



Cloud Computing and Artificial Intelligence: A Scoping Literature Review

Naiema M.A. Mohamed

Computer Department, Faculty of Information Technology, Sirte University, Sirte, Libya

Corresponding author email: naima.musa@su.edu.ly

ARTICLE INFO

Article history:

Received 4 March 2023

Revised 11 April 2023

Accepted 15 April 2023

Available online:

4 May 2023

ABSTRACT

In the past two decades, Cloud Computing (CC) and Artificial Intelligence (AI) technologies have witnessed amazing growth, and the majority of organizations and companies around the world have become more aware of the importance of these technologies. AI and CC together are often referred to as the "AI cloud". Using AI in the cloud can improve cloud performance and efficiency while driving digital transformation in enterprises and making business operations more efficient and strategic, while also providing additional flexibility, agility, and cost savings. As a result, AI helps make the complex processes of the AI cloud better. Academics from different fields of expertise try to solve cloud-related problems; there are an increasing number of studies underway in CC service formation and AI applications. This paper will discuss some theoretical points of view, the impact of using AI in the cloud field, and discover the most important AI techniques used to find solutions to various challenges related to the cloud.

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Keywords: *Cloud Computing, Artificial Intelligence, AI Cloud.*

1. Introduction

AI is one of the most recent fields in science and engineering. There has been a great deal of theoretical progress, particularly in areas such as probabilistic reasoning, machine learning, and computer vision.

There are a few AI-driven security solutions that have already been used in traditional applications for many generations, such as firewalls, automatic intrusion detection systems, encrypted traffic identification, malware detection, and many other applications. Therefore, this would also be very suitable and supportive for ensuring security in cloud-based computation [1].

The ultimate goal of AI is to create a strong AI system that is capable of managing a wide range of activities and tasks in general. The influence that computers have on individuals and society is a key factor when it comes to AI development. Studies are being carried out in this field worldwide, and the optimal goal is to create computers that, in the future, will not interfere with people. Thus, it is guaranteed that AI will continue to be closely scrutinized and that its potential in the upcoming years will be clear. There has been a rapid increase in the number of studies on the composition of CC services due to the problems related to CC that are being addressed by researchers of different expertise. A scoping review on CC service composition is necessary and will help facilitate future research.

This paper intends to contribute to a thorough understanding of CC by looking at the current standards and reference models. In addition, this paper aims to give some theoretical views about the use of AI in the CC field by identifying the CC integration with AI that seems like it could help discover solutions to some issues in CC.

The first section of this paper presents the outline of CC and AI, the second section examines the literature on how AI approaches were employed to advance CC. The recommendations are discussed in the final sections.

2. Overview of CC and AI

Before discussing some of the best aspects of the benefits of AI in cloud computing, the following terms are summarized:

A. Cloud Computing

In recent years, CC has become a new and essential paradigm for computing and is receiving a lot of attention in the carrier computing community. According to the International Institute of Standards and Technology (NIST), the phrase "CC" refers broadly to everything that involves the delivery of hosted services online [2]. In other words, it is a method for running programs and applications, storing associated data in given computer systems, and granting customers or other users access via the Internet [3].

B. Categories of Cloud Computing

There are many ways to categorize cloud computing, but service border and service type are two that are frequently used. Public, private, and hybrid clouds are the three types of clouds that can be categorized from the standpoint of the service border. Services offered to outside parties are referred to as public cloud services. Businesses create and manage their own private clouds. A secure network allows hybrid clouds to share resources between private and public clouds. Examples of hybrid clouds are the Virtual Private Cloud (VPC) services offered by Google and Amazon. Cloud computing can be categorized as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) from the perspective of the service type.

SaaS offers services to customers, but IaaS and PaaS offer services to independent software vendors and developers, leaving room for third-party application developers [4].

C. Hierarchical CC Architecture

This section provides background information on a number of architectural components that create the framework for CC. The CC business model implies two main actors: a cloud service provider (CSP) and a cloud service user (CSU). The CSUs access the applications that the CSPs supply online through web browsers, desktop software, and mobile apps. However, the data and business software are kept at a remote location [5].

A hierarchical structure of CC architecture is shown in Figure 1. From the backside, the figure is quality defined. The system level (the gadget level) is on the backside, which serves as the foundation and spine of the cloud. It comprises a group of data facilities that offer processing power in the cloud environment. At this level, there exist substantial bodily resources such as storage disks, CPUs, and memories.

The virtualization level is located just above the levelling system. The term "virtualization" refers to the component of CC that allows for the separation of applications and services from the underlying physical services. It is accomplished with the aid of a hypervisor, software, or hardware that acts as a link between physical devices and digital applications. This abstraction makes sure that no carrier or application is directly coupled to the hardware resources. User-level middleware consists of software-hosting platforms like Web 2.0 interfaces that enable programmers to design attractive, reasonably priced user interfaces for web-based applications. Additionally, it offers the programming environments and resources

needed to make it simpler to develop, distribute, and run cloud applications. This level seeks to offer PaaS features.

The top user level concentrates, as its name implies, on offering application services by utilizing CC to give clients access to a variety of virtualized resources employing diverse contemporary technologies, for example, Web services, virtualization, and multi-tenancy [5].

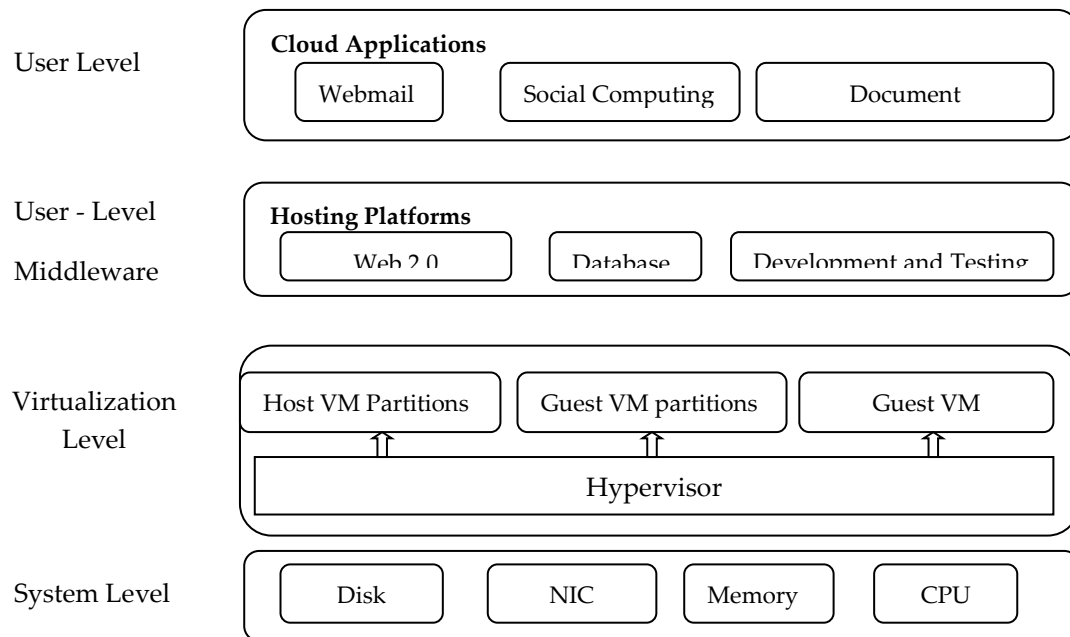


Figure 1: Hierarchical CC Architecture

3. Cloud computing challenges

The current adoption of CC is associated with numerous challenges, including the following:

A. Security

We can define security as a subdomain of computer security and network security, and it also generally includes information security as shown in figure 2. There are significant risks to an organization's data and software from well-known security vulnerabilities, including data loss, phishing, and botnets. Moreover, the multi-tenancy model and the pooled computing resources in CC have introduced new security challenges that require novel techniques to tackle.

For example, hackers can use the cloud to organize a botnet, as the cloud often provides more reliable infrastructure services at a relatively cheaper price for them to start an attack.

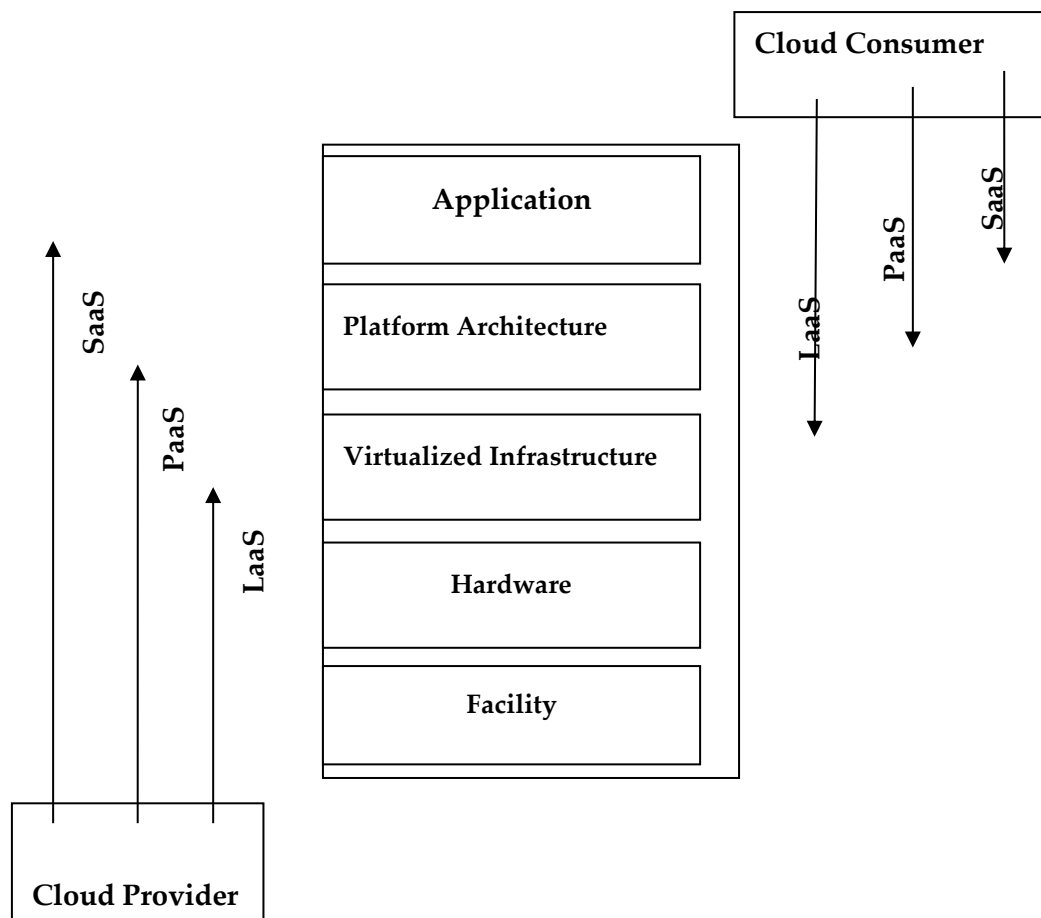


Figure 2: Security aspects of CC infrastructure

The organizations still have security and privacy concerns about moving their data to the cloud. Currently, peripheral functions such as IT management and personal applications are the easiest IT systems to move. In addition, organizations are conservative in employing IaaS compared to SaaS [5].

B. Costing and Charging Model

The three trade-offs that CC users must take into account are computation, communication, and integration. The expense of integrating multitenancy into a SaaS cloud provider's product might be very high. As a result, SaaS providers must consider the trade-off between offering multi-tenancy and the cost benefits it produces, such as decreased overhead through amortization, a decreased number of on-site software licenses, etc. and so, a viable charging model for SaaS providers is imperative for the sustainability and profitability of SaaS cloud providers [6].

C. Service Level Agreement (SLA)

Consumers must guarantee the quality, availability, reliability, and performance of computing resources when moving their core business operations to a trusted cloud. This is known as a service level agreement (SLA). These are often offered via service level agreements that are negotiated between providers and customers.

D. Cloud Interoperability Issue

Currently, each cloud offering has its own way of defining how cloud clients, applications, and users interact with the cloud, leading to the «Hazy Cloud» phenomenon.

There are a number of levels at which interoperability is essential for CC. Second, more often than not, for the purpose of optimization, an organization may need to outsource a number of marginal functions to cloud services offered by different vendors [6].

4. Artificial Intelligence

AI is defined as intelligence exhibited by an artificial entity to solve complex problems, and such a system is generally assumed to be a computer or machine, as shown in figure 3. And also, there is an integration of computer science and physiology. In simple terms, intelligence is the computational part of the ability to achieve goals in the world.

Intelligence is the ability to think, imagine, create, memorize, understand, recognize patterns to make choices, adapt to change, and learn from experience. AI is concerned with making computers behave in a more human-like fashion and in much less time than a human does. The computing world has a lot to gain or benefit from various AI approaches. Their ability to learn by example makes them very flexible and powerful. Furthermore, it does not require devising an algorithm in order to perform a specific task because there is no need to understand the internal mechanisms of that task. Due to their parallel architecture, they have fast response and computation times, which is why they are very suitable for real-time systems. The goal of AI is to create computers whose intelligence equals or surpasses that of humans [7].

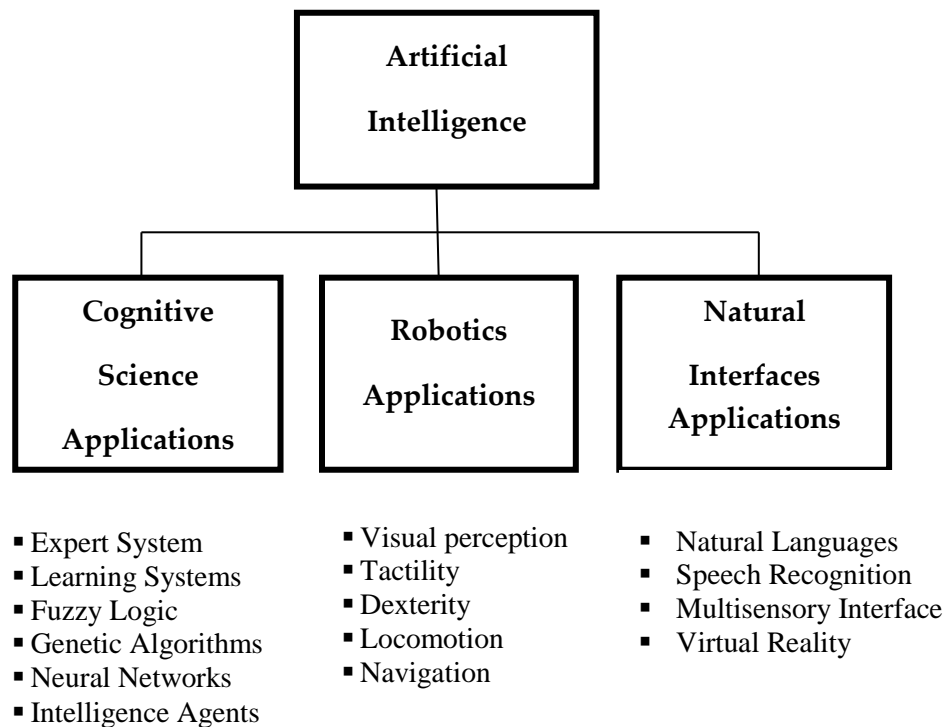


Figure 3: Overview of AI

The 4th Industrial Revolution is a new era of innovation in technology influenced by AI-driven technology. Industry 4.0 is a term used to describe the present trend of automation and data exchange, which includes cyber-physical systems, the Internet of Things, cloud computing, and cognitive computing, as well as the development of the smart factory [8].

5. Benefits and Drawbacks of CC and AI

Owing to the adoption of new digital transformation strategies, technologies like cloud and AI have been thriving in industry. They are the two most emerging technologies in the present era. Combined, they can create a revolution and improve the lives of individuals in different ways.

Merging CC technology with AI is an essential part of the modern world's business and commerce. It creates a seamless, flexible environment, allowing better data management to improve business decisions.

Productivity in the cloud is increased by automating routine tasks within the IT infrastructure using AI. They work together, and the outcome is a vast network that can store massive amounts of data while constantly learning and growing.

The best public cloud service providers, like Google Cloud Vertex AI, Microsoft Azure AI, IBM Watson, and the AWS AI services portfolio, have tools that make advanced AI and machine learning capabilities more accessible to businesses.

Services provided by AI projects are speech, vision, text analytics, and machine learning, which, when included in cloud projects, allow for personalized handling and better delivery of prospects.

Every new technology is associated with benefits and drawbacks. Therefore, the combination of CC and AI has not escaped its fair share of setbacks.

In the following table, we have compared the important points that give us the ability to draw a strong relationship between the usage of CC and AI.

In order to identify their commonalities, we focused on the benefits and drawbacks of both.

Table 1: benefits of AI and CC

	Cloud computing	Artificial Intelligence
Benefits	<ol style="list-style-type: none"> 1. Simplicity of administration and utility estimating. 2. cost-effectiveness and lower impact failures and upgrades. 3. The methodology of storing information in remote. 4. Storage on cloud servers is known as "cloud storage". 5. Elasticity, a simplified layout, and competitiveness [9]. 	<ol style="list-style-type: none"> 1. Programming and self-writing. 2. The machines may be reprogrammed to operate for extended periods of time without getting bored; they are also simple, quick, and profitable. 3. Machines don't need breaks like people do. 4. By using robotics and AI in mining and other fuel exploration processes, we can prevent the needless loss of human life, as humans can create new robots but not new humans. 5. AI can be deployed in industries and companies [10].

<p>Drawbacks</p>	<ol style="list-style-type: none"> 1. Leaks and unauthorized data access between virtual machines using the same server. 2. Due to glitches and system failures, the cloud service may occasionally be unavailable for protracted periods of time. 3. Hackers might breach and access client apps that are hosted in the cloud, gaining access to and disseminating sensitive data. reliability issues. 4. Potentially being unable to maintain data integrity (ensuring that the information saved is "accurate") . 5. Limited setups: Vendors of public cloud solutions have a standard arrangement of foundation setups that meet the necessities of the overall population [9]. 	<ol style="list-style-type: none"> 1. It will be difficult to create the machines due to expensive equipment, and it will also cost more money to reconstruct and repair them. 2. Robots may result in significant unemployment as they replace jobs, unless humans are able to fill the void with tasks AI is unable to perform or drastically alter the political system to one based on communism. 3. Because AI applications automate the majority of the work, they encourage human laziness, which could harm future generations. 4. Human interference is decreasing as robots take over the majority of tasks, which could lead to a serious issue with the utilization standards. 5. Machines are far superior to humans when it comes to productivity, but human bonding is a crucial element in team management and cannot be achieved by machines. Machines can only perform the tasks that they're designed to do; they can easily cause destruction if in the wrong hands [10].
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6. Integration and Application of CC and AI

CC and AI are both actively being developed, and they are being used in numerous disciplines and industries. Additionally, the use of AI has expanded the market for CC. The Internet of Things and AI can expand and become more widely used thanks to the storage and computational capabilities of the cloud, as shown in Figure 4. As a result, there will be more room for CC development. Additionally, CC is required to process and compute enormous amounts of data and information as the quantity and variety of data keep growing. This demonstrates that the usefulness of CC and cloud services has been completely realized and has established itself as the cornerstone for the development of AI.

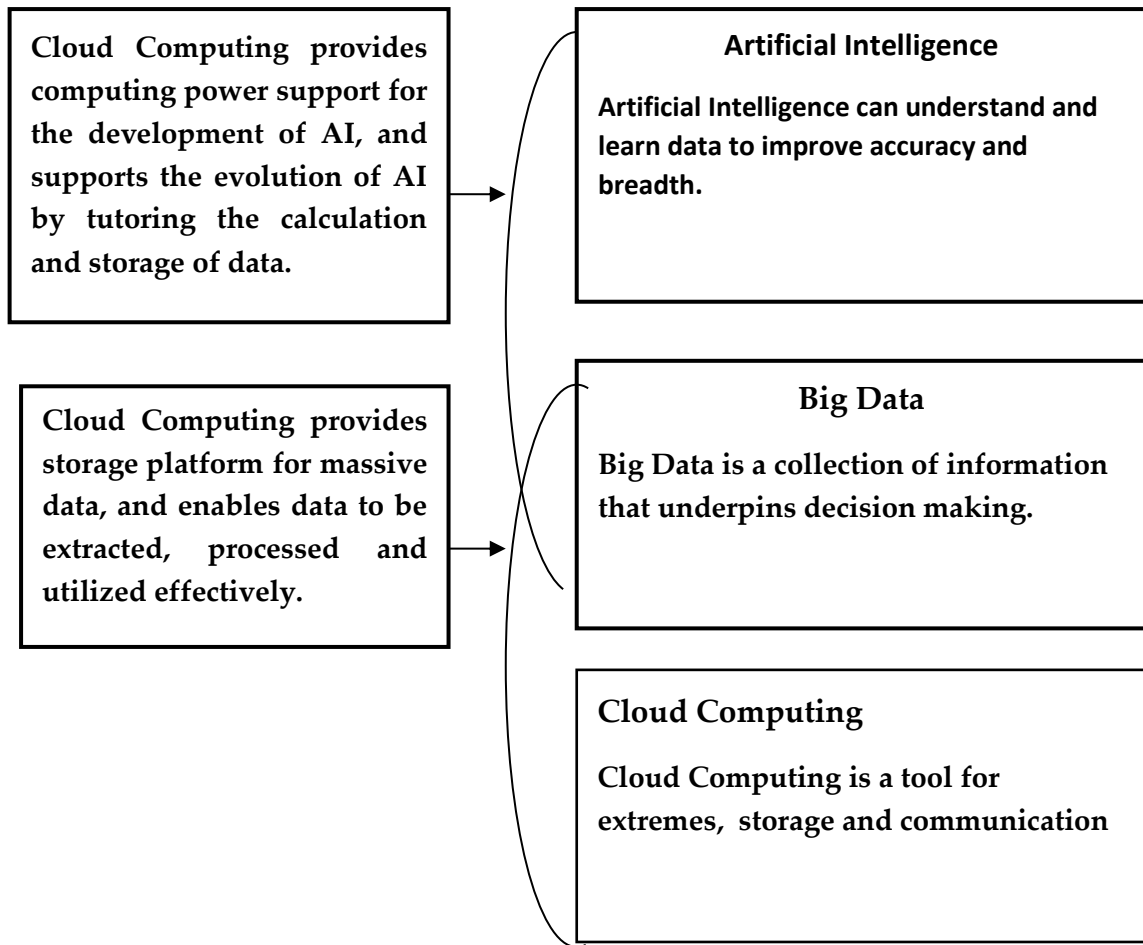


Figure 4: Functions AI, Big data and CC

The updating of internet technology creates significant economic value, and CC offers the fundamental technology for this activity. Several different industries have been greatly impacted by the development of CC. As a result, CC will be utilized more and more frequently as it matures and will eventually be regarded as a key yardstick for evaluating industry standards.

AI has limitations in the upgrading and reform process. To solve these problems, we must rely on big data and CC. However, the application of traditional big data and CC cannot completely solve the problems of the flexibility and practicality of AI. The development of AI is inseparable from big data. This data must be analyzed and processed through CC technology to achieve the diversification of AI development. For example, smart logistics in hospitals use CC technology to scientifically classify and manage all kinds of drugs. In order for AI to progress, it also needs the support of big data, which is inseparable from big data science. The advance of big data science has made AI technology reach new heights. Therefore, the relationship

among AI, big data, and CC is complementary to each other, as shown in Figure 5 [11].

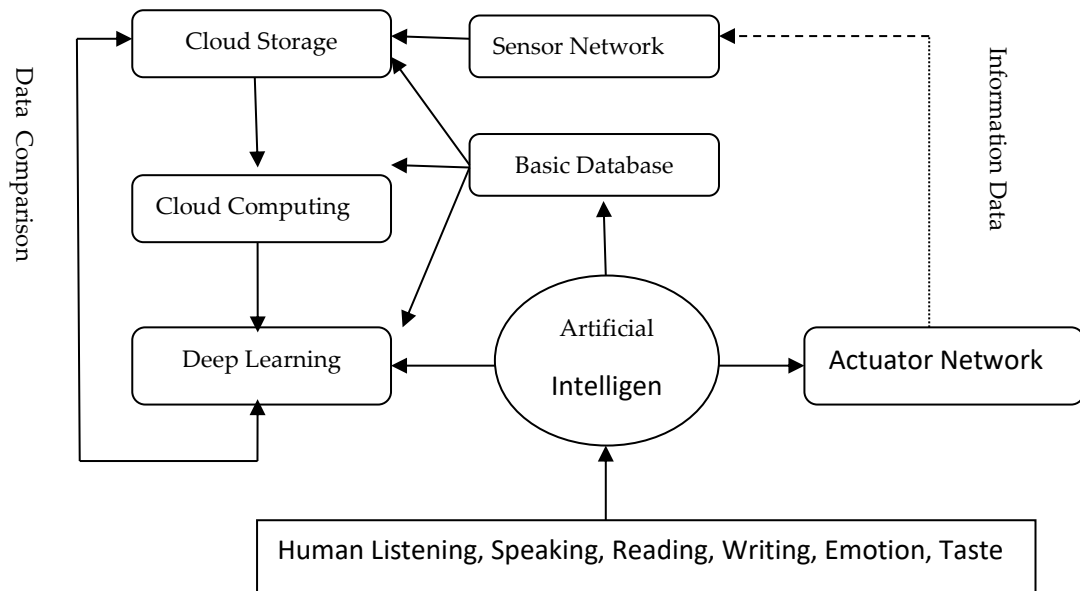


Figure 5: The connection between AI and CC

7. Literature Review

Several approaches have been proposed for CC that suggest the use of AI techniques. Many papers have looked at the integration between CC and AI in different ways; some of them are introduced here.

To start with, [12] looked into the issue of information security in distributed computing storage in order to guarantee the accuracy of the customer's information in the distributed storage. Then, they came up with an innovative and adaptable security framework for AI accessibility in cloud processing that enhances the cloud client's security for efficient data processing and solves accessibility issues.

In another study [13] proposed an agent-aid model for the working load balancing problem in large clouds by combining decision-making theory and a multi-agent system.

A heuristic approach to finding optimal providers with agents' partial observations of global working load distributions was developed by abstracting the cooperation of agents to locate the requests for working loads as tokens. The simulation results demonstrated that agents can intelligently pass tokens to the team in order to maximize efficiency while minimizing the cost of communication.

There are numerous issues and concerns that need to be resolved during the initial stages of agent-based scalable clouding. First, they believe that efficiency could be greatly enhanced if the logical network design matched the characteristics of cloud physical distributions. In the future, it will be enjoyable to conduct research to locate a suitable logical network. Second, the model will become more intelligent if additional heuristic rules are imported.

A previous study [14] attempted to offer some theoretical perspectives regarding the future application of robots in the educational sector and discussed the possibility of combining AI and CC.

The online healthcare system was presented by [15] as a cost-effective way to provide information on labs, doctors, preventive care, appropriate medicine, online appointment booking, and expert knowledge. Since this system provides a central online repository for the patient's data and health records, it aids in report portability and reduces paperwork. To help the patient maintain a healthy lifestyle, the expert system will use AI to provide general health advice and preventive steps based on the symptoms. As a result, the suggested system is a comprehensive system for all health-related data and inquiries and may be used for optimal health care administration.

For intelligent robot systems in mobile education, [16] developed a framework of cognition-based context-aware CC and suggested fusing multimodal emotion information, such as voice and facial expression. The framework was then used to support an English instructional app, and the evaluation findings indicate that it can considerably increase the app's intelligence and engagement.

In order to provide machine learning practitioners with a set of tools and cloud services that cover the entire machine learning development cycle—from the creation, training, validation, and testing of models to the models serving as a service, sharing, and publication [17] proposed a distributed architecture. This allows transparent access to existing e-infrastructures and efficiently utilizes distributed resources for the most compute-intensive tasks coming from the machine-learning domain.

By evaluating the design of the e-learning system and discussing the impact of AI on the implementation of the paradigm in business processes as well as e-learning systems, [18] showed the interaction between cloud-based e-learning architecture and education 4.0. It aims to create a cloud-based E-Learning System Architecture that can be used as a roadmap for Education 4.0. Additionally, it is intended to give

stakeholders advice on how to improve their services in cloud-based e-learning systems.

An architecture-based defence mechanism was proposed by [19] and it incorporates five models to guarantee continuous data integrity provisioning for secure AI settings that adhere to NIST Cybersecurity Framework recommendations.

With the use of cutting-edge algorithms, [20] proposed a new paradigm for cloud data protection. This technology is described as a branch of computer science that focuses on creating intelligent machines that behave and react much like people do while enhancing security and privacy in cloud environments. The primary sectors of cutting-edge technological processes are AI, which is particularly interested in speech recognition technologies, machine learning systems, planning decision systems, and problem-solving systems.

A conceptual framework for integrating cutting-edge technology in the future was developed by [21] to provide effective computing services. Various potential risks of AI-integrated next-generation computing have been presented and examined in terms of how current computing issues would be affected in the future by trends. In addition, the authors discussed challenges and potential opportunities for leveraging AI and ML in next-generation computing for emerging computing paradigms, which include cloud, fog, edge, serverless, and quantum computing environments.

8. Benefits of CC with AI

Based on what was described in the literature, it is concluded that AI and CC have an integrative relationship. The market context has changed substantially over the past few months as a result of the combination of CC and AI, and it is now seen as necessary for any kind of financial success.

Thanks to AI, which enables devices to accurately read information and data about the world and data patterns, the performance of devices can be more specifically designed to make rapid and effective decisions. By doing this, the satisfaction of the final user is guaranteed.

This fully automated process eliminates human error, which is a good approach. As a result, there have been permanent changes made to how data is processed and used across several websites and resources. When assessing the most recent advancements in the cloud and AI industries, it is safe to say that highly skilled and knowledgeable cloud and AI specialists are in high demand. Different advantages

and advances in businesses or services can be produced using CC and AI strategies [20].

9. The impact of using AI and CC on the cost

Combining AI and CC can be beneficial in cost-effectiveness. Since cloud application creation is accessible online, no on-site hardware or software is needed to be purchased or configured. Additionally, it eliminates the need for on-site data centres and the accompanying expenses, such as hiring IT professionals to run the facilities, purchasing servers, and providing the servers with constant power and cooling[22].

Therefore, it is claimed that using AI in CC is anticipated to drastically lower the cost of cloud services. As the use of AI, tasks may be automated and resource allocation can be optimized, resulting in more effective resource use and cheaper costs for cloud providers. Clients who employ cloud services may ultimately pay less as a result of this [23].

In a study of the application of CC in a telecom MGA-MENA Company in the middle east, it was evident that the telecom industry was a significant player in the AI revolution. This approach was adopted by the MGA-MENA company to get rid of human errors and move forward with operational excellence. This resulted in lower costs and a quicker response time to network failures, which improved customer satisfaction [24].

10. Discussion

This paper attempts to interpret the effects of these two cutting-edge technologies that altered the nature of modern business and the significance of increasing their future integration to boost cloud performance by focusing on the following:

A. Decision Making and Deep Learning

Each organization relies heavily on decision-making. The finest outcomes in decision-making can be achieved by combining cloud-based AI. By learning from historical data and contrasting current patterns in the data, AI assists in identifying patterns and trends in various datasets. AI is also responsible for quicker data analysis, which enables companies to quickly and accurately address client needs. Therefore, the interaction between AI and the cloud can lead to beneficial results.

B. Pattern Recognition

Processing and automatic interpretation using mathematical computations are examples of some of the functions included in pattern recognition. Future progress will focus heavily on the study of complicated psychological processing, and the growth of pattern recognition will enable humans to better understand their own intelligence. In the modern world, intelligent recognition plays a significant role in the recognition of acoustic, visual, and fingerprint information. A more precise and effective recognition procedure may be facilitated by AI and CC unification.

C. Robotics and Machine Learning

Cloud Robotics Innovations found that intelligent robots using CC would have better computing performance and use less electricity. Because there will be less hardware and fewer pollutants, these qualities will reduce manufacturing costs. Due to attempts by major firms like Google and IBM as well as the involvement of research institutes in several active projects globally, the field of cloud robotics has seen increased innovation. The main goal of research efforts has been to create robots that are both highly effective and easily accessible.

D. Expert Systems

The expert system keeps a lot of industry and professional knowledge, which will help the next AI version go in the right direction. The development of an expert system still requires assistance from two areas: first, a field-appropriate expert problem-solving mechanism must be identified; second, the knowledge creation of the expert database must be improved. The fusion of AI and CC can offer assistance in both domains.

E. Artificial Neural Networks (ANN)

The idea of AI has been applied in many industries, and soon, ANN could play an important role in the development of AI. According to recent studies and analyses, emotion plays an important role in thought. Therefore, integrating human emotions into computers is essential for the advancement of AI. This skill will lead to significant improvements in the field of AI, and thus, this progress will reflect positively on CC, making the work of organizations more efficient, strategic, and insight-based on a larger scale.

11. Conclusion

AI and CC have set a very exciting direction for organizations of all sizes to go forward. This direction will evolve with years of study and analysis. The innovations that resulted from their integration are of great importance to society. The basic purpose of the cloud is to store and administer data safely, while the AI enhances the cloud client's security for efficient data processing and accessibility issues. It can be said that using cloud and AI strategies in organizations can maximize the system's capabilities and costs. By following this approach, all manner of firms will be more efficient and will undoubtedly produce greater profits than before.

Combining AI and CC provides analytics solutions, data mining and processing applications, cloud security automation, total cost reduction, and improved decision-making. Even though, there are also concerns about privacy, security, and job displacement that need to be addressed, the demand for integrated systems to support flexibility, security, and efficiency grows as big data takes off. Overall, the future looks bright for this powerful combination of technologies as long as it is continued to innovate responsibly.

This research aims to provide a better understanding and pave the way for further research that can contribute to optimally utilizing the CC environment by using AI in different domains.

Acknowledgments

I would like to first express my gratitude to Prof. Hassan Amreiz and Mr Jamal Manssour for the guidance and advice that helped with the completion of this paper.

I would also like to thank Ghada Mohamed, from the department of English of Sirte university, for the language editing and proofreading.

Last but not least, many thanks to my family who have been supportive and encouraging throughout this work.

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