



## Age-of-Experience: A Factor for Direct Trust Computation in Cloud Service Provider Selection

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**Abstract**— *Trust is a very major factor of consideration in cloud computing; in present day practices trust depends largely on perception of reputation by cloud users and cloud brokers, and self-assessment by providers of cloud services. Direct Trust is the most contributing factor for trust computation. This paper introduces a variation on how to consider the factors for Direct Trust computation, with a survey of existing mechanisms for establishing trust, involving approaches related to Direct Trust and comments on their limitations. This paper then adds by proposing a more important factor namely ‘age-of-experience’ which is to be applied on the satisfaction component of Direct Trust computation. This is to be done by setting a threshold value for a cloud element (services, services provided, infrastructure, platform, etc.) based on the frequency of update subjected for a cloud element. When the Direct Trust is computed based on the ‘age-of-experience’, it is evident that more appropriate trust value is obtained.*

**Keywords** - *Trust, Direct Trust, Cloud Service Provider Selection, Trust mechanisms, Satisfaction, Reputation, Age-of-experience*

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### I. INTRODUCTION

Cloud computing is a gradually maturing computing service paradigm where infrastructure and software resources are provided over the Internet as scalable and available on-demand to anybody anywhere[1]. This concept of cloud computing works between three important entities namely:

- The Cloud User (CU) – one who makes use of services from the cloud and
- The Cloud Service Provider(CSP) – one who manages and offers services on the cloud.
- The Cloud Service (CS) – the services available in the cloud

With cloud environment becoming more complicated and unpredictable, cloud services are not always trustworthy, and the Service Level agreements (SLAs) may not satisfy the users’ dynamic requirements.

In the above background, the major concerns of cloud service users can be recapped as follows:

- (1) Can the cloud service providers, especially those new comers, be trusted or not?
- (2) Users have to make sure that the cloud providers will not spy their data or sell them to their competitors.
- (3) Whether the cloud service providers should protect the cloud users data and applications from any way of damage?
- (4) Whether the services are available all the time or not, as users usually care about the property of plug and play as if the applications are equipped on local disks? and
- (5) Whether other non-functional requirements such as Quality of Services (QoS), are covered by cloud according to SLA?

Therefore, users cannot trust a cloud service by just considering one factor only. Many dimensions are to be considered addressing different aspects of the performance of the cloud services. To ensure the normal operation and running of the whole cloud service system, trust management is essential for CUs to evaluate the CSPs and make satisfactory selection and so can interact with those ones with high reputation. Hence, there should be a mechanism to help users to make right decisions on selecting trustworthy cloud services for better interactions. (eg.[2],[4]and [5])

Trust is an expanded concept of security which includes mental and practical criteria[12]. The level of trust in cloud computing is regarded as the basic or primary trust because the cloud computing is a recent technology and its role players do not have much valid and meaningful knowledge about each other. Besides different mechanisms of trust in cloud, Reputation based trust is a very important one and it is the primary approach in trust that comprises of direct and indirect trust(eg.[7],[13],[14])This paper aims to introduce an important element for trust computation for direct trust in reputation-based approach.

This paper is organized in the following sections: Section I: Introduction- introduces the basic concept of cloud, its elements and the basics of trust. Section II: Related Work – introduces the concepts related with the current paper, Section III - Direct Trust Computation in Cloud is the section where the basic work of this paper is taken into account

and elaborated, Section IV - Use of Age-of-Experience in satisfaction factor which explains about the newly introduced concept of this paper, Section V –Conclusion concludes the work by giving a gist of the work done through this paper, Section VI – Future Work gives the areas of future scope and study and Section VII - References, all the reference journals, papers, articles and books that helped in bringing up this paper.

## II. RELATED WORK

According to the NIST Cloud Computing Reference Architecture [10], Service provider will be projecting all the benefits of the services provided which will be helpful for the Cloud User in deciding to choose that particular Service Provider. Cloud brokers and cloud auditors are identified as entities who conduct assessment of cloud services.

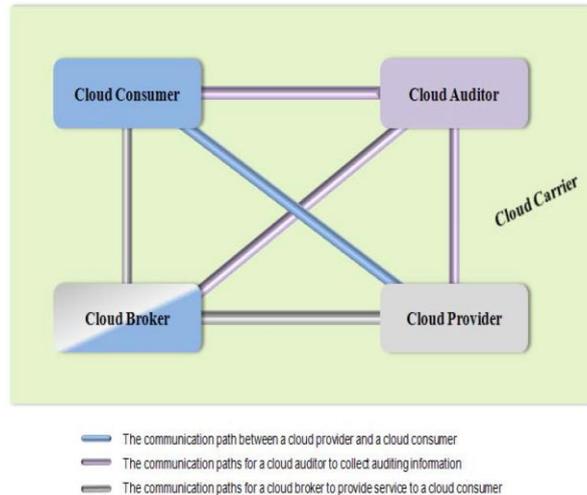


Figure 1. Architecture of interaction between system elements

Trust is a complex social phenomenon. For example, an entity A is considered to trust another entity B when entity A believes that entity B will behave exactly as expected and required (International Telecommunication Union, 2001). The notion of trust in an organization could be defined as the customers certainty that the organization is capable of providing the required services accurately and infallibly [15]. Trust involves many associated factors, such as reputation, risk, uncertainty, expectation, and so on. First of all, by evaluating and storing the reputation of other members, it is possible to calculate how much those members can be trusted to perform a particular task [9]. There are different trust mechanisms adopted in clouds as below such that each category focuses one or more unique dimensions of belief and reliability pertaining to cloud services and its providers[7]

- Reputation based trust
- SLA based trust
- Transparency Mechanism
- Trust as a service
- Formal accreditation, audit and standard

The authors mention that Reputation-based Trust is the basic element of trust computation. The reputation of an entity is the aggregated opinion of a community towards that entity. Usually, an entity that has high reputation is trusted by many entities in that community; an entity, who needs to make trust computation on a trustee, may use the reputation to calculate or estimate the trust level of that trustee [7]. The reputation in a cloud can be gained through:

- Direct Trust - the primary source of information which can be completely relied upon.
- Indirect Trust – the secondary source such as recommendations and third party opinions.

In the words of [7], CU is the one who is exactly in need of the service. The CU will be one of the prime attribute of assessment in choosing a Service Provider. If a cloud user has already interacted with a cloud service or a cloud service provider, then the experience will be the user's direct basis for cloud attribute assessment. Experience is a fundamental factor of trust and hence called 'direct trust'. The advantage of using direct interaction experience is that the data used are first-hand and may be most relevant [7]. However, a limitation of direct trust noticed is that the trust computation reflects only the past experience but may not always be at that time of the selection of a Service Provider or the just immediate-past. Trust changes dynamically, as a function of dynamic monitoring of behavior.

Assessment of attributes may also be carried out through different other sources such as the peer users, the service provider, cloud auditor/accreditor, and cloud broker that contribute under the head 'indirect trust'.

Knowingly or unknowingly we go along with trust in our day to life. Be it for purchasing of groceries or choosing a school for the education of kids. The basic method we follow to choose something is based on our own personal experiences with the particular shop or organization. This is what we call as the Direct Trust. When we don't have any proper source of assessment we go for a third party's opinion which is considered as an Indirect Trust i.e. views and comments from our friends and relatives or the customers of the shop.

From the above literature studied, it is understood that the direct trust computed at a point of time may not reflect/contribute appropriate trust for a node. Because the cloud user's personal interaction with a specific node is not of present or immediate past experience, the trust computation will not be appropriate.

### III. DIRECT TRUST COMPUTATION IN CLOUD

As per the work of [11], a Direct Trust is the belief that one entity holds on another entity in certain context, based on its own evidence of past experience with that entity. The direct trust of a platform A about platform B is calculated by combining satisfaction and certification opinion on the platform properties. Certain Logic AND (^) operator is used for this operation as both opinions are essential for deriving direct trust on the platform B. The rationale behind using this operator is that if the CA is not trusted, then the certified property may not be trusted.

$$\begin{aligned}
 A-dir O_{B,(c_i,p_j)} &= A O_{B,sat(c_i,p_j)} \wedge A O_{CA,cer(c_i,p_j)} \\
 A-dir O_{B,(p_k)} &= A O_{B,sat(p_k)} \wedge A O_{CA,cer(p_k)} \\
 A-dir O_{B,(c,p_l)} &= A O_{B,sat(c,p_l)}
 \end{aligned}$$

Figure 2: Direct trust computation using Satisfaction and Certification

[6] have defined an Intra-domain Evaluation as – in a local domain, an evaluation value will be given when an entity complete interaction with another entity, represented by the symbol E, which  $-1 \leq E \leq 1$ . Negative value indicates not satisfied and it will reduce the trust degree, while positive value expresses satisfaction and it will increase the trust degree. After the k-th interaction, entity j n will give entity i n an evaluation value, which can be formalized as  $ki j$ . In Direct Trust Degree(DTD) an entity's intra-domain direct trust degree is related to its intra-domain evaluation value. The value of DTD is usually initialized to zero. In domain A, after the k-th interaction, direct trust degree between entity i n and j n is as given in Figure 3:[6]

$$DTD(n_i, n_j)^k = \alpha \times DTD(n_i, n_j)^{k-1} + (1 - \alpha) \times E(n_i, n_j)^k$$

Figure 3: Direct trust computation using DTD and Evaluation Value

[8] proposed a mathematical model for effective resource selection for allocating jobs by considering past behaviors of resource providers. The authors have considered two variables in their proposed function for the computation of their Trust Scheduling Function (TSF) for any resource 'i'. The two variables considered are: i) Credibility function and ii) Availability function. Empirical weights for these two functions have been suggested by the authors; in terms of  $\alpha$  and  $\beta$  [8]. The equation is reproduced:

$$TSF(i) = \alpha * Credibility \text{ of } i + \beta * Availability \text{ of } i \text{ (where } \alpha = \beta = 0.5)$$

The above given Reputation-based Trust computation approaches are the three different works on cloud computing which all includes without fail the user satisfaction and as an addition certification or evaluation value or availability. Therefore, it is clear that direct trust computation is purely based on cloud user satisfaction component to a major extent at all times. It is understood that the satisfaction factor considered in all the direct trust computation approaches have not taken into consideration the 'age-of-experience'. It is also verified from the literature that the 'age-of-user-experience' was not been the additional component anywhere which the proposed approach would like to bring in.

The authors of the paper would like to stress upon the importance of 'Age-of- experience' as an important component to be used for considering the satisfaction factor. Though all the three papers take into account, satisfaction and certification, one important factor which gives the impact on selection of the cloud service or the provider is the cloud user. Even though the cloud user has got previous experience on the provider, the time of experience has to be taken into account(i.e.) if the experience of the user is very long back, the result of the cloud on the provider or the service will not be appropriate. So, a mechanism is suggested here which takes care of the changes occurring.

The significance of the proposed element is based on the fact that experience yesterday is outdated today due to the following reasons:

1. As the technology grows faster, the infrastructure also gets updated very frequently.
2. Service requested in the previous interaction might be different from the one needed this time.
3. Infrastructure used previous time would be mostly different this time.
4. The tools and techniques have lot of version improvements every now and then.
5. User feedback based value-added services are promoted and made available.
6. Choice of CYOD (Choose Your Own Device) and BYOD (Buy Your Own Device) approaches gives long list of new and latest devices for use.
7. The cloud service providers business is well-established than before.

Hence, in the proposed approach of direct trust computation, the authors stress upon to introduce the 'age-of-experience' factor to be considered before considering the satisfaction factor. The 'age-of-experience' must be set a threshold value which differs CSP to CSP; cloud service to cloud service; time to time; based on request to request, etc.

#### IV. USE OF AGE-OF-EXPERIENCE IN SATISFACTION FACTOR

As mentioned in the previous section, the age-of-experience factor has to be considered when the satisfaction factor based on the past or previous experience of the cloud users is beyond the threshold value assumed for each of the cloud stakeholders.

Generally, the direct trust computed does not follow any specific proportion between Satisfaction factor and Certification or Availability or Evaluation value factor. However, there must be some empirical assumption adopted in any cloud environment for estimating the trustworthiness. According to [8], the impact of using trust of a resource broker in computational grids has been studied through experiments. They have proposed a novel trust model for estimating the trustworthiness of the resource provider of the Grid infrastructure. When 'R' is the problem, all the possible solutions are represented by a set 'S', the solution set of the problem. The authors have considered the credibility of the resource provider in addition to the availability of the resource. Thus, the authors have formulated a Trust Scheduling Function. They have included two empirical coefficients for 'Credibility' and 'Availability' in their function. The authors have concluded that the system proposed by them is reliable, and provide trustworthy resources for the submitted job for execution. However, they have used equal values for these two coefficients. This indicates that the two coefficients are averaged out values (0.5 each). They have demonstrated that their model provides increased throughput of the broker.

With the consideration of the above work, the authors of this paper bring out a pseudo code as given in Figure 4.

```
If age-of-exp(service-needi)<=
threshold(service-needi) then
    Direct-trust = (0.5*Satisfaction)+
                (0.5*Certification(or)
                Availability(or)
                Evaluation value)
Else
Direct-trust = (0.2*Satisfaction)+
(0.3*Third-party-trust) +
                (0.5*Certification (or)
                Availability (or)
                Evaluation value)
Endif
```

Figure 4. Pseudo code for Trust computation using age-of-experience

As given in Figure 4, the trust computation formula depends solely on age-of-experience of a cloud element 'i' that is needed for this service request of a cloud user. At yet another instance, if the cloud user needs some other service through a different cloud element that is a different 'i' value, then that corresponding threshold value set. Such collection of threshold values are to be used (on assumption) depending on the frequency of update possible of each of the cloud element[8]. While age-of-experience influences the direct trust computation, the satisfaction component with 50% weightage is distributed as 20% and 30% among satisfaction and third-party trust respectively.

#### V. CONCLUSION

During the process of the proposal of this paper, a survey was conducted to check the approaches of different Direct Trust techniques which involve a calculation based on the major factor of satisfaction of cloud users using their previous experiences. But, an important factor contributing to the calculation (i.e.) the age-of-experience of the cloud user with the provider was not considered. Hence, this paper stresses that the age-of-experience is a mandatory factor and should be considered which will have a great impact in the computation of direct trust with assumptions.

#### VI. FUTURE WORK

The assumptions made on direct trust computation in the proposed work do not carry any scientific computation. Hence, this proposed work can be extended further by exploring a scientific computational approach through empirical results.

#### REFERENCES

- [1] Andrzej G. and M. Brock, "Toward dynamic and attribute based publication, discovery and selection for cloud computing", *Future generation computer systems*, 2010, Vol. 26, No.7, pp. 947-970.
- [2] Everett C, "Cloud computing: A question of trust", *Computer Fraud Security*, 2009, Vol.6, pp. 5-7.
- [3] Fan Wenjuan , Yang Shanlin, Perros Harry Pei Jun, "A Multi-dimensional trust-aware cloud service selection mechanism based on Evidential Reasoning Approach", *International Journal of Automation and Computing*, 0,V(),0-0.
- [4] Garrison G, Kim S, Wakefield RL, "Success factors for deploying cloud computing", *Communications of ACM*, Vol. 55, No. 9, pp. 62-68.
- [5] Ghosh A, Arce I, "Guest editors' Introduction: In cloud computing we trust – but should we? Secur Privacy", *IEEE*, Vol. 8, No.6, pp. 14-16.
- [6] Guoyuan Lin, Yuyu Bie and Min Lei, "Trust Based Access Control Policy in Multi-domain of Cloud Computing", *Journal of Computers*, 2013, Vol. 8, No.5, pp.13-57.

- [7] Jingwei Huang and David M Nicol, "Trust Mechanisms for Cloud Computing", *Journal of Cloud Computing: Advances, Systems and Applications*, 2013, Vol.2, No.9, pp. 6-14.
- [8] Kumar Rangasamy and Thamaraiselvi S, 'Trust Management System for Computational Grids', *European Journal of Science and Research*, Vol. 79, No. 1, pp. 15-23.
- [9] Lopez, J R. Roman, A. Isaac, and F. Carmen, "Trust management systems for wireless sensor networks: Best practices", *Computer Communications*, 2010, Vol. 33, No. 9, pp. 1086-1093.
- [10] NIST, "NIST cloud computing standards roadmap", NIST CCSRWG-092. First edition. NIST, Gaithersburg, USA. [http://www.nist.gov/itl/cloud/upload/NIST\\_SP-500-291\\_Jul15A.pdf](http://www.nist.gov/itl/cloud/upload/NIST_SP-500-291_Jul15A.pdf).
- [11] Sheikh Mahbub Habib, Vijay Varadharajan and Max Muhlhauser, "A Trust-aware Framework for Evaluating Security Controls of Service Providers in Cloud Marketplaces", 12th IEEE International Conference on Trust, Security and Privacy in Computing and Communications (TrustCom), 2013, V( ) pp: 459-468
- [12] Siani Pearson, "Privacy, Security and Trust in Cloud Computing", HP Laboratories, appeared as a book chapter by Springer, UK, 2012.
- [13] X. Li, F. Zhou, and X. Yang, "A multi-dimensional trust evaluation model for large-scale P2P computing", *Journal of Parallel Distributed Computing*, 2011, Vol. 17, No. 6, pp. 837-847.
- [14] Xiong L. and Liu L., "PeerTrust: supporting reputation-based trust in peer-to-peer communities". *IEEE Transactions on Knowledge and Data Engineering*, 2010, Vol. 17, No. 6, pp. 843-857.
- [15] Z. Dimitrios and L. Dimitrios, "Addressing cloud computing security issues", *Future Generation Computer Systems*, x2012, Vol. 28, No. 3, pp. 583-592.