

Chapter 4

A Game Theoretic Model for Cloud Federation

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Abstract Cloud federation has become a consolidated paradigm in which set of cooperative service providers share their unused computing resources with other members of the federation to gain some extra revenue. Due to increase in consciousness about cloud computing, demand for cloud services among cloud users have increased, thus making it hard for any single cloud service provider to cope up with cloud users demands and satisfying the promised quality of service. Hence, the cloud federation overcomes the limitation of each cloud service provider for maintaining their individual cloud resources. This chapter emphasizes on different approaches for cloud federation formation based on game theory and also highlights the importance of trust (soft security) in federated cloud environment. Different models for cloud federation formation using coalition game and the role of a cloud service broker in cloud federation are presented in this chapter.

4.1 Introduction

In recent years, Cloud computing has emerged as a new computing paradigm, where different cloud services like Infrastructure as a Service (IaaS), Software as a Service (SaaS), Platform as a Service (PaaS) are provision on-demand. The on demand provisioning of computing resources has attracted many big organization and led to rapid increase in cloud market due to their cost benefit. Moreover, with the increase in consciousness and growth in the cloud, requirement for computing resources has increased in such a way that, single service provider available resources become

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insufficient to deal with cloud users resources requests. Therefore, not able to deliver cloud services with committed QoS. This necessitates service providers to reshape their business plan in order to deliver uninterrupted cloud service to cloud users by increasing their resource scaling capabilities and availability (uptime) of resources. Hence federated cloud offers a practical platform to service provider for delivering uninterrupted cloud service to cloud users.

Cloud federation is a paradigm where the cloud environments of two or more service providers can collaborate and share their unused computing resources with other member service providers to obtain some extra revenue. In federation user applications need to be provider independent so that they can be easily migrated across multiple cloud service providers within the federation. In addition to this, the security, privacy and independence of the members of federation should be preserved to motivate cloud providers to take part in federation. Cloud federation provides substantial advantages to service providers and cloud users. Cloud federation enables service providers to earn some extra revenue by sharing their idle or underutilized computing resources. Second, cloud federation also allow service providers to increase their geographic space and allow to overcome unexpected rise in resources (virtual machine) request without having to invest in new infrastructure. Third, cloud users can avoid vendor lockin scenarios if their associated cloud service providers support more than one federations standards.

Cloud broker plays an important role in forming the cloud federation. A cloud broker is a middleware that provides cloud services to cloud users but may not provide any of its own computing resources. Cloud federation introduces new avenues of research based on the assistance it receives from the cloud broker, such as:

- Formation and management of the cloud federation.
- determining the number of computing resources, each cloud service provider should contribute within the federation and how the profits can be shared among the member of federation.
- Standardizing and monitoring the QoS and promised SLA among the cloud service providers within the federation.
- Providing a single unified view to the applications and cloud users.
- Formation and management of Trust of the cloud service providers for ensuring security of sensitive data and computation within the federation.

Forming cloud federation among different cloud service providers and sharing revenue among them are often complicated acts; so cloud broker helps different cloud service providers to work in federation.

Recently, popularity of game theory has considerably increased in the research field of cloud computing. This chapter will focus on a broker based cloud federation framework using game theory. We present the formation of cloud federation as a cooperative (coalition) game where different service providers collaborate to form a federation to cope up with fluctuation of users resources demands. The framework calculate the profit of every member service providers of federation based on their contribution of resources in federation and help them to gain highest profit while being part of federation. The cloud broker determines the individual satisfaction

level of each CSP in a federation and based on that the existing federations are merged or split. It produces a stable federation partition where not a single service providers get better incentives in a different federation. Cloud broker is responsible for managing cloud federation, allocation of resources to cloud service users, service level monitoring etc. If these service providers can collaborate to form a federation then the available computing resources of these service providers can be combined to maximize their profit by using idle resources and support more cloud users. One of the main problems for service providers to take part in federation is the absence of trust between different service providers taking part in federation. Moreover, to guarantee the committed QoS and security of critical and sensitive data of cloud users, it is necessary to evaluate the trust of service providers and then form federation. The framework maintains the trust of each CSPs and the cloud broker selects trusted cloud service providers based on their individual QoS parameters like performance, scalability, availability. Cloud broker also combined services of more than one cloud service providers and provides an combined framework to the service providers or cloud users. This framework provides immense advantage to both cloud users and as well as service providers as cloud broker provides a single entry point to multiple heterogeneous cloud environments. Our focus is on laying emphasis on different approaches for cloud federation formation based on game theory and also highlighting the importance of trust (soft security) in federated environment.

The chapter is organized as follows. The Sect. 4.2 presents the role of cloud broker in cloud ecosystem. Section 4.3 provides brief overview of cooperative game theory. A game theoretical model for cloud federation formation is discussed in Sect. 4.4 followed by discussion of different framework based on coalition game theory. Section 4.5 discusses about the importance of trust in cloud federation. Section 4.6 concludes this chapter.

4.2 Role of a Cloud Broker in the Cloud Ecosystem

A cloud broker is a middleware that provides cloud services to cloud users but may not provide any of its own computing resources. Due to increase in cloud computing demands, the need for some expert to provide the optimal cloud offerings for enterprise business and technical requirements is also increasing. The provisioning task becomes more complicated in a heterogeneous cloud environment. Cloud service broker plays an important role by leveraging specialize expertise to provision cloud services in such a heterogeneous environment. In order to deliver reliable services, cloud service broker should be trusted and should have sound knowledge of the available cloud market. Trusted cloud service broker will make cloud service more secure to select and manage complicated cloud services, in federated cloud environments. A cloud service broker help cloud users by clearly defining technical and business needs while cautiously assessing the security policies, infrastructure capabilities and unique differentiating features provided by every service providers. Thus cloud broker provides a brokerage services to the cloud user's. The important characteristics of cloud service brokers are:

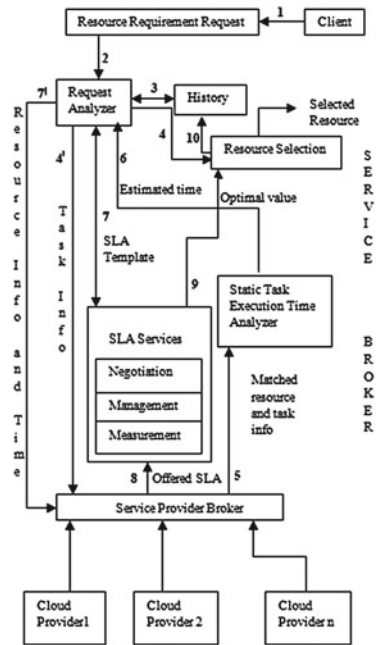
- It is a middleware between cloud service providers and cloud users.
- It does not provide cloud service of its own.
- Manages relationships between cloud service providers and cloud users.
- Provide single platform to deal with heterogeneous cloud providers.
- Cloud service broker provision resources optimally and add some value to interaction.

Increase in consciousness and growth in the cloud market, resulted in increase of variety of heterogeneous cloud services, thus increasing the need for specialized expertise (cloud service broker). As the demands of cloud service increases and number of service provider and infrastructure increases, the complexity service offered by cloud market also increases. Due to increase in complexity of cloud market, users have to manage many different heterogeneous services in terms of cloud interfaces, type of instances and price schema. For example, virtual machine instances are characterized, based on their configuration (number of core, memory, storage, compute unit) and each virtual machine provided by different service providers are of different quality as it these service providers provides service with different quality. In this scenario, the problem for cloud user was to select, best cloud service provider, who can deliver good quality service at low price. The cloud service broker's help cloud users to save their time by analyzing best negotiated services from different service providers and availing the cloud users with information about the best quality services at negotiated price. After analyzing best negotiated service, the broker provides the cloud users with a short list of selected service providers.

Based on above discussion, cloud brokering procedure will be essential to overcome variety of heterogeneous cloud services, for example, choosing computing resources for task at negotiated price, management of Service Level Agreement, monitoring of service for SLA violation. Ray et al. [1] in their work, proposed (a) broker based cloud service provider selection architecture and (b) game theory based SLA negotiation framework is proposed. The objective of cloud service broker was to determine a most suitable cloud provider, who can deliver good quality service at low price to cloud user and negotiating SLA on behalf of both cloud providers and cloud users and determine optimal value for price and quality for both cloud providers and cloud users. Their service broker architecture is given in Fig. 4.1.

In the proposed architecture, as shown in Fig. 4.1 [1], the service broker is considered as third party between cloud provider and cloud user. Their service broker assists cloud user to select the most suitable provider who will provide cloud service based on negotiation on parameters like price and quality. The working principle of the architecture is describe as follows, (a) Client submit task and SLA template to Resource Request Requirement (RRR), (b) Forward resource request to Request Analyzer (RA), (c) RA check for similar task in history, (d) If task matched then its corresponding resource details are forward to Resource selection module otherwise task information is forward to Service Provider Broker (SPB) module, (e) SPB submit the details of matched resource with task to Execution Time Analyzer module, (f) Execution Time Analyzer module, after analyzing time t for task on different selected resource, submitted to RA module, (g) RA forward cloud user SLA template to SLA

Fig. 4.1 Cloud broker architecture



negotiation module and ask initial offered value (price and quality) to execute task for estimated time t from SPB module (consist of different service providers), (h) best values for chargeable price and quality of service of service providers are submitted to resource selection module and (i) History module is updated.

Cloud service broker can deliver different categories of services. Cloud service broker are categorized based on functionality provided by them. As stated by National Institute of Standards and Technology [NIST], (2011) cloud service brokers are of three different categories and are differentiated based on their functionality. They are discussed below:

Service Aggregation: service broker unites many heterogeneous cloud services into one or more new services. The cloud service broker offer data integration and guarantee secure movement of critical data among users and service providers.

Service Intermediation: Cloud service broker upgrade a cloud service by enhancing some particular capacity and deliver value-added services to cloud users. The capability enhancement includes access and identity management, security enhancements, etc.

Service Arbitrage: Service arbitrage and service aggregation are almost similar, but the only difference is, that the combined cloud services not stable. Service arbitrage means a cloud service broker is flexible to pick cloud services from multitude of cloud services.

Cloud service broker plays a major part in forming the federation. A cloud broker aggregates and integrates cloud service providers and managed their services from multiple providers through a single entry point. Cloud brokering establishes relationships with multiple cloud service providers. Forming cloud federation between multiple private and public clouds and sharing revenue are often complicated acts; so cloud broker helps different cloud service providers to work in federations. Cloud federation introduces new avenues of research based on the assistance it receives from the cloud service broker. Some of them are, (a) Formation and management of cloud at federation level, (b) Management of resources at cloud provider level and (c) Standardizing and monitoring the QoS and promised SLA.

Cloud broker can make profit from aggregating all types of services from multiple cloud providers and delivering that service to users and thus easily include their own value-added services into the overall solution. Users of cloud broker gain substantial amount of benefit by continuously outsourcing their IT needs while cloud broker able to manage the complexity, cost and risk of using cloud services. Currently many cloud users, beyond selecting the cloud service providers, are looking for trusted third party (cloud broker) for monitoring, managing of cloud services provided by cloud providers. In addition to strategic and technical challenges, commonly associated with migration of application workload to other cloud, the cloud providers also need support over post-deployment, so that they may maximize their return from their investment. For instance, it is very essential to obtain suitable service broker such that it can guide a user to understand the technical and business aspects of cloud.

4.3 Overview of Cooperative Game Theory

Game theory is the branch of mathematics which dealt with the study of strategic decision making. Specifically, determines strategies for dealing with situations where the outcome of one players choice of action depends on the actions of other players. The cloud federation formation framework is modeled based on problem of a cooperative game. In cooperative game, a group of players can take a set of joint actions. These groups of rational players are referred to as coalition and enforce a cooperative behavior. The outcome of a cooperative game will be specified by which coalitions forms, and the combine action that group takes. Cooperative game theory examines condition where set of players can cooperate to create value by joining coalitions.

In coalition game two important components are the players and the coalition value. Let currently set of rational players be indicated by $\xi = [1, m]$ who interact with each other to form cooperative group (coalition) and try to improve their payoff in the coalition game. In a coalition game coalition $\mathbb{F} \subseteq \xi$ represents group of player cooperative with each other and act as a single entity in a given game. On the other hand the coalition value $u(\text{payoff})$, is defined as the utility of a coalition in a cooperative game. Again, based on the considered definition of coalition value, different properties of a coalition game can be defined. Therefore a coalition game

can be defined by the pair (ξ, u) . The mathematical model of the Coalition Game is given by:

Definition: A coalition \mathbb{F} in any subset of ξ . The set of all coalitions is denoted by 2^ξ . A coalition game is mapping $u : 2^\xi \rightarrow \mathbb{R}$ such that $u(\emptyset) = 0$. For any coalition $\mathbb{F} \subseteq \xi$, the number $u(\mathbb{F})$ is called the worth of \mathbb{F} .

In general, a coalition value can be of three different types:

Characteristic form: The characteristic form is the most popular form of coalition value in game theory and it was first introduced by Neumann [2]. The value of coalition in characteristic form depends on each players of coalition, i.e., the value or utility of any coalition $\mathbb{F} \subseteq \xi$ is not relied on the coalitions formed between the players which are not the part of \mathbb{F} .

Partition form: Any coalition $\mathbb{F} \subseteq \xi$ are in partition form if utility of coalition game is dependent on the coalitions formed by the members in $\xi \setminus \mathbb{F}$ and as well as members of \mathbb{F} . The concept of the partition form was introduced by Thrall and Lucas [3].

Graph form: In coalition game, the value of game may be strongly affected if members of coalition may communicate through pairwise links in a graph. Therefore in such coalition game, the value of game is considered in graph form because a different game value can be determined for each different graph structure. The characteristic form and the partition form are not suitable to determine the value of a coalition \mathbb{F} , as they are not dependent on the connection between the members of coalition. The concept of modeling interconnection graph within coalition game was first introduced by Myerson [4].

In any coalition game, the value of any coalition denotes the total utility obtained by a coalition. The payoff of a player, denotes the total utility obtained by an individual player. Based on how payoff is divided among the members of coalition, the coalition game can either be with non-transferable utility or with transferable utility. In transferable utility game the total utility obtained by any coalition \mathbb{F} can be shared in any way among the players of coalition \mathbb{F} . For an example, in transferable utility game, if the value represents an amount of money, it can be distributed in any way among the coalition members. Based on property of transferable utility, the total utility obtained can be distributed in any order among the players of coalition (using some fairness rule). The amount of utility that an each players of coalition obtained from the sharing of total utility $u(\mathbb{F})$ comprise the players payoff and is represented by y^j . The vector $y \in \mathbb{R}^{\mathbb{F}}$ with each element y^j being the payoff of players $j \in \mathbb{F}$ constitutes a payoff allocation.

Coalition game with transferable utility is a popular and accepted method, there exist a number of circumstances, where the value of coalition cannot be assigned a single real number or there exists a rigid restriction on the utility division. These types of coalitional games are known as game with non-transferable utility. The concept was known using basis of non-cooperative strategic games according to Aumann and Peleg [5]. In a game of non-transferable utility, the payoff received by each player of coalition \mathbb{F} depends on the joint action taken by the players of that

coalition. In game theory literature most aspect of coalition game theory are studied in characteristic form with non-transferable utility or transferable utility. For these types of coalition game, different game properties and solution concepts are defined. Some of the properties of a game in characteristic form with transferable utility are provided below:

- **Superadditive:** The subset of two disjoint coalition will have an incentive to cooperate only when profit obtained in case of cooperation are greater than the profit obtained alone according to Drechsel [6].

$$\mathbb{F}_1 \cap \mathbb{F}_2 = \emptyset \Rightarrow u(\mathbb{F}_1 \cup \mathbb{F}_2) \geq u(\mathbb{F}_1) + u(\mathbb{F}_2)$$

- **Monotone:** A cooperative game (ξ, u) in characteristic form is monotone if for all $\mathbb{F}_1, \mathbb{F}_2 \in 2^\xi$.

$$\mathbb{F}_1 \subseteq \mathbb{F}_2 \Rightarrow u(\mathbb{F}_1) \leq u(\mathbb{F}_2)$$

- **Symmetric:** A coalition game (ξ, u) is symmetry if the coalition value $u(\mathbb{F}_1)$ only based on the number of players in the coalitions \mathbb{F}_1 according to Gilles [7]. Hence there is some function $f : \xi \rightarrow R$ such that $u(\mathbb{F}_1) = f(|\mathbb{F}_1|)$ for all \mathbb{F}_1 subset ξ .
- **Constant-sum:** A cooperative game (ξ, u) is constant sum if for every coalition \mathbb{F}_1 subset ξ is

$$u(\mathbb{F}_1) + u(\xi \setminus \mathbb{F}_1) = u(\xi)$$

- **Simple:** A cooperative game (ξ, u) is simple if, for each coalition \mathbb{F}_1 subset of ξ we have either $u(\mathbb{F}_1) = 0$ or $u(\mathbb{F}_1) = 1$.

4.3.1 Classification of Coalitional Game Theory

Based on the properties, coalitional game can be mapped into three different groups. The three different types of coalition game are (i) Canonical coalitional games, (ii) Coalition formation games and (iv) Coalitional game games.

4.3.1.1 Canonical Coalitional Games

Canonical coalitional games refer to the group of most popular type of coalition game, which is well studied in cooperative game theory. These groups of coalition game are widely used, thoroughly formalized, well understood and its solution concepts are clear. To classify the game in canonical form, the game must satisfy the following properties:

1. The value of the game must be in characteristic form or the value may be mapped to this form through some assumptions. The characteristic form will either be of the transferable utility form or non-transferable utility form.

2. The game follows a superadditive property. Increasing the number of participating players in the coalition will not decrease its value, i.e. no group of players will worsen off while joining the coalition. That is, cooperation among members of coalition will always be beneficial.
- 3 Proper study is needed to divide utility and gain among the members of coalition in a fair manner, so that grand coalition (coalition of all the players) can be stabilized.

The motive of canonical game is to examine the stability of grand coalition under certain payoff allocation rule. Hence assessing the total profit that the grand coalition can obtained and fair payoff division is also another important key objective of canonical game. In game theory, various methods and broad range of concepts are available for solving canonical game. Almost all the solution concepts, which are used for solving canonical game, satisfy all the properties and key objective of canonical game. Thus the solution concepts which are used for finding solution of canonical game are (i) The core, (ii) the Shapley value and (iii) the nucleolus.

The Core

The existing game theoretical literature considers the core as the most important concept for solving a canonical coalitional game. In canonical coalitional game the core defines the set of payoff allocations which assured that not a single player in a group will have an incentive to join new coalition $\mathbb{F} \subseteq \xi$ while leaving the grand coalition ξ . Therefore the main idea of the core in canonical games is to distribute the payoff to players that will stabilize the grand coalition. It is to be noted that in canonical game, the grand coalition will help to generate maximum payoff due to superadditivity. Though mathematically, the core definition is different for both transferable utility and non-transferable utility game, the important concept of core is applied to both. The core of a canonical coalitional game (ξ, u) in a characteristic form with transferable utility game is defined as follows:

$$core_{Tu} = \{y : \sum_{i \in \xi} y_i = u(\xi)\} \text{ and } \{\sum_{i \in \mathbb{F}} y_i \geq u(\mathbb{F}) \forall \mathbb{F} \subseteq \xi\}$$

Therefore, the core denotes the set of payoff allocation where none of the coalition $\mathbb{F} \subseteq \xi$ has benefit to leave grand coalition and form other coalition \mathbb{F} and reject the allocated payoff to the players. The concept of core guarantee that deviation from grand coalition does not occur due to the reason that in the core any allocated payoff y , guarantees at least $u(\mathbb{F})$ amount of utility for every single coalition $\mathbb{F} \subset \xi$. Note that, for an NTU game, an analogous definition of the core can be used according to Saad et al. [8].

At any instance, in canonical coalition game, solution of grand coalition will be stable and optimal, only if obtained payoff allocation lies in the core. This highlights the important of core in solution concept. However, the core of a coalitional game suffers from several drawbacks, such as (a) In canonical coalition game if the core is empty, there does not exist payoff allocation that can stabilize grand coalition,

(b) If there exists a payoff allocation that can stabilize the grand coalition, then the core will be a vast set and providing a fair payoff allocation from this set will be a complicated task. So to avoid this type of problem, there exists many classes of canonical coalitional games where the core is non-empty and based on this class of game respective properties may be derived. More detailed explanation can be found in [8].

The Shapley Value

To deal with the drawback of the core, the Shapley value is used as a solution concept for canonical coalition game. Shapley value deals with the concept of value. Shapley provides a unique approach to assign unique payoff vector (value) to each game in coalition form given by (ξ, u) . Let $\phi_j(u)$ denote the payoff provided to player j by the Shapley value ϕ with characteristic function u . Therefore, $\phi(u) = (\phi_1(u), \phi_1(u), \dots, \phi_n(u))$ is the value function that is assigned to each possible characteristic function of a n -person game. According to Shapley, there exist a unique mapping, Shapley value $\phi(u)$ from the space of all coalition games to \mathbb{R}^ξ .

Alternative definition of Shapley value considers the order of each player joining in grand coalition. In coalition game, if a player randomly joins the grand coalition, the allocated payoff (calculated based on Shapley value) to player $j \in \xi$ is said to be the expected marginal contribution to player j . Thus based on this interpretation for any canonical coalition game with transferable utility game (ξ, u) , the payoff $\phi_j(u)$ assigned to each player $j \in \xi$ of Shapley value $\phi(u)$ can be given as:

$$\phi_j(u) = \sum_{\mathbb{F} \subseteq \xi \setminus \{j\}} \frac{|\mathbb{F}|!(\xi - |\mathbb{F}| - 1)!}{\xi!} [u(\mathbb{F} \cup \{j\}) - u(\mathbb{F})]$$

From above equation, $u(\mathbb{F} \cup \{j\}) - u(\mathbb{F})$ denotes the marginal distribution of each player $j \in \mathbb{F}$. The weight before $u(\mathbb{F} \cup \{j\}) - u(\mathbb{F})$ denotes the probability of player j facing the \mathbb{F} , while joining in random order. Therefore from $\frac{|\mathbb{F}|!(\xi - |\mathbb{F}| - 1)!}{\xi!}$ it can be noted that in coalition \mathbb{F} the players can be positioned at the start of ordering in $|\mathbb{F}|!$ ways and the remaining players can be positioned at the end of an ordering in $(\xi - |\mathbb{F}| - 1)!$ ways. The probability of occurrence of such order is $\frac{|\mathbb{F}|!(\xi - |\mathbb{F}| - 1)!}{\xi!}$ and the finally calculated value $\phi_j(u)$ denotes the expected marginal contribution of player j . The Shapley value is mostly used, but the problem of using this solution concept is that the complexity of finding the solution by Shapley value will increase as the numbers of players increases.

The Nucleolus

Other than core and Shapley value, solution concept used for n -person canonical coalition game is nucleolus. The solution concept of nucleolus was introduced by Schmeidler [9]. Nucleolus as a solution concept in cooperative canonical coalitional game (ξ, u) , provides a payoff allocation that reduces the dissatisfaction of players in coalition from obtained allocation. Thus nucleolus help to find imputation y ,

that minimize the maximum dissatisfaction. For a given coalition \mathbb{F} , the measure of dissatisfaction of an imputation y for \mathbb{F} is defined as the excess and is given by:

$$e(y, \mathbb{F}) = u(\mathbb{F}) - \sum_{j \in \mathbb{F}} y_j$$

It measures the excess by which coalition \mathbb{F} falls short of its potential in the imputation y . Thus, this is one of the main reasons behind the concept of nucleolus.

4.3.1.2 Coalition Formation Games (CFG)

In many cooperative scenario, cooperation among the members may accompanied with an extra hidden cost, and hence limit from getting advantage of this cooperation. Thus formation of grand coalition may not be always guaranteed. In this type of scenario, using of canonical coalitional games for modeling the cooperative behavior between the players is not preferred. In CFG cost of cooperation and network structure play a vital role. Some important characteristics of a coalition formation game are discussed below:

1. Coalition formation game is non-superadditive in nature and grand coalition formation is not guaranteed. This due to the reason that, though coalition formation brings profit to its members, the profits of member are limited to the cost of coalition formation.
2. The coalition formation game can be in characteristic form or in partition form.
3. The CFG important aim is to study the coalitional network structure. From coalitional structure, the question which can be answered are (j) what is the size of optimal coalition, (ii) which coalition will form and (iii) how structures characteristics, can be assess and many other.

In contrast to canonical game finding solution to coalition formation game is much more difficult. This is because in many coalition game problems, coalition formation bear an extra cost for an information exchange process and negotiation process, thus reducing the overall profit obtained from coalition formation. In coalition formation game, finding solution in presence of coalition structure by using previous solution concept is not easy and need significant changes in their definition. But even after significant change in definition, finding solution of game is not straightforward and can be complicated. Therefore it will be quite challenging to find optimal coalition structure and characterizing their formation. In case of coalition formation game no formal and unified solution concepts exist unlike canonical coalition game. Therefore in many research works, dealing with coalition formation game, the solution concepts which are defined are specific to the problem.

In this type of coalition game, the most important part is to determine the coalition partition that is appropriate to the respective game. The respective coalition structure of the game in transferable utility, helps to maximize the total payoff of the game and in non-transferable utility game, the coalition structure is found with

Pareto optimal payoff distribution. For finding this type of solution a centralized approach is used and such approaches are mostly NP-complete as has been shown [10] and [11]. The problem is NP-complete because, finding optimal coalition partition (which provide highest payoff) required continuous iteration over all coalition partitions of player in ξ . If players in ξ increases then number of coalition partition in set ξ also increases exponentially [12]. In order to avoid complexity of centralized approach, in many practical application it was observed that the process of coalition formation takes place in a distributed manner. In distributed process, players can make their own decision to join or leave current coalition. Hence the demand for distributed approach and complexity of the centralized approach has requirement for huge development in the coalition formation. The objective of this requirement is to find low complexity centralized approach and distributed algorithm for coalition formation. The different approaches used for distributed coalition formation are (i) Markov chain-based methods, (ii) heuristic methods, (iii) set theory based methods and (iv) method that use negotiation technique or bargaining theory from economics. Again it is noted that, there are two approaches for coalition formation, fully reversible and partially reversible [13]. In coalition formation game, with fully reversible approach, players can leave or join particular coalition with no limitation whereas in partially reversible approach, players are not allowed to leave coalition after coalition formation. Though fully reversible approach is flexible and practical, forming such an approach is complicated. In case of partial reversible approach, it is easy to construct but their practicality is limited, because players are not allowed to leave from current coalition and join new coalition thus breaking the agreement. Depending on the type of application, most favorable approach can be selected.

4.3.1.3 Coalitional Graph Games (CGG)

Overview of two types of cooperative coalition game (a) canonical game and (b) coalition formation game are discussed above. The utility or value of coalition for these games is not depended on the internal connection of players within the coalition. But in many coalition games, the impact of interconnection or communication between the players can be reflected on the characteristic function and outcome of the game. The interconnection between the players can be captured by graph. This graph helps to determine connectivity of the players among each other in coalition. Therefore some of the properties that differentiate CGG from others are discussed below:

1. The cooperative coalitional graph game can be of type transferable utility or non-transferable utility and the value of the game may depend on internal interconnection between players within the coalition.
2. The internal structures of player within the coalition have great impact on outcome and characteristics of the game.

The main objective of CGG are given below:

1. Study the properties like stability, efficiency, etc. of the formed directed or undirected network graph. If network graph is provided for some coalition game, then analyzing properties like efficiency and stability is the only goal of the game.
2. Coalitional graph games are a suitable tool for the games where hierarchy governs the interactions between the players.

In [4] Myerson et al. first proposed the idea of coalitional graph game, through the graph function form for transferable utility games. In their work, Myerson et al. tried to define fair solution for the game, starting from canonical coalitional game with transferable utility and in presence of undirected graph (interconnects the players) in the game. Afterwards these fair solution proposed by Myerson et al. was defined as Myerson value. Myerson et al. work, motivated the future work significantly, and many new approaches was developed for coalition graph game and one of them is network formation games. Network formation game is a mixture of two game, CGG and non-cooperative games. The main aim of Network formation game is to study the interactions between the players in a group that wants to form a graph. The more details literature can be found in [4, 8].

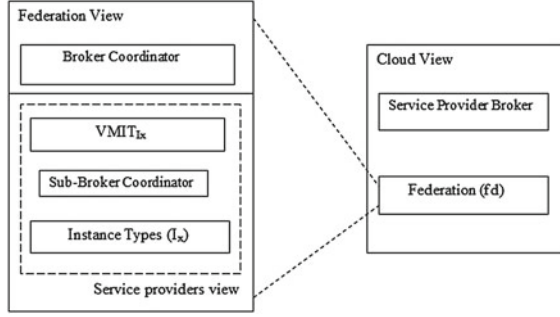
4.4 Coalition Game in Cloud Federation Formation

Coalition games have huge application within cloud federation. For instance, in cloud federation cooperation always required between different cloud service providers. Cooperation helps cloud service providers to maximize the use of idle resource and increase their profit. This section presents three different models of cloud federation formation. Ray et al. [14] in their work proposed a cloud federation framework based on satisfaction level. Mashayekhy et al. have also model cloud federation formation problem using coalitional game theory. Their model let the cloud service providers to decide of its own, to form a federation and obtaining the highest gross profit [15]. The author of [16] have present trust based cloud federation formation model based on hedonic coalition game theory. The different models are discussed as follows:

4.4.1 Cloud Federation Formation Based on Satisfaction Level

The objective of the work by Ray et al. in [14] was to find best federation for individual cloud service provider. The criterion for selecting most suitable federation is, on the basis of two important Quality of Service (QoS) attributes price and availability. Availability a is stated as the uptime of the cloud service. Price p on the other hand is the amount paid by cloud user for using the cloud service. It is assumed that cloud service provider with high availability will have higher price. Thus relation between

Fig. 4.2 Broker based cloud federation architecture



availability and price is given by $p_i = \rho * a_i$ where $a = \{a_1, \dots, a_n\}$ denotes the availability, $p = \{p_1, \dots, p_n\}$ denotes the price of ξ number of players and ρ is considered as the proportionality constant and its value represent the price of cloud service provider with availability 1. It has been assumed that cloud service provider with same availability will have same price.

Cloud brokers are identified as the key component for federation. The role and responsibility of the service broker is to find the best federation from a set of federations. Ray et al. [14] describes, broker based cloud federation formation framework. The cloud federation framework are divided into two module (a) Federation View and (b) Cloud View (see Fig. 4.2). The detail discussion of each component of individual module is discussed below.

Cloud View

- **Service Provider Broker (SPB):** manage a set of service providers and cloud federation.
- **Federation:** Federation are formed among different service providers. Each federation consist its own broker coordinator and heterogeneous set instance of different cloud service providers.

Federation View

- **Broker Coordinator (BC):** handles all the resource requests by user on behalf of federation and provide each and every update to SPB.
- **Virtual machine instance type (VMIT_{ix}):** retain information of homogeneous types of instances of different cloud service provider of particular federation where $I = \{I_x, \dots, I_y\}$ denotes different instance types.
- **Sub Broker Coordinator (SBC):** keep details of all instances in VMIT_{ix}. It also handles all the request received from BC.

A coalition game with transferable utility is used to form federation among different service providers. Here a set of rational player is denoted by ξ and u is the value of the game, i.e., the total profit achieved by member of cloud service providers in a federation. Here players are referred as cloud service providers. Broker coordinator manage the cooperation among the members of cloud service providers in federation, based

on optimal arrangement order $\alpha = \{E_j^{SP^i} | j = [1, z] \text{ and } SP^i \in \xi\}$. Therefore cloud users requests are processed based on arrangement order of cloud service providers in α . Again, availability of $VMIT_{I_x}$ (service of resource) of cloud service providers in federation is achieved by cooperation among them. When, unavailability of each cloud service providers will have effect on overall availability of federation. Thus based on conditional probability, probability of availability of $VMIT_{I_x}$ in federation fd_j is given by:

$$A_{fd_j}^{VMIT_{I_x}}(\alpha) = 1 - \prod_{i=1}^{\xi} u_{I_x}^{SP^i}$$

Each instance type $I_x^{SP^i}$ are differentiated according to amount of compute unit $Cu_{I_x}^{SP^i}$, amount of storage $m_{I_x}^{SP^i}$, amount of memory $s_{I_x}^{SP^i}$ and specific number of cores $Co_{I_x}^{SP^i}$. The cost incurred by instance type $I_x^{SP^i}$ of cloud service providers are given by:

$$c_{I_x}^{SP^i} = Co_{I_x}^{SP^i} \cdot pc + Cu_{I_x}^{SP^i} \cdot pcu + m_{I_x}^{SP^i} \cdot p_m + s_{I_x}^{SP^i} \cdot p_s$$

In these equation pc denotes the cost of single core, pcu is the cost of each compute unit, p_m is the cost of one GB of memory and p_s is the cost of one GB of storage. The cost of federation is formulated based on the availability of each $VMIT_{I_x}$ in federation. Therefore the total cost of federation fd_j will be define as the sum of cost of all instances $I_x^{SP^i}$ of all the service providers in federation and is given by:

$$C_{fd_j}(\alpha) = \sum_{I_x \in I} \sum_{i=1}^{\xi} \prod_{k=1}^{i-1} u_{I_x}^{SP^k} \cdot a_{I_x}^{SP^i} \cdot c_{I_x}^{SP^i} \quad (4.1)$$

In this equation $a_{I_x}^{SP^i}$ represent the availability of cloud providers SP^i of I_x types of instance. The chargeable price for each instance depends on the availability provided by federation. Hence that is defined as follows:

$$P_{fd_j}(\alpha) = \sum_{I_x \in I} \rho_{I_x}^{SP^i}(\alpha) \cdot C_{fd_j}(\alpha) \quad (4.2)$$

The characteristic function (payoff) of federation is model based on total profit obtained by group of cloud service provider in federation. That is, payoff $u_\alpha(fd_j)$ is the difference between the revenue $P_{fd_j}(\alpha)$ received by cloud users and cost $C_{fd_j}(\alpha)$ incurred by cloud federation. Process of Shapley value is used for fair allocation of payoff among the members of federation in this coalition game. The payoff of cloud federation is given by:

$$u_\alpha(fd_j) = P_{fd_j}(\alpha) - C_{fd_j}(\alpha) \quad (4.3)$$

To form federation they introduce the concept of satisfaction level. The different measured satisfaction levels are (i) $sat^{SP^i}(fd_j)$ denotes the satisfaction level of SP^i in federation fd_j , (ii) $sat^{SP^i}(I(SP^i))$ denotes the satisfaction level of single service provider in federation or satisfaction level of service provider without being in any federation and (iii) $sat(fd_j)$ denotes the satisfaction level of federation. The value of satisfaction level $sat^{SP^i}(fd_j)$ and $sat^{SP^i}(I(SP^i))$ are calculated based on cloud providers two QoS parameters, availability and profit and satisfaction level $sat(fd_j)$ is determined based on payoff value and availability of federation. The satisfaction level are model based on idea describe in [14].

The Coalition (federation) formation algorithm follows a distributed approach. It is assumed that at any instant of time any cloud service providers may merge new federation or split from existing federation. At each time period SPB checks for available of each type of instances for every federation. If available resource (virtual machine) is below certain threshold value, then BC of those federation are informed by SPB. BC on being informed it request to join with new federation or cloud service providers. Based on satisfaction level, some set of preference rules are defined over possible federation (coalition) partition. The preference rule are (i) a cloud service providers merge with new federation only if, its satisfaction level maximizes during formation of federation otherwise service provider will leave the federation (ii) federation will collaborate with other providers, if its satisfaction level increases in newly formed federation.

4.4.2 Merge and Split Based Cloud Federation Formation

Mashayekhy et al. [15] proposed the model for the problem of cloud federation formation based on hedonic coalition game. According to their proposed model every single service provider form federation to serve users' virtual machine requests. Their model maximize the overall profit obtained by federation by delivering required request to cloud users. Further their proposed model consider group of service providers and group of cloud users that submits their requirements about different types of virtual machine instances. Out of this group of service providers a subset of this group will be selected as a federation to serve the required virtual machine request of users.

A hedonic game with additional properties of fairness and stability has been chosen as a model for the proposed game, with well-defined preference relations. Further their proposed model enables the formation of a federation yielding the highest total profit. Merge and split operations are performed on cloud federations in order to form a federation serving the user with his requested resources. According to Mashayekhy et al. every service providers obtain its discrete profit based on its market share. Their cloud federation model provides a stable federation structure, i.e., not single service providers, will get extra benefit to join with new federation or split from an existing federation to join with new federation.

4.4.2.1 Proposed Model

Their system model is comprised of (a) group of service providers, (b) a cloud broker, and (c) cloud users. In their model broker is considered as the trusted third party entrusted with 1. receiving requests, 2. executing CFFM, 3. receiving payment, and 4. profit division. A set of cloud providers serve resources requests of cloud users. Each VM instance are characterized by their total cores, size of memory, and storage. A specific capacity is reserved by a cloud provider for private users, and the balance virtual machine load is contributed to the federation according to current load conditions.

A user request is consists of the number instances of different virtual machine types. The broker receives the request, and charges a user based on the virtual machine instances types apportioned to him, who finally pays an amount that is free of the service provider providing the virtual machine instances.

4.4.2.2 IP-CFPM

The problem of federation formation with the objective of profit maximization is formulated as an integer program, called IP-CFPM. The total profit is determined by the weighted sum of the profits per VM instance, the weights being the number of allocated virtual machine instances of different types, which are the decision variables here and are constrained to be integers. The constraints ensure that the resources (cores, memory and storage) delivered by a service providers taking part in federation formation process are less than their respective total amounts of resources. A separate constraint ensures that every single provider at least provide one virtual machine in federation.

4.4.2.3 Game Formulation

The cloud federation game is a coalitional game that models federations among different service providers. A cloud federation game is defined based on the concept of coalitional game (I, u) with transferable utility. Every single service provider in I (set of service providers) is considered to be player of the game, and u is the utility function, of the federation $F \subset I$. In this game, profit is considered as the characteristic function i.e., if federation is formed then profit is considered as the utility of the game otherwise the utility is 0 if no federation can be formed. Their cloud federation game satisfies two main properties (a) *Fairness* means a fair division of the profit achieved by a federation by dividing the total profit among the members of federation and (b) *Stability* means a federation should be stable, providing no incentives to the participating cloud providers to leave the federation.

4.4.2.4 Profit Division

The system employs a fair profit distribution among the member of federation based on the share of the service providers. The author have used normalized Banzhaf value for distribution of profit among the members of federation. The normalized Banzhaf value ensures that the member of federation which contributes more resources in federation obtain higher profit. The main idea of Banzhaf value technique is to divide the payoff for the grand federation that takes into consideration the power of the players and represents the average marginal contribution of provider C_i over all possible federations containing C_i . Although computing the Banzhaf value for a game is NP-hard, some of the possible federations are checked by iteratively applying the merge and split rules and their values are estimated. These checked values are used to define an estimated Banzhaf value.

4.4.2.5 Cloud Federation Formation Framework

The salient features of their proposed model are:

1. Players are partitioned into disjoint sets.
2. The formed federation partition consist of the single federation to deliver the service to the corresponding requests of the users.
3. The remaining service providers are free to take part in federation formation with other service providers to service the requests of the users, without affecting the decision of the other service providers participating in the corresponding federation.
4. The preference relation for the hedonic game is based on the characteristic function, which is in turn based on profit.
5. A CSP prefers a federation over another if the characteristic function for that federation with respect to that CSP higher than that for the other, i.e. if it yields more profit.
6. The merge comparison relations and split comparison relations are defined for service provider.
7. The merge comparison compares the merged federation to its two constituents and is valid only if all CSPs prefer the merged federation to the constituents.
8. The split comparison compares two disjoint federations to their merged form and is valid if any CSP prefers the constituents to the merged form.
9. Two rules - Merge Rule and Split Rule are defined based on these comparisons.
10. According to merge rule two federations will merge to form a new federation if total profit of new federation increases.
11. According to the split rule a federation will splits if there is present atleast one subfederation that achieves identical profit with respect to its constituent service providers.
12. A split may lead to decrease in the profit of the other sub-federations.

4.4.2.6 Algorithm CFFM

The CFFM mechanism is carry out by a broker and uses merge and split rules discussed previously. The CFFM algorithm takes users request as input. From an initial federation structure consisting of singleton federations a final federation is obtained by repeatedly solving IP-CFPM and applying the merge and split rules in two procedures - MergeFederations() and SplitFederation(). The proposed algorithm converges to a federation partition consisting of only single federation and produces an individually stable federation. CFFM avoids performing an extensive search on the set of federation by employing the merge and split procedures.

4.4.3 Trust Based Federation

The trust-based model of cloud federation formation, called DEBT (Discovery, Establishment, and Bootstrapping Trust, Wahab et al. [16]) aims to address the problem of credibility assignment to different cloud service providers in the scenario where it is uncertain that they will adhere to their commitments detailed in the clauses of official contracts such as SLAs. The malicious agents (here, other providers) may collude to give false information regarding the trustworthiness of a provider. Their purpose is to artificially raise or lower a provider's face value. Also, in the situation where there is no past interaction between two providers, it is important to assign initial trust values. This is called trust bootstrapping. The DEBT framework provides a stepwise guide for services to build trust relationships starting from discovering services and collecting feedback, down to bootstrapping new services and aggregating feedback in a collusion-resistant manner. Here trust is modeled as a private relationship between each pair of services rather than a global absolute value that can be referenced by all services. Based on DEBT it is possible to design a trust-based hedonic coalitional game with nontransferable utility that aims to find the coalition partition that minimizes the number of malicious members.

4.4.3.1 System Model

Since services may be either truthful or collusive in judging the other services, each pair of services ($\mathbb{F}_i, \mathbb{F}_j$) has a belief in credibility, $Cr(\mathbb{F}_i \rightarrow \mathbb{F}_j) = n$, $Cr(\mathbb{F}_j \rightarrow \mathbb{F}_i) = m$, also called a *credibility score*, that represents each services accuracy level in judging the other services, where n and m are two decimal numbers. Each service \mathbb{F}_i develops a measure of belief in the trustworthiness of another provider \mathbb{F}_j , referred to as $belief_{\mathbb{F}_i}^{\mathbb{F}_j}(T)$ and a belief in its maliciousness, denoted by $belief_{\mathbb{F}_i}^{\mathbb{F}_j}(M)$ before forming a coalition. These belief measures are based on a satisfaction metric which is the ratio of the number of satisfactory experiences to the total number of experiences. Thus, these measures depend on past history between the two services.

The community formation is designed as a hedonic coalition game, which results in a coalition structure or partition. It is a set of non-empty coalitions that partitions the existing set of services into mutually exclusive and exhaustive subsets. The utility of service \mathbb{F}_i in a certain coalition C_k is obtained by summing up \mathbb{F}_i 's beliefs in trustworthiness in C_k 's members. This utility is given by

$$U_{\mathbb{F}_i}(C_k) = \sum_{\mathbb{F}_j \in C_k} \text{belief}_{\mathbb{F}_i}^{\mathbb{F}_j}(T)$$

4.4.3.2 Attack Model

There are two situations when attacks are likely: (1) during trust establishment (2) during and after communities formation. During trust establishment, collusion attacks may take place between services to mislead the results. During and after communities formation, passive malicious services may misbehave to save their resources and gain illegal advantage over the other services. Two major attack types are considered

- **Collusion Attacks:** Such attacks occur when several malignant services collaborate together to give misleading judgments either to increase the trust score of some services (i.e., a promoting attack) or to decrease the trust score of some other services (i.e., a slandering attack).
- **Passive Attacks:** Such attacks occur when passive malicious services cheat about their available resources and/or QoS potential during communities formation in order to increase their chances of being grouped into powerful communities. After communities are formed, these malicious services would renege on their agreements with both services and clients by benefiting from the other services resources (e.g., physical computing infrastructure) and refraining from sharing their own resources to dedicate them for their own workload.

4.4.4 DEBT Framework

DEBT (Discovery, Establishment, and Bootstrapping Trust) framework presents a step by step guide for services to build trust relationships beginning from discovering services and collecting feedback, down to bootstrapping new services and aggregating feedback in a collusion-resistant manner. The brief description is provided below.

4.4.4.1 Service Discovery

DEBT incorporates a discovery algorithm that allows services to inquire about each other from their direct neighbors is proposed to collect judgments for the purpose of establishing trust. The algorithm capitalizes on the concept of tagging in online

social networks (e.g., Facebook, LinkedIn) to explore the direct neighbors of a certain service. The basic idea is to keep tagging or nominating intermediate services until identifying all the reachable direct neighbors of the intended service. The algorithm is a variation of the Breadth-First Search (BFS) strategy in graph theory.

4.4.4.2 Trust Establishment

During the trust establishment process, services may collude with each other and provide dishonest judgments, generating false trust results. Moreover, these services usually tend to refrain from revealing their opinions due to a lack of incentives for doing so, which leads to meaningless or biased computations of the aggregate trust value.

In recognition of these problems, the DEBT system includes an aggregation model for the collected judgments that is able to overcome the collusion attacks even when attackers are the majority and an incentive model for the services to motivate them to participate in the trust establishment process. An aggregation technique based on the Dempster-Shafer theory of evidence which takes into account the existence of colluding services is used. The performance of the aggregation technique depends heavily on the *credibility scores* assigned to the services. The proposed aggregation technique overcomes the collusion attacks even when attackers are the majority if and only if (1) the credibility values are between 0 and 1, and (2) the credibility scores of the trustworthy raters are higher than those of colluding ones. Thus, the authenticity of this metric is essential to the trust establishment process and should be protected. Therefore, the credibility metric should be updated continuously to ensure that truthful services always hold higher credibility scores than those of colluding ones.

4.4.4.3 Trust Bootstrapping

Trust bootstrapping is assessing trust, i.e. allocating initial trust values for newly deployed Web services, in the absence of historical information about the past behavior of newcomers. The bootstrapping mechanism is based on the concept of endorsement in online social networks that is resilient to white-washing. Each service maintains a dataset that records its previous interactions with several services having different functional and non-functional specifications. Whenever a request from service i to bootstrap a new service j is received, the services that are interested in the request train a decision tree classifier on their datasets to predict an initial trust value for j . The decision tree classifier analyzes services training dataset that contains properties and specifications for some existing services (e.g., providers name, deployment country, etc.) and learns the patterns of the data by pairing each set of inputs with the expected output (e.g., the judgment on the services).

4.4.5 Trust-Based Hedonic Coalitional Game

4.4.5.1 Game Formulation

In the proposed game the players are the services that seek to form multi-cloud communities. The objective is to form trusted communities wherein the number of malicious members is minimal. The proposed coalitional game is a *non-cohesive* game and utility of the game is non-transferable. It is hedonic in nature, with a preference relation defined as follows:

$$P_{\mathbb{F}_i}(C) = \begin{cases} -\infty, & \text{if } a \in C \text{ and } \text{belief}_{\mathbb{F}_i}^a(T) < \text{belief}_{\mathbb{F}_i}^a(M), \\ 0, & \text{if } C \in h_{\mathbb{F}_i}(t), \\ U_{\mathbb{F}_i}(C), & \text{otherwise} \end{cases} \quad (4.4)$$

where $h_{\mathbb{F}_i}(t)$ represents the history set of service \mathbb{F}_i at time t , consisting of all the coalitions it has joined and left at any time $t' < t$.

4.4.5.2 Hedonic Coalition Formation Algorithm

The system relies on a distributed hedonic coalition formation algorithm that enables services to make decisions about which coalitions to join so that the number of malicious services is minimized in the final coalition structure. The algorithm takes as input an initial partition of services at a certain time t and outputs the final coalition partition. The algorithm converges to a final coalition partition consisting of a number of disjoint coalitions which is Nash-stable as well as individually stable.

4.5 Role of Trust in Forming Cloud Federation

In above sections, following are discussed: (1) the importance of formation of cloud federation by different cloud service providers (2) different technique based on game theory for cloud federation formation (3) role of broker in cloud federation formation. But above of all these topics discussion about importance of trust or soft security in cloud federation formation is important. Formation of cloud federation by cloud service providers has various advantages, but though has various challenges to overcome like allocation of optimum resource, interoperability service issue, migration of resource, establishing trust between cloud service providers in federation. Absence of trust between cloud service providers in federation, establish the major problems for cloud service providers in adoption of federation. To guarantee committed QoS and security of critical data of cloud users, it will be necessary to assess and build trust between multitudes of cloud providers. Again in federation, image of instances or partial data objects are migrated from one cloud service provider to other and

hence there is matter of concern for privacy and security of cloud user's. Thus in order to guarantee, privacy and security of data of cloud user on new cloud provider's platform, it is necessary to identify trusted service provider. Thus evaluating trust of each participating cloud service providers in federation is identified as essential condition to participate in Cloud federation according to Kanwal et al. [17]. Trust is an important issue for cloud federation. The issues which need to be taken care off are as follows:

1. Defining specification of security policy for cloud federation.
2. Defining techniques to manage and implement security policies for cloud federation.
3. Some security measure must be present to guarantee the security of the information. The considered security measures are (a) Encryption of data integrity, (b) access controls, (c) confidentiality of the data and (d) availability of data.
4. Determining reliable cloud service supplied by different providers.

The trustworthiness of cloud service providers can be determined based on their reputation and reliability. The reputation can be defined based on the opinions of cloud users, cloud broker and other cloud service providers, whereas reliability of particular cloud service providers is measured through observation obtained by the cloud user while using the service according to Zant et al. [18]. In cloud federation every security system may depend on the trust of different cloud service providers in federation [19]. A very basic security problem faced by cloud service providers in federation is the service which is delivered to cloud user is trusted or reliable. Thus to tackle this problem there is a need to develop trust based security mechanism in cloud federation. In case of soft security one service provider in federation may not trust any other member of same federation initially but if some security mechanism is used to select cloud service providers in federation then every member of federation may trust on each other as trustworthiness of each cloud service providers, have already been verified. If suppose, there are no security mechanism available for selecting service providers then no service provider will have belief on service delivered by other cloud service providers in federation, because there is no trust between them. Therefore if some security mechanism is provided then these service providers will surely trust each other in federation, thus increasing overall Quality of delivered services. The trust of cloud service provider can be obtain based on defined set of rules in security system.

Though considerable amount of work over the last few years have been done on trust evaluation and establishment in cloud computing, the issue of trust evaluation in cloud federation is important challenge to overcome. Some of the works done on this respect are discussed below:

Mashayekhy et al. [20] in their work, have proposed data protection framework for cloud federation. Their framework considers the data privacy and security restrictions as well as minimizes the cost of outsource computing resources to the service providers which are member of federation. They have proposed two conflict graph for restricting privacy of data (1) one graph denotes the conflicts among virtual machine and (2) second graph represents the conflicts among virtual machine. An integer

program is used to formulate the problem of data protection in cloud federation. An extensive experimental analysis is performed and obtained result is compared with the optimal result.

Kanwal et al. in [17] have also proposed the security model to guarantee the security of critical data of cloud users. Thus proposed protocol will help each cloud service providers to determine the trustworthiness of each cloud providers before taking part in federation to share their resources in reliable and trusted way. The main objective the author was to establish two-way trust between home and foreign cloud service providers. They have formulated trust value based on service level agreement of provider and feedback obtained from registered cloud users. Based on this two parameters final value of trust is formulated and this trust score is considered as the overall level of trustworthiness of each cloud service providers. On getting trust score, the credentials of trust are interchanged between home and foreign cloud service providers. The credentials are (a) aggregated trust value, (b) service level agreement of service providers and (c) their Level of Trust.

In [21] Messina et al. dealt with problem of measurement of trust of cloud service providers in cloud federation environment. They have proposed their model as an extension of RRAF model [22]. The RRAF model is used widely with the advancement of multi-dimensional approach. This new approach of RRAF model solve many reliability issue, which originally exists in cloud computing. Their trust model identify trusted service provider based on (a) measuring of reputation, is obtained based on recommendation made by other cloud service provider and user and (b) evaluation of services delivered in the past. This technique helps cloud users to make a fine grained evaluation of cloud services, which are delivered in the past by service providers.

4.6 Conclusion

With the advent of cloud computing technology, it has become utmost importance to extract benefits out of idle or underutilized resources maintained by different cloud service providers to yield more revenue. This requirement has led to the birth of the concept of cloud federation. This chapter deals with how the concept of cooperative game theory can be applied in forming the cloud federation. It also discusses different framework of cloud federation formation based on coalition game theory where different cloud service providers form a cooperative group based on some preference rule and examines the benefit of a cloud service broker in cloud federation. Establishing trust between cloud service providers is necessary, so this chapter presents some brief theoretical idea about the importance of trust in cloud federation and discusses some existing problem and its solution.

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