A Systematic Mapping Study of Architectural Models for Achieving Utility in the Cloud

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Abstract. Cloud computing is an important model that allows for information exchange between the various aspects of the Cloud using different service types and models. The issue of deciding a specific research scope mostly in terms of architectural models used in achieving utility in the Cloud, is usually a complex process for a researcher. However, a review or survey paper assists in easily identifying likely topics of research. The objective of this work is to carry out a systematic mapping study of architectural models for achieving utility in the Cloud. A systematic mapping research allows for categorization in a subject area using a scheme based on certain classification process. The scheme used in this paper was categorized into three facets namely: topic, research and contribution facets. The results showed for example that, 30.77% of the papers reviewed on architectural models for achieving utility in Cloud computing are related to evaluation research. The breakdown identified that 5.98% of the evaluation research dealt with design, 6.84% considered applications, 10.26% focused on performance models, 3.42% discussed implementation, 1.71% was on platforms and 2.56% dealt with component models. This study vividly identified gaps in the field of architectural models for achieving utility in the Cloud. This will stimulate interest for advanced studies by both researchers and industry practitioners.

Keyword: Cloud computing, Cloud Models, Utility, Systematic Map.

1. INTRODUCTION

The Cloud is a framework comprising of interconnected and virtualized PCs, progressively provisioned and exhibited as a unified computing resource, which is dependent on service-level understanding between the users and the Cloud service providers [1]. Cloud computing provides services to users through the most advanced facilities available to Cloud Service Providers (CSPs). The Cloud services are elastic and available on demand at any time. There are three primary Cloud service types namely Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS).

SaaS is provided by the CSP through provision of applications that can be utilized by the consumers, hence the users do not have to install such applications or pay for the licenses. PaaS allows...
a user to develop, design and deploy an application on the infrastructure provided by the CSP. The user has control of data and the application while the CSP controls the rest of the infrastructure. IaaS provides the user with Cloud infrastructure to store, compute and utilize network bandwidth all on a per–use basis. Although the CSPs are trying hard to provide efficient and reliable services on the cloud, we also need to be concerned with the issues of trust [2].

Cloud architecture comprises of four models. The private Cloud, which are hosted in-house by an organization and they are considered more secure. The public Cloud, which are hosted by CSPs with large infrastructure spanning continents. The community Cloud, which are hosted by institutions with shared common interest working independently, and the hybrid Cloud, which allows organization to take advantage of the benefits available on the different Cloud types. The effectiveness of Cloud computing has brought about improved conveyance and constant expansion of services, which is based on the fundamental architecture and applications running on the cloud[3, 4].

The services provided on the Cloud can be considered as utility. This is because they are available on request and provided on a pay as you use basis. Cloud computing as utility is a process of delivering infrastructure, application and business processes for a fee through the internet [5]. The Cloud services and models allow the user to assign a utility value to their workloads. There is a valuation assigned to the utility based on the users’ need, the amount to be paid, and profit consideration by the CSPs [5]. This process is usually done through virtualization and multitenancy making the utility environment a market place. However, security remains a significant point of concern because of the procedure of virtualization and multitenancy on the cloud[6, 7]. Utility can be in form of social networks, office suites, programming languages, computer servers and data storage [8].

A lot of research is taking place in terms of architectural models and utility on the Cloud and it is sometimes important to take a look at the research and the summarized activities. In article or research writing, a researcher needs to recognize a technical area of focus. It entails searching lots of studies for better understanding of the topic, thus resulting in the difficult process of pinpointing a research area[9]. Systematic mapping studies enables the structured presentation of results and reports that have been published through categorization and provision of a summary [10]. Such summary is done in a visual form using a map of the classification scheme and structure. It is built by examining the Cloud models and how it is being used to achieve utility. This was used to determine the frequency of publications and research in the area of Cloud computing architectural models for achieving utility. By providing this over-view, it was possible to identify the research coverage in this area. A systematic study yields a review of research areas that are under infancy requiring further attention by researchers [11]. Three facets were used for the mapping studies which are the research, contribution and topic facets [10]. The research facet considered the type of research carried out in using architectural models to achieve Cloud utility. The contribution facet examined the kind of contributions of the study. Finally, in the topic facet, key topics discussed in the reviewed papers were outlined in relation to Cloud models and utility. This research work is aimed at conducting a systematic mapping study of architectural models used for achieving utility in the Cloud. The order of the paper is organized as follows; Section 2 examined related works, section 3 discussed the materials and method. Section 4 is used for results and discussion. Section 5 concludes the paper and suggests future work.

2. RELATED WORKS

[12] explained the planning stage of systematic mapping study. It recognized software patterns as a fundamental amid the requirement engineering stage of designs/projects. A protocol was designed for the study, with simple directions to aid in the redesigning of their work by the research environment for an affirmation of the potency of the research. The guidelines shown by [10] were adhered to for this work.
The work of [13] carried out a systematic mapping study of domain-specific languages (DSLs), to have a firm grasp of the DSL field, seek out research trends, and identify research gaps. The study covering from 2013 to 2014 utilized three review guidelines: planning, conducting and reporting the review.

[14] is based on the analyzing the utilization of concept maps in Computer Science for systematic mapping study. The resultant map is centered the compilation and assessment of researches on concept maps in the field of Computer Science. Two searching processes were used also, namely; backward snowballing and the manual approaches. It displayed extensive focus and thorough examination of concept maps, using learning and teaching aids.

The authors in [15] utilized a mapping study to explore the adoption game-related methods in software engineering, while identifying research gaps. An aggregate of 156 essential investigations between 1974 to June 2016 were distinguished in this examination. The mapping procedure of the work was done couple with [10].

[16] focused on the power system model by giving an analysis of the power system and its applications using the mapping process. It is used by European organizations for analyzing modeling features and identifying modeling gaps. Over 228 surveys were conveyed to power specialists to elicit information, leaving only 82 questionnaires to be completed and used for the mapping.

Using a systematic mapping study, [17] discussed about domain-specific languages (DSLs) with major concern on its contribution, form of research, and the research area. Searches were gotten from trustworthy sources dated 2006 to 2012, while the resultant map was created in relation to the process of explaining research questions, administering the search, screening, categorizing and the extraction of data.

In [18] is a mapping study of the literature on legal core ontologies. The authors identified publications on “legal theory” and “legal concepts”, which were categorized in accordance to languages, tools, methods and models. Other processes include recognition of the existing legal theories in legal core ontologies and building process.

The research paper of [19] gave a summary of a factual research on software cloud-based testing using systematic mapping study in the building of classification scheme. The authors examined the uniqueness and application of functional and non-functional testing processes. Sixty-Nine (69) essential studies were utilized for a thorough factual investigation, leading to quantitative results.

[20] presented a detailed overview of the knowledge management in organizations, with special emphasis on the role of Information Technology. They went ahead to discuss several important issues centering on knowledge management processes and the procedures IT plays in driving and aiding these steps. Attention was also raised on the need to aid the creating, storing, and transferring process of knowledge in organizations.

[21] Explained the information gotten from applying systematic literature review processes within software engineering domain. The researchers explained the systematic literature review process and also described lots of reviews undertaken by them and other researchers and finally extracted and discussed some lessons about application of the practice to software engineering domain.

[22] stated the impact of systematic literature review where it recommended evidence-based software engineering processes for combining evidence. Amongst twenty (20) relevant studies researched on, eight (8) examined research trends rather than evaluating technique, seven (7) systematic literature reviews examine cost estimation, and the quality of systematic literature reviews was fair with only three scoring less than 2 out of 4.

[23] was of the opinion that evaluating how the process of systematic mapping is conducted is of paramount significance. In the affirmative, the authors discovered that in the substantial number of the research carried out, several guidelines were utilized and integrated, thus resulting in numerous approaches to conducting systematic mapping research.

Finally, [24] emphasized on the significance of scientifically conducting literature review and the need to avoid relying on sparse works for improving the content of related works. The authors further
discussed problems encountered in research work. They also proffer solutions to the problems addressed.

3. MATERIALS AND METHOD

This systematic mapping study shows a pictorial portrayal of results, which are dependent on a thorough review of publication in a related research area. The formal guidelines for systematic studies in [10] was utilized, which is a replicable process for eliciting and interpreting materials as regards the research objective [11]. Figure 1 shows a few essential procedures taken in a typical systematic mapping study. There is the explanation of research questions whereby the scope of review is considered. Searches are usually conducted on all papers available in that particular field of study. After which the papers are checked to determine the relevant ones. Keywording using the abstracts on the papers is carried out with a view to designing a classification scheme. The processes of data extraction, which results in the production a systematic map, concludes the process. At every stage there is an outcome. The various stages were used in the establishing of a systematic map for architectural models used in achieving utility in Cloud computing.

![Figure 1. The Mapping Process][10]

3.1. Definition of Research Questions

Defining the research questions for this study results in a summary of the amount and kind of research done on the research topic, and the identification of the places the research has been published. In this paper, the following are the research questions:

**RQ1**: What are the addressed areas in architectural models to achieve utility in the Cloud, and what are the number of published papers in the distinctive areas?

**RQ2**: What kind of papers are published in the distinctive areas, and specifically what are the established innovativeness?

3.2. Conduct of Search for Primary Studies

Performing a search for primary studies is typically the starting point of any review. The conduct of search for primary studies is usually done by exploring major databases. This can also be accomplished through manual search on conferences and journals. In order to get papers for this systematic mapping study, search for papers was performed on the digital libraries shown on Table 1, due to the high meeting determinant of the conferences and journal publication in these databases. The search focus was not placed on information from books and printed resources.

| Electronic Database | URL         |
|---------------------|-------------|
| ACM                 | http://dl.acm.org/ |
The utilized search string was designed in terms of outcome, population, comparison and intervention. Also, the utilized keywords in the search string was extracted from every aspect of the structure of the title for this study. For this study on architectural models used in Cloud utility the search string used on the selected databases is:

( TITLE ( "Architectural model" ) AND TITLE-ABS-KEY ( Cloud ) AND TITLE-ABS-KEY ( utility ) )

Performing the search involved using the customized search string above on document Meta data to ensure that relevant studies were not missed out, and extracting only the studies from the selected databases that relates to the field of study. In view of our paper choice criteria, characterized by the requirements of the goals and research questions, 117 papers were found relevant to be added out of the initial list 1561 papers.

3.3. Screening process for Inclusion and Exclusion

The inclusion and exclusion criteria, as shown in Table 2, was utilized in adding or removing publications not relevant to this study on architectural models for achieving utility in the Cloud, and the research questions.

| Inclusion Criteria                                                                 | Exclusion Criteria                                                                 |
|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| The abstract expressly specifies architectural models in relation to cloud computing. Furthermore, such architectural models from the focus of the paper contribute to achieving utility on the cloud. | The paper is not within the domain of cloud computing especially as it relate to architectural models. The paper does not contribute to achieving cloud utility. |

3.4. Key-wording of Abstracts

The Key-wording of abstracts is a major part of the systematic mapping process because it influences the building of the classification scheme.

1. Abstract
2. Keyword
3. Classification scheme
   a. Articles
   b. Sorting articles into the scheme
   c. Updating scheme
4. Systematic Map

Key-wording is fundamental in decreasing the time expected to build up the classification scheme for the architectural studies and ensuring that all relevant studies are considered in terms of the scheme. This process involves examining the abstracts to highlight keywords essential to the study, thereby understanding its meaning. The keywords from the primary studies were collected for further insight into the type and contribution to the study, which resulted in the development of the classification scheme, and subsequently the categories used.
In this study on architectural models and utility in the Cloud, 3 facets were utilized in discussing the results. The first facets focused on the topic in terms of architectural models for achieving utility and they are in terms of design, applications, performance models, implementation, platforms and component models. The second facet focused on the types of contributions in terms of metric, tool, model, method and the process as suggested in [10]. All these categories and their components were generally derived from the key-wording of abstracts. The third facet dealt with research types such as validation and evaluation research.

3.5. Research Facets with Categories and Descriptions

The classification of research approaches in [25] was utilized in the research category of this study and are listed below:

1. Validation Research: These includes techniques that are unique but have not been implemented as proof of concept.
2. Evaluation Research: These includes implemented techniques, whose results have been discussed in relation to points of interest and hindrances.
3. Solution Proposal: These include papers that present unique solutions to specified problems, while highlighting the advantages and applications of such solutions.
4. Philosophical papers: These include papers that offer alternate perspective to examining problems with respect to concepts and frameworks.
5. Opinion Paper: These include papers that rely on the researcher’s opinion rather than any known research methodology.
6. Experience Paper: These include papers that rely on the experience of the researcher and emphasizes on the ‘what’ rather than the ‘why’.

The classification of research approaches was appraised as satisfactory for use in the facets of this study, as all selected papers were scrutinized in accordance to the various categories and descriptions. The outcome of this process was used to construct the research category.

3.6. Data Extraction and Mapping of Study

During the classification phase, the significant studies were grouped into the scheme. The next phase was used for the data extraction from the various papers that were included in the primary studies. The data extraction process succeeds the outcome of the classification scheme. During the process, new categories are usually added, some categories are merged and others not considered sufficiently relevant are removed. After the classification process, the procedure of data extraction for this study was done on a Microsoft Excel table. Subsequently, the frequencies of papers contained in each table was combined into the tables comprising of either the topic/contribution or the topic/research category. Eventually, the analysis presented the frequencies of the publication using the results on the excel table. This enabled the identification of different aspects of the selected topics on architectural model in Cloud computing in relation to Cloud utility that were emphasized more in the study.

A bubble plot was utilized in the presentation of the frequencies from the results on the excel tables, thereby resulting in the creation of the systematic map. The map was a two x-y scatter plot with bubbles at the intersection of the categories. The coordinates had bubble sizes that matches the number of articles in the category. The utilization of three (3) facets in the categories resulted in the design of two (2) quadrants, with each quadrant offering a visible map on the focal point of this study at the node of topics category, hence, making it easier to examine the different facets simultaneously.

4. RESULTS AND DISCUSSION
This study is focused on classification and thematic analysis. It may sometimes be necessary to identify the publication fora. The resultant systematic map on architectural models for achieving utility in the Cloud is shown at Figure 2, while Table 3 and Table 4 shows the selected primary studies as it relates to the topics, the contribution facet and the research facet.

4.1. Topics and Contribution Facet

The topics category is central to this study. The topics selected during the classification scheme in the area of architectural models used to achieve utility in Cloud computing are:

- Design
- Applications
- Performance Models
- Implementation
- Platforms
- Components Models

Listed in Table 3 is the primary studies utilized in analysing the topics against the types of contributions. The contribution facet showed the types of inputs in the focus of study. The results indicated that publications that discussed metrics in relation to Cloud architectural models used to achieve utility was 4.59% out of the 109 papers in this category. Also, tool had 26.61%, model had 39.45%, method had 12.84% and process had 16.51%. For example, the breakdown of Metric contribution showed that 1.83% of metric discussions were on design issues, 0.92% focused on performance models and 1.83% of metric contribution were on components models. There were no metric contribution in terms of applications, implementations and platforms as it relates to architectural models. Other aspect of the contribution category as it relates to topic are also shown in Table 3 and Figure 2.

### Table 3. Topics and Contribution Facet Primary Studies

| Contribution Facet | Metric | Tool | Model | Method | Process |
|--------------------|--------|------|-------|--------|---------|
| Design             | 7, 18  | 1,4,16,20,21,31,47,109,44,45,52,53 |
| Applications       | 6,8,27,50,65,90,102,89,108,37,40,43,69,78 |
| Performance Models | 23     | 3,5,9,25,64,2,10,12,13,35,36,46,57,48,81,82,97,106,110,112,117,103,115,116,15,30,33,80,83,86,96,100 |
| Implementation     | 14,101 | 17,19,28,49,55,56,111,62,29,41,54,58,79,84, |
| Platforms          | 11,76,99 | 71,77,104,91,98 |
| Component Models   | 68,88  | 66,73,85,114,59,66,67,70,72,92,113,105,114,59,95,105,66,93,107, |
| Percentage         | 4.59%  | 26.61% | 39.45% | 12.84% | 16.51% |

4.2. Topics and Research Facet

Listed in Table 4 is the primary studies utilized in analysing the topics against the types of research. The results indicated that publications that discussed evaluation research in relation to Cloud architectural models used to achieve utility was 30.77% of 117 papers in this category. Also,
validation research was 19.66%, solution research was 29.91%, philosophical research was 11.11%, and experience research was 6.84%, while opinion research was 1.71%. For example, the breakdown showed that 5.98% of the evaluation research discussion dealt with design, 6.84% considered applications, 10.26% focused on performance models, 3.42% discussed implementation, 1.71% focused on platforms and 2.56% dealt with component models.

Table 4. Topics and Contribution Facet Primary Studies

| Research Facet | Evaluation | Validation | Solution | Philosophical | Experience | Opinion |
|----------------|------------|------------|----------|---------------|------------|----------|
| Design         | 1,4,7,18,24,32,47 | 20,21,31 | 16, 44, 45, 52, 53, 75, 94, 109 |              |            |          |
| Applications   | 6,8,27,50,65,89,90,92,102 | 108, | 40,78 | 37 | 43,69,51, |          |
| Performance Models | 2, 10, 12, 13, 15, 26, 29, 32, 35, 36, 46, 48, 97,106,110,112 | 3, 5, 9, 22, 23, 25, 39, 42, 64, | 57,81,82, | 15, 30, 33, 34, 38, 103, 115, 116, 117 | 80,83,86, 90,102 | 26, 61 |
| Implementation | 14, 17, 19, 101 | 49, 55, 56, 111 | 28,29,41,54,58, 60,62, 63, 74, 87, 79, 84, 91 |              |            |          |
| Platforms      | 76, 98 | 11,99 | 71,77,104 |              |            |          |
| Component Models | 68, 88, 113 | 66, 73, 85, 14 | 67, 70, 72, 92, 93, 107 | 59, 95, 105 |              |          |
| Percentage     | 30.77% | 19.66% | 29.91% | 11.11% | 6.84% | 1.71% |

4.3. Major Findings

From Figure 2, the first quadrant shows the intersection of the topic and contribution facet, while the second quadrant shows the intersection of the topic and research facet. The following are the major findings from the result:

a. Starting with the left quadrant, it can be identified that there are more publications in terms of design and component models in the area of metrics with both having 1.84% each, more publications in the area of design in terms of tools (7.34%), more publication dealt with performance models in the area of model (14.68%), there were more articles in terms of applications in the area of methods (4.95%) and more publications relating to performance models in the aspect of process (7.34%).

b. Similar, the right quadrant indicated that there were more articles that discussed performance models in the area of evaluation, validation, philosophical, experience and opinion research with 10.26%, 7.69%, 7.69%, 4.27% and 1.71% respectively. There were more publications related to implementation in the aspect of solution research (11.11%). On the topic of review, there were more work done on performance models and there were more articles also that did reviews on evaluation research.

c. On the other hand, there were no articles in the study of architectural models used to achieve utility in the aspect applications, implementations and platforms that considered metric (0%), no studies on design and component models in terms of process (0%), and no articles on design in terms of method. Furthermore, publications dealing with evaluation research on platforms relating to this study was the least with 1.71%. Articles relating to applications based on validation, solution, philosophical and experience research were the least, with
0.85%, 1.71%, 0.85% and 2.56% respectively. There were no publications on design, implementation and platforms in terms of philosophical, experience and opinion research.

5. CONCLUSION

Cloud computing is presently issuing services to assisting industry as well as individuals alike. This services could be utilized through web browser or by connecting to the internet to use a Cloud providers services. There are lots of papers relating to using Cloud architectural models for achieving utility on Cloud. It is sometimes imperative to determine the level of such publications to identify areas sufficiently covered and those that are not, using a systematic mapping study. This paper discussed various categories and conducted an analysis on the result obtained using a bubble plot. Several gaps were identified in the course of the analysis, which would be useful to interested researchers in this field and also industry practitioners.

In view of the categories used in the analysis for this research, this systematic mapping study has identified areas where less emphasis in terms of architectural models were used to achieve utility, thus adding to knowledge by showing distinctive parts of the study where there are gaps. The identified gaps are recommended for further studies, as they are relied upon to fill in as an extensive guide into research areas on architectural models used to achieve utility. Further research could likewise be done for the justification of this study or to resolve opposing observations.

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Appendix: List Of Primary Studies

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