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A Systematic Mapping Study of Cloud Management: Autonomic, Adaptive, SLAs, and Monitoring

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Abstract

Cloud computing is a service paradigm that provides infrastructure to users from a CSP and allows self-service. There are primarily 3 types of services offered by the cloud namely: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). In addition, there are four cloud architectural models which are the private, public, community and Hybrid clouds. The cloud has ability to run in autonomic models, it is also very adaptive and has various provisions for monitoring. Self-service and service level agreements (SLA) provide the enabling environment for smooth cloud operations. A systematic mapping study provides a structural survey into a research area or field of interest. It is possible to map frequencies of activities in such an area using a scheme and results are presented pictorially. The objective of this paper is to conduct a systematic mapping study of cloud management, monitoring, autonomic, adaptive, SLA and self-service. Three facets were applied in conducting the categorization. These are the research, contribution and topic facets. The purpose was to determine the level of work so far carried out in the area of cloud computing management. This enabled the creation of a pictorial representation of the research coverage. Papers published in peer-reviewed journals and reputable magazines were utilized for the review. The result of the study showed that there are no opinion research on cloud

management. Generally, articles on validation, philosophical and evaluation research are the lowest.

Keywords: Cloud computing, cloud management, autonomic, adaptive, SLA, monitoring, self-services.

1. INTRODUCTION

Cloud is a parallel and distributive computing system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource based on service level agreement established through negotiation between the service provider and the consumers [1]. Cloud computing provides resources that facilitate the information technology needs of the user. A unique aspect of the cloud is that the user can participate in the management of cloud activities albeit in a very limited manner. Everything-as-a-Service covers all layers of services provided in the cloud; however, there are primarily three cloud service types which are the Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS). SaaS allows a user to utilize custom made applications and services offered by the cloud service provider (CSP). Hence, the user does not need to bother about installation and license fees. PaaS enables a user to deploy an application on a CSP's infrastructure. The user only manages his application and data, while the CSP provides the remaining resources. IaaS offers compute, storage and network bandwidth to users through the massive data centers available to the CSP. Cloud computing operates four architectural models which are the private, public, community and hybrid clouds. The private cloud is hosted by institutions and organizations on premises and sometimes considered an extension of an organization's datacenter. It is considered more secure because in-house staff are utilized. Public clouds are the most common and are hosted by major CSPs who have state of the art infrastructure spread across continents. Community clouds are hosted by institutions such as universities having common interest for research and learning. Hybrid clouds allows organizations to take advantage of the secure network of private clouds to host core information, while less critical information are hosted in public clouds. In view of the massive infrastructure on the cloud, it lends itself to various forms of management. Autonomic form allows activities to run with little or no human interaction. Adaptive nature of the cloud allows flexibility in user operation. Cloud computing fully lends

itself to self-service on the part of the user and there are cloud monitoring tools for this purpose. They ensure a mutually beneficial operation; there are SLA's that determine the nature of contract between the CSP and the consumer. Traditionally, SLA monitoring involves periodically testing specific service metrics and verifying if the results comply with the terms of the SLA [2]. Autonomic communication services has the ability to dynamically instantiate and reconfigure services, and also transparently end applications, in response to changes in the network environment [3]. For an SaaS provider to guarantee smooth operations, there are several critical quality of service (QOS) parameters that must be considered in a service requiring provisioning such as response time [4]. There are other metrics that must be considered such as availability and uptime, list of services and resources being offered by the CSP to the user [5]. In cloud computing, cloud monitoring can be either high level or low level; high level monitoring is related to the virtual platform status, while low level monitoring is related to the information collected on the status of the physical infrastructure [6]. There are volumes of studies in cloud management, hence it becomes necessary to summarize and provide an overview of what has been done so far. Systematic mapping studies assists in providing the nature of research by categorizing them and presenting it in a pictorial manner using a map [7]. Such information allows for greater insights in research efforts conducted so far. The systematic map for this study was actualized by categorizing the study using three (3) facets. The facets are the contribution, research and the topic facets. The contribution facets relates to things like the method or process. The research facet focuses on the nature of study, while the topic facet uses keywords to extract issues in the area of cloud management. An amalgamation of these facets is used to generate the map of the results obtained. The purpose of this paper is to carry out a systematic mapping study of cloud management; autonomic, adaptive, self-service, SLA and monitoring. The remaining part of the papers is organized as follows: Section 2 is a discussion on the systematic mapping process; section 3 presents the analysis and discussion. Section 4 concludes the paper with suggestion for future work.

2. THE SYSTEMATIC MAPPING PROCESS

A systematic mapping study provides an overview of work that has been carried out in an area of study. The primary objective is to visualize areas where there are shortages in publication. This systematic mapping study on cloud management autonomic adaptive self-SLAS and monitoring was conducted using the formal guidelines for systematic mapping study in [7][8]. A systematic mapping study is a repeatable process for extracting and interpreting available

materials related to research objectives [9]. There are mandatory steps for carrying out a systematic mapping study. It starts with the definition of research questions in which the scope of the review is outlined. The papers obtained are screened to determine the relevant ones. Keywording is conducted by using the abstracts on the papers to design a classification scheme. The final step is the process of data extraction that leads to the creation of a systematic map. At every stage there is an outcome that allows for assessment of the process. All the stages of conducting a systematic mapping study were utilized in creating a systematic map on cloud management; autonomic, adaptive, SLA and monitoring. In view of the paper choice criteria in terms of requirement and objectives, a total of 136 papers were considered relevant to this study out of an initial list of 1920 papers.

2.1 Definition of Research Questions

One of the goals of a systematic map is to enable the visualization of the type and volume of research that has been carried out in an area of study. It is sometime necessary to know where the materials were published. These issues assist in determining the revelation questions that should be applied to the study. In this particular systematic mapping study the research questions are as follows:

RQ1: What areas in cloud autonomic, adaptive, SLAs and monitoring are addressed and how many articles cover the different areas?

RQ2: What types of papers are published in the areas and in particular what evaluation and novelty do they constitute?

2.2 Conduct of Search for Primary Studies

The conduct of search for primary studies is usually done by examining appropriate databases. This is achievable through manual search for conference and journal publications in the databases. Papers obtained for this study resulted from searches on the major databases available and accessible online.

Table 1. Electronic Databases used for the Search for Primary Studies

Electronic Databases	URL
ACM	http://dl.acm.org/
IEEE	http://ieeexplore.ieee.org/xplore
SCIENCE DIRECT	http://www.sciencedirect.com/
SPRINGER	http;//www.springerlink.com/

Information from books and printed materials was not a focus of the search. There was need to use high quality papers hence the search was conducted on 4 major databases which has high impact conference and journal publications. Table 1 contains the list of databases searched and their URL. The search string was designed to reflect the outcome, population, comparison and intervention in the field of study for this paper. The keyword used is based on the various aspects of cloud management associated with the title of this work. For this study on cloud autonomic, adaptive, SLAs and monitoring, the search string used on the major databases is

(TITLE (“CLOUD management’’) OR TITLE (service level agreement “) OR TITLE (“SLA’’) AND (TITLE (adaptive) or TITLE (monitoring) OR TITLE (autonomic) AND (KEY (CLOUD) OR KEY (SLA)

The searches were performed using the customized string above on document metadata to ensure that all applicable articles were captured. For this study on cloud management, all the results from relevant databases relating to cloud and computer science were considered.

2.3 Screening of the Papers for Inclusion and Exclusion

Screening of the articles obtained during search is a vital component of the systematic mapping process. The essence of this was to find and include all papers relevant to the review. The inclusion and exclusion criteria is to remove studies or papers that are not relevant to cloud management and articles that are not relevant to the research questions. Abstracts that mention only the main focus of this study without further details were excluded. This study did not include presentation slides, summaries, tutorials, editorials, panel discussions and prefaces. Papers that discussed the main focus of this study with some additional secondary aspects of this paper were also considered. The inclusion and exclusion criteria is as stated in Table II.

Table 2. Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
The abstract explicity mentions cloud management, autonomic, self*, adaptive, SLA and monitoring in relation to cloud computing. Furthermore, discussions in this area are meant to achieve cloud management.	The paper lies outside the domain of cloud computing as it relates to cloud management. The paper does not contribute to issues of management in the cloud.

2.4 Keywording of Abstracts

Keywording is a core aspect of the systematic mapping study. The keywording process is vital in determining the classification scheme of the study. It has the following stages [7].

- Abstract
- Key wording
- Classification scheme
  - Articles
  - Sorting articles into scheme
  - Updating scheme
- Systematic map

Keywording is essential in reducing the time needed to design the classification scheme for this study. Keywording ensures that the classification scheme examines all relevant articles. The keywording process involves studying the abstracts to extract concepts and keywords relating to the study. Keywords from the various articles relating to cloud management were combined to ensure adequate insight into the type of contributions and types of research. The outcome of this was used to determine the set of categories adopted in this study. Some abstract are usually ambiguous, hence it was sometimes necessary to study the introduction and conclusion of an article to be able determine appropriate category. Finally, a cluster of keywords were used to determine the categories employed for the systematic map. In this study 3 facets were adopted. The first facet focused on the topic which was derived from the keyword and the constituent parts of the title of this work. The topic facet has SLA monitoring, security, autonomic management, self-adaptive SLA, architectures and simulation. The second facet discussed the types of contribution to the research in terms of metric, tool, method, process and model. The third facet involves research issues.

2.5 Research Type Facet with Category and Description

The third facet deals with the type of research that was conducted in the field of study. This facet is independent of the focus of this study and the classification of research approaches in [10] was utilized. The approach has the following categories and descriptions [10].

1) Validation research: The techniques used in the research are unique but not yet implemented. No experiments are conducted.

2) Evaluation research: The techniques outlined in the research have been implemented and evaluated. There are results discussing the advantages and disadvantages.

3) Solution disposal: The technique proposes a unique solution to a problem. The benefits and application of such solution are also discussed.

4) Philosophical papers: The research offers new ways to solve a problem by proffering concepts and framework.

5) Opinion papers: This kind of study does not rely on any known research methodology, but simple expresses the opinion of individual.

6) Experience paper: An author's personal experience is provided. Such experience details how things can be done.

These categories were considered appropriate for use in this study. This was used as part of the classification scheme; hence the papers included in this study were classified using the various research categories.

2.6 Data Extraction and Mapping Studies

During the classification process the included articles were sorted in the scheme. This step allows for data extraction from the various papers that were included in the study. The data extraction process was used to determine the nature of the classification scheme. During the extraction process new categories were added some categories were merged and those not sufficiently relevant were removed. The process of data extraction was done on an excel table. The excel table contained each category of the classification scheme. The frequencies of publication in the contribution and research facets were extracted on different excel tables. The overall frequency of publication was obtained from a combined table containing either the topic/contribution aspects or topic/research issues. The analysis is centered on presenting the frequencies of publication for categories within the scheme. The essence of this is to determine which aspects of autonomic, adaptive, SLA, and monitoring on cloud was

emphasized more in the study. This enables the determination of gaps and it provides an avenue for recommending further research. Based on the results in the excel tables for this study, bubble plots were created to present the frequencies of articles which is the map. This map was created using a two x-y scatter plot with bubbles in the intersection of the categories. The bubble coordinates have bubble sizes that correspond to the number of articles in that category. There are 2 quadrants due to the fact that 3 facets were used in this study. Each quadrant provides a visual map based on the intersection of the topics category with either the research or contribution category. Hence, it becomes easy to visualize the 2 quadrants simultaneously. In addition, summary statistics were added to the bubble providing a quick overview of the study on cloud management.

3 ANALYSIS AND DISCUSSION

The analysis of the result focuses on presenting the frequencies of publication for each category. This makes it possible to see which categories have been emphasized in past research and thus identify gaps and a possibility for future research. The main focus of the systematic mapping study on cloud management; autonomic, adaptive SLA and monitoring is thematic analysis, classification, and to possibly identify the publication. From the analysis, gaps were identified through graphing, this indicating which topic areas has a shortage of articles. Conversely the map shows the areas that are sufficiently covered in terms of publications. In this mapping study, high level categories were used to assess paper included in producing the frequencies and creating the map.

3.1 Contribution Category

The systematic map of autonomic, adaptive SLAs and monitoring on the cloud is shown in Figure 1. On the x-axis of the left quadrant is the result of the contribution facet. The contribution facet deals with the types of contribution in the papers included in this study. The result indicates that articles that discussed metric in relation to cloud management are 1.9% out of 105 papers in this category. Also tool has 17.14%, model has 52.38%, method 13.33% and process 15.24%.

3.2 Research Type Category

On the x-axis of the right quadrant of Fig. 1 is the result of the type of research carried out in the area of cloud management focusing on autonomic, adaptive, SLAs and monitoring issues.

The result shows that evaluation type research has 31.62% out of 136 papers reviewed. In addition validation research has 11.03%, solution research has 46.31%, philosophical 4.41% and experience has 6.62%. There was no result for opinion research.

3.3 Topic and Contribution Facet

The topics that were extracted during the classification scheme in relation to cloud management are:

- SLA monitoring.
- Security.
- Autonomous management.
- Self-adaptive SLA.
- Architectures.
- Simulations.

The left quadrant of Figure 1 shows the relationship between the topics and contribution facet. For example, model contributed 52.38% of the papers reviewed. The breakdown in relation to the topic facet shows that 1.9% of model contributions were on simulation, 11.43% were on architectures, 8.57% were on self-adaptive SLA, and 2.86% were on autonomous management, 14.29% on security and 13.33% on SLA monitoring. Other aspects of the contribution category as it relates to topic is as shown in Fig. 1

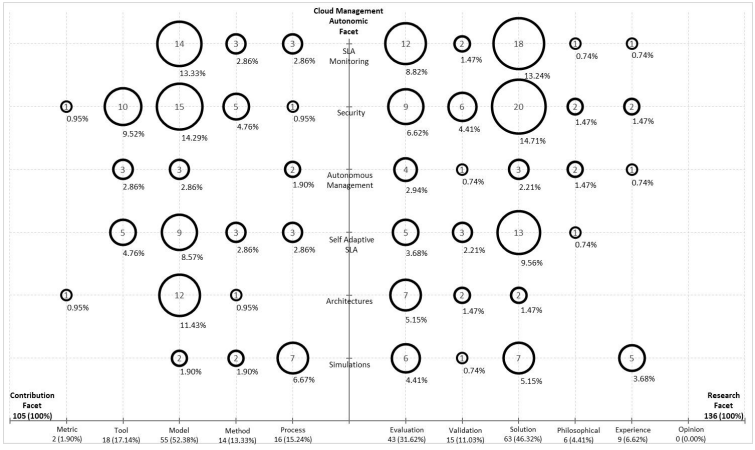

Fig. 1. **Systematic Map of Autonomic, Adaptive, SLAs and Monitoring on the Cloud**

3.4 Topic and Research Facet

The right quadrant of Figure 1 indicates the relationship between the topics and research type facet. From Figure 1, 46.32% of the papers reviewed on cloud management are on solution research out of the 136 papers. The breakdown shows that 5.15% of solution research is on simulation, 1.47% on architectures, 9.56% on self-adaptive SLAs, 2.21% on autonomous management, 14.71% on security and 13.24% on SLA monitoring. Other aspects of the research type category are in Figure 1.

3.5 Systematic Map of Autonomic, Adaptive SLAS and Monitoring on the Cloud

The right quadrant of the systematic map in Figure 1 provides the two x-y scatter plot with bubbles at the intersection of the topic and contribution facets. The second quadrant is the map that shows the intersection of the topics and research facet also using a two x-y scatter plot with bubbles. As mentioned earlier, analysis makes it easy to see which categories have been emphasized in past research. In Figure 1, it can been seen that there are more publications on tool as it relates to security (9.52%), more publications on model in terms of security (14.29%) more articles on method as it relates to security (4.76%) and more papers on process as it relates to simulation (6.67%). Similarly, on the right quadrant it can be seen that more papers discussed SLA monitoring as it relates to evaluation research, more articles discussed security in terms of validation and solution research with 4.41% respectively. Also there are more papers on simulation with respect to experience research (3.68%). At a glance, it was depicted that there are generally more articles on cloud monitoring as it relates to security.

On the other hand, there are no publications in the area of simulation, self-adaptive SLA, autonomous management and SLA monitoring on tool as a contribution. In addition there are no publications that focus on process in terms of architectures and lack of papers on autonomous management in the area of method. On the right quadrant there are no publications on philosophical research in terms of simulations and architectures on cloud management. There are no articles on experience research in the area of architectures and self-adaptive SLA. Interestingly, there are no opinions on cloud management. Generally, articles on validation philosophical and evaluation research are the lowest. The visual appeal of a systematic map easily arouses interest and assists in transferring results to researchers. Suffice to mention that a systematic review has a unique value as it helps to identify shortage of publication in a topic area, hence revealing gaps.

4 CONCLUSION

Cloud computing has continued to evolve in different topic areas. This evolution has led to volumes of publications and articles providing insight into various aspects of the cloud. Despite the quantity of publications, several areas still have shortage of articles. A classification scheme was used to extract data in the area of cloud management as it relates to autonomic adaptive, self-*, SLAs and monitoring. Based on the categories produced in the classification, a systematic map was created using a two x-y scatter plot with bubbles. This visual representation allows researchers to see frequencies of publications with an indication of areas where there is shortage of publications. This outcome provides vast opportunities for further research.

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REFERENCES

[1] Buyya, R., Bromberg J., and Goscinski, A., (2011) ”Cloud computing: principles and paradigms,” John Wiley and Son, New Jersey, 2011, pp. 4-10.

[2] Clark, K. P., Warnier, M., and Brazie, F. M., (2011) “Self-Adaptive Service level Agreement Monitoring in cloud Environments,” International Conference on intelligence and Adaptive systems.

[3] Samimi, F. A., Makinley, P. K., Sadjadi, S. M., (2007), “Mobile Service Clouds: A self-managing infrastructure for Autonomic mobile computing services,” Michigan State University, USA, 2007.

[4] Wu, L., Garg, S. K., and Buyya, R. (2015), “SLA-based admission control for a Software-as-a-Service provider in Cloud computing environments” IEEE 21st International Conference On Parallel And Distributed Systems, 2015.

[5] Chandana, O.R., Divya, C., Drunda, B.V., and Rajeshwari, B.V. (2017) “A Study on Service Level Agreement Management Technique in the Cloud,” International Journal of Advance Research in Computer Science and Management Studies, Vol 5, No. 5 May, 2017.

[6] Alhamazami, K., Ranja, R., Mitia, K., Rabhi, E., Khan, S.U., Guabtni, A., and Bhainagar, V. (2014) “An Overview of the Commercial Cloud Monitoring Tools: Research Dimensions, Design Issues, and State-of-the-Art,” University of New South Wales, Australia, 2014.

[7] Petersen, K., Feldt, R,. Mujtaba S., and Matisson, M. (2008), “Systematic Mapping Studies In Software Engineering”, EASE'08 Proceedings of the 12th international conference on Evaluation and Assessment in Software Engineering, Italy — June 26 - 27, 2008, pp. 68-77

[8] Kitchenham, B., and Characters, S. (2007) “Guidelines for performing systematic literature review in software engineering,” Version vol. 2 ed, 2007, pp. 2007-01.

[9] Muhammed A.B., and Muhammed, A.C. (2014), “A systematic Mapping study of software architectures for cloud based systems,” Software System section, IT University of Copenhagen, 2014.

[10] Wieringa, R., Maiden, M.A.M., Mead N.R., and Rolland, C., (2006) “Requirement engineering paper classification and evaluation criteria. A proposal and a discussion,” Requirement Engineering, Vol. 11, pp. 102-107, 2006.