SERVICE ORIENTED QUALITY REQUIREMENT FRAMEWORK FOR CLOUD COMPUTING

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ABSTRACT

This research paper introduces a framework to identify the quality requirements of cloud computing services. It considered two dominant sub-layers; functional layer and runtime layer against cloud characteristics. SERVQUAL model attributes and the opinions of the industry experts were used to derive the quality constructs in cloud computing environment. The framework gives proper identification of cloud computing service quality expectations of users. The validity of the framework was evaluated by using questionnaire based survey. Partial least squares-structural equation modelling (PLS-SEM) technique was used to evaluate the outcome. The research findings shows that the significance of functional layer is higher than runtime layer and prioritized quality factors of two layers are Service time, Information and data security, Recoverability, Service Transparency, and Accessibility.

KEYWORDS

Quality of Service, Service Oriented Cloud_ Computing, Functional layer and Runtime layer.

1. INTRODUCTION

Today business context shows that the usability of cloud computing is beyond just an IT function where it directs strategic business objectives of organizations to achieve competitive advantage. Since it plays a generic role in business competitiveness, many enterprises keen on using virtualized IT resources (software, platform, data center as services) [1]. The use of service oriented cloud technology is beneficial financially as it improves virtualized business relationships. At the same time the mismatch of quality with dynamic business environment could possibly discourage the cloud users [2]. To analyse the problem time to time evaluation of Quality of Services (QoSs) has been worthwhile by appending the concept of Requirement based Services (RbS) [3].

Enterprise has to identify the need of proper quality requirement of cloud computing to make sure that the cloud strategy benefits the organizations than conventional way of doing business. Hoever, there has bee on research done to identify the service quality requirement of coud computing. This research paper proposed a framework to identify the quality expectations of endusers towards the dimensions (capabilities/ attributes) of service oriented cloud services, and proposed prioritized quality requirements in a cloud computing environment.

2. RELAETED WORK

The quality of a Web-based customer support system consist of service it provides, information it supplies, its effectiveness which reflects the satisfaction of users and characteristics of the system itself [9]. The framework SERVQUAL is best fitted instrument for measuring Quality of Service

(QoS) of uses. Five key indicators that indicate web based QoS factors are namely user friendliness, reliability, responsiveness, assurance, and user orientation. Further, the quality of cloud based services can be described in term of specific governance requirements, applicability of standard, business or application-driven requirements [3].

Reference [5] proposed a framework for Infrastructure level service requirements of cloud users and has focused on a set of infrastructure level quality attributes such as Service Level Agreement support, Reusability, Customization, Multi-tenancy, Adaptation, Flexibility, Business alignment and Technological transparency. Some researchers use service measurement indicators at different levels of web based services. The best example is the study conducted by [6] where the quality attributes of virtual web based services are measured based on two levels; namely Functional and Runtime. Further this model presents taxonomy of Quality of Web (QoW) parameters to identify the different quality aspects of Web services where these parameters are measured quantitatively. Further, reference [6] shows the relationship between each quality parameter in the model and also identified the key features of a Web Service Management System (WSMS).

Frameworks focused on data management level and interoperability over web services that are managed by an integrated WSMS are proposed by [7, 8]. In there the term interoperability was focusing on ontology management for web services, functions like metadata schema with rich descriptive capacity which facilitate the Information exchange between computer and people. Further, the framework elaborate the security, privacy, response time, transaction reliability, accessibility, cost, reputation, regulatory, monitoring, value addition, service level as parameters to identify the QoWs. The stated quality variables at runtime layer are resource utilization; reliability, response time, and ease of terminal use, and data accuracy. Ease of use, completeness, reliability and system flexibility are considered as the measurements standard of system quality component [4].

Though the current business environment sees the cloud computing resources as a strategic option, the frustration towards the reliability, QoS may results in reluctance of using cloud services. Reference [9,10] have clearly stated the issue of loosely interconnected Service Level Agreements (SLAs) with consumers and the unavailability of data & data processing and loss of integrity are another risk often faced by cloud computing providers.

The key characteristics of cloud computing based on subjective models and frameworks have been defined as critical characteristics of service oriented cloud computing. The studies conducted by [1, 9, 12] have presented cloud attributes, Interoperable service architecture, Cloud service management, Multi tenancy and Service Level Agreements as critical attributes of cloud domain. Further, reference [17] stated that the cloud computing model has positive impact on performance of server infrastructure in increasing the utilization of computing resources.

3. RESEARCH METHOD

Quality of service can be evaluated under different perspectives of cloud stakeholders. This research study focuses on the perspective of cloud users. Thus the model validity is performed with the user response. The target respondents are cloud users such as software engineers, IT professionals, business analysts, ERP consultants etc. The major focus of this research is to identify the service quality factors that are embracing within the domain of cloud technology and the SOCC dimension (the attributes of existing driving factors of service based cloud technology). However, there has been no research done to analyze as to how the existing driving factors (SOCC dimensions) of cloud services have influenced towards the quality of service.

Hence the focus of the research is to find whether there is a relationship between SOCC dimensions and the quality of cloud service. Therefore, the main hypothesis is constructed as:

- H1: Service Quality requirements and SOCC dimensions has positive relationship

The term "quality of service" can be defined as the difference between expected and perceived service [13]. They state "the key to ensuring good service quality is meeting or exceeding what (customers) expect from the service". Based on the above definition, it is implied that the requirement of quality is depend on the user expectation and if user meets or exceeds the service we can use the term "User satisfaction" and also it is derived along the experience that user can archive with services. The same term is applicable in cloud computing where we can observe how the existing service factors could pursue quality of service in general usage.

The conceptual model shown in figure 1 depicts the current position of service oriented cloud computing as a set of variables where it is measured by the service oriented cloud computing dimensions (SOCC dimensions) as given in Table 1 and measure against the Quality of Services (QoSs) that pursue the cloud based service quality requirements. Further, the quality of service factors are measured over two layers: Functional layer and Runtime layer as depicted in figure 1, where the main construct of quality of service is assumed to be derived from the quality factors at Functional and Runtime layer.

- **Functional layer-** refers the functional requirement of the service should be met within the context of the business unit and the enterprise [1]. The attribute of functional objectives are elaborated as customer relationship management (CRM), service information and entitlements, service management, financing and Intra-enterprise services. In this layer thirteen variables are measured to satisfy the QoS parameters as describe in table 2.
- **Runtime layer**- refers the functional operations run on cloud computing models (Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as Services (IaaS), and Data storages). This phase where cloud service providers and users interact by service provisioning. The measurement of properties that are identified in runtime layer is described in table 3.

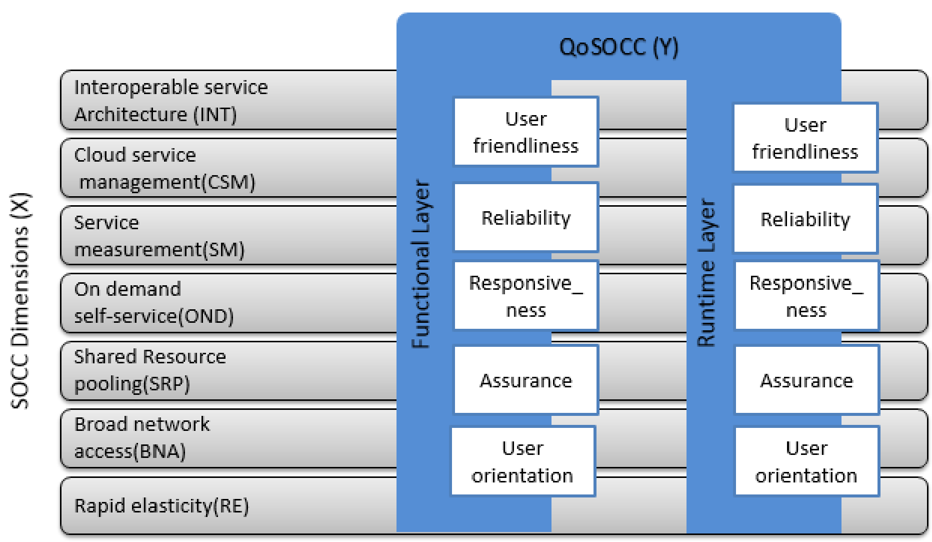

Figure 1. Overview of the Proposed Service oriented quality requirement framework

The hypothesis development for the relationship between quality of service construct and the quality derived factors at Functional and Runtime layer can be described as:

- H2: Functional Layer quality requirements are positively related with service quality requirements of users
- H3: Runtime Layer quality requirements are positively related with service quality requirements of users
- **SOCC dimensions** –The characteristics of service oriented cloud computing that defined by the US National Institute of Standards and Technology (NIST) implicate the current technological capabilities of cloud computing. This study uses these attributes as the dimensions of SOCC namely, On demand self-service, Broad network access, Service measurement, Shared resource pooling and Rapid elasticity[12]. Cloud service management is abstracted from the IT Service Management Framework on Cloud Computing Environment that is proposed by [11]. In this framework it has been identified that service management is an important factor on cloud environment. The another important factor in web based services is interoperability which is proposed as a main attribute in framework of Multi- tenancy architecture proposed in [6] for deploying & managing web service. These two attributes; service management and interoperability are added to the conceptual model that is not appeared in the NIST model.

Further, the indicators of each dimension are defined in table 1 and the definitions of seven SOCC dimensions are described as follow:

Table 1. SOCC dimensions

	SOCC Dimensions		
	Dimension	**Indicators**	**Variable name**
1.	Interoperable service architecture(INT)	Systematic interoperability	INT1
		Semantic interoperability	INT2
2.	Cloud service management(CSM)	Service provisioning management	CPM3
		Business and operational support management	CSM4
3.	Service measurement(SM)	Service billing	BIL5
		Service monitoring	SMN6
4.	On demand self-service(OND)	Service provisioning capability	SPR7
5.	Shared Resource pooling(SRP)	Multi-tenant model	MLT8
		Capability of assigning Different physical and virtual resources dynamically	RES9
6.	Broad network access(BNA)	Access over the networks	NET10
		Access over client platforms	CLP11
7.	Rapid elasticity(RE)	Number of versions released	V12
		Availability at any given time	AVI13

- **Interoperable service architecture (INT)** - The term interoperability explains several attributes of cloud computing which are systematic interoperability, semantic interoperability and interoperability over device, platform and legacy systems.

- **Cloud service management (CSM)** – This refers service provisioning management, business and operational support management, service monitoring, service level agreement support, evaluating and upgrading.
- **Service measurement(SM)** – This refers the pay per use or billing procedure based on service utility.

Table 2. Service quality requirement dimensions at Functional Layer

QoS (Functional Layer)		
Dimension	Indicators	Variable Name
User friendliness (F_UF) The physical features of the system, appealing and looks good.	Attractiveness of the application	F_UF1
	Consistency	F_UF2
	Understandability	F_UF3
Reliability(F_REL) - focusing on whether the system is right, useful, and dependable	Relevance	F_REL1
	Dependability	F_REL2
	Cost benefit	F_REL3
	Accuracy	F_REL4
Responsiveness(F_RES) The readiness of the service to provide service	Service time	F_RES1
Assurance(F_AS) - The knowledge and courtesy expressed in the system and its ability to inspire trust and confidence in its safety	Service Transparency(SLAs)	F_AS1
	Reputation	F_AS2
	Information security	F_AS3
	Completeness	F_AS4
	Sufficiency	F_AS5
User orientation(F_UO) individualized attention	Customization of application	F_UO1

Table 3. Service quality requirement dimensions at Runtime Layer

QoS (Runtime Layer)		
Dimension	Indicators	Variable Name
User friendliness (R_UF)	Throughput	R_UF1
	Number of active sessions (concurrency level)	R_UF2
	Resource allocation	R_UF3
	Redundancy	R_UF4
Reliability (R_REL)	Dependability	R_REL1
	Recoverability	R_REL2
Responsiveness(R_RES)	Response time	R_RES1
Assurance (R_ASS)	Availability	R_ASS1
	Accessibility	R_ASS2
	Data security	R_ASS3
	Technical support service	R_ASS4
User orientation (R_UO)	Integrity	R_UO1

- **On demand self-service (OND)** – This refers the unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Shared Resource pooling (SRP)** – This refers the provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- **Broad network access (BNA)** – This describes the capabilities that are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- **Rapid elasticity (RE)** – This refers the capabilities available for provisioning unlimited services in any quantity at any time.

Indicators of each dimension are defined in table 2 and table 3 respectively for Functional layer and Runtime Layer.

- **Qualities of Services (QoSs) are** the dependent measurement that encompasses different quality parameters that characterize the behavior of cloud service in delivering its functionalities. These parameters are categorized into two major quality layers: Functional layer and Runtime layer. To derive indicators of each layer, this study uses SERVQUAL model with five key performance indicators (KPIs) for measuring service quality as explained in [11]. They are User friendliness, Reliability, Responsiveness, Assurance, and User orientation.

4. RESULTS AND ANALYSIS

The research uses questionnaire based data collection approach to validate the above identified indicators. After conducting a pilot survey, the finalized online questionnaire was distributed by targeting industry wide cloud users and the main variables were measured using 5 degrees likert scale. 53 responses were collected. The selected sample assures higher level of reliability since almost all the respondents have used at least one cloud service including Microsoft Azure, IBM, and Google App Engine etc. While 85% of them are experienced in cloud related services for more than 2 years, 43 of given 53 respondents have got expertise in software engineering with 81.13% of the sample.

Out of the structural equation modelling (SEM) techniques Partial Least Squares (PLS) is the well-established technique for estimating path coefficients in structural models and has been widely used in various research studies [14]. The PLS data analysis was done using the software package SmartPLS (Version: 2.0.M3).

According to the guidelines, Cronbach Alpha should be above 0.60 for exploratory research and above 0.70 for confirmatory research [15]. When the composite reliability is a measure of internal consistency, Cronbach Alpha must not be lower than 0.6. However, according to [16] if an indicator's reliability is low, 0.40 for Cronbach Alpha can be considered as the minimum threshold value and ignoring indicators less than 0.4 is acceptable.

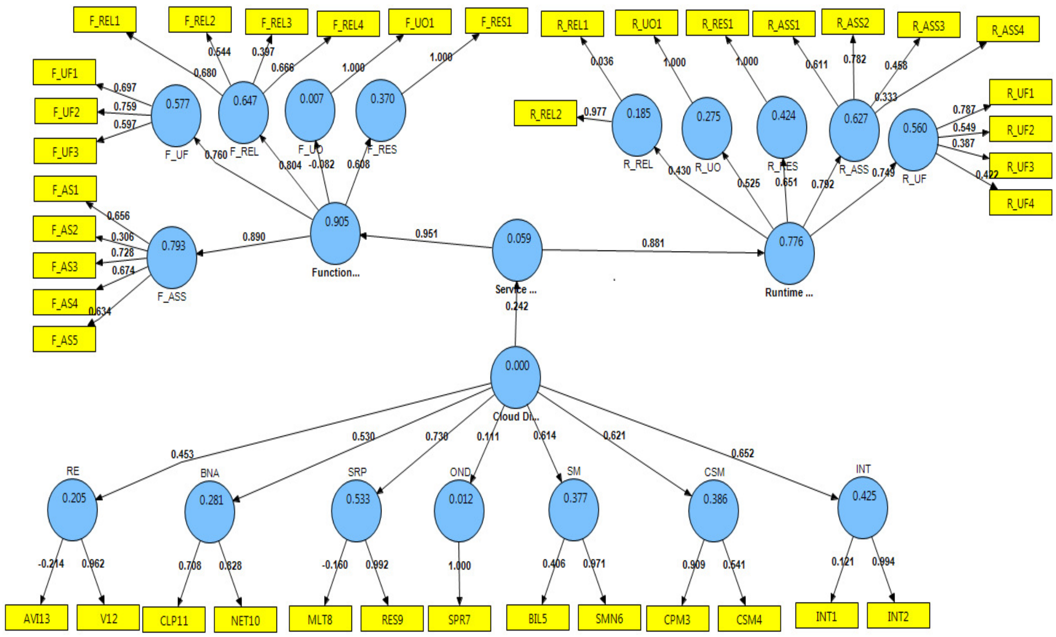

Figure 2. PLS values for whole sample

Figure 2 gives an overview of all components for constructs as a second order and first order hierarchical. In the first step, estimation of the first order constructs for Functional layer quality requirement and Run time layer quality requirement were conducted against SOCC dimension layer and latent variable scores were saved.

Latent variables are the measurement of each construct that indicates in square boxes as depicted in figure 2. Then the obtained latent variable scores were used as reflective indicators. When come to the second assessment, all variables with least reflects in the constructs should be removed from the conceptual model. After reconstruction, the validated model is depicted as in figure 3. In our model the assessment was terminated in two tries as the model met the least conditions after two tries. Table 4 displays the composite Reliability, Cronbach Alpaha coefficient and R square value for the validated model.

Table 4. Composite Reliability and Cronbach α coefficient

	Composite Reliability	R Square	Cronbach's Alpha (CA)
SOCC dimensions	0.7673	0	0.6362
Service Quality requirement	0.8634	0.0538	0.8321
FLQRs	0.8282	0.9146	0.7717
RLQRs	0.7407	0.7877	0.6106

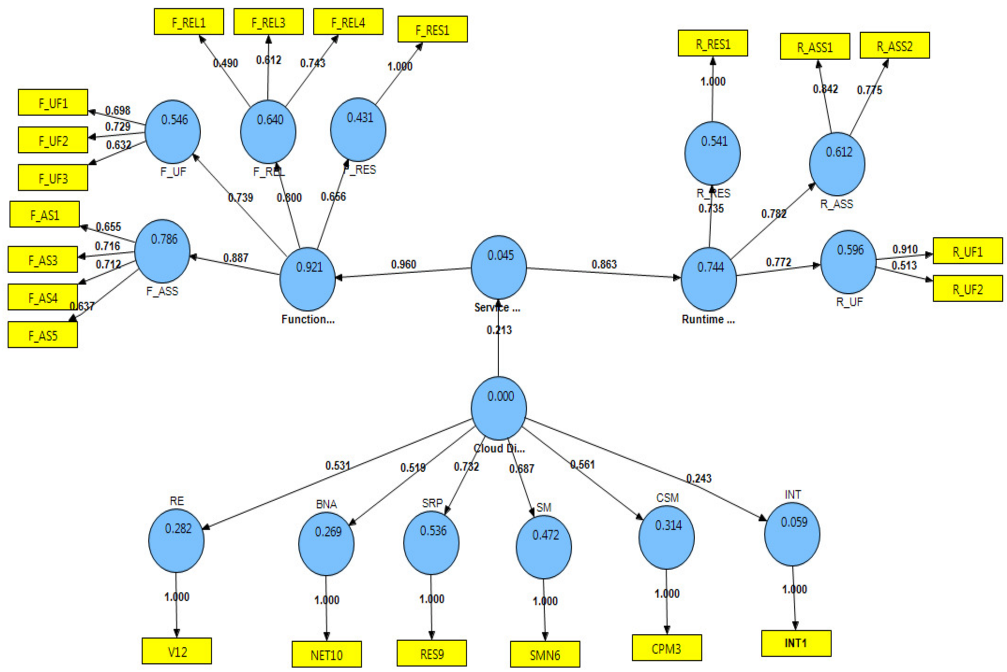

Figure 3. PLS values for the validated model

As depicted in Figure 4 the path coefficient of the validated model is proven between 90% confidence levels. Hence we accepted the hypothesis that has been derived as shown below in fifure 4: (significance P value <0.01). Since all T values are greater than 1.674, null hypothesis were rejected and H1, H2, H3 were accepted.

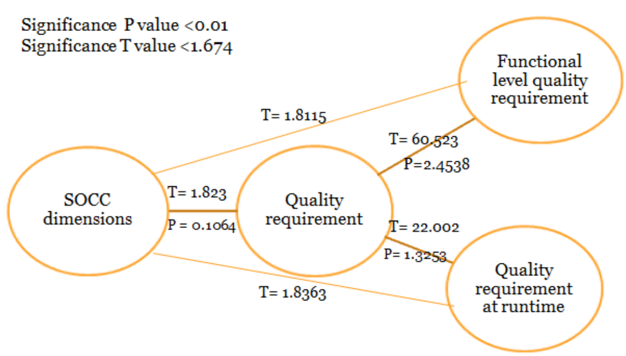

Figure 4. T values and path coefficient of the validated model

The valid indictors of QoS for overall model were prioritized under the functional and Runtime levels as given in Figure 5 and 6 based on t values. When separately analyzed, each quality requirements of two layers along with the SOCC dimensions, the given t values for functional and runtime are 2.819, 1.801 respectively. Thereby the outcome is cleared that the functional quality requirements are considered to be more important than runtime quality requirements.

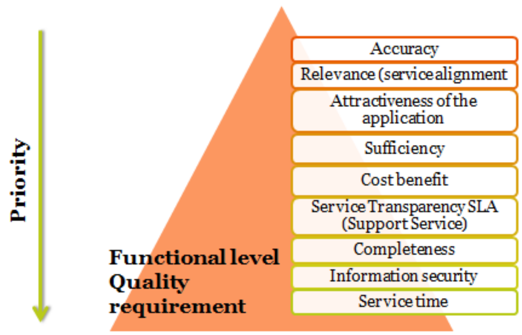

Figure 5. FLQRs Prioritization

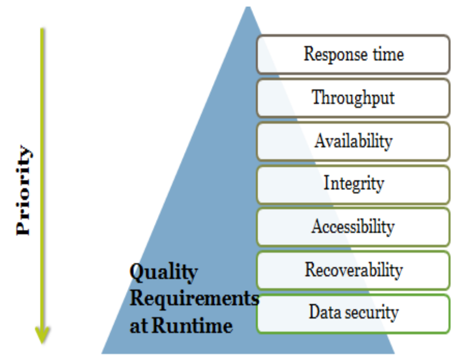

Figure 6. RLQRs Prioritization

5. Conclusion

The objective of the research is to measure the relationship between Service Oriented Cloud Computing dimensions and Quality of Services (QoSs) that are perceived by users. A conceptual model was developed and hierarchical PLS path modeling technique was used to validate the model. In the validated model QoS attributes are prioritized based on t values. Model shows that the highest priority attributes are service time and information security for functional layer and data security and recoverability are best prioritized attributes in runtime layer. Further analysis shows that relationships between attributes of functional and runtime layer have higher correlation against SOCC dimensions and among them QoS attributes at functional layer shows the highest correlation. Thereby it can be stated that cloud users are more concern of service quality at functional layer than runtime layer.

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