covered and how a cloud testing is investigated and reported. We identify relevant studies to classify which testing methods were sufficiently explored with cloud ecosystem at either software, platform or infrastructure levels. The study covers a period from January 2008 to November 2016. The paper also answers the mapping questions related to the publication fora, authors and years that have the most articles related to cloud testing. We identified 152 relevant publications and reported aggregated results for these categories cloud-based on testing.

Index Terms—Cloud Computing (CC), Cloud Testing, Testing as a Service, TaaS, Systematic Mapping, Cloud Testing Ecosystem.

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1 Introduction

CLOUD Computing used to be a buzz phrase but now has entered its next maturity stage. It represents a utility-based computing model that provides information technology resources (hardware and software) as a utility service rather than the traditional products or licensing of products [1]. The Cloud delivery model allows companies to lease infrastructure and develop software on top of these without worrying about resource availability using a pay-per-use model [2-4]. Services are offered in the form of software applications, computational tasks, data storage, processing and accessing, among others. These resources can be accessed remotely using thin client applications such as web browsers and API calls. Major industry players such as Amazon, Microsoft, Google and RackSpace are offering clients virtual machines to hire with an advanced fee to use (such as Amazon i2.xlarge=$0.853/hr, d2.8xlarge=$5.520/hr). Designing, developing and testing software and services virtually, is projected worth over $100 billion in the market [5].

With the continuing growth of massive and diverse data volumes, along with intensive software, testing of cloud services becomes imperative. A recent Gartner report highlighted that due to error-prone software, service downtimes of 80% in mission-critical services had cost businesses $98,000 per hour [6]. Among these, increased challenges of network availability, security and reliability are the biggest business concerns migrating to clouds [6]. Customers use service level agreements (SLAs) to define the expected quality of service parameters (QoS) to guarantee their services. Failure to meet any of the specified contractual agreements can lead to penalties and loss of business reliability.

Testing, however, as a concept encompasses a wide variety of testing methods, techniques, and dimensions. Cloud models combine software services with provider infrastructure, introducing concerns about security, availability and more. Kiran et al. [7, 8] focused on functional testing methods, using model-based testing to develop automated test cases for testing functional cloud service behavior. Oliviera et al. [9] used meta-models to create platform-independent model test cases. Other approaches have focused on non-functional attributes, such as using WS agreements to define performance requirements and guarantee service behavior [10], SLA testing [11] and documenting violations [12]. Researchers use SLAs to test for load, response time, resource utilization and availability. Additionally, tools such as Cloud Test, SOA Test, D-cloud [13] have been used to test performance and stress. Using Selenium to test service functionality by embedding in browsers, similar to client-server testing models. Other tools, such as EggPlant and Sahi used Blackbox approaches for constructing test cases and performing end-to-end testing through simulation to identify security vulnerabilities. A methodology known as Testing as a Service (TaaS) has allowed developed software to be tested on cloud ecosystems externally, introducing a new business and service model where the cloud provider performs software testing under multiple attributes of both functional and non-functional testing.

With a significant number of research activities in Cloud and Testing methods, it is important to characterize these studies and understand their role in the cloud ecosystem. In this paper,

we present, to the best of our knowledge, a most comprehensive mapping study of testing approaches in Cloud ecosystems. The mapping has been organized by answering the mapping questions identified. This includes the number of publications per year, the most active authors, and the publication that contributed the most in the area. Similarly, the research examines the layer that receives more attention within the ecosystem layers (IaaS, PaaS, SaaS and TaaS). We adopted guidelines for conducting mapping studies from [14, 15]. We first start by explaining the context of cloud ecosystem testing compared to traditional testing methods of service-oriented architectures. Our aim in these sections is to explain how Cloud itself is not novel as a technological advance, but its existence is rooted with the intersection of multiple 'old' ideas, technology drivers and needs. By explaining the three layers of cloud ecosystems, Software as a service, platform as a service and infrastructure as a service, we explain how testing plays different roles across these layers.

Section 3 (methodology) is the core of this study, presenting a systematic mapping of the publications in the field of testing methods in cloud ecosystems. We use the ISO standard for defining testing approaches and techniques to identify the publications based on functional and non-functional attribute testing as well as the most used testing methods in cloud layers. Section 4 discusses the various categorization methods adopted to answer the mapping questions. Section 5 outlined the conclusion and future work of this research work.

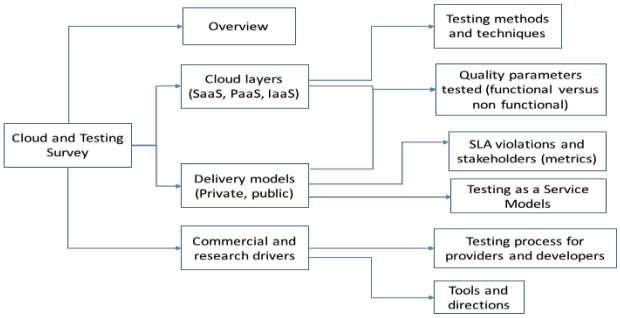

Fig 1: Scope of this mapping study

2 Related Works

There have been many studies (i.e., systematic reviews, systematic mappings, surveys, among others) and other relevant studies that focussed in the area of cloud testing. We provided an overview of these identified studies in TABLE I below. Although most of the studies provided a strong assessment and synthesis from the body of literature in cloud testing, none of them to the best of our knowledge, attempted to provide a comprehensive, thorough, and wider analysis of articles that reported research in the entire ecosystem of cloud testing (IaaS, PaaS and SaaS as well as TaaS). Our study also provides more period of coverage from 2005 to the end of 2016.

TABLE 1: SUMMARY OF RELATED WORK AND THEIR FOCUS IN CLOUD TESTING

Articles	Publisher	Published Year	Type of Study	Period Covered	Focus on Cloud testing	
[16]	Software Engineering an International Journal	2011	Classification of cloud testing and their comparisons. Opportunities of using Cloud for testing, challenges of testing Cloud and using Cloud to test as well as current practices	2008 - 2010	All aspects of cloud testing but mainly categorization, classification of various testing types, tools, environment and Cloud testing facets, forms and types. Services testing, application testing, platform, and hardware testing	
[17]	IEEE Conference (SoSe)	2011	Tools survey	Not specified Cited 2007 2011	Cloud testing tools, prototypes and providers categorization and classification	
[18]	IEEE Conference (Sere-C)	2012	Survey of test areas covered in research	2009 – 2012	Test level – uses V-model Test type – diff types of tests Contribution and Delivery model	Uses tables
[19]	ACM SE Notes	2012	SLR Cloud based testing techniques	2004 - 2011	4 groups Cloud based testing Automated Test case generation Testing frameworks Testing models Cloud application frameworks	Proposed models Model based testing Perf testing Symbolic execution Fault injection Random testing Privacy testing
[20]	SE Frameworks for the Cloud computing paradigm, CCN	2013		Not specified	Discusses economics of cloud testing	
[21]	IEEE conference (ACSAT)	2013	Review of features and models of Mobile cloud testing and Mobile applications testing on the Cloud	Not specified		
[22]	Journal of Systems and Software	2016	Review of the 38 articles using Who, Why, What, where, when and How questions approach	2010 – 2012	Discusses the dimension of using 5W+1H in reviewing cloud testing as well as the.	Though acknowledge the testing at the cloud service layers but have not categories the articles on those layers

3 METHODOLOGY

A systematic mapping study SMS (also known as scoping) provides a broad structure and categorization of the type of research that is reported, and the results presented that have been published through classifying them and usually providing a graphical summary, and the mapping of the results [23, 24]. It often requires less effort and provides an overview in a more coarse-grained compared to systematic review. This SMS was conducted by adopting and synthesizing guidelines of the mapping [15, 25] as well as from other related work [26-32]. We devised three broad overlapping phases of Planning, Conducting and Reporting. These

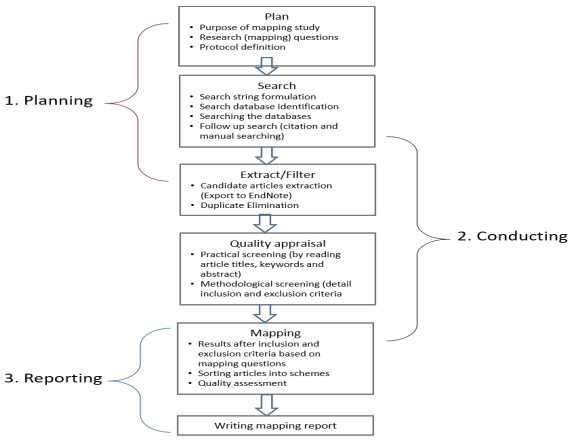

Fig 2: Systematic mapping Phases/Stages

phases were divided into six stages as shown in Fig 2. The details of the stages and the activities involved are described as follows:

3.1 PLANNING

The main activity in the planning stage is the identification of the purpose for the mapping studies and objectives/mapping questions as well as the protocol definition. Protocol definition involves the selection of methodology to be adopted in undertaking the study [14, 25] so that it satisfies all the major characteristics of SMS of comprehensive, reproducible, and explicit, so that other professionals may reproduce the same protocol and judge the adequacy and quality of the research.

a) Purpose of the mapping study:

First, the rationale for conducting this SMS is similar to those articulated in the guidelines that we adopted from scientific sources, which is finding and evaluating the available research related to the researcher's questions, subject area, and related phenomena. The guiding articles gave the reasons for conducting systematic review/mapping [14, 15, 25, 33, 34]. These include:

- Summarise the existing evidence concerning technology.
- Identify any gaps in the current literature to suggest further investigation and
- Produce a framework or background that will be used to position further research activities.

Secondly, our SMS is unique because to the best of our knowledge, there is no related work that captures the entire cloud ecosystem of review/mapping the area of cloud testing. That is capturing cloud testing across all the service layers as well as testing as a service with similar questions as this work.

b) Research (mapping) questions

It allows a scoping to provide an overview of a research area through classifying and outlining the contributions about the categories of that classification, and to provide an indication about the quantity and type of research available within it. It involves searching the literature to know what topics covered and published in the body of literature, and where the literature has been published. Although a systematic review and mapping studies share some common attributes (such as searching and study selection), they differ in their aim, goals, and data analysis and interpretations [35]. Hence, the mapping research questions of this study were concerned with the structure and publication patterns of testing within the cloud computing ecosystem. The following are the research questions this mapping study seeks to address:

- MQ1: What is the distribution pattern of Cloud testing publications across the years under review?
- MQ2: Which cloud testing area receives more publications, and who are the most active authors?
- MQ3: Which publication forums publish more research in cloud testing service ecosystem
- MQ4: Which Cloud layer (SaaS, PaaS, IaaS) have received the most attention in testing literature?

3.2 SEARCHING

The research questions drive the selection of search terms used in searching for articles from various sources. The search query, keyword terms, and their synonyms were carefully composed. The search comprises of two main terms, 'Cloud' and 'Testing' and their synonyms. However, the synonyms of the word 'cloud' in the online thesaurus were the synonyms of the original word 'cloud', not the computing term. As a result of this, we selected terms used in computing to represent Cloud, such as virtualization, distributed and networked. For the term testing, we use synonyms such as verification, validation and assessment [36, 37]. The search strings present a set of statements that combine keywords and their synonyms. Table 2 below shows the search strings used and their connecting Boolean operators. The wordings in the quest string S1 and S2 were defined

based on previous systematic literature reviews.

TABLE 2: SEARCH STRING KEYWORDS AND SYNONYMS

	Category	Search terms
S1	**Cloud (C)**	Cloud software, service oriented, distributed, virtualized
S2	**Testing (T)**	Testing, Verification, Assessment, Analysis

The search terms were defined by combining S1 and S2 shown in Table 2 using "AND" and "OR" Boolean operators, thus: $(C_1\ OR\ C_2\ OR\ \ldots\ OR\ C_n)\ AND\ (T_1\ OR\ T_2\ OR\ \ldots\ OR\ T_n)$ resulting to the following search strings:
(Cloud OR "Cloud Software" OR "Service Oriented" OR "Service-Oriented" OR distributed OR virtual) AND (Test* OR Verification OR Validation OR Assessment)*
The string above was also augmented with another string formulated using keywords of related studies as follows:
("Cloud" AND Testing) OR ("Testing as a Service") OR ("Cloud Services" AND Testing) OR ("Cloud-based Testing") OR ("Cloud-based Software Testing") OR ("Infrastructure as a Service" AND Testing) OR ("Platform as a Service" AND Testing) OR ("Software as a Service" AND Testing)
The strings formed were used to retrieve candidate articles from the following databases: IEEE Xplore Digital Library[1], ACM Digital Library[2], Engineering Village[3], Web of Science[4], Scopus[5] and Science direct[6]. The databases were selected based on the previous studies [19, 38]. In addition to this, in-depth manual searches were conducted using snowballing the citations of the related reviews.

3.3 Extraction, Screening, and Inclusion/Exclusion

After successfully searching the articles, they are immediately extracted from various databases. The articles were also screened at the same time by reading titles and abstracts. This is followed by inclusion and exclusion criteria whereby articles are selected based on relevance to the research topic and the underlying research questions. The criteria used were based on [15, 34] guidelines augmented by other related research [29]. Figure 3 highlights the details of the process leading to the final articles considered for primary studies.

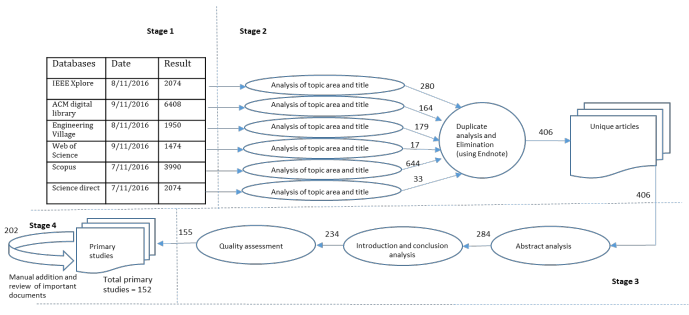

Fig 3 Detailed of the article selection process

All articles selected were analyzed based on methods, selection criteria and ideas discussed. Articles that discuss about testing/evaluating IaaS/PaaS/SaaS but relevant to provision of testing service were not included as deemed not relevant to the research topic and research questions. The following were the type of articles included and excluded from the main primary study articles:

- Journal articles and conference papers and proceedings. Other published academic and industry papers (e.g., research gate, white papers)
- Articles written in English language

Excluded articles are:

- Short papers (e.g., research proposal)
- Published Books
- Book chapters or sections
- Unpublished articles
- Academic projects (thesis and dissertations)
- Web pages/blogs and social media postings

3.4 Quality appraisal

Although the phases/stages seem linear, that is, one after the other, many activities in various stages are carried out simultaneously. For example, the searching, extraction, and practical screening all happen at the database results screen. It was then followed by the first level of screening the articles based on their titles. The second level of screening was reading the abstract, introduction and conclusion.

To minimize bias and ensure quality, stages all the authors conducted 3 and 4.

3.5 Conducting the mapping analysis

At this juncture, articles are sorted into schemes from different classifications and categorizations. The categorization will be to address the research questions of the study. Other schemes can be deducted because of a particular identified pattern. In this study, we categorized our primary study articles to address the research questions as follows:

3.5.1 Classifying papers into categories

We categorize papers based on the evaluation criteria by Wieringa et al. [38] to help present a landscape of research in the field of cloud testing.

- PP = Philosophical papers: These papers sketch a new way of looking at things, a new conceptual framework, etc.
- ER = Evaluation research: Investigation of a problem in cloud testing (CT) ecosystem practice or an implementation of a CT technique in practice. Its novelty is based

[1] http://ieeexplore.ieee.org
[2] http://portal.acm.org
[3] https://www.engineeringvillage.com
[4] apps.webofknowledge.com
[5] http://www.scopus.com/
[6] http://www.sciencedirect.com/

on the knowledge claim and soundness of the research method used

- SP = Solution Proposal: Papers that propose a solution technique and argue for its relevance without a full-blown validation. The technique must be novel or at least a significant improvement of an existing technique, e.g. a proof-of-concept papers.
- OP = Opinion Papers: These papers contain the author's opinion about what is wrong or good about something, how we should do something, etc.
- VR = Validation Research: Papers investigate the properties of a solution proposal that has not yet been implemented in cloud testing practice. The solution may have been proposed elsewhere by the author or by someone else. The investigation uses a thorough, methodologically sound research setup. Possible research methods are experiments, simulation, prototyping, mathematical analysis, mathematical proof of properties, etc.
- EP = Experience Papers: In these papers, the emphasis is on what and not on why. The experience may concern one project or more, but it must be the author's personal experience. The paper should contain a list of lessons learned by the author from his or her experience. Papers in this category will often come from industry practitioners or from researchers who have used their tools in practice and the experience will be reported without a discussion of research methods.

3.5.2 classification based on research (mapping) questions:

This classification scheme is based on the four research (mapping) questions the paper seeks to address. These are:

- MQ1: What is the distribution pattern of Cloud testing publications across the years under review?
- This question seeks to address the issue of knowing the years the reported Cloud testing the most and the focus of that cloud testing
- MQ2: Which cloud testing area receives more publications and who are the most active authors?
- This question seeks to address the most active researchers who publish more articles and see their area of interest in cloud testing. This will further help in understanding the areas that have more grounded research.
- MQ3: Which publication forums publish more research in the cloud testing service ecosystem?
- This question will address the most used publication media and the articles published there.
- MQ4: Which Cloud layer (SaaS, PaaS, IaaS) have received the most attention in testing literature?
- This question seeks to address the layers covered within the ecosystem and how testing research was reported.

The detailed description of the visual results of all the questions as well as the categorization of the articles within each domain, will be presented in the next section under results.

4 RESULTS

This section provides the results of the mapping studies conducted with answers to the mapping questions highlighted above.

4.1 Article classification based on categorization scheme

The first results present the classification of the articles based on the categorization of the research type adopted from [38]. Figure 4 shows the research types with philosophical papers were reported the most. It also shows the increasing interest in the solution proposal, especially in the year 2013 and 2014.

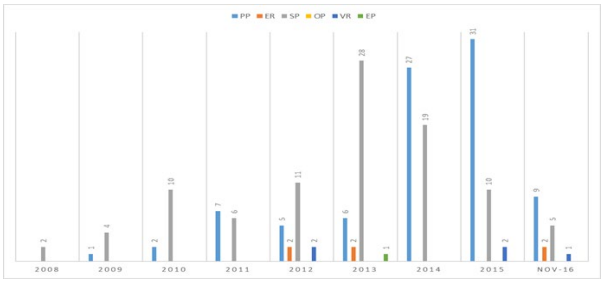

Fig 4: Articles classification based on research type

4.2 Articles classification based on mapping question MQ1

To answer mapping question MQ1 What is the distribution pattern of Cloud testing publications across the years under review? Figure 5 presented what we found. From the figure, we can deduce that the number of articles increases with years. The papers are from all kinds of research with 2015 reporting the highest number of research related to cloud testing.

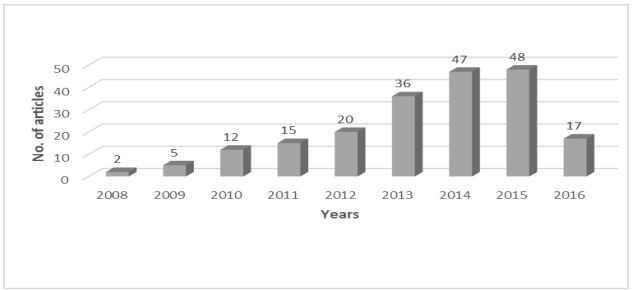

Fig 5: Relevant publications per year

4.3. Articles classification based on mapping question MQ2

To answer mapping question MQ2: Which cloud testing area receives more publications, and who are the most active

authors? Figure 6 shows the authors that published more articles. However, we counted the number of articles authored by most cited authors without considering whether they are the main or associated authors. From the figure, we can deduct that Tsai, Wei-Tek produce more papers in the area than the remaining authors.

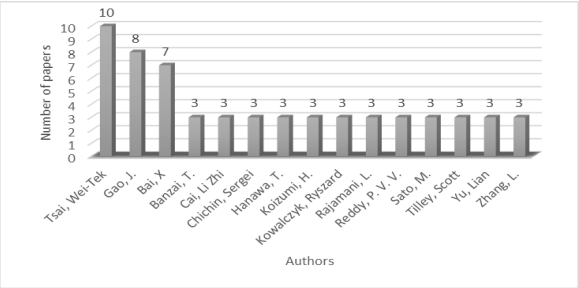

Fig 6: Authors with their number of publications

4.4. Articles classification based on mapping question MQ3

To answer mapping question MQ3 Which publication forums publish more research in cloud testing service ecosystem? Understanding the forum for publishing papers related to Cloud testing. To answer the mapping question, we divided the primary study articles into conference/workshops and journals. Interestingly, a total of 20 different journal articles were used for publishing the 35 (17.32 %) articles while the remaining 167 (82.67%) papers were published in conference papers/proceedings and workshops. Furthermore, 99 different conferences/workshops were used for publishing the papers from which International Conference on Software Testing, Verification, and Validation Workshops (ICSTW) have the highest number of papers (totalling 12). Likewise, the conference that follows with publication track of 10 papers is the IEEE International Symposium on Service-Oriented System Engineering (SOSE). Some of the published papers were in the same proceedings, while others were in subsequent (proceeding and succeeding) ones. A summary of the papers and conferences were presented in TABLE I and a detailed list of all articles used for primary studies were enumerated.

TABLE *3*: SUMMARY OF FORA THAT PUBLISHES THREE OR MORE PAPERS

SN	Conferences/Workshops	Number of papers
1	ICSTW	12
2	SOSE	10
3	CLOUD	5
4	CLOUDCOM	4
5	UCC, SERE, AST, COMPSAC, CCGRID, MIPRO, SERVICES	3

Conferences/workshops key: *International Conference on Software Testing, Verification, and Validation Workshops (ICSTW); IEEE International Symposium on Service-Oriented System Engineering (SOSE); IEEE International Conference on Cloud Computing (CLOUD); IEEE/ACM International Conference on Utility and Cloud Computing (UCC); International Conference on Software Security and Reliability (SERE); International Workshop on Automation of Software Test, (AST); IEEE International Conference on Cloud Computing Technology and Science (CloudCom); IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGRID); International Convention on Information and Communication Technology, Electronics and Microelectronics, (MIPRO); IEEE Annual International Computer Software and Applications Conference (Compsac); IEEE World Congress on Services (SERVICES).*

4.5. Articles classification based on mapping question MQ4

To answer mapping question MQ4, Which Cloud layer (SaaS, PaaS, IaaS) have received the most attention in testing literature? Here, we first categorize all the articles according to two broad testing types: functional (F) and non-functional (NF). The second categorization was based on testing types reported in the papers. For example, some papers reported security testing, unit testing, integration testing, and so on. We also classify these testing types at each of the cloud ecosystem layers. A detailed classification was represented in Table 4 below.

Moreover, we found different testing techniques used in various layers, for instance, at IaaS layer, there were some articles that reported research on performance testing but mainly at the framework level, hence considered as philosophical papers, such as IaaS – performance and non-functional testing methods. Only one article was found to determine path coverage even though many articles concentrated on performance measures, surprisingly, no relation to SLA.
For SaaS, most testing methods followed functional testing. Some examples did look at measures of performance such as [58] using model-based tools
For PaaS, we found that test case generation, a functional approach to performance measures, as well as security testing, has the least focused area.
TaaS, however, uses various testing methods, from functional to non-functional testing. Most techniques showed TaaS has been most popular outsourcing tools on the cloud to be used for other testing. However, there is also some research on `Testing as a service' (TaaS) for the Cloud [37, 39]. This allows an application to be tested online before deploying it, taking advantage of the benefit of the Cloud by outsourcing the issue. Vengattaraman et al. [38] used modelling tools to focus on the relationships between the applications and the services being tested but lacks the intricate details of how these will be done. TaaS can be presented as two views, which focus on service testing from the viewpoints of the developer and the end-user [40].
Mobile-based testing is another interesting and exciting area

with remarkable research reported in it. In this category, most of the articles presented mobile testing as a service (MTaaS) which is a sub of TaaS. This further shows that many of the cloud testing research focus more on the benefit of outsourcing testing service using cloud computing resource with little on testing the Cloud itself.

Within the 255 reported studies we found that the most researched area of cloud testing concentrates in the TaaS service model.

TABLE 4: SUMMARY OF ARTICLE CLASSIFICATION BASED ON TESTING ON EACH CLOUD SERVICE LAYER

Testing topic (F- functional, NF-non-functional)	**TaaS**	**SaaS**	**PaaS**	**IaaS**
Performance testing (NF)	PS - 50, 52, 56, 192, 204, 209, 237	PS - 104, 105, 182, 225	PS - 153	PS - 52, 70, 91,92, 109, 111, 114, 115, 128, 131, 142, 144, 146, 147, 163, 170, 171, 173, 177, 188, 189, 197, 199, 200, 211, 242
Unit testing and test case generations (F)	PS - 51, 53, 55, 57, 239, 247	PS - 103, 120		
Interoperability (NF)	PS - 66		PS - 182	PS - 156
Load and stress testing (NF)	PS - 125, 205, 235	PS - 97, 149, 201	PS - 68	PS - 116, 148
Web service testing (NF)	PS - 12, 9, 106, 145, 162, 173, 177, 199	PS - 25,152	PS - 8	PS - 195
VM migration (NF)	PS - 17, 19, 147	PS - 14		
Testing environment (NF/F)	PS - 13,15, 18, 28,34, 53, 75, 83, 97, 126,128, 144, 150, 156, 157, 167, 171, 172, 176, 178, 194, 203, 205	PS - 84, 90, 133,134		PS - 43, 64,114,135
Fault injection methods (F)	PS - 16			
Survey of methods (F/NF)	PS - 21,33, 49, 54, 66, 76, 77,105, 119,129, 146, 190, 200			PS - 93, 95,102, 113, 197
SLA based testing (NF)	PS - 23, 104,108,139, 185, 192	PS - 123	PS - 123	PS - 123
Testing mobile apps using Cloud (F/NF)	PS - 26, 29, 30, 31,36, 39,50, 86, 94, 109, 111,112,115, 118, 121, 182, 186, 188, 202	PS - 41, 47, 48, 89, 94, 120	PS - 91	PS - 40, 44, 166
Regression (NF)	PS - 27			
Scalability testing/elasticity/availability (NF)	PS - 56, 170, 198	[39], 73		PS - 67, 160
Testing tools (F/NF)	PS - 35, 132, 140, 174, 175, 184		PS - 137	
Security testing (NF)	PS - 37, 71, 72,138, 169, 183	[40], 60, 61		PS - 70, 141
Path coverage and test case generation (F)	PS - 38, 42, 55			PS - 164
Anomaly injection (F)	PS - 78	PS - 88		PS - 130
Search-based testing (NF)	PS - 81			
Evaluating cloud users (out of scope)	PS - 122			
Network analysis and offerings (NF)	PS - 87, 181			PS - 149, 161, 168
VM testing (F/NF)				PS - 187, 204

6 Conclusions and Future Work

Cloud computing is quickly becoming the model for industries to deploy and use to increase their market prospects, particularly the successful examples of Netflix and Coursera hosted on Amazon servers. Also, verifying the true capabilities of the service satisfying user and provider objectives, is a cornerstone in ensuring the business's success. Broadening links with industry and university affiliations provides greater visibility and potential for research to be extended in all the layers of the ecosystem where SLAs and quality of experience for users are becoming more critical. Using Cloud applications in Big Data and IoT processing, service performance plays a vital role in data analysis and speed of delivery. There are also pressing problems to optimize user experience regarding SLA and QoS agreements. This paper provides an SMS approach in cloud testing ecosystems. The mapping has been organized by answering the mapping questions identified. This includes the number of publications per year, the most active authors, and the publication fora that contributed the most research in the area. Similarly, the study examines the layer that receives more attention within the ecosystem layers of (IaaS, PaaS, SaaS and TaaS). Articles were categorized and classified using SMS methodology.

This work will be extended with a more in-depth review using a systematic literature review (SLR) of the cloud testing ecosystem in general and the SLR and SMS of articles around analytical performance analysis of cloud computing platforms in particular.

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