Social Cloud: Concept, Current Trends and Future Scope

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Abstract

In recent years, the idea of Social Cloud has been coming to the forefront of research. Social Cloud is a metaphor of collaborative resource sharing framework on online Social network. The central theme of Social Cloud is to utilize computational resources on the basis of ‘give-and-take’ policy for mutual benefit. By keeping Social Cloud is a collaborative resource sharing framework and as a center point, researchers visualize Social Cloud from various perspective. The series of reported views regarding Social Cloud, on the one hand, shows its potential to act as a unique computing, on the other hand, makes the overall picture confusing. Moreover, research and development on Social Cloud is currently at its infancy, with many issues still to be addressed. In this paper, we present a survey on Social Cloud, highlighting its key concept, current trends as well as research challenges. The aim of our work is to provide a better understanding of the theoretical challenges of Social Cloud.

1 Social Cloud

Computing paradigm has seen a massive shift in last few years. This gradual shift in computing paradigm is essentially to address the different needs of the hour. Distributed computing concept emerged with an aim to connect users and computing resources in a transparent, reliable and scalable way to achieve huge computing power. Subsequently, Cluster computing, a form of distributed computing enables to utilize computational power of standalone computers by integrating them. Cluster computing logically provides a single unified computational resource. This follows a number of resources sharing computing paradigms namely Grid computing [1], P2P computing [2], Volunteer computing [3], Utility computing [4] and recently Cloud computing. These computing paradigm share common characteristics like resource sharing or to utilize computational power of standalone resources. However, these are distinguishable with respect to their resource provision mechanisms, domains of applicability and associated principal stakeholders. For example, Grid and Volunteer computing operates in trustless framework wherein risk is associated with the notion of ‘sharing’ resources or services [5]. In Volunteer computing, the volunteered hosts are unreliable and insecure, hence, it is likely that incorrect result can be yielded by malicious volunteer [6]. Recently emerged Cloud computing is very much business centric and may not fit well for those who concerns about
cost or do not bother about strong performance guarantees [7].

Of late, researchers present collaborative resource sharing framework standing on on-line Social network. The idea is to take advantage of pre-established trust between users for collaborative resource sharing. Increasing trends to donate computational resources to scientific project in Volunteer computing and Virtual Organization policy in Grid inspires researchers to think about Social Cloud. In simple words, traditional Cloud computing can be defined as ‘computational resources on network’. And these computational resources are provided by private data-centers to users in the form of service. Whereas Social Cloud can be defined as ‘computational resources on on-line Social network’ and these computational resources is shared and traded by users of online Social network for mutual benefit. In recent years, many researchers keep resource sharing on Social network as a central theme of Social Cloud and visualize it through various visions and outlooks. The series of recently reported views show potential of Social Cloud to act as complimentary to other computing paradigms such as Volunteer computing, Cloud computing or Grid computing. Despite this, several views creates a confusion regarding Social Cloud paradigm. This confusion is in terms of resource definition and visualization of Social Cloud.

Various views presented to define Social Cloud can be classified on the basis of resource definition and principal stakeholders. Resource definition such as: a) physical or virtual entity of limited availability (e.g. underutilized storage space of personal computer [8] [9] [10]), b) user’s own virtual machines image or virtual machines image of third party vendor (e.g. Amazon S3 [11]), c) user’s hired resources from third party vendor (such as Amazon EC2 [12]). On the other side, every other computing framework such as Cloud, Grid or Volunteer computing elucidate principal stakeholders. In Cloud computing, provider and consumer are beneficiary, in Grid computing, virtual organization members take benefit form resource sharing whereas in Volunteer computing, scientific projects benefitted by voluntarily shared resources. While describing Social Cloud computing, researchers look at various principal stakeholders of this novel concept. Chard et al. [8] looks Social Cloud a as mutually beneficial resource sharing framework where all group members are benefited by resource sharing. Christian et al. [9] argue that Volunteer computing does not allow users to avail shared resources but Social Cloud does. John et al. [13] consider Social Cloud as an extension of Volunteer computing where scientific projects are principal stakeholders.

Although different views have been put forwarded, still the research and development in Social Cloud is at an early stage and leads to confusion in terms of resource definition or prominent stakeholders. Our initial study and understanding reveal that Social Cloud has a very promising prospect comparable to other distributed computing paradigms. With this as the state of the art, in this paper, we cast a glance on Social Cloud concept, present review of current trends and try to bring forward pivotal research issues of Social Cloud. The primary objective of this paper is to highlight the current trends and research challenges to make way for further development in the field of Social Cloud.

The rest of the paper is organized as follows. Section 2 includes concept of Social Cloud. Section 3 presents a survey of current trends in Social Cloud. In Section 4, we highlight research challenges such as service availability, group formation, design of market model, social loafing. Section 5 summarizes the survey result and concludes the work.

2 Social Cloud: The Concept

In this section, we discuss the concept of Social Cloud, its potential as a computing framework and relate Social Cloud with other computing paradigms namely Volunteer, Grid and Cloud computing paradigms.
2.1 Definition of Social Cloud

A Social network is a set of actors and a set of ties representing some relationship among the actors [14]. Actors in a Social network (people, organizations or other social entities) are connected by a set of relationships, such as friendship, affiliation, financial exchanges, trading relations or information exchange [15]. Facebook, Google+, LinkedIn are some examples of Social networking sites as web-based services which allow users to create their profile and articulate a list of other users with whom they share a connection. Users share their information, thoughts, ideas, photos and videos from their personal desktop or laptop to friends in online Social network community. Most of the times when people work on their PC or laptop, utilize small fraction of resources and hence major section of resources like processor, working environment, and storage are in under utilization. If people are able to share photos or videos, then why not a part of their laptop or PC? Social Cloud aims to provide mechanism for such resource sharing. Social Cloud model allows users to fulfill computational need of an individual by availing underutilized resources of other users in Social network environment. With this concept in mind, Chard et al. [8] defines Social Cloud as a resources and service sharing framework utilizing relationships established between members of a Social network.

Social Cloud is a novel concept which considers computational resource sharing standing on the layer of online Social network framework. In Social Cloud, computational resources represent virtualized storage, working environment (e.g. GnuPlot, program execution environment or virtual machine). Users of Social network take benefit of inbuilt trustful relationship to contribute underutilized resources to others and avails others’ contributed resources to satisfy personal need. On the foundation of trustful relationship, users on Social network builds the group. The objective is to collaborate under utilized computational resources within the group for mutual benefit. This shared services or resources create an illusion of virtual data-center which we term as Social Cloud. Figure 1 shows Social Cloud view standing on Social network, where people donate under utilized computational resources to other group members and in return utilizes others’ resources in need.

To facilitate resource sharing and trading, group members can decide a suitable medium of resource exchange. For example, resource trading in Social Cloud is in the form of either monetary or non-monetary (e.g. credit points, reputation). Adoption of suitable resource trading and sharing (resource management) mechanism is a choice of the group. Social Cloud members can select either economical or non-economical market metaphor for such resource trading.

In Social Cloud, group members decide membership policies for new members. Group decides entry level resource contribution as a membership policy. For example, should we allow free entry for a new user or with some constraint in terms of minimum resource sharing? It is also possible that multiple Social Cloud can exist on Social network controlled by different groups with their own suitable market metaphor. Selection of suitable metaphor is a choice of group and depends on the requirement and groups foci. One member of a Social Cloud can be a member of another Social Cloud but bound to trading policies of associated Social Clouds. And this can be true for all Cloud members, those are having membership of two or more Social Clouds. Figure 2 shows multiple membership scenario in Social Clouds. In Fig. 2, user ‘E’ is associated with Social Cloud SC-1 and SC-2 but user ‘K’ is a member of all three Social Clouds. In other words, user ‘E’ has membership of Social Cloud SC-1 and SC-2 whereas user ‘K’ has membership of all three Social Clouds. In future, multiple membership could be utilized to overcome an issue of service availability. In other words, a member having membership of two or more cloud can act as intermediate between two Social Clouds existed on Social network. For example, in Fig 2, ‘B’ being a member of Social Cloud (SC-1) can avail services offered by member ‘N’ of SC-3 through ‘K’.
2.2 Potential of Social Cloud

Social Cloud can serve computational need of an individual. Social Cloud also has potential like Volunteer computing to present huge computational power and support to high computational intensive scientific projects. Following application oriented examples demonstrate, how Social Cloud satisfies computational need of an individual as well as allows to perform distributed computing.

- Social Cloud as traditional Cloud
Social Cloud members can offer under utilized storage space to their friends. For example, a member of Social Cloud as like commercial data center offers storage-as-a-service to needful member of that Social Cloud. The proof of concept of such efforts is worked out in [8].

- Social Cloud as Volunteer computing
  Like BOINC [16], where volunteers donate their idle resources to do scientific computing where volunteers can form team and do so. Social Cloud also can be thought as a team. This team can donate their computational resources for scientific computing and gain credit as in Volunteer computing community. The proof of concept of amalgamation of Social Cloud and Volunteer computing is given in [17].

- Social Cloud as distributed computing
  Distributed computing only works if many people participate along with their computing resources. Social Cloud is an ideal framework for distributed computing. One friend can outsource a computational task to other group member. Let us say a college friend deploy Social Cloud on the Social network. Among them one group member is enrolled for parallel computing. She can perform an assignment of parallel computing task by availing shared resources. Mohaisen et al. [18] give proof of concept and shows how Social Cloud acts as distributed computing.

2.3 Social Cloud versus other Computing Paradigms

Current research in Social Cloud demonstrates the potential of Social Cloud and also compare with existing distributed computing paradigms like Grid computing, Volunteer computing or Cloud computing. Although, Social Cloud is inspired by Volunteer computing (VC) and Virtual organization (VO) in Grid, but Social Cloud emerge with its own characteristics like different resource sharing framework and its principal stakeholders and domain of applicability.

In Volunteer computing, users donate their idle resources to scientific projects through BOINC [16] middleware. Note that in this framework, users are anonymous and are not accountable for their actions. In Volunteer computing, project faces issue like application crash owing to incorrect output may result from a hardware malfunction, or a intentional malicious attack by volunteers [6]. On the other hand, in Social Cloud, as users are tied through relationship and maintain obligations and hence bestow accountability. Social Cloud, a trustful computing framework, can resolve issue of application crash (such as in Volunteer computing). In Grid, a number of mutually distrustful and self interested participants with varying degrees of prior relationship (perhaps none at all) want to share resources in order to perform some task [1]. Grid computing faces issues like data integrity, resource security and safety, resource selection or malicious computation owing to distrustful environment [19]. In this sense, Social Cloud is lucrative. In Social Cloud, resource sharing performs among trustful group members and hence can overcome issues like data integrity, malicious computation, resource security etc.

Recently emerged Cloud computing is a large pool of easily usable and accessible virtualized resources like platform, infrastructure, applications [20]. This pool of resources is typically exploited by pay-per-use model in which guarantees are offered by means of customized SLAs [21]. Further, the scalable resource provision managed by centralized control, Cloud service provider dynamically reconfigure resources according to a variable load. Nevertheless, Social Cloud does not follow inherent characteristics of classical Cloud computing. In contrast to Cloud computing, Social Cloud is a resource pool of heterogeneous virtualized resources controlled by users of Social network. These virtualized resources are managed by decentralized control. Another and most notable feature of
Table 1: Summary of comparison of Social Cloud with other distributed computing paradigms

| Parameter          | Grid computing | Cloud computing | Social computing | Volunteer computing |
|--------------------|----------------|-----------------|------------------|---------------------|
| SLA                | No             | Yes             | Remit            | No                  |
| Trust              | No             | No              | Yes              | No                  |
| Service availability | Margin-able    | Yes             | An issue         | An issue            |
| Resource Control   | Decentralize   | Centralize      | Decentralize     | Decentralize        |
| Payment Mode       | Pay and Use    | Pay-per-Use     | Optional         | Credit              |
| Heterogeneity      | Yes            | Yes             | Yes              | Yes                 |
| QoS                | Not committed  | Through SLA     | Common understanding | No                  |

Social Cloud is that pre-established trust and common understanding among group members remit SLA. However, this depends on resource sharing model adopted by group members and also group nature. For example, if Social Cloud members share resources voluntarily, then SLA is insignificant. But, if Social Cloud operates with an economic model where resource trading done through monetary form, SLA plays an important role to assure QoS. Table 1 summarizes a comparison of Social Cloud with other distributed computing paradigms.

3 Current Trends

In this section, we take a look on the recent status of Social Cloud computing. In recent literature, a number of work have been reported related to design, development and implementation of Social Cloud computing. We survey the work with reference to the views of Social Cloud, application domains, infrastructure deployment, resource trading and sharing mechanisms, incentive and trust aspects.

3.1 Views of Social Cloud

Researchers view Social Cloud in various aspects. In a nutshell, Social Cloud is a metaphor of resource sharing framework on Social network which is everyones’ consensus. But resource definition, principal stakeholder and more or less different application scenarios lead to several views of Social Cloud. Chard et al. [8] outlines veracious aspects of Social Cloud. They consider resource as a physical or virtual entity of limited availability (e.g. underutilized storage space of personal computer). Here, a resource can be people, information, computing capacity or software licenses. In Cloud computing, virtual images offer great flexibility to commercial data-center in Cloud service provision. Thaufeeg et al. [11] propose virtual machines as the unit of resource sharing unit. Users
share their own virtual machine images or virtual machine images of third party vendors such as Amazon S3. Ali et al. [12] visualize Social Cloud as an integration of commercial Cloud computing and Social network, where users hire resources from third party vendor, for example, Amazon AWS, and latter these resources are shared in Social Cloud.

While describing Social Cloud, researchers look at various principal stakeholders. John et al. [13] and Bubendorfer et al. [17] propose Social Cloud for scientific research (Their combined work is termed as eResearch). They integrate Social network and BOINC [16]. Users on Social network donate resources to scientific project and by this both user and projects get benefited. Chard et al. [8] looks Social Cloud is mutually beneficial resource sharing framework. Here, Social Cloud members are benefited with resource sharing and trading. Haas et al. [9] differentiate Social Cloud to Volunteer computing in terms of resource consumption. In Volunteer computing, users only donate resources to scientific project but not able to consume, whereas Social Cloud allows resource consumption of other users for mutual benefit.

Caton et al. [10] visualize Social Cloud as an alternative concept to Cloud computing. Social Cloud overcomes obstacle issues of Cloud computing such as trust, security, anonymity and sometime reliability. Mohaisen et al. [18] holds the view that, Social Cloud as distributed computing paradigm, overlay on Social graph. To put it more simply, Social Cloud is built on top of another on-line Social network. Mohaisen et al. describe Social Cloud as a pool of computing resources shared by nodes in Social graph. They define two types of nodes: a task outsourcer who has to perform a distributed computing task and other node is workers who perform the task on behalf of the task outsourcer. In their proposed computing framework, a node (friend) would avail shared resources of other nodes (friends) to perform a distributed computational task. They compare proposed computing framework with Grid computing on the basis of trust. Mohaisen et al. [18] argues that sometimes the Grid computing computation is error prone owing to malicious act of node. In contrast, Social Cloud stands on pre-defined relationship between task outsourcer and the computing worker, assures less malicious activity thus resulting less wrong computation.

3.2 Application Domain of Social Cloud

Chard et al. [8] demonstrate the significance of Social Cloud. Authors developed a Web-service based Social Storage Cloud (SSC). This is an effort to provide storage as a service within Social Cloud. To participate in the Social Cloud, each user must allocate a certain amount of their resources to be used by others.

Thaufeg et al. [11] proposes Social Collaborative Cloud (SoCC) to facilitate scientist to collaborate and to share resources to implement computation intensive algorithms and large data sets in virtualized research environment. This work considers virtual machine (VM) as a low level computational resource for sharing purpose. Members of the Social Cloud can contribute, request, and use virtual machine from other members to perform scientific computation.

While describing Social Cloud as distributed computing framework, Mohaisen et al. [18] mention that Social Cloud framework could be complementary for Grid-like system, like in Nebula [7], SETI@home [22], Condor [23]. These listed Grid systems built to compute intensive applications such as blog analysis [24], scientific computing [25], Web crawling and social apps (image processing or collaborative filtering [26]). Indeed, above stated, volunteer resource sharing based Grid systems confront an issue like Sybil attack [27] on account of lack of trust feature. Mohaisen et al. [18] envisage Social Cloud computing framework could defense Sybil attack because of trust between nodes, and deployment of Social Cloud provides an infrastructure to compute above mentioned applications (i.e. blog analysis, scientific computing etc.)

John et al. [13] propose Social Cloud for Public eResearch by integrating Social networking and
Volunteer computing (e.g. BOINC) to link research and public on Social network. In this work, John et al. [13] pay attention, to make available huge computational power to perform high computation intensive task in a cost effective way. In other words, a huge computational power can be achieved incorporating Social network users, and obtained computational power to realize scientific projects (like SETI@home). It may be noted that in its present form, BOINC [16] provides an account management system to ease the process of joining and contributing resources and allows users to set up a meta-account over multiple selected projects. But BOINC account management system does not have any social features that would bring in new users and keep existing users involved for resource contribution. On the contrary, Social Cloud for Public eResearch is an account management system, that helps volunteers on Social network to select interested project to contribute. More precisely, Social Cloud for Public eResearch helps researchers to publish their projects to Social network users.

3.3 Infrastructure Deployment in Social Cloud

Cloud computing is not necessarily a one size fits all computing model. Infrastructure deployment varies according to application. There are several different ways the infrastructure can deploy to build Cloud solution. Social Cloud has been initiated as an effort to build Cloud like environment in Social network premises. At present, various ways suggested by researchers to deploy infrastructure for achieving specific goal. Major research in Social Cloud considers Facebook application as a middleware to facilitate resource provision. Facebook application is a choice due to OpenGraph API. Open APIs (Open Application Programming Interface) support interoperability by providing the tools to share data used to develop useful Web applications [25]. Open API, allows integration of social media services and third-party site application development that can be built on the top of the Social network platforms. Facebook introduced OpenGraph on April 21, 2010. It has three parts: a) The OpenGraph Protocol which facilitates third party developer to tag their application into the Social graph, b) Graph API which allows to access Facebook data such as friends, events, groups to third party developer to build apps c) Social plugins which allows user to extend Facebook application by adding few lines of code. Social Cloud researchers prefer Facebook application due to Facebook Markup Language (FBML), Facebook JavaScript (FBJS) and Facebook Query Language (FQL). FBML enables the creation of application that integrates completely with Facebook look whereas FBJS permits developers to use it in their applications. FQL allows third party to use an SQL-style interface to query some Facebook social data easily, such as the name or friends list, group membership of a user etc.

A Web service based Social Storage Cloud (SSC) is deployed as a Facebook application. Social Storage Cloud enables storage provision within group members, and users can share unutilized storage space with other users who are in need, within the group. Social Storage Cloud uses XML-based metadata to advertise storage capacity available with users. This metadata is periodically refreshed and stored in Globus Monitoring and Discovery System (MDS) [29]. Deployed Social Storage Cloud is based on a Web Services Resource Framework (WSRF) storage service, which provides an interface for users to access virtualized storage. In Social Cloud requires coordination mechanism (like market structure, scheduling algorithm or bilateral exchange between users) to facilitate basic operations such as resource allocation, resource trading and sharing, user management etc. Indeed, its essential to have computational infrastructure

1 http://boinc.berkeley.edu/trac/wiki/AccountManagement
2 http://wiki.developers.facebook.com/index.php/FBML
3 http://wiki.developers.facebook.com/index.php/FBJS
4 http://wiki.developers.facebook.com/index.php/FQL
or platform needed to implement such coordination mechanism. Haas et al. [31] pointed out the issue of formation of computational by viewing a question that how platform be supported and by whom? They propose a ‘co-op a scalable computing infrastructure owned and managed by its users. In co-op model each user has to share certain quantity of computational resources to build platform. Haas et al. [31] follows two schemes for contribution:

- Enforced fixed contribution: In this scheme its compulsory for each user to share a certain quantity of resources to build computational platform.
- Voluntary variable contribution: In this scheme user can freely choose certain level of quantity for sharing.

Haas et al. [31], evaluate above two scheme, they found that both the scheme achieve minimum level of computational requirement that is necessary to build Social Cloud infrastructure. However, the utility of user is higher in voluntary variable contribution scheme than enforced fixed contribution scheme. The infrastructure deployment for Social Collaborative Cloud [11] is developed as an integrated Social network application that leverage functionalities of the host Social network (e.g. Facebook), such as user authentication, registration, user relationship. The prototype of Social Collaborative Cloud is implemented as a Facebook application and includes Virtual Machine (VM) scheduling and a VM Image Store. The architecture of the Social Collaborative Cloud includes major components such as Application server, which hosts the Facebook application that integrates Social Collaborative Cloud with the Social network. VM Image Store contains the base set of operating system images for the VM and prepackaged images ease quick instantiation for users and scheduler, ensures VM images are distributed fairly and evenly among individual resource contributors. Thaufeeg et al. [11] also describe the functionality of the proposed Social Collaborative Cloud in terms of interaction between various components including users and external services. Two VM image distribution methods are implemented for Social Collaborative Cloud performance evaluation namely Direct-package of VM and second one is Pre-package. First method follows direct packaging of VM images, users submit path of VM image to Social Collaborative Cloud and later the host machine downloads image from the given path. But this method is more time consuming owing to instantiation. Advantage of direct packaging is higher user level customization of the image. In second method, VM image is prepackaged by Social Collaborative Cloud and distributed in advance. This method takes less time compare to direct packaging. After evaluation, Thaufeeg et al. [11] conclude that direct packaging of image is more suitable for small sizes whereas prepackaging is suitable for quick deployment of VM.

In traditional Volunteer computing, volunteer donate computational resources (storage or processing power) through BOINC (an open source middleware) [16] client. In Volunteer computing, all projects are independent and each one operates its own servers. There is no central approval process. Volunteer can donate their resources to more than one projects. A BOINC account manager is an application that manages multiple BOINC project accounts. Through BOINC account manager, volunteers can attach or detach project. Without BOINC account manager, volunteer needs to find project by ‘word-of-mouth’ or using a search engine and further for every project volunteer needs to open separate account. To overcome this difficulty, John et al. [13] give proof of concept of infrastructure deployment for proposed Social Cloud for Public eResearch. In this work, Social Cloud is merely an account management system that run as Facebook application. Like BOINC account manager, Social Cloud connects projects server using BOINC WebRpc[5]. BOINC project server supports Web remote procedure call. John et al. [13], describes two way to attach BOINC client to Social Cloud. Either, information about the Social Cloud can bundle with client installer or

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[5] http://boinc.berkeley.edu/trac/wiki/WebRpc
user can specify Social Cloud as their account management system. But, in either case user has to provide authentication details to BOINC client, to receive projects and resource sharing preferences form the Social Cloud. John et al. [13] argues that as long as project support WebRpc, the Social Cloud account manager supports it.

In another deployment method, Mohaisen et al. [18] investigate potential of the Social Cloud in order to construct distributed computing services. It should be underlined that, Mohaisen et al. [18] omit a lot of details about the underlying infrastructure, and present only an abstract of Social Cloud infrastructure. Mohaisen et al. [18] verify the potential of the Social Cloud through Batch-based-simulator [6]. In this computing framework, a node is defined as a task outsourcer who outsource a task to 1-hop neighbor nodes, defined as workers. At a given instance, any node can act as a task outsourcer while others play role of workers. Each worker computes the assigned task independently. In this work, Mohaisen et al. [18] give design specification of their Social Cloud. It includes scheduling entity, scheduling policy and outlier handling. The Scheduling entity contains two type of schedulers. One scheduler is at the end of task outsourcer side to determine the proportion of task to be outsourced. Another one is at worker side to determine computation order of outsourced task. Here, a task outsourcer uses local information to outsource a task to 1-hop worker. Task outsourcer schedule the amount of computation to each and every one of the worker to take care of. In this Social Cloud, task outsourcer further has two choices for scheduler either decentralized scheduler or centralized scheduler. Decentralized scheduler explicitly decides to whom (i.e. worker) to allocate a task. Whereas, the centralized scheduler implemented as a central server, suggests best worker set to task outsourcer and accordingly task outsourcer assign the task to workers. The task scheduling policy is another part of Social Cloud design, concerns how much computation to outsource each worker and how much time a worker should spent on a given task. To address scheduling policy issue, Mohaisen et al. [18] suggest off-the-shelf scheduling algorithms such as round robin, shortest job first scheduling algorithm etc. How much time requires to all workers (nodes) to compute a task is the performance evaluation criteria of the Social Cloud. On the basis of this criteria, Mohaisen et al. [18] suggest a simple mechanism to detect and handle an outlier (a malicious node). While allocating a task to nodes, total time is given in advance. In this approach, if any node takes longer time to perform a task while others are idle then that node is treated as outlier. To handle this node, outsource the remaining tasks to all other idle nodes. In this work, Mohaisen et al. [18] came up with important outcome, that is, even the number of outsourcers computation is high, it takes relatively shorter time to finish the computation.

3.4 Resource Sharing and Trading Mechanism

To regulate and facilitate resource sharing and trading, researchers suggested several models. Chard et al. [8] implement ‘Posted Price’ and auction marketplace. In Posted Price, a user can select any advertised service by her friends and define specific requirements (such as storage amount, duration, availability and penalties) of the provision. In the reverse auction (tender or procurement) market, a user can specify their storage requirements and then submit an auction request to the social storage cloud. Users’ friend then bid to provide the requested storage. In this work, Chard et al. [8] discuss following market metaphors as candidates for resource sharing and trading that group member can use.

- **Bartering based model**

All group members need to own resources and trade/share resources by exchanges (e.g. storage-as-service for platform-as-service). Receive one resource in exchange of another resource.

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[6] SCloud Team, "Social Cloud," http://socialcloud.cypriv.com, July 2012.
• **Price based model**  
Group members use monetary medium for resource trading. In this model, resources can be allocated with the help of auction or posted price market models.

• **Volunteer or altruistic based model**  
Altruism is a form of unconditional kindness, that is, altruism does not emerge as a response to altruism received. Users trade their resources without seeking future gain.

• **Reciprocation based model**  
An example of reciprocity is, ‘A’ man ought to be a friend to his friend and repay gift with gift. People should meet smiles with smiles and lies with treachery. Member can do share and trade in this way. However, in reciprocate model user could see future expected gain [32].

• **Reputation based model**  
Social cloud member can use reputation points as medium of resource exchange, where a user with higher reputation point favored to allocate resources or services.

Mohaisen et al. [18] visualize Social Cloud as a distributed computing paradigm, adopts altruistic model, in which users donates their idle computing resources to others to perform specific distributed computing task. Ali et al. [12] proposes Cloud Resource Bartering model (CRB-model) for sharing and trading resources in a Social Cloud. Bartering helps Social Cloud members to barter cloud resources without money exchange in hands.

### 3.5 Trust and Incentives in Social Cloud

Trust is backbone of Social Cloud. In Social Cloud, trust plays vital role to enable resource collaboration. Trust provides uniqueness to Social Cloud compared to other computing paradigms such as Cloud, Grid, and Volunteer computing. Several efforts have been given to define trust within the context of Social Cloud. Caton et al. [10] present a three-staged cycle to define the role of trust in the context of Social Cloud. These three stages are: prior expectation, social interchange and completion. In first stage, prior expectation, Caton et al. [10] discusses about why a user considers joining Social Cloud and how users think about their benefit by the contribution they can make. Caton et al. [10] claim that users motivation and existing supply and demand are driving forces behind users participation. Motivation is expressed via outcome of the social exchange where social context considers relationship types and interaction history. Whereas supply and demand in the Social Cloud compels other users to make their excess resources or capabilities available as a form of social capital. Second stage namely social interchange captures the identification and allocation of demand and supply using socio-economic mechanism. Completion, the last stage, addresses the process and actions to finalize an exchange. It contains three concepts: feedback, recommendation and interaction archiving. Finally, Caton et al. [10] define trust in the context of Social Cloud, where trust is a positive expectation or assumption on future outcome that results from proven contextualized personal interaction-histories corresponding to conventional relationship types and can be leveraged by formal and informal rules and convention within a Social Cloud to facilitate as well as influence the scope of collaborative exchange.

What incentives user has for resource contribution defines active participation. Desired behavior of participant can define by proper incentives. By considering incentive role Punceva et al. [33] propose Sharing Model to address an issue of inter- and intra-community service exchange support within edge device (e.g. TV, mobile) based environment. This Sharing Model provides incentive for both provider and consumer to offer services and provide feedback on offered services, respectively. In the Sharing Model, every node (exchanging entity) have their own currencies. The value of currency
fluctuate according to the reputation of node. Reputation of node as provider is based on the ability to offer a service. Punceva et al. [33] assumes that nodes (resource exchanging entities) either belong to same or different community. Punceva et al. [33] propose payment methods for two cases a) intra-community b) inter-community. In intra-community, there is a need for currency conversion between two nodes as provider and as consumer. The currency conversion depends on the currency exchange rate known within community and reputation of node as service provider. The currency conversion can be illustrated as follows. Suppose, node A uses A-dollars and node B uses B-dollars, and both these nodes are in same community. During transaction the node A offers a service to node B, then B pays to node A. In this case, B will transform A-dollars into B-dollars according to the current exchange rate. If reputation of node A is rep(A) and Bs reputation is rep(B) then 1 A-dollars equals rep(A)/rep(B) B-dollars. In inter community, node B will keep A-dollars and uses these as credit with A for a future transaction, currency conversion is not allowed rather payment for service kept only as credit similar to credit network [34][35]. Punceva et al. [33] perform simulation using CometCloud [36] to find the following questions: how does the number and sizes of cluster affect the number of transaction completed and the proposed approach is scalable or not? Simulation result shows network size, clustering strategy, reputation distribution density of the social graph and credit limit impact on the successful transaction and the overall credit gain.

Haas et al. [9] relate several incentivisation aspects of user participation to market mechanism. Haas et al. [9] identify three different phases namely discovery of participants, encouraging active participation and incentivising social behavior. Every phases post some incentive requirements. The discovery of participant phase concerns how to invite new participants to join Social Cloud. For the discovery of new users, Haas et al. [9] suggest to consider direct and automatic discovery. For direct discovery, the existing relationship between members could be utilized. Whereas automatic discovery can be done through automated advertisement. Encouraging active participation is phase concerns how active participation achievable in Social Cloud. For active participation, Haas et al. [9] express a need to design a marketplace in such a way that users have incentive to share resources. Haas et al. [9] believe that designing a proper mechanism according to choice of group members could be incentivizing users to share resources. In Social Cloud, even if users share and offer services, it is not guaranteed that they will adhere their commitment and can discontinue their offerings. While considering incentivising social behavior, Haas et al. [9] hold the view that hard SLA may not be an identical approach to resolve social misbehavior issue in Social Cloud; as an alternative, need to design a social oriented mechanism to curb misbehavior in Social Cloud. John et al. [13] propose mechanism to incentivizing involvement, contribution and growth in Social Cloud for Public eResearch. John et al. [13] introduce three high scoring sets of users as a title: Project Champions, Social Anchors and Compute Magnates based on project credits, social scores and compute scores, respectively. Project Champions title goes to those who give highest contribution for a given project. Social Anchors is titled to those, who brings maximum new users in Social Cloud. A set of users that generate computational time for the public research through their own Social Cloud is rewarded as Compute Magnet [13]. Yu Zhang et al. [37], propose reputation based pricing and collective punishment to avoid free riding as well job allocation scheme that improves social welfare. Authors outline Social Cloud frame work in following way: User (a buyer) initiates a task and submit it to the operator. The operator is the owner of the market. The operator divides the task in to small jobs, and then operator selects a group of suppliers (who are also user) with sufficient idle resources and allocates the divided task to these suppliers. The operator determines the payment for the task. Buyer submits the payment for the task. The payment given by buyer to suppliers is based on the reputation that suppliers has. If the supplier has minimum level reputation get payment according the workload that user performed else supplier will not get any payment. The reputation scheme determines how the reputation of each supplier should be updated according
to its past behavior. Authors propose collective punishment mechanism to ensure that there is no free riding from supplier.

4 Security in Social Cloud

L. Chen et al. [38], proposed a security architecture for securing Social Cloud called CryptoOverlay (cryptographic overlaying). CryptoOverlay, a cryptographic architecture derived for privacy preserving access control needs. In CryptoOverlay security architecture authors explored two primitives called assembly signature and identification scheme. L. Chen et al. [38], envision three aspect (dynamic membership, trust and policies) od Social Cloud while proposing CryptoOverlay. They also classify target based threats in context of Social Cloud: 1) Threat against data confidentiality 2) threat against data integrity 3) threats against data availability 4) threats against resource providers. Chen et al. [38], porposed security architecture consists of following components.

- Privacy-preserving access control that enforces access control policies and dynamic in nature.
- Periodic proactivization to overcome the potential availability weakness. Proactivization based on proactive cryptography to mitigate the possible damage by compromised virtual machines of providers.
- On demand proactivization- is an intrusion detection system assures that providers resource is not compromised by malware.
- Secure data, replication, storage, retrievability and recovery. The component takes care of data by replicating it over many virtual machines. Data confidentiality is ensured through data encryption. The integrity and availability is ensured by implementing advanced techniques such as the proof of retrievability.

5 Research Challenges

Although several views and approaches to Social Cloud are known, but there are still many issues yet to be addressed. Few major issues are related to service availability, group formation, design of market model and marketplace, service enrichment and social loafing. With respect to the above mentioned issues, we point out the future research direction in the following.

5.1 Service Availability

In classical Cloud computing, availability of service is a single sided issue where concern is service duration, that is, whether $24 \times 7$ hours services is made available by the service provider or not [20]. But in case of Social Cloud, availability issue has two aspects which can be stated as follows.

1. Availability of a particular service
   Service domain of traditional Cloud computing is wide, in the sense that various kind of services are offered by service providers. Cloud computing offers X-as-a-service (XaaS), where X is platform, software, or infrastructure to consumer and an on demand access to these services regardless of time and location [39]. Number of such services is increasing day-by-day and hence considerable services are available in marketplace. Moreover, consumer has a certain guarantee to obtain a requested service on the basis of pay-per-use economic model through Public Cloud. On the other hand, in a Social Cloud market, availability of any service
depends on the size of the group and set of varied services. If a group contains low population or membership, then rate of sharing services or resources is also limited. Apart from this, lack of diversified resources gives rise to unavailability of different services (homogeneous resource sharing by group members). In such a situation, Social Cloud consumer has very limited search space for required services by which many service requests from consumer can not be fulfilled successfully.

2. 24 × 7 hours service availability

In Social Cloud, service provider is not professional rather his nature is same as like other members in the group. In this environment, system down rate of service provider is high. Users on Social network can go offline due to technical reason like maintenance or system upgradation of personal desktop or laptop. During a time, a provider may be offline, the consumer for the same may face service lock-in due to the unavailability of migration features.

Thus, how to make user’s specific service available for 24 × 7 hours is a critical issue in Social Cloud.

5.2 Group Formation

Aim of Social Cloud is to maximize social welfare thus maximizing utility of all group members. A user of a group is interested to maximize her utility by availing offered services from other trustful group members. In fact, utility of an individual is maximized when her service requirement are fulfilled within the group. Now the question is who should be in a group? She, who is trustful from the point of view of other group members or she, who is less trustful but offer unique service to other group members. These two questions define the structure of a group in Social Cloud. And consideration of these questions is important in the context of social welfare and group formation. Indeed, social welfare is correlated with or rather depends on group formation. Present literature in Social Cloud emphasis on trust for group formation. In particular, though some members come together on the basis of trust to from a Social Cloud, but it is not only a single factor which defines, whether group can be formed or not for mutual beneficial resource sharing. Rather, what kind of services or resources that different group members can contribute within the group play important role. In addition to this, group sustainability defines utility of each member in Social Cloud. Our notion of group sustainability is how long group members continue resource sharing (i.e. sustainable resource sharing). Haas et al. [9] relate, dependency of sustainable resource sharing on active participation and thus can derived by proper incentive. In fact, appropriate incentive is not only sufficient for sustainable resource sharing but consideration of group structure (membership relation) also plays an important role. Moreover, the success (utility) of both the individual and the group depends on group structure: the way that individuals are arranged into groups. Several research papers [40][41][42] analyzes the structure feature that influence membership, growth and foci change over time, membership constraints etc. In addition to this, how and why such networks and groups form, and this structure affect on outcomes of social and economic interaction is important aspect to be taken into account. The organization of individual agents into networks and groups has an important role in the determination of the outcome of group interaction [40]. In the context of Social Cloud, outcome of group interaction is group sustainability. In this sense, formation of a group of users having heterogeneous resources with maintaining optimum trust is an important issue in Social Cloud.
5.3 Design Market Model and Marketplace

In Social Cloud, users share their resources with others in the group, either voluntarily or in expectation that they are allowed to utilize resource owned by others in return. So, a set computational economic or non-economic market models is needed to control the sharing and allocation of resources within Social Cloud. The idea of applying economics to resource management has discussed in several papers [43][44][45]. Majority of them investigate the economy in general equilibrium. Buyya et al. [46] suggests different economic models like auction, posted price, bargaining or tenders for resource management in Grid and P2P resource sharing frameworks. However, all these suggested economic models consider an agent in these systems which acts selfishly and tries to maximize profit. However, for Social Cloud, this need not be always true because those social clouds adopt altruistic approach which may not match consideration (agents selfishness and profit maximization). In general, allocation method can be classified into two categories [47][48]: 1) Market mechanism: if objects are exchanged for money (e.g. auction, posted price models). 2) Non-market mechanism: if objects are allocated free of charges (lotteries, higher reputation, barter models). In the context of Social Cloud, both market and non-market mechanisms are applicable according to medium of resource exchange, and also depend on predefined economic or non-economic model adopted by Social Cloud members. However, it is a challenging issue, to design a market based mechanism for resource allocation, where participants are not selfish and does not strive for profit maximization but use monetary form as a medium of resource exchange. On the other hand, those Social Cloud operates altruistic or voluntarily attach value to resolve an issue of resource management where resource exchange form is non-monetary with non-market mechanism approach. For example, reputation points [49][50], trophy [8], bargaining [51] or reciprocation [52][53] etc. are possible candidates of non-market mechanism approach. Secondly, in Social Cloud, users offers idle resource like storage, platform, information as a service to other group members. This service provision is performing like commodity market where provider decides prices of their resources on the basis of supply and demand of services in Social Cloud. To develop a computational market exchange framework (marketplace) which facilitates group members exchange of services is a matter of importance. In other words, a marketplace should be able to provide flexibility to provider and consumer for service sharing and trading and allows coexistence of multiple market models like auction, post price or tenders. Garg et al. [54] propose ‘Mandi’ a service exchange framework for traditional Cloud environment which allows consumer and provider to trade resources according to their requirements. Some features of ‘Mandi’, like resource discovery or coexistence of multiple market models is suitable for commodity market based Social Cloud. Uniqueness of Social Cloud computing paradigm is the existence of multiple Social Cloud operated by different market metaphor which is adopted by different groups according to their choice for resource management. This uniqueness impels us to design such market exchange framework which not only provide place for intra-Social Cloud service exchange but also provide mechanism for inter-Social Cloud service exchange. There is another challenge in design of marketplace is to support reputation points, credits as well as trophy which acts as medium of resource exchange. In summary, designing a market which incorporates following features are key concerns in Social Cloud.

1. Service/resource advertisement.
2. Resource discovery.
3. To support currency form like trophy, credit as well as monetary.
4. Service registrations where service provider can advertise their resource for trade as well as consumer publish their required services.
5. Co-existences of multiple market models like auction, post price, bargaining.

5.4 Service Enrichment

We know that Wikipedia is a collaborative edited encyclopedia, where users edited their known information to its content. Note that, this enrichment depends upon active user participation. Social Cloud is another example of such collaborative resource sharing model, where virtual resources or services are shared by group members. In this scenario, active contribution decides abundance of Social Cloud resource pool. In other words, motivated users for resource sharing decide resource enrichment in Social Cloud. How to motivate contributors for active participation and desired user behavior (according to group goal) is another issue in Social Cloud. Haas et al. [9] discuss incentive and motivation issue in Social Cloud at broad level and concludes that there is a need to design a suitable incentive to motivate contributors for resource sharing according to operating environment (market metaphor for resource management) of Social Cloud.

5.5 Social Loafing

We consider that collaborative resource sharing in Social Cloud is an additive task and conjunctive task. An additive task in which members’ input are added to produce a group result whereas conjunctive task, requires that each group member perform at a minimally acceptable level for the team to succeed [55]. In Social Cloud scenario, service enrichment is a group result. The goal of Social Cloud is to fulfill request of consumer successfully within a group. To achieve this goal each member of a group pay his/her best effort to make service available by sharing unutilized resources to other group members in need. But Social Cloud can suffer from social loafing and free riding. Social loafing is the tendency to reduce individual effort when working in group compared to the individual effort spends when working alone [56]. Kidwell et al. [57] argued that there is a considerable difference between social loafing and free riding, determined by the reason for lack of participation. Otherwise, both share similar characteristics and defines a person who is not providing the maximum efforts because of lack of motivation or circumstances. The Ringelmann effect [58] is another issue for Social Cloud. This effect describes inverse relationship between size of the team and effort expended. This is a paradox that, at one hand, Social Cloud resource enrichment cannot achieve unless a maximum number of users with their heterogeneous type services participated in group, and on the other hand, this huge membership can be a cause to rise Social loafing. To make Social Cloud free from social loafing is one of the major concern.

6 Summary and Conclusion

Social Cloud, as on today, appears with many views. All these views mainly to conceptualize two things: resource definition and principal stakeholders. Further, a technology cannot emerge and sustain unless it has application potential and incentives in some sense. Our summary on Social Cloud attempts to reconcile the above facts. A summary of our observation is tabulated in Table 2. Table lists most of the views of Social Cloud that we have discussed in this paper. These views mapped to resource definition, principle stakeholder, application model and infrastructure deployment of Social Cloud in different context. Some of the aspect of Social Cloud such as trust and incentive not included in Table 2 since they do not provide application scenario or does not talk about certain views of Social Cloud, rather discuss about trust aspect and role of incentive for resource contribution in Social Cloud. We admit that Table 2 is not exhaustive rather a glimpse of the current state of the arts. We understand that the current states of arts are some attempts to leverage
the potential of Social Cloud. Undoubtedly, these starting efforts show potential of Social Cloud to acts as complementary to other computing paradigms such as Grid, Volunteer, Cloud computing. Unfortunately, most of the papers limits to proof of concept and lack of implementation. These early stage works in Social Cloud does not provide the actual system. There is strong need to consensus on resource representation, whether resource represents idle resources of users end edge devices such as personal desktop, mobile, etc. or users hired resources from commercial data-center are yet to be settled. Another strong debate on the issues, whether Social Cloud is an alternative to Cloud computing. We are in the opinion that both these paradigm are not dominating each other, rather has their own merits as well limitations. More precisely, Social Cloud should be dealt with different research care and development so that ultimately it can emerge as another fruitful distributed computing. Many issues like reliability, scalability of users resources deployed in Social Cloud infrastructure are the major concerns, which need immediate research attention.

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| Family           | Input                                | Resource Definition                  | Deployment | Application | Social Cloud Model | Resource Trading Mechanism |
|------------------|--------------------------------------|--------------------------------------|------------|-------------|--------------------|---------------------------|
| K. Chard et al.  | User’s computational resources       | Social Cloud member                  | Facebook   | Storage-as-Service | Social Storage Cloud | Reverse auction, Posted Price |
| Z. Ali et al.    | User’s hired resources from commercial data-center(e.g. Amazon EC2) | Social Network user                  | Facebook Application | -           | CRB-Model           | Bartering                 |
| A. Thaufeeg et al. & K. Bubendorfer et al. | Virtual Machine Image(VM) of user or VM of Third party vendor (e.g. Amazon S3) | Scientist | Facebook Application | Platform-as-Service (PaaS) | Social Collaborative Cloud | -                         |
| A. Mohaisen et al. | User’s computational resources       | Social Network user                  | Overlay on Social Graph | Task outsourcing | Distributed Computing | Altruistic                |
| K. John et al. & K. Bubendorfer et al. | User’s computational resources       | BOINC project and Facebook & BOINC user | amalgamation of Facebook & BOINC | Volunteer Computing on Social Network | Social Cloud for Public eResearch | -                         |