Analysis of Intelligent Agent and Its Components for the SLA Negotiation Process in Cloud Computing

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Abstract Cloud service providers (CSP) are facing a competitive environment in the cloud-computing world and CSP is huge in demand with the growing field of IoT, fog, and cloud services. Consumers are always looking forward to acquiring services as per requirement. Due to the competitive field in the market of cloud computing, consumers face issues during the delivery of services. Consumer and CSP need an intelligent agent to mediate which performs the negotiations process on behalf of both parties and maintaining other responsibilities. An intelligent agent-based negotiation system (IANS) is required to perform the negotiation process and measure the KPIs during the process that helps to make quick decisions in minimum time. Researchers suggested many learning algorithm-based agents that maximize the success rate and speed of negotiation. IANS with behavior analysis of consumers and CSP helps to opt for more reliable and secure services. IANS uses negotiation metrics, performance factors, and evaluation measures for decision. Due to the dynamic environment of cloud services, IANS is recommended for the negotiation process.

Keywords Agent · SLA · Cloud services · Negotiation · Intelligent system · Cloud computing

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1 Introduction

Cloud computing services provide solutions to many ventures in form of infrastructure, software, and platform, and business process [1]. A cloud is a large group of interconnected computers that provide the required services to any scale of the enterprise [2]. To obtain required services both consumers and providers must settle on pre-established contracts called Service Level Agreements (SLA) [3]. The resources assigned are based on SLA that contain Service Level Objectives (SLOs) for each SLA parameter, like price, availability, response time, reliability, CPU utilization, etc. [4]. Consumers and CSP have struggled over requirements; negotiation can provide a solution to established deliverable SLA between them [5].

Negotiation is a process of settlement of SLA requirements between consumers and CSP via the agent [6]. Consumer's requirements are dynamic and change according to time and demand, in this manner consumers cannot stick to one CSP [7]. To sustain those dynamic requirements with compound services, there is a necessity of designing an intelligent agent-based negotiation system (IANS) [7, 8].

IANS can provide negotiation, decision-making, resource management, interacting with other interconnected CSP also called inter-cloud, knowledge acquisition; analyze behavior, monitoring, maximizing success rate in minimum time [9–11]. IANS maintains the requirements for cloud services within minimum response time, maximum availability, reliable server, and services at the minimum price [3, 4].

2 Background Study

SLA is legal documents that are defined and modeled on which CSP and consumers must agree, approved, and signed after SLA negotiation [12]. SLA violations may lead to monetary penalties, credibility, and reduced reliability for services. SLA management describes complete assistance to configure SLA negotiation metrics information, automatic negotiation, and monitoring, speedy recovery over issues, and quick response over violation [2, 13].

Negotiation between CSP and a consumer based on metrics mainly price (P), availability (Av), the response time (RT), reliability (R) [3]. Performance of cloud services, negotiation strategy, and the process can be measure by a utility function (UF), negotiation speed (NS), success rate (S) [14]. Factors to evaluate the strategy of the negotiation process are the number of resources (NoR), Deadline (DL), degree of satisfaction (DoS) [3, 6, 15, 16].

In the Negotiation process, consumers want to fulfill maximum requirements and on the other hand, providers want to maximize sales of services. IANS focus on the cycle of negotiation, negotiation matrices, and performance metrics [17].

Negotiation metrics: Cloud consumers must understand the key performance indicators (KPI) for better negotiation. In Table 1, there are eight major high-level cloud service attributes and under each level, some major KPIs to evaluate and

Table 1 High-level cloud services attributes and KPIs [4]

S. No.	Cloud service attributes	Key performance indicators
1	Financial	**Price of service**, free features, cost of security
2	Security and privacy	Data center and location, encryption and decryption, privacy, trust
3	Performance	**Response time**, efficiency, latency, load balancing, network quality, robustness, throughput, scaling latency
4	Agility	Adaptability, elasticity, flexibility, portability
5	Usability	Accessibility, compatibility, controllability, functionality, maintainability, suitability, transparency, pooling
6	Accountability	Auditability, integration support, sustainability
7	Assurance	**Reliability, availability**, credibility, fault tolerance, service stability
8	Management	Data management, monitoring, value-added services

negotiate [4]. According to [3, 6, 11, 16], major negotiation metrics are price (P), availability (Av), the response time (RT), reliability (R).

3 Framework and Workflow of Ians

The proposed IANS design in Fig. 1. Follow the life cycle of SLA. IANS helps to finds out the suitable CSP concerning the consumer requirements [7]. Agent components allow us to understand the behavior of CSP by learning algorithms like reinforcement learning [15], which help to speed up the process of negotiation.

There are five steps for SLA satisfaction between CSP and consumer [2, 5].

1. **SLA Definition:** CSP provides SLA with available offers and resources. A CONSUMER SLA covers the requirements of the resource. Both types of SLA can customize later [2].
2. **Published and Discovery:** Consumer published requirement to IANS, which translates and analyzes the SLA and discover suitable CSP from its database. Discovery of CSP based on rank-based that depends upon security, trust, performance, financial, etc. IANS analyzes behavior property based on the functioning of KPIs [2, 4].
3. **Negotiation:** Negotiation process has five major steps, (i) assessment of SLA, (ii) allowance computation, (iii) achievable solution development, (iv) produce offer, and (v) negotiation termination [16].
    (a) **Assessment of SLA:** IANS assess the SLA and analyze the requirements of resources with price, response time, and availability. IANS computes UF, if the value of UF maximum, the agent gives positive feedback [16, 19].

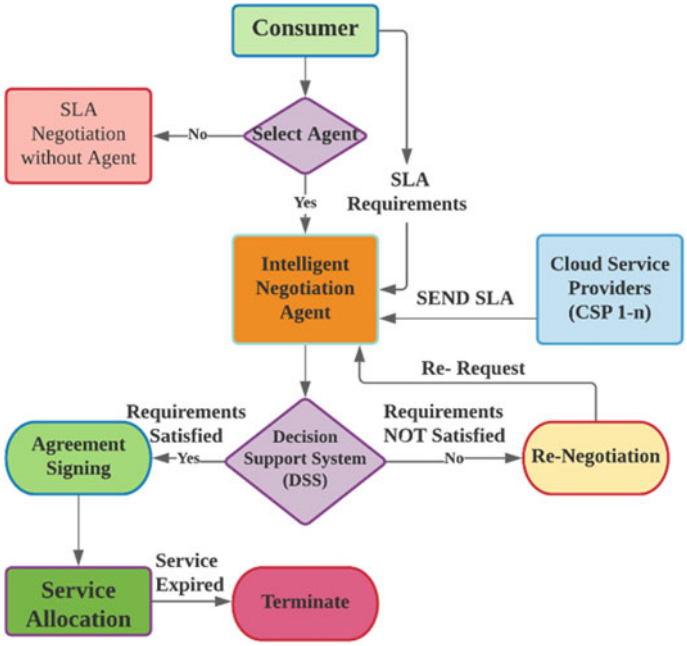

Fig. 1 The framework of intelligent agent-based negotiation system [18]

(b) **Allowance Computation:** IANS computes discounts over the prices of different resources. IANS computes the difference between previous offers and current offers and produces satisfaction value [16].

(c) **Achievable Solution Development:** IANS keep threshold value (TV) for KPI. If there is a vast difference concerning TV, then IANS produce negative feedback, in case of negligible difference, gives positive feedback, which reduces '*Ti*' and '*Nr*' and increases NS [11, 16].

(d) **Produce Offer:** While comparing and analyzing the latest offer by CSP, IANS makes the final call to produce an SLA offer. Results will mainly depend upon the DoS of consumers and CSP for SLA and UF of consumers [11, 16].

(d) **Negotiation Termination:** The termination of the negotiation process has two values success and failure. Successes, if the process meets with requirements before the deadline (DL) with a minimum number of negotiation rounds. Failure, when define deadline is over before settlement. In case of failure, the consumer offered a new SLA or new CSP for the further process [11, 16].

4. **Operationalization:** The decision support system (DSS) of IANS will finalize the agreement and start operation. Operationalization of SLA means negotiation completed successfully. Operationalization includes monitoring of secure service delivery, accounting of SLA, execution of SLA [2].

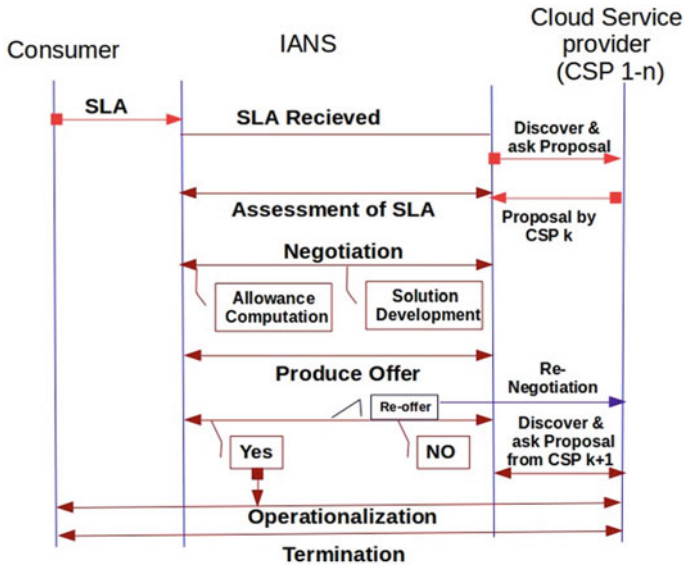

Fig. 2 Workflow diagram of negotiation process in IANS [16]

5. **Termination:** After the completion of the process, sharing of resources and all activities ended [2].

In Fig. 2 [16], Workflow Diagram of Negotiation process showing communication between consumer and CSP via IANS. IANS helps to make the process fast, secure, and provide the best options for the consumer from a massive number of CSP [12].

4 Conclusion and Future Work

In this research study, IANS functioning explored dependency factors of SLA negotiation process for cloud services. It is defined that cloud SLA negotiation process with IANS for negotiation will understand the requirement of the client and produces perfect match from the massive number of CSPs with maintaining KPIs price, availability, response time and reliable. The descriptive analysis of the agent, its key factor, and functioning is to develop an intelligent intermediary for the negotiation process. IANS can focus on the dynamic environment of the cloud market and consumers' requirements. Management of SLA described understanding the roles and responsibilities of SLA. The framework of IANS discussed the workflow diagram of the negotiation process. In future aspects, IANS may explore various learning algorithms to design agents, decision-making algorithms for optimizing solution, security, monitoring solution, and add more attributes for analysis.

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