Model of an Intelligent and Automated Negotiation Agent for the Service Level Agreement Negotiation Process in Cloud Computing

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ABSTRACT

With the help of an intelligent agent, a cloud service provider (CSP) offers various services and resources to their customers over the internet. Consumers and CSPs in the cloud market are in a constant state of negotiation over their individual needs. Competition among CSPs is fierce because of the enormous number of CSPs in the market. Intelligent negotiation agents are highly demanding as a timesaving and success rate-enhancing tool. While negotiating, multiple attributes such as price, resources, reliability, CSP performance, utility value, and many more are considered. There's increased false negotiations, faulty servers, and exorbitant fees are all issues arising because of the forever changing CSP market. An intelligent and automated negotiation agent (IANA) understands the conduct of the opponent and the needs of both parties. This need of users and CSP information is utilized in negotiations to find the best possible delivery of services between the customer and the CSP. As a result of the proposed design, negotiations are expedited, and there is a higher success rate and better oversight of service delivery.

1. Introduction

The term "cloud" refers to a massive network of computers connected and working together to deliver the necessary services to businesses of any size. Computing refers to achieving a predetermined objective through the application of computer technology [1]. Computing may include designing and developing hardware and software systems for several different purposes, most commonly structuring, processing, and managing any information. These functions are often performed to pursue scientific studies, make intelligent systems, and create and use various channels [2-6]. Cloud Computing is a branch of information technology (I.T.). It offers solutions, support, and development environments over the internet for software, platform, and infrastructure. Cloud Computing, including the internet of things, fog computing, and edge computing, has recently been responsible for developing new business trends and hastened the scientific research pace [7-9]. The

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term "Software as a Service" (SaaS), "Platform as a Service" (PaaS), and "Infrastructure as a Service" (IaaS) refers to the act of providing customers with applications that ought to be accommodated by a cloud service provider (CSP) and delivered to them via the internet [1,3]. The usage of applications flexibly produces business for the CSP, allowing for limitless use while still allowing users to pay for access to the services based on demand. IaaS enables on-demand access to computing resources, storage capacity space, and communication services. PaaS provides a background for programming utilized to construct applications [10-13]. These applications can use the facilities of processors, memory, and other tools. The term "SaaS" refers to software applications; customers can access and use virtually any application online. Cloud computing has opened several doors of opportunity for business for cloud service providers (CSPs). It has allowed customers to access I.T. infrastructure by altering the number of resources per user's need and only paying for the resources they consume. Figure 1 explains the services offered by cloud computing that can help many businesses in several ways, including with their infrastructure, software, platforms, and business processes [4,14-16].
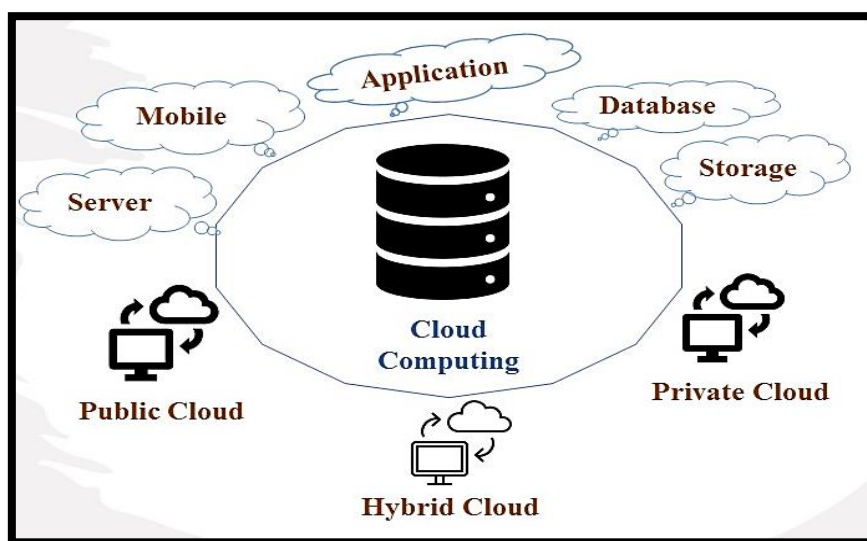

Fig. 1. Cloud Computing and its facilities in different fields

These days, cloud services are widely available over the internet; users need to pay the appropriate fee to use them. CSP offers IaaS, PaaS, and SaaS services to enterprises of all sizes, from tiny to giant. CSP provides its customers with a Service Level Agreement (SLA) that details the resources and service assurances made available to them. This agreement is included with each service. Cloud SLA also promoted new policies to attract new consumers and offered a variety of resources to market their services to increase awareness of CSP services [16-18]. Service Level Agreements (SLAs) are negotiated among cloud service providers, customers, and network carriers [19]. According to Sim [20], cloud computing systems are a collection of virtualized and connected computing devices that provide computation resources through negotiated Service Level Agreements (SLAs). Cloud computing is an "on-demand resource" and has on-demand self-service that allows consumers to request computing capabilities (such as server time and network storage) without human interaction [2,21]. The cloud is swiftly elastic because it can be fast, elastically, or immediately available to the customer while still giving the impression of being boundless. It is necessary to have the capability to monitor, control, and report on the utilization of cloud resources. It is negotiating between both parties, on-demand of resources, pricing, availability, and other factors, to establish final agreements between the CSP and the consumer [20]. There is a significant

void in negotiating a standing service SLA, which neither specifies the duties incumbent upon CSPs if a malicious incident occurs [7,22,23].

There is room for an intelligent automated negotiation agent (IANA) to be implemented to bridge those gaps and deal with those minor incidents. IANA can provide services including negotiating, decision-making, resource management, cooperating with other interlinked cloud service providers (also known as inter-cloud), knowledge acquisition, behaviour analysis, monitoring, and maximizing success rate in the shortest possible time. IANA ensures that user requests for cloud services are met within the parameters of minimum reaction time, maximum availability, reliable server, and services offered at the lowest possible cost [8,24].

2. Background Study

Cloud computing distributes services like storage capacity and databases to clients via the internet to facilitate rapid innovation, flexible resource allocation, and cost savings. Customers only pay for the cloud services they use, reducing operational expenses, improving infrastructure management, and allowing businesses to grow more rapidly. All these services are obtained after SLA consent [5,25,26].

SLAs are legal contracts specified and modelled on which CSP and users must comply, accept, and contract once SLA negotiation has occurred. SLAs are service-level agreements (SLAs). Infractions of the SLA can result in monetary fines, loss of confidence, and a reduction in the reliability of the provided services. The phrase "SLA management" refers to offering complete assistance in creating SLA negotiation metrics information, automatic negotiation and monitoring, rapid recovery from difficulties, and prompt response to violations [27-30].
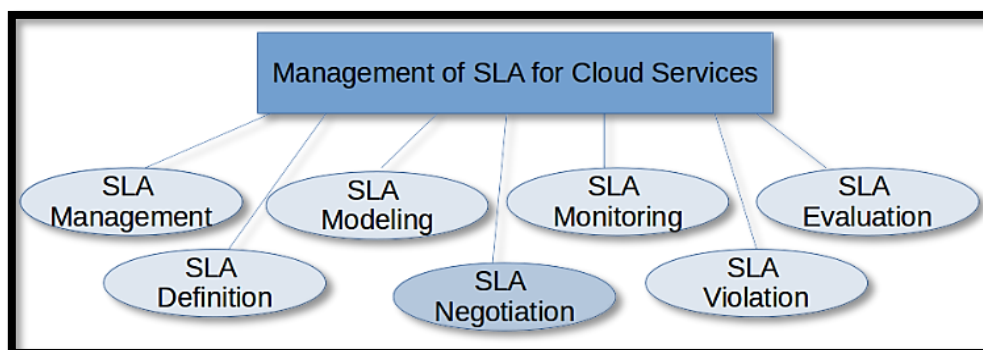

Fig. 2. Categorization of Management of SLA for cloud services [30,31]

The management of SLAs offers extensive assistance for negotiating SLAs and metrics information, automatic negotiation, monitoring of SLAs, and swift response to violations. Improving the flexibility of service level agreements in an ever-changing environment is more manageable with agent-based technology [18,31].

Customers and service providers negotiate SLA criteria via the agent. Customers' needs are fluid and shift with the times [2]. Therefore, they cannot stick with a single CSP. Consumers and service providers seek to meet their maximum needs during the negotiation process. An intelligent automated negotiation agent (IANA) is needed to meet the dynamic needs of compound services. Consumers and service providers seek to meet their maximum needs during the negotiation process. IANA focuses on the negotiation cycle, the negotiation matrix, and performance measures in the process of negotiations [5,22-24,26].

Figure 3 depicts a one-to-one negotiating process in which consumers and CSP use different tools to analyze the SLA [2,7,8]. The consumer puts SLA requirements into the SLA generator and submits requirements to the CSP. CSP assesses the demand for resources and makes a recommendation [32,33]. Consumers look at a deal. Once an accurate or false decision is made, the bargaining process can begin once both parties are satisfied [34,35].
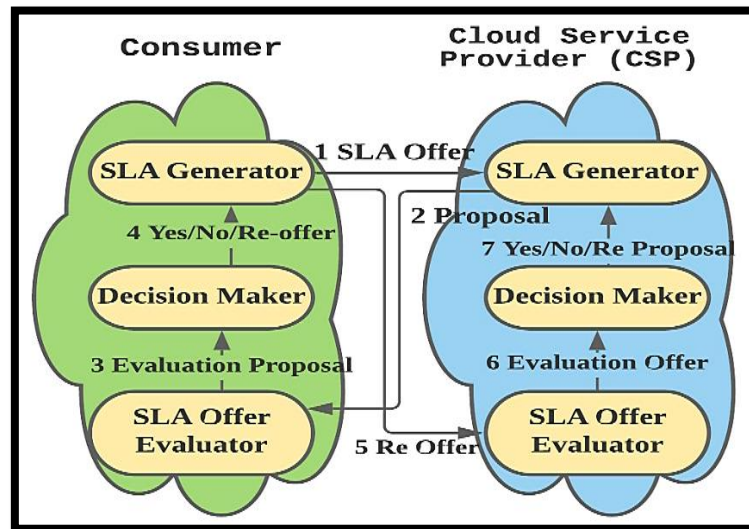

Fig. 3. One to One SLA Negotiation Process [2]

Customers of cloud services need to be familiar with key performance indicators (KPI), so they may negotiate more effectively. Table 1 outlines the eight most critical high-level characteristics of cloud services and specific key performance indicators (KPIs) for each level to be evaluated and negotiated [26].

Table 1
High-Level Cloud Services Attributes and KPIs [2,26]

S. No.	Cloud Service Attributes	Key Performance Indicators
1	Financial	Price of Service, Free features, Cost of Security
2	Security and Privacy	Data Centre and location, Encryption & 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

A cloud management system now offers only semi-personalized service-level agreements (SLAs). The projection forecasts that customers with specific Quality of Service (QoS) standards may not be satisfied by the service provider to maximize income [8,25]. On the other hand, the cloud service provider can't offer specific services to customers with specific quality requirements [36].

There is an increased need for cloud services, fog computing, and IoT data in the future [23]. Several articles have suggested a cloud management system that includes an intelligent agent to satisfy consumers' and service providers' needs [35].

3. Intelligent Automated Negotiation Agent (IANA)

The need for intelligent negotiating agents that operate on the service provider layer of cloud computing and offer balance establishment to consumers and providers following QoS requirements is relatively high. These agents are needed to work on the service provider layer. The negotiating agent can satisfy SLA needs and administration even with high customer demand for cloud, fog, and IoT services. An Intelligent Automated Negotiation Agent (IANA) that can satisfy requirements, management, and dynamic adjustments on SLA during cloud services is a goal for researchers in this situation. In a dynamic context, an automated negotiating agent in cloud computing must consider additional service discovery, scaling, monitoring, and decommissioning procedures [28,37,38].

The flow of service level agreement (SLA) negotiations between customers and service providers is illustrated in Figure 4 of the IANA process model. Consumers request service level agreements (SLAs) and publicize the requirements; the IANA operating model allows consumers to negotiate either with or without intermediaries. IANA is the first to start the process and suggested selecting the CSP from the list of CSPs and getting the negotiating process underway. The DSS, which stands for the decision support system, makes the call based on whether or not the conditions have been met. If the criteria of both parties can be satisfied, even if it means compromising on some characteristics, then the final SLA can be signed, and services can begin being provided. When the services were no longer needed, the procedure was finished, and the final billing was processed.
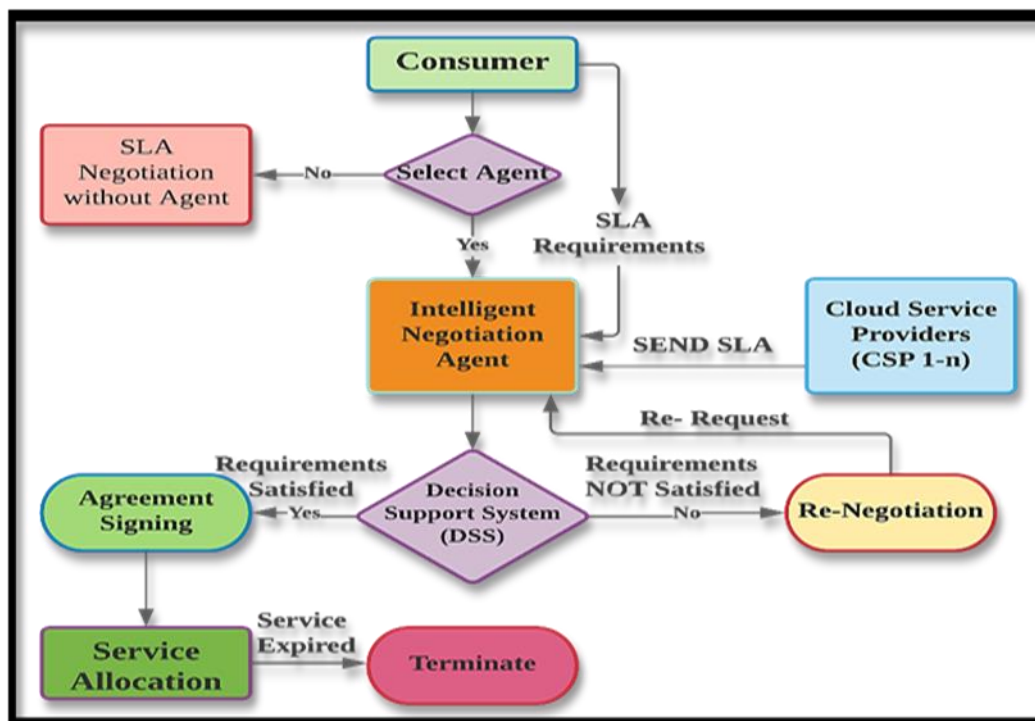

Fig. 4. The Process Model of Intelligent Automated Negotiation Agent (IANA)

The negotiation process in IANA between a consumer and a CSP is represented by a communication diagram in Figure 5 that includes three-way handshake communication. The process starts with sending a communication request, which response to a request accepted or rejected. If the request is accepted, the negotiation phase is started by IANA. After the negotiation phase, consumers send an acknowledgement for accepted or rejected proposals and vice versa by CSP. Here, IANA builds a safe and quick communication phase for the negotiating phase between customers and CSPs. It makes the process more expedient and risk-free while offering the customer the most advantageous choices from the many CSPs on the market. When a customer requests CSP for a proposal, IANA fulfils the request and distributes CSP to the customer. It then begins the negotiating process [3,5,39].
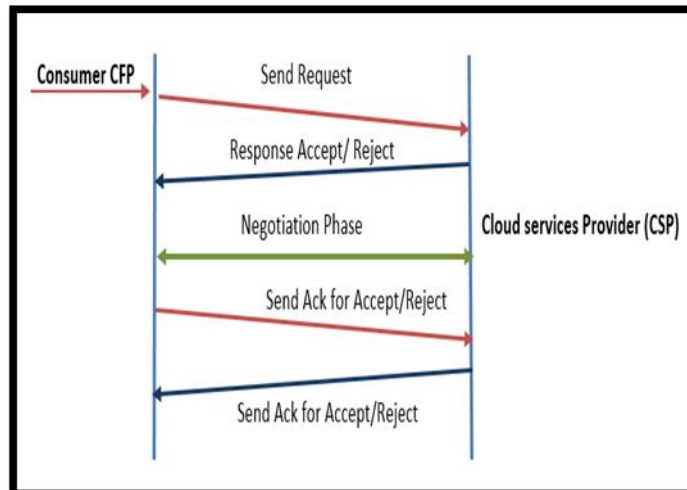

Fig. 5. Three-Way Handshaking communication for negotiation process by IANA

As presented in Figure 6, the functioning of the IANA process is distributed over five significant steps: Initiator, Search and Recommend, Negotiation process, operationalization, and Conclusion [34,35].

    i.   **Initiator:** The agent gets initiated after receiving the request from the consumer. A consumer SLA is an agreement that covers the needs of the resource. After accepting the request, IANA proceeds to receive and process the request. It does an in-depth analysis of the consumer's requirements and classifies those requirements according to the relevance of the consumer. IANA started the process of searching and recommending.

   ii.   **Search and Recommend:** IANA has released the SLA to locate appropriate CSP within its database. The ranking of CSPs is based on various characteristics, including security, trustworthiness, performance, cost, and other consumer requirements. IANA does behavioural analysis on CSPs and consumers to give the most beneficial services to both groups [2].

  iii.   **Negotiation Process:** The negotiation process consists of five basic steps: (i) measuring the service level agreement (SLA) attributes, (ii) Reduction calculations, (iii) solution building, (iv) proposal generation, and (v) final agreement [35].

       • Measuring SLA Attributes: During the negotiation process, the SLAs of both parties get evaluated, and the requirements for resources, including pricing, response time, availability, and other factors, are analysed. The agent provides positive

feedback if the value of the satisfaction factor reaches the threshold after the process has computed the essential attributes.

- Reduction Calculations: During this process step, discounts are computed over the pricing of various resources. After each negotiation round, the agent contributes to the computation of the difference between prior and current offers to adjust the new threshold values.

- Solution Building: Each KPI's threshold value (T.V.) is constantly monitored by IANA. If there is a significant discrepancy in T.V., IANA creates negative feedback, and if it's the only issue, positive feedback if the discrepancy is resolved within the negotiating round's limits. IANA continues to aid in enhancing the speed of negotiations. There is always a solution at the end of every negotiation.

- Proposal Generations: Following the building of the solution, the newly developed proposal is reviewed and compared to the CSP's earlier offer. IANA has the last say in deciding whether to produce an SLA offer. The production of proposals depends on how customers and CSPs are satisfied with the service they receive.

- Final Agreement: The conclusion of the negotiation process might have two outcomes: a successful negotiation or an unsuccessful one. The procedure is successful if it satisfies the requirements well before the deadline, requiring only a few negotiation rounds. Failure occurs when the defined deadline passes before the settlement is completed. If the transaction is unsuccessful, the customer is given the option to switch to a new CSP or new SLA. Based on the outcomes of other levels, the DSS can help both parties decide.

iv. **Operationalization:** IANA's decision support system (DSS) touches the SLA and begins normal operations. When the SLA is operationalized, the negotiation is fruitfully concluded. Monitoring the supply of secure services, keeping accounts of service level agreements, and carrying out service level agreements are all part of operationalization.

v. **Conclusion of IANA:** After operationalization, when services are over, the final delivery of service has been concluded. Billing has been updated and sent to the consumer. IANA takes the feedback from the monitoring process, during the delivery of services, and overall security for future recommendation and behavioural analysis [40].
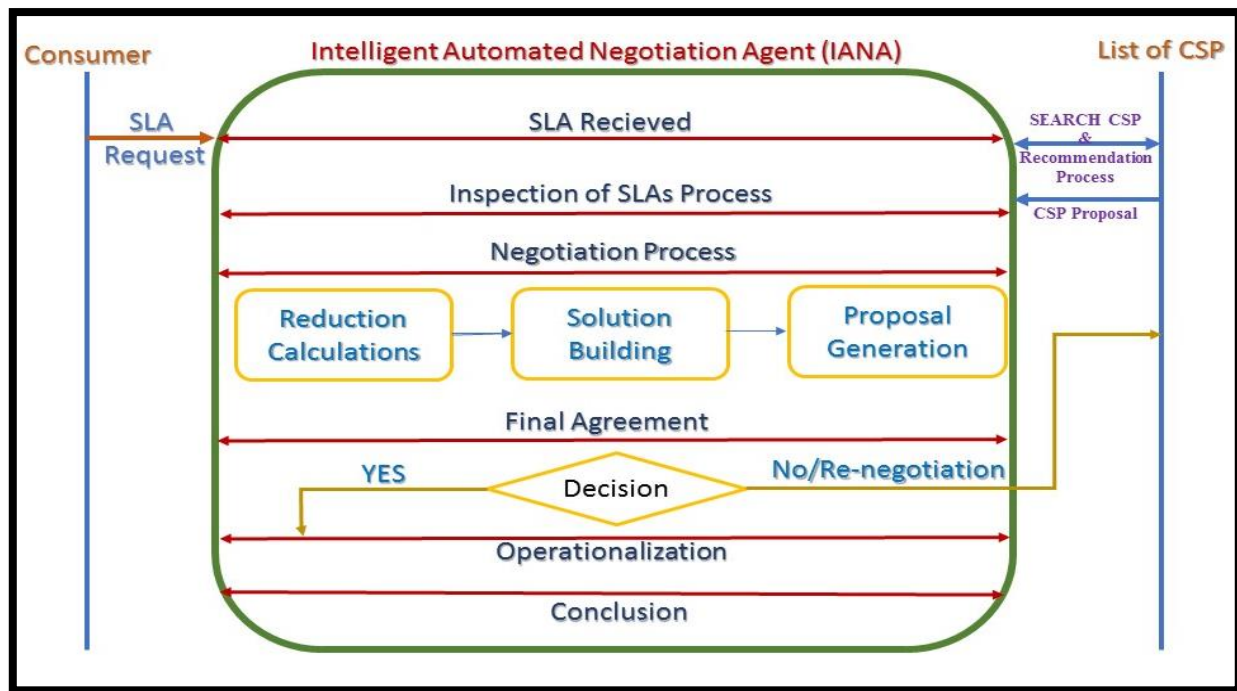
Fig. 6. Functioning of IANA

After obtaining the customer's specifications, the algorithm begins the negotiating process. According to SLA requirements, the agent recommends the closest CSP and facilitates a negotiation between the CSP and the customer. Start with t = 0, the time limit for negotiations up to the time of the next timeout, t. Once the request is accepted, the negotiation process begins with the abovementioned steps. A service level agreement is agreed upon after n rounds of negotiation if the consumer's satisfaction is greater than the CSP's; otherwise, negotiations continue until the deadline has passed. While the negotiation is going on, the agent notes how each party behaves and saves them for future use and recommendation. Training for the suggestion and negotiating process is done using reinforcement learning. Another benefit is monitoring the delivery of resources following the signing of the agreement.

A large number of CSPs are represented by IANA, which speeds up and secures the process for the consumer. Within the negotiation process context, the negotiator agent's role is critical. It stores all the behavioural records of customers and service providers, including information about price, availability, reliability, and security, among other things [41]. For starters, the system will save all pertinent data if the client or CSP is new to the negotiation process. To better future outcomes, it examines the negotiating and service processes. The request goes through a series of steps between the client and the CSP. The process doesn't start until it's been translated into machine language [11,13]. The negotiator engine begins the negotiation process with the assistance of the knowledge reference system. Service Level Agreement (SLA) revamping occurs if the negotiation is denied, and the same process continues with the negotiator's performance report [42]. Too many negotiations occur at the outset, but with the help of AI-powered matching tools, negotiators can find more favourable agreements. If the parties agree to the plan, the service process will proceed [2,7,8].

Table 2
Algorithm: Pseudo-Code for Model of Intelligent Automated Negotiation Agent (IANA)

Algorithm: Pseudo-Code for Model of Intelligent Automated Negotiation Agent (IANA)	
Begin	18. Begin Learning Process ()
1. Initialize Negotiation Process between Consumer and CSP,	19. If Satisfaction(Consumer) > Satisfaction(CSP) && SatisfactionValue > 0.75
2. Initiate Consumer's SLA Proposal,	20. OfferAccept () ;
3. Send Request to IANA for requirements,	21. else if
4. Time, t == 0;	22. renegotiation ();
5. If (Request = Accept)	23. counter-offer ();
6. Move to Initiator ()	24. else reject ();
7. Call Search&Recommend()	25. Learning Process ()
8. Call NegotiationPhase()	26. Check out and evaluate the CSP offer and the consumer offer,
9. Negotiation Phase ()	
10. Initiated negotiation time deadline (t)	27. perceive negotiation pattern information, monitoring;
11. For (t = [0,t])	
12. IANA receive offer from CSP	28. update information,
13. Calculate Atrributes(),	29. select Decision Rule
14. Calculate Recuction(),	30. return ();
15. Solutionbinding(),	31. End if
16. ProposalGenerations(),	32. Operationalization()
17. FinalAgreement()	33. Terminate()
	END

Here is the algorithm for the negotiation process between a customer and a cloud service provider (CSP) using IANA:

The customer provides specifications for the desired services, including the service level agreement (SLA) requirements.

i. The algorithm recommends the closest CSP that meets the customer's specifications.
ii. The algorithm starts the negotiation process with t = 0, the time limit for negotiations.
iii. The IANA agent facilitates communication between the CSP and the customer and begins negotiation rounds.
iv. In each round, the IANA agent makes an offer to the CSP, and the CSP responds with a counteroffer.
v. The agent uses a utility function to evaluate the offers and counteroffers, considering the customer's satisfaction and the CSP's requirements.
vi. The agent uses learning techniques to learn from the negotiation process and improve future negotiation strategies.
vii. The agent monitors the negotiation process and saves the behavior of each party for future use and recommendations.
viii. The negotiation process continues until a service level agreement is reached and the customer's satisfaction exceeds that of CSPs.
ix. The negotiation process ends without an agreement if the deadline has passed, and no agreement is reached.
x. Once an agreement is reached, the IANA agent monitors the delivery of resources following the signing of the agreement.

Here is more information on how the algorithm can handle SLA revamping and continue the negotiation process:

i. If the initial negotiation between the customer and the CSP is denied, the algorithm will revamp the Service Level Agreement (SLA) based on the customer's specifications and the CSP's requirements.

ii. The algorithm will use an AI-powered matching tool i.e., The IANA agent, to find more favorable agreements by analyzing the customer's and CSP's preferences and constraints.

iii. The IANA tool will also consider the negotiator's performance report, which includes information on the negotiation process, the party's behavior, and the negotiation's outcome.

iv. The IANA algorithm will start a new negotiation process with the updated SLA and the customer's revised requirements.

v. The algorithm will continue to use the IANA to find more favorable agreements and improve the negotiation process.

vi. The algorithm will also use the negotiator's performance report to monitor the negotiation process and adjust as needed.

vii. If the parties agree to the new plan, the service process will proceed, and the algorithm will continue to monitor the delivery of resources following the signing of the agreement.

viii. If the parties do not agree to the new plan, the algorithm will continue to revamp the SLA and repeat the negotiation process until a mutually acceptable agreement is reached.

It is worth noting that using IANA and performance reporting can help to improve the negotiation process and increase the chances of reaching a favourable agreement. Additionally, AI-powered IANA can help reduce the number of negotiations needed, making the process more efficient.

4. Results

In this part, the performance of the IANA, along with some preliminary results, is discussed. A computer program written in Python was built to carry out the IANA algorithm described before. The software's running will make some assumptions about the users and the CSP. When there are fewer discussed aspects, we have seen a relatively higher success rate in the negotiation process, according to the early findings of the model. When more characteristics are at play, calculating the probability of a successful negotiation gets more complicated. The fact that the model produced effective results despite having fewer data to work with is one of the beneficial outcomes of the agent described above. Negotiation time also decreases in fewer attributes, but it may vary with the change in the number of attributes versus the number of CSPs in the list. Overall, this model helps provide better success rate results within less negotiation time.

According to the analysis of the performance of IANA, as shown in Figure 7, the early findings of the IANA model show that when there are five discussed aspects in the negotiation process, the success rate of the negotiation process is 95%. This indicates that the model can effectively negotiate and reach agreements when considering five aspects. It suggests that the model is well-suited for handling a moderate number of negotiation attributes and can reach mutually acceptable agreements for both parties. However, it is worth noting that this success rate may change when more or fewer attributes are considered, and the model's performance should be evaluated with more data.
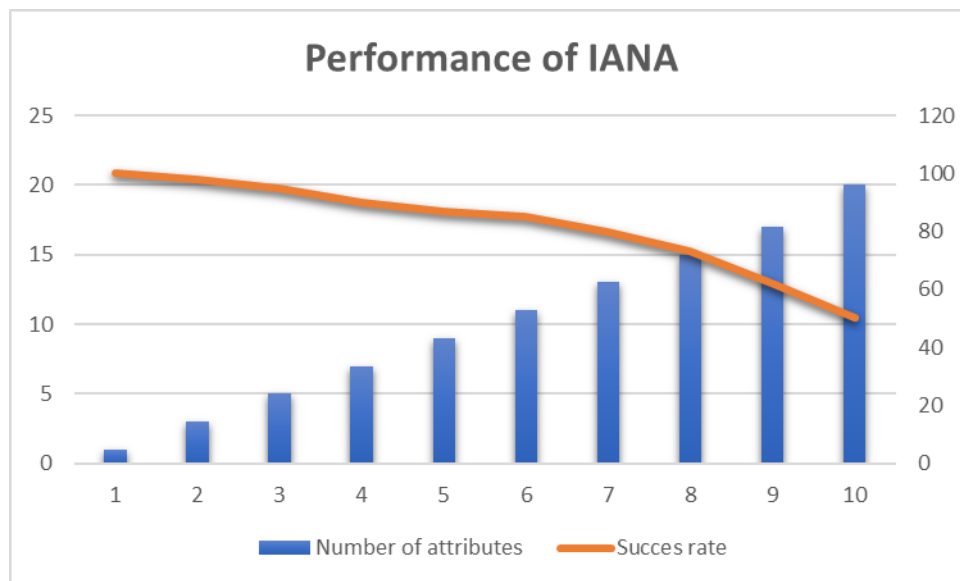
Fig. 7. Performance of IANA

5. Conclusions

An investigation of the SLA negotiation procedure for cloud services was conducted using the IANA model. As specified, cloud SLA negotiation using IANA aims to comprehend client needs to make a perfect match among the many CSPs while keeping KPIs such as price point stability, availability, and reaction time. To come up with a competent intermediary for the negotiating process, it is required to conduct an in-depth investigation of the agent. IANA can focus on the evolving cloud market and the needs of users. Understanding the duties and responsibilities of SLA is the central focus of SLA management. IANA's model discussed the negotiating process and its functioning. In addition, IANA mainly concentrates on the cloud business's ever-changing nature and user demand. It helps the negotiation process speed up, the number of rounds reduced, and practical solutions for negotiating for users.

Additionally, it assists users in reaching the perfect service provider, which allows the organization to accomplish its goals and objectives. It is worth noting that this is a high-level possible IANA agent algorithm, and many details would need to be considered in the implementation, such as the design of the utility function, the learning techniques, and the decision rules. Additionally, negotiation is a complex and dynamic process, and the algorithm should be carefully tested and evaluated in a simulated environment before being implemented in real-world scenarios. In the future, we may look at several other learning algorithms, such as decision-making algorithms for improving security and monitoring and more characteristics for attribute analysis.

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