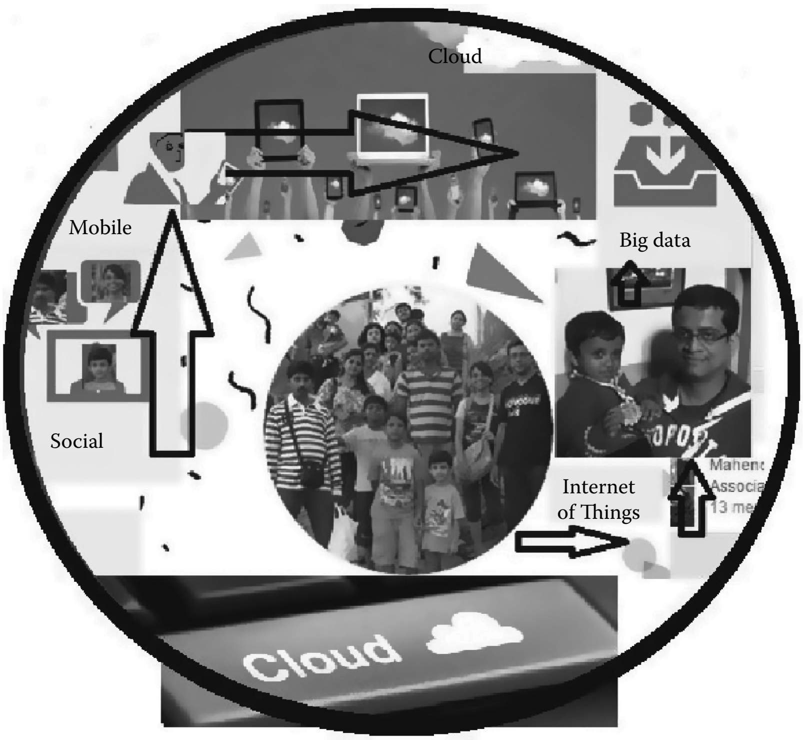
LECTURE NOTES

Mobile Technology and Cloud Computing

Session 10
Mobile Social Cloud Computing

8

Mobile Social Cloud Computing



ABSTRACT The convergence of mobile, social network, and cloud has turned out to be the platform for cyber digital industry. Digital industry is forming new business designs by big data analysis. The combined power of these four forces explores some of the interesting distinct patterns that define that platform. With the concept of cloud computing, inherent constraints of mobile computing such as resource scarcity, battery life, frequent disconnections, etc., have been addressed, and integrated mobile cloud computing is growing exponentially around the world. Cloud computing also solves the problem of social networking sites that deal with a huge amount of data. With the enlarging pervasive nature of the social networks and cloud computing, users are exploring new methods to interact with, and utilize, these growing paradigms. A social network allows users to split information and build connection for generating dynamic virtual organizations.

Massive use of mobile technologies such as laptop, smartphones, etc., is also drawing attention to the clouds for processing power, storage space, and energy saving, which in turn leads to a new concept known as Mobile Social Cloud.

KEY WORDS: *mobile cloud computing, social cloud, tweet Data, social network, resource sharing, social cloud exchange structure.*

8.1 Introduction

The widespread growth of social networking sites has enormously changed the way we interact and liaise among ourselves. It allows us to interact with an effective platform, to establish an effective community, and to document, represent, and analyze interpersonal relationships. Today, the consumption and acquisitioning of Internet services have rapidly increased, and issues such as security, trust, reliability, and sometimes anonymity have become the major problems of the cloud computing paradigm. The progression of the web in terms of user-generated content, crowd sourcing, and the large number of online social networks has generated a tremendous amount of information describing dynamic interaction among people with their surroundings, in both online and offline mode in the real world. In this respect, the amount of information available from the connected world, belonging to either virtual or physical sources, can describe the aspects of reality in a detailed manner if both sources are combined. The kind of dynamics generated by the integration of the digital and physical worlds will have an impact on different levels involving human socio-environmental dimensions as well as on network organizations. In this regard, many novel research challenges have arisen for dealing with such integration of information.

Social networking is an online service by which many people who are members of the same social networking application can communicate with each other [1–10]. Facebook, Twitter, Orkut, etc., are different types of social networking sites. Sometimes, people may not access social networking sites on their computers or laptops; this increases the use of mobile phones day by day. More than 60% of users access social networks through mobile phones. The sensing, analyzing, and storing of a large amount of social data have become a very important issue. Apart from physical sensors, today social sensor is an emerging terminology [1]. Social sensors are effective human–device combinations that send torrents of data as a result of social interactions and events. Laptops, smartphones, tablets, i-pads, etc., are gaining popularity daily. All these devices are equipped with various kinds of sensor elements such as speed cameras, Internet fridges, transducers, and GPS and proximity detectors. The data generated appear in different formats such as photographs, videos, and short text messages. To gather numerous amount of data, we can use social networking sites such as Facebook, Twitter, and YouTube.

Social networking sites are used to represent realistic types of relationships that allow users to share or distribute information among intended users such as friends and family members. A person can use a smartphone to make videos and upload to YouTube, to tweet on Twitter, or take a picture to post on Facebook. By analyzing all these data, various activities can be done such as event detection, marketing, disaster detection and reporting, mobile social TV, and video streaming. A social sensor also generates a lot of data. But the problem with a huge amount of data is how to analyze, cluster, store, and compute the data. Cloud can be the finest solution to this problem. A seamless integrated cloud platform such as Amazon EC2 and Google App engine can be used to do all these jobs. We call it "social cloud," which is a combination of social networking and cloud. Massive use of mobile technologies such as laptops and smartphones is also drawing attention toward the cloud for processing power, storage space, and energy saving, which in turn leads to a new concept known as "mobile social cloud." The mobile social cloud simplifies the access to different devices and manages the huge volume of data transmitting across different computing networks and storage.

The social cloud furnishes an environment where sharing and provisioning scenarios can be inaugurated based on absolute trust. This trust comes from mutual relationships within social networks [11–20]. The social cloud is the conduit that uses social networks for efficient mutual interactions between the users. Social networking sites serve as an effective resource for multiple users, with different interaction and access patterns that are very difficult to predict. Their websites are basically multi-tiered web applications where each component runs in different virtual machines. Moreover, every plug-in developer has the independence to choose a suitable cloud service provider. As a result, several web applications of different social networking sites are being hosted by different cloud-based data centers. Social cloud storage can be used for developing a cloud framework in a social networking site environment.

This chapter presents a comprehensive survey on mobile social cloud where the applications and problems of mobile social cloud are discussed along with their future scope.

8.2 Mobile Social Cloud Architecture

People have shown significant interest in adopting social networks in mobile computing and cloud computing environments in order to meet their integrated requirements. The mobile social cloud is an emerging concept providing access to social networking sites using cloud, which enables elastic utilization of resources required to store social data in an on-demand fashion. Nowadays, people access social networking sites using mobile phones, even dealing with a huge amount of data. But a conventional computing system is not sufficient to analyze and store high volumes of data, which are referred to as "big data," that can be addressed by cloud only. The architecture of the mobile social cloud, demonstrated in Figure 8.1, is composed of four modules:

1. *User*: A term referring to the social network user who accesses social networking sites through mobile devices.
2. *Mobile devices*: Mobile devices are laptops, smartphones, i-pads, i-phones, etc., with high configuration and mobility.
3. *Social networks*: A social network is actually an implementation of a general network in which each node indicates a user and the edges indicate connection between them. There are a huge number of social networking sites such as Facebook, Twitter, MySpace, etc.
4. *Cloud*: The cloud is a combination of virtualization of a large amount of resources with a distributed computing paradigm incorporated with software as a service,

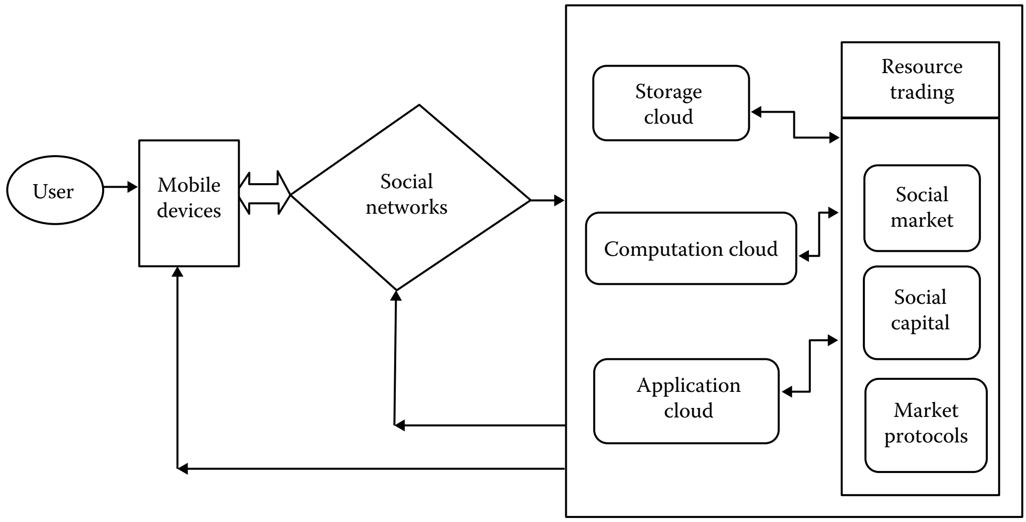


FIGURE 8.1
Architecture of mobile social cloud.

platform as a service, and infrastructure as a service. It can be of different types. The cloud module of this architecture contains three sub-modules:

a. *Storage*: The social data are stored inside the cloud. As social networks generate tremendous amounts of data, it is not feasible to store them without cloud. These data will be used for big data analysis.
b. *Computation*: The computations of data analysis are performed inside the cloud. These data are received from social networks.
c. *Application*: Various social applications such as Facebook and Twitter apps run on the cloud.

Resource trading is the functional module that balances resource sharing, allocation, and trading among the members of a particular social network or community and cloud providers. This module has three functional parts:

1. *Social marketplace*: A social marketplace is a virtual place where users from different social network groups or communities participate in resource trading. They share and utilize resources in return for some benefit, for example, Olx, Quicker, Gumtree, etc.
2. *Social capital*: Social capital generates from the social relationships and interactions between traders and consumers, for example, Amazon.
3. *Market metaphors*: These are real-life economic models for trading such as Posted Price, Auction, Trophy, Spot Price, etc. (e.g., Flipkart).

The Facebook application [2] can be used as an example to describe the social cloud. Its services are mapped to particular users by their identifications or interactions among users. A banking component always handles the transferring of credits among the users and also stores information related to the user's current reservation.

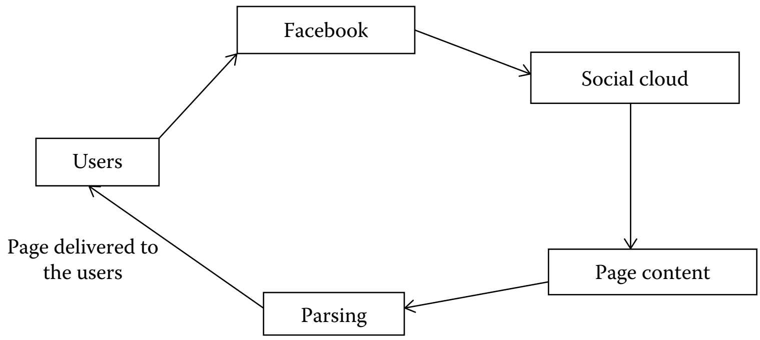


FIGURE 8.2
Facebook application environment.

Facebook handles application programming interfaces (APIs) by REST-like interface. Various Facebook applications can be built to gather data using I-FRAME, FBJS, and FQL languages. FBJS is the Facebook version of Java Scripts, FQL is the Facebook version of SQL, and I-FRAME is the Facebook version of HTML. Previously, instead of I-FRAME, FBML was used. But now Facebook has introduced I-FRAME to build Facebook apps. To integrate all applications with Facebook's look and feel, new Facebook versions are used. These applications are not hosted in Facebook but independently in the cloud. A Facebook URL accessed by users is created. This user-accessed URL is mapped to the remotely hosted callback URL. Through the Facebook URL, users request the page. The Facebook server sends the user-requested URL to the callback-defined URL. The application page is created based on the user's request and finally returns to Facebook. At this point, the Facebook page is parsed, and its important content is added according to the instruction in FBML. The final or ultimate page is returned to the user accordingly, as shown in Figure 8.2.

This is one of the case studies on social cloud. We can use different social networks or social communities instead of Facebook and build applications to fetch a huge amount of data and perform all analyses and store in the cloud. Useful decisions can be made based on the generated results.

8.3 Resource Sharing in Mobile Social Cloud

A cloud itself consists of a huge amount of resources. One of the main goals of the social cloud is to share resources among people through social networking sites as a platform. A social cloud resource represents a physical or virtual entity or capability of limited availability. A resource [3] could be information, storage, computing capacity, software license, personal ability or skills, etc. In a social cloud, one user may share storage in exchange for accessing a specific workflow; for example, a user may keep back up of photos from digital cameras in the hard disk of another member in the social network. To participate in a social cloud, each user must allocate a certain amount of resources to be used by others. This sharing is controlled by a socially oriented marketplace, which adapts common allocation protocols to a social context.

8.3.1 Motivation for Contribution of Resources

In a social cloud [3], social networking users invest in the community by joining the cloud, sharing resources, and utilizing other's resources. Some social incentives present in a social cloud motivate users to participate in, and contribute resources to, their community in different ways. Thus, users become more interested in sharing resources in return for tangible or intangible benefits. The motivation of resource contribution [3] has been studied in a large number of online domains, for example, sharing information and photos on social networks, sharing metadata and tags in online communities, and building collaborative knowledge through online content projects or open source software projects. Motivation is generally categorized as either intrinsic or extrinsic. Extrinsic motivation means motivating users by an external reward so that while they have little interest in the community, they will contribute to that community when the expected benefit exceeds the cost of contribution. Intrinsic motivation represents an internal satisfaction obtained from the task itself rather than the rewards or benefits. This sense of satisfaction may be for completing the task or for the enjoyment and reciprocation of simply working on the task.

8.3.2 Social Capital

Social capital [3] represents an investment in social relationships with expected return. From an individual point of view, social capital is similar to human capital as users of a social network may gain individual returns for specific actions, for example, selling goods or finding a new job. From a group perspective, social capital represents the intrinsic value of the social community, that is, this social community as a whole generates return by the action of its members. The sharing of resources in a social cloud is to invest and generate value from individual actions. The sharing model in a social cloud could be considered for generating both social and physical capital as it reflects the real world. The resource owners invest their resources and produce some individual returns. Thus, investing resource becomes beneficial for both the investors and the community.

8.3.3 Virtualized Resources

Cloud computing depends on virtualized resources. A social cloud provides any resource that users may wish to use, ranging from low-level computation or storage to high-level mash-ups, for example, photo storage. There are two types of requirements: (1) the interface should provide a stateful instance, (2) for discovering those services that need advertisement for incorporating them in the market.

8.3.4 Banking

The social cloud has introduced the credit-based system that recompenses users for contributing resources and charges for using the resources. Every user registers in the cloud for storing credits as well as for their participation in the banking.

8.3.5 Registration

In the registration process, users specify the cloud service they want to render. Then, user instances are created through which banking services can be transparently accessed using the users' IDs. After the registration, users are provided with MDS (monitoring

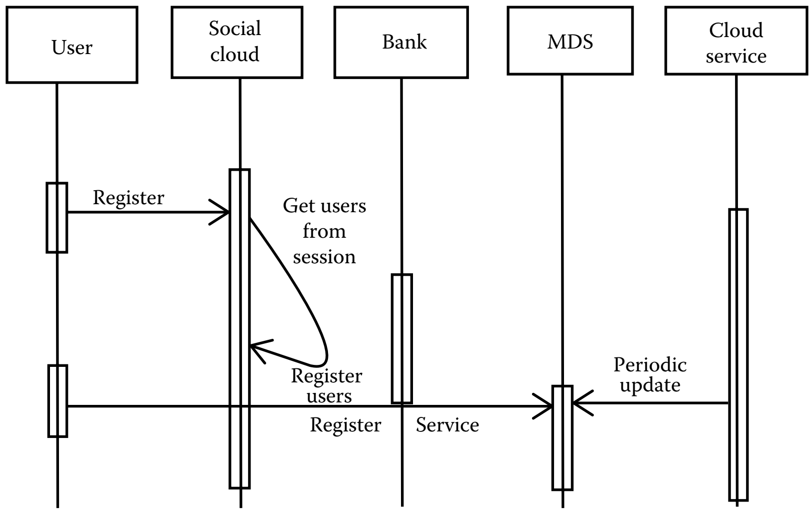


FIGURE 8.3
Registration in social cloud.

and distributed system) endpoint reference and cloud ID. A market service uses the MDS XPath to find good services based on IDs and real capacity. The registration process is shown in Figure 8.3.

8.3.6 Social Market

The social market [3] is the core of the social cloud. It regulates resource sharing among groups that are associated with the separate instances of the market. It allocates resources between peers according to predefined economic or noneconomic protocols. The social market is pictorially depicted in Figure 8.4 where several protocols [3] provide the appropriate allocation of resources for a particular user request.

The choice of protocol depends on the social cloud and the requirements of its members. The protocols are discussed as follows:

1. *Volunteer*: It is an idealistic sharing model in which users contribute resources for no personal gain, but their actions are without accountability.

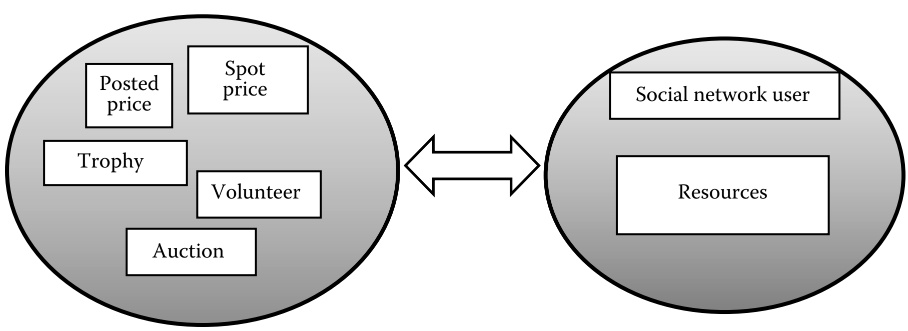


FIGURE 8.4
Social market place.

2. *Trophy*: This is a nonmonetary model in which users are rewarded with intangible credits.
3. *Reciprocation*: In this sharing model, users contributing most to the cloud are proportionally favored when they are requesting resources.
4. *Reputation*: This model is entirely based on the reputation of individuals. Reputation is established through interactions in the community. Higher reputation is favored with higher resources.
5. *Posted price marketplace*: This model provider makes advertisement offers related to a specific service level, and resources are offered at a predefined price. This will help users to create a service level agreement (SLA) with a specified parameter. This service market requires much coordination among different components of the social cloud such as discovering cloud service that first requires checking whether the user is already registered with the bank and has sufficient credits. After that the user selects a particular cloud service, and the social cloud application creates an SLA, which is ultimately sent to the cloud. It is assumed that both the parties have accepted the agreement, which is sent to the bank for transfers of credits among users. Commercial cloud providers use this model frequently. This is shown in Figure 8.5.
6. *Auction/tender*: This is a dynamic multi-participant mechanism designed to establish the market price for a particular resource. Online selling sites often use this model. In auction-based marketing, trades are mainly established by a competitive bidding process between services or users. Here, a list of friends, when discovered, is further passed to a specialized auctioneer for creating or running the auction. In Figure 8.6, reverse auction protocols are used in which cloud services bid (compete) for hosting users' task. The list of friends discovered is used by auctioneers to locate every group with a worthy cloud service. Each service provider needs an agent who acts on behalf to fulfill resource requests. After that

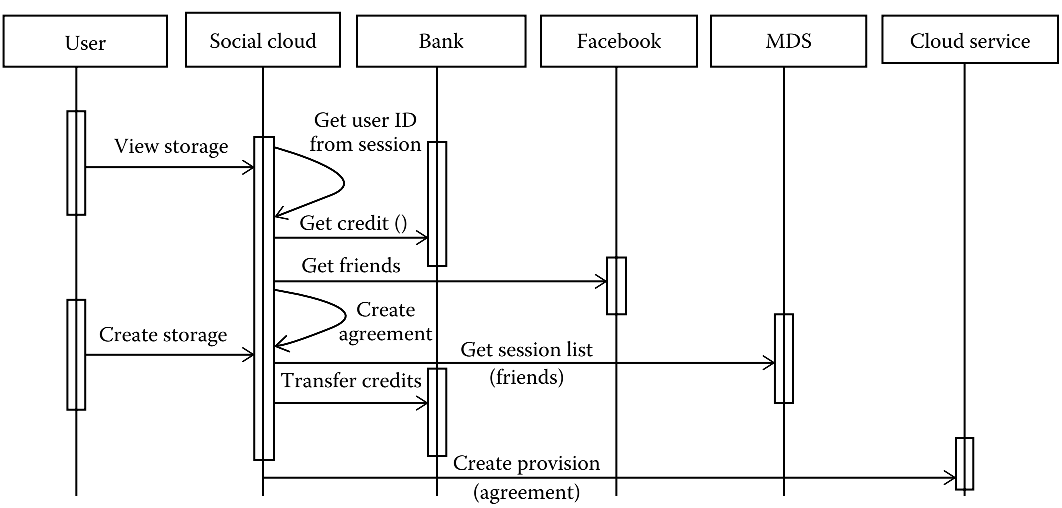


FIGURE 8.5
Posted price in social cloud.

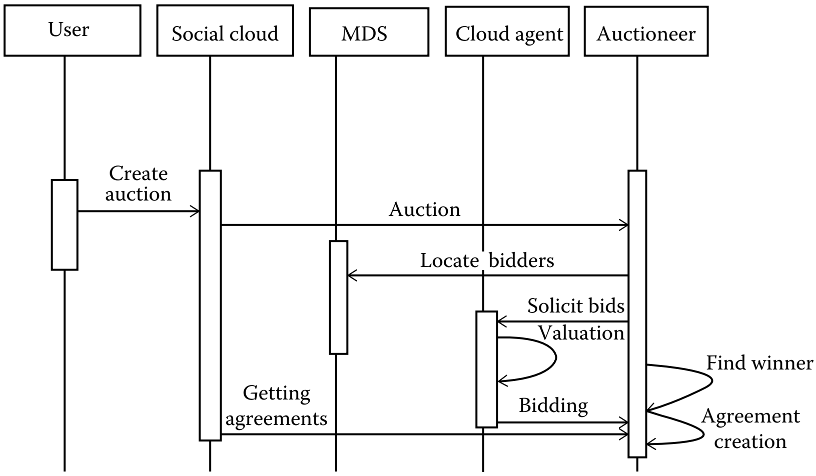


FIGURE 8.6
Auction marketplace in social cloud.

auctioneers determine the winner of the auction and ultimately create an SLA between the winning bidder and the auction initiator. Then, the agreement is sent for instantiation and finally to bank for transfer of credits.

7. *Spot price*: This is a dynamic pricing protocol in which a commodity is offered at a price given at a particular time and location.

8.4 Warehousing and Analyzing Social Data Using Cloud

Warehousing and analyzing social network data are always a big issue due to the high volume of data. These data are messy and noisy. So it becomes time consuming to analyze them. The cloud is the best solution to this problem. Social networks have three types of elements [4]: actors, ties, and relationships. Actors are people, events, objects, organizations, and so forth that are represented by nodes. Nodes are connected by lines that show the relationship between actors. Ties are used to construct the relationships between actors. Ties are divided into strong and weak categories according to the strength of the relationship. So through social network analysis, we can analyze ties, relationships, and actors in social networks.

8.4.1 Architecture of Analysis and Warehousing of Social Network Data

The architecture [4] of the social network analysis using cloud is divided into three major parts:

1. Front-end data collection component
2. Intermediate system analysis component
3. Analysis result producing component

The process of analyzing and warehousing social data is depicted pictorially in Figure 8.7.

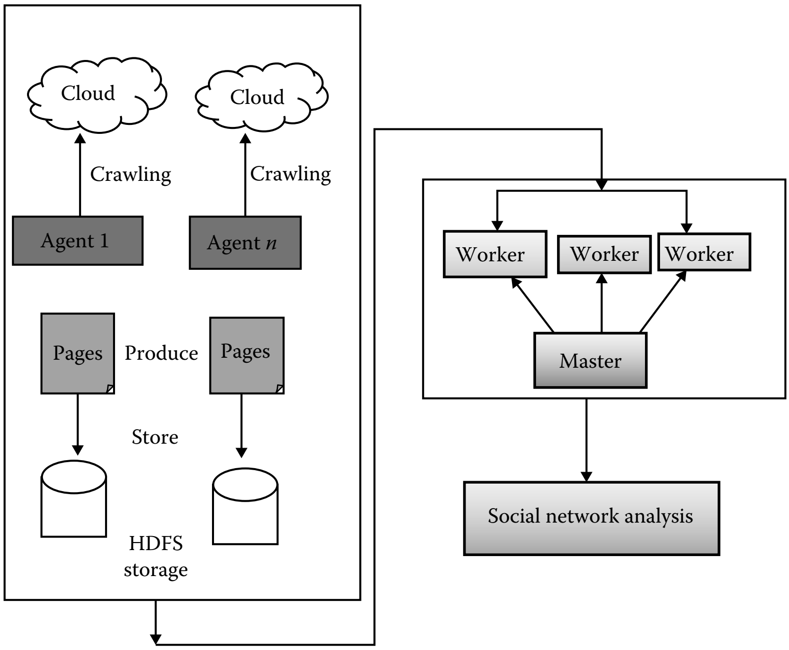


FIGURE 8.7
Process of warehousing and analyzing of social data.

The front-end data collection component gathers social data from various social networking websites such as Facebook and Twitter. Well-designed crawling programs to collect data are attached with this component. Then, it stores these data in a distributed environment, using the Hadoop Distributed File System [4], which is highly reliable. The Hadoop Distributed File System breaks the incoming files into blocks and stores them across the machines in the cluster environment. This prevents hardware failure in the distributed environment. After collecting and storing data, the system performs different levels of data processing according to user requirement. The bulk synchronous parallel (BSP) [4] model is used to process social data according to various algorithms based on the master/worker structure: The master assigns work to workers; the workers perform their work according to the assignment from the master; and finally the master acquires the processed result. This component produces the final result from the analyzed data. Now, users can get results according to the required analysis. They can interact with the help of web interfaces or APIs. This component should provide a platform-independent web interface or API to users, which is treated as the main feature of it. Thus, users can send queries and get analyzed results from various operating systems and platforms.

Two types of methods are used for social network analysis: MapReduce and Hama BSP [4]. MapReduce can be used for computer programs that need to be processed and generate a large amount of data. It has strength in locality, fault tolerance, and parallel processing. It is used to generate the index of Google. But this technique is not feasible while dealing with the processing of a graphical algorithm. In social network analysis, computation and processing of graphs are essential, so the MapReduce [4] approach is not very efficient. The Hama BSP model [4] is used to reduce the drawbacks of the MapReduce model. Pregel technology is based on the concept of BSP developed by Google, and it is used to implement graphical processing. As BSP is not an open source algorithm, Apache is now running a BSP-based project called Hama.

8.4.2 Case Study on Tweet Data Analysis

In a case study on twitter data analysis [1], we have analyzed the mood of people on twitter on the basis of changes in the weather of a particular area. This is something like a fusion of social and sensor data. The data gathered from twitter are social data, and weather data are sensor data. A mood space is created where both social and sensor data are mapped. In the mood space, a mood word is represented as a score according to three dimensions [1]—valance, arousal, and dominance—where value in each dimension ranges from 1 to 9, as shown in Figure 8.8.

Valence is defined by its two poles—negative/bad and positive/good—whereas the arousal dimension spans between the two poles: sleepy/calm for very low arousal and aroused/excited for very high arousal. Dominance is proposed to differentiate subtle emotions such as fear and anger. As valance and arousal are the main dimensions to create the mood space, a 2D plane is considered using valance and arousal matrices (V × A) to generate the mood space. This plane is divided into 12 regions, which are mapped to each mood. For example, a high value of valence as well as arousal indicates someone is happy.

8.4.2.1 Tweet Mapping

Each tweet consists of some words. Each of them has some valance and arousal score [1]. We have computed the overall score of the tweet as well as which data point will be in the mood space. Let us consider a mood space set M, which consists of 12 moods in the mood space. Let T_i be each tweet in the tweet set T, that is, $T_i \in T$. The mood expressed by the tweet using conditional probabilities is $P(M_k|T_i)$ where $M_k \in M$. A tweet word set $\{wrd_i^j\}$ is considered.

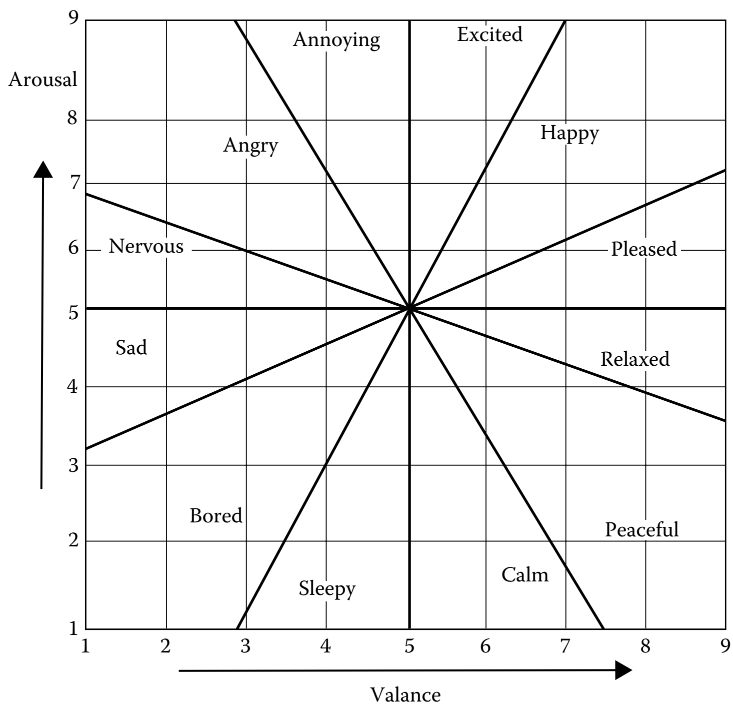


FIGURE 8.8
Graphical representation of mood space.

It is assumed that each word independently contributes to the overall mood of the Twitter message. The words that do not express mood will make zero contribution to the final mood. The mood expressed by the tweet using conditional probabilities is given by

$$P(M_k|T_i) = \frac{P(M_k) \cdot P(T_i|M_k)}{P(T_i)} = \frac{P(M_k) \cdot P\left(wrd_1^i, \ldots, wrd_n^i|M_k\right)}{P(T_i)}$$

$$= C_k \prod_{j=1}^{n} P\left(wrd_1^i|M_k\right) \tag{8.1}$$

where $P(wrd_1^i|M_k)$ signifies the amount of contribution of a particular word to make a mood M_k. It will be derived from "Affective norms of English words (anew): Instruction manual and affective ratings." Along with the term weight, the constant C_k is also determined based on the training set. Depending on the mood M_k for which the term $P(M_k|T_i)$ is largest, the tweet T_i is classified as expressing that mood. For example, consider the following tweet T_0: "Weather it is seasonal, warmish, some rain or sun, greenery or beautiful." The tweet is composed of 12 words, in which 4 of them are listed in the "Affective norms of English words (anew): Instruction manual and affective ratings" set of words. For these four words, valence scores (rain = 5.08; sun = 7.55; green = 6.18; beautiful = 7.60) and arousal scores (rain = 3.65; sun = 5.04; green = 4.28; beautiful = 6.17) are generated by looking up the "anew" list. Finally, applying the aforementioned procedure, the overall tweet valence and arousal scores (6.60, 4.78) are obtained, which form a data point in the mood space and get a "relaxed" mood label.

8.4.2.2 Mood Probabilities

This section describes how the fusion of framework computes a set of mood probabilities [1] according to day, location, and weather. Each tweet T_i carries information about the location L, time stamp t, and weather label W; it also carries the mood information M_i. For each tweet $T_i \in T$, a record is maintained denoted by R: (T_i, L, t, W_j, M_i). Essentially, each tweet is mapped as a point in the 2D mood space. The complete set of twitter data is mapped on the 2D mood space as a distribution of points. For easy querying, the distribution points are summarized on the social metric space.

Once all the tweet records R's are obtained, the mood–weather information can be summarized using p_{ijk} probabilities, where p_{ijk} represents the probability of witnessing mood M_i when the weather is W_j, and the day is D_k: {Monday,…, Sunday}, that is, the conditional probability is $P(M_i|W_j, D_k)$. Different models can be considered for computing p_{ijk} ranging from a simple model that summarizes all the events ignoring temporal aspects such as time and weekday. According to the simple model, all the tweet records are grouped corresponding to a particular location L. Different weather labels W_j, mood labels M_i, and day labels D_k associated with each of these tweets are observed and P_{ijk} is computed as follows:

$$P_{ijk} = \frac{(\#\,\text{tweets with } M_i, W_j, D_k)}{\sum_{a=1}^{12} \#(\text{tweets with } M_i, W_j, D_k)} \tag{8.2}$$

It is determined as the fraction of tweets expressing a certain mood M_i for a particular weather label W_j and day D_k.

8.5 Social Compute Cloud: Sharing and Allocating Resources

Nowadays, it is quite easy to share our own resources, services, and data through social networks because we all believe that "apps" are becoming more sophisticated. To justify the statement, a social compute cloud, in which we furnish the cloud infrastructure by "friend" relationship, is presented. Sometimes a group of people needs access to resources that are made available only through connected peers. The social compute cloud is a platform for sharing infrastructure resources within a social network [19]. By using this approach, downloading and installing a middleware, leveraging on personal networks such as Facebook application, and providing resources or consuming resources from friends through a social clearinghouse have become very easy. We predict that resources present in the social cloud are shared as they are idle, underutilized, and made accessible altruistically.

Several challenges of social clouds include technical facilitation for the cloud platform, its interpretation, its inclusion in social network structure, and also its implementation as well as design of socio-economical models, which is required for abetment of exchange and platform infrastructure. Technical facilitation entitles users to supply resources and utilize resources from others. The idea of social cloud is based on a certain height of trust among each other. The social compute cloud architecture requires adequate sandboxing methods [19] as well as security for protecting resources from incompetent and potentially malicious users. Leveraging on social network makes it easy to share and compute resources inside social network. To exploit resource sharing of social cloud users, it must allow access to a social network and trust the platform that contains their social network data. We can say that a social cloud is a type of community cloud because here the resources are consumed, owned, and provided by the members of the social community. This is shown in Figure 8.9.

The models of a social compute cloud are as follows:

Socio-economic model: This model is for allocating resources within the social compute cloud [17]. The concept mainly focuses on sharing (and not selling) of resources.

Platform facilitation: This model mainly focuses on sharing resources. Here, the users are not paying for the services that are offered via the cloud platform. Rather, the platform needs computational resources in order to function.

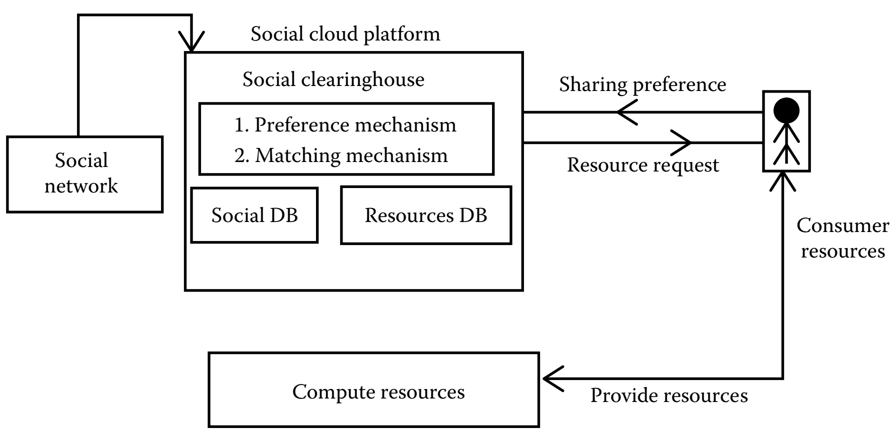


FIGURE 8.9
A social compute cloud and its core components.

8.5.1 Architecture of Social Compute Cloud

The social compute cloud platform requires proper coordination and execution, and its primary functionalities are resource allocation, user management, and so forth.

The social clearinghouse defines how user demands are fulfilled with the perfect supplies. It is the middle point of the system in which all information regarding users as well as shared information, demand, and resource supply are kept. The social clearing home needs two databases:

1. One database to capture the sharing preferences and social graph of the users
2. One database to work as a resource manager for tracking resource availability and resource allocation

The middleware provides basic resource virtualization, resource fabrics, and several mechanisms for consuming and provisioning resources. It also defines different protocols that users mainly need as well as resources to leave or join the system.

The social-technical adapter provides access to the necessary features of social networks. It represents a method of authentication. The preference module mainly provides the necessary functionality to represent and capture the sharing preferences when required. These adapters require special consideration as well as methods, which can be applied to capture preference. Matching mechanism is the socio-economic enactment of the social clearinghouse, which determines where the resources should be allocated by analyzing user's sharing preferences on social networks.

Compute resources are the technical funding of users, what they consume and provide to the social cloud. Here, resources mainly require personal computers, clusters, or servers. For the establishment of social sharing preferences, the social cloud needs to access a user's network. We are motivated to use a social adapter instead of an implementing platform as a social network application. The main misconception is that users always misinterpret between a social network and its application. Another misconception among users is that social networks can access users' data or resources that are kept in the social cloud.

Social graphs can be constructed through matching methods by following authorization. Many platforms are provided APIs for accessing a user's profile and the social graph. In the case of Facebook, Twitter, and Google+, a basic assumption is that the social cloud follows bilateral approval. In a different way, we can say that once a user commences the initiation of the digital tie, the other user must confirm in order to establish the request. But here the users are free to decide whom they want to follow, but the users cannot decide who will follow them. Therefore, another problem of trust among the participants arises.

Until today, there is no perfect methodology for the explanation of these social ties, which are often context dependent. Three methods can be applied either in combination or separately [17]:

1. Users themselves rank their friends.
2. Leverage methods to identify the attribute of social ties, which can be used for artificially constructing preference.
3. Use interaction theories for social networks to establish a social sharing and the interaction models for the social compute cloud.

But these methodologies have some advantages and disadvantages. If we are using user-provided lists, then it will be easy for implementation without the need for special permission. But the fact is that today most Facebook users have more than 200 friends, so the approach could not scale a huge number of friends to join social clouds. In contrast, if we move with computation methods, we can scale a large number of users as social cloud always grows. But the major problem with this approach is that it also requires huge data from social network platform and it is more protruding of users' privacy.

The socio-economic model is used to specify which kind of preference matching can be implemented and used. The first step it follows is capturing users' supply and their demand. This is done by the social clearinghouse. Here, centralized implementation is done, which means we know all the supply and demand of the market. The only disadvantage is that we have to manage an additional overhead for storing and updating the information. Although it has some disadvantages, it is still very useful in finding a solution to matching problems that are either stable or minimizing the overall welfare of users and provides complete fairness between two sides.

8.6 3D Visualization of Social Network Data

In this revolutionized age of technology, 3D data visualization and analysis [5] have become popular in many fields such as process control, decision support systems, and scientific data analysis. As the amount of data is continuously changing, analysis of data becomes a daunting task. The outstanding capabilities of cloud computing can help to solve this 3D data visualization and analysis problem by providing resources. A popular data analysis method called online analytical processing (OLAP) can be used to analyze social data.

8.6.1 Visualization of Social Network Data

The 3D graphical interfaces for knowledge or information navigation are based on a model view controller (MVC) [5] framework implemented in Windows Presentation Foundation. An example is a connection made between cloud computing and the social networking applications. With the help of cloud computing, businesses can search for people who are related to their company. The posted information can be captured, and future conversations about their company can be tracked. The information obtained from these conversations assists to create customer service cases. Thus, cloud computing helps businesses to access the existing social networks, optimize search engine tools, and connect with other businesses.

8.6.2 OLAP Data Analysis and Cube Generation

OLAP is a tool for answering multidimensional analytical problems that encompass data mining and a relational database. It enables users by analyzing multidimensional data interactively from multiple perspectives. An OLAP system generally uses a 2D plot that places multiple dimensions of column or row factors. The user must have some

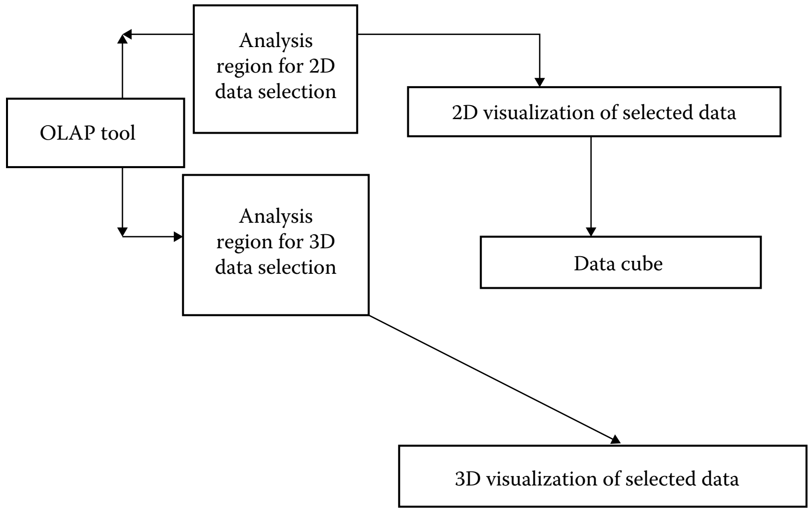


FIGURE 8.10
OLAP data analysis process.

domain knowledge for the selection of appropriate dimensions. But in the presence of new trends, it is very difficult for users to select new dimensions and range. Moreover, most of the existing OLAP systems support 2D or partially limited 3D charts with which users have limited or no interaction. The 3D information represented by an eCube is composed of selected attributes of the given database and its dimensions, as shown in Figure 8.10 [5,8].

The user can visualize the 3D cube by using operations that include rolling-up, drilling-down, slicing, and pivoting operations [17]. Rolling-up consists of combination of data that can be gathered and found in more dimensions. Drilling-down allows users to navigate through the data details. By slicing, users can take out a specific set of data from the OLAP cube. Pivoting allows the user to rotate the 3D cube to see its various faces. Interaction of users with the eCube can happen in a variety of methods, including selection, navigation, and zoom in or zoom out.

8.6.3 MVC-Based Model for Visualization

The system for 3D visualization of large and complex social network data is based on the MVC model. This model represents and manages the targeted information selected by users from huge social networking data. The targeted information is a subset of raw data and statistics obtained from social networking sites. This model uses extensible markup language (XML). The view comprises an interpreter for XML and a 3D graphics renderer. After interpretation of the XML file, the information is shown in a predefined 3D graphical environment. The controller monitors the interaction of the users with 3D visualization space. The flow diagram of MVC is depicted in Figure 8.11.

Based on the type of interaction, the controller governs the model to perform changes. If the state of the model is changed by the controller, the connected views are also changed.

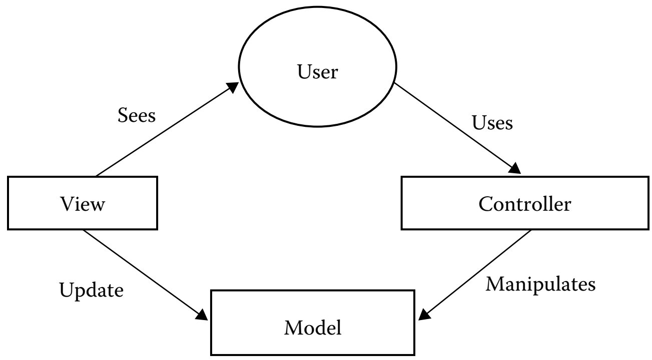


FIGURE 8.11
Model view controller.

8.7 Security in Mobile Social Cloud

As it is the integration of two different fields, that is, cloud computing and mobile networks, MCC has to face many technical challenges. With the innovative blow-up of mobile cloud technology, the demand for social data security is increasing sharply. It is a great responsibility to provide security to social data, which are shared in social networking sites and ultimately stored in the cloud. So, security of the mobile social cloud is the integration of mobile device security, social network security, and cloud security. Zhibin and Huang [9] have proposed the Privacy Protecting Ciphertext-Policy Attribute-Based Encryption [20] (PP-CP-ABE) method to protect the sensing data. It is pictorially depicted in Figure 8.12.

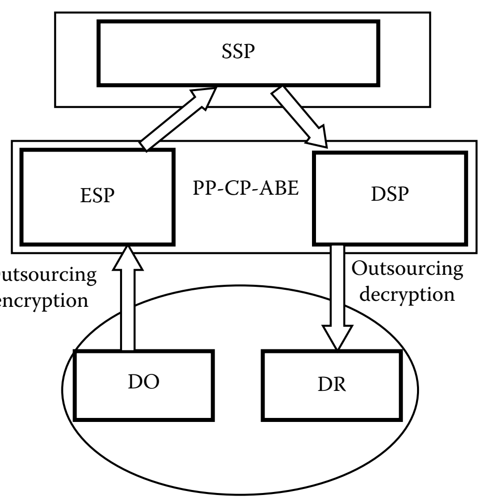


FIGURE 8.12
System architecture of security for light-weight devices. *Note:* SSP, storage service provider; ESP, encryption service provider; DSP, decryption service provider; DO, data owner; DR, data receiver.

Using PP-CP-ABE, heavy encryption and decryption operations can be securely outsourced from lightweight devices to cloud service providers. A data owner (DO) can request or store information from or in the cloud. This information is first encrypted by the encryption service provider before going to the storage service provider. When the data receiver (DR) requests for that data, the data are sent to the DR after the decryption is done by the decryption service provider.

8.7.1 Security in Social Network

A social network is like a virtual communication medium where users share multimedia data with others. In these sites, users provide their name, address, date of birth, gender, place of birth, school, interest, and other personal information. This information is shared with other users. Hence, attackers can gain personal information easily by using the social networking sites, which helps them in a wide range of network crimes such as identity theft.

8.7.1.1 Purpose of Attackers

Attackers have found social networking sites a better way to commit network crimes. Targets of attacks can be the following [6]:

- *Access control*: The attacker aims to get control of the computers of other users with malicious intention. The adverse effect is that the controlled computers are organized to perform some types of attacks such as denial of service attacks.
- *Personal information*: Some attackers are looking for important personal information such as bank account details, passwords, and social security number to commit further crimes.
- *Jokes*: Some users just want to play jokes with other users to improve their reputation. These types of attacks sometimes cause network congestion and affect the users' quality of experience.
- *Company information*: Users are business customers in most cases. In the past, attackers could not easily break the intranet because companies had strict protection measures. In contrast it is easier for attackers to obtain the trust of others with the advantage of social networks, which help them to gain professional information of users and customers.
- *Money*: Attacks on social networking sites have increasingly become financially driven. Most attackers target to gain bank account details, financial secrets, and private information.

By the end of 2008, the Kaspersky Lab collected a number of programs that attack social networking sites [8], as shown in Figure 8.13.

According to Figure 8.13, the number of malicious programs is increasing daily. From 2001 to 2005, the number of malicious programs was almost negligible. But since 2005, malicious programs have increased rapidly. MySpace has been attacked by higher numbers of malicious programs than other social networking sites. Though Facebook is comparatively secure compared with other social networking sites, it is still not free from malicious attacks.

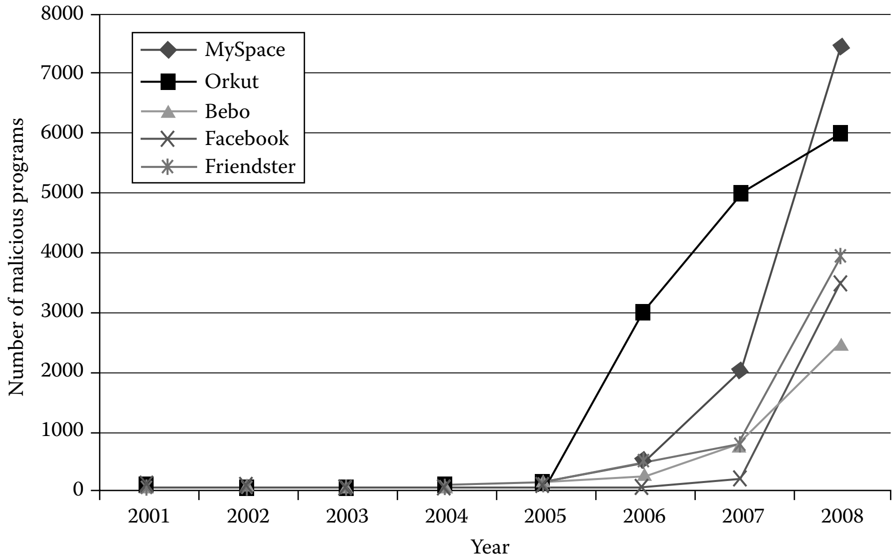


FIGURE 8.13
Attack on social network by malicious programs. (From Luo et al., An analysis of security in social networks, *Eighth IEEE International Conference on Dependable, Autonomic and Secure Computing*, pp. 648–651, 2009.)

8.7.1.2 Method of Attacks

Attacks on social networks are performed in different ways. Traditional spams are spread via e-mails, but now they spread fast via friend lists in social networks. The primary objective of spammers in online social networks is to reach a large number of social friends by spreading malicious code. Worms can self-replicate and spread automatically for stealing private information such as passwords and bank account numbers. Attackers can also use vulnerabilities that can be generated into the web page code to steal COOKIE, run FLASH, hijack accounts, force users to download malware, etc. [6,12]. Some plug-ins such as Flash are permitted to run on browsers, which brings a new threat to social networks. We must admit that both users and social networking sites have an impact on the security of social networks; therefore, social networking sites could provide enough security supports. Users should also increase their security awareness to combat the growing number of attacks.

8.7.2 Resource Allocation for Security Services

Numerous challenges exist in the mobile social cloud, including data replication, consistency, unreliability, availability of cloud resources, trust, security, and privacy. Research organizations and academia have undertaken a massive amount of work to secure a cloud computing environment. To attract potential consumers, the cloud service provider must target all security issues to provide a complete secure environment. Cloud security services are classified into two categories: normal security (NS) services and critical security (CS) services. CS service involves more complex security implementations such as stronger authentication and encryption algorithms, longer key size, strict security access policies, and so on. The NS service uses only basic security approaches such as authentication to validate users and access control tasks. NS service also involves low-complexity

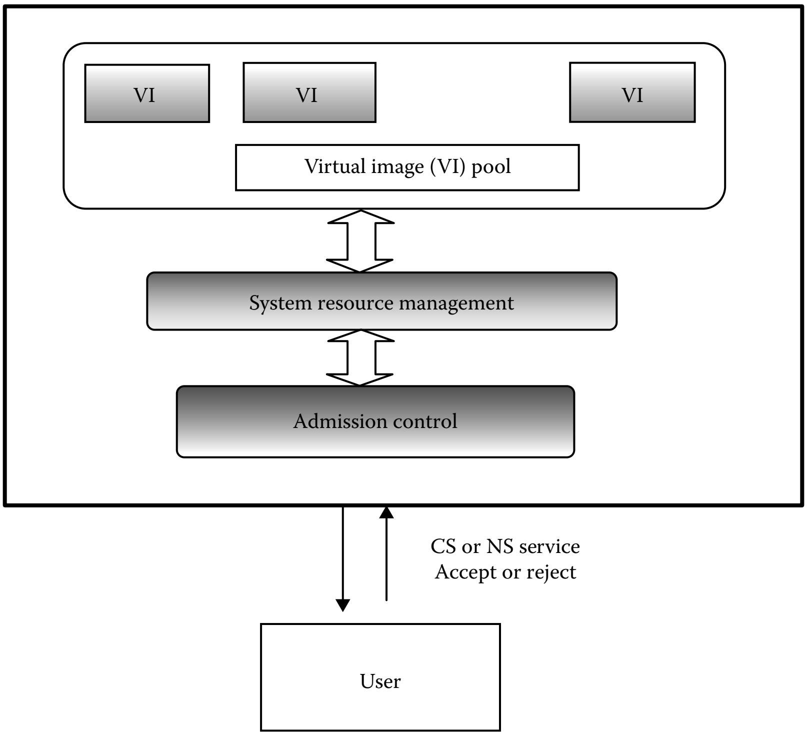


FIGURE 8.14
Resource virtualization in cloud for security services.

computing and resource isolation as the first requirement in order to provide these security services. It comprises a virtual image (VI), which manages a portion of the cloud system resources such as CPU and storage. Figure 8.14 shows how resource virtualization is done to provide various security services to mobile cloud users. When a security service request comes from the user, the system admission control consults with the system resource management model about the availability of resources, that is, VIs. If VIs are available, then the request is accepted and one or more VIs will be allocated to that security service. If resources are not available, the request is rejected and increases the probability of blocking [7]. But the cloud decides whether to accept or reject a security service request based on the currently available cloud resources and the arrival rate of future security service requests.

8.8 Trust in Mobile Social Cloud

With the explosive growth of cloud computing, the demand of social networking sites is increasing sharply. Users are mutually connected through social computing to form a social network. Trust is the foundation of all social interactions among society members. Users make decisions based on the trust between users and their friends and are more willing to accept information from trusted friends. Users also share their personal data with trusted friends, and the data are stored in the cloud. A social network connected by

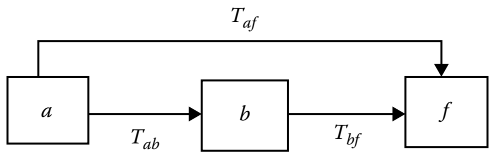


FIGURE 8.15
Trust transmission in friend path.

trust scores of people and a model propagating those trust scores are the basic building blocks in many of today's recommendation systems. Therefore, estimating how much one user will trust another is the most challenging issue in the social cloud environment. In social networks, users trust their friends and the friends of their friends; this is how trust can be transmitted [11]. With the help of trust transmission, users can obtain their indirect friend's trust value. Trust transmission is shown in Figure 8.15.

Cloud users are more concerned about whether data center owners will misuse their data by releasing them to third parties. Kai and Li [11] have proposed a trust management scheme augmented with data coloring, which can help address this issue. In this method, cloud drops, that is, data colors are added to the input data such as image, video, and document.

In a social cloud, trust plays a vital role as a collaboration enabler. However, trust is not trivial to define and observe; it represents an analysis to understand exactly what role trust plays in enabling the collaboration. This is done through the definition of the structure of a social cloud as a sequence of social and cognitive processes.

8.8.1 Trust Inference in Social Networks

In the context of social networks, trust is nothing but a commitment to an action based on belief that the future action of a person will lead to a good outcome. It gives indications for a participant's decision making in various activities on social networking sites. Trust inference actually aims to infer a trust value accurately, which may exist between two people without direct connections, based on trust transitivity [10,12]. A participant can give better recommendations to participants who have intimate social relationships with him/her. An intimate degree value r ($0 \le r \le 1$) of social relationships between participants and a role impact value ρ ($0 \le \rho \le 1$) are defined in trust-oriented social networks to calculate the trust value [12]. This value indicates the impact of the participant's recommendation roles if the participant is an expert or beginner in a specific domain.

From Figure 8.16, it is observed that if X trusts Y and Y trusts Z, then X can trust Z to some extent. The probability that X can trust Z is calculated as

$$P(T_{XZ} \mid r_{YZ,}\ \rho_Y) = \frac{\Pi(\theta) \cdot P(r_{YZ} \mid T_{XZ}) \cdot P(\rho_Y \mid T_{XZ})}{P(r_{YZ}) \cdot P(\rho_Y)} \quad (8.3)$$

where

$\Pi(\theta) = (T_{XY}) \cdot (T_{YZ})$ is the prior probability of trust inference

$P(r_{YZ}|T_{XZ})$ represents the probability of intimate degree value $r = r_{YZ}$ with the given condition that there is a trust relation between X and Z

$P(\rho_Y|T_{XZ})$ represents the probability of role impact value $\rho = \rho_Y$ with the given condition that there is a trust relation between X and Z

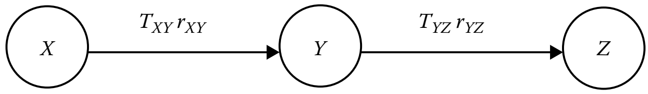


FIGURE 8.16
Trust inference in single trust path.

But in mobile cloud computing, trust may not be symmetric. Participants have different purposes in social networks, such as making friends, advertising, and carrying out business. In certain circumstances, these mechanisms may not deliver realistic trust values between those who trust and those who are trusted. So, before inferring trust, some constraints of recommendation roles and social relationship preferences need to be specified.

8.8.2 Trust Contextualizing in Social Clouds

The notion of trust actually needs an analytical perception as an idea of context and social action. So to address the provocation of understanding and defining trust, the social cloud can be griped like an exchange enabler, investigated, and specified experimentally [1]. To understand the concept of trust and social cloud context, there is a brief description about the social cloud structure.

8.8.3 Social Cloud Exchange Structure

A social cloud is a sequence of cognitive and social processes. It is represented in three stages [18]:

1. Prior expectation
2. Social interchange
3. Completion

The social cloud exchange structure [18] is shown in Figure 8.17.

8.8.3.1 Prior Expectation

Prior expectation deals with why a user would join or use a social cloud and how it would fulfill users' expectations for their contribution. Motivation, demand, and supply are expected by users. Motivation can be expressed through expected outcome, which includes a gain inutility, goal fulfillment, task completion, and feeling of usefulness or inclusion. These also include a sense of togetherness or belonging through participation in a cloud. The social context specifies special features of the social cloud and its users, for example, relationships such as close friend, family, colleague, and acquaintance, special features of the social graph such as connectivity and centrality, and the implicit trust between the users of social cloud and their friends. The interaction history describes the completion of all the three stages. Supply is the inferential availability of some useful resources in a cloud. Demand is the monitoring of individual requirements that motivate users to furnish to their squint, for example, the demand being persuaded in social capital. In this case, the requirements of the users of social cloud are compelled by one or more

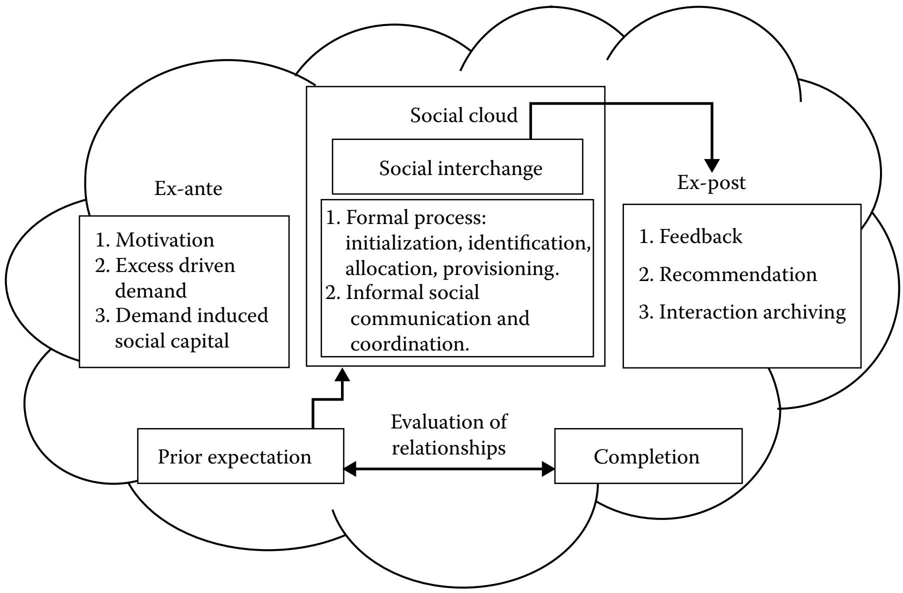


FIGURE 8.17
Social cloud exchange structure.

other users so that their capabilities and their resources can be exceeded. These resources are available in social capital form.

8.8.3.2 Social Interchange

Social interchange entails the abetment of exchange and collaboration among socially connected peers. It includes formal process, informal social communication, and coordination. In the formal aspects, we define collaboration like economic systems. In informal aspects, we define context specific and social structures, which help us to facilitate exchange like a socially driven procedure. The main aspects at this stage are to focus around allocation and identification of supply and demand. These can be implemented through socio-economic processes, messaging processes for coordination and communication, and the delivery and provisioning of exchange facts.

8.8.3.3 Completion

Completion is a process that addresses the actions that resolve an exchange and includes major components such as feedback, archiving, and recommendation. Feedback is a social distribution for exchange like an exercise in communication and reflection through two modes: (1) public feedback, which is the means of social channels such as notification, Facebook timeline, and newsfeed; and (2) local feedback, which is for potentially private users. Feedback includes possibly a reward disposed to providers or a thank you message.

Recommendation is a proposal for an activity after a negative or positive exchange result, that is, whether users are rewarded or have to pay penalty. This recommendation process is mainly dependent on a social context from collaboration. Archives act like a repository for governing social cohesion, that is, often an interaction history result and collaboration performance based on good expectation.

8.9 Applications of Mobile Social Cloud

Numerous applications have been developed with the integrated mobile social cloud environment.

8.9.1 Cloud-Assisted Adaptive Video Streaming

Disruptions and buffering delays are the major problems in video streaming, nowadays. To address these issues, a framework of cloud-assisted services has emerged [13]. Traditional adaptive streaming frameworks, such as Microsoft's smooth streaming technique as well as Adobe's and Apple's HTTP adaptive live streaming, had to maintain multiple replicas of the video with various bit rates, thus putting a huge storage burden on the server. Therefore, the recent H.264 Scalable Video Coding (SVC) technique has gained much attention. SVC defines a diverse profile of video streaming with one base layer (BL) and multiple enhancement layers (ELs). If only the BL is delivered, a video can be decoded and displayed at the lowest quality. When more ELs are delivered, a better quality of the video stream can be achieved. These sub-streams can be encoded by exploiting three scalabilities:

1. Spatial scalability by layering image resolution, that is, screen pixels
2. Temporal scalability by layering the frame rate
3. Quality scalability by layering the image compression, which can offer videos for a high variety of qualities with relatively less storage overhead

Cloud-assisted adaptive video streaming is shown in Figure 8.18.

The whole video storing and streaming system in the cloud is called Video Cloud (VC). There is a large-scale Video Base (VB) in VC. The VB stores most of the popular video clips from video service providers (VSPs). A temporary Video Base (tempVB) stores new candidates for popular videos to serve as a cache. The VC also keeps running a collector to seek popular videos from VSPs, re-encode the collected videos into SVC format,

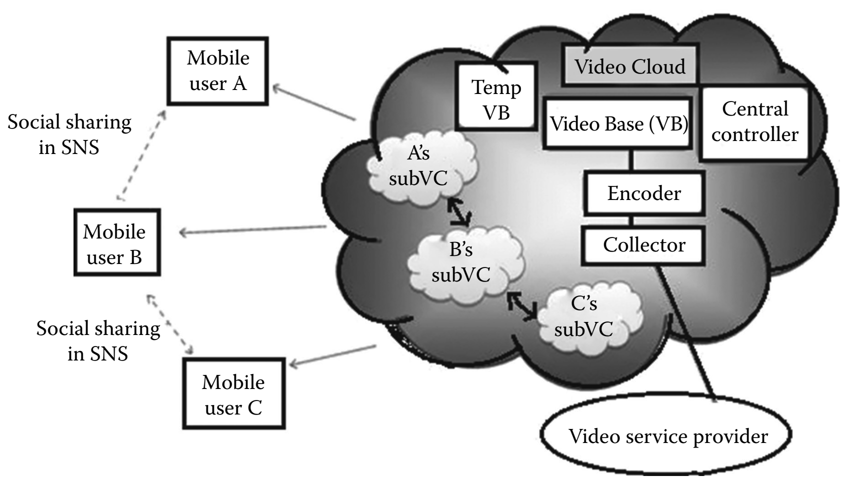


FIGURE 8.18
Cloud-assisted adaptive video streaming.

and then store in the tempVB [13]. When a mobile user requests video streaming, a sub-Video Cloud (subVC) is dynamically created for each active mobile user. Each subVC has a sub-Video Base (subVB) that stores the recently fetched video segments. If the mobile user requests for a new video that is not in the subVB or in the VB, the subVC fetches, encodes, and transfers the video. During the video streaming, mobile users will always periodically report link conditions to their corresponding subVCs. Then, the subVCs predict the available bandwidth of the next time window and adjust the combination of BL and ELs adaptively.

8.9.2 Personal Emergency Preparedness Plan

With the increasing growth of mobile computing, cloud computing and social services have become an integral part of the society during the event of an emergency or disaster. The Department of Health and Human Services (HHS) had sponsored a challenge for software application developers to design a Facebook application that will help people to prepare for emergencies and to obtain support from friends and families during its aftermath.

A dynamic application has been developed, which identifies and connects friends on Facebook who are willing to be "lifelines." HHS identifies a lifeline as someone who will act as the point of contact in the aftermath of an emergency or disaster. The department claims that a tremendous number of people use Facebook to share information about those who are potentially affected by the disaster. Social networking sites help people to connect with each other. In the event of an emergency, people can connect with their friends and family through these sites. There are web applications that provide a registry and message board for survivors, family, and loved ones who have been affected by a natural disaster. The application allows users to post and search for information about another person's well-being and location. The application operates by allowing agencies to collaborate with local officials to share information such as maps, reports, pictures, and videos. This information can be streamed in real time from a command and control center to the hands of first responders with mobile devices.

The motivation behind the Personal Emergency Preparedness Plan (PEPP) [10] application is to improve upon Google's Person Finder and Lockheed Martin's Open911 web application by incorporating a social networking platform such as Facebook. The PEPP app integrates features that would provide critical information for an emergency responder such as the geographical information system. In the aftermath of a disaster, traditional channels of communication such as cell phones and land line networks are frequently overwhelmed. Although SMS messaging has been an invaluable source of communication, it is reliable. Therefore, integrating with social networking sites such as Facebook and Twitter will decompress those channels of communication.

8.9.2.1 System Architecture

A high-level architectural overview of the PEPP app [10] is shown in Figure 8.19. It shows two interconnected hybrid clouds consisting of a social network platform on the left and cloud on the right. The composition of the clouds remains its unique entities and is joined by configuration settings that enable data sharing between the cloud entities.

Social networking platforms such as Facebook provide the core features that are available for integration, such as news feeds, notifications, platform dialogs, and the social graph. Facebook does not provide a hosting service for apps. Therefore, a developer who

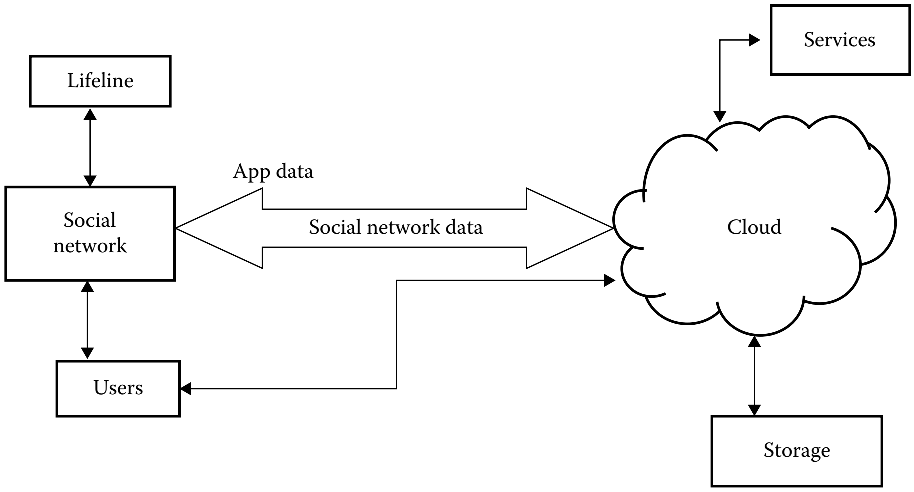


FIGURE 8.19
Architecture of personal preparedness emergency plan.

is creating a Facebook app must find his or her own hosting service. After subscribing to the hosting service and registering the app's URL, the next step is to sign up for a Facebook developer account. Specifically, the app will be loaded within an HTML <iframe> element. The web interface for the PEPP application appears as a native Facebook app. The app is integrated into the Facebook canvas while leveraging core features of the platform such as notifications, authorization dialogs, and the social graph.

8.9.3 Massively Multiplayer Online Games

The massively multiplayer online game (MMOG) [11] represents a beautiful application of social cloud computing. Millions of users are playing various kinds of games through the Internet daily. For example, Farmville and other similar games have more than 10,000,000 constant players. These players turn into a collaborative community to exchange information such as game review, news, advice, and expertise. Third parties such as volunteers and small businesses have built online communities that provide all this information to users of respective games or groups of similar types of games. Now these communities need to analyze various data such as news and advice to provide users' demands such as player reports and clan statistics. An analyzing architecture is depicted in Figure 8.20 using the cloud service called Continuous Analytics for Massive Multiplayer Online (CAMEO) games.

The CAMEO is the architecture for MMOG analytics in cloud. It mines information from the web and collects information by web 2.0 interfaces provided by various MMOG operators and their collaborators. Then, it integrates the information into comprehensive and time-spanning MMOG datasets. Finally, it analyzes the dataset and presents application-specific results. To analyze this huge amount of data, cloud is used, for example, Amazon EC2 service.

8.9.3.1 Challenges in CAMEO Architecture

Challenges in the CAMEO architecture are described in the following sections.

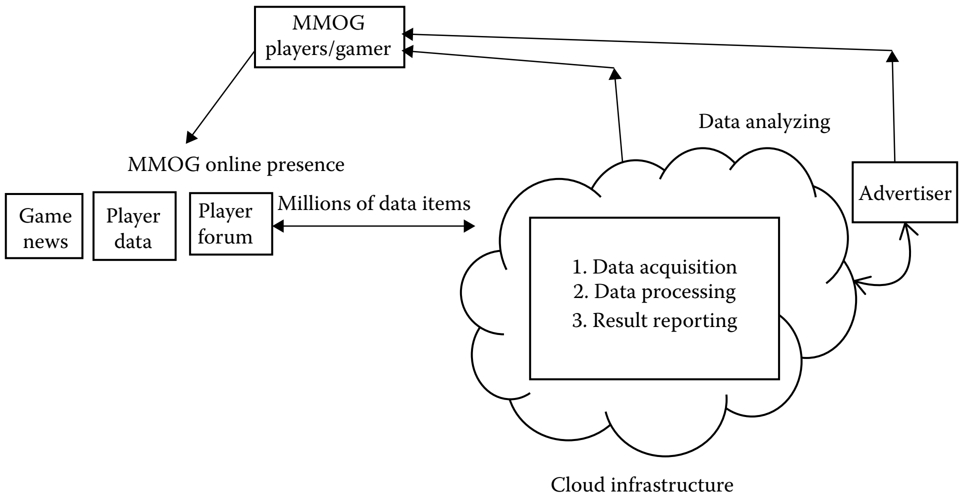


FIGURE 8.20
CAMEO architecture for analyzing MMOG.

8.9.3.1.1 Understanding User Community Need

Various kinds of data are generated during online gaming. CAMEO needs to analyze data of numerous types. It can do various kinds of analysis such as the following:

- Analyze skill, experience points, rank of a player and process information from single or multiple data snapshots, allowing for single time point and evolution analysis.
- Rank players according to one or more skills, extract the statistical properties for the whole community for one or more skills, extract the characteristics of the key players who improved most during a period such as a week, and compute the evolution of the top players during a period.

8.9.3.1.2 Data Management and Storage

Data management and storage have always been important issues in CAMEO. For simplification, CAMEO stores data centrally using a single administrator. For data management, it interacts automatically with the storage administrator. Three main solutions to store data are available to CAMEO:

1. Store the data on the same machine that acquires or generates it
2. Store the data outside the cloud
3. Store the data using the dedicated cloud storage services such as Amazon S3

By default, CAMEO uses the third solution, which is centralized, reliable, and scalable. It provides the highest transfer speed between storage and processing nodes for continuous analytics workload.

8.9.3.1.3 Performance, Scalability, and Robustness

All these characteristics are very important to maintain mainly the quality of service of CAMEO. As we use cloud service, it provides the scalability and robustness to CAMEO.

8.9.4 Geosmart: Social Media Education

Geosmart [12] is another application of social cloud computing. It is an interactive, informative, and communicative social media for education purposes. Geosmart is the combination of social media and could compute. It aims to increase intelligence in the Indonesian society and is a kind of online education system that uses the cloud and has become more interactive and interesting to users.

8.9.4.1 Entities of Geosmart

There are four main entities of Geosmart: user entity, technology entity, feature entity, and materials entity.

1. *User entity*: Any person involved directly or indirectly with the education system is a user of Geosmart. There can be six kinds of users involved in the system: students, teachers, lectures, campus students, parents, and the public. Students can collaborate and share their knowledge within the school or with other school students. Teachers can collaborate and share their knowledge of good teaching methodology with other teachers as well as students. Lectures found in video and power point presentation format in Geosmart are very interactive and useful for students. Through Geosmart students can collaborate and share with other students across campus. Geosmart can be a beneficial platform for discussion, communication, and information sharing among students. Parents can interact with teachers and various authorities to monitor their students. The media for alumni or education practitioners help to communicate and provide information about their school or campus through Geosmart. The entities of Geosmart are shown in Figure 8.21.
2. *Technology entity*: Technology is a vital fact of any social system to increase reliability and availability. The technology entities are web platform and mobile platform. Geosmart application represents the web 2.0 generation where the Internet is utilized to run the web applications. To increase the utility and portability of the

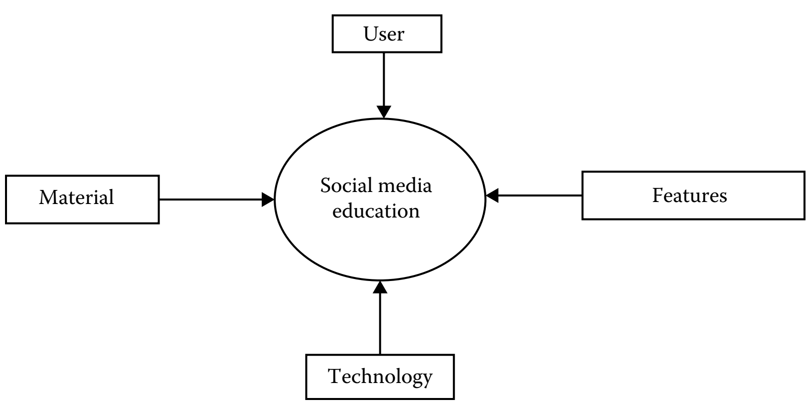


FIGURE 8.21
Conceptual diagram of Geosmart.

application, a mobile platform is needed. Massive uses of mobile devices led to the development of Geosmart messenger, which is an android app to control and use the application from mobile devices also.

3. *Feature entity*: Geosmart has various features for users such as discussion forum, chatting, educational materials, competition, album, ranking, try out, school page, badge, and Geosmart mobile.
4. *Materials entity*: Numerous educational services are available in Geosmart on demand, such as ebooks, videos, games, materials, try outs, and tutorials.

8.9.4.2 Architecture of Geosmart

Geosmart uses social cloud, which involves many third parties to contribute resources. Every service should be accessible to Geosmart registered users. The objective is to provide interaction between users and services. The architecture is given in Figure 8.22.

The users or contributors of Geosmart's service should perform the registration process first to get a Geosmart ID. The Geosmart API is used as an interface for third parties to deliver both content and application services to the site Geosmart. Users who upload the service to the Geosmart site are given a page with the URL interface (http://apps.goesmart.com/socialcloud/) access, which will be forwarded to the server and will result in a response page as interface/preview content. The Monitoring and Discovery System (MDS) is a component that provides information services that are contained in the resource server. Services are updated periodically through the MDS and stored in the server side. Telecommunication providers offer the content to system services. The system communicates with the existing services on the Geosmart's web transaction processing conducted for Geosmart's registered users only. For example, a teacher would like to contribute paid material/content/application education to the user community with a charging mechanism from Telco provider.

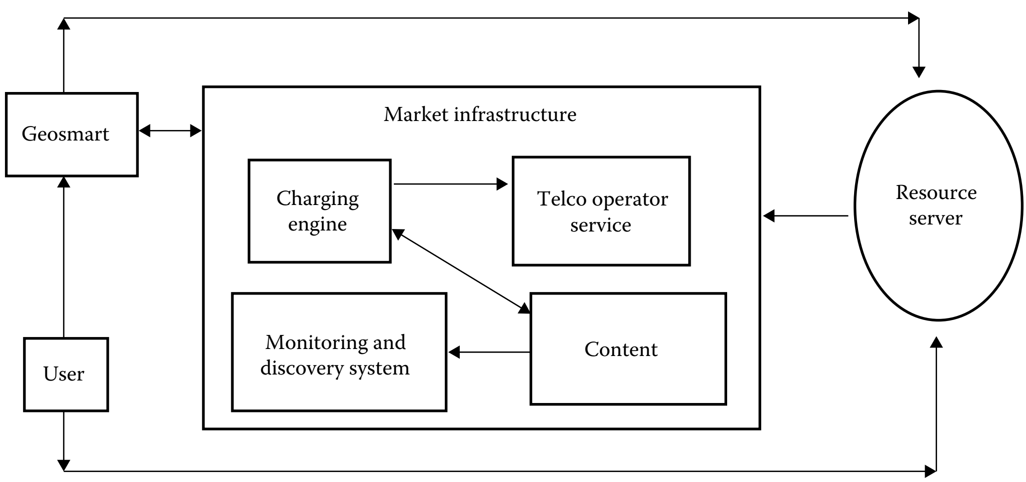


FIGURE 8.22
Geosmart architecture.

8.10 Conclusion

The tremendous popularity of mobile devices and social networks as well as the significant utility of cloud is behind the creation of mobile social cloud computing. This chapter has focused on various aspects of mobile social cloud computing. The social network platform can be used to gather a huge amount of user data for resource sharing and data analysis. Facebook, Twitter, online gaming, online video streaming, online TV streaming, and online education systems are using the concept of mobile social cloud computing and have become very popular nowadays. Although handling big data is challenging, the mobile social cloud has become feasible due to the growth of social network users. Security plays a major role in this field since a huge amount of social data is stored in the cloud. So, to provide security services to users, efficient resource allocation is required. Trust is another important aspect of mobile social cloud. The mobile social cloud leverages the existing relationships of people in social networks for service and resource sharing. Social networks are based on digital relationships mapped from real-world relationships. These relations are all about trust between people. In a social network, the question of whom to trust and whom to not is now of vital importance. Though there are many trust models, it is not always true that a real-world person is the same person on a social network. On the other hand, we send our social and personal data to the cloud. Therefore, data integrity and privacy are very important concerns. Consequently, the trust of the mobile cloud provider is also a vital issue, which has been discussed in this chapter.

Questions

1. Describe social mobile cloud computing with an example. Explain its architecture.
2. Explain resource sharing in social mobile cloud computing.
3. What is a social market? Explain all its protocols.
4. What is warehousing and analysis of social data? Explain their architecture.
5. What is tweet mapping and mood probability of social mobile cloud computing?
6. What is social compute cloud? Explain its architecture.
7. Discuss the 3D visualization of social network data.
8. Discuss the security issues in mobile social cloud computing.
9. Explain trust in mobile social cloud.
10. What is trust contextualizing in social cloud?
11. What are the applications of mobile social cloud?

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