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Cloud Based Development Issues: A Methodical Analysis

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ABSTRACT

Cloud based development is a challenging task for various software engineering projects, especifically for those which demand extraordinary quality, reusability and security along with general architecture. In this paper we present a report on a methodical analysis of cloud based development problems published in major computer science and software engineering journals and conferences organized by various researchers. Research papers were collected from different scholarly databases using search engines within a particular period of time. A total of 89 research papers were analyzed in this methodical study and we categorized into four classes according to the problems addressed by them. The majority of the research papers focused on quality (24 papers) associated with cloud based development and 16 papers focused on analysis and design. By considering the areas focused by existing authors and their gaps, untouched areas of cloud based development can be discovered for future research works.

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1. INTRODUCTION

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet) [91]. The name comes from the use of a cloud-shaped symbol as an abstraction for the complex infrastructure it contains in system diagrams. As per Manaco, cloud computing entrusts remote services with a user's data, software and computation [51].

End users access cloud-based applications through a web browser or a light-weight desktop or mobile app while the business software and user's data is stored on servers at a remote location [85] [89]. Oestreich Ken claimed that cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance, and enables IT to more rapidly adjust resources to meet fluctuating and unpredictable business demand [52] [53]. Security could improve due to centralization of data, increased security-focused resources, etc., but the concerns can persist about loss of control over certain sensitive data, and lack of security for storing kernels [54].

In cloud computing, service providers develop and deploy services with common and reusable features among various applications, service consumers locate and reuse them in building their applications. Hence, reusability is a key intrinsic characteristic of cloud services. Cloud computing architecture refers to the components and subcomponents required for cloud computing. These components typically consist of a front end platform (e.g. Fat client, thin client, mobile device), a back end platform (servers, storage), a cloud based delivery, and a network (e.g. Internet, Intranet, Intercloud) [4].

Cloud computing has been increasing its data centers due to demand. This newly emerging paradigm is heavily based on Software as a Service concept, which provides services on demand utilizing resources more effectively within the Cloud environment. The Cloud architecture, its layers and its

composition of components and services need to be designed for scalability and re-configurability, as they support services and their agreements (e.g. Service level agreements). The resource management of Cloud computing is the key to achieving potential benefits. Therefore, it is essential to design Cloud applications as web service components based on well-proven CBSE (component-based software engineering) methods and techniques with appropriate security controls [28].

By using offloading data and cloud computing, a lot of companies can greatly reduce their IT cost. However, despite tons of merits of cloud computing, many companies' owners began to worry about the security threats. Because of the cloud-based computing environment, the employees can easily access, falsify and divulge the data. Sometime such behavior is a disaster for a big and famous company. Encryption is a kind of ideal way to solve such problem, whereas for the customers who are using the cloud computing system cannot use such encrypted data. The original data must be used in the host memory otherwise the host VM machine cannot do applications on-demand. For that sake, people can hardly achieve better security in today's Cloud services. Understanding the characteristics of computer service performance has become critical for service applications in cloud computing. For the commercial success of this new computing paradigm, the ability to deliver Quality of Services (QoS) guaranteed services is crucial [62]. Figure 1 shows top most issues in the cloud.

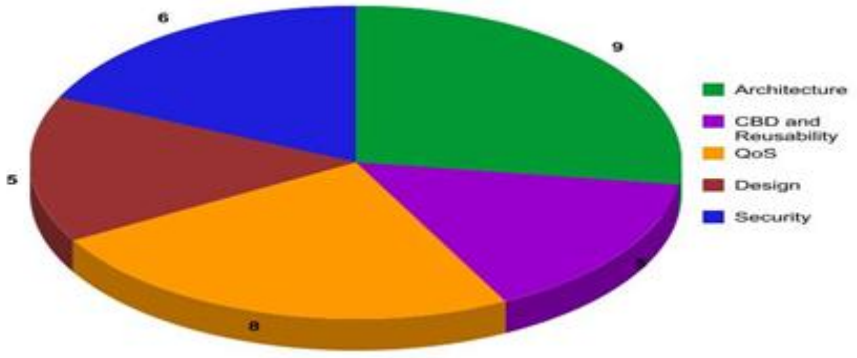

Figure 1. Topmost issues in cloud

Reliability is improved if multiple redundant sites are used, which makes well-designed cloud computing suitable for business continuity and disaster recovery [65]. To enable Cloud computing to further realize the business value from asset reusability, composite applications, and mash-up services [27]. The Cloud Horizontal Business Services consist of various platform services that hide the complexities of middleware, database, and tools [63]. Liang-Jie Zhang et. al. described that the Cloud Vertical Business Services include all domain specific or industry-specific utility services [1]. It can be reused to enable Cloud core's provisioning and subscription services, as well as to build cloud offerings such as Infrastructure as a Service, Application as a service, and Business Process as a Service [67]. There are various factors that account for the migration of these issues in cloud based development [55] [57] [58] [59] [63] [64] [66].

I. Development of general architecture for multi communications.
II. Provide appropriate security.
III. Incorporating reusability in cloud based development to reduce cost and time.
IV. To provide the quality of service.
V. Design to build a resilient and trustworthy cloud infrastructure.

The study is interested in finding the state of research in cloud based development issues. The paper aims to provide an overview of the state of research in these mentioned issues with the intention of providing future research area by finding the gaps and untouched areas. This paper organized as follows: Section 2 describes the research techniques in conducting studies. Section 3 reports result of study. Section 4 describes threats to validity. Section 5 concludes the work and suggests future research direction.

2. RESEARCH TECHNIQUE

2.1 Research Areas

This review aims at summarizing the cloud based development issues research by proposing answers to the following questions classified according to broad categories:

2.1.1 Cloud Based Architecture

1. Cloud Computing is the lack of a de facto standard or single architectural method, which can meet the requirements of an enterprise cloud approach?

2. How will the applications behave due to dynamic infrastructure scaling? Can the users design their application in such a way as to maximize the scaling advantage? How to minimize the response time of elastic demand and maximize the throughput of requests?
3. How to understand the Cloud workload (e.g. Transactional database, file server, web server, and application server, batch data processing) to design successful IaaS?
4. How to assess the power consumption and environmental impact? How to isolate of service failure within each tenant?
5. What kind of architectural components are frequently used in building dynamic large cloud systems?
6. How do architectural components relate to a provider's and enterprise's system requirements?
7. How do we abstract key architectural assessment made in existing cloud application/ systems?
8. How CCOA is an extensible and configurable architecture for providing normative guidance and enabling infrastructure, software, application, and business process sharing in a unified manner?
9. How ABB (Architecture Building Blocks) modeling can be applied to any layered or tiered architecture?

2.1.2 Component based Development and Reusability

1. How can we be able to extract the generic and reusable model to classify relations between requirements and architectural components/ patterns?
2. How to improve architecture using Map Reduced for component Library Retrieval on the cloud?
3. How to improve the recall ratio and precision ratio of components for component library based on cloud computing?
4. How we can assess the quality of cloud services and hence in improving their reusability in quantitative manner?
5. How to enhance reusability in Learning Management System through the integration of Third party tools?

2.1.3 Quality

1. How to define effective QA guidelines for the phases and to define a traceability framework where all the artefacts can be cross related and consistency can be verified.
2. A clearinghouse and brokers for mapping service requests to providers who can meet QoS expectations?
3. How to apply the QFD for the development of SOA based Web service systems to improve their customer satisfaction.
4. How multiple QoS constrained scheduling strategy of multiple workflows will be implemented for cloud computing?
5. How successfully adapting to changing Quality Attribute optimization needs?
6. What are effective techniques to adaptively allocate system resources to each service satisfying the QoS requirements of multiple workflows?
7. How Quality Tracking System Based on Cloud Computing will be implemented?
8. How to architecting cloud applications to achieve high software qualities (including performance, availability, elasticity)?

2.1.4 Design

1. How to develop the ontology systems needed for a working Service-Oriented Cloud Computing Architecture?
2. How to implement system architecture for Tangible Cloud Computing?
3. What are various methods and tools for monitoring and managing enterprise required SLA?
4. Cost benefit and risk analysis and management of cloud computing?
5. How to extend our toolset and provide a full integration of the tools within an Eclipse development environment to design SaaS applications?

2.1.5 Security

1. How to implement Virtual network model in Xen platform to validate its security, and how to evaluate the performance of the model in the Virtualization environment?
2. Data security and privacy protection issues separation of sensitive data and access control?
3. How we can use of semantic web technologies to enhance the functionality of this cloud middleware?
4. When a customer leaves the cloud, what obligations does the provider have to assist in the transition?
5. How to reduce the complexity of cloud which provides security aspects of Virtualization?
6. How to improve security of dynamic data storage in case fine-grained data error location?

2.2 Sources of Information

In direction to gain wide outlook, we searched usually in search engines. The databases used are:

- ACM Digital Library (<portal.acm.org>)
- IEEE Explore (<ieeexplore.ieee.org>)
- Springer LNCS (<www.springer.com/lncs>)
- Google Scholar (<scholar.google.co.in >)

The databases cover the most relevant journals, conference and workshop proceeding within cloud computing.

2.3 Searching Criteria

Based on research areas in section 2.1, a set of keywords and its synonyms were defined as search strings, described in Table 1.

Table 1. Searching keywords and Synonyms

Keywords	Synonyms
Cloud Based Architecture	Structure of clouds
CBD & Reusability	Component Reuse
Design	Pattern
Quality of Service	Fitness for use
Cloud Security	Protection, Reliability

2.4 Study Selection

Figure 2 illustrates the research procedure. The methodical analysis process started with defining research areas as stated in section 2.1 by collecting cloud based development issues. In the next step we find the status of the present work by using existing techniques. The redundant issues have been eliminated in the next stage. In the last step finalize the research areas by outlining the research issues.

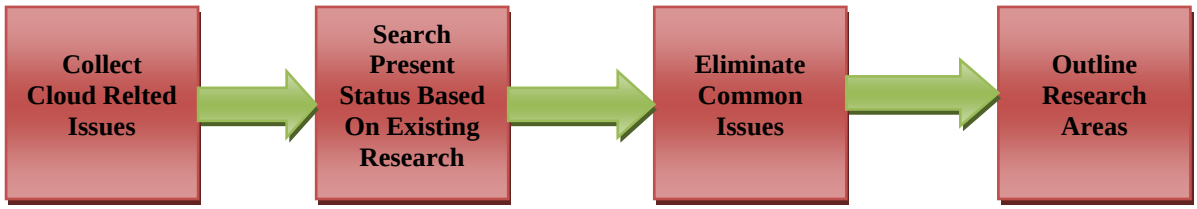

Figure 2. Research procedure

3. RESULTS AND DISCUSSION

A total of 89 research papers related to cloud based development issues were returned by the research procedure.

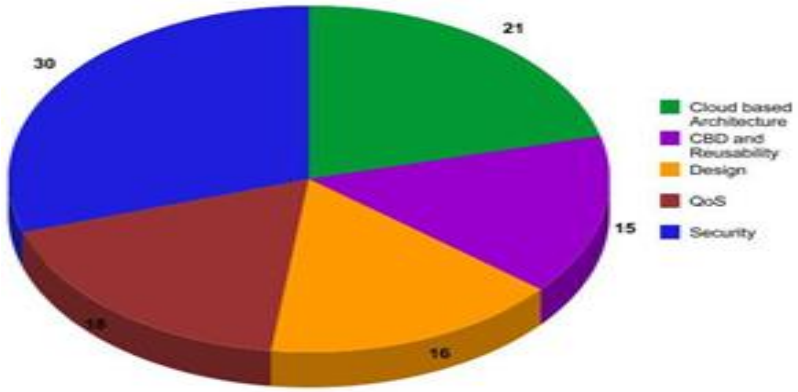

Figure 3. Analysis of Research Paper Category

The research papers are classified into five groups which are cloud based architecture, component based development, design of cloud, Quality of service and security. Figure 3 shows the analysis of research paper

category. Based on Figure 3, the majority of research papers focused on security (30%) followed by cloud based architecture (21%).

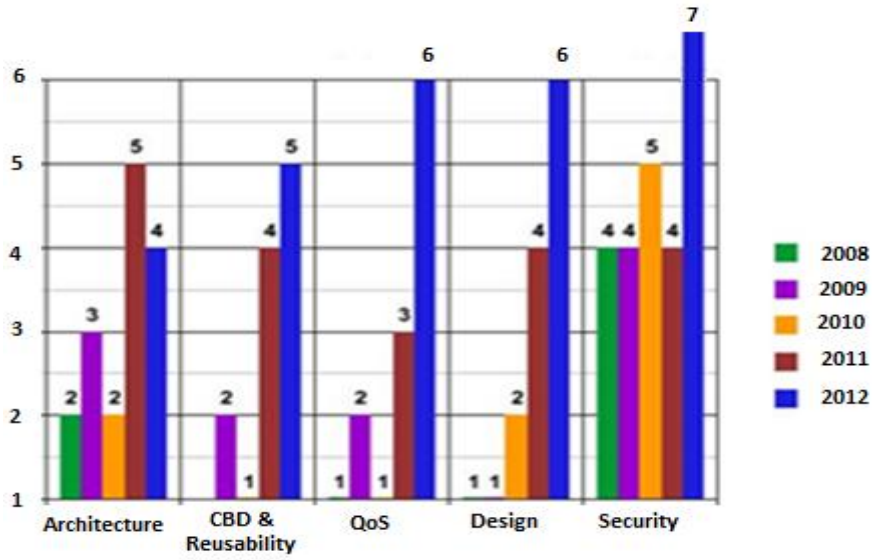

Figure 4. Numbers of papers publish in each year in each category

The component based development and reusability (15% papers), Design (16% papers) and QoS contributed 18% papers. The research publication on CBD and reusability started from year 2009 and reached to 15 publications in September 2012. Based on Figure 4, research papers on design, security and QoS have the highest number of increase in publications as compared to other research category.

Table 2. Number of papers publish in each category

Issues/Year	2008	2009	2010	2011	2012
Architecture	2	3	2	5	4
CBD & Reusability	0	2	1	4	5
Design	1	2	1	3	6
QoS	1	1	2	4	6
Security	4	4	5	4	7

Table 2 describes a number of papers published from the year 2008 to 2012 according to each category. There are seven papers published on cloud security. The research on CBD and reusability is growing from year 2008 to 2012. The published papers were categorized based on different prospect varieties, similar to systematic review [68] conducted by (Khan KS et. al., 2003).

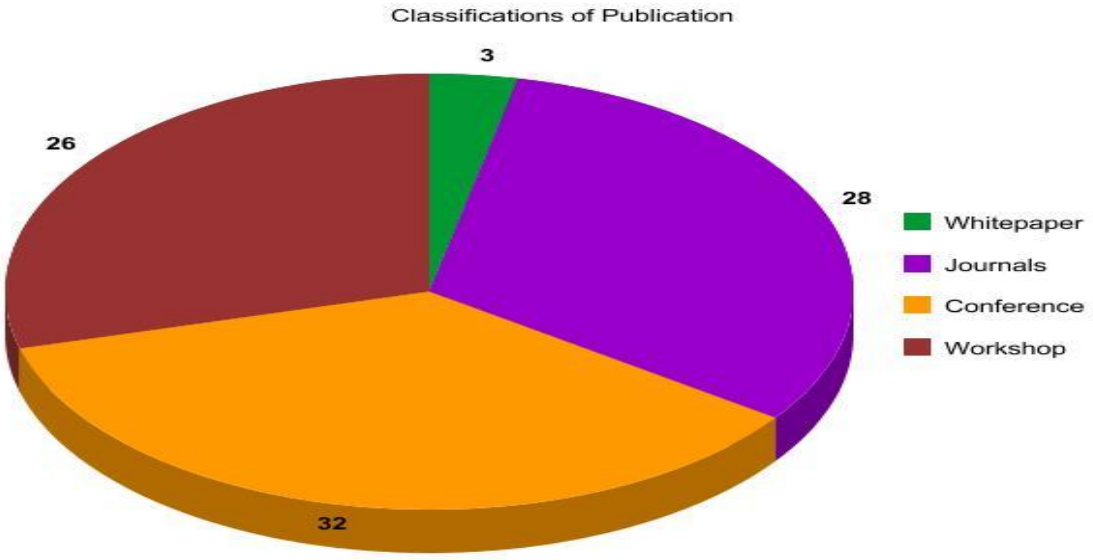

Figure 5. Classification of publications

The outlook kinds are Whitepapers, journals, conferences and workshops. The largest percentages of publications came from conferences (32 papers) followed by journals (28 papers). The conferences (26 papers) and white papers contributed 3 papers to each of the overall publication categories. We observed a large number of conference papers as compared to other categories is illustrated in Figure 5. The following section will discuss the findings of a research study for each focused area classified in Figure 3.

3.1. Cloud Based Development Issues

Based on the literature survey, the cloud based development issues can be observed from four perspectives:

(i) Characteristics of cloud computing : e.g. Agility, Application programming interface, Cost, Device and location independence, Virtualization, Multitenancy, Reliability, Performance, Security, Maintenance etc.
(ii) Cloud computing providers offer their services according to three fundamental models: e.g. Infrastructure as a service (IaaS), Platform as a service (PaaS) and Software as a service (SaaS).
(iii) Deployment models: e.g. Public cloud, Community cloud, Hybrid cloud and Private cloud.
(iv) Cloud architecture: the systems architecture of the software systems involved in the delivery of cloud computing, typically involves the Intercloud and cloud engineering.

The challenges of cloud based development issues are as follows [28] [78] [39] [50] [81]:

a. Lack of generic and reusable model
b. Lack of defacto standard or single architectural method.
c. QoS requirements of multiple workflows.
d. Architecture for Tangible cloud computing.
e. Security aspects of Virtualization.

In order to analyze the cloud based development issues, the following question was identified:

(i) What are the issues related to cloud based development?
(ii) What are the existing approaches to solve these issues?

We have categorized cloud based development issues into five groups as shown in Table 3.

- Cloud based architecture
- CBD and reusability
- Design
- Quality of service
- Security

Table 3 contains 44 papers along with problems, there are 8 issues of cloud based architecture and 6 issues are related to component based development and reusability. 12 issues of Quality of service and 10 issues of design are found. The 8 issues related to cloud security has been found during the research process. There are some critical challenges related to cloud based developments.

3.1.1. Cloud Based Architecture

A cloud-based architecture (CBA) is a conceptual model encompassing all elements in a cloud environment. In information technology, architecture refers to the overall structure of an information system and the interrelationships of entities that make up that system [61] [66]. The Cloud Computing Architecture of a cloud solution is the structure of the system, which comprises on-premise and cloud resources, services, middleware, and software components, geo-location, the externally visible properties of those, and the relationships between them. The term also refers to documentation of a system's cloud computing architecture. Documenting facilitates communication between stakeholders, documents early decisions about high-level design, and allows reuse of design components and patterns between projects. [60] [67].

Liang-Jie Zhang et. al. described that the cloud-oriented architecture is related to both service-oriented architectures (SOA) and event-driven architectures (EDA) and is a combination of two other architectural models: the resource-oriented architecture (ROA) and the hypermedia-oriented architecture

(HOA). A ROA is based on the idea that any entity that can be assigned a uniform resource identifier (URI) is a resource [69] [44] [45].

Table 3. Cloud issues and problems addressed

Classification	Author	Year	Problems Addressed
Cloud Based Architecture	Bhaskar Prasad Rimal et.al. [28]	2011	Single architecture method
	Liang-Jie Zhang et. al. [67]	2009	Dynamic infrastructure scaling
	Margaret Rouse [69]	2012	Cloud workload
	Feng-Cheng Lin et. al. [80]	2009	Power consumption
	GE Junwei et.al. [6]	2011	Dynamic large cloud system
	Jyoti Namjoshi and Archana [33]	2009	Architecture components
	Liang-Jie Zhang et.al.[79]	2009	Extensible and configurable architecture
CBD and Reusability	GE Junwei et.al. [6]	2011	Component library architecture
	Bhaskar Prasad Rimal et.al. [28]	2011	Generic and reusable model
	Hongyan Zhao et.al. [5]	2011	Recall and precision ratio
	Sang Hun Oh et. al. [4]	2011	Reliability of cloud services
	Jorge F. González et. al. [1]	2009	Learning management system
	RCS [71]	2012	Cloud development using components
Quality of Service	Meng Xu et.al. [7]	2009	Add more QoS constrained (reliability, availability, etc.) to workflows
	Rajkumar Buyya et. al. [8]	2008	Payment management and accounting infrastructure for trading services
	Zohar Ganon et.al. [9]	2009	Lack of network-management aspect of a communication network
	Xiaoqing (Frank) Liu et.al. [10]	2009	Apply QFD improves customer satisfaction
	Jun-bin Liang et. al. [12]	2009	Verification of multi-dimensional QoS evaluation and complete QoS guarantee framework prototype based on service-oriented middleware
	Vivek Nallur, et.al. [13]	2009	Scalability rules capturing non-linear (with respect to load) service requirements
	Jae Yoo Lee et. al. [14]	2009	Optimization of the matching algorithm for service placement
	Lian Yu et.al. [17]	2010	Deploy more testing services on TaaS cloud platform, and collect a variety of runtime information to perform corresponding analysis on scalability and reliability.
	Michael Jarschel et.al. [18]		
	M. Brent Reynolds et.al. [19]	2011	How would such a concept scale and be financially successful?
	William Jenkins et.al., [23]	2011	Quality configurations to on-line algorithms.
	John Grundy et.al. [25]	2011	Advanced test generation and the automatic detection of different specific types of faults
		2012	Performance measurements, security conformance evaluations, and assessment reliability determinations
Design	Li Zhang et. al. [29]	2011	Perform corresponding analysis on fault tolerance and reliability Building a scientific Cloud for a data center
	Lizhe Wang et.al [30]	2008	The load being distributed among them dynamically.
	Ian Foster et.al. [31]	2008	To improve security of cloud computing and customer satisfaction
	Mehmet Yildiz et.al. [34]	2009	Ontology systems needed for a working SOCCA
	Wei-Tek Tsai et.al [36]	2010	Certification processes of the C3-aware Cloud providers.
	Ivona Brandic et.al [37]	2010	Implementation of the Cloud Computing ecosystem
	Kevin Lee and Danny Hughes[39]	2010	Methods and tools for monitoring and managing enterprise required SLA
	Anna Liu and Rainbow Cai [41]	2011	Quality feature models
	Bedir Tekinerdogan et.al. [42]	2011	Add trusted computing functionality
	Imran Khan et.al. [43]		
Security	Sara Qaisar and Kausar Fiaz Khawaja,[47]	2012	Evaluate the performance of the model in the Virtualization environment
	Hanqian Wu et.al [48]	2010	Implement this model in Xen platform to validate its security
	Deyan Chen et.al.[49]	2012	Separation of sensitive data and access control.
	Ajith Ranabahu et.al [82]	2009	Semantic web technologies to enhance the functionality of this cloud middleware
	Kevin Hamlen et. al. [84]	2010	Strong authentication and security aspects of Virtualization
	Naveen Sharma et.al., [86]	2011	Hardware costs down
	B. Shwetha Bindu et.al.[87]	2011	Identification Probability for Misbehaving Servers
	Jack Newton CLIO[88]	2010	Privacy and availability
	Kevin Hamlen et. al., [90]	2010	Building trusted application from interested applications

3.1.2. CBD and reusability

Services with high reusability would yield high return-on-investment. Cloud services have characteristics which do not appear in conventional programming paradigms, existing quality models for software reusability would not apply to services. Component-Based Software Engineering (CBSE) and Service-Oriented Software Engineering (SOSE) are two established development paradigms which rely on the same principle of reusability: how to exploit existing software entities, specified as Component or

Service. Both of them are based on the concept of Software Architecture in which a system is seen as a structure with clearly identified entities and relationships between these entities [21].

3.1.3. Design

Many companies think that the cloud has the potential to dramatically reduce the costs of managing their technology infrastructure [52]. Before you jump into cloud computing you need to take the time to design a cloud computing strategy that will work best for your company [20]. According to Judith Hurwitz et.al., there are five key areas that you should consider when designing your cloud computing strategy: 1) when and how should you use a public, private, and the hybrid cloud service [68] [16]? 2) What is your company's strategy for managing capital and operational expenses over time? 3) How do you plan to achieve the right level of service across the cloud and the data center [70]? 4) What are the rules and regulations that your cloud provider needs to adhere to, to keep your company safe and in compliance? 5) How are you planning to control the data as it moves out of your data center into external clouds [65]?

3.1.4. Quality of service

Cloud computing is a new cost-efficient computing paradigm in which information and computer power can be accessed from a Web browser by customers [2]. Cloud Quality Assurance Services is a company focused on Performance and Functional testing Cloud Computing based systems. Keith G Jeffery described the challenges of quality [27]: quality of the service provision (quality of service, service level agreement management); quality in modelling business requirements in a Cloud environment; quality in the languages used to express those requirements and to execute them; quality in the services in both what they provide and how they provide it; quality in service composition including dynamicity; quality in scheduling execution including partitioning and parallelism; quality in monitoring execution and triggering actions to maintain quality of service [41]. Keith G Jeffery also explained the quality of business continuity provision and the quality of virtualisation – including seamless execution transfers to assure timeliness and the quality of the Cloud infrastructure and platform.

3.1.5. Security

Cloud security concerns can be grouped into any number of dimensions these dimensions have been aggregated into three general areas: Security and Privacy, Compliance, and Legal or Contractual Issues [57] [58] [59]. There are a number of security issues/concerns associated with cloud computing but these issues fall into two broad categories: Security issues faced by cloud providers (organizations providing software-, platform-, or infrastructure-as-a-service via the cloud) and security issues faced by their customers [22]. In most cases, the provider must ensure that their infrastructure is secure and that their clients' data and applications are protected while the customer must ensure that the provider has taken the proper security measures to protect their information [23] [81] [83]. The extensive use of Virtualization in implementing cloud infrastructure brings unique security concerns for customers or tenants of a public cloud service [24]. Hickey and Kathleen described the Virtualization alters the relationship between the OS and underlying hardware - be it computing, storage or even networking. This introduces an additional layer - Virtualization - that it must be properly configured, managed and secured [76] [25]. Specific concerns include the potential to compromise the Virtualization software, or "hypervisor". While these concerns are largely theoretical, they do exist [26].

4. THREATS TO VALIDITY

The validity of this representing study is threatened by the following concerns:

(i) The research papers were obtained by keyword searching and reference analysis. Exclusions were made by reading the title, abstract and conclusions. However, there is a possibility that there exist papers that were missed due to the above searching and exclusion method.
(ii) Hypercritical inaccuracies in categorizing the papers into each kind.

5. CONCLUSION AND FUTURE WORK

This review paper has described the systematic representing process, discussed the results of the research study and threats to the validity of the study. The systematic research process was described in terms of the research questions defined, searching keywords used, the exclusion and inclusion criteria. The results of the study were classified into several categories and analyzed. The paper has shown the areas of research within Cloud based development that has been done by answering the questions that were defined initially. Most of the research papers are from journals and conference papers (67%), which is an indication that the research area is still immature. In this paper we presented results from a methodical analysis of cloud based

development issues. Related to our research questions we have identified that: 1) there are 9 empirically evaluated issues on Cloud based architecture published, 2) these issues might be classified according to the type of cloud service (SaaS, IaaS, PaaS). We have identified that there is a lack of generic and reusable model and defacto standard or single architectural method, QoS requirements of multiple workflows, architecture for tangible cloud computing and security aspects of Virtualization. Although 11 researchers have explored in the field of component based development and reusability. Only 5 papers have been found that address cloud security. More work needs to be done in order to improve the current state of research in cloud based development.

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