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Research Article

ROAP: Resource Optimization, Allocation and Provisioning in cloud ecosystem with cognitive computing

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ABSTRACT

In the domain of Artificial Intelligence, many academicians and researchers predict that cognitive computing represents the future. But can it address the issues and challenges of cloud computing? This is precisely what has been explored in this paper. Among the many issues plaguing cloud computing is the challenge of efficient resource management by cloud service providers, including both the allocation and deallocation of resources on demand to cloud service requesters. To address this challenge efficiently, a cognitive framework has been proposed. This framework applies the principles of cognitive computing to detect and evaluate patterns, if any, in cloud requests, enabling more effective future resource allocation.

Keywords: Cloud Computing, Edge Computing, Fog Computing, Dew Computing, Cognitive computing, Resource Management

INTRODUCTION

Cloud, **D**ew, **E**dge, and **F**og [CDEF] is a fast-evolving Computing paradigm that is revolutionizing the way, **CCR**[**C**onfigurable **C**omputing **R**esources] are accessed over the web by the **C**loud **S**ervice **R**equester[**CSR**] from the **C**loud **S**ervice **P**rovider[**CSP**]. Cloud Service Providers which are usually comprised of **MANG** Group of Companies namely: **M**icrosoft, **M**eta, **A**mazon, **A**dobe, **A**pple, **N**etflix, and **G**oogle et al. are utilizing the concept of Virtualization to fully exploit the power of Hypervisor to create, configure, and initialize the CCR [**C**onfigurable **C**omputing **R**esources] such as Storage Space(Memory), Operating System, Web Server, Database Server, Application server, a set of peripheral devices and networking and internetworking components such as Routers, switches, Hubs and Gateways et al. The technocrats and DevOps specialists working in these companies are now tapping the power of human intelligence by combining the way humans think, understand, learn, adapt, and perform with Cognitive Computing.

In the last couple of years, many technical evangelists have tried to define Cognitive Cloud, and the most widely acceptable definition that has come up is "**Cognitive Cloud is a Context Aware System that is highly capable of sensing the environment in which it operates, learn from it (either sequentially or exponentially), and opportunistically or dynamically adapt its computational workload as well as its outcome**." Popularly Cognition exists into two categories: hot and cold. Hot cognition refers to mental psychological processes in which emotion plays an important role, such as reward-based learning whereas cold cognition computing refers to thought processes that don't involve feelings or emotions, such as working memory. Modern-day Cognitive computing systems possess the capability to process gigabytes and terabytes of data and exploit the **PIN** [**P**redictive analytics, **I**mage recognition, **N**atural language processing] cognitive technologies to identify patterns and relationships that would otherwise be if not impossible, but difficult for humans to identify and detect.

Today Cognitive System find their utility and applications in a wide variety of domains such as:

1. Med-Tech and HealthCare: Predicting the future set of diseases a person is likely to suffer based on his current medical conditions and clinical and psychological test data.

2. Automotive Sector: Design and Development of Self-driving Autonomous Vehicles.
3. Banking and Finance Sector: Fraud detection and Risk Management with ease and help make investment decisions for the client.
4. Meteorological and Weather Forecasting System.
5. Seismic Vibrations and Earthquake prediction etc.
6. Cyber Security: Cyber Crime Investigations and Computer Forensics

PROBLEM STATEMENT

Ever since Peter Mell and Timothy Grance coined the definition of Cloud Computing in September 2011, millions of organizations have delved into the world of cloud computing. With so many players in the cloud business dealing with sharing, management, and distribution of the data between the cloud service requester and cloud service provider multiple issues related to Cloud Computing such as Broker Initialization, Virtualization, Multi-tenancy, Security, Congestion, Quality of service(QoS), Reducing downtime of Cloud Service Provider, Availability of Configurable Computing resources(CCR) and Cloudlet initialization(CI) have cropped up. One of the most common questions that usually crop up in the mind of the reader is that can all of these be resolved with cognitive computing?

In this paper, sincere efforts have been made to bring together multiple facets of various Cloud Computing technologies such as Dew Computing, Edge Computing, Elastic Computing, Fluid Computing, Mist Computing and Fog Computing et al. on a single common platter and inter-mix with Cognitive Computing to yield good results.

Solving Cloud Computing Issues with Cognitive Computing on selected parameters:

Solving cloud computing issues with cognitive computing leverages artificial intelligence (AI) and machine learning (ML) techniques to improve the efficiency, scalability, and security of cloud-based systems.

Here's how cognitive computing can address some key cloud computing challenges:

Table 1. Cognitive computing solutions for several cloud computing issue

S.No.	Parameters	Cloud Computing Issue	Cognitive Computing Solutions
1	Dynamic Resource Management and Optimization of Configurable Computing resources	Managing resources dynamically to meet varying computing demands such as CPU, storage, etc. without over-provisioning or underutilizing resources	Cognitive systems possess the capability to predict workload patterns and dynamically adjust **C**onfigurable **C**omputing **R**esources (**CCR**) in real-time using data science and machine learning algorithms. This would ensure optimizing resource utilization, cutting down computing costs, and improving performance.
2	Security and Privacy	Some of the well-known attacks in Cloud ecosystem referred to as **ACIDS**[**A**ccount Hijacking, **C**loud Malware Injection Attacks, **I**nsider Threats, **D**enial-of-Service Attacks, **S**ecurity Misconfiguration] attacks, prominent Cloud	AI-driven cognitive systems possess the capability to wide detect major anomalies, recognize everchanging computing patterns which are indicative of security breaches, and respond proactively so as to prevent and eliminate the incident of security breaches. The usage of Cognitive toolkits can also automate cryptographic features such as

		threats, data breaches, cloud vulnerabilities and national and international compliance with privacy regulations especially in respect of private cloud and community cloud are major concerns in cloud computing.	encryption and decryption thereby ensuring data privacy and security and national and international compliance with global regulatory standards.
3	Data Management and Analysis	Handling the humongous volume of data generated dynamically and captured by edge devices and stored in cloud landscapes possess the capability to completely overwhelm traditional legacy systems.	PIN [Predictive analytics, Image recognition, Natural language processing] are the prominent Cognitive Computing driven technologies that possess the capability to process large datasets. This helps extract meaningful inference from semi-structured and unstructured data, which would go a long way in making cloud environments smarter.
4	Scalability and Automation	Scaling cloud services to handle varying workloads without manual intervention can be challenging at times, but now a days with onset of multiple number of automated tools	Cognitive systems can enable auto-scaling and auto tuning by predicting/forecasting demand spikes or drops and automatically adjusting infrastructure accordingly. This improves the overall performance of applications and ensures seamless user experiences without human intervention.
5	Network Management	Network latency, bandwidth limitations, and unpredictable traffic can impact the performance of cloud-based services.	AI-powered cognitive systems can monitor network traffic, predict congestion, and reroute data to optimize network performance. This ensures that cloud applications maintain high availability and minimal downtime
6	Disaster Recovery and Fault Tolerance	Ensuring uninterrupted services during hardware failures or other disruptions can be difficult.	Cognitive systems can predict failures before they happen in real time by analyzing data from sensors and logs. They can trigger backup and recovery processes or reroute traffic to alternative servers, minimizing downtime and ensuring fault tolerance

Research shows that cognitive computing can complement cloud computing by making it more intelligent, adaptive, and efficient. Through advanced AI techniques, cloud platforms can better manage resources, enhance security, and deliver smarter solutions to cloud service requesters. The same has been schematically represented by means of block diagram as illustrated in figure 1.

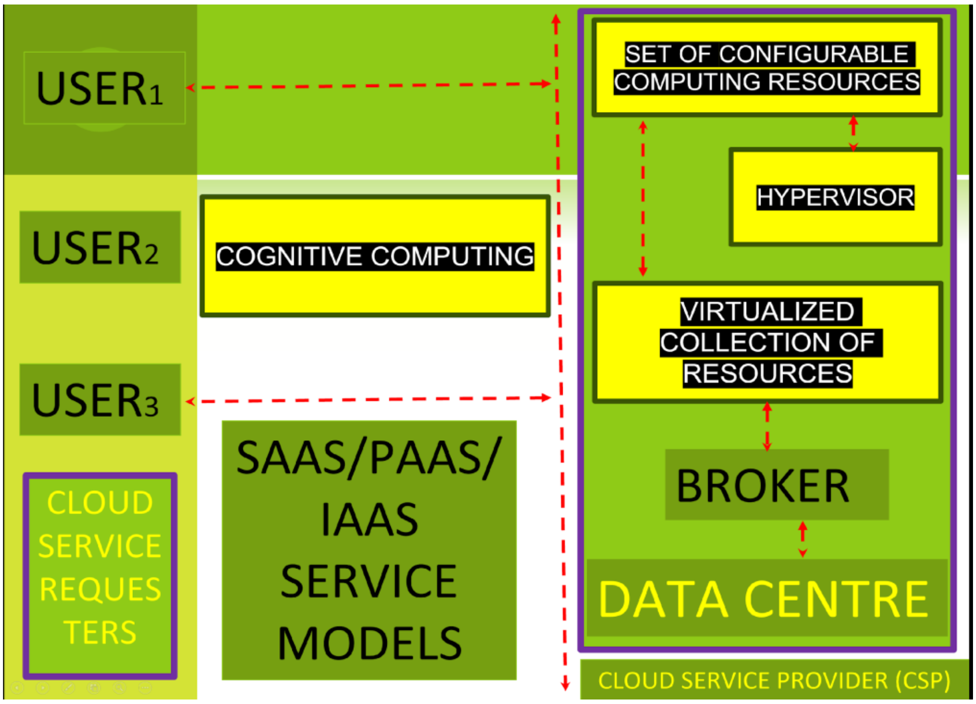

Figure 1: Cloud Architectural Diagram with a blend of Cognitive Computing

LITERATURE REVIEW

Big data, cognitive science, knowledge discovery, and cognitive computing are the four areas from which the authors in [1] presented the development of cognitive computing. The three components of the proposed cognitive computing system architecture are cloud computing, big data analysis, and the Internet of Things. They also touched upon cognitive computing-enabling technologies, such as deep learning and reinforcement learning. The authors in [2] introduced a method to enhance the performance of MapReduce processing for big data in cloud computing environments by combining the CombineFileInputFormat technique with the reuse feature of the Java Virtual Machine (JVM). Unlike traditional methods that create a separate mapper for each small file, their approach decreases the number of mappers by processing many files as a single split. Furthermore, to boost MapReduce performance, the method minimizes setup time by utilizing a single JVM to run multiple mappers instead of launching a new JVM for each one. In a multiprocessor setting, GAACO, a hybrid method to task scheduling, performs better than ACO and GA alone, particularly when it comes to scheduling IoT applications[3]. When compared to the ACO and GA algorithms used independently to solve task scheduling problem, the cognitive GAACO approach significantly decreases makespan as the number of processors increases and is more optimum.

The authors of [4] suggested a novel paradigm for protecting confidential data and using cognitive algorithms to explain the significance of shared data. In a novel family of protocols known as linguistic-biometric threshold schemes, cognitive interpretation, and data analysis paradigms have been incorporated into the data description process. One unique aspect of the suggested method is its universality, which ensures that it can be applied to different organizations, structures, and secret management levels.

The authors [5] examined the viability of switching to cognition-based communications in wireless communication networks by fusing cloud-based communications with the widely used cognitive computing technologies of today. To better serve users, conserve computing resources, and attain energy efficiency, they suggested the architecture of cognition-based communications and outlined the two key modules, namely the resource cognitive engine and the data cognitive engine. Additionally, they demonstrated two exemplary applications of cognition-based communications: the cognitive internet of vehicles and user-centric cognitive communications. The waste management challenge, which calls for more intricate solutions and the integration of several interoperable systems, was the focus of the authors [6].

They concentrated on creating and testing a cognitive computing-based automatic visual recognition system and gathering information and metadata to provide alerts in accordance with the specifications. In [7], a bidirectional cognitive computing paradigm is put out that uses bidirectional cognitive transformation operators to achieve bidirectional cognitive transformation between concept connotation and extension. The forward and backward cloud transformations in the cloud model are used to investigate the bidirectional cognitive computing process in conjunction with the features of human cognition. Authors have also addressed "drifting" in the cognitive process using the symmetric KL divergence. One of the newest technologies, cognitive computing (CC), holds enormous promise for solving numerous problems in an array of fields, including robotics, healthcare, big data, IoT, education, and security, among other commercial uses. Because the four applications of cognitive computing (CC)—healthcare, cybersecurity, big data, and IoT—are of societal interest and contain persuasive methods and approaches that instill CC, the authors of [8] have given a thorough review of them. There has been much discussion about the special cognitive techniques used to address the modern issues in these four application fields.

The authors have reviewed the substantial consequences of integrating machine intelligence and cognitive computing into Industry 5.0 [9]. It addressed the shift from Industry 4.0 to Industry 5.0 and provided an empirical study on the efficacy of implementing a DRL-based decision-making system in industrial settings. With a focus on the influence of cognitive computing, the authors gave a thorough analysis of practical solutions for security, scalability, interoperability, and integration of quick technical breakthroughs in dynamic environments for the development of Industry 5.0, taking into account the current era of industrial transformation.

According to [10], interaction with others, connectivity, problem-solving, decision-making, and data privacy security are the five ways that cloud technology affects human behavior. Using the system literature review approach, the study analysis yielded five implications, with the most important ones being decision-making, data privacy, social interaction, and security. It demonstrates how cloud computing can be used for social interaction. In addition, consumers feel secure and at ease in their everyday lives thanks to cloud technology service providers' assurances of data security and confidentiality. This study also demonstrates how cloud computing has become essential to society due to its accessibility and simplicity. A **CRACLE**(**C**ustomer **R**esource **A**llocation in **CL**oud **E**nvironment) was proposed and simulated by authors of [11]. The framework caters to the customers' dynamic requirements and allocates cloud resources based on their requirements.

METHODOLOGY ADOPTED

The process of resource allocation and deallocation, optimized resource allocation, and the dynamic provisioning and deprovisioning of resources from the resource pool has been schematically represented using a flowchart, as illustrated in figure 2.

When the network boots up for the first time, the Cloud Service Provider (CSP) initializes all components of the resource pool and waits for incoming client requests from anywhere in the world, regardless of national or international boundaries. The Cloud Service Requester (CSR) generates the Cloud Allocation Request (CAR)(for example:16vCPU, 8 GB RAM, 64 GB HDISK, MAC OS, and IBM WebSphere) and sends it to the Cloud Service Provider(CSP) for the resource allocation. The Cloud Service Provider (CSP) determines the type of Customer: Old or new Customer.

a. If the Client/Customer is a new Cloud Service Requester (CSR) then the Cloud Service Provider (CSP) evaluates the login credentials and authenticates the customer. Once authentication is successful, the Cloud Service Provider (CSP) allocates the required resources however if the Cloud Service Provider (CSP) is unable to fulfil the desired request then the request is redirected to another Cloud Service Provider (CSP).

b. If the Client/Customer is an old Cloud Service Requester (CSR) or traditional subscriber then the Cloud Service Provider (CSP) applies Cognitive Computing (CoCo) Algorithms to detect and check the presence of the data pattern in the Cloud Service Requester (CSR) request. If the pattern is detected, preserve the pattern and archive it in the database, so that the same can be utilized to ascertain the future cloud service request likely made by the customer. The Cloud Service Provider (CSP) then allocates the required resources however if the Cloud Service Provider (CSP) is unable to fulfil the desired request then the request is redirected to another Cloud Service Provider (CSP).

c. However, if no pattern is detected, an effort can be made to re-apply the Cognitive Computing elements to detect possible patterns in the Cloud service request.

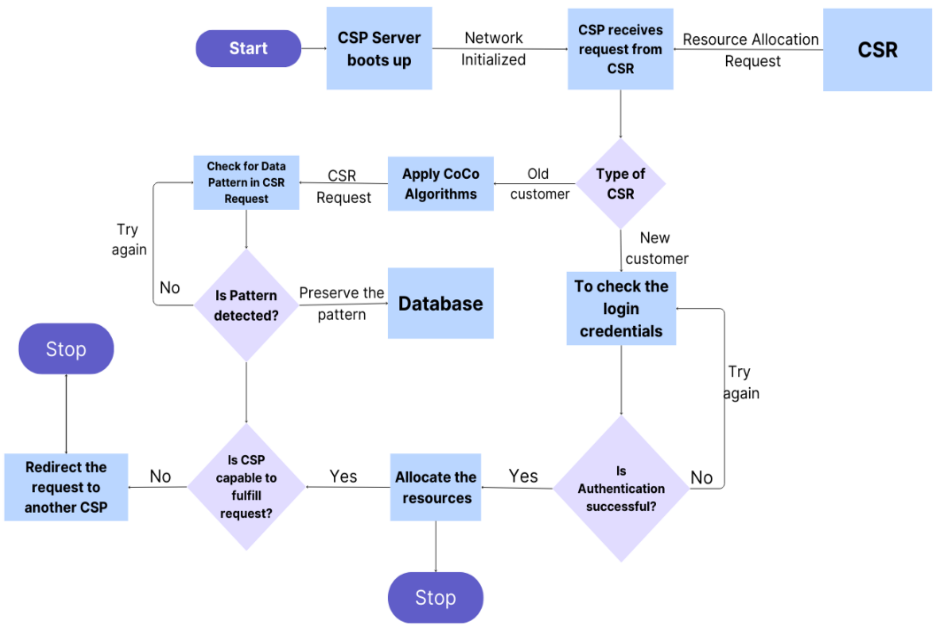

Figure 2. Flowchart depicting the methodology

SIMULATION AND RESULTS

To show the task of efficient resource management (allocation-deallocation and optimization) the well-formed XML Document [W3C compliant] was written in **SOAP** (**S**imple **O**bject **A**ccess **P**rotocol) [Header and Body] and simulated in the Oxygen XML Editor 26.1.

SOAP ENVELOPE

HEADER

POST/CSPAccess/SOAP/1.2

host: www.cspprovider.org

content-Type: application/soap+xml; charset=utf-8

content-Length: 299

SOAPAction: http://www.cspprovider.org/2025/01/soap-envelope

BODY

<?xml version="1.0"?>

<soap:envelope xmlns:soap= "http ://www.cspprovider.org/2025/01/soap-envelope”

<soap:header> CSP PROVIDER </soap:header>

<soap:body>

<m:GetCloudResources>

<m: vCPU> 4 </m:vCPU>

<m:Buffer Space>

<m:RAM> 16GB </m:RAM>

<m:HDISK> 40GB </m:HDISK>

<m:PRINTER> HP</m: PRINTER >

</m:Buffer Space>

<m: OS> Windows </m:OS>

<m:Web Server> Apache Tomcat Server </m:Web Server>

m:Database Server> MySQL </m:Database Server>

</m:GetCloudResources>

</soap:body>

</soap:envelope>

COMPARATIVE ANALYSIS OF COGNITIVE COMPUTING TOOLS

Organizations leveraging artificial intelligence (AI) to address complex challenges, streamline processes, and enhance decision-making rely heavily on cognitive computing tools. A comparative analysis of various cognitive computing tools, highlighting their features, strengths, and cost efficiency is shown in figure 3.

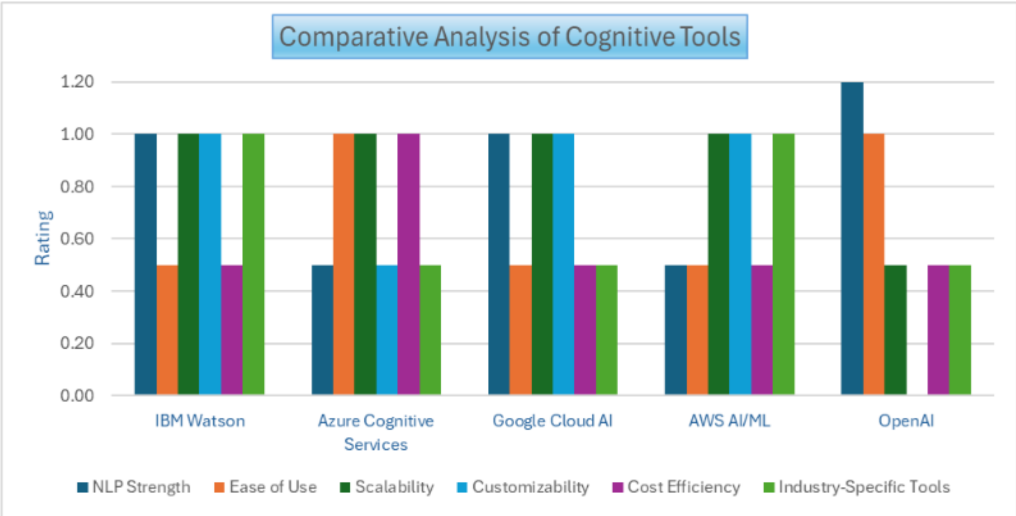

Figure 3. Comparative Analysis of Cognitive Tools

CONCLUSION

This paper explores and applies the principles of cognitive computing to evaluate patterns in resource requests generated by Cloud Service Requesters for Cloud Service Providers. In the proposed framework, cognitive computing elements are utilized to identify and detect patterns in cloud service requests generated by customers over time. If a pattern is successfully identified, the Cloud Service Provider can proactively meet the customer's future resource requirements, enabling more efficient resource management.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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