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Distributed Systems Meet Cloud Computing: A Review of Convergence and Integration

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Abstract: Conventional cloud computing, in which processing, storage, and networking resources are hosted in one or a few centralised data centres, has been made unsuitable as a result of the stringent latency requirements of emerging applications. Additionally, the rapid expansion of networks has led to the emergence of a trend known as network cloudification, which involves the delivery of network services based on cloud service models. Therefore, the development of the new distributed cloud model represents a progression from the conventional centralised cloud computing model to the worldwide distributed cloud computing services that are positioned according to the needs of the application. In this essay, we make an effort to provide a comprehensive overview of clouds that are dispersed. The first thing that is discussed is the concept of distributed cloud computing. We will now continue to outline the architecture of the distributed cloud as well as the technologies that are linked with it. We also carry out a case study as part of our work. When it comes down to it, we tackle open research problems that are associated with distributed cloud computing. by conducting a comprehensive review of twenty-one papers that cover a wide range of methodology and approaches.

Keywords: *stringent, cloudification, comprehensive, architecture, methodology*

1. Introduction

In the rapidly evolving landscape of modern computing, the convergence of two groundbreaking technologies, distributed systems, and cloud computing, has ushered in a new era of scalable, resilient, and efficient computing paradigms. The synergy between distributed systems and cloud computing has become a driving force behind the architecture and infrastructure that power today's digital world. This intersection brings forth a wealth of opportunities and challenges, as traditional distributed systems principles intertwine with the elastic and on-demand nature of cloud resources. Many modeling techniques have proliferated in the last few years due to developments in network-based computing, such as cloud computing, community networks, online stores, software as a service, and many more [1]. Distributed systems, characterized by the seamless coordination of multiple interconnected nodes to achieve a common goal, find new dimensions in the cloud environment. Cloud computing, with its promise of ubiquitous access to a shared pool of configurable resources, introduces novel ways to design, deploy, and manage distributed systems. This convergence not only transforms the way applications are built and operated but also shapes the fabric of our interconnected, data-driven society. With the use of contemporary technology, a third-party "cloud provider" can offer services to customers in a number of scenarios, from any location, at any time. Virtualization and service delivery platforms are used by cloud computing to meet customer requirements and provide cloud resources. Utilizing the resources of a distant computer is possible with cloud computing as an alternative to storing and retrieving data from your computer. Clients are not aware of the network's infrastructure since they rely on cloud services instead of running on their own hardware [2]. This exploration delves into the symbiotic relationship between distributed systems and cloud computing, uncovering the intricacies of their integration and the transformative impact on scalability, fault tolerance, and performance. From the intricacies of data distribution and consistency to the challenges of managing resources across a dynamic cloud infrastructure, the journey of these two technological realms intertwines, offering a glimpse into the future of computing architectures. Customers can use apps and access content from any connected device with cloud computing. In addition to central processing power, a distributed computing system known as "cloud computing" provides memory, hard drives, software, and other computer resources. It offers pay-per-use on-demand products and services to customers [3, 4]. Cloud computing is comprised of three technologies: virtualization, on-demand computing, and data centers. A cloud system can use resources more efficiently thanks to task distribution, which is essentially required [5] .

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2. Background Theory

2.1 Distributed Systems

The essential components of a distributed system are shown in Figure 1. Distributed systems consist of multiple independent computers and components that are dispersed over multiple systems yet communicate with each other to function as a unified entity. In this thorough introduction, learn about distributed systems' workings, some real-world applications, basic architectures, advantages and disadvantages, and common solutions for real-time distributed streaming [6]. The cloud has risen, and with it, a new era of distributed computing has dawned. No longer are systems chained to the confines of physical servers, but instead stretch and flex across the boundless expanse of the cloud, their components dancing amongst the virtual winds. This convergence of distributed systems, masters of parallel processing and fault tolerance, and cloud computing, the agile architect of on-demand resources, unlocks a realm of possibilities for building scalable, flexible, and resilient applications. Founded by the same guys who brought us Apache Kafka, Confluent is a comprehensive data streaming platform that connects over 120 data sources. It is perfect for analytics, processing, and real-time data integration [7, 8]. Distributed computing is the study of distributed systems in computer science. A system is a distributed system. By exchanging messages between computers and other devices, they can speak with each other. Distributed computing systems are becoming more and more popular as a result of improvements in computer network technology and declining hardware costs [9].

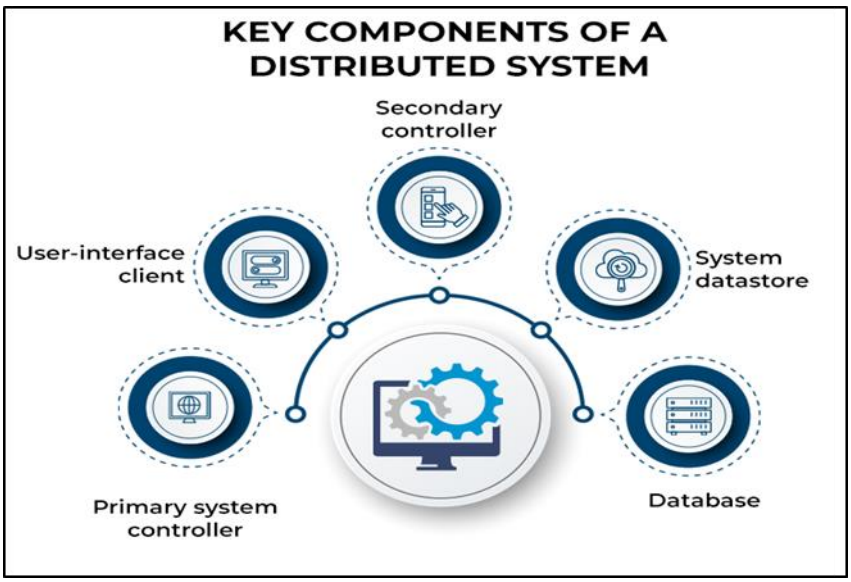

Fig 1: Key components of distributed system[6]

The primary purposes of distributed computing include [10]:

- Resource sharing - whether it be data, software, or hardware that is shared.
- Openness - To what extent is the software meant to be developed and shared between others.
- Concurrency - The same function can be processed concurrently by numerous machines.
- Scalability - How do processing and computing powers grow when applied to multiple machines.
- Fault tolerance - How fast and easily can system problems in different parts be identified and fixed.
- Transparency - How much access does a node have within the system to find and connect with other nodes?

2.2 Cloud Computing

Imagine a world where the vast computing resources of the cloud seamlessly intertwine with the distributed intelligence of powerful systems. This is the exciting intersection explored in "Distributed Systems Meet Cloud Computing," a book that delves into the transformative convergence of these two technological giants. On one hand, distributed systems have revolutionized our ability to tackle complex problems by parceling them out across a network of interconnected devices. From managing massive online transactions to powering scientific simulations, distributed systems have become the backbone of modern computing. On the other hand, cloud computing has democratized access to computing power, offering on-demand scalability and flexibility. It has reshaped how businesses and individuals operate, providing a platform for innovation and agility. "Cloud computing" is a word used to describe the Internet metaphorically. Global applications: Serving users across continents with imperceptible latency, powered by a geographically distributed network of cloud servers. Microservices in motion: Independent software components, each a cloud-hosted citizen, collaborating

seamlessly to deliver complex functionality. Elasticity unbound: Resources scaling up and down like the tide, adjusting effortlessly to demand, never burdened by idle infrastructure. Fault tolerance unshackled: System failures become mere blips, as redundancy woven into the cloud fabric automatically reroutes tasks and heals the wound. As Figure 2 shows, the Internet is usually represented in network diagrams as a cloud. The cloud emblem is meant to symbolize "all that other stuff" that keeps the network going. It works something like "etc." for the rest of the solution map. When it typically refers to a portion of the diagram or solution that is the duty of another individual, why diagram it all out? This concept most likely applies to the idea of cloud computing [11, 12]. Figure 2 how the internet represented by a cloud. [13].

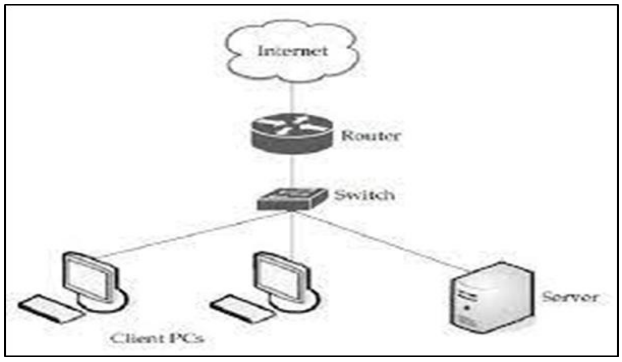

Fig (2): The Internet is represented by a cloud in network diagrams [13]

Even though cloud computing offers a lot of benefits, corporate executives and IT teams can also benefit from it. Concerns about security and uneven performance are the most prevalent restrictions that still hinder cloud viewing. It is possible to receive a web-based network, RAM, software resources, storage, and CPU using this alternative technology for the internet [14]. Cloud computing uses hardware and software to provide a service across a network. Users can share resources, software, and other services, as well as get information, at any time that covers their charges, with cloud computing, an on-demand service that is commonly utilized on the Internet [15, 16]. A cloud can be used to represent the Internet as a whole. Using the cloud reduces the cost of development and operations. Additionally, the cloud provider bears the obligation for maintaining and monitoring data stored on the cloud [15, 17].

a. Cloud Components

Imagine a world where the vast computing resources of the cloud seamlessly intertwine with the distributed intelligence of powerful systems. This is the exciting intersection explored in "Distributed Systems Meet Cloud Computing," a book that delves into the transformative convergence of these two technological giants. On one hand, distributed systems have revolutionized our ability to tackle complex problems by parceling them out across a network of interconnected devices. From managing massive online transactions to powering scientific simulations, distributed systems have become the backbone of modern computing. On the other hand, cloud computing has democratized access to computing power, offering on-demand scalability and flexibility. It has reshaped how businesses and individuals operate, providing a platform for innovation and agility. In a topologically simple sense, a cloud computing system consists of clients, dispersed servers, and the datacenter. These components, as shown in Figure (3), constitute the three components of a cloud computing solution. Let's take a closer look at each element. Each one serves a different purpose and helps to produce a functional cloud application. [18].

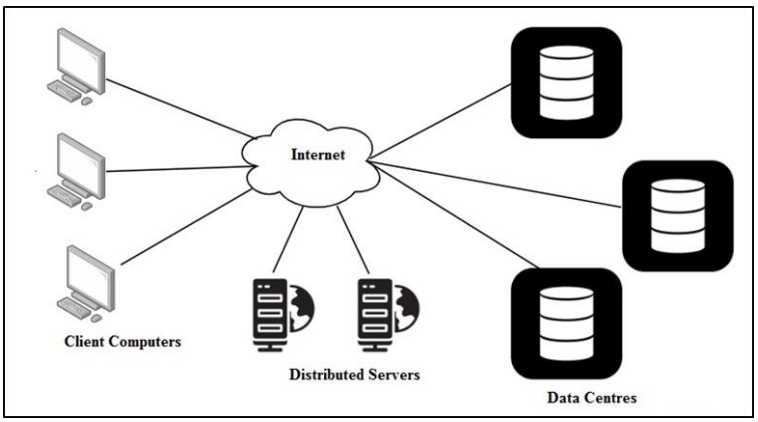

Fig (3): Three components make up a cloud computing solution [19].

Where:

A cloud computing architecture includes all of the elements found in a typical, daily local area network (LAN), including the clients. These are, in general, desktop computers. However, because of their portability, they may also be smartphones, tablets, PDAs, or laptops—all of which are important contributors to cloud computing. Clients, by whatever name you choose, are the devices that end users use to access and control their cloud data. Typically, clients fall into three types [20, 21]:

- **Mobile**: Mobile devices include PDAs or smartphones, like a Blackberry, Windows Mobile Smartphone, or an iPhone.
- **Thin**: Clients are computers that do not have internal hard drives, but rather let the server do all the work, but then display the information.
- **Thick** : This type of client is a regular PC that is linked to the cloud using a web browser like Firefox or Internet Explorer. Thin clients are a solution that is becoming more and more popular due to their price and environmental impact. The following are some benefits of hiring thin clients: [22]:
- **Lower hardware costs**: Due to their reduced hardware content, thin clients are less expensive than thick clients. They also have a longer lifespan before they need to be updated or replaced.
- **Lower IT costs**: With thin clients, there are fewer points of failure because they are managed at the server.
- **Security**: There is less possibility of malware infecting the device because processing occurs on the server rather than the hard drive. Additionally, there is less likelihood of thin clients being physically stolen because they require a server to function.
- **Data security:** Data loss from client computer crashes or theft is less likely because data is saved on the server.
- **Less power consumption**: Compared to thick clients, thin clients use less electricity. This implies that the cost of air conditioning the office and powering them will both be lower.
- **Ease of repair or replacement**: It is simple to replace a thin client in case of death. The user's desktop is restored to its pre-failure state by simply replacing the box.
- **Less noise**: The thin client can use quieter fans because there isn't a rotating hard drive producing as much heat.

b. Datacenter

A datacenter, also spelled data center or data centre, is a facility that houses computer systems and associated components, primarily used for: Storing large amounts of data: Think of it as a giant vault for digital information, from personal emails and online transactions to business records and scientific research data. Processing and distributing data: Servers within the datacenter perform calculations, run applications, and deliver data to users across the internet or within internal networks. Providing access to shared resources: Datacenters can host applications and services accessible by many users, like email platforms, streaming services, and cloud storage solutions. The importance of datacenters continues to grow in today's data-driven world. They are the crucial backbone of the internet, powering everything from online communication and entertainment to essential business operations and scientific research. The program you are presently running is stored on the collection of servers known as the datacenter. Either a large basement space in your building or a room full of servers located on the other side of the world that you can access online may be your options. Within IT, virtualizing servers is becoming more and more popular. Stated differently, software that allows many virtual server instances to run can be installed. This allows you to host six virtual servers on one physical server [23, 24].

c. Distributed Servers

It is not necessary to keep every server in one location, though. Servers are often located across different geographic regions. But to you, the cloud subscriber, these servers seem to be working almost next to each other. The service provider now has more alternatives and security. One illustration is the Amazon global server network, which houses their cloud service [25, 26]. In the event that something went wrong at one place, there would still be a way to use the service through another website. Furthermore, if the cloud requires more hardware, it may be expanded to include more servers at a different location, doing away with the requirement to house them in the safe room [27].

d. Infrastructure

There are several approaches to implement the infrastructure. The ideal method for constructing the infrastructure by the cloud solution provider will depend on the particular application [28]. This is one of the key advantages of using the cloud. Operating such servers inside can be far more expensive than you would like to because of your demanding requirements. Alternatively, you might only need a little amount of processing power, in which case buying and maintaining a dedicated server wouldn't be necessary. The cloud satisfies both requirements [29].

2.3 Grid Computing

Grid computing and cloud computing are often confused, despite their stark differences. Using the resources of

several computers linked to a network to work on a single task at once is known as grid computing. Usually, this is done to address a scientific or technological issue [30].

Grid computing is appealing for a variety of reasons, including: • It can solve issues needing a lot of processing power; • It is an affordable approach to employ a certain amount of computer resources; and • It allows multiple computers' resources to be shared cooperatively without one machine directing the others. What then is the relationship between grid computing and cloud computing? Not particularly, as they function in essentially different ways. Grid computing divides a large project over numerous computers in order to optimize their resources [31, 32]. Quite the reverse is true with cloud computing. It makes it possible to run several smaller apps simultaneously [33].

The idea of using fine-grained, reusable components across a vendor's network is referred to as services in cloud computing. Most people refer to this as "as a service." Services that have the following characteristics are offered as a suffix [34]:

• Device independence, allowing users to access the systems on different hardware;

• Multitenancy, allowing resources to be shared by several users;

• Low entry hurdles, making them accessible to small enterprises.

a. Software as a Service

The concept known as Software as a Service (SaaS) allows users to access applications hosted as services over the Internet [35]. The customer is relieved of the responsibility for software maintenance and support when it is hosted off-site as shown in figure 4. However, when the hosting service decided to change it, the consumer had no control over it. The objective is to utilize the software just as it is out of the box, without requiring extensive customization or system integration. The supplier maintains the infrastructure and handles all patching and upgrades [36, 37].

Fig (4): SaaS [38].

b. Platform as a Service

PaaS, which stands for Platform as a Service, is a type of cloud computing service model that provides everything developers need to build, run, and manage applications without getting bogged down in managing the underlying infrastructure. Think of it as a pre-built workspace with all the tools and resources neatly laid out for you to focus on building cool stuff. Another application delivery paradigm that comes right after Software as a Service (SaaS) is Platform as a Service (PaaS). Without the need to download or install software, PaaS provides all the tools needed to develop apps and services entirely from the Internet [39]. Application development, testing, hosting, and deployment are all included in PaaS services [40]. Figure 5 show the structure of PaaS.

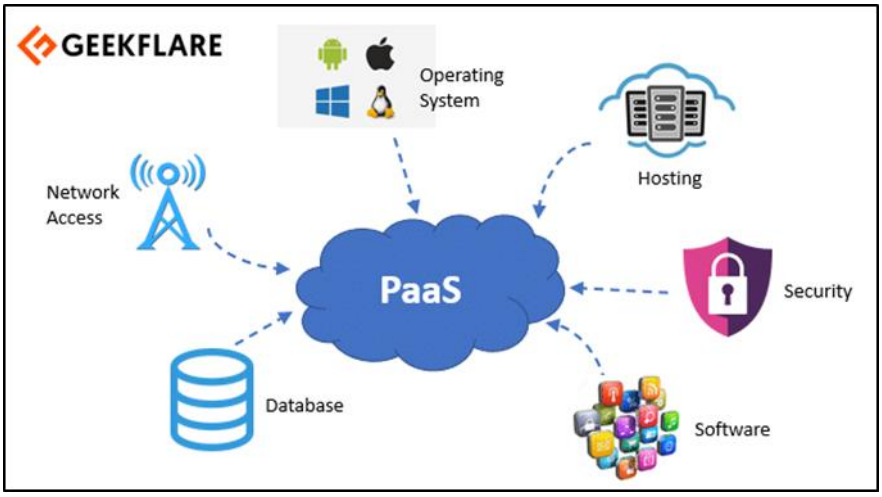

Fig (5): PaaS [41].

Additional capabilities include storage, versioning, security, scalability, web service integration, database integration, and team communication. Lack of provider mobility and interoperability is a drawback for PaaS users [42-44]. That example, if you develop an application with one cloud provider and then wish to switch to another provider, you might not be able to do so—or you'll have to pay a steep price—to do so. Moreover, your apps and data will be destroyed if the supplier fails to continue operating [45].

Based primarily on HTML or JavaScript, PaaS typically provides some assistance to aid in the building of user interfaces [46]. Since multiple users are anticipated to use Concurrently, PaaS is made for that kind of application and usually provides security features, scalability, failover, and automatic concurrency management. Furthermore, PaaS enables web development interfaces like Simple Object Access Protocol (SOAP) and Representational State Transfer (REST) that make it possible to create a variety of online services, often known as mashups. The interfaces can also reuse services from within a private network and access archives [47].

c. Hardware as a Service

A business model where companies pay for the usage of hardware (often IT equipment) instead of purchasing it outright. Think of it like leasing hardware with a subscription fee that covers maintenance and updates. Benefits include lower upfront costs, scalability, and easier management. The Service of Hardware Cloud computing's next generation of services is called (HaaS). Customers can access apps through SaaS and PaaS, but not through HaaS [48] as shown in figure 6. All it provides is the hardware, meaning your company can install whatever on it. [8, 49]. The HaaS model can be a cost-effective way for small or mid-sized businesses to provide employees with state-of-the-art hardware in a cost-effective manner [50].

Fig (6): HaaS [51].

3. Literature Review

In 2023 M. S. Al Reshan et al [52] It was suggested that load-balancing in cloud computing may be accomplished via the use of Swarm Intelligence (SI). Numerous alternatives, including genetic algorithms, ACOs, PSOs, BATs, and GWOs, are investigated in the published literature; however, none of these alternatives take into account the convergence time of load balancing in the

context of global optimisation. Grey Wolf Optimisation (GWO) and Particle Swarm Optimisation (PSO) are the two algorithms that are especially investigated in this study. Through the use of a GWO-PSO strategy, this research introduces a unique approach that combines the benefits of global optimisation with the speed with which convergence occurs. Both the performance of the system and the allocation of its resources are improved by the combination of these two methodologies, which allows the load-balancing issue to be resolved simultaneously.

A. N. Malti et al. [53], To address the challenge of multi-objective task scheduling in heterogeneous infrastructure as a service (IaaS) cloud systems, a unique hybrid optimisation technique has been proposed. The search exploration capabilities of the grey wolf optimizer algorithm and the pollination behaviour of flowers are the foundations upon which this approach is built. Time makespan, resource utilisation, degree of imbalance, and throughput are the four optimisation criteria that are used to assess the approach that has been recommended. Several other test-bed scenarios, in addition to synthetic and traditional workload traces, are included in the requirements, which are developed from the CloudSim framework. A number of well-established optimization-based scheduling strategies, including TSMGWO, GGWO, LPGWO, and FPA, were compared to our suggested method within the context of the existing body of research.

Also in the same year, K. Malathi and K. Priyadarsini [54], During the process of building the load balancer algorithm for cloud computing, we investigated the opportunities presented by heuristic approaches. In this section, two significant enhancements to load balancing methods are shown. The hybrid approach has been successful in achieving better applicability as well as remarkable performance in terms of maximising turnaround time and resource usage on virtual machines. The development of the Lion Optimizer, which enables load balancing by optimising the selection of virtual machine characteristics, is a noteworthy accomplishment that has been accomplished. Two probabilities are developed in order to improve the selection process. These probabilities are the probability of picking a virtual machine and the chance of scheduling a work. Fitness criteria are used by the lion optimizer, and these criteria are dependent on the features of both the work and the virtual machine.

C. Chandrashekar et al. [55], In order to address and overcome the scheduling problem, the goal of this research was to use an improved meta-heuristic method known as the Hybrid Weighted Ant Colony Optimisation (HWACO) algorithm. This algorithm is a more complex version of the Ant Colony Optimisation method, which was established before. The suggestion outlines a system that is both perfect and optimal for arranging job responsibilities. A comparison is made between this algorithm and other algorithms that are currently in use, taking into consideration characteristics such as efficiency, makespan, and cost. In light of the fact that the goal of achieving quick convergence was effectively attained, the use of the HWACO that was recommended results in further advantages in the findings that were obtained. A number of different traditional algorithms, including Ant Colony Optimisation (ACO), Quantum-Based Avian Navigation Optimizer Algorithm (QANA), Modified-Transfer-Function-Based Binary Particle Swarm Optimisation (MTF-BPSO), MIN-MIN Algorithm (MM), and First-Come-First-Serve (FCFS), were surpassed by the model that was projected.

P. Pirozmand,et al. [56], By using a multi-adaptive learning mechanism, we were able to cut down on the amount of time required for the first Particle Swarm Optimisation (PSO) method to cloud computing assignment scheduling. In order to address the issue of job scheduling, a number of different approaches have been proposed up to this point. The Improved Particle Swarm Optimisation (IPSO) approach is presented as a potential solution to the problem that was mentioned before in this article. Ordinary particles and locally best particles are the two categories of particles that are defined by the Multi Adaptive Learning for Particle Swarm Optimisation (MALPSO) algorithm that has been presented. During this phase, the population goes through a period in which its variety decreases, which ultimately leads to an increased possibility of reaching the local optimum. Makespan, load balancing, stability, and efficiency are the four criteria that are used in this study in order to evaluate the suggested technique in comparison to a number of other algorithms.

In 2022 S. Duan et a [57], explored a broad variety of computing paradigms that are commonly utilised, emphasised the advantages of the EECC paradigm in terms of supporting distributed artificial intelligence, and spoke about the underlying technologies that are employed in distributed AI. Afterwards, in order to enhance distributed training and inference in a different manner, it is necessary to construct a comprehensive classification system for the cutting-edge optimisation techniques that are made available by EECC. Following that, the authors describe the security and privacy flaws that are present in the DAI-EECC architecture and evaluate the benefits and drawbacks of each protection strategy in respect to the risks that have been revealed. In the end, they outline a number of research challenges that have not yet been resolved, investigate the complications that are connected with immersive performance capture, and shed light on the potential fascinating applications that may be made possible by DAI-EECC.

In the same year, M. S. Al-Abiad et al [58], Research was conducted on resource allocation strategies with the goal of lowering the amount of energy that is used by distributed learning (DL) inside Internet of Things (IoT) networks. These networks are supported by integrated fog-cloud computing. In order to create a connection between Internet of Things (IoT) devices and the cloud server (CS), the proposed architecture makes use of a number of fog access points, also known as F-APs. These F-APs are responsible for training local models using data acquired from Internet of Things devices. For the purpose of updating the model parameters, the F-APs work in conjunction with the CS.

In 2022 Y. Wang and J. Zhao, [59], The usage of MEC inside the Metaverse was investigated in this article, and an explanation of the motivations for the incorporation of MEC into the Metaverse was offered. The 6G with MEC paradigm and MEC upgraded by blockchain are two of the many technological fusions that are garnering a lot of attention. Cloud computing is being compared to a number of other technical fusions. Furthermore, the merger of MEC with other impending technologies, such as the Metaverse, 6G wireless communications, artificial intelligence (AI), and blockchain, addresses difficulties concerning the allocation of network resources, the rising of network traffic, and the demands for latency.

N. Bhalaji [60], It was suggested that the Water Wave Algorithm (WWA) be used for the purpose of resource allocation in cloud-based applications. When compared to resource scheduling calculations, the WWA approach that was proposed displayed improved performance both in terms of response time and turnaround time, as well as cloudlets migration time. The comparison between WWA and the algorithms that were presented is shown in the graph that may be seen below. The First-Come, First-Served (FCFS) assessment has allowed WWA to achieve a reduction in the amount of time it takes to complete a transaction. When compared to other methods, the response time, migration performance, and turnaround time have all shown considerable improvements. There is a considerable relationship between the features of service parameters and the stability and flexibility of distributed cloud computing. Through the use of water wave enhancement computation and the consideration of a multitude of quality of service (QOS) characteristics, it is possible that future study may improve the approach of determining the optimum virtual machine.

R. Gulbaz, et al. [61], The Balancer Genetic Algorithm (BGA) is a revolutionary load balancing scheduler that I developed with the intention of enhancing both the makespan and the load balancing capabilities. It is possible that insufficient load balancing will result in excessive resource usage owing to the availability of resources that are not being used. The method of load balancing that is used by BGA takes into account the real load, which is quantified in terms of the million instructions that are assigned to virtual machines (VMs). In addition, it is highlighted that multi-objective optimisation should be employed in order to improve both the makespan and the load balancing. In comparison to certain technologies that are considered to be state-of-the-art, BGA has shown considerable gains in terms of makespan, throughput, and load balancing.

H. S. Alatawi and S. A. Sharaf [62], Work scheduling and cloud balancing were accomplished via the use of a hybrid technique that combines fuzzy logic with the benefits of the honeybee behaviour algorithm. This hybrid algorithm was designed expressly with the intention of improving the performance of approaches that were previously used. In addition to including power consumption and other quality of service elements, the design is compliant with the ABC requirements. This makes it possible to get precise measurements of the amount of power that is used by virtual machines (VMs) on the host, which guarantees the successful implementation of an effective load balancing algorithm. The purpose of this study is to determine the energy consumption of virtual machines (VMs) while taking into consideration key quality of service (QoS) elements. This will allow for the selection of the host and virtual machine that are the best suitable for the task at hand. In order to simulate the ILBA_HB algorithm, CloudSim was used. In terms of average response time, makespan, and degree of imbalance, the ILBA HB algorithm is evaluated in comparison to the LBA HB algorithm and the HBB-LB algorithm. According to the data, the algorithm that was recommended displayed greater performance when compared to both LBA_HB and HBB-LB approaches.

D. Lindsay et al. [63], Conducted an analysis and investigation of the key factors that have influenced and driven the advancement of distributed system paradigms, beginning with the initial mainframe computers and the establishment of the worldwide internetwork, and concluding with the present-day systems such as edge computing, fog computing, and the Internet of Things. As a result of the investigation, it has been shown that there are significant shifts taking place in the fundamental assumptions surrounding distributed systems. The following are some of the changes that have taken place: (1) an increase in the fragmentation of paradigms as a result of business considerations and the limitations imposed by the end of Moore's law; (2) a transition from generalised architectures and frameworks to more specialised ones; and (3) each paradigm architecture involves a shifting balance between centralization and decentralisation in terms of coordination.

A. M. Senthil Kumar et al. [64], a method that maximises the success of the endeavour while limiting the amount of

time required to finish it. Increasing the speed at which Grey Wolf Optimisation is performed is the goal of the approach that has been presented, which includes the use of Particle Swarm Optimisation (PSO). When dealing with non-deterministic polynomial (NP) hard problems, such as job scheduling, optimisation techniques may be used to solve the problem. An innovative hybrid approach is presented in this research paper. This methodology combines the particle swarm optimisation algorithm (PSO) with the grey wolf optimisation (GWO) algorithm. With a cloud environment, user task scheduling is of the utmost importance. In order to efficiently distribute resources and improve the Quality of Service (QoS) parameter result for user tasks, it is necessary to have a task scheduling strategy that is efficient.

S. Ouhame and Y. Hadi [65], Energy consumption, data processing speed, network dependability, and average network response time are the four primary scheduling criteria that make up the resource allocation system of virtual machines (VMs) for cloud computing. The technique that is being used tries to enhance these four essential scheduling criteria. The GWO approach is comprised of three major components, all of which have been reinforced. The first improvement is made to the local search section of the website. Specifically, the Grey Wolf Optimisation (GWO) method and the Artificial Bee Colony (ABC) algorithm are both components of the hybrid strategy. During the process of using the local search strategy of the ABC algorithm, an extra improvement is made to both the fitness function and the energy parameter. The technique that has been provided makes an effort to enhance four essential scheduling characteristics that are included in the resource allocation system of virtual machines (VMs) for cloud computing. These characteristics are electricity consumption, throughput, network stability, and the average network expectation time.

G. Muthsamy and S. Ravi Chandran [66], plans that will be used in the process of assigning the jobs to the appropriate virtual machines that have been specified. A scheduling problem in distributed systems, such as cloud data centres, is regarded to be NP-complete on the basis of its complexity. By uniformly distributing the workload among virtual machines (VMs), an effective scheduling approach will maximise the utilisation of available resources without sacrificing efficiency. As a result, there is a need for an innovative scheduling system that is capable of successfully distributing workloads while taking into consideration a number of quality of service (QoS) measures. These metrics include makespan, response time, execution time, and priorities for tasks. It is advised to apply task scheduling using artificial bee foraging (TSABF) optimisation in order to achieve the most effective schedule for assigning work to virtual machines (VMs), while taking into consideration the criteria that were mentioned before.

J.-q. Li and Y.-q. Han [67], In order to solve the problem of flexible task scheduling in a cloud computing environment, a hybrid discrete artificial bee colony (ABC) strategy was investigated using this approach. Initially, it is determined that the issue is a hybrid flowshop scheduling (HFS) problem. Consideration is given to both single and multiple goals simultaneously. Three objectives are simultaneously evaluated in multiple objective HFS problems: reducing the greatest amount of time required to complete the task, limiting the maximum amount of stress placed on the device, and minimising the total amount of work that is performed by all of the devices. HFS will be broken down into two categories: HFS that involves computers that are not linked to one another, and HFS that uses machines that are identical to one another in parallel. Three different types of fake bees are included into the proposed algorithm, which is similar to the traditional ABC technique. These artificial bees are the employed bee, the spectator bee, and the scout bee. A string of integers acts as a representation of each and every solution. In order to address the peculiarities of the problem, several types of perturbation structures are investigated in order to enhance the capabilities of the search.

R. Agarwal, et al. [68], A approach that takes into account the MakeSpan parameters has been proposed as a solution to the difficulty that is linked with the metaheuristic procedures that are currently in use. The solution that has been presented makes use of the mutation-based Particle Swarm algorithm in order to distribute the load evenly across all of the data centres. A user's degree of demand determines the amount of money they pay for resources. It is necessary for a cloud provider to overcome a number of obstacles. Load balancing presents a number of key issues, including a reduction in the pace of convergence, an early convergence, an initial random selection of solutions, and the possibility of being trapped in a local optimal solution.

L. Xingjun et al. [69], The well-known grey wolf optimisation technique was presented as a novel way to reduce the amount of time required for responding. They came to the conclusion that if all of the duties had the same amount of time to do them, then the response time should also be decreased. For the purpose of determining the state of virtual machines, the present load is used. The tasks will be assigned to the appropriate virtual machine based on a criterion that takes into account the shortest distance, and they will be removed from the machine that is now experiencing the greatest stress depending on the status of the virtual machine.

A. Saadat and E. Masehian [70], The following is a proposal for a hybrid intelligent load-balancing approach: a fuzzy logic module provides the objective function to identify the busy statuses of servers by taking into consideration their RAM and CPU task queues, and a genetic algorithm module randomly organises the work. Instances of inaccurate inputs include fuzzy input variables, which include the degree of satisfaction provided by the service as well as the beginning and ending times of the service. On the other hand, service availability is an example of an output that is not exact. When it comes to load balancing, the use of task scheduling algorithms has the potential to be quite successful owing to the enormous state space that is involved in such a situation. Within the scope of this investigation, the researchers developed a hybrid intelligent strategy for load balancing use. To be more specific, a fuzzy logic module is used in order to construct an objective function that analyses the busy statuses of servers, taking into consideration the amount of RAM and CPU that is being utilised by the servers. In addition, a module of a genetic algorithm is used in order to randomly distribute the duties.The percentage of customers who are satisfied with the service, as well as the beginning and ending times of the service, are the factors that feed into the fuzzy system. It is the availability of the service that is represented by the fuzzy output, on the other hand.

A. Ragmani, et al. [71], A approach that takes into account the response time of the cloud and tries to accomplish load balancing has been proposed. Furthermore, there is a considerable connection between the overall performance of the ACO algorithm and the values that are supplied to the parameters that it uses. The Taguchi experimental design is used in order to determine the optimal value of the ACO parameters, and a fuzzy module is implemented in order to assess the pheromone value. The proposed method is intended to cut down on the amount of time required for computing. Through the use of an evaporation process derived from the pheromone experiment, the method is designed to avoid an untimely convergence towards solutions that are not suitable. The results of the simulations that were carried out on the CloudAnalyst platform shown that the approach that was recommended has the potential to improve load balancing in the Cloud architecture. Additionally, it has the potential to reduce response time by as much as 82%, processing time by as much as 90%, and total cost by as much as 9%, depending on the particular case. On the other hand, they extend the use of the provided technique in order to enhance the formulation of pheromones and the operation of algorithms within a framework that is feasible.

L. Shen et al. [72], The Artificial Bee Colony (ABC) optimisation problem is being proposed. This problem makes use of the load balance technique in order to improve the overall load balancing performance as well as the increase in additivity. The ABC method is improved by making use of the sophisticated capabilities of smart grid cloud sources in order to effectively group virtual machines (VMs) together. When it comes to ensuring that resources are used in the most efficient manner and that energy is managed in an efficient manner, the load balancing algorithm of the cloud data centre is very essential. When it comes to load balancing in the cloud, the approaches that are now available give priority to solving the needs of certain systems or applications that are not scalable.

4. Comparison Among Reviewed Works

Twenty-one publications covering various algorithms are included in the following table, as shown below in Table 1:

Table (1): Comparison among reviewed works.

#	Ref.	Techniques and Algorithms	Results
1.	[52] 2023	Swarm Intelligence (SI) is a technology that has been proposed as a means of distributing the burden in cloud computing with the intention of achieving load-balancing. There are many different approaches that have been investigated in the literature. Some of these methodologies include genetic algorithm, ACO, PSO, BAT, and GWO. Unfortunately, none of them take into consideration the amount of time it takes for load balancing to reach a point of convergence with global optimisation.	Assuring while attaining fast convergence that is globally optimized and cutting down on reaction time overall. When compared to alternative algorithms, the suggested technique's overall response time is, on average, 12% faster. Additionally, PSO is improved to 97.253% in terms of convergence by the best optimal value found from the suggested GWO-PSO algorithm's objective function.
2.	[53] 2023	In order to find a solution to the issue of multi-objective work scheduling in a variety of IaaS cloud situations, it is recommended to make use of a hybrid optimisation approach that is suited to the specific conditions. This will allow for the	These advantages of the hybrid algorithm that was recently presented are shown by the data that was acquired as a consequence of the method's success. The hybrid algorithm was recently proposed. In contrast to the

		problem to be solved. Our expectations are high that this will assist us in finding a solution to the problem that we are facing. The search exploration skills of the grey wolf optimizer algorithm are taken into consideration by this method, in addition to the pollination behaviour of flowers, which is taken into account by this methodology. To phrase it another way, it is a system that encompasses its reach in a manner that is very comprehensive.	optimization-based scheduling methods that are often discussed in the literature, this methodology does not include any kind of optimisation into its constituent parts. A few examples of the methodologies that are included in this category are the FPA method, the TSMGWO method, the GGWO method, and the LPGWO method.
3.	[54] 2023	The load balancer technique for cloud computing is developed by doing an analysis of the benefits that heuristic methods provide when used. There is an emphasis placed on enhancing the selection process by taking into account the likelihood of work scheduling and the chance of selecting virtual machines. The invention of a genetic algorithm that alters the global search criteria in order to align with the lion optimizer is the second contribution that has been made.	The use of a hybrid genetic algorithm that is founded on lion genetics has been shown to result in beneficial consequences, as indicated by the findings of a number of study studies. The results of the research indicate that these statements are correct and should be taken seriously.
4.	[55] 2023	In this paper, the Hybrid Weighted Ant Colony Optimisation (HWACO) approach is introduced. This technique is an upgraded meta-heuristic strategy that is used to address the scheduling issue. During the course of this inquiry, this approach was devised and refined. In this study, the HWACO algorithm is analysed and contrasted with a number of other algorithms that are already in existence, with regard to the areas of efficiency, makespan, and cost efficiency. It is necessary to carry out this examination and comparison. Both the Ant Colony Optimisation Algorithm and this more powerful version have been included into the algorithm, which has already undergone improvements.	In comparison to other conventional algorithms, such as the MIN-MIN Algorithm (MM), Ant Colony Optimisation (ACO), Quantum-Based Avian Navigation Optimizer Algorithm (QANA), Modified-Transfer-Function-Based Binary Particle Swarm Optimisation (MTF-BPSO), and First-Come-First-Serve (FCFS), the proposed algorithm is regarded as the most efficient method for task scheduling. This is as a result of the fact that it displays superior performance in comparison to these other algorithms.
5.	[56] 2023	In order to address the issue that was discussed before, a fresh Particle Swarm Optimisation (PSO) approach that is referred to as Improved Particle Swarm Optimisation (IPSO) has been presented. When it comes to work scheduling in the cloud computing environment, a multi-adaptive learning strategy is used in order to cut down on the amount of time required for the original Particle Swarm Optimisation (PSO) method to complete its execution.	The CEC 2017 benchmark was used as the foundation throughout the process of developing the solution that was recommended. Not only does the strategy that has been presented have the potential to provide optimal outcomes for the majority of the criteria, but it also has the capability to solve the issue in a more expedient manner than what is now known.
6.	[57] 2022	Distributed artificial intelligence (DAI) is enhanced by incorporating end-edge cloud computing (EECC) in order to satisfy the multiple demands that are presented by resource-intensive and distributed AI computation. This is done in order to fulfil the numerous demands that are posed by AI computation. It is possible to efficiently integrate the various capabilities of on-device computing, edge computing, and cloud computing via the utilisation of this sort of computing.	This paragraph presents an explanation of the concept of distributed artificial intelligence (DAI), which is made feasible by end-edge cloud computing (EECC). DAI is an acronym for distributed artificial intelligence. Particularly, it focuses on how the many requirements of resource-intensive and distributed artificial intelligence computation may be achieved by effectively coordinating the diverse capabilities of cloud computing, edge computing, and on-

			device application development. Specifically, it focuses on how this can be accomplished.
7.	[58] 2022	It is necessary to construct a combined optimisation problem. This is something that must be implemented. The scheduling of Internet of Things devices with F-APs, the allocation of transmit power, and the allocation of compute frequency at the F-APs should all be discussed in relation to this problem. It is essential that each and every one of these components will be included into the problem. The subsequent step that has to be taken is to split this issue into two distinct groups according to the type of the difficulties. This is the next step that needs to be taken.	When it comes to Internet of things (IoT) networks that are enabled by integrated fog-cloud computing, it is essential to cut down on the amount of energy that is used by distributed learning (DL). Determine the most effective way to maximise the energy efficiency of F-APs while taking into consideration the limitations that are imposed on the amount of time that is spent computing and transmitting. In order to solve the two subproblems in an iterative way, you will need to build a technique that is based on conflict graphs. It has been shown via numerical data that the strategy that has been recommended is superior to the alternatives that are now available in terms of energy efficiency.
8.	[59] 2022	Offers a study into the computational frameworks that are used in order to fulfil the severe criteria that are imposed by current applications. The purpose of this article is to offer an overview of the application scenarios that are suggested for Mobile Edge Computing (MEC) in Mobile Augmented Reality (MAR1).	The integration of MEC with cutting-edge technologies such as the Metaverse, 6G wireless communications, artificial intelligence (AI), and blockchain helps to address the challenges that are associated with the distribution of network resources, the increase in network traffic, and the requirements for latency. These challenges are addressed in order to address the challenges that are associated with these issues.
9.	[60] 2022	On the subject of cloud computing, it is suggested that the Water Wave Algorithm (WWA) be used with the intention of achieving the aim of controlling the distribution of resources in an effective way.	The WWA algorithm is better than the FCFS, MCT, MET, and OLB algorithms in terms of throughput, response time, turnaround time, migration time, resource utilisation, fault tolerance, and scalability, according to the findings of a research that compared the performance of these algorithms.
10.	[61] 2021	This load balancing scheduler is an innovative one that aims to increase both the makespan and the load balancing of the system. This particular technique is most often referred to by its acronym, BGA, which stands for the Balancer Genetic technique.	It has been shown that the BGA approach has demonstrated a substantial increase in terms of its efficacy when compared to other advanced methodologies for monitoring makespan, throughput, and load balancing.
11.	[62] 2021	By combining the major quality of service characteristics with power consumption, ABC is able to precisely analyse the amount of power that is being used by virtual machines (VMs) on the host, which ensures that an efficient load balancing system is in place. The purpose of this study is to evaluate the power consumption of virtual machines (VMs) while taking into account significant quality of service (QoS) metrics. With the aid of this evaluation, you will be able to choose the host and virtual machine that are appropriate for carrying out the task at hand.	Compared to LBA_HB and HBB-LB, the recommended technique not only improves the average reaction time and makespan, but it also increases the amount of imbalance. This is the conclusion that can be drawn from the data of the simulation. The study showed that there is a significant positive link between energy usage and cost; however, it also highlighted that there is a distinct lack of connection between the amount of energy consumed and the length of time it takes to process the data. This was one of the findings of the research.
12.	[63] 2021	A substantial amount of change is taking place in the assumptions that have historically served as the foundation for the creation of distributed systems. A fast fragmentation of paradigms, driven by economic interests and physical restrictions coming from the termination of Moore's law, is one of the changes that have occurred as a consequence of these shifts. A further development is that there is a movement away	As a result of the shift away from generalist architectures and frameworks and towards more specialisation and paradigm architecture, there has been a movement in coordination between centralization and decentralisation. This movement has occurred as a consequence of the change. The alteration that took happened is directly responsible for this movement that has

		from generalist designs and frameworks and towards a greater focus on specialism.	taken place. There is a clear correlation between the first shift and the occurrence of this shift.
13.	[64] 2021	The creation of a unique hybrid approach has been brought about as a consequence of the merging of the grey wolf optimisation (GWO) technique with the particle swarm optimisation algorithm (PSO). It was the combination of these two approaches that led to this breakthrough, which was brought about as a result of the combination. The combination of these two methods has resulted in the creation of this strategy, which has been brought about as a consequence of both of these techniques coming together.	Both GA and GWO algorithms are used in order to carry out the process of evaluating and analysing the performance of the approach that is proposed via the usage of both of these algorithms. The GWO-PSO algorithm that was created produces superior results in terms of response time and makespan for the whole of the algorithm's execution when compared to the outcomes of the GWO and GA algorithms. This is the case when the algorithm is compared to the GWO method. In point of fact, this is the current state of affairs.
14.	[65] 2020	For the purpose of improving the VM allocation system, a hybrid approach is used. The combination of the Grey Wolf Optimisation (GWO) and the Artificial Bee Colony (ABC) algorithms is what constitutes the hybrid method. The GWO approach is broken down into three primary components, with the initial improvement happening in the local search portion of the technique.	When comparing the results of the suggested approach to those of the ABC, GWO, and RAA algorithms, comparisons are performed between the outcomes of each of these algorithms. The findings of those comparisons indicate that the approach that was presented resulted in a 1.25 percent increase in both the accuracy and efficiency of the resource allocation system in virtual machines (VMs) for cloud computing. This improvement was achieved by the method.
15.	[66] 2020	A one-of-a-kind scheduling paradigm has been established in order to provide load balancing while simultaneously taking into account a broad range of quality of service (QoS) metrics. These measurements include makespan, reaction time, execution time, and task priority. With this in mind, the recommendation is to make use of artificial bee foraging (TSABF) optimisation for task scheduling in order to achieve an optimum allocation of work to virtual machines (VMs). This is done in consideration of the methodologies that have been discussed before.	Through the use of a set of virtual machines, the fulfilment of the ideal timetable is accomplished. The objective of task preemption is to cut down on the amount of time that is required to react to and complete all of the tasks that are connected with the various priorities. This article presents a study of the similarities and differences between the outcomes of the experiment and the honey bee behavior-inspired load balancing (HBB-LB) algorithm that is presently being used. According to the results, TSABF is better than HBB-LB in terms of quality of service metrics and has the potential to be used as an alternate scheduling mechanism for load balancing.
16.	[67] 2020	A challenge that is related to the scheduling of tasks inside a cloud computing management system is the primary focus of this investigation, which is being carried out with the objective of finding a solution to the problem. This objective will be accomplished by the use of a hybrid discrete artificial bee colony (ABC) technology through the utilisation of this technology. To get things started, the issue that has to be resolved is known to as a hybrid flowshop scheduling (HFS) problem.	By constructing an improved scout bee that employs a variety of local search strategies in order to find the most acceptable food source or abandoned solution, it is possible that the capacity of the proposed algorithm to converge might be improved. If this were to occur, the algorithm would be able to converge more rapidly. The performance of the approach that was provided will be certified when it has been evaluated on a number of different sets of well-known benchmark situations. This will take place after the technique has been inspected.
17.	[68] 2020	In order to find answers to the problems that are connected to the metaheuristic methods that are presently being used, it is essential to conduct an inquiry into the settings of MakeSpan. This will allow for the identification of potential remedies.	The development of an efficient load balancing strategy is now underway with the objective of improving the fitness function of cloud computing and lowering performance metrics such as the amount of time required to complete MakeSpan.
18.	[69] 2020	An approach that is one of a kind in terms of reducing reaction time by using a grey wolf optimisation method that is well recognised	The findings of the CloudSim simulation environment demonstrated that the response time has significantly improved, in contrast to the EBCA-LB and HBB-LB algorithms, which

		throughout the majority of the industries in which it is used.	showed that the reaction time had significantly altered. In addition to the fact that the degree of load balancing is far higher than it was with TSLBACO and HJSA, this adds an additional insult to the situation.
19.	[70] 2019	In order to divide the work in a way that is fair and equitable, the following is a mix of several different challenging methods: It is the responsibility of the Genetic Algorithm module to randomly organise the tasks, while the fuzzy logic module is in charge of generating the goal function on its own. It is possible to determine the busy statuses of servers by using the objective function, which takes into account the task queues employed by the CPU and RAM.	According to the findings of the computer trials, the optimal solution was found in half the amount of time that was allotted for its implementation, which led to an increase in the level of satisfaction experienced by the customers with the product.
20.	[71] 2019	A unique hybrid method that makes use of fuzzy logic and ant colony optimisation (ACO) ideas has been devised with the intention of enhancing load balancing in the setting of the cloud. This was done in order to achieve the goal of increasing load performance.	In each and every one of the simulations that were executed using the Cloud Analyst platform, the efficacy of the combined Fuzzy-ACO algorithm was shown. The combined method is compared to the many alternative load balancing strategies via the use of these simulations.
21.	[72] 2019	Based on the load balance method, the suggested optimisation problem for the Artificial Bee Colony (ABC) aims to enhance the overall performance of the load balance and obtain improved adaptability. This is the purpose of the proposed problem. Cloud computing is used by the smart grid in order to successfully cluster virtual machines (VMs) that exhibit certain qualities, all while simultaneously enhancing the ABC algorithm.	It has been shown that the strategy that has been suggested is effective via the use of simulation analysis.

5. Extracted Statistics from Reviewed Works

In this section of the review paper, we will extract data from nearly all of the research listed in Table 1 in order to analyze and compare the findings, we will also need to collect data from other relevant studies.

The Grey Wolf Optimizer (GWO) was used in conjunction with a number of different approaches, and it was dependent on a number of different metrics in the study that was cited in references [52], [53], [64], [65], and [69]. As a consequence of the researchers' ability to achieve the maximum optimum value that could be obtained from the objective function of the suggested GWO-PSO strategy, the researchers were able to achieve a convergence improvement of 97.253% when compared to the PSO method. In addition to this, it was shown that the degree of load balancing was remarkable in contrast to both TSLBACO and HJSA. The approach that is described in [53] makes use of the crossover operators of evolutionary algorithms in order to achieve a beneficial equilibrium between exploring innovative solutions and employing previously established ones. On the other hand, the approach that is described in [64] optimises the result in order to reduce the makespan. The Particle Swarm Optimisation (PSO) approach has been shown to be more effective than the Grey Wolf Optimisation algorithm. This has been demonstrated via extensive research.

In both [61] and [70], a Genetic Algorithm module was used to produce a random order for the tasks, and a fuzzy logic module was utilised to construct the objective function that determines the busy statuses of servers based on their RAM and CPU task queues. Both of these modules were utilised to execute the tasks. Both of these modules made it possible to arrange the tasks in a haphazard manner. There is an algorithm known as ACO that was created by researchers [55] and [71] with the intention of lowering the amount of time and money that is necessary for the process while simultaneously enhancing the effectiveness of the cloud computing environment. In the second piece of study, load balancing and response time objectives in the cloud were also taken into consideration as considerations of major importance. To make matters worse, the effectiveness of the ACO algorithm is directly linked to the specific values that are assigned to the ACO parameters. This is a further insult to the injury. MALPSO, which stands for Multi Adaptive Learning for Particle Swarm Optimisation, was provided in the study [56], and PSO and GWO were used in the

research [64] in an attempt to cut down on the quantity of spam that was produced. An approach to obtaining an optimal work schedule for virtual machines (VMs) was provided in both [62] and [66]. This approach was presented in both of these documents. The recommended method is better to the LBA_HB and HBB-LB approaches in terms of the average reaction time, makespan, and degree of imbalance. This is the case when compared to the techniques. The study [67] [72] has led to the development of an enhanced version of the ABC algorithm. The use of simulation analysis has shown that the technique that was suggested is successful in achieving the desired results. The MakeSpan requirements were taken into consideration in relation to the metaheuristic techniques that are now being used, namely [55], [65], [66], [68], [71], and [72]. This was done while taking into consideration the current conditions. By using load balancing algorithms, the suggested technique proposes to achieve load balancing across all of the data centres, hence ensuring stability and increasing throughput. This will be accomplished while simultaneously optimising throughput.

The simulations that were performed on the CloudAnalyst platform demonstrated that the approach that was proposed is capable of providing a contribution to an improvement in load balancing within the Cloud infrastructure. This was shown by the fact that the technique was able to make a contribution to the improvement. This enhancement may result in a decrease in response time by as much as 82 percent, a reduction in processing time by as much as 90 percent, and a reduction in total cost by as much as nine percent and nine percent, respectively, depending on the precise conditions that are being employed. However, if we generalise the method that has been described, we could be able to enhance the formulation of pheromones and optimise the performance of the algorithm in a setting that is typical of the real world. This would be a significant step forward.

6. Discussion for Compared Metrics

Specifically, Grey Wolf Optimisation (GWO) and Particle Swarm Optimisation (PSO) are the topics that are being investigated in the study that is being carried out by 51. The outcomes of the study show that there is potential for decreasing the overall reaction time and reaching globally optimum rapid convergence. This suggests that there is possibility for achieving both of these goals when compared to other conventional approaches. According to the results of a comparison between the recommended approach and other competing algorithms, the suggested method has an average total reaction time that is 12% quicker than the results of the other ways. The user's text is where the "[53]" comes from. A comparison was done between the well-known optimization-based scheduling strategies, such as TSMGWO, GGWO, LPGWO, and FPA approach, and the alternatives that were supplied for them in the literature. The comparison was made before and after the techniques were used. Some of the limitations of previous methods, such as the local optimality trap and immature convergence, have been successfully addressed by the newly constructed hybrid algorithm. Immature convergence and the local optimality trap are two examples. The findings that were acquired are presented here in order to illustrate the advantages that may be gained by using this strategy. The goal of this unique hybrid optimisation approach is to handle the problem of multi-objective task scheduling in heterogeneous infrastructure as a service cloud settings. This technique was created in order to address the issue. In order to make things easier for you, the number 54 is enclosed inside square brackets. Two probabilities are constructed in order to enhance the selection process. These probabilities are the likelihood of selecting a virtual machine and the chance of scheduling a job. In this analysis, each of these probability are considered separately. It is the lion optimizer that makes use of fitness criteria, and these criteria are depending on the characteristics of both the job and the virtual machine. The second contribution was the modification of the global search criteria via the use of a genetic algorithm in order to enhance the performance of the lion optimizer. The second most important contribution was this one.

Specifically, it is enclosed in square brackets, each of which contains the number 55. The HWACO was found to have produced average increases in makespan of 3.83 percent, 16.54 percent, 25.34 percent, 8.66 percent, and 57.1 percent, respectively, when compared to the QANA, MTF-BPSO, ACO, MIN-MIN, and FCFS, respectively. These figures were determined after comparing the HWACO to the aforementioned other models. Furthermore, in compared to other businesses of a similar kind, it was able to achieve cost reductions of 12.15 percent, 18.88 percent, 23.6 percent, 27.05 percent, and 32.9 percent respectively. The conclusion that can be drawn from this is that the technique that has been offered is capable of optimising the performance of the task scheduler in terms of both the makespan and the cost. This is something that can be done because of the information that has been supplied. The conclusions of the research [56] indicate that the recommended approach is assessed by comparing it to a variety of algorithms based on four parameters: makespan, load balancing, stability, and efficiency. This evaluation is carried out in order to determine the effectiveness of the solution. The CEC 2017 benchmark is also taken into account while we are analysing the technique that has been provided. Not only does the strategy that has been presented have the potential to provide optimal outcomes for the majority of the criteria, but it also has the capability to solve the issue in a more expedient manner than what is now known. The

study article [57] investigated a variety of research challenges and concerns that have not yet been addressed in connection to immersive performance acquisition. These difficulties and concerns have not yet been resolved. In the study, a number of common computing paradigms were discussed, and the merits of the EECC paradigm were emphasised in terms of its ability to enable distributed artificial intelligence. In addition to that, the article investigated the core technologies that are necessary for distributed artificial intelligence. In addition to this, they exhibited a broad range of potential applications that may be made feasible by the DAI-EECC. Following that, we construct an all-encompassing classification system for the advanced optimisation tools that are made possible by EECC in order to improve distributed training and inference. This is done in order to optimise the performance of these tools.

[58] The major focus of the research that was carried out was on optimising the scheduling and power allocation for Internet of Things devices, as well as the computing frequency allocation for the second subproblem. This was the core focus of the study. Following this, they devised an iterative technique that involved the application of a conflict graph in order to find a solution to the two subproblems that they had encountered after that. It has been shown via numerical data that the strategy that has been recommended is superior to the alternatives that are now available in terms of energy efficiency. In the course of the research project [59], the paradigms of computing that are used in order to satisfy the severe requirements of the applications that are now underway were investigated. There is a variety of mobile augmented reality (MAR) use cases that are available for mobile augmented reality (MEC). In addition, the objective of this study is to analyse the utilisation of Mobile Edge Computing (MEC) in the Metaverse and to offer an explanation of the reasoning that led to the choice to approach the establishment of the Metaverse from a viewpoint that is centred on MEC. In this particular instance, certain technological fusions that have been considered in the past are given significant emphasis. Two examples of these fusions are the incorporation of 6G technology into the MEC paradigm and the use of blockchain technology to strengthen the MEC paradigm. The study is focused on the number [60] as its primary emphasis. It is necessary to possess both resilience and the capacity to grow. Through the use of these algorithms, it was discovered that WWA generates a greater throughput in comparison to MCT and MET. It was revealed when the performance of the cloud was reviewed that this was the case. A decrease in turnaround time has been accomplished by WWA as a result of the use of the First-Come, First-Served (FCFS) evaluation approach. The use of a variety of algorithms has resulted in a significant enhancement in response, migration, and turnaround time. This improvement has been accomplished. There exists a significant connection between the characteristics of service parameters and the stability and adaptability of cloud computing that is distributed. Using water wave augmentation calculations, it is likely that future study may examine additional quality of service factors in order to improve the process of selecting the suitable virtual machine. This would be done in order to improve the virtual machine selection process.

[61] [61] The focus of the investigation that is being conducted Within the context of task scheduling, it is essential to take into consideration load balancing as an essential element in addition to makespan in order to achieve the highest possible level of efficiency. The importance of multi-objective optimisation is shown by this. The use of meta-heuristics makes it possible to conduct a systematic examination of a large search space that contains viable solutions. Furthermore, the incorporation of heuristic merging further enhances the capacity to investigate even more ideal answers. A platform that mimics the behaviour of processes that are housed in a cloud data centre is called CloudSim. This platform does this by making use of a broad range of resources and tasks that are allocated to them. In terms of the performance criteria of makespan, throughput, and load balancing, it has been shown via thorough testing that BGA is superior than the extremely sophisticated schedulers MGGS, ETA-GA, DSOS, and RALBA. This demonstrates that BGA delivers better results. For the purpose of avoiding the biassed experimentation that is brought about by the dataset, it is essential to implement a diverse workload distribution that is made up of a large number of task batches. The primary emphasis of the investigation is on the number 62. In contrast to LBA-HB and HBB-LB, the overall performance of the system is improved as a consequence of the use of fuzzy logic, which leads to an improvement in the reaction time and Makespan of the method that is presented. This, in turn, leads to an increase in the overall performance of the system. The results that are produced by the ILBA-HB technique are promising, despite the fact that it only provides a little improvement. Compared to LBA_HB and HBB-LB, the recommended technique not only improves the average reaction time and makespan, but it also increases the amount of imbalance. This is the conclusion that can be drawn from the data of the simulation. The data reveals that there is a significant positive correlation between energy consumption and cost, while also revealing that there is a little link between the amount of energy consumed and the length of time it takes to process the data. In other words, the data demonstrates that there is a good relationship between the two. [63] [63] [63] [63] Within the framework of climate change, it is of utmost importance to explore the advantages and disadvantages of doing research on distributed systems, as well as the

challenges that distributed researchers face when trying to analyse complex phenomena on a wide scale. It is [64] that serves as the investigation's primary focus. It is vital to adopt a task scheduling strategy that is both effective and efficient, with the potential to effectively allocate resources for the fulfilment of user tasks, in order to improve the performance of quality of service characteristics. This is because it is essential to increase the performance of quality of service characteristics. A performance assessment and analysis of the suggested technique is carried out with the assistance of the GA and GWO algorithms. This evaluation and analysis is carried out. In terms of reaction time and makespan, the GWO-PSO strategy that has been proposed provides better performance to both the GWO and GA algorithms. This is the case by delivering greater performance.

There is a particular emphasis placed on [65] in this study. A comparison is made between their findings with the outcomes that were achieved by the ABC algorithm, the GWO algorithm, and the RAA algorithm individually. In accordance with the comparisons that were carried out, the solution that was offered results in a 1.25 percent improvement in both the accuracy and efficiency of the mechanism that is responsible for allocating resources in virtual machines (VMs) for cloud computing utilisation. The mechanism that is responsible for resource allocation in virtual machines (VMs) is the subject of this study, which makes use of a hybrid method in order to enhance it. Because of this, virtual machines (VMs) in cloud data centres may sometimes experience overloading or underloading due to poor load balancing measures. This is the reason why this is the case. It is [66] that serves as the investigation's primary focus. Utilising the existing resources in the most effective and efficient manner feasible. In order to provide load balancing while taking into account a broad variety of quality of service (QoS) requirements, it is necessary to have a scheduling system that is inventive. Makespan, reaction time, execution time, and task priority are some of the features included under this category. For this reason, it is recommended that the artificial bee foraging (TSABF) optimisation technique be used for the purpose of managing job scheduling. The purpose of this method is to obtain an optimal distribution of workloads across virtual machines (VMs), while taking into account the characteristics that have been stated in the previous section. To put it simply, the production of the ideal schedule is ultimately the responsibility of a group of virtual machines (VMs) that are outfitted with preemptive task scheduling. Task preemption is a method that seeks to reduce the amount of time that is necessary for activities that are connected with different priorities to react and carry out their execution. According to the investigation into the number 67 Additionally, in order to attain the best possible equilibrium between the capabilities of exploration and exploitation, the recommended method incorporates an improved version of the adaptive perturbation framework. This goal is accomplished by including the framework. It is necessary to use a revised technique and a strategy that is straightforward while yet being effective in order to enhance the process of exploitation. The purpose of deep-exploitation operators is to further increase the capabilities of exploitation in order to make the most of their potential. For the purpose of locating the most suitable food supply or solution that has been abandoned, a more efficient scout bee programme that makes use of a range of local search tactics is used. As a consequence of this, the level of convergence that the suggested method is capable of achieving may be enhanced. For the purpose of determining whether or not the approach in question is effective, an evaluation of the method's performance on previously established benchmark datasets is carried out.

An technique to load balancing that is extremely effective has been devised by [68] with the aim of lowering performance indicators such as MakeSpan time and enhancing the fitness function pertaining to cloud computing. Within the scope of this project, an investigation is being conducted to determine how the condition of virtual machines is affected by the workload that is now being operated. It is determined that the tasks will be assigned to the virtual machine that is most suited for processing them, and this decision is made based on the criteria of the least distance, which is utilised to select how tasks are distributed. In addition, the tasks will be taken from the machine that is now facing an excessive level of burden, but this will depend on the present condition of the virtual machine on which they are being removed. When the findings of the simulation environment known as CloudSim were compared to the algorithms known as EBCA-LB and HBB-LB, it was found that the CloudSim environment generated a much longer response time. When contrasted with TSLBACO and HJSA, the amount of load imbalance that exists in this scenario is much greater. The user's text is where the "[70]" comes from. Load balancing is the primary concern that stands out as the most significant characteristic when it comes to strategically distributing incoming network traffic across several servers in an effective manner. Therefore, it is assured that no one server is capable of handling an excessive amount of requests, which eventually leads to an increase in the accessibility of websites and services to consumers. This is accomplished via the use of this method. The outcomes of computer testing indicated that the ideal solution was discovered within half of the allocated execution time, which resulted in an increase in the degree of pleasure that would be experienced by consumers. During the course of the research that was carried out by [71], a fuzzy logic module was used in order to ascertain the pheromone value. In addition, the Taguchi concept was used in order to

improve the parameters of the algorithm. Because of this integration, the algorithm for the ant colony has undergone a substantial development that has led to a considerable progress. It has been concluded, on the basis of the findings of the tests that were carried out on the Cloud Analyst simulator, that the method is better appropriate for the administration of complex networks. The employment of fuzzy logic for the calculation of pheromones and the utilisation of the Taguchi technique for determining the most suited ACO parameters are two of the most significant advancements that have been achieved by the technology that has been provided. The research focused on the specific needs that must be met by applications or systems that are unable to expand or adjust in response to shifting conditions. The Artificial Bee Colony (ABC) algorithm is presented with a challenge over the course of this study. This challenge is accomplished via the use of the load balancing approach. The major purpose of this investigation is to improve the algorithm's overall load balancing performance as well as the adaptive outcomes it produces.

7. Recommendations

An experimental simulation was carried out, and a statistical t-test was carried out for the aim of conducting research. When the HWACO technique was compared against the QANA algorithm, the MTF-BPSO methodology, the ACO algorithm, the MIN-MIN algorithm, and the FCFS algorithm, it demonstrated average increases in terms of makespan that were 3.83%, 16.54%, 25.34%, 8.66%, and 57.11% respectively. When it comes to the reduction of costs, the QANA, MTF-BPSO, ACO, MIN-MIN, and FCFS all succeeded in achieving improvements of 12.15 percent, 18.88 percent, 23.6 percent, 27.05 percent, and 32.9 percent respectively. When this is taken into consideration, it is feasible to arrive at the conclusion that the solution that was developed optimises the task scheduler in terms of both the amount of time it takes to complete the work and the amount of money it saves. In addition to this, it not only enhances the fitness function of cloud computing but also decreases performance metrics such as makespan time, amongst other things. Several additional scholars' contributions have resulted in the enhancement of the ABC algorithm. By doing simulation study, it has been shown that the suggested strategy is successful, hence indicating that it is effectively implemented.

8. Conclusion

Conventional cloud computing, in which processing, storage, and networking resources are housed in one or a few centralised data centres, is unsuited for new applications because of the strict latency requirements that these applications have. As a further point of interest, the rapid expansion of networks has ushered in the trend of cloudification of networks and the supply of network services based on cloud service models. This movement is a result of the greater availability of connection, which has brought about several changes. As a consequence of this, the new distributed cloud architecture represents an advancement in comparison to the traditional centralised cloud computing. Across the whole planet, it offers services for distributed cloud computing that are structured in accordance with the requirements of the application using those services. Within the confines of this essay, we will make an effort to provide a comprehensive review of distributed clouds. At the beginning of this article, there is a description of distributed cloud computing that is given. Following that, we will talk about the architecture of the distributed cloud as well as the technologies that are associated with it once we have finished that. We take on the responsibility of addressing the open research questions that are linked with distributed cloud computing. as a result of the analysis of twenty-one articles that explored a variety of strategies and procedures.

References

[1] P. Mundhenk, A. Hamann, A. Heyl, and D. Ziegenbein, "Reliable distributed systems," in *2022 Design, Automation & Test in Europe Conference & Exhibition (DATE)*, 2022, pp. 287-291.

[2] D. Senapati, A. Sarkar, and C. Karfa, "Performance-effective DAG scheduling for heterogeneous distributed systems," in *Proceedings of the 23rd International Conference on Distributed Computing and Networking*, 2022, pp. 234-235.

[3] N. T. Muhammed, S. R. Zeebaree, and Z. N. Rashid, "Distributed Cloud Computing and Mobile Cloud Computing: A Review," *QALAAI ZANIST JOURNAL*, vol. 7, pp. 1183-1201, 2022.

[4] Z. N. Rashid, S. R. Zebari, K. H. Sharif, and K. Jacksi, "Distributed cloud computing and distributed parallel computing: A review," in *2018 International Conference on Advanced Science and Engineering (ICOASE)*, 2018, pp. 167-172.

[5] G. Cavallaro, D. B. Heras, Z. Wu, M. Maskey, S. Lopez, P. Gawron, *et al.*, "High-Performance and Disruptive Computing in Remote Sensing: HDCRS—A new Working Group of the GRSS Earth Science Informatics Technical Committee [Technical Committees]," *IEEE Geoscience and Remote Sensing Magazine*, vol. 10, pp. 329-345, 2022.

[6] Y. Jiang, J. Kang, D. Niyato, X. Ge, Z. Xiong, C. Miao, *et al.*, "Reliable distributed computing for metaverse: A hierarchical game-theoretic approach,"

IEEE Transactions on Vehicular Technology, vol. 72, pp. 1084-1100, 2022.

[7] Q. Li, J. Zhang, J. Zhao, J. Ye, W. Song, and F. Li, "Adaptive hierarchical cyber attack detection and localization in active distribution systems," *IEEE transactions on smart grid*, vol. 13, pp. 2369-2380, 2022.

[8] Z. Ageed, M. R. Mahmood, M. Sadeeq, M. B. Abdulrazzaq, and H. Dino, "Cloud computing resources impacts on heavy-load parallel processing approaches," *IOSR Journal of Computer Engineering (IOSR-JCE)*, vol. 22, pp. 30-41, 2020.

[9] Y. S. Jghef and S. Zeebaree, "State of art survey for significant relations between cloud computing and distributed computing," *International Journal of Science and Business*, vol. 4, pp. 53-61, 2020.

[10] J. P. Sahoo, A. K. Tripathy, M. Mohanty, K.-C. Li, and A. K. Nayak, *Advances in Distributed Computing and Machine Learning*: Springer, 2022.

[11] K. Peng, H. Huang, B. Zhao, A. Jolfaei, X. Xu, and M. Bilal, "Intelligent computation offloading and resource allocation in IIoT with end-edge-cloud computing using NSGA-III," *IEEE Transactions on Network Science and Engineering*, 2022.

[12] S. Zebari and N. O. Yaseen, "Effects of parallel processing implementation on balanced load-division depending on distributed memory systems," *J. Univ. Anbar Pure Sci*, vol. 5, pp. 50-56, 2011.

[13] D. Yu, Z. Ma, and R. Wang, "Efficient smart grid load balancing via fog and cloud computing," *Mathematical Problems in Engineering*, vol. 2022, pp. 1-11, 2022.

[14] Y. Ding, K. Li, C. Liu, and K. Li, "A potential game theoretic approach to computation offloading strategy optimization in end-edge-cloud computing," *IEEE Transactions on Parallel and Distributed Systems*, vol. 33, pp. 1503-1519, 2021.

[15] T. Eltaeib and N. Islam, "Taxonomy of challenges in cloud security," in *2021 8th IEEE International Conference on Cyber Security and Cloud Computing (CSCloud)/2021 7th IEEE International Conference on Edge Computing and Scalable Cloud (EdgeCom)*, 2021, pp. 42-46.

[16] S. R. Zeebaree, H. M. Shukur, L. M. Haji, R. R. Zebari, K. Jacksi, and S. M. Abas, "Characteristics and analysis of hadoop distributed systems," *Technology Reports of Kansai University*, vol. 62, pp. 1555-1564, 2020.

[17] P. Arthurs, L. Gillam, P. Krause, N. Wang, K. Halder, and A. Mouzakitis, "A taxonomy and survey of edge cloud computing for intelligent transportation systems and connected vehicles," *IEEE Transactions on Intelligent Transportation Systems*, 2021.

[18] M. K. I. Rahmani, M. Shuaib, S. Alam, S. T. Siddiqui, S. Ahmad, S. Bhatia, *et al.*, "Blockchain-based trust management framework for cloud computing-based internet of medical things (IoMT): a systematic review," *Computational Intelligence and Neuroscience*, vol. 2022, 2022.

[19] A. Alam, "Cloud-based e-learning: scaffolding the environment for adaptive e-learning ecosystem based on cloud computing infrastructure," in *Computer Communication, Networking and IoT: Proceedings of 5th ICICC 2021, Volume 2*, ed: Springer, 2022, pp. 1-9.

[20] F. J. G. Peñalvo, A. Sharma, A. Chhabra, S. K. Singh, S. Kumar, V. Arya, *et al.*, "Mobile cloud computing and sustainable development: Opportunities, challenges, and future directions," *International Journal of Cloud Applications and Computing (IJCAC)*, vol. 12, pp. 1-20, 2022.

[21] J. Saeed and S. Zeebaree, "Skin lesion classification based on deep convolutional neural networks architectures," *Journal of Applied Science and Technology Trends*, vol. 2, pp. 41-51, 2021.

[22] L. Wen, "Cloud computing intrusion detection technology based on BP-NN," *Wireless Personal Communications*, vol. 126, pp. 1917-1934, 2022.

[23] P. K. Bal, S. K. Mohapatra, T. K. Das, K. Srinivasan, and Y.-C. Hu, "A joint resource allocation, security with efficient task scheduling in cloud computing using hybrid machine learning techniques," *Sensors*, vol. 22, p. 1242, 2022.

[24] P. Y. Abdullah, S. Zeebaree, K. Jacksi, and R. R. Zeabri, "An hrm system for small and medium enterprises (sme) s based on cloud computing technology," *International Journal of Research-GRANTHAALAYAH*, vol. 8, pp. 56-64, 2020.

[25] Z. S. Ageed, S. R. Zeebaree, M. M. Sadeeq, S. F. Kak, H. S. Yahia, M. R. Mahmood, *et al.*, "Comprehensive survey of big data mining approaches in cloud systems," *Qubahan Academic Journal*, vol. 1, pp. 29-38, 2021.

[26] P. Y. Abdullah, S. Zeebaree, H. M. Shukur, and K. Jacksi, "HRM system using cloud computing for Small and Medium Enterprises (SMEs)," *Technology Reports of Kansai University*, vol. 62, p. 04, 2020.

[27] R. R. Kumar, A. Tomar, M. Shameem, and M. N. Alam, "Optcloud: An optimal cloud service

selection framework using QoS correlation lens," *Computational Intelligence and Neuroscience*, vol. 2022, 2022.

[28] Z. S. Ageed, R. K. Ibrahim, and M. A. Sadeeq, "Unified ontology implementation of cloud computing for distributed systems," *Current Journal of Applied Science and Technology*, vol. 39, pp. 82-97, 2020.

[29] N. Manikandan, N. Gobalakrishnan, and K. Pradeep, "Bee optimization based random double adaptive whale optimization model for task scheduling in cloud computing environment," *Computer Communications*, vol. 187, pp. 35-44, 2022.

[30] S. Shen, Y. Ren, Y. Ju, X. Wang, W. Wang, and V. C. Leung, "Edgematrix: A resource-redefined scheduling framework for sla-guaranteed multi-tier edge-cloud computing systems," *IEEE Journal on Selected Areas in Communications*, vol. 41, pp. 820-834, 2022.

[31] Z. S. Ageed, S. R. Zeebaree, M. A. Sadeeq, R. K. Ibrahim, H. M. Shukur, and A. Alkhayyat, "Comprehensive Study of Moving from Grid and Cloud Computing Through Fog and Edge Computing towards Dew Computing," in *2021 4th International Iraqi Conference on Engineering Technology and Their Applications (IICETA)*, 2021, pp. 68-74.

[32] S. I. Ahmed, S. Y. Ameen, and S. R. Zeebaree, "5G Mobile Communication System Performance Improvement with Caching: A Review," in *2021 International Conference of Modern Trends in Information and Communication Technology Industry (MTICTI)*, 2021, pp. 1-8.

[33] A. Belgacem and K. Beghdad-Bey, "Multi-objective workflow scheduling in cloud computing: trade-off between makespan and cost," *Cluster Computing*, vol. 25, pp. 579-595, 2022.

[34] L. Surya, "Software as a service in cloud computing," *International Journal of Creative Research Thoughts (IJCRT), ISSN*, pp. 2320-2882, 2019.

[35] V. D. Majety, N. Sharmili, C. R. Pattanaik, E. L. Lydia, S. R. Zeebaree, S. N. Mahmood, *et al.*, "Ensemble of Handcrafted and Deep Learning Model for Histopathological Image Classification," *Computers, Materials & Continua*, vol. 73, 2022.

[36] S. Raghavan R, J. KR, and R. V. Nargundkar, "Impact of software as a service (SaaS) on software acquisition process," *Journal of Business & Industrial Marketing*, vol. 35, pp. 757-770, 2020.

[37] L. M. ABDULRAHMAN, Z. S. AGEED, T. M. G. SAMI, R. QASHI, and M. J. AHMED, "CLOUD-BASED AND ENTERPRISE SYSTEMS: CONCEPTS, ARCHITECTURE, POLICES, COMPATIBILITY, AND INFORMATION EXCHANGING."

[38] M. B. Ali, T. Wood-Harper, and R. Ramlogan, "The Role of SaaS Applications in Business IT Alignment: A Closer Look at Value Creation in Service Industry," *United Kingdom Academy for Information Systems*, 2020.

[39] D. Cunha, P. Neves, and P. Sousa, "PaaS manager: A platform-as-a-service aggregation framework," 2014.

[40] M. Viggiato, D. Paas, C. Buzon, and C.-P. Bezemer, "Using natural language processing techniques to improve manual test case descriptions," in *Proceedings of the 44th International Conference on Software Engineering: Software Engineering in Practice*, 2022, pp. 311-320.

[41] Z. N. Rashid, S. R. Zeebaree, M. A. Sadeeq, R. R. Zebari, H. M. Shukur, and A. Alkhayyat, "Cloud-based Parallel Computing System Via Single-Client Multi-Hash Single-Server Multi-Thread," in *2021 International Conference on Advance of Sustainable Engineering and its Application (ICASEA)*, 2021, pp. 59-64.

[42] S. F. KHORSHID, L. M. ABDULRAHMAN, Z. S. AGEED, T. M. G. SAMI, and M. J. AHMED, "INFLUENCES OF CLOUD AND WEB TECHNOLOGY ON IOT COMMUNICATION FOR EMBEDDED SYSTEMS."

[43] O. H. Jader, S. R. Zeebaree, R. R. Zebari, H. M. Shukur, Z. N. Rashid, M. A. Sadeeq, *et al.*, "Ultra-Dense Request Impact on Cluster-Based Web Server Performance," in *2021 4th International Iraqi Conference on Engineering Technology and Their Applications (IICETA)*, 2021, pp. 252-257.

[44] M. A. Sadeeq and S. R. Zeebaree, "Design and analysis of intelligent energy management system based on multi-agent and distributed iot: Dpu case study," in *2021 7th International Conference on Contemporary Information Technology and Mathematics (ICCITM)*, 2021, pp. 48-53.

[45] S. Bharany, K. Kaur, S. Badotra, S. Rani, Kavita, M. Wozniak, *et al.*, "Efficient middleware for the portability of paas services consuming applications among heterogeneous clouds," *Sensors*, vol. 22, p. 5013, 2022.

[46] D. M. Abdulqader and S. R. Zeebaree, "Impact of Distributed-Memory Parallel Processing Approach

on Performance Enhancing of Multicomputer-Multicore Systems: A Review," *QALAAI ZANIST JOURNAL*, vol. 6, pp. 1137-1140, 2021.

[47] M. Liu, M. J. Gorgievski, J. Qi, and F. Paas, "Increasing teaching effectiveness in entrepreneurship education: Course characteristics and student needs differences," *Learning and Individual Differences*, vol. 96, p. 102147, 2022.

[48] T. Ernawati and F. Febiansyah, "Peer to peer (P2P) and cloud computing on infrastructure as a service (IaaS) performance analysis," *Jurnal Infotel*, vol. 14, pp. 161-167, 2022.

[49] F. K. Parast, C. Sindhav, S. Nikam, H. I. Yekta, K. B. Kent, and S. Hakak, "Cloud computing security: A survey of service-based models," *Computers & Security*, vol. 114, p. 102580, 2022.

[50] M. Bozdal, M. Randa, M. Samie, and I. Jennions, "Hardware trojan enabled denial of service attack on can bus," *Procedia Manufacturing*, vol. 16, pp. 47-52, 2018.

[51] S. A. Mostafa, A. Mustapha, A. A. Ramli, R. Darman, S. R. Zeebaree, M. A. Mohammed, *et al.*, "Applying Trajectory Tracking and Positioning Techniques for Real-time Autonomous Flight Performance Assessment of UAV Systems," *Journal of Southwest Jiaotong University*, vol. 54, 2019.

[52] M. S. Al Reshan, D. Syed, N. Islam, A. Shaikh, M. Hamdi, M. A. Elmagzoub, *et al.*, "A Fast Converging and Globally Optimized Approach for Load Balancing in Cloud Computing," *IEEE Access*, vol. 11, pp. 11390-11404, 2023.

[53] A. N. Malti, M. Hakem, and B. Benmammar, "A new hybrid multi-objective optimization algorithm for task scheduling in cloud systems," *Cluster Computing*, pp. 1-24, 2023.

[54] K. Malathi and K. Priyadarsini, "Hybrid lion–GA optimization algorithm-based task scheduling approach in cloud computing," *Applied Nanoscience*, vol. 13, pp. 2601-2610, 2023.

[55] C. Chandrashekar, P. Krishnadoss, V. Kedalu Poornachary, B. Ananthakrishnan, and K. Rangasamy, "HWACOA scheduler: Hybrid weighted ant colony optimization algorithm for task scheduling in cloud computing," *Applied Sciences*, vol. 13, p. 3433, 2023.

[56] P. Pirozmand, H. Jalalinejad, A. A. R. Hosseinabadi, S. Mirkamali, and Y. Li, "An improved particle swarm optimization algorithm for task scheduling in cloud computing," *Journal of Ambient Intelligence and Humanized Computing*, vol. 14, pp. 4313-4327, 2023.

[57] S. Duan, D. Wang, J. Ren, F. Lyu, Y. Zhang, H. Wu, *et al.*, "Distributed artificial intelligence empowered by end-edge-cloud computing: A survey," *IEEE Communications Surveys & Tutorials*, 2022.

[58] M. S. Al-Abiad, M. Z. Hassan, and M. J. Hossain, "Energy efficient distributed learning in integrated fog-cloud computing enabled IoT networks," in *2022 IEEE International Conference on Communications Workshops (ICC Workshops)*, 2022, pp. 872-877.

[59] Y. Wang and J. Zhao, "Mobile edge computing, metaverse, 6G wireless communications, artificial intelligence, and blockchain: Survey and their convergence," in *2022 IEEE 8th World Forum on Internet of Things (WF-IoT)*, 2022, pp. 1-8.

[60] N. Bhalaji, "Load balancing in cloud computing using water wave algorithm," *Concurrency Comput., Pract. Exper.*, vol. 34, 2022.

[61] R. Gulbaz, A. B. Siddiqui, N. Anjum, A. A. Alotaibi, T. Althobaiti, and N. Ramzan, "Balancer genetic algorithm—A novel task scheduling optimization approach in cloud computing," *Applied Sciences*, vol. 11, p. 6244, 2021.

[62] H. S. Alatawi and S. A. Sharaf, "Hybrid load balancing approach based on the integration of QoS and power consumption in cloud computing," *International Journal*, vol. 10, 2021.

[63] D. Lindsay, S. S. Gill, D. Smirnova, and P. Garraghan, "The evolution of distributed computing systems: from fundamental to new frontiers," *Computing*, vol. 103, pp. 1859-1878, 2021.

[64] A. M. Senthil Kumar, P. Krishnamoorthy, S. Soubraylu, J. K. Venugopal, and K. Marimuthu, "An efficient task scheduling using GWO-PSO algorithm in a cloud computing environment," in *Proceedings of International Conference on Intelligent Computing, Information and Control Systems: ICICCS 2020*, 2021, pp. 751-761.

[65] S. Ouhame and Y. Hadi, "A Hybrid Grey Wolf Optimizer and Artificial Bee Colony Algorithm Used for Improvement in Resource Allocation System for Cloud Technology," *International Journal of Online & Biomedical Engineering*, vol. 16, 2020.

[66] G. Muthsamy and S. Ravi Chandran, "Task scheduling using artificial bee foraging optimization for load balancing in cloud data centers," *Computer Applications in Engineering Education*, vol. 28, pp. 769-778, 2020.

[67] J.-q. Li and Y.-q. Han, "A hybrid multi-objective artificial bee colony algorithm for flexible task

scheduling problems in cloud computing system," *Cluster Computing*, vol. 23, pp. 2483-2499, 2020.

[68] R. Agarwal, N. Baghel, and M. A. Khan, "Load balancing in cloud computing using mutation based particle swarm optimization," in *2020 International Conference on Contemporary Computing and Applications (IC3A)*, 2020, pp. 191-195.

[69] L. Xingjun, S. Zhiwei, C. Hongping, and B. O. Mohammed, "A new fuzzy-based method for load balancing in the cloud-based Internet of things using a grey wolf optimization algorithm," *International Journal of Communication Systems*, vol. 33, p. e4370, 2020.

[70] A. Saadat and E. Masehian, "Load balancing in cloud computing using genetic algorithm and fuzzy logic," in *2019 International Conference on Computational Science and Computational Intelligence (CSCI)*, 2019, pp. 1435-1440.

[71] A. Ragmani, A. Elomri, N. Abghour, K. Moussaid, and M. Rida, "An improved hybrid fuzzy-ant colony algorithm applied to load balancing in cloud computing environment," *Procedia Computer Science*, vol. 151, pp. 519-526, 2019.

[72] L. Shen, J. Li, Y. Wu, Z. Tang, and Y. Wang, "Optimization of artificial bee colony algorithm based load balancing in smart grid cloud," in *2019 IEEE Innovative Smart Grid Technologies-Asia (ISGT Asia)*, 2019, pp. 1131-1134.