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Embracing Distributed Systems for Efficient Cloud Resource Management: A Review of Techniques and Methodologies

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Abstract

The development of parallel computing, distributed computing, and grid computing has introduced a new computing model, combining elements of grid, public computing, and SaaS. Cloud computing, a key component of this model, assigns computing to distributed computers rather than local computers or remote servers. Research papers from 2017 to 2023 provide an overview of the advancements and challenges in cloud computing and distributed systems, focusing on resource management and the integration of advanced technologies like machine learning, AI-centric strategies, and fuzzy meta-heuristics. These studies aim to improve operational efficiency, scalability, and adaptability in cloud environments, focusing on energy efficiency and cost reduction. However, these advancements also present challenges, such as implementation complexity, adaptability in diverse environments, and the rapid pace of technological advancements. These issues necessitate practical, efficient, and forward-thinking solutions in real-world settings. The research conducted between 2017 and 2023 highlights the dynamic and rapidly evolving field of cloud computing and distributed systems, providing valuable guidance for ongoing and future research. This body of work serves as a crucial reference point for advancing the field and emphasizing the need for practical, efficient, and forward-thinking solutions in the ever-evolving landscape of cloud computing and distributed systems.

A. Introduction

Distributed systems have become an integral part of modern computing, allowing organizations to distribute tasks and data across multiple components in a network. These systems are used in a wide range of applications, including data processing, storage, and retrieval, network communication, and web services [1]. Cloud computing is a new technology which is managed by a third party "cloud provider" to provide the clients with services anywhere, at any time, and under various circumstances [2]. In order to provide clients with cloud resources and satisfy their needs, cloud computing employs virtualization and resource provisioning techniques [3].

The primary focus of distributed computing is to provide access to information as well as to allow for the computation and sharing of information. Distributed computing is achieved by connecting various processing units that are linked to one another via the use of computer networks. These networks may consist of the internet or a local area network (LAN) [4]. Cloud computing is an evolution of information technology and a dominant business model for delivering IT resources. With cloud computing, individuals and organizations can gain on demand network access to a shared pool of managed and scalable IT resources, such as servers, storage, and applications [5][6]. Recently, academics as well as practitioners have paid a great deal of attention to cloud computing. We rely heavily on cloud services in our daily lives, e.g., for storing data, writing documents, managing businesses, and playing games online. Cloud computing also provides the infrastructure that has powered key digital trends such as mobile computing, the Internet of Things, big data, and artificial intelligence, thereby accelerating industry dynamics, disrupting existing business models, and fueling the digital transformation [7].

This review explores the use of distributed systems for efficient cloud resource management. It categorizes key research studies. The review provides a comprehensive overview of the advancements in distributed systems, addressing both technological progress and challenges. It aims to contribute to the ongoing discourse in this dynamic field, offering valuable insights for current practitioners and future research.

B. Background Theory

a. Cloud Computing

Cloud computing represents a form of computing that operates over the Internet, offering on-demand processing resources and capabilities. It enables access to a collective pool of configurable technological assets, including networks, servers, and various applications. These resources are readily available and can be allocated or relinquished with minimal management effort [8]. Cloud computing enables individuals and organizations to store and process data in data centers owned by third-party providers, which may be located in distant geographical areas [9]. One major advantage of this technology is its ability to assist firms in avoiding significant upfront costs related to infrastructure, such as the acquisition of hardware and servers. Moreover, it allows organizations to focus on their primary business operations, rather than on overseeing tangible infrastructure. [10]. Further, Cloud computing allows enterprises to quickly implement their applications, greatly lowering the time required to become operational. Additionally, it provides firms with a practical method to adapt resources in accordance with fluctuating demands. This adaptability enables organizations to easily expand their computing capacities in response to growing requirements and likewise reduce them when the demand decreases [11]. Cloud service providers generally employ a pricing mechanism known as "pay-as-you-go." Figure 1 depicts the different essential elements of cloud computing in this method [12]. Notable cloud computing platforms comprise Amazon's Elastic Compute Cloud (EC2), Microsoft's Azure, and Oracle Cloud. Virtualization is the fundamental technology that enables cloud computing. It involves dividing a single physical computing unit into many virtual devices [13]. Virtualization enables seamless use and management of each virtual device for computing operations. This results in the creation of a scalable system consisting of multiple autonomous computing devices, which improves the allocation and utilization of unused physical resources more efficiently [14]. Cloud computing vendors offer their services using several models. Infrastructure as a Service (IaaS) provides users with computing infrastructure, such as virtual machines and other resources, in the form of a service. Platform as a Service (PaaS) enables users to deploy projects, including infrastructure and applications, onto the cloud with assistance from the provider. PaaS suppliers offer a specialised platform that caters to the needs of application developers. Software as a Service (SaaS) allows users to utilise the applications provided by a service provider. These applications are hosted on cloud infrastructure and can be accessed by web browsers other program interfaces [15]. Cloud providers are accountable for overseeing the infrastructure and platforms that enable the applications in these model [16] [17].

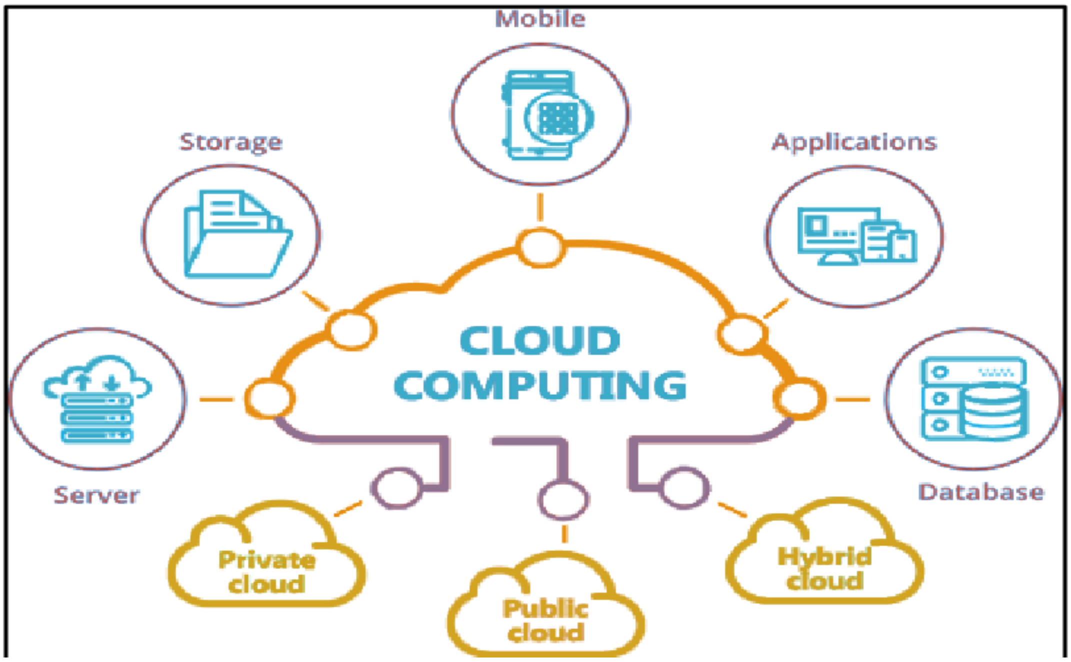

Figure 1. Cloud Computing [12].

i. Main Types of Cloud Computing

Infrastructure as a Service (IaaS) Offers virtualized computing resources across the internet, encompassing storage, computational capacity, and networking. The user has the ability to allocate processing, storage, networks, and other essential computing resources. Users have the ability to install and execute any software of their choice, including operating systems and apps [18]. The consumer lacks authority over the core cloud infrastructure, but retains control on operating systems, storage, deployed applications, and maybe has limited control over certain networking components such as host firewalls [19].

Platform as a Service (PaaS) Enables users to create, execute, and oversee applications without having to handle intricate infrastructure intricacies. The user is responsible for deploying consumer-developed or acquired apps into the cloud infrastructure, using programming languages and tools that are supported by the provider. The consumer lacks authority or jurisdiction over the cloud infrastructure, but retains control over the deployed apps and potentially the configurations of the application hosting environment [17].

Software as a Service (SaaS) Deploys diverse software programs via the Internet, obviating the need for local installs. The consumer utilizes the applications provided by the supplier, which are hosted on a cloud infrastructure. The apps can be accessed by different client devices through a thin client interface, such as a web browser, for example, web-based email. The consumer lacks the ability to oversee or manipulate the fundamental cloud infrastructure, such as the network, servers, operating systems, storage, and even specific application functionalities, except for potentially limited user-specific configuration settings for applications [17].

Function as a Service (FaaS) With serverless computing, developers may handle event-driven execution of processes without worrying about the underlying infrastructure [20].

ii. The Benefits of Cloud Computing

In the modern era, cloud computing has revolutionized the way businesses and individuals utilize technology, offering a myriad of benefits that cater to diverse needs and operational scales. This paradigm shift in computing has brought forth several key advantages that have fundamentally altered the landscape of digital services and infrastructure management [21], [22].

One of the primary advantages of cloud computing is **Cost Efficiency**. Unlike traditional computing models that often require significant upfront investment in infrastructure, cloud computing operates on a pay-as-you-go basis. This model allows users to pay only for the resources they use, significantly reducing initial expenses and enabling more efficient budgeting. This cost-effective approach is particularly beneficial for small and medium-sized enterprises (SMEs) and startups, as it provides them with access to high-end technology without the hefty price tag [23].

Another significant benefit is the provision of **Managed Services**. Cloud providers take on the responsibility of maintaining and updating the infrastructure, which includes regular software updates, security patches, and system upgrades [24]. This relieves users from the complex and time-consuming tasks associated with infrastructure management, allowing them to focus more on their core business activities [25], [26].

Scalability is a hallmark of cloud services. The flexibility to scale resources up or down based on current demands is a game-changer, especially in today's dynamic market environment. Businesses can easily adjust their resource usage to handle peak loads during high-demand periods or scale down during slower periods, ensuring operational efficiency and cost-effectiveness [27].

Lastly, **Accessibility** is a crucial aspect of cloud computing. Users can access cloud services and data from any location, provided they have an internet connection. This level of accessibility facilitates remote collaboration and offers unprecedented flexibility, making it easier for teams to work together from different geographical locations. This feature is especially relevant in the current landscape where remote working and digital collaboration have become more prevalent [28].

b. Distributed Systems

Distributed computing represents a model of computation in which tasks are segmented and executed across a network of interconnected computers. This method promotes simultaneous processing and cooperative efforts, in contrast to the conventional centralized computing model. It leverages the combined capabilities of a network, facilitating effective resolution of problems and optimal use of resources [29].

A distributed system (Fig. 2)[30] A distributed system is a network of computers working together to accomplish a task. It presents itself as an integrated computing entity, and is commonly used in large-scale computer systems. Nodes are dispersed across networked computers, allowing each to operate distinctively at different times. Communication occurs through message passing, and distributed systems facilitate the sharing of hardware and software resources, as well as information exchange between individuals and processes [30][31].

A distributed system is characterized by its support for concurrency, with several processors operating simultaneously across different networked computers. These processors run in parallel [32], with each computer functioning under its own local operating system. A key design feature of such a system is its resilience to failures of individual computers. It is engineered to maintain continuous service and operation even in the event of a node failure [33]. In essence, a distributed system is engineered for fault tolerance, ensuring continuous operation despite hardware, software, or network failures [34]. To achieve this, it incorporates recovery and redundancy mechanisms, such as duplicating information across multiple computers. These features are integral to maintaining service continuity, albeit potentially at a reduced capacity, in the event of system failures [35].

The architectural design of a distributed system is notably more intricate compared to a centralized system, owing to the potential complexity in interactions among its various components and the underlying system infrastructure. The performance of a distributed system is significantly influenced by factors such as network bandwidth, system load, and the processing speed of the individual computers within the network. This contrasts with a centralized system, where performance largely hinges on the speed of a singular processor [36] [37]. The efficiency and response time of a distributed system can fluctuate based on network load and bandwidth, leading to varying user experiences. Nodes within such a system typically operate as independent entities without centralized oversight. Additionally, the network linking these nodes constitutes a complex system, independent of the control of the computers utilizing it. Distributed systems find application in a myriad of settings, including fixed-line, mobile, and wireless networks, corporate intranets, the Internet, and the World Wide Web [38].

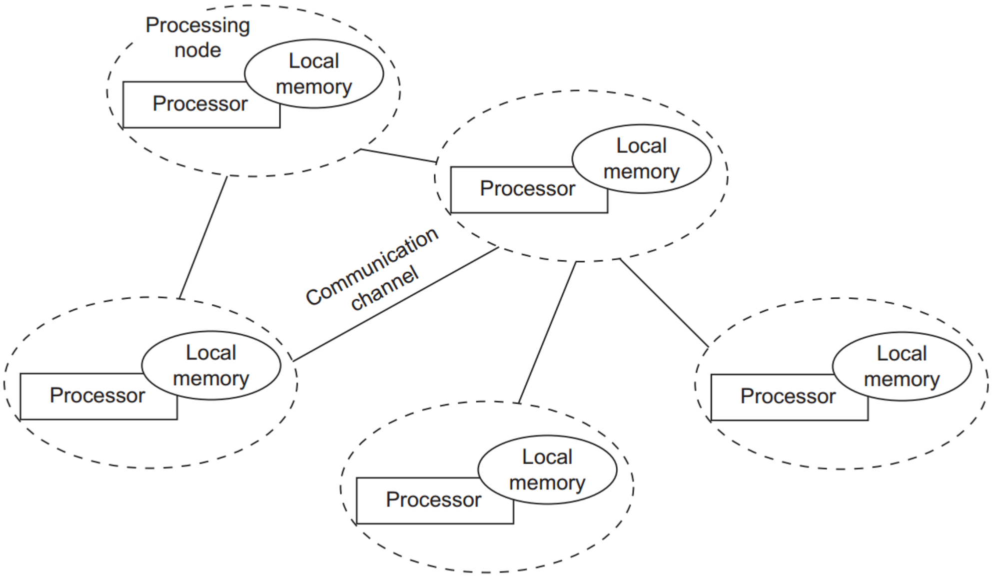

Figure 2. A distributed system [30].

i. Benefits of Distributed Computing

In the realm of distributed computing systems, several key principles stand out as pillars of their effectiveness and efficiency: parallel processing, scalability, fault tolerance, and resource efficiency [39].

Parallel Processing: The implementation of parallel processing in distributed systems involves the distribution of computational tasks across multiple computing units. This method allows for the simultaneous processing of different parts of a complex problem, which significantly reduces the overall processing time. By leveraging the capabilities of multiple computers, parallel processing effectively addresses the computational demands of intricate and resource-intensive tasks [40].

Scalability: Scalability is a fundamental characteristic of distributed systems, enabling them to efficiently manage increases in workload. This is achieved by augmenting the system with additional nodes as needed. The inherent design of distributed systems allows for this expansion without adversely affecting system performance. As a result, the system remains adept at handling growing demands, ensuring that the addition of new nodes or resources is a seamless process that maintains operational efficiency [41].

Fault Tolerance: Distributed systems are inherently designed to exhibit a high degree of fault tolerance. This is achieved through their ability to remain operational even in the event of individual node failures. The architecture of distributed systems ensures that the failure of one or more nodes does not compromise the overall functionality of the system. This robustness against hardware issues is crucial in maintaining continuous operation, thereby enhancing the reliability and resilience of the system [42].

Resource Efficiency: The efficient utilization of resources is a key advantage of distributed systems. By strategically distributing computational tasks across various nodes in the network, these systems optimize the use of available resources. This approach not only maximizes the performance of individual nodes but also enhances the overall responsiveness and efficiency of the system. Consequently, distributed systems are able to achieve a higher level of operational effectiveness, making practical and optimal use of the resources distributed throughout the network [43].

ii. Main Types of Distributed Computing

In the diverse landscape of modern computing, various architectures play pivotal roles in addressing specific computational needs and challenges. Among these, cluster computing, grid computing, parallel computing, and Peer-to-Peer (P2P) computing stand out for their unique approaches and applications.

Cluster Computing: Cluster computing refers to the technique of linking multiple computers, often known as nodes, to function collectively as a single, more powerful system. This interconnected group of computers shares processing tasks and resources, working in tandem to handle computationally intensive tasks. Each node in a cluster operates in concert with others, resulting in enhanced processing capabilities and higher availability. Cluster computing is particularly effective in scenarios requiring high-performance computing, as it combines the power of individual nodes to form a robust and scalable solution [44][45].

Grid Computing: Grid computing is a form of distributed computing that involves harnessing the power of a vast network of computers spread across different geographical locations. These computers collaborate to work on a common task, typically involving large-scale, complex computations such as scientific research, data analysis, and simulations. Unlike cluster computing, where nodes are closely connected and often homogenous, grid computing leverages a more heterogeneous and expansive network, pooling resources from various systems. This approach is ideal for tasks that require immense computational power and data processing, often transcending the capabilities of a single machine or local cluster [46].

Parallel Computing: Parallel computing is a computational approach where a large task is divided into smaller subtasks, which are then processed concurrently across multiple processors [47] [48]. The method optimizes computational speed and efficiency by allowing different parts of a task to be executed simultaneously rather than sequentially [49]. It effectively reduces the time taken to process complex and large-scale computations, making it an essential approach in high-performance computing environments [50]. Parallel computing is often used in scientific simulations, image processing, and complex mathematical calculations, where the ability to process multiple operations at the same time significantly accelerates the overall task completion.

Peer-to-Peer (P2P) Computing: Peer-to-Peer computing, commonly known as P2P computing, is a decentralized network model where each computer, or peer, in the network shares resources and processing power directly with other peers without the need for a centralized administrative system. In a P2P network, all computers participate in data sharing and processing, making the network highly resilient and scalable. This model is frequently used for file sharing, distributed computing, and collaborative work. P2P computing allows for a more efficient use of resources as each peer contributes to and benefits from the network, leading to a more robust and fault-tolerant system [51].

C. Literature Review

Gonzalez et al. in 2017 conducted a systematic review of over 110 publications on cloud resource management, developing a taxonomy and highlighting future challenges. Their work, while comprehensive, notes potential biases and scope limitations. Key findings include identifying gaps in security and dynamic resource allocation in diverse cloud environments [52].

2019 - Aziz et al. analyzed Spark's resource allocation, emphasizing machine learning's impact on performance, offering practical tuning advice. Their findings, specific to certain setups, may have limited wider applicability. They conclude that optimal allocation significantly enhances Spark's performance, particularly noting the role of RDDs' persistence [53] .

Paper [54] proposes Dynamic Resource Allocation (DRA) and Energy Saving techniques using VM live migration in OpenStack. These methods aim to enhance VM efficiency and reduce energy consumption in physical machines, achieving approximately 39.89% energy savings. However, scalability and reliance on OpenStack are potential challenges. The study demonstrates that integrating DRA with energy-saving approaches significantly enhances energy efficiency and resource utilization in cloud environments.

2019 - Guo et al. utilized stochastic dynamic models for backup resource provisioning in cloud computing. Their comprehensive and practical approach, validated on Amazon EC2, provides efficient strategies for SLA formulation and resource management in cloud data centers [55].

2020 - Fard et al. conducted a systematic review of resource allocation mechanisms in cloud computing. They offered a detailed classification and analysis of various strategies. However, the rapid evolution of cloud computing could quickly outdate some methods. The study provides a detailed overview of the current state of cloud resource allocation, highlighting potential areas for future research [56].

2020 - Shukur et al. examined various approaches and algorithms for resource allocation in cloud computing through virtualization. The study highlights how virtualization impacts cloud resource allocation, network performance, and cost-efficiency. Despite benefits, challenges such as scalability and adaptability in diverse cloud environments were noted. Key findings include that each approach and algorithm contribute to optimizing cloud resource use, balancing loads, and conserving energy [57] [50].

[58] presented a taxonomy focusing on autonomic and elastic resource management in cloud environments. Their study analyzes the design and applications, offering crucial insights for future research and development in cloud computing resource management. It addresses the efficiency and adaptability of current resource management strategies, especially under varying cloud demands. The classification emphasizes the need for more efficient and adaptable resource management solutions in cloud computing.

–Lindsay [2021] et al. conducted a comprehensive review of distributed computing's evolution over six decades, focusing on its development, decentralization, and influences on centralization trends. The paper provides a historical perspective, charting the technological progression and shift towards decentralization in various computing paradigms. However, its broad scope might limit the depth of analysis for each paradigm. Key observations include a trend towards diversification and specialization in distributed systems, especially for low-latency tasks, and the adaptation to challenges like increasing complexity and technological constraints such as the end of Moore's Law [59].

[60] focused on the application of machine learning in cloud resource management. Their study offers a thorough analysis of current practices and outlines potential directions for future research. They identify those inefficiencies in Virtual Machine Placement (VMP) lead to significant resource wastage and increased operational costs. The paper provides an in-depth insight into cloud resource management, particularly emphasizing the applications and implications of machine learning in this field.

2022 - Yu et al. introduced a novel approach to cloud resource scheduling using deep reinforcement learning, specifically tailored for distributed services with a focus on container-based models and algorithms [61]. Their work offers a detailed and innovative perspective on resource scheduling, potentially increasing efficiency in cloud service operations. However, the complexity of implementation and the need for adaptability in various cloud environments present significant challenges. The study demonstrates the effectiveness of deep reinforcement learning in cloud scheduling, notably improving both reliability and efficiency of cloud services [62].

[63] focused on the analysis of scheduling within cloud computing, particularly emphasizing the application of machine learning. Their study provides a comprehensive overview of the various challenges associated with resource scheduling in cloud environments. They acknowledge that rapid advancements in cloud technology may render some earlier concepts obsolete. The paper advocates for the use of machine learning as a key tool for intelligent scheduling, addressing the complexities inherent in modern cloud computing scenarios.

[64] conducted a review focusing on distributed intelligence across the Edge-to-Cloud continuum, delving into aspects of Machine Learning and Data Analytics. Their paper presents a comprehensive overview of distributed intelligence technologies, outlining the key challenges faced and potential directions for future research. They note that the rapid evolution of technology in this field might constrain the scope of their study and affect the longevity of its findings. The study emphasizes the critical need for continued research in

performance optimization and the efficient deployment of machine learning and data analytics within the realm of distributed computing.

2022 - Debauche et al. employed a systematic review methodology to compare various computing architectures within the context of Agriculture 4.0. Their study assesses the suitability, adaptability, and potential for industrial transition of Collaborative Computing models in agriculture. However, they acknowledge potential biases in source selection and the rapid evolution of technology, which might limit the relevance of their findings over time. The abstract of their paper provides a comparative analysis of different architectures in Agriculture 4.0, evaluating them against eight specific criteria and discussing the advantages and disadvantages of each [65].

[66] conducted an in-depth study on dynamic resource allocation (DRA) in cloud computing, reviewing a range of approaches, scheduling techniques, and optimization metrics. The paper effectively reviews and clarifies various DRA methods, providing a detailed categorization of scheduling and optimization techniques pivotal in the evolution of cloud computing. However, it is noted that the study primarily consolidates existing knowledge and lacks empirical testing of these methods, offering no new data or groundbreaking methodologies. The paper concludes that DRA in cloud computing encompasses heuristic, numerical, and learning methods, underscoring the importance of efficiency, scalability, and adaptability within cloud environments.

The study [67] presents a novel integration of machine learning, task scheduling, and NSUPREME encryption to enhance security in cloud computing. The approach not only optimizes resource usage and reduces power consumption but also significantly improves the responsiveness of cloud computing systems. Despite its advantages, the study recognizes challenges in adaptability due to rapidly changing technologies in the field. The findings demonstrate that this hybrid approach, combining machine learning with advanced scheduling techniques, outperforms existing methods in cloud resource management, marking a significant advancement in the efficiency and security of cloud computing operations.

Research by [68] proposes an AI-centric, data-driven Resource Management System (RMS) model designed for resource management in distributed computing systems. The study highlights how AI-driven resource management significantly enhances efficiency and adaptability within complex computing environments. However, it acknowledges the challenges associated with implementing AI-centric solutions in diverse and varying environments. The findings of the study demonstrate the feasibility and potential of AI-centric approaches in the context of modern computing, suggesting promising directions for future research in this field.

Conducted an examination of resource allocation algorithms across different computing environments, including cloud computing and cellular networks. Their work provides a comprehensive comparison of a variety of algorithms, along with their respective applications and the environments in which they are implemented. The study goes beyond mere comparison, offering a critical evaluation of these resource allocation algorithms. It delves into the strengths and weaknesses of each algorithm and discusses the factors that influence their performance. This critical assessment aids in understanding the effectiveness and suitability of these algorithms in different contexts [69].

2023 - Ilager et al., in their study marked as n.d.-b, delve into AI-centric resource management within distributed systems, emphasizing data-driven solutions and AI-based systems. Their research underscores the feasibility and advantages of AI-centric methods in distributed computing, particularly noting improvements in efficiency and adaptability. However, they caution that the rapid evolution of technology could potentially impact the long-term relevance of their findings. The study highlights the significant role of AI in enhancing resource management, pointing out its practical applications and suggesting directions for future research in this rapidly advancing area [70].

[71]introduced an innovative method for cloud resource allocation, utilizing fuzzy meta-heuristics that integrate Takagi–Sugeno–Kang (TSK) neural-fuzzy systems with ant colony optimization (ACO). This approach primarily targets enhancing energy efficiency and optimizing virtual machine (VM) migration processes. The method adeptly combines fuzzy logic and ACO, leading to more efficient cloud resource prediction and allocation, significantly reducing energy consumption while boosting overall system efficiency. However, the complexity of this proposed method poses potential challenges in practical implementation, especially in large-scale systems, and its real-world application might vary from the results observed in theoretical simulations. Nevertheless, simulation results indicate a notable reduction in energy usage and an improvement in resource allocation efficiency, demonstrating the effective integration of neural-fuzzy systems with ACO in the realm of cloud computing.

D. Discussion and Comparison

The collection of reviewed works presents a comprehensive exploration of various aspects of resource management in cloud and distributed computing, highlighting advancements and challenges from 2017 to 2023. These studies collectively underscore the evolving landscape of cloud and distributed computing, emphasizing the role of machine learning, AI, and innovative algorithms in enhancing efficiency, security, and adaptability, while also acknowledging the challenges posed by rapid technological advancements and implementation complexities.

Table 1 provides a comprehensive overview of research studies, organized into six columns: Author, Year, Techniques/Methodology, Strengths/Benefits, Weaknesses/Limitations, and Key Findings/Results. It provides basic bibliographic information, outlines research methods, offers a balanced perspective, and summarizes the main research outcomes.

Table 1. Comparative Analysis of Research Studies in Distributed Systems and Cloud Resource Management

Author/ years	Techniques/ Methodology	Strengths/Benefits	Weaknesses/Limitations	Key findings/ results
[52] **2017**	Systematic review of 110+ publications on cloud resource	Paper develops taxonomy for cloud resource management,	Limitations include scope and potential biases in selected articles for systematic	Paper finds gaps in security, dynamic resource allocation, proposes taxonomy for

	management, chosen from journals and conferences.	quantitatively assessing solutions and future challenges.	reviews.	heterogeneous, multicloud, and data-intensive environments.
[53] 2019	Analyzes Spark's resource allocation, focusing on machine learning's performance impact.	Offers detailed evaluations and advice for Apache Spark resource tuning.	Findings specific to tested setups, potentially limiting broader applicability.	Optimal resource allocation boosts Spark's performance, highlighting RDDs' persistence role.
[54] 2019	Paper suggests DRA and Energy Saving methods using VM live migration in OpenStack.	Methods focus on efficient VM use and cutting physical machine energy use, saving ~39.89%.	Scalability issues and dependency on OpenStack infrastructure may arise.	Study shows combining DRA with energy-saving methods effectively saves energy and improves resource use in clouds.
[55] 2019	Uses stochastic dynamic models for backup resource provisioning in cloud computing.	Comprehensive, practical approach validated on Amazon EC2.		Offers guidelines for efficient SLA creation and resource management in cloud data centers.
[56] 2020	Conducts systematic review of cloud computing resource allocation mechanisms.	Offers detailed classification and analysis of diverse resource allocation strategies.	Rapid cloud computing evolution may quickly date some methods.	Details current cloud computing resource allocation state, suggesting future research areas.
[57] 2020	Examines approaches and algorithms for cloud computing resource allocation via virtualization.	Shows virtualization's impact on cloud resource allocation, network performance, and cost-efficiency.	Challenges include scalability and adaptability in diverse cloud environments.	Study reveals each approach and algorithm optimizes cloud resource use, balances load, and saves energy.
[58] 2021	Presents taxonomy of autonomic, elastic resource management in clouds, analyzing design and applications	Provides key insights for future cloud computing resource management research and development.	Addresses efficiency and adaptability of current resource management in fluctuating cloud demands.	Classifies resource management in cloud computing, emphasizing efficiency and adaptability needs.
[59] 2021	Reviews six-decade evolution of distributed computing, exploring	Paper gives historical view of distributed computing, its technological	Broad scope may restrict in-depth analysis of each distributed computing paradigm.	Paper notes trend in diversifying, specializing distributed systems for low-latency tasks, scaling

	development, decentralization, and influences on centralization trends.	progression, and shift towards decentralization across various paradigms.		complexity, and adapting to technological limits like Moore's Law's end.
[60] **2022**	Machine learning for resource management in cloud settings.	Offers thorough analysis and outlines future research directions	VMP inefficiency causes resource waste and higher operational costs.	In-depth insight into cloud resource management, focusing on machine learning applications.
[62] **2022**	Introduces deep reinforcement learning-based cloud resource scheduling for distributed services, with a novel container-focused model and algorithm.	Offers a detailed and innovative approach to resource scheduling, potentially enhancing efficiency in cloud services.	However, implementation complexity and adaptability to diverse cloud environments pose challenges.	Shows deep reinforcement learning's effectiveness in cloud scheduling, enhancing reliability and efficiency.
[63] **2022**	Analyzes scheduling in cloud computing, emphasizing machine learning application.	Offers a detailed overview of resource scheduling challenges in cloud computing.	Advancements in cloud technology could surpass earlier ideas.	Machine learning proposed for intelligent scheduling in complex cloud computing.
[64] **2022**	Reviews distributed intelligence in Edge-to-Cloud, covering Machine Learning and Data Analytics.	Offers overview of distributed intelligence tech, with key challenges and future research directions.	Rapid tech evolution in the field may limit the study's scope and findings' longevity.	Emphasizes the need for research in optimizing performance and efficient deployment of machine learning and data analytics in distributed computing.
[65] **2022**	Used systematic review to compare architectures in Agriculture 4.0 context.	Collaborative Computing in Agriculture 4.0, assessing suitability, adaptability, and industrial transition.	Biases in source selection and technology's rapid evolution may date some findings.	Abstract compares architectures in Agriculture 4.0 on eight criteria, analyzing each's pros and cons.
[66] **2022**	Paper studies dynamic resource allocation in cloud computing, reviewing various approaches, scheduling, and optimization metrics.	Reviews and clarifies DRA methods, identifying and categorizing scheduling and optimization techniques in cloud computing evolution.	Lacks empirical testing of methods, primarily consolidates existing knowledge without new data or methods.	Paper shows cloud computing's DRA includes heuristic, numerical, and learning methods, stressing efficiency, scalability, and adaptability in cloud environments.

[67] **2022**	a shared-memory parallel processing method	Method improves system control and speed in diverse multicore setups.	potential issues include complex management and hardware reliance	More cores in multicore systems reduce execution time, boost OS performance
[68] **2023**	Proposes AI-centric, data-driven RMS model for resource management in distributed systems.	AI-driven resource management enhances efficiency and adaptability in complex computing environments.	AI-centric solutions face challenges in diverse environment implementation.	Shows AI-centric approaches' feasibility and potential in modern computing, hinting at future research paths.
[69] **2023**	Examines resource allocation algorithms in environments like cloud computing and cellular networks.	Provides a broad comparison of various algorithms, applications, and environments.		Critically evaluates resource allocation algorithms, highlighting strengths, weaknesses, and performance factors.
[70] **2023**	AI-centric resource management in distributed systems with data-driven solutions and AI-based systems.	Highlights AI-centric methods' feasibility and benefits in distributed computing for efficiency and adaptability.	Technology's fast evolution may affect the findings' relevance.	AI's role in improving resource management highlighted, with practical applications and future research directions.
[71] **2023**	Proposes fuzzy meta-heuristics for cloud resource allocation, combining TSK neural-fuzzy systems and ACO, focusing on energy efficiency and VM migration.	Method integrates fuzzy logic and ACO for efficient cloud resource prediction and allocation, reducing energy consumption, and improving overall efficiency.	Proposed method's complexity may challenge practical implementation, especially in large systems; real-world application may differ from theoretical simulations.	Method shows in simulations reduced energy use, improved resource allocation efficiency, and effective integration of neural-fuzzy systems with ACO in cloud computing.

E. Extracted Statistics

The research spans from 2017 to 2023, beginning with the identification of gaps in cloud resource management, particularly in security and dynamic allocation. Studies in 2019 and 2020 address these challenges with energy-efficient DRA and guidelines for resource management. The role of machine learning and AI becomes prominent in 2022 and 2023, with insights into intelligent scheduling, performance optimization, and the introduction of innovative methods like deep reinforcement learning and neural-fuzzy systems. Recommendations and classifications for efficient resource management emerge in

2020 and 2021, while 2021 and 2022 also bring attention to specific fields like distributed systems and Agriculture 4.0. The research concludes in 2023 with evaluations of resource allocation algorithms and the potential of AI-centric approaches, highlighting the continuous evolution in cloud and distributed computing and the critical need for ongoing research and development.

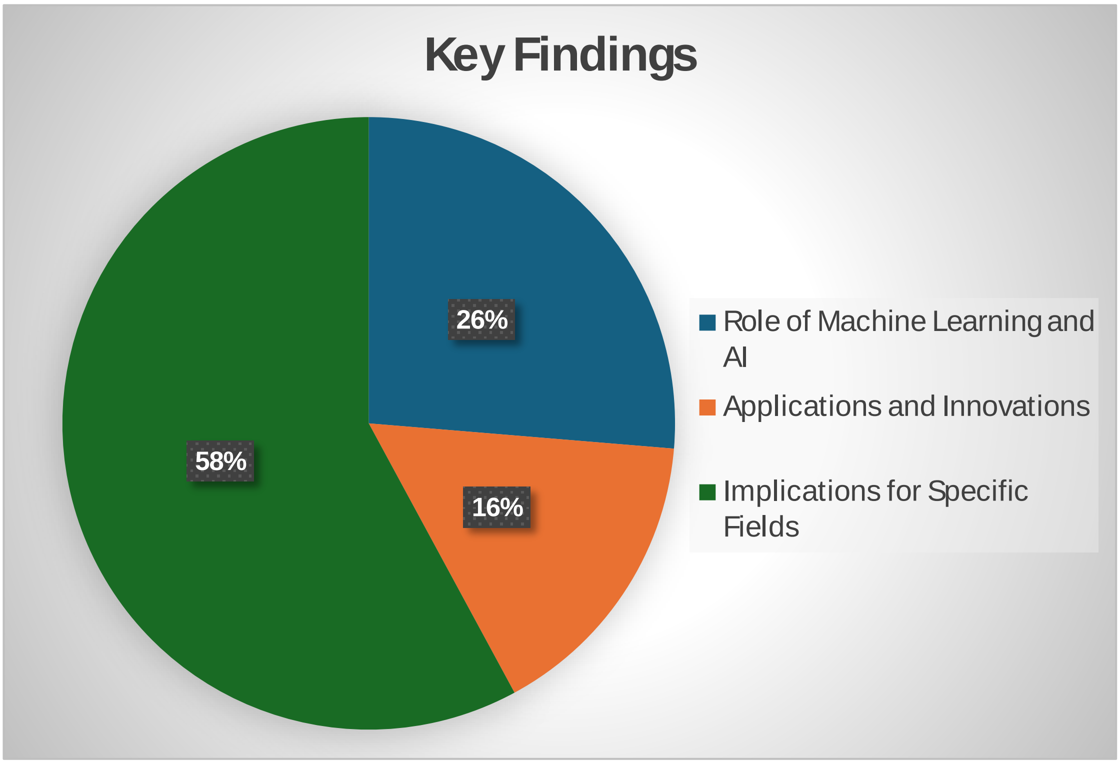

Figure 3. Thematic Distribution of Research Articles in Cloud Resource Management (2017-2023).

The chart in the document represents a distribution of 19 research articles related to cloud resource management, categorized into three main areas of focus:

Role of Machine Learning and AI: Out of the 19 articles, 5 are dedicated to exploring the role of machine learning and artificial intelligence in cloud resource management. This signifies a substantial interest in how AI and machine learning technologies are shaping the landscape of cloud computing, specifically in the context of resource management. Applications and Innovations: 3 of the 19 articles delve into applications and innovations in the field. This category likely covers new technologies, methods, or innovative approaches being developed and applied in cloud resource management, showcasing the advancements and novel solutions in the domain.

Implications for Specific Fields: The largest category, with 11 articles, focuses on the implications of cloud resource management in specific fields or industries. This indicates a broad and diverse range of applications and impacts of cloud computing advancements across various sectors, highlighting how these innovations are being applied and the consequences they have in different contexts.

In a comprehensive overview of advancements in cloud and distributed computing from 2017 to 2023, the papers collectively emphasize a diverse range of methodologies and techniques. Key focuses include systematic reviews of cloud resource management and allocation mechanisms, highlighting the evolution of technologies and methodologies over the years. A significant portion of the research concentrates on integrating machine learning and AI into resource management, aiming to optimize performance, efficiency, and security. Techniques such as dynamic resource allocation, deep reinforcement learning, and the use of fuzzy meta-heuristics demonstrate innovative approaches to enhance cloud computing efficiency, particularly in VM efficiency, energy saving, and resource scheduling. Overall, these studies reflect a dynamic and evolving field, increasingly relying on sophisticated algorithms and AI-driven strategies to address the complexities of modern cloud and distributed computing environments.

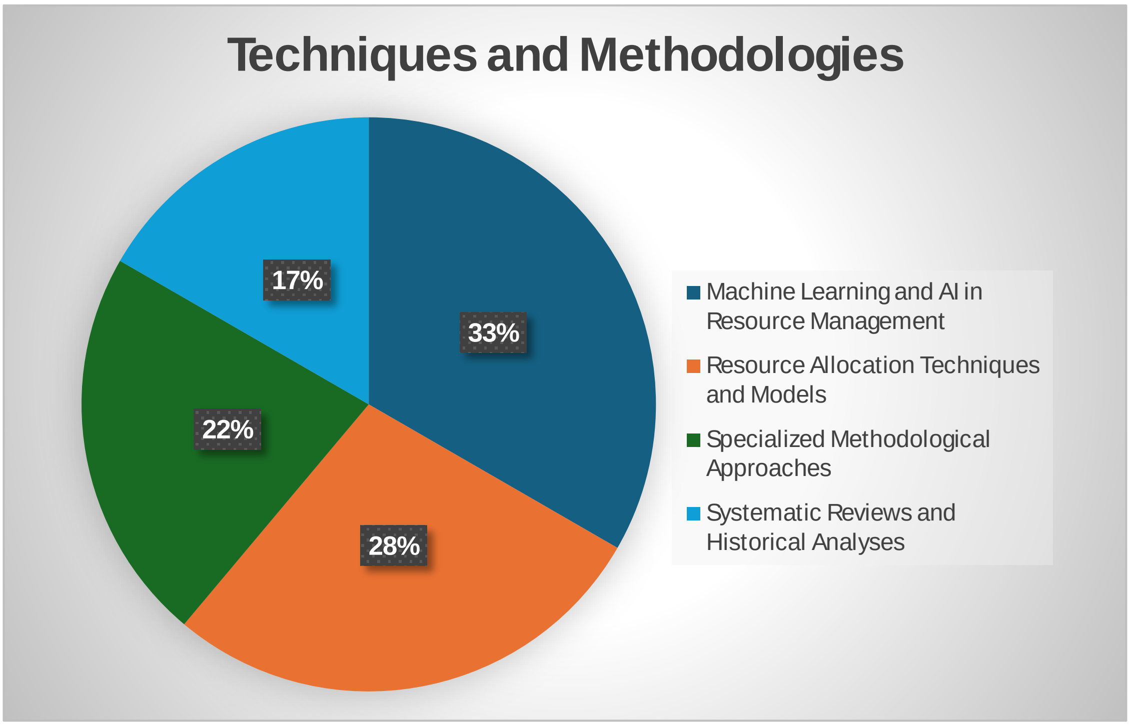

Figure 4. Techniques and Methodologies in Cloud and Distributed Systems: A 2017-2023 Perspective.

In the domain of cloud and distributed computing research, the categorization and analysis of various scholarly papers reveal distinct focus areas, each represented by a specific number of studies. Firstly, the category of "Systematic Reviews and Historical Analyses" comprises 4 papers, reflecting a scholarly interest in comprehensive overviews and historical perspectives of cloud computing's evolution. The second category, "Machine Learning and AI in Resource Management," is the most prominent, with 6 papers. This underscores a significant trend towards integrating advanced technologies like machine learning and artificial intelligence in managing cloud resources. The third category, "Resource Allocation Techniques and Models," includes 5 papers, indicating a strong research focus on developing and refining methods for efficient resource distribution in cloud environments. Lastly, the "Specialized Methodological Approaches" category, also comprising 4 papers, highlights research dedicated to specific, innovative techniques and models in cloud computing. Collectively, these counts not only offer a quantitative overview of the research landscape but also qualitatively underscore the diverse methodologies and thematic areas that are shaping the field of cloud and distributed computing.

F. Recommendations

In the rapidly evolving field of cloud and distributed computing, two pivotal recommendations stand out for driving future progress. Firstly, a significant emphasis should be placed on integrating artificial intelligence (AI) and machine learning technologies. This integration is crucial as it promises to significantly enhance the efficiency and security of cloud computing environments. By leveraging AI, cloud systems can become more adaptive and intelligent, leading to optimized resource management and improved performance. Secondly, the development of dynamic and adaptive resource management strategies is essential. Such strategies will allow cloud systems to efficiently adapt to fluctuating demands and workloads, ensuring optimal resource utilization. This focus on adaptability not only improves the overall efficiency of cloud services but also ensures their scalability and reliability, catering to the growing and diverse needs of modern digital infrastructures.

G. Conclusion

The papers reviewed from 2017 to 2023 present a comprehensive and evolving landscape of research in the field of cloud computing and distributed systems, each contributing significantly to our understanding and capabilities in these areas. continuously pushing the boundaries of what's possible in cloud computing and distributed systems. These studies collectively underscore the importance of innovative approaches to resource management, Highlighting the significant potential of advanced computational technologies to revolutionize distributed systems and cloud computing resource management. They also bring to light the critical balance between advancing technology and addressing practical implementation challenges, ensuring that these solutions are not only theoretically sound but also viable in real-world applications. As we move forward, the insights from these papers will undoubtedly guide future research and development, shaping the next generation of cloud computing and distributed system technologies.

H. References

[1] B. N. Taha, “Distributed And Cloud Systems Influences On Pattern Matching Techniques”, 2023.

[2] Z. S. Ageed and S. R. M. Zeebaree, “Distributed Systems Meet Cloud Computing: A Review of Convergence and Integration,” International Journal of Intelligent Systems and Applications in Engineering, vol. 12, no. 11s, pp. 469–490, 2024.

[3] S. Koehler, H. Desamsetti, V. K. R. Ballamudi, and S. Dekkati, “Real World Applications of Cloud Computing: Architecture, Reasons for Using, and Challenges,” Asia Pacific Journal of Energy and Environment, vol. 7, no. 2, pp. 93–102, 2020.

[4] S. R. Swain, A. K. Singh, and C. N. Lee, “Efficient resource management in cloud environment,” arXiv preprint arXiv:2207.12085, 2022.
[5] A. Sunyaev and A. Sunyaev, “Cloud computing,” Internet Computing: Principles of Distributed Systems and Emerging Internet-Based Technologies, pp. 195–236, 2020.
[6] I. M. I. Zebari, S. R. M. Zeebaree, and H. M. Yasin, “Real time video streaming from multi-source using client-server for video distribution,” in 2019 4th Scientific International Conference Najaf (SICN), IEEE, 2019, pp. 109–114.
[7] R. Mahajan, P. R. Patil, M. Shahakar, and A. Potgantwar, “An Analytical Evaluation of Various Approaches for Load Optimization in Distributed System,” International Journal of Intelligent Systems and Applications in Engineering, vol. 12, no. 1s, pp. 526–548, 2024.
[8] S. T. Siddiqui, S. Alam, Z. A. Khan, and A. Gupta, “Cloud-based e-learning: using cloud computing platform for an effective e-learning,” in Smart innovations in communication and computational sciences: proceedings of ICSICCS-2018, Springer, 2019, pp. 335–346.
[9] P. Y. Abdullah, S. R. 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, no. 04, p. 04, 2020.
[10] S. Giri and S. Shakya, “Cloud computing and data security challenges: A Nepal case,” International Journal of Engineering Trends and Technology, vol. 67, no. 3, p. 146, 2019.
[11] M. Attaran and J. Woods, “Cloud computing technology: improving small business performance using the Internet,” Journal of Small Business & Entrepreneurship, vol. 31, no. 6, pp. 495–519, 2019.
[12] D. C. Marinescu, Cloud computing: theory and practice. Morgan Kaufmann, 2022.
[13] V. Premnath and M. Vetrivel, “Energy Efficient Search Scheme Over Encrypted Data On Mobile Users On Cloud,” South Asian Journal of Engineering and Technology, vol. 8, no. 2, pp. 217–222, 2019.
[14] Ltd. Huawei Technologies Co., “Virtualization Technology,” in Cloud Computing Technology, Springer, 2022, pp. 97–144.
[15] S. R. M. 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, no. 4, pp. 1555–1564, 2020.
[16] M. E. Suliman and K. S. A. Madinah, “A brief analysis of cloud computing Infrastructure as a Service (IaaS),” International Journal of Innovative Science and Research Technology–IJISRT, vol. 6, no. 1, pp. 1409–1412, 2021.
[17] F. Wulf, T. Lindner, S. Strahringer, and M. Westner, “IaaS, PaaS, or SaaS? The Why of Cloud Computing Delivery Model Selection: Vignettes on the Post-Adoption of Cloud Computing,” in Proceedings of the 54th Hawaii International Conference on System Sciences, 2021, 2021, pp. 6285–6294.
[18] H. Malallah et al., “A comprehensive study of kernel (issues and concepts) in different operating systems,” Asian Journal of Research in Computer Science, vol. 8, no. 3, pp. 16–31, 2021.
[19] H. B. Patel and N. Kansara, “Cloud Computing Deployment Models: A Comparative Study,” International Journal of Innovative Research in Computer Science & Technology (IJIRCST), 2021.

[20] A. P. Rajan, "A review on serverless architectures-function as a service (FaaS) in cloud computing," Telkomnika (Telecommunication Computing Electronics and Control), vol. 18, no. 1, pp. 530–537, 2020.
[21] A. E. Oke, A. F. Kineber, I. Al-Bukhari, I. Famakin, and C. Kingsley, "Exploring the benefits of cloud computing for sustainable construction in Nigeria," Journal of Engineering, Design and Technology, vol. 21, no. 4, pp. 973–990, 2023.
[22] S. A. Bello et al., "Cloud computing in construction industry: Use cases, benefits and challenges," Autom Constr, vol. 122, p. 103441, 2021.
[23] R. Kollolu, "Infrastructural constraints of Cloud computing," International Journal of Management, Technology and Engineering, vol. 10, pp. 255–260, 2020.
[24] S. R. Zeebaree, "DES encryption and decryption algorithm implementation based on FPGA," Indones. J. Electr. Eng. Comput. Sci, vol. 18, no. 2, pp. 774–781, 2020.
[25] M. Norman et al., "CloudBank: Managed Services to Simplify Cloud Access for Computer Science Research and Education," in Practice and Experience in Advanced Research Computing, 2021, pp. 1–4.
[26] O. Anicho and T. Abdullah, "Impact of Cloud-based Infrastructure on Telecom Managed Services Models," Data Science: Journal of Computing and Applied Informatics, vol. 4, no. 2, pp. 71–88, 2020.
[27] S. El Kafhali, I. El Mir, K. Salah, and M. Hanini, "Dynamic scalability model for containerized cloud services," Arab J Sci Eng, vol. 45, pp. 10693–10708, 2020.
[28] M. N. Abdullah and W. S. Bhaya, "Predication of Quality of Service (QoS) in Cloud Services: A Survey," in Journal of Physics: Conference Series, IOP Publishing, 2021, p. 012049.
[29] Z. N. Rashid, S. R. M. Zeebaree, R. R. Zebari, S. H. Ahmed, H. M. Shukur, and A. Alkhayyat, "Distributed and Parallel Computing System Using Single-Client Multi-Hash Multi-Server Multi-Thread," in 2021 1st Babylon International Conference on Information Technology and Science (BICITS), IEEE, 2021, pp. 222–227.
[30] D. Sitaram and G. Manjunath, "Chapter 9 - Related Technologies," in Moving To The Cloud, D. Sitaram and G. Manjunath, Eds., Boston: Syngress, 2012, pp. 351–387. doi: https://doi.org/10.1016/B978-1-59749-725-1.00009-3.
[31] H. Shukur, S. Zeebaree, R. Zebari, O. Ahmed, L. Haji, and D. Abdulqader, "Cache coherence protocols in distributed systems," Journal of Applied Science and Technology Trends, vol. 1, no. 3, pp. 92–97, 2020.
[32] S. R. M. Zeebaree, A. B. Sallow, B. K. Hussan, and S. M. Ali, "Design and Simulation of High-Speed Parallel/Sequential Simplified DES Code Breaking Based on FPGA," in 2019 International Conference on Advanced Science and Engineering (ICOASE), 2019, pp. 76–81. doi: 10.1109/ICOASE.2019.8723792.
[33] Z. N. Rashid, S. R. M. Zeebaree, M. A. M. 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), IEEE, 2021, pp. 59–64.
[34] D. A. Hasan, B. K. Hussan, S. R. M. Zeebaree, D. M. Ahmed, O. S. Kareem, and M. A. M. Sadeeq, "The impact of test case generation methods on the software performance: A review," International Journal of Science and Business, vol. 5, no. 6, pp. 33–44, 2021.
[35] M. Khaldi, M. Rebbah, B. Meftah, and O. Smail, "Fault tolerance for a scientific workflow system in a cloud computing environment," International Journal of Computers and Applications, vol. 42, no. 7, pp. 705–714, 2020.

[36] M. Wolsink, "Distributed energy systems as common goods: Socio-political acceptance of renewables in intelligent microgrids," Renewable and Sustainable Energy Reviews, vol. 127, p. 109841, 2020.

[37] D. M. ABDULQADER, S. R. M. ZEEBAREE, R. R. ZEBARI, S. A. L. I. SALEH, Z. N. RASHID, and M. A. M. SADEEQ, "SINGLE-THREADING BASED DISTRIBUTED-MULTIPROCESSOR-MACHINES AFFECTING BY DISTRIBUTED-PARALLEL-COMPUTING TECHNOLOGY," Journal of Duhok University, vol. 26, no. 2, pp. 416–426, 2023.

[38] E. M. Portnov, A. K. Myo, A. A. Anisimov, R. A. Kasimov, and K. O. Epishin, "Development of a Method for Managing Resource-Intensive Applications in Distributed Computing Systems," in 2020 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), IEEE, 2020, pp. 2401–2405.

[39] A. Z. A. L. Shaqsi, K. Sopian, and A. Al-Hinai, "Review of energy storage services, applications, limitations, and benefits," Energy Reports, vol. 6, pp. 288–306, 2020.

[40] Z. Wu, J. Sun, Y. Zhang, Z. Wei, and J. Chanussot, "Recent developments in parallel and distributed computing for remotely sensed big data processing," Proceedings of the IEEE, vol. 109, no. 8, pp. 1282–1305, 2021.

[41] A. Chakravorty, W. S. Cleveland, and P. J. Wolfe, "Statistical scalability and approximate inference in distributed computing environments," arXiv preprint arXiv:2112.15572, 2021.

[42] N. Gupta and N. H. Vaidya, "Fault-tolerance in distributed optimization: The case of redundancy," in Proceedings of the 39th Symposium on Principles of Distributed Computing, 2020, pp. 365–374.

[43] A. B. Klimenko, "Distributed Data Proceeding Systems Architectures Resource Efficiency Improvement on the Basis of Apriory Data about the Jobs Late Completion Times," Юго-Западного государственного университета, p. 125, 2023.

[44] F. Es-Sabery and A. Hair, "Big data solutions proposed for cluster computing systems challenges: A survey," in Proceedings of the 3rd International Conference on Networking, Information Systems & Security, 2020, pp. 1–7.

[45] S. M. Mohammed, K. Jacksi, and S. Zeebaree, "A state-of-the-art survey on semantic similarity for document clustering using GloVe and density-based algorithms," Indonesian Journal of Electrical Engineering and Computer Science, vol. 22, no. 1, pp. 552–562, 2021.

[46] M. Rahmany, A. Sundararajan, and A. Zin, "A review of desktop grid computing middlewares on non-dedicated resources," J. Theor. Appl. Inf. Technol, vol. 98, no. 10, pp. 1654–1663, 2020.

[47] S. R. M. Zeebaree et al., "Multicomputer multicore system influence on maximum multi-processes execution time," TEST Engineering & Management, vol. 83, no. 03, pp. 14921–14931, 2020.

[48] L. M. Haji, S. R. M. Zeebaree, O. M. Ahmed, M. A. M. Sadeeq, H. M. Shukur, and A. Alkhavvat, "Performance Monitoring for Processes and Threads Execution-Controlling," in 2021 International Conference on Communication & Information Technology (ICICT), IEEE, 2021, pp. 161–166.

[49] Y. S. Jghef, S. R. M. Zeebaree, Z. S. Ageed, and H. M. Shukur, "Performance Measurement of Distributed Systems via Single-Host Parallel Requesting using (Single, Multi and Pool) Threads," in 2022 3rd Information Technology To Enhance e-learning and Other Application (IT-ELA), IEEE, 2022, pp. 38–43.

[50] M. A. M. Sadeeq and S. R. M. Zeebaree, "Design and implementation of an energy management system based on distributed IoT," Computers and Electrical Engineering, vol. 109, p. 108775, 2023.
[51] A. Mamonov, R. Varlamov, and S. Salpagarov, "Computing Load Distribution by Using Peer-to-Peer Network," in Distributed Computer and Communication Networks: Control, Computation, Communications: 23rd International Conference, DCCN 2020, Moscow, Russia, September 14-18, 2020, Revised Selected Papers 23, Springer, 2020, pp. 521–532.
[52] N. M. Gonzalez, T. C. M. de B. Carvalho, and C. C. Miers, "Cloud resource management: towards efficient execution of large-scale scientific applications and workflows on complex infrastructures," Journal of Cloud Computing, vol. 6, no. 1. Springer Verlag, Dec. 01, 2017. doi: 10.1186/s13677-017-0081-4.
[53] K. Aziz, D. Zaidouni, and M. Bellafkih, "Leveraging resource management for efficient performance of Apache Spark," J Big Data, vol. 6, no. 1, Dec. 2019, doi: 10.1186/s40537-019-0240-1.
[54] C. T. Yang, S. T. Chen, J. C. Liu, Y. W. Chan, C. C. Chen, and V. K. Verma, "An energy-efficient cloud system with novel dynamic resource allocation methods," Journal of Supercomputing, vol. 75, no. 8, pp. 4408–4429, Aug. 2019, doi: 10.1007/s11227-019-02794-w.
[55] Z. Guo, J. Li, and R. Ramesh, "Optimal management of virtual infrastructures under flexible cloud service agreements," Information Systems Research, vol. 30, no. 4, pp. 1424–1446, 2019, doi: 10.1287/isre.2019.0871.
[56] M. V. Fard, A. Sahafi, A. M. Rahmani, and P. S. Mashhadi, "Resource allocation mechanisms in cloud computing: A systematic literature review," IET Software, vol. 14, no. 6. Institution of Engineering and Technology, pp. 638–653, Dec. 01, 2020. doi: 10.1049/iet-sen.2019.0338.
[57] H. Shukur, S. Zeebaree, R. Zebari, D. Zeebaree, O. Ahmed, and A. Salih, "Cloud computing virtualization of resources allocation for distributed systems," Journal of Applied Science and Technology Trends, vol. 1, no. 3, pp. 98–105, 2020.
[58] M. A. N. Saif, S. K. Niranjan, and H. D. E. Al-ariki, "Efficient autonomic and elastic resource management techniques in cloud environment: taxonomy and analysis," Wireless Networks, vol. 27, no. 4, pp. 2829–2866, May 2021, doi: 10.1007/s11276-021-02614-1.
[59] D. Lindsay, S. S. Gill, D. Smirnova, and P. Garraghan, "The evolution of distributed computing systems: from fundamental to new frontiers," Computing, vol. 103, no. 8, pp. 1859–1878, Aug. 2021, doi: 10.1007/s00607-020-00900-y.
[60] S. R. Swain, A. K. Singh, and C. N. Lee, "Efficient Resource Management in Cloud Environment," Jun. 2022, [Online]. Available: http://arxiv.org/abs/2207.12085
[61] N. A. Kako, "DDLS: Distributed Deep Learning Systems: A Review," Turkish Journal of Computer and Mathematics Education (TURCOMAT), vol. 12, no. 10, pp. 7395–7407, 2021.
[62] L. Yu, P. S. Yu, Y. Duan, and H. Qiao, "A resource scheduling method for reliable and trusted distributed composite services in cloud environment based on deep reinforcement learning," Front Genet, vol. 13, Oct. 2022, doi: 10.3389/fgene.2022.964784.
[63] W. Khallouli and J. Huang, "Cluster resource scheduling in cloud computing: literature review and research challenges," Journal of Supercomputing, vol. 78, no. 5, pp. 6898–6943, Apr. 2022, doi: 10.1007/s11227-021-04138-z.

[64] D. Rosendo, A. Costan, P. Valduriez, and G. Antoniu, “Distributed intelligence on the Edge-to-Cloud Continuum: A systematic literature review,” J Parallel Distrib Comput, vol. 166, pp. 71–94, Aug. 2022, doi: 10.1016/j.jpdc.2022.04.004.

[65] O. Debauche, S. Mahmoudi, P. Manneback, and F. Lebeau, “Cloud and distributed architectures for data management in agriculture 4.0: Review and future trends,” Journal of King Saud University - Computer and Information Sciences, vol. 34, no. 9. King Saud bin Abdulaziz University, pp. 7494–7514, Oct. 01, 2022. doi: 10.1016/j.jksuci.2021.09.015.

[66] A. Belgacem, “Dynamic resource allocation in cloud computing: analysis and taxonomies,” Computing, vol. 104, no. 3, pp. 681–710, Mar. 2022, doi: 10.1007/s00607-021-01045-2.

[67] L. M. Haji, S. R. M. Zeebaree, Z. S. Ageed, O. M. Ahmed, M. A. M. Sadeeq, and H. M. Shukur, “Performance Monitoring and Controlling of Multicore Shared-Memory Parallel Processing Systems,” in 2022 3rd Information Technology To Enhance e-learning and Other Application (IT-ELA), IEEE, 2022, pp. 44–48.

[68] S. Ilager, R. Muralidhar, and R. Buyya, “Artificial Intelligence (AI)-Centric Management of Resources in Modern Distributed Computing Systems Artificial Intelligence (AI)Centric Management of Resources in Modern Distributed Computing Systems.” [Online]. Available: https://www.researchgate.net/publication/342093888

[69] K. Wns Hamaali, K. Wns HamaAli, and S. R. M Zeebaree, “Resources Allocation for Distributed Systems: A Review”, doi: 10.5281/zenodo.4462088.

[70] S. Ilager, R. Muralidhar, and R. Buyya, “Artificial Intelligence (AI)-Centric Management of Resources in Modern Distributed Computing Systems Artificial Intelligence (AI)Centric Management of Resources in Modern Distributed Computing Systems.” [Online]. Available: https://www.researchgate.net/publication/342093888

[71] A. K. Sangaiah, A. Javadpour, P. Pinto, S. Rezaei, and W. Zhang, “Enhanced resource allocation in distributed cloud using fuzzy meta-heuristics optimization,” Comput Commun, vol. 209, pp. 14–25, Sep. 2023, doi: 10.1016/j.comcom.2023.06.018.