Social Cloud Computing: Architecture and Application

Santosh Kumar and **Sandip Kumar Goyal**

Abstract With the increase in the use of social networks and cloud computing, users have started a new way to interact with people, including their friends, colleagues, etc. Social networks reflect real-world relationships, which allows users to share information and establish connections with each other, thereby creating dynamic virtual organizations. Cloud applications need to provide a large number of heterogeneous, geographically distributed resources, which are managed and shared by many stakeholders who may or may not know earlier. Online relationships in social networks are usually based on real-world relationships, so they can be used to infer the degree of trust between users. Due to this, many security issues are arising, which, if not addressed carefully, may affect the adoption of this promising computing model. Apt response to these threats is of special significance in the social cloud environment. In the social cloud environment, computing resources are provided by users themselves. We believe that considering trust and reputation requirements can take advantage of security by incorporating the concepts of trust relationship and reputation into these schemes. In this paper, a survey is presented on the social cloud. The article includes its architecture, application on Facebook as a social networking site, and other usages. At last, the relation between trust and reputation is presented that is essential while sharing cloud resources in the social cloud environment.

Keywords Cloud computing · Social networking · Social cloud · Trust · And reputation

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1 Introduction

Social networks provide individuals with new ways to communicate and share information. For scientists, multiagency collaboration is widespread, but face-to-face meetings usually only happen occasionally in conferences and seminars, so communication is often difficult. Social networks can provide a higher level of scientific co-operation to enhance communication and facilitate the discovery of other scientists working on the same projects. However, scientific co-operation usually also has resources that are expected to be dynamically shared during the course of the project. Currently, this is a difficult process, requiring manual (peer-to-peer) user account registration, and creation, etc. [1].

In this digital lifestyle, social networks play an important role in communicating with friends, family, and colleagues. The rapid and continuous growth of social networking platforms has proved this. For example, Facebook has more than 500 million active users, of which 50% log in every day. A platform for information sharing is provided by social networks so that a real-time model can be established [2]. For example, there are many integrated applications, and some organizations even use users' Facebook credentials for authentication instead of requiring their own credentials (e.g., Calgary Airport Authority, Canada, uses authentication protocol to authenticate users for granting access to its WiFi network).

A social network is a dynamic virtual organization that is structured based on the trust between social users. We recommend that based on this trust, social users can share resources like information, hardware, and services through a social cloud. Cloud system is used to provide services to their users by sharing virtual services rather than accessing physical products. To offer better services to cloud users, cloud providers used an efficient storage cloud. These clouds offered a high level of services to their users. These clouds are also used to enhance the workability of limited storage devices like mobile phones, laptops, and many more and provide data access from anywhere. There are a number of small scales (Nimbus [3], and Eucalyptus [4]) and large-scale (Amazon EC2/S3) cloud providers are available [5]. Access to scalable virtualized resources such as computing, storage, and applications is provided by storage cloud providers through the pre-posted cost-based mechanism. Therefore, the social cloud provides a scalable computing environment in which virtualized resources are contributed by users that is dynamically past participated among a group of friends. The use of compensation is optional because users may wish to share resources without paying but instead use a model based on mutual credit (or bartering) [6]. Before registering users into the cloud environment, the service-level agreement (SLA) is signed. It is an agreement between the service provider and the service users that the services are provided in a quality and cost-efficient manner. Similarly, in the social cloud, SLA is signed between both parties (user and service providers).

Thaufeeg et al. (2011) have believed that the combination of cloud structure with social network offered the following benefits to the scientific community. These include:

(1) During the collaboration, the resources can be shared among scientists. Therefore, scientists who do not have enough computing resources are allowed to make requests to other members of their social cloud. Furthermore, even if other parties do not belong to a specific research group, they can share computing resources through the trust established by the social network.
(2) Social networks can make more effective use of available resources because scientists with the same projects will be encouraged to integrate resources to achieve common goals. In turn, this helps to reduce research costs and save time.
(3) Most importantly, it uses the familiar tools, publicity, and networking opportunities provided by social networks to promote greater collaboration between the scientific communities. In this way, social networking is not only an additional function but is actually the main function of the social cloud.

Like any community, each user of a social network is constrained by limited abilities and capacities. However, in many cases, members like friends in the social cloud may have redundant abilities, and if shared, they can be used to meet changing needs. The social cloud utilizes the pre-established trust relationship between users to realize mutually beneficial sharing in the perspectives of social networks. In the social cloud, data is exchanged between users not only point to point basis but can be shared among the entire social community group.

Chard et al. (2011) have stated that "a social cloud is a resource and service sharing platform that uses the relationship established between members of a social network [7]."

In Sect. 2, the state of the art related to the social cloud is presented. In Sect. 3, the social cloud, along with an example, is explained. Social cloud architecture that includes extra work performed by the social site (Fb) and registration process is discussed in Sect. 4. In Sect. 5, trust and reputation toward the social cloud are discussed. The application Scenario is presented in Sect. 6. The conclusion is presented in Sect. 7, followed by references.

2 Related Work

In this section, the work related to the social cloud, preferably related to trust management, is discussed. The concept of trust and reputation takes advantage of cloud security that can be studied in multiple research articles. Generally, trust and reputation can be utilized to help cloud users to make decisions about the services they want to interact with.

Habib et al. (2014) have explored how these concepts were support users in choosing a trusted cloud provider [8], while **Limam and Butaba (2010)** have proposed a reputation system to enhance the process of selecting external services that can be integrated to the project for further development [9].

Abawajy (2009) has achieved a similar goal by developing a model that suggests cloud users determine the trusted cloud environment [10].

Xiao et al. (2010) have proposed a reputation-based quality of service (QoS) supply model. As far as we know, no proposal aims to establish a unified framework that allows developers to implement existing or new trust models in the social cloud platform. However, there are other platforms or models, the aim of which is to build a trust model for different applications [11].

Singh et al. (2020) have been presented a trust model for e-government to monitor and control government policies using a social cloud environment. The researchers have used the pragmatic scheme to integrate the abilities of both cloud computing and social media platforms. The results show better results while tested to analyze Goods and Services Tax (GST) [12].

Suryanarayana et al. (2006) have presented a 4C framework, in which a trust model is described, which consists of four sub-models that are a content sub-model, communication sub-model, computation sub-model, and reaction sub-model. For all sub-models, the authors have recognized the main building block similar to the pre-existing reputation model. Finally, the researchers have used a Java-based editor and followed a personalized XML mechanism to create an XML document in which the trust model was described based on these components. Then, a PACE support generator has been used to design a software component, which can be merged into the PACE structure [13]. Later on, in the same research article, **Suryanarayana et al. (2006)** have described it further. In this research article, the authors have discussed the feasibility of an event-based structure with full guidelines on how a user can use the trust model in a decentralized app [14].

Huynh (2009) have proposed a personalized trust management model with the goal to replicate the process of trust evaluation that was performed by humans in a computing environment. People have the ability to find out the environment in which to perform a trust assessment, but this is a challenge for computers. To overcome this challenge, the researchers have proposed a policy-based system, which has been designed using semantic technology. Using this concept, the knowledge from different contexts has been gathered, and after applying the semantic approach, the most appropriate trust model based on these contexts has been determined. Although this is an interesting contribution, it focuses only on resolving the perspective dependence of trust. It lacks a framework-oriented scheme because it does not provide guidelines or any application interface to create a new trust model [15].

Yew (2011) has proposed a computational-based trust model and a middleware known by SCOUT. The middleware is composed of three services that have been used to implement the model: evidence collection service, belief formation service, and emotional trust service. Although this is a comprehensive trust model that considers many aspects of human trust, it is not created as an enhanced framework of existing research, and it is not even clear how developers implement the proposed trust models [16].

Encalada and Sequera (2017) have proposed social cloud architecture to provide experimental skills for information technology, which are called Massive Open Online Courses (MOOC). The purpose of this research is to establish a virtual community through various services and resources on the basis of trust, sharing and collaboration, and conduct large-scale, ubiquitous, and open access according to demand. The proposed framework mainly combines three important key aspects, like content, guiding principles, and technology [17].

Adelmeyer et al. (2018) have analyzed the key role of trust and replication, that is, to obtain a certain degree of trust from the directly established trustworthy relationship between a single customer and an intermediary and between online service providers and thereby obtain a certain degree of trust. The results show that there is no large amount of evidence to prove the transfer of trust, that is, the complete distribution of trust among participants in the cloud computing trust chain. The confidence of each customer is distributed between middlemen and cloud service providers. This evidence is important to providers because it can minimize direct trust issues by providing indirect services [18].

Ruan and Durresi (2019) developed a trust management method to defend cloud providers and customers from large-scale attacks. In the link or flow level, the trust level of the node and the task has been considered as a novel security parameter to determine the trust degree and hence calculate the level of security. Here, trustworthiness is used to measure the trust of a system that can be trusted under a specific attack vector. It can be used to reveal the design space of resource allocation so that it can choose the correctness between trustworthiness and the resources used [19].

Ghazvini et al. (2020) proposed a novel multilevel trust management model, which improves the existing method by defining new components to enhance the data quality of feedback storage. In the method proposed here, a new component can solve the inefficiency and sparseness of feedback storage. Some restrictions are deducted; for example, the number of existing feedback levels is invalid because some suspicious cloud users (CU) transmit unfair feedback to modify the trust evaluation value. Choosing a trusted cloud service provider (CSP) is the main challenge for CU because many CSP provides cloud services with the same functions [20].

3 Social Cloud

An individual can be a part of the social network, which is called a “friend.” He/she can be added to the social network based on some understanding between the individuals. This kind of connectivity between individuals can be utilized to understand a trust relationship between them. On the other hand, it does not describe the context of trust levels or relationships. For example, “friends” can be family members, colleagues, college friends, sports or dance club members, etc. Presently, FB has created different groups in order to distinguish friends and other communities like colleagues, sports club friends, friend members, etc. The group in the social cloud is created based on the level of trust. For example, users can restrict sharing information with close friends, friends in the same community or group, and other friends [21].

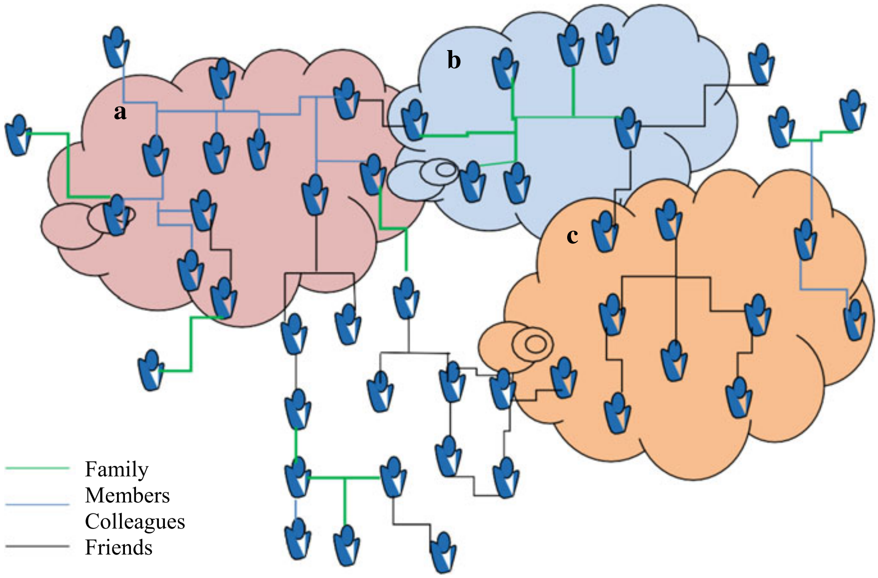

Fig. 1 Example of social cloud Chard et al. [7]

Another way to think about social clouds is to consider social network groups that are similar to dynamic virtual organizations (VO). Like VO, the created groups have some set of rules that define group intent, group membership, and group sharing policies. The related social model is shown in Fig. 1. The example considered three communities that are divided into three groups Group A (colleagues), Group B (family members), and Group C (friends). It is clear that the level of trust between colleagues, friends, and family members is different for all groups.

From Fig. 1, it is seen that the social network users may be a member of any community. For example, in group A, which is considered as the community of colleagues but instead of consisting of colleagues, the group also consists of few family members. Therefore, one can say that social clouds are not mutually exclusive. The group lasts longer and can be used for multiple applications.

4 Social Cloud Architecture

The social cloud structure designed for the Facebook application is shown in Fig. 2.

Social cloud is accessed by the user through Facebook logos by following some set of policies. For example, a user can restrict his or her trade with close friends in the same community and in the same country or region. A dedicated banking component manages credit transfers between users and also stores information related to current reservations.

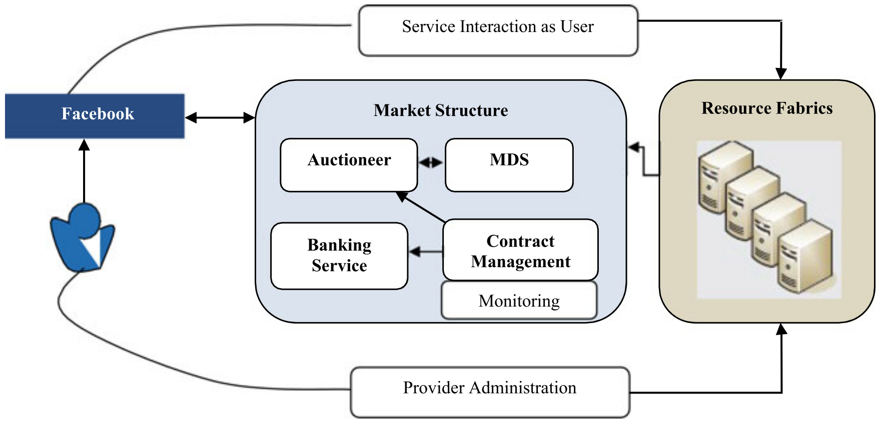

Fig. 2 Social cloud: architecture Chard et al. [22]

4.1 Extra Work Performed by FB

In this section, additional work that has to be performed by the Facebook Application Program Interface (API) in order to discuss its relation with the cloud has been discussed. The outside application can run in the Fb as a user interface; an API-based Fb graph is used to retrieve information and present it as social information. Both users and applications should use the OAuth protocol on Fb for authentication to access the Graph API. This permits the Graph API to display a basic social graph that consists of users along with their interconnections to other nodes in the social graph. This means that people, photos, events, videos, and pages can be accessed visually as well as in the form of a graph. Combining the use of Graph API with a large number of users on Fb can properly demonstrate the concept of social cloud [23]. The Facebook application is hosted independently and outside the Fb environment. An image-based Facebook URL is created for users to access, which is mapped to a remotely hosted user-defined callback URL. The process of accessing the application page is illustrated in Fig. 3. Initially, the user sends a request to the social cloud through the Fb interface that is by login his/her ID and password. The accepted request is then forwarded to the called URL. The application creates a page as per user request and returns it to the Facebook account of the user.

4.2 Registration Process of Social Cloud

The registration process for the user in the social cloud is shown in Fig. 4.

Firstly, the user has to register him/her and then select the services he/she want to access from the social cloud as the user is registered through their FB ID (login and password); therefore, during banking services, user instances can be created transparently by using his/her Fb ID.

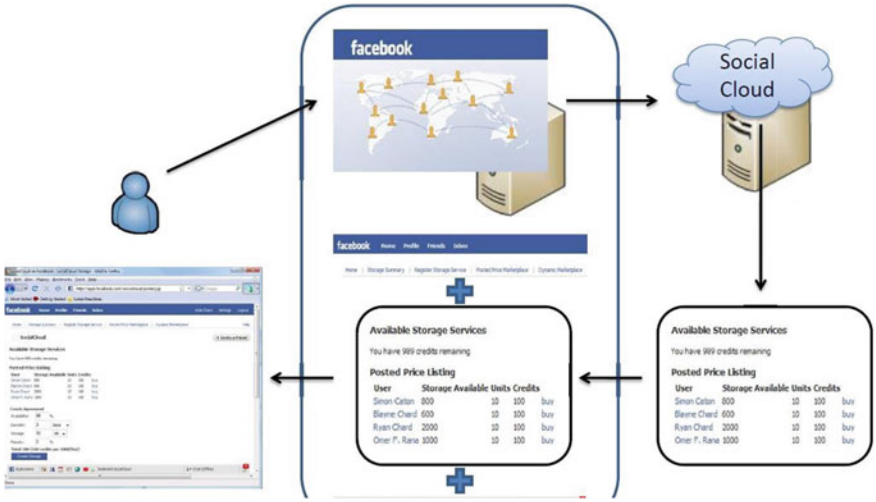

Fig. 3 Page deliver process requested by the social cloud user Chard et al. [22]

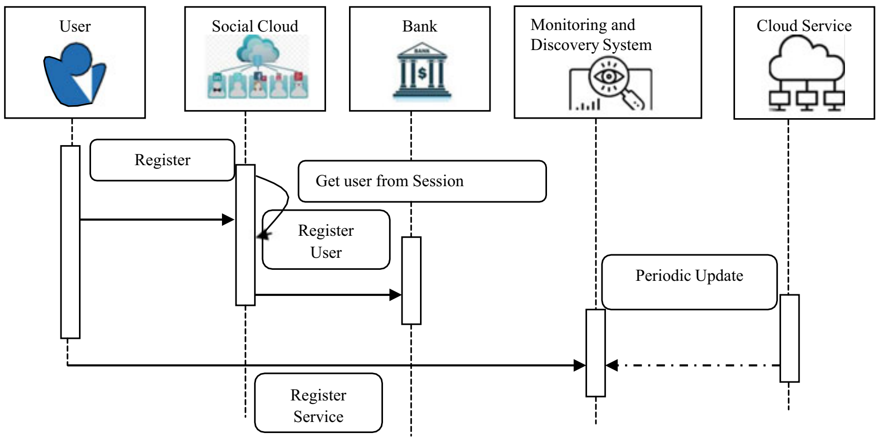

Fig. 4 Social cloud registration process Chard et al. [22]

5 Exploiting Trust in the Cloud: Toward the Social Cloud

To enhance the cloud model in collaborative network environments (such as social networks), trust and reputation are the major issues. Chard et al. (2010) have proposed architecture for the social cloud that basically uses traditional social networks to create a trusted cloud environment, where social cloud users can effortlessly share storage resources of the cloud. The researchers have implemented the prototype by utilizing an API that is provided by Facebook, which allows the use of pre-established trust relationships between friends.

We believe that although this method is interesting and new, it also has a disadvantage: it assumes that the trust relationship completely depends upon the relationship between friends, which is far from the truth. The reason behind this is that social networking users accept friend's requests from known as well as unknown persons who ask for friendship. Moreover, when any of the user's friends start an annoying behavior, the user tried to not finish the relationship because it can be considered as an impolite reaction. On the other hand, due to the status and quality of the services provided, the author does not consider changes in reputation or trust relationships.

For the above reasons, we observed that the need for a more comprehensive approach that considers both trust and reputation requirements from the beginning, and a framework to help developers to build this environment from scratch is required [24].

5.1 Scenario Description of Social Cloud

Developers need to implement social networking sites for cloud providers. Next, briefly explain the purpose and operation of the site to figure out a real situation that requires trust and reputation considerations. To access the services, cloud users have to register on the site. After registration, the web services are published on their sites, and the entire detail related to the web service can be obtained by calling the API app. Web services can find out by the cloud providers based on their needs. Then, these services are used to create larger and mixed web services. After utilizing the services offered by the cloud providers, cloud users have to pay as per the complexity and the type of services. Therefore, the websites are acting as a "software-as-a-service" market among CSP. In the end, each CSP will use its own infrastructure to deliver the final service to its cloud users, although this is beyond the scope of the solution [24].

5.2 Trust and Reputation Requirements

For cloud providers, the core framework should apply trust and reputation requirements to avoid risks and increase site trust.

There are two main influential people in this scenario: Cloud providers and web service providers. The reputation of each provider depends upon the personal opinion or can be obtained from the providers of another site. For example, if the services provided by the CSP are not up to mark, then the user rates it negatively, which affects the reputation of the CSP negatively.

As shown in Fig. 5, when a service holder demands or searches or aims to buy things up for the processing, the cloud service provider looks for the reputation

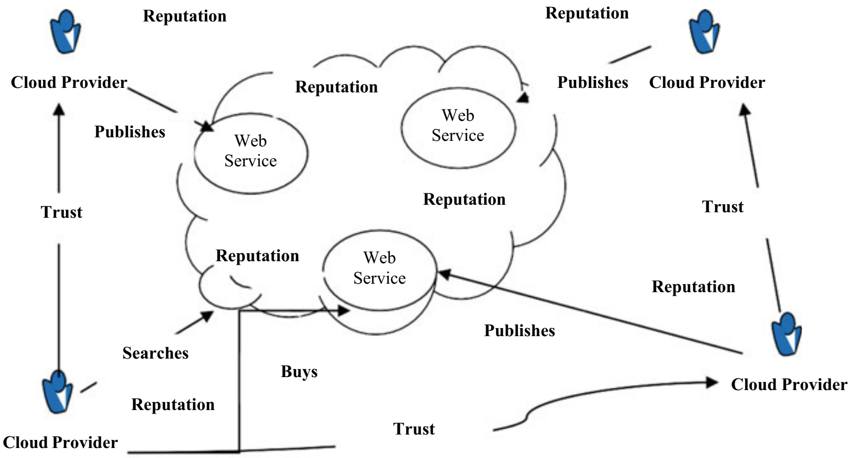

Fig. 5 Trust and reputation scenario Moyano et al. [25]

holders for the selection of the provider. There are various ways through which the reputation can be evaluated and are discussed in the proceeding sections.

In addition to reputation, cloud providers can also establish trust relationships with each other. Although there is a significant relationship exists between trust and reputation, both should be required to be established on the website. The relationship between trust and reputation is shown in Fig. 5. The way to calculate trust and reputation depends on the model being implemented and should provide a mechanism for accessing cloud services to decide which model the user should use while accessing services.

Trust plays a vital role in the selection of a service-oriented architecture for the process of user demand. There are many ways through which trust can be evaluated in the cloud network. There are some of the foremost application architectures and independent evaluation bodies that have already given evaluation methods and architecture [26]. In the trust evaluation, there are certain aspects that have been discussed and are illustrated as follows in Fig. 6.

There are several factors that are responsible for the evaluation of trust in the real-time network. Some of the parameters are well known, whereas some of the parameters are strictly performance-oriented. As shown in Fig. 6, trust has four evaluation factors, namely co-work, co-location, co-operations, and performance. Two people are said to be in work relation if they work together. Co-operations are similar to co-work with the difference that two people should have worked at least once in order to come under co-operations, including the fact that the produced outcome should be positive. If all the aspects are combined, it will form an equation as follows

$$T = \mu \times W1 + \rho \times W2 + € \times W3 \quad (1)$$

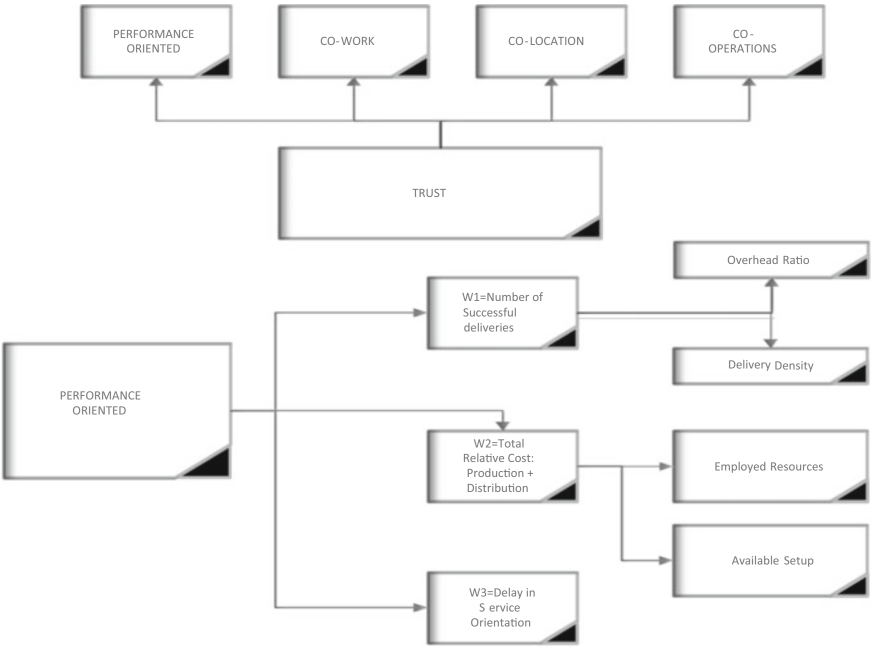

Fig. 6 Trust evaluation and factors

where $W1$, $W2$, and $W3$ are converted factors attained from the trust model, and μ, ρ and €are coefficients that may increase with the increase in the factors affecting the trust model. This paper takes the service contrast in action and analyzes how reputation can be generated using the service factor. It is not necessary that if a user is associated with another user in any term of work, the second user will provide the best facilities for the desired work. Hence, an analytical model evaluation is required based on the services provided by the user in the past.

Based on the service orientation, two feedback architectures have been studied and used in the modern frame. The first one is called direct feedback, and another one is called transactional feedback. Direct feedback is attained when a person demands work from another user and develop a feedback mechanism on his own based on the type of service he/she gets. The transitional feedback involves a lot of other processing that the user exhibits in the current network. All the work areas are different, and their attained potentials are also different, and hence to use them, it has to be bring brought to one scale. There are different methods of normalization and scaling, as shown in Fig. 7 [27].

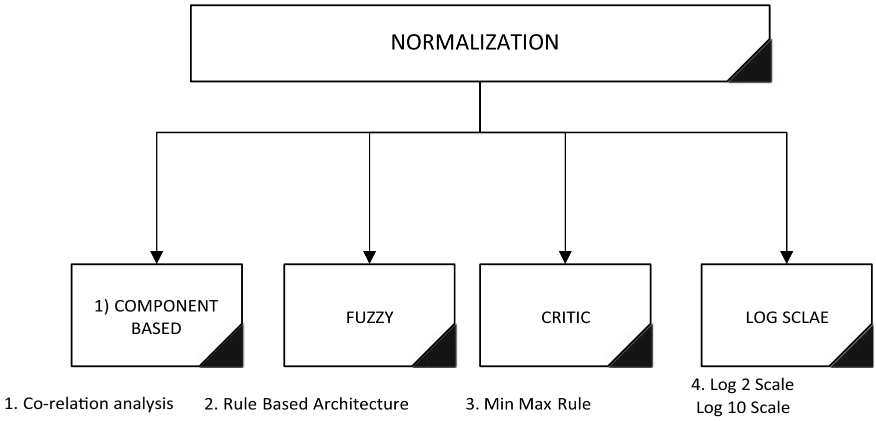

Fig. 7 Normalization methods

6 Application Scenarios

This section represents the application scenarios of the social cloud. There are enormous benefits while one uses the social cloud. The difference with social cloud is that applications can use user relationships to provide or shared resources and services.

A social computation cloud: It is common for personal computers not to use large amounts of computing power. Using the social cloud, an infrastructure is provided where users can easily share computing resources among friends or groups.

A social storage cloud: Storage is one of the simplest and easiest ways to share resource whenever cloud user needs in a social cloud environment. Online storage is mostly used by cloud users to save, backup, and to create a duplicate copy of the data. An open use for social storage cloud is to store and share multimedia data such as photos. Although most social networks like Facebook, Twitter, Instagram, etc., already save photos, to balance the load, these photos can be moved from the service providers to their members so that the scalability can be increased with the reduction in infrastructure cost.

A collaborative social cloud: Increasingly, collaborations are turning the concept of social networking that can be used to share information as well as resources within diverse user communities. The usefulness of the social cloud can be realized by hosting it in the existing social networks. Storage services can be utilized to save or share data (e.g., academic papers, scientific workflows, databases, and analysis, etc.).

A social cloud for public science: Social cloud provides a platform for a scientist to solve complex problems by using communities of social networks. There are a number of projects that are working as volunteer computing to solve the problem; one such project is Berkeley Open Infrastructure for Network Computing (BOINC) [28]. This project requires a large amount of computing power from the available resources. Using the social cloud, resources of social networking sites are utilized in an efficient manner with the aim to provide services to the social users with high service-level agreement (SLA).

An enterprise Social Cloud: Depending on the community social cloud serves, the configuration of it may vary. For all organizations, it is mainly common for all; for example, educational institutes like schools, colleges, and universities all have a public cloud. This offers great opportunities for a professional organization with the social cloud. The users get double benefits. That is, one is from the available sources, and the other is from the shared resources [7].

7 Conclusion

This article introduced social cloud computing, which the integration of cloud is computing and social networks. The uniqueness of the social cloud is that it provides heterogeneous resource transactions based on the inherent social motivation in social networks and the external real-world relationship. The architecture and registration process of social clouds and extra work performed by Fb has been discussed. The trust relationship established by the face book user to discover and use cloud storage space with their friends and communities has been discussed. Also, a trust framework that can help developers to implement applications that need to consider trust and reputation requirements has been presented. Such applications are appearing steadily in response to users' growing needs eager to share their information in collaborative environments. With the increase in blogging and social networking sites, social cloud applications take a step forward by turning users into service providers, which raises a lot of security and trust issues. This requires a holistic approach to solve these problems. We believe that trust and reputation requirements have become particularly important elements to take advantage of the security and promote the adoption of such applications.

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