Psychological Dimensions in Trust-Based Models in Cloud Computing

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Abstract—Cloud computing has been rapidly evolving and various organizations are updating their infrastructure and services to the cloud computing system. However, being a relatively new technology, users of cloud computing are facing various issues that need to be addressed. Identifying the risks associated and establishing trust in that is one such major issue that needs to be addressed. This article has focused on the various concepts related to trust in the cloud environment, technicalities of trust being used and evaluated, the trust models with an objective of identifying the inclusion of psychological dimensions and attributes in the assessment, evaluation, and management process. The results from the review have indicated that as such there are no models found which contribute to incorporating the psychological attributes. As an extension of the assessment, an integration of two important aspects are recommended in the existing trust model. The inclusion of psychological attributes that consist of motivation, perception, learning, and personality attributes; and an initial stage of assessment model in a top-down approach scheme for identifying the effectiveness of cloud service providers based on the collaborative trust information-sharing mechanism and by using techniques such as rankings and ratings.

Keywords: Trust, Trust Models, Cloud Computing, Psychological

I. INTRODUCTION

One of the emerging technologies of computing applications is cloud computing that focuses on minimizing the cost of the resources by sharing, computing and storage resources. It provides customized services on-demand with a hassle-free licensing process of various administrative activities relating to information technology. Its large-scale services and applications make it a promising technology solution for large-scale enterprises. Though cloud computing provides various services, there are concerns related to the areas of security, privacy, and data protection, and also in the process of deploying technology [1]. The new features provided can have a direct effect on the IT cost and also conventional security, trust, and privacy techniques. The vast range of services with increasing functionalities makes the existing mechanisms inadequate, and now the need for building trust in its domain offering various services with minimal costs is getting higher and higher [2]. Various authors have discussed and presented their views on issues and challenges in cloud computing from different perspectives, which reflects the large scope of cloud computing, and the issues surrounding it [3]–[5]. It was proposed by a number of models [6]–[8]. Nevertheless, each study presents a limited view of trust in the cloud. Therefore, this study

would review the existing concepts of trust mechanisms, and models. Based on the review, the need for including the psychological dimensions would be assessed and reviewed.

II. THE CONCEPT OF TRUST IN CLOUD COMPUTING

Trust is a sophisticated phenomenon that is closely linked with social sciences [9]. Various definitions were given by different authors from different perspectives. Mayer et al. [10] and Blomqvist [11] gave some early definitions of trust and its concepts are from the perspective of the social sciences. Ghosh [5] stated it as a term used for privacy and security in literature related to cloud computing. Josang et al. [12] explained "trust as a subjective belief of one entity about the other entity within a specific context in a specified time".

III. TYPES OF TRUST

Govinda and Jaisankar [13] stated that trust can be broadly categorized according to trustor's expectancy and experience. Huang and Nicol [14] classified trustor's expectancy into: performance and belief. Performance based is about what conducts by trustee, and belief based is about what the trustee thinks. Trust in performance can be attributed to the truth stated by trustee of to the success achieved by trustee. Trust in performance is not transitive, whereas trust in belief is transitive. Trust in performance can propagate through trust in belief [9], [15]. For example, the mental state of a trustor's belief or expectancy is based on available evidence about trustee's competence such as success, reputation, integrity and goodwill. Trust based on experience is further classified into two types, mainly direct and indirect trust [16]. Forthright trust is dependent on the trustor's own experience; while indirect is based on the recommendations of third-party trustor or entity to another entity or trustor. An overview of the classification of trust is presented in Figure 1.
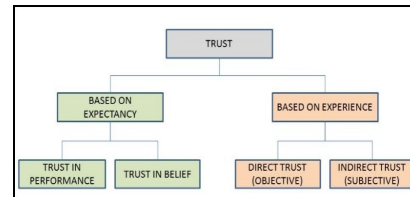

Figure 1.   Classification of Trust

IV. TRUST MECHANISMS IN CLOUD COMPUTING

To examine the various mechanisms used in the assessing or understanding the trust, the compliance and standards being used, there is a need to oversee various aspects regarding to the trust in cloud computing. Some of the major mechanisms for understanding trust in cloud computing includes the following:

A. Reputation Based Trust

Reputation is derived from collective or aggregated opinions about an entity in a community. It is common that people trust entities with a high reputation compared with those with a low reputation. For example, a cloud user trusts Amazon cloud service more than a local cloud service providing company, because of the reputation Amazon carries with it. Reputation models are mostly used in e-commerce, but considering cloud computing as a service, the reputation-based models finds its place in the cloud computing as there is a concept of buying and selling of cloud services. It was supported by many authors that reputation would affect the process of selecting the cloud service provider by the cloud users, as a result, reputation-based approach is a mechanism used in making the trust judgment in cloud computing [6], [8].

B. SLA verification-based trust

It is essential that the trust has to be assessed, monitored, and evaluated during the various stages of cloud computing deployment; right from the selection of provider and through the process of using the services. SLA (Service Level Agreement) could help the users in re-evaluating the trust in a specific service provider. SLA is a legal contract between the cloud service provider and the user, in which the user can evaluate the services which would be delivered [7], [8].

C. Trust As A Service

RSA one of the leading cyber security companies launched CTA (Cloud Trust Authority) as a service in cloud computing called as TaaS (Trust as a Service). It can be used as a single point platform for assessing and configuring services from various providers. The platform is built to gain more control through visibility acting as parameters for building trust [17], [18].

V. CLOUD TRANSPARENCY MECHANISMS

One of the effective mechanisms to build trust is to provide transparency and accountability features in the cloud services. CSA launched STAR program to integrate the transparency feature into the cloud business. STAR is a public platform which is used by the service provisioners to release their assessments of their protection cog in CAIQ (Consensus Assessments Initiative Questionnaire) or CCM (Cloud Controls Matrix) which are considered to be best practices for publishing security assessments by CSA [19]. The platform can also, be accessed by the cloud users using CTP (Cloud Trust Protocol) to obtain information about various transparency attributes such as vulnerability, audit log, service management, service statistics in specific to a cloud service provider [20]. This approach can be regarded as evidence-based approach, as the users would come to know if the capabilities claimed by the service providers are for real. However, one of the loopholes in CTP is the provided information by the service provisioner, similar to the process in STAR, as a result the users may get access to modified information [21].

VI. TRUST MODELS IN CLOUD COMPUTING

Various authors have classified the trust models from various perspectives. These models are used to evaluate the trust in cloud computing domain. Huang and Nicol [9], [14] proposed various methods based on SLA verification, policy-based trust, reputation-based trust, trust as a service, attributes assessment and standards, etc. Corradini et al. [22] classified trust models into reputation based, recommendation based, and feedback-based trust. This classification is made to avoid complexity in identifying the right models for assessment based on the requirements of the users. Similarly, Manuel et al. [23] proposed trust models based on reputation and transition. The transition-based model uses belief as a concept, which is transitive; but the performance is considered as non-transitive. Kanwal et al. [24] proposed trust models and evaluation attributes based on security, data control, and quality parameters. So, the trust models are classified either by the dimensions of trust or by the metrics used for evaluation. The dimension focuses on the various areas such as data control, access control, security, adaptability, etc. whereas the metric-based classification uses parameters or techniques for assessing and evaluating trust, such as SLAs, feedbacks, support, and audits, etc. To simplify the classification process, Govinda and Jaisankar [13] classified trust models based on: SLA; Recommendation; and Reputation.

However, more detailed classification of trust models was identified by Kanwal et al. [24], which are based on agreements, certificate/secret keys, feedbacks, domain-specific, and subjective trust as shown in Figure 2.
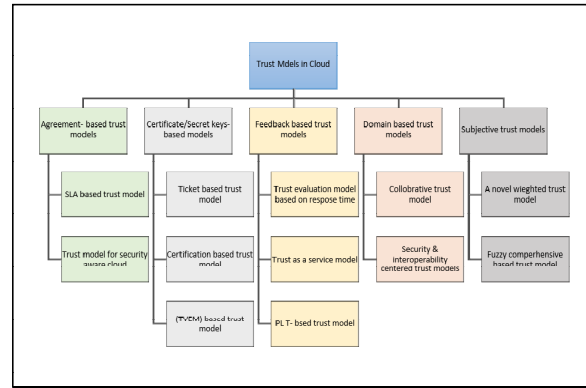

Figure 2.   Kanwal et al. [8] Classification of Trust Models

VII. DISCUSSION

Trust as identified by various authors is one of the important factors that require to be counted in the cloud environment. As this technology is relatively new and expanding rapidly by providing various services at low costs, it is not only being preferred by new organizations but also by existing organization which are updating their whole IT infrastructure on to the cloud. However, taking such a huge leap is considered to be a risky approach and could have large impact on the functioning of the

organizations. Therefore, there is a need for various models that can be used to build trust by assessing various attributes relating to services, quality, data integrity, process execution, access controls, and various other IT related issues.

This review has explained the semantics of trust and various mechanisms used for evaluating and establishing trust in cloud computing. Different techniques were identified and proposed by the various authors are reviewed. It is identified that dimensions and parameters are the two key concepts used in the majority of the trust models. Various mechanisms such as SLA verification, reputation, transparency, policies, evidence-based mechanisms were suggested by various authors [6]–[8], [14], [17], [21], [25].

A trust model in cloud computing would enhance the process of trust establishment and management. Various trust models which are based on agreements [26], [27], certificate/secret keys [25], [28], feedbacks [24], [29], domains [30], [31], subjective [32], [33] were mentioned in Figure 2. However, it was identified that there is a need to develop an integrated mechanism or approach that would address all the issues relating to trust in cloud computing. All the models mentioned were focusing on various dimensions and had drawbacks of not being able to assess the parameters out of that dimension. Therefore, it is essential to use a combination of models to completely assess, evaluate, establish, and manage trust in the cloud environment.

Trust is an entity that is not only related to the belief but also to the behavioral aspects of the people [34]. As trust establishment in cloud computing results in making a decision to either buy or not to buy, there is a relationship between trust and decision making. The various studies used different statistical metrics such as QoS, performance, values, etc. The decision-making process is also influenced by the psychological aspects of the user or service provider [35]. One of the major aspects identified in this review is that there was no study identified that had analyzed the role of psychological attributes such as motivation, perception, learning, and personality attributes, etc. Considering it as one of the areas to be investigated, this study explains the role of psychological aspects in trust management in a cloud services environment.

A. Psychological Factors in Trust: A New Dimension in Cloud Computing

1) Trust and Decision Making in Cloud

Any transaction that in any environment made with incomplete or imperfect knowledge will always carry a degree of risk. When dealing with any organization, especially the service-oriented organizations in IT such as cloud service providers, the relative knowledge about the organization, its behaviour, and service parameters can be perceived as trust. However, assessing the trust in such environments is a complex task due to the impersonal aspects of computer networks, lack of recognized standards of measurements and models for evaluation [36]. The vast nature of the trust spectrum makes it more complex as there are various relationships between various entities and different parameters for evaluation and management. A top-down approach could be an effective strategy to adopt in such instances. Rather than focusing

on the subjective measures of fine-grained parameters of trust, the approach should initially focus on the higher dimensions, then the evaluation can be streamlined into the subjective measures.

2) Trust and Psychological Attributes

Four important psychological attributes are considered in this study which includes motivation, perception, learning, and personality attributes as identified by Szyszka [35]. These attributes have an impact on the trust assessment, establishment, and management. The relationship between them is discussed in the following sections.

a) Motivation and Trust in Cloud Environment

Motivation is an important aspect in any environment results in effective outcomes. A motivation in a cloud environment can be assessed from two perspectives: the motivational parameters of the service provisioners in providing effective and efficient services to the users; and the motivational parameters of the cloud service users which would enable them to establish and manage trust on the cloud service provider. Motivation can enable trust among the technology users [37]. There can be various aspects that can motivate the users and considering the cloud environment the motivational parameters can be identified for both users and service provisioners in trust's building.

b) Perception and Trust in Cloud Environment

The perceptions in a cloud environment can be understood from both service providers and users perspectives. The consumer's perception in cyberspace can influence the establishment of trust which in return would influence the decision-making process [38]. The perceptions are based on the observations and thoughts of the users. The trust levels can be varied based on the perceptions about service-related aspects.

c) Learning and Trust in Cloud Environment

Learning would enable users in making effective decisions [39], [40]. Learning has a positive impact on both cloud service providers and users. By learning about the cloud users, the service providers can take effective measures in developing the strategies and processes that would enable the trust building mechanisms. Similarly, by learning the cloud users can build their relative knowledge about various services, trust mechanisms, and service providers. This knowledge would enable them in taking decisions more effectively. However, learning factor depends on the availability of information. The information sources in the cloud environment must be reliable for the establishment of trust.

d) Personality Attributes and Trust in Cloud Environment

The personality of a user can be defined as unique psychological makeup and how it consistently influences the way a user responds to the environment. The personality can be analyzed by observing the behavioral patterns and reactions of the users. The personality attributes can be identified from a person's characteristics which reflect his/her personality. The parameters such as Communication Skills, Honesty, Education, shopping/technical knowledge etc. can be used to assess the personality of a person [41]. In a cloud environment these factors play an important role, as the user's personality impacts the way service-related aspects are

observed and perceived, and thus affecting the trust establishment.

3) Recommended Model

Based on the reviews and the explanation given in the previous sections, two major recommendations are made in this study as shown in Figure 3, which include: A top-down approach for evaluating the trust in cloud computing and using the trust information-sharing approach and techniques like ranking and ratings of cloud service providers. This would help in establishing the trust in the initial stage, and then the domain-specific or subjective specific models can be used for trust evaluation and management and using four psychological attributes including motivation, perception, learning, and personality attributes that need to be considered in the existing trust models as needed.
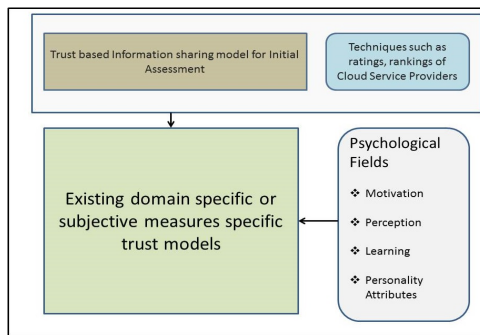

Figure 3. Recommended Trust Model

VIII. CONCLUSION

This study has been conducted with an objective of assessing the concept of trust, the evaluation of trust mechanisms and trust models in the cloud environment and assessing the need for the inclusion of psychological attributes in the trust models which can influence the decision making process. The review of trust mechanisms has identified various approaches based on various parameters including reputation, evidence, certification, encryption, shared security keys, SLA verification, policies, and various other subjective and domain-specific aspects.

In addition, the study has also found that no model has considered the psychological attributes in the process of evaluating or assessing the trust. Therefore, the psychological attributes including motivation, perception, learning, and personality attributes are recommended in the process of assessing and evaluating the trust in a cloud environment. To simplify the process of trust evaluation, a top-down approach is suggested, where the initial assessment is made on various cloud service providers using the concept of trust information sharing in a collaborative system using techniques like rankings and ratings to differentiate various cloud service providers. Thus, this study concludes by assessing the need to include psychological attributes for trust evaluation. The future studies can focus on evaluating the existing models by including the psychological attributes. The recommended model in this study can be evaluated by applying it along with the existing models and the psychological attributes can be further investigated and their relationship with trust can be studied with respect to various dimensions.

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