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Bankruptcy approach to integrity aware resource management in a cloud federation

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Abstract
There has been a debate surrounding cloud federation in recent studies partly because of the cloud providers' profit increases and also because of resource utilization improvement. However, the main part of these studies suffers from the lack of considering integrity issues. In this paper, we provide a formal definition of cloud federation integrity in a proposing architecture and introduce a resource management mechanism inspired by the proposed solutions to the bankruptcy problem such as Talmud, Constrained Equal Awards, and Constrained Equal Loss. We utilize Social-Gap, Gini-Coefficient, Participation motivation, Deviant member destiny, and Deviation's social effects to evaluate the proposed mechanism. The obtained result in the conducted simulations based on the available bankruptcy award rules reveals that Talmud reduces the social gap by 37–55% and improves the Gini coefficient by 12–30% than other rules. Our study confirms that there is no motivation to deviate from honesty in announcing the number of virtual machines and the federation's bid price.

Keywords Cloud computing · Cloud federation · Bankruptcy · Integrity

1 Introduction

The ICT industries try to trade through cloud computing by outsourcing their facilities via providing services on the Internet and Pay-Per-Use perspective. This type of service also prevents expensive investments in providing infrastructure and the costs of maintaining and upgrading it for consumers.In other words, customers can easily experience ICT services, such as daily routine facilities. Thus, cloud computing has become more important and has increased resource efficiency by using virtualization technology and hosting several virtual machines on one physical machine. Virtualization enables cloud providers to provide abstract physical infrastructure in which the complexity of the infrastructure is hidden. They offer a pool of virtual resources to users as different types of virtual machines. In addition to virtualization technology, flexibility, elasticity, computing power, and unlimited storage resources are other attractive features of the cloud.

Inter-cloud, multi-cloud, and cloud federation are examples of recent solutions to overcome the service and infrastructure requirements of a cloud by other allied clouds [9]. The general meaning of cloud service providers' integration causes cloud-federation and inter-cloud used interchangeably, but it is essential to clarify what these two terms mean and how each is applied to cloud computing. A federation is a group with centralized contractual management that each member has independence in its internal affairs. In cloud computing, the word federation does not exactly this meaning, but it implies an agreement between different cloud providers that allows them to use each other's services in a specific way by exchanging points between them.

The cloud federation can be considered as a possible mechanism to increase resource utilization and

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consequently increase profits. To avoid wasting non-storage-able resources, providers in a cloud federation can lease part of their idle capacity in the data center to other providers that need additional resources [8].

The term inter-cloud mainly refers to the overall landscape in which interoperability between different cloud providers meets official standards, resulting in an open platform in which applications can move their workload freely to choose services from different sources. On the other hand, the concept of cloud federation includes the masses of temporary partners between cloud providers based on private contracts and dedicated relationships [10].

Due to the distinctive features of the cloud federation compared to other inter-cloud approaches, this method will have a brighter future than other competitors. For example, autonomy in participation is one of the distinguishing features of the cloud federation with other approaches.

From an architectural perspective, the cloud federation can be classified into two groups, centralized and peer-to-peer [12, 20]. In a centralized architecture, a central unit is responsible for facilitating allocating resources. Typically, this central unit acts as a repository in which available cloud resources are registered, but it may also have other responsibilities, such as acting as a resource market. Whereas in peer-to-peer architecture, clouds communicate and negotiate directly with each other and without intermediaries. Also, in terms of interoperability, the federation's architectures are divided into two groups: user-centric and provider-centric [34]. Provider-centric approaches rely on provider agreements to achieve a certain level of interoperability, while user-centric approaches are independent of provider-level agreements. In fact, the broker provides the ability to collaborate and agree on user-centric approaches. As their thought, the cloud federation is the most common provider-centric solution, and the existence of a federation-level agreement (FLA) and relevant standards is necessary to establish a federation space. Therefore, according to their hypothesis, multi-cloud is an example of user-centered approaches. This categorization has also been discussed in [20]. In this paper, the authors argue that inter-cloud architectures in which the broker receives and manages client requests fall into the multi-cloud category. The federation will make meaningful when it is essentially either peer-to-peer or has a central coordinator that only manages the business interaction of resources and services between members.

Regardless of the type of cloud federation architecture, each federation must have a series of functional and non-functional properties [3]. Integrity is a feature that describes the consistency and stability of the federation's supply and demand environment for cloud providers owned by the federation. Integrity is one of the most critical functional properties because, without it, the federation character will become another organization formed only from multiple clouds. For example, if integrity is not supported, certain cloud providers can only consume resources and provide no services to other clouds.

In the rest of this paper, the recent strategies and methods in formation, trust management, and resource management in the cloud federation, published by well-known publishers, are reviewed in Sect. 2. Also, in Sect. 2.4, solutions that can support integrity are discussed, and at the end of Sect. 2, the research gap and our contribution are introduced. In Sect. 3, integrity and bankruptcy issues are explored as research background. In Sect. 4, the system model, including the formal definition of integrity, conceptual architecture, pricing model, and proposed resource management method, are introduced, and the evaluation parameters of the model are also discussed. Section 5 deals with the simulation and presents the experimental results. In the discussion section, the achievements, limitations, and future work are mentioned, and finally, in the last section, the conclusion of this work is discussed.

2 Related works

According to the study domain, we review the related work from four perspectives, which are moot here: federation formation, trust management, resource management, and integrity awareness. Table 1 shows the summarization of the related papers based on thses point of views.

2.1 Federation formation

The Cloud Federation formation is one of the fundamental challenges in this area. Because if a federation is not formed, the benefits of the federal environment are unattainable. Since participation and membership in the federation are voluntary, motivational factors must be necessary for cloud providers to join the federation. Maintaining this motivation is also essential for the federation's survival because leaving the federation is entirely voluntary. Since the federation's survival is threatened by violating the integrity, the federation formation is affected by the integrity.

Most methods that focus on forming a federation have used game theory to achieve the goal. For example, Mashayekhi et al. [36] proposed a federation formation game. For Each user request, one federation is formed. Hassan et al. [25] proposed a cloud federation formation mechanism by utilizing a trust–based cooperative game theory, enabling the CPs to form a federation based on profit maximization dynamically. Coronado and Altmann [15]. have proposed a repeated game mechanism and used agent-based modeling for forming a cloud federation