Applications of Artificial Intelligence in Wireless Communication Systems

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The world is advancing towards automation that provides timely solutions to real-time problems. Depending on varied customer demands, network management would be complex and diverse with advanced technologies, and it is hard for IT staff to analyze the reports manually, which may even include manual errors affecting the system. Thus, ML and AI can be utilized to train on numerous sources of data from multiple platforms, which on consolidation give speedy auto-diagnoses of problems in network management. In this chapter, the benefits of ML and AI are studied to efficiently handle big data and automate troubleshooting with personalized responses. The role of new technologies in the areas of various time-sensitive problems of network management are explored including congestion regulation, capacity designing, and security surveillance. ML and AI can also enhance the security of the system, and the challenges of using these new technologies are also discussed, hence paving the way to efficiently use ML and AI in the management of networks and providing directions for contributing to future research.

Significant research interest has been shown in wireless sensor networks (WSNs), particularly in the context of internet of things (IoT) technologies. However, obtaining the optimal WSN lifespan network is a challenging issue that needs to be analyzed critically prior to any network setup. In recent years, new bio-inspired algorithms have been developed drawing their inspiration from biological and natural phenomena. Bio-inspired optimization algorithms have been compared with the traditional optimization algorithms and are showing promise as a solution to complex real-life problems. This chapter provides a survey and tutorial of recent research trends and development efforts addressing WSN issues by using bio-inspired optimization algorithms. The key intention of this work is to serve as a foundation for analysis of the emerging area of bio-inspired algorithms and multi-objective bio-inspired optimization algorithms for solving the underlying issues in wireless sensor networks.

Today's world is a new digital world where most of the things have moved online. As the digital world is enhancing, advancing, and evolving every day, various new and unique innovations and developments are rolling out in the IT industry. These innovations and developments are helping humans overcome existing problems, improve processes, and enhance the user experience by providing specific and personalized solutions to users. User needs are the main reason behind all this digital change and innovation. One such important innovation which has changed the digital world's face is known as cloud computing. Cloud computing is an internet-based service, which enables on-demand network access to share a collection of all configurable computational resources (such as servers, repositories, networks, applications, resources). As the amount of data is increasing day by day, the security of users' data has become a major and crucial concern to provide protected communication between users and the cloud service provider.

Cognitive radio networks (CRNs) promise to meet device-to-device communication requirements for effective spectrum utilization and power control in a distributed environment for industrial applications. The architecture of the CRN must maintain a high data rate (throughput) at low power consumption, which requires both radio spectrum efficient and energy efficient system design. In order to attain these objectives, the architecture adopts a CRN model needs to operate in an interweave mode that allows spectrum sensing followed by opportunistic secondary user (SU) data transmission over the unused bandwidth of the primary user (PU) in an operating structure. It improves the usage of the radio spectrum intelligently. Cognitive radio works in tandem with artificial intelligence (AI) techniques to provide an intelligent allocation of resources for its users. This chapter aims to highlight the various AI techniques used in cognitive radio operations to enhance cognition capabilities in CRNs and present a review of the subject.

Metaverse is the future of internet and an amalgamation of VR, AR, blockchain technology, AI, and 5G, and beyond. Metaverse can be seen as a self-sustaining system with its economy, structure, and trade of virtual items. Currently, there is no common platform for this in a decentralized manner. Thus, there is a need for an interdependent architecture that can provide interaction amongst layers. This chapter focuses on a seven-layered architecture that is simple to comprehend theoretically but cannot represent the true essence of all aspects of Metaverse. Hence, a novel interdependent architecture that includes physical and virtual world interaction is proposed in this chapter. Next, some potential applications and services of Metaverse are discussed. Later, two case studies, that of a virtual city and a virtual university campus using Metaverse, were analyzed based on the proposed architecture. Finally, the chapter is concluded with the open issues and challenges faced while dealing with Metaverse.

Artificial intelligence (AI) techniques, particularly those in machine learning (ML), have been successfully applied in various areas, leading to widespread belief that AI will collectively play an important role in future wireless communications. Risks associated with the utilisation of cloud components during service delivery can be mitigated through the implementation of safety measures. Protection and efficiency are the two pillars upon which the security and scalability of cloud computing rest. AI is the study of algorithmic enhancements to the real world. The issues and worries associated with utilising one or more AI algorithms in the cloud are outlined, including supervised, unregulated, semi-controlled, and enhanced cloud safety issues. In the future framework, cutting-edge algorithms usher in a new era of cloud data security. Specifically, it is the aim of improving cloud security and privacy. Computers with AI are particularly keen on voice recognition technology, ML systems, decision-planning systems, and problem-solving systems.

In trendy wireless communication networks, the inflated shopper demands for multi-type applications and top-quality services became a distinguished trend and placed hefty pressure on the wireless network. The standard of expertise (QoE) has received a lot of attention and has become a key performance measuring for the appliance and repair so as to fulfill the users' expectations. The management of the resource is crucial in wireless networks, particularly the QoE-based resource allocation. One amongst the effective ways for resource allocation management is correct application identification. In this chapter, the authors propose a unique deep learning-based technique for application identification. It explores QoE for wireless communication and reviews the restrictions of the standard identification strategies. After that, a deep learning-based technique is projected for mechanically extracting the options and characteristics.

Fog computing reduces network usage and latency. The fog layer connects IoT users to the cloud by executing applications or processing data in network infrastructure devices. Cloud-based IoT can provide communication, computing, and storage. Offloading computer-intensive apps with fog is promising. Fog computing expands IoT roles at the network edge and supports cloud platforms. Clients can send control signals using fog computing and cloud services. Offload latency-sensitive user experiences to broken fog nodes at the network's edge. This makes real-time cloud management of sensors, actuators, and wi-fi routers difficult. Most cloud efforts allocate communication and computational resources. Fog computing emphasizes communication or computation.

Advances in wireless systems have encouraged the growth and improvement of tiny, low-cost, efficient, and multi-tasking smart sensors. Wireless sensor networks are employed for sensing, collecting data and information, analysing it, and sending it to the main center to be considered quickly. During the performance, a wide range of issues appear, and the existence of some restrictions on the movement of sensors, reliable data collection mechanisms and transferring them properly and securely to the main center, and issues in the sensor network topology. In fact, all traditional methods need more ability to deal with and solve these situations. In this regard, the authors decided to highlight the importance and role of artificial intelligence technologies in designing wireless sensor networks by proposing a hybrid model that helps to construct a more practical sensor network and solve all the situations it faces. These techniques significantly improve network performance, extend battery life, develop smart nodes, and improve network functionality.

One of the main causes of learners getting poor grades is a communication problem between the instructors and students. There are times when students miss tests and proposal due dates, which results in poor grades. Short messaging service (SMS) is an efficient way to remind and disseminate information among students within and outside the school campus. The aim of having no verbal communication between students and teachers would be helped by this feature. When a student is registered in the departmental information dissimilation portal, their mobile phone will be updated with any academic related information at any point in time. We employed web technology to achieve this goal, which enables each registered student to have access to updated information from the department within and outside the institution campus. The proposed system achieved an efficiency through the various menu implemented on the system by reducing the stress and printing cost of notifying the student.

Artificial intelligence (AI) is not very prevalent in the healthcare sector. It will promote and enhance automation in various aspects of patient care by promoting diagnosis of disease at a subclinical stage which can be otherwise missed by human clinicians. There is a rapidly increasing interest in machine learning (ML) applications in medical care. Precision medicine, neural networks, and deep learning methods of ML have gained importance in the healthcare domain. Based upon the patient attributes, the prediction about the prognosis of disease is possible through precision medicine approach of ML. Likewise, neural networks and deep learning methods are sufficiently capable of predicting the outcomes of the patient disease, which is otherwise less predictable due to the lack of prediction models in the clinical practice. WSN, IoT, IoMT have gained popularity among all the stakeholders in the hospital settings. Monitoring of the patients has become more viable with an application of wireless communication, which is more cost effective and energy saving for the patients.

Debris are human-made objects in earth orbit that have no usefulness but create hazards for the valuable space assets. The space activities are considerably huge in low earth orbit (LEO), and hence, most orbital debris resides within the orbital altitude of 500 – 1000km from Earth's surface. This is the region where the highest concentration of debris is detected. The ground-based radars are in practice globally to detect and characterize the LEO debris environment with the help of collected statistical data. Radar systems used for the monitoring and tracking of space debris will help in generating alert messages for avoiding a collision between operational spacecraft and debris. Multiple input multiple output (MIMO)-based radar has the potential to provide optimum solutions for space debris tracking. It provides wider illumination area, clutter reduction, and hence improvising the object detection capabilities. This chapter provides a study of performance estimation for MIMO radar and comparing the detector performance for signal-to-noise ratio (SNR) improvement.

Today's cloud is a frequently used global technology that shifts local network content to network centric content, where huge quantities of data processing are performed on powerful computational farms and accessed via the internet. This technical reality uses the metered service for accessing the resource and distinct data centres. The purpose of this work is to present a fundamental review concept of cloud computing where we have mentioned its key characteristic, services, and deployment models. The authors have also looked into how quickly COVID-19 accelerates the market. They attempted to decipher the concept of virtualization approach through the chapter, which is widely acceptable. How cloud computing technology is beneficial over conventional farming is also highlighted. Here they have also focused on cloud computing applications, trends, and the most recent adoption challenges employed in different sectors.

Preface

The upcoming wireless communications are expected to satisfy the diverse service requirements in various aspects of our daily life from resident, work, recreation to transport. The future wireless technologies includes fifth generation (5G) communication, fog networking, molecular communication, and millimeter wave communication. These new technologies will have different service requirements than traditional wireless technologies i.e. extremely low delays and complicated system models that are more difficult to manage with conventional approaches. Because of the extremely wide range of 5G requirements for user experience, efficiency, performance and complex network environments, it is very difficult to design and optimize 5G networks. The upcoming 5G network will need strong smart algorithms to Adapt network protocols and resource management to different departments based on different scenarios.

Artificial Intelligence (AI), which refers to any process or device who perceives their surroundings and takes measures that maximize the chances of success for certain predefined goals, is an achievable solution to the emergent design of a complex communication system. The latest developments in deep learning, convolutional neural networks and reinforcement learning are very promising for solving very complex problems regarded as insoluble until now. More specifically, the data driven approaches can change the research paradigm from a sophisticated mathematical model-based approach to a learning-based one. The application of artificial intelligence technology to 5G wireless communications is now appropriate to address the design of optimized physical layers, complicated decision-making, network management and resource optimisation tasks within these networks. In addition, the emerging technology of big data has presented us with an excellent opportunity to explore the critical features of wireless networks and to assist us in obtaining a clearer and deeper understanding of the behavior of 5G wireless networks. In exploring 5G wireless technologies and communication systems, Artificial intelligence will be a powerful tool and a topical research topic with numerous potential fields of application.

Target Audience and Potential Uses will be Ph.D Scholars, Industry Persons, Intra disciplinary research scholars, Practitioners, UG/PG Projects Students.

Preface

The world is advancing towards automation that provide timely solutions to real-time problems. Depending on varied customer demands, network management would be complex and diverse with advanced technologies hard for IT staffs to analyze the reports manually even may include manual errors affecting the system. Thus, ML and AI can be utilized to train on numerous sources of data from multiple platforms which on consolidation gives speedy auto-diagnoses of problems in network management. Chapter 1 benefits of ML and AI are studied to efficiently handle big data and automate troubleshooting with personalized responses. The role of new technologies in the areas of various time sensitive problems of network management are explored including congestion regulation, capacity designing and security surveillance. ML and AI can also enhance the security of the system and the challenges of using these new technologies are also discussed. Hence, paving the way to efficiently use ML and AI in the management of networks and providing directions for contributing to future research.

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Chapter 3 focuses on how today's world is a new digital world where most of the things have moved online. As the digital world is enhancing, advancing, and evolving every day, various new and unique innovations and developments are rolling out in the IT industry. These innovations and developments are helping humans overcome existing problems, improve processes and enhance the user experience by providing specific and personalized solutions to users. User needs are the main reason behind all this digital change and innovation. One such important innovation which has changed the digital world's face is known as cloud computing. computing is an internet-based service, which enables on-demand network access to share a collection of all configurable computational resources (such as - servers, repositories, networks, applications, resources). As the amount of data is increasing day by day, the security of users' data has become a major and crucial concern to provide protected communication between users and the cloud service provider.

Cognitive Radio Networks (CRNs) are ushering in the future of wireless technologies that provide innovative mobile communication connectivity. One of the essential characteristics of CRN is opportunistic spectrum access to mitigate the mobile communication spectrum scarcity-related issues. In CRNs, the communicating parties dynamically exploit the radio spectrum band that is not utilized by the primary wireless services licensed to operate over such band. In this way, to improve the usage of the radio range, a cognitive radio hub detects the weather, evaluates the open-air qualities, and then makes certain decisions and distributes the executives' space assets. The cognitive radio works in tandem with artificial intelligence techniques to provide a flexible and intelligent allocation of resources for its users. The primary aim of Chapter 4 is to highlight the various artificial intelligence techniques used in cognitive radio operations to enhance cognition capabilities in CRNs and present a review of the subject.

Metaverse is the future of internet and an amalgamation of VR, AR, blockchain technology, AI and 5G and beyond. Metaverse can be seen as a self-sustaining system with its economy, structure, and trade of virtual items. Currently, there is no common platform for this in a decentralized manner. Thus, there is a need for an interdependent architecture that can provide interaction amongst layers. Chapter 5 focuses on a seven-layered architecture that is simple to comprehend theoretically but cannot represent the true essence of all aspects of Metaverse. Hence, a novel interdependent architecture that includes physical and virtual world interaction is proposed in this chapter. Next, some potential applications and services of Metaverse are discussed. Later, two case studies, that of a virtual city and a virtual university campus using Metaverse were analyzed based on the proposed architecture. Finally, the chapter is concluded with the open issues and challenges faced, while dealing with Metaverse.

In Chapter 6, artificial intelligence (AI) techniques, particularly those in machine learning (ML), have been successfully applied in various areas, leading to widespread belief that AI will collectively play an important role in future wireless communications. Risks associated with the utilization of cloud components during service delivery can be mitigated through the implementation of safety measures. Protection and efficiency are the two pillars upon which the security and scalability of cloud computing rest. AI is the study of algorithmic enhancements to the real world. The issues and worries associated with utilizing one or more AI algorithms in the cloud are outlined, including supervised, unregulated, semi-controlled, and enhanced cloud safety issues. In the future framework, cutting-edge algorithms will usher in a new era of cloud data security. Specifically, it is the aim of improving cloud security and privacy. Computers with AI are particularly keen on voice recognition technology, ML systems, decision planning systems and problem-solving systems.

In trendy wireless communication networks, the inflated shopper demands for multi-type applications and top-quality services became a distinguished trend, and place hefty pressure on the wireless network. In case, the standard of expertise (QoE) has received a lot of attention and has become a key performance measuring for the appliance and repair so as to fulfill the users' expectations, the management of the resource is crucial in wireless networks, particularly the QoE based mostly resource allocation. One amongst the effective ways for resource allocation management is correct application identification. In Chapter 7, the authors propose a unique deep learning based mostly technique for application identification. The need of initial analyze managing is QoE for wireless communication and review the restrictions of the standard identification strategies. After that, a deep learning based mostly technique is projected for mechanically extracting the options and characteristic the kind of application.

Fog computing reduces network usage and latency. The fog layer connects IoT users to the cloud by executing applications or processing data in network infrastructure devices. Cloud-based IoT can provide communication, computing, and storage. Offloading compute-intensive apps with Fog is promising. Fog computing expands IoT roles at the network edge and supports cloud platforms. Clients can send control signals using fog computing and cloud services. Offload latency-sensitive user experiences to broken fog nodes at the network's edge. This makes real-time cloud management of sensors, actuators, and Wi-Fi routers difficult. Most cloud efforts allocate communication and computational resources. Fog computing emphasizes communication or computation. Fog computing can improve service quality and manage network challenges caused by real-time, latency-sensitive applications and IoT bandwidth and user resource limitations. Chapter 8 examines computing and communication resource allocation. In this chapter author also discusses service delay, link quality, and mandatory benefits.

In Chapter 9, introduction of the 4G mobile network has addressed the major obstacle of high capacity, allowing for the construction of real broadband Internet. It was primarily designed by a flexible physical layer. New ways have been opted to develop bandwidth requiring services such as VR (virtual reality), AR (augmented reality) etc. Innovations in applications, like vehicle communications or Internet-of-Vehicles, raise a great demand on stability of mobile networks. 5G has overcome some of these obstacles by employing a new radio interface based on massive MIMO. Furthermore, the rise of Software-Defined Networks (SDN) and Network Function Virtualization (NFV) has provided operators with greater.

Advances in wireless systems have encouraged the growth and improvement of tiny, low-cost, efficient, and multi-tasking smart sensors. Wireless sensor networks are employed for sensing, collecting data and information, analyzing them, and sending them to the main center to be considered quickly. During the performance, a wide range of issues appear and the existence of some restrictions on the movement of sensors, reliable data collection mechanisms and transferring them properly and securely to the main center, and issues in the sensor network topology. In fact, all traditional methods need more ability to deal with and solve these situations. In this regard, the authors decided to highlight the importance and role of artificial intelligence technologies in designing wireless sensor networks in Chapter 10 by proposing a hybrid model that helps to construct a more practical sensor network and solve all the situations it faces. These techniques significantly improve network performance, extend battery life, develop smart nodes, and improve network functionality.

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In Chapter 12, we see how Artificial Intelligence (AI) is not much prevalent in the healthcare sector. It can promote and enhance automation at various aspects of patient care by promoting diagnosis of disease at a subclinical stage which can be otherwise missed by human clinicians. There is a rapidly increasing interest in Machine Learning (ML) applications in medical care. Precision medicine, Neural networks and Deep learning methods of ML have gained importance in the health care domain. Based upon the patient attributes, beliefs the prediction about the prognosis of disease is possible through precision medicine approach of ML. Likewise, neural networks and deep learning methods are sufficiently capable of predicting the outcomes of the patient disease which is otherwise less predictable due to the lack of prediction models in the clinical practice. WSN, IoT, IoMT have gained popularity among all the stakeholders in the hospital settings. Monitoring of patients have become more viable with an application of wireless communication, being more cost effective and energy saver for the patients.

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This book will provide the chapters which include applications of artificial intelligence for optimization of wireless communication systems, including channel models, channel state estimation, beamforming, code book design and signal processing etc. It will be an extensive work in this particular domain rather than abstract form. It will also explore not just the theoretical aspects but the practical implementation of this.

The main objective of this book is to concise or to actually come up with the something that should be collection of recent research or advances in the research happens in the field. As per the recent advancement, this is the one of the most interesting topic.

As such there is no further study which has explored this particular domain in this context. There is no other work which has actually explored the use of artificial intelligence and new technology in context to the wireless communication although wireless communication being one of the prime factor in almost all the global economy in this digital era. But literature is actually limited to the artificial intelligence in other industry or in other domain.

As our book is actually covering all the latest and recent advancements in this field, the chapters of this book will provide the novel approaches and the framework which will be beneficial for the industry and the practitioner who are working in this.

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Chapter 1
Artificial Intelligence and Machine Learning for Network Management

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ABSTRACT

The world is advancing towards automation that provides timely solutions to real-time problems. Depending on varied customer demands, network management would be complex and diverse with advanced technologies, and it is hard for IT staff to analyze the reports manually, which may even include manual errors affecting the system. Thus, ML and AI can be utilized to train on numerous sources of data from multiple platforms, which on consolidation give speedy auto-diagnoses of problems in network management. In this chapter, the benefits of ML and AI are studied to efficiently handle big data and automate troubleshooting with personalized responses. The role of new technologies in the areas of various time-sensitive problems of network management are explored including congestion regulation, capacity designing, and security surveillance. ML and AI can also enhance the security of the system, and the challenges of using these new technologies are also discussed, hence paving the way to efficiently use ML and AI in the management of networks and providing directions for contributing to future research.

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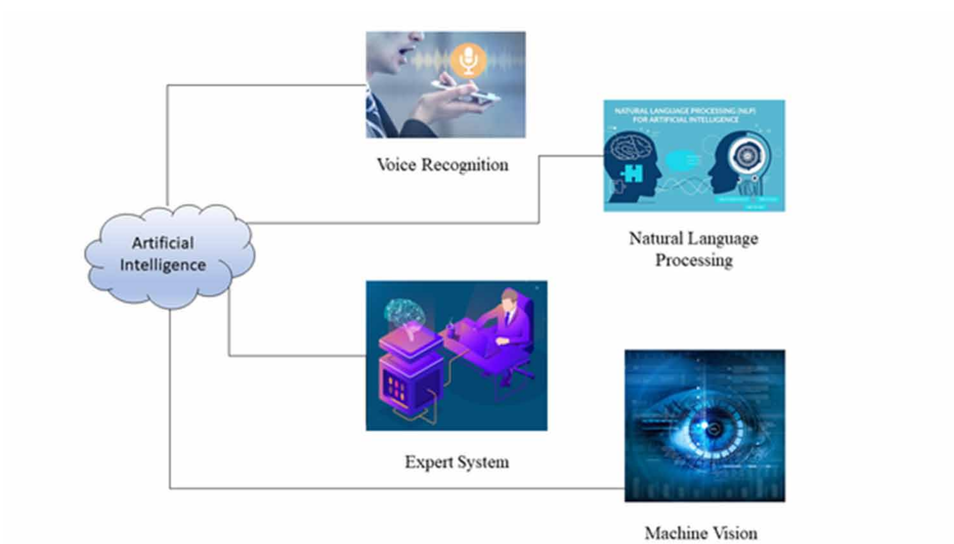
INTRODUCTION

AI in the Digital Era

Artificial Intelligence is the ability of the computer machine to simulate the intelligence process of the human which has improved drastically in the recent years (Chui et al., 2022). The machines with artificial intelligence consist of Natural Language Processing (NLP) (Khurana et al., 2022), voice recognition (Cui & Rao, 2022), machine vision (Karn, 2021), expert system (Wauters & Vanhoucke, 2016), etc to process the information like a human as shown in Figure 1 In the era of digital life, artificial intelligence plays a vital role in various industries including eCommerce, finance, education, health care, automotive, education, internet of things, network management and many more. A problem can only be fixed if the cause is known and IT systems do a good job of recording all the activities and maintaining logs using various management tools which could be used to find the source of the problem from which artificial intelligence blends human brain simulation with computer speed to reach out a quick solution. The major benefit is that artificial intelligence helps in processing huge datasets from which the results are utilized for expanding the organization's market and attaining superiority in the competitive world.

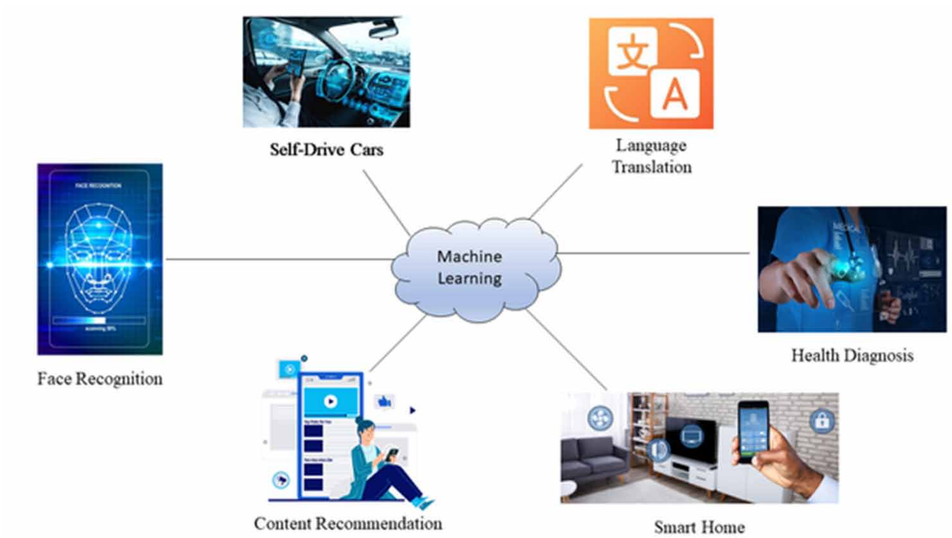
Figure 1. Applications of artificial intelligence



Machine Learning

Machine learning is breaking grounds in teams of predictive analysis and computer vision that are seen as applications in our day-to-day lives including self-drive cars (Sharma, 2020), facial recognition (Nath et al., 2021), health diagnosis (Richens et al., 2020), language translation (Popel et al., 2020), content recommendation (Tai et al. 2021), home security (Artem & Vasyl, 2017), etc. as shown in Figure 2. The availability of massive data paves way for machines to train and learn the hidden pattern of data to make a drastic improvement in predicting or providing quick useful suggestions to people in need. The development of smart software with machine learning enables people to manage complex tasks with ease. Corporates such as Netflix, Amazon and Flipkart (Agarwal, 2018) (Maddodi, 2019) (Zulaikha et al., 2020) use predictive analysis for recommending products, suggesting movies and tv shows and delivering better service to their customers. In the case of malicious user detection, a user could be tracked deeply if the account shows malicious behavior else tracking all the users only results in resource wastage.

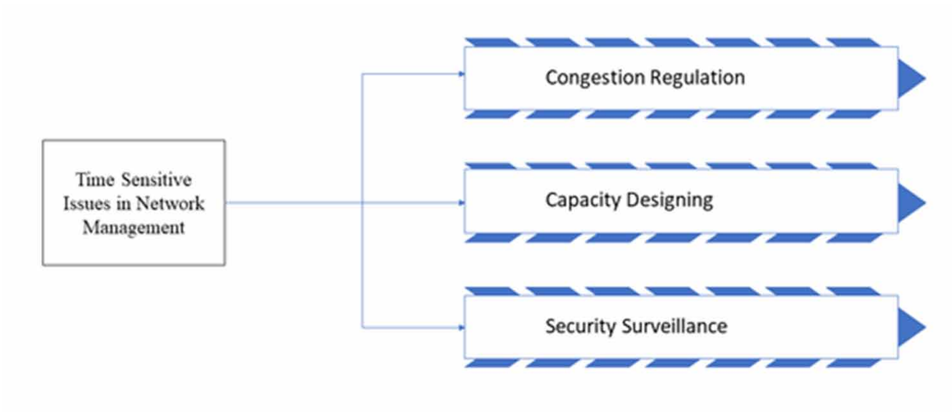
Figure 2. Applications of machine learning



Importance of AI and ML in Network Management

As the network is growing distributed and more complex and instant responses are essential to solve the issues that arises in various areas of network management. The time sensitive issues in the network management that are to be addressed using artificial intelligence and machine learning includes congestion regulation, capacity designing and security surveillance as shown in Figure 3. In the majority of cases, problems of artificial intelligence are addressed by machine learning serving as a supporting aide. The artificial intelligence and machine learning can be utilized to send a timely response for a real time problem or could be able to predict the issues of the network even before it occurs. Also playing a role in threat response, behavior analysis of users and intrusion detection.

Figure 3. Time-sensitive issues in network management



BENEFITS OF AI AND ML

Big Data Processing and Analysis

The data are generated in tons on the network each day. Thus, network management prefers computers for processing all the data produced for understanding the happenings within the network. In network management, artificial intelligence travels along the network and delves into huge set of data to accomplish the task of data processing. Real-time analysis of data provides insight on received and sent out network information. As the result of a steady examination of present and historical data the network management implements machine learning to learn about the trends of the network. The data with problems are also studied with machine learning and thus if an issue arrives, network management has the ability to identify the issue. Furthermore, immediately alerts the user where it is not necessary to conduct a comprehensive analysis each time when new data arrives in the network.

Automated Troubleshooting

Detection of issues to alert users can be incorporated with solutions from artificial intelligence for familiar trained issues which can be applied for eliminating the human involvement. Network management upon training with artificial intelligence and machine learning, learns the frequently familiar issues affecting the users in the network. On repeated observation of same issue, artificial intelligence deciphers the best solution and handles the issue. Thus, attaining sufficient data leads to finding the network issues on the real time basis and automating the troubleshooting ability. Artificial intelligence has the power with which the problems in the network can be found and stopped even before affecting the network. As the artificial intelligence finds the trained issues, the users of the network could focus on issues where more insights and analysis are necessary.

Personalized Response

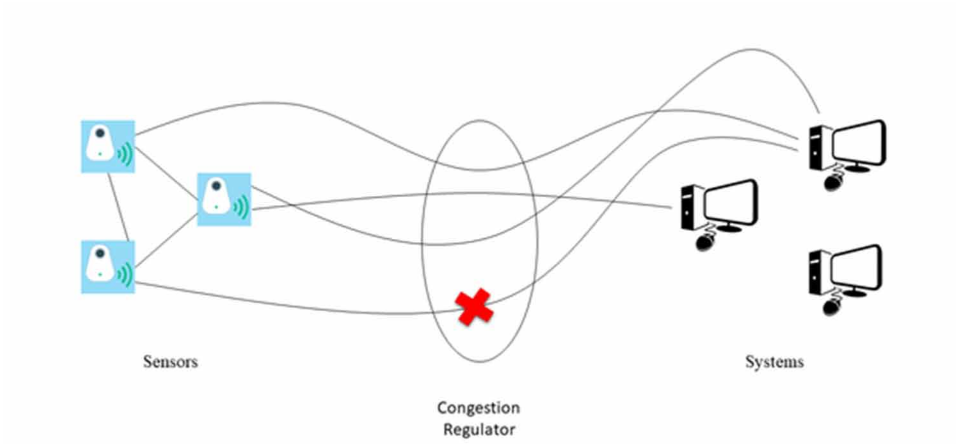
Sometimes, for considering external elements and other factors, the user does not want an automatic solution but just an alert from the network when an issue occurs. Therefore, AI can be personalized in such a way that it can deliver a personalized response to the user during the arrival of particular events in the network. But if the system has to work on its own then the machine learning and artificial intelligence have to be trained so that when an incident occurs, the response, instructions or solutions can be directed to the users automatically according to the events arising on the network.

TIME-SENSITIVE PROBLEMS AND NETWORK MANAGEMENT

Congestion Regulation

In the network devices, the packet flow is monitored by the congestion regulator whereas the status report from these network devices are monitored by network management and thus, they are closely linked as shown in Figure 4. The physical performance is fully exploited by network managers with the help of congestion shaping. To plan a budget friendly congestion regulation, the information technology department lowers the capacity than the throughput at its peak where the priority is given to interactive applications including surveillance CCTVs, VoIP and systems to perform video conferencing when passing through switches of the systems. A VLAN is designed to regulate the voice traffic in the telephone networks, where the voice signals flow through the same wires that have been carrying the data.

Figure 4. Congestion regulation without AI



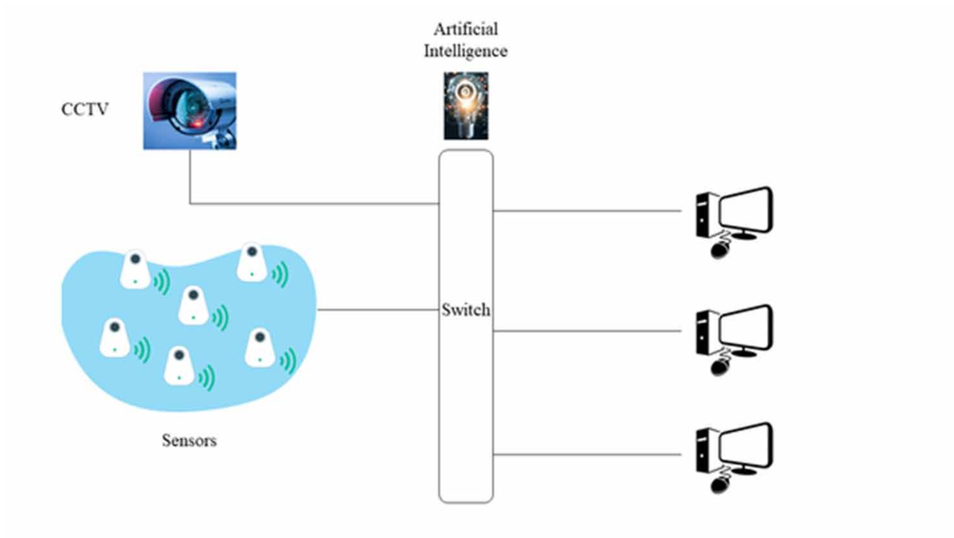
Artificial intelligence is not yet fully introduced in the congestion regulation system but a multinational networking company D-Link is advancing with the usage of Auto Voice VLAN (AVV) and Auto Surveillance VLAN (ASV) systems which are developed in their smart switches. A separate channel ASV is created with a target of saving the video footage of security cameras from data congestion whereas AVV is developed for avoiding voice traffic. Here AI is utilized for switches to automate the detection of the voice and video congestion furthermore prioritizing them as shown in Figure 5. Thus, eliminating the need of network manager involvement in VLAN packets switching and specifying the treatment of traffics in the network.

Another advancing producer of a switch, Cisco Systems uses AI in software management and network monitoring (Cisco, 2021) that are utilized on the servers of the company but it is not yet implemented in the switches.

Capacity Designing

A lot of input sources are required for capacity designing where AI and ML can be used to automate and simplify the tasks of network management. History of data can be studied with little urgency to predict trends in congestion growth but unexpected failures in the equipment should be taken care of instantly by re-routing and may require additional measures for congestion regulation that are to be executed instantly. Capacity designing for long term goals and instant action to be taken in case of failure that requires replanning are complex and generates pressure on staffs of network management thus, in need of tools to automate the analyzing process.

Figure 5. Congestion regulation with AI



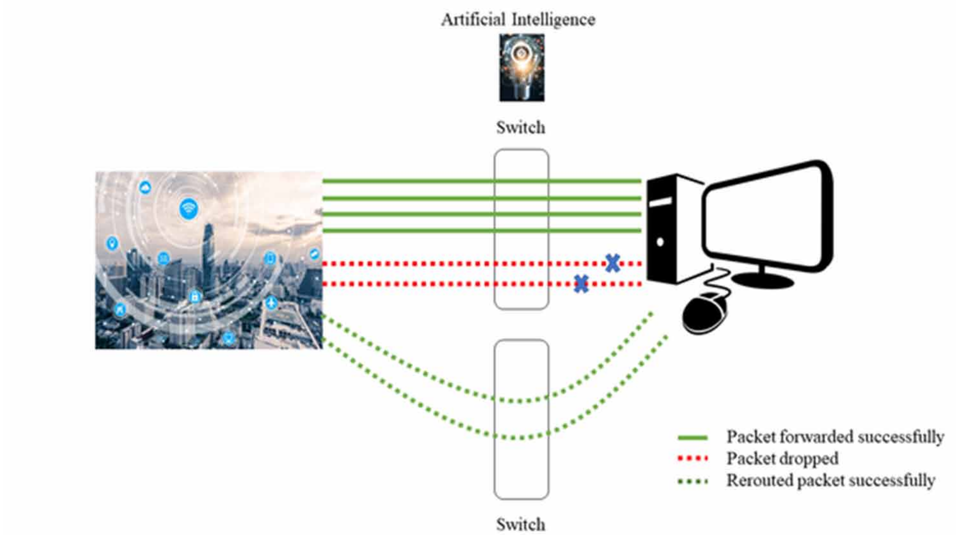
Juniper Networks (Juniper, 2022) and Cisco Systems (Cisco, 2021) working on building products with AI to quicken the process of congestion shaping and capacity shaping. Enterprise Integration developed service delivery intelligence with AI for increasing the pace of performance analysis which can be used to detect the network problem and provide the suggestions for action to be taken.

The capacity designing should be higher than the overall expected congestion of the network considering the load on every single switch present in the network. If a network area experience capacity expansion, then pressure on the switches increases automatically. So, it is important to simulate the flow of network data congestion in the capacity designing and the expectations of the performance of each switch in the network. These tasks can be accomplished with ease if the capacity design is trained with AI as shown in Figure 6.

Security Surveillance

The automated security surveillance could inspect the traffic and devices in the network for any types of distrustful activities, menace and vulnerabilities which are utilized to detect the security breaches furthermore quick actions could be taken. Various metrics are gathered by the security surveillance team from the communication channel of the client and server, encrypted sessions of traffic, network payload and other relevant operations used to find the vulnerabilities. Machine learning can be utilized to study the hidden patterns present in the traffic flow of

Figure 6. Rerouting dropped packets automatically using AI



the network. Whereas, Artificial intelligence could be responsible for provoking the automated alerts and reports thus quick action could be taken for menace arising in the network. The visualized graphs and charts generated by the tools of security surveillance identifies the ill-natured activities and help to restore them. Both User and Entity Behavior Analytics (UEBA) along with Security Information and Event Management (SIEM) can enhance the security with the help of Artificial intelligence and machine learning.

UEBA acts as an activity tracker based on endpoint (entity) and user where system log is maintained for access event of every system, file usage by user accounts along with the IP address. The extension of entity tracking is made possible when all the actions accomplished outside the network by all source IP addresses are registered. As the recorded information are trained with machine learning algorithms, instant behavior variation triggers alert in the IP address or the specific account. Thus, eliminating full surveillance on every user in the network and detailed tracking begins when UEBA sends signal to a particular account. Many tools in cybersecurity including Next-Generation Anti-virus Systems (NGAV) Intrusion detection system (IDS) utilize the UEBA approach.

The user and entity behavior analysis turns out crucial for the Intrusion prevention systems (IPS) which are basically the IDS enhanced with automatic actions to be taken on the rise of menace. IPS nowadays are more enhanced but previously the system is designed to automate the shut down process of user access whenever there hikes a variation in the activity pattern denoting suspicion. The early vigilant systems tend to ban the mass population and even block staffs. As the designers are also beginners, misconception happens even to normal activities as the rules are not well defined. Thus, arising the rate of false positive reports which affects the purpose of IPS. The advantage of using UEBA annihilate the reporting rate of false positive which boosts the usage of the IPS in network management.

The Anti-Virus production nearly died when there was a rapid rise in different types of state of art viruses simultaneously. However, the usage of UEBA saved the anti-virus from major traditional problems initiating the next-generation products of anti-virus and firewalls. The issue with traditional anti-virus is that the system should already have the experience of a user to know that the virus exists. Accordingly, the viruses are analyzed to study what the virus is capable of affecting but it consumes a lot of time. Besides amid the research period, large users are exposed and possibly be affected by the virus. The users never want to be affected by a new virus that the system could not identify and the usage of UEBA in anti-virus solves the problem where any new virus is possibly identified by the behavior analysis on every process running at the endpoint in addition alert is sent to the user.

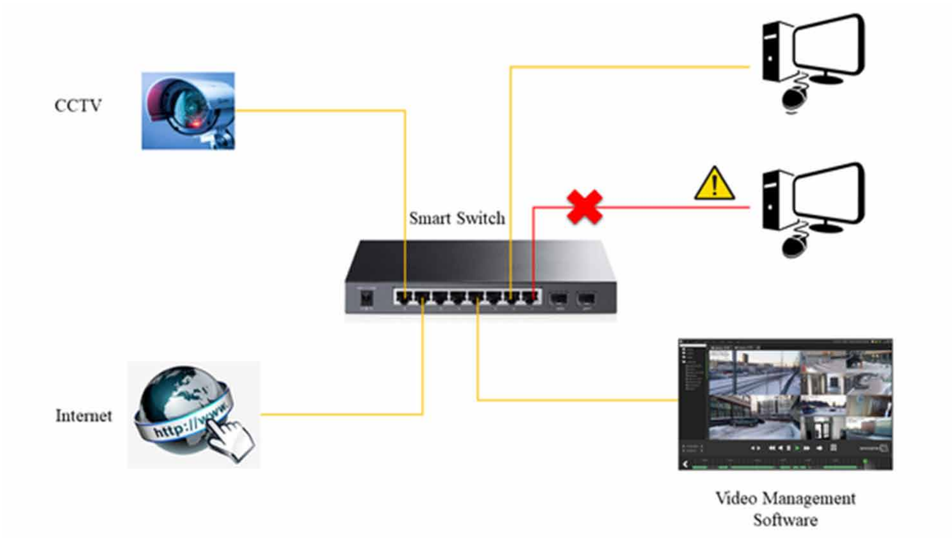
Security information and event management comprises of two different modules such as Security Event Management (SEM) and Security Information Management (SIM). Where, SEM works depending on the analysis of network traffic and SIM examines logs for mistrustful tasks. In the traditional methods Every single log file is collected from all the software and equipment involved in the network. The collected data is stored within a single pool for easy search but becomes difficult and the processing time grows as the huge data is involved from various sources. AI can minimize the time taken to process big data and identify mistrustful tasks with ease. Speed plays a key role in security surveillance as it would be a huge loss if the hacker gets identified after the occurrence of the damage. Indeed, AI works towards pattern identification enabling team the power to lock the hacker even before the occurrence of a huge destruction and the malicious node can be blocked easily as shown in Figure 7.

CHALLENGES IN USING AI AND ML FOR NETWORK MANAGEMENT

The Quality of data, scalability and ethical issues are the three main challenges when implementing AI and ML in network management.

The decisions of AI only become efficient when they are trained with the large set of real time data yet some companies train AI with stimulated data which is not the actual real time data. As the data integrity is in question, the trained model has the risk of flagging false negatives and missing the real problem. Thus, the

Figure 7. Blocking malicious node automatically using AI



quality of data should be considered important while utilizing AI and ML in the network management.

As the number of users and sensors hikes each day exponentially the system must be ready to quickly collect the big data without the loss of accuracy. Thus, the management tools and services that provides security must be in synchronization to deliver an efficient output in the network management.

The usage of ML and AI makes the system and devices smarter and there arises a problem of how the data can be used and what data are not to be exposed as the data should never be misused by anyone or for a personal use. Governments are looking ahead to set rules and regulations for the usage of AI data yet it is a tedious task to format.

CONCLUSION AND FUTURE DIRECTION

The automation is necessary for the constantly advancing world in which timely solutions are needed to all real time problems which can be made possible only with the help of training the systems with AI and ML. The advancement in day-to-day technologies paves a way for users to demand varied customer services and manual management turns tough leading to errors and faults affecting the whole system. Therefore, ML and AI are essential in the field of network management for the quick processing, speedy delivery of services and auto handling of threats that arises in the system. The benefits are studied to handle hug set of data from varied sources efficiently and to automate the process of troubleshooting in which responses can even be customized. Various time sensitive problems are discussed along with the suggested solutions in which AI and ML are used to enhance the ability and security of the system. The wise usage of AI and ML can minimize the work of the managing team, minimize manual error, saves time and improves accuracy paving a way for future development.

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Chapter 2
Bio-Inspired Algorithms for Wireless Network Optimization:
Recent Trends and Applications

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ABSTRACT

Significant research interest has been shown in wireless sensor networks (WSNs), particularly in the context of internet of things (IoT) technologies. However, obtaining the optimal WSN lifespan network is a challenging issue that needs to be analyzed critically prior to any network setup. In recent years, new bio-inspired algorithms have been developed drawing their inspiration from biological and natural phenomena. Bio-inspired optimization algorithms have been compared with the traditional optimization algorithms and are showing promise as a solution to complex real-life problems. This chapter provides a survey and tutorial of recent research trends and development efforts addressing WSN issues by using bio-inspired optimization algorithms. The key intention of this work is to serve as a foundation for analysis of the emerging area of bio-inspired algorithms and multi-objective bio-inspired optimization algorithms for solving the underlying issues in wireless sensor networks.

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1. INTRODUCTION

Wireless sensor technology is developing rapidly due to its advancement in the fields of distributed computing, data mining and wireless networks (Matin & Islam, 2012) (Sohrabi et al., 2000). There are numerous sensors located throughout the network, to collect and transmit information, where wireless networks with computing capability are crucial. Thus, the deployment of wireless sensor network (WSN) is a challenging process, where issues with localization, routing, and energy efficient clustering, if not resolved correctly, impair the utility due to drastically reduced network life.

Most of the real-world problems in various research fields are dynamic optimization problems, which are characterized by a set of nonlinear equations under different complex constraints. As the problem search space increases, traditional optimization techniques become increasingly computationally intensive and prone to failure. This motivates for employing bio-inspired algorithms which demonstrate robust, reliable performance and higher computational efficiency. Bio-inspired computation is a rapidly evolving field with many real-world applications including: food processing (Sarkar et al., 2022), healthcare (Gupta, 2022), Internet of things (CSS Anupama, 2022), engineering (Eid, Garcia-Hernandez, et al., 2022) (Zhao et al., 2022) and image processing (Hao et al., 2023) (Escorcia-Gutierrez et al., 2022).

This chapter seeks to analyze the presence literature in wireless sensor network challenges and problems resolved by bio-inspired optimization algorithms. The goal is to summarize several bio-inspired optimization algorithms and their use in wireless sensor networks in order to provide direction for the applicable research community. This encourages trans-disciplinary research, which is a key innovation driver. Additionally, this chapter covers multi-objective bio-inspired optimization of wireless sensor network in extensive detail.

The rest of the chapter is organized as follows: Section 2 deals with optimization and bio-inspired algorithms, Section 3 discusses multi-objective bio-inspired optimization. Section 4 briefs about wireless sensor networks, Section 5 summarizes various optimization problems in WSNs. While, the recent applications of bio-inspired algorithms in WSN will be discussed in Section 6 and section 7 presents the chapter's conclusions.

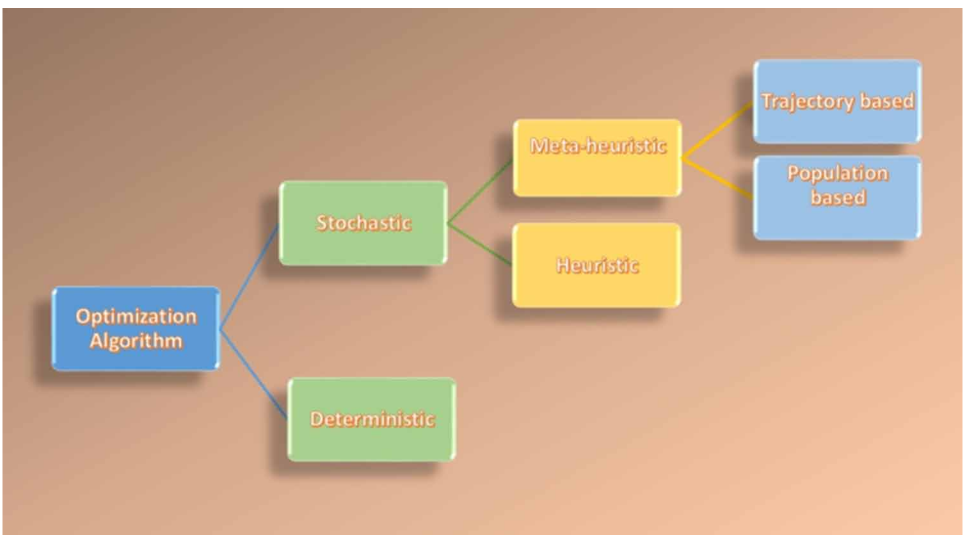
2. OPTIMIZATION AND BIO-INSPIRED ALGORITHMS

Every aspect of nature and existence, aims to be at its optimum. All optimal seeking involves achieving goals or objectives and satisfying the constraints wherein the optimum must be reached (Chow, 2014) (Chen et al., 2014). This optimal searching can be expressed as an optimization problem (Peng & Ouyang, 2014) (Eid &

Abraham, 2018). Based on the produced solutions, optimization algorithms are classified into two categories: deterministic and stochastic algorithms (Yang, 2010). Deterministic algorithms operate without the use of randomness, whereby, the same path is repeatedly taken by the algorithm, and it consistently produces the same result across different runs. In contrast, stochastic algorithms display some randomness and provide varying results between runs.

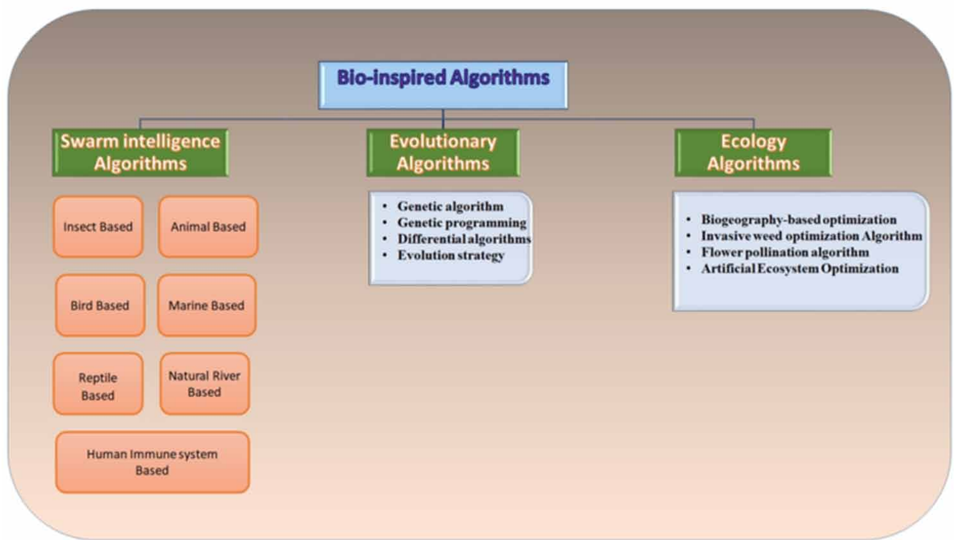
Stochastic algorithms have the benefit of simultaneously exploring several areas of the search space, being able to escape the local optima, and being able to achieve the global optimum (Li & Grossmann, 2021). Stochastic optimization algorithms fall into one of two categories: heuristics and meta-heuristics. Heuristic refers to a method of finding or discovering the optimum via trial and error. While, the meta-heuristic algorithm iteratively directs a subordinated heuristic by fusing some specified rules for exploring and exploiting the search space. Meta-heuristic algorithms have been categorized in a variety of ways in the literature. They may be divided into two categories: trajectory based and population based (I et al., 2013), as shown in Figure 1. While population-based algorithms utilize several agents (multiple solutions), which will interact and move towards objectives simultaneously, trajectory-based algorithms only use one agent (single solution) at a time.

Figure 1. Optimization algorithm classification



Several problems emerge in our daily life that are challenging to resolve due to the limits of traditional solutions, as a result, modern optimization algorithms are concentrating on finding solutions to these complex problems that are inspired by nature rather than the conventional methods. Bio-inspired algorithms belong to a class of meta-heuristic algorithms that are modelled after or drawn inspiration from certain characteristics and mechanisms of biological systems (Eid, Mansour, et al., 2022). The process of designing algorithms through biological inspiration includes the following stages: understanding the biological process, developing patterns of the biological process, and technical and mathematical modelling (Wagh & Prasad, 2013). The three main categories of bio-inspired algorithms are: swarm intelligence, evolutionary, and ecology-based algorithms, as shown in Figure 2.

Figure 2. Taxonomy of bio-inspired algorithms



One of the most crucial uses of artificial intelligence is the development of bio-inspired algorithms, as they emulate the idea of making the machine think and selecting the best option from a range of options. Table 1 describes a set of recent swarm optimization algorithms.

3. MULTI-OBJECTIVE BIO-INSPIRED OPTIMIZATION

In single objective optimization problems, the optimal solution is distinct, while, multi-objective optimization expands the optimization process by enabling the simultaneous optimization of many objectives (Deb, 2001) (Cac et al., 2007). However, properly

Table 1. Swarm intelligence optimization algorithms

Biological System	Algorithm	Reference
Animal based	Polar Bear Optimization Algorithm	(Polap & Wozniak, 2017)
	Red fox optimization algorithm	(Polap & Wozniak, 2021)
	Chimp optimization algorithm	(Khishe & Mosavi, 2020)
	Coyote optimization algorithm	(Pierezan & LS, 2018)
Bird based	Golden Eagle Optimizer	(Mohammadi-Balani et al., 2021)
	Particle Swarm Optimization	(Eberhart & Kennedy, 1995)
	Cuckoo Search	(Gandomi et al., 2013)
	Pigeon-Inspired Optimization	(Zhong et al., 2019)
Insect based	Dragonfly Optimization Algorithm	(Mirjalili, 2016)
	Moth-flame optimization algorithm	(Mirjalili, 2015)
	Black Widow Optimization Algorithm	(Hayyolalam & Kazem, 2020)
	Ant Colony Algorithm	(Dorigo & Birattari, 2010)
Reptile based	Chameleon Swarm Algorithm	(Braik, 2021)
	Reptile Search Algorithm	(Abualigah et al., 2022)
Marine based	Marine Predators Algorithm Salp Swarm Algorithm	(Faramarzi et al., 2020) (Mirjalili et al., 2017)
	Whale Optimization Algorithm	(Mirjalili & Lewis, 2016)
Human Immune system based	Immune plasma algorithm	(Aslan & Demirci, 2022)
	Coronavirus Herd Immunity Optimizer	(Al-Betar et al., 2021)
Natural River based	Water Cycle Algorithm	(Hadi Eskandar et al., 2012)
	Evaporation Rate Based Water Cycle Algorithm	(Sadollah, Eskandar, Bahreininejad, et al., 2015)

addressing numerous objectives, which sometimes have contradictory natures, is the major problem in multi-objective optimization.

A multi-objective optimization problem is typically formulated as:

$$min\ /\ max: \quad F\left(x\right)=\left\{f_1\left(x\right), f_2\left(x\right), \ldots, f_m\left(x\right)\right\}$$

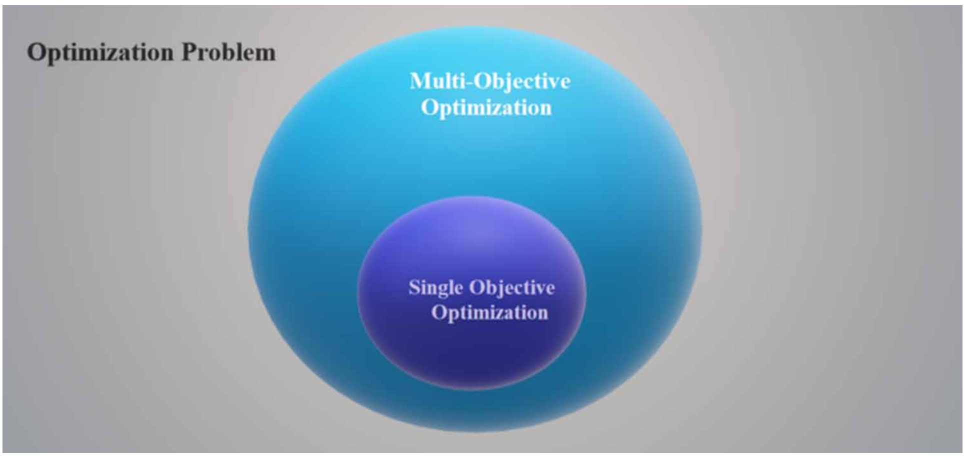
$$subject\ \ to: \quad g_i\left(x\right)\leq 0,\ \ i=1,2,\ldots,k \tag{1}$$

$$h_i(x) = 0, \; i = 1, 2, \ldots, p$$

$$LB \leq x_i \leq UB, \; i = 1, 2, \ldots, n$$

where F is a multi-dimensional objective function vector; x is a n-dimensional decision vector; h and g symbolize the equality and inequality constraints respectively; and [LB, UB] represent the i-th variable boundaries.

Figure 3. Optimization problems type

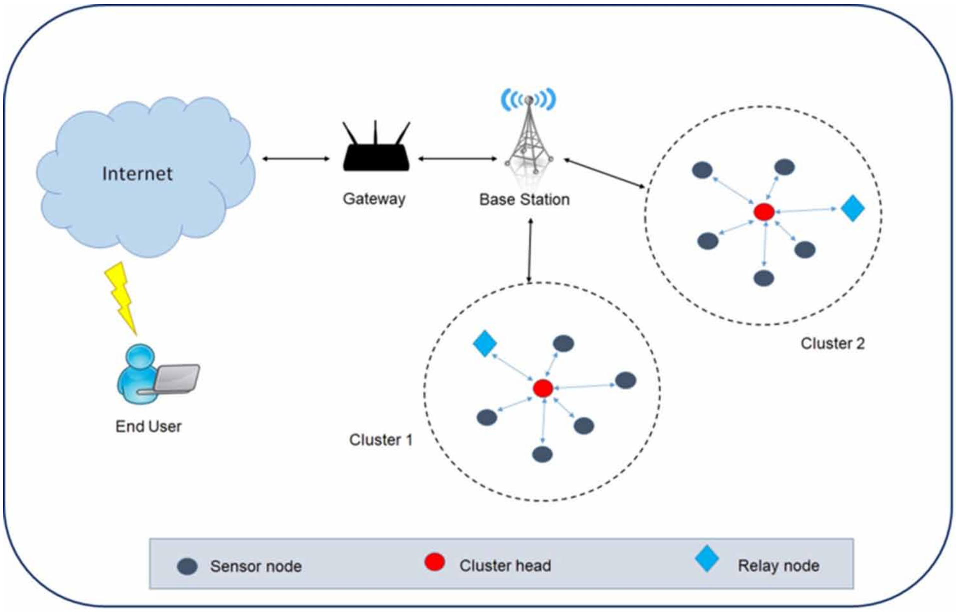


In recent years, many multi-objective bio-inspired optimizers have emerged in the literature in an effort to solve multi-objective optimization problems such as: Multi-Objective Particle Swarm Optimization (MOPSO) (Coello et al., 2004), Non-dominated Sorting Genetic Algorithm (Srinivas & Deb, 1994), Multi-objective water cycle algorithm (MOWCA) (Sadollah, Eskandar, & A, 2015), Objective Evolutionary Algorithm based on Decomposition (MOEA/D) (Q. Zhang & Li, 2007), Multi-objective Spiral WCA (MOSWCA) (Eid, Garcia-Hernandez, et al., 2022).

4. WIRELESS SENSOR NETWORKS

A wireless sensor network (WSN) is generally composed of several sensor nodes spread out across a vast area, as illustrated in Figure 4. These nodes are inexpensive, small in size, and have low energy, computation, and storage requirements (Akyildiz

Figure 4. Wireless sensor network architecture

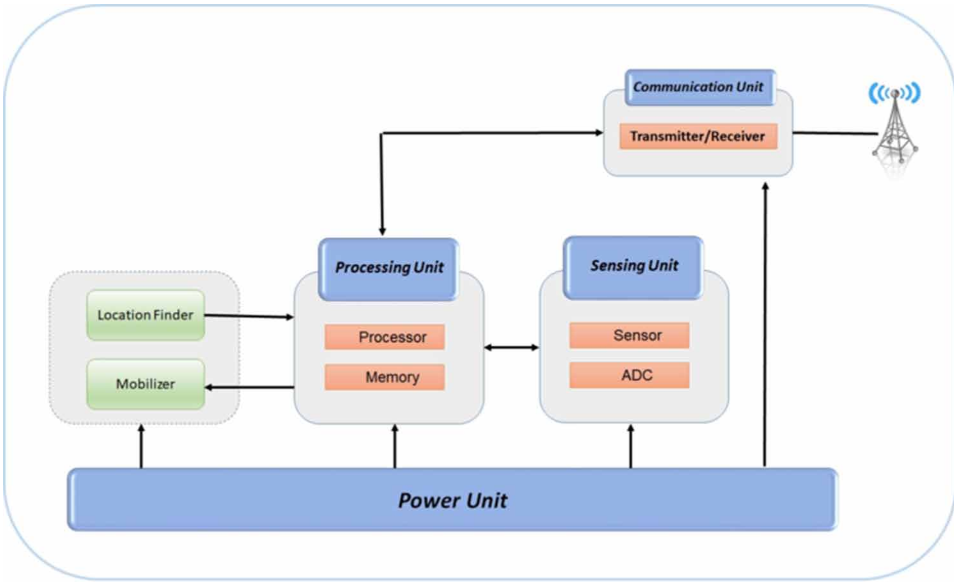


et al., 2002). Different WSNs are utilized for various purposes, including bio-medical, agriculture, health, traffic and industry (Alkhateeb et al., 2022) (Ketu & Mishra, 2021) (Gavrilovi´c & Mishra, 2020). This is crucial to the development of Internet of Things technology (IoT), which is a key component of building smart cities. Figure 5 depicts the sensor node architecture, which has four major units: power unit, sensing unit, processing unit, and communication unit (Heydarishahreza et al., 2020) (Kishor et al., 2015).

The WSN consists of the following components (Aiswariya et al., 2018):

- **Sensor Node:** A small low-powered node that is capable of gathering data, performing some processing on it, and distributes it to other WSN nodes.
- **Cluster Head:** A High bandwidth, secure and reliable node used to collect data from sensor nodes. Depending on the needs of the application, the cluster may contain one or more.
- **Relay Node:** The Relay node shares the burden of the sensor nodes by facilitating communication with the neighboring node. It provides energy efficient data gathering and increases the network lifetime.
- **Base Station (Sink Node):** A WSN node used to aggregate data from other deployed sensor nodes in the network.

Figure 5. Sensor node architecture



- **Gateway Node:** A gateway acts as a network's entry and exit point to provide the link between the WSN and external networks.

5. OPTIMIZATION IN WIRELESS SENSOR NETWORK

WSN challenges are often associated with its strict restrictions on energy use, deployment, and localization. In this section, various optimization problems in WSNs related to deployment, area coverage, sensor localization, sink node placement, energy clustering, routing, and data aggregation are reviewed.

Deployment

A crucial stage that has a considerable impact on the WSN's functionality and performance is the deployment of the sensor nodes. In WSNs, deployment refers to a practical strategy of effectively allocating sensor nodes to guarantee enough coverage of the area of interest (Mnasri et al., 2014). The optimal deployment of sensor nodes ensures that the most effective network node communication occurs with the minimum number of nodes, while covering the entire required region (Luna et al., 2018). Depending on the application needed, deployment can be either static or dynamic. Static deployment is further separated into random and deterministic deployment (Gajbhiye & Mahajan, 2018).

Coverage and Connectivity

Since optimal coverage is vital, it becomes a crucial subject in the research of WSNs. A sensor node is said to be covered by the WSN if it is operational active and capable of detecting an object within the monitored area. Three categories of coverage can be distinguished: area, point, and barrier coverage (Maheshwari & Chand, 2019; Harizan & Kuila, 2020; Farsi et al., 2019). Covering the region of interest is the primary goal in areal coverage. While, point coverage covers certain points of the interest region. In barrier coverage, nodes are deployed in such a way as to create a barrier in a certain direction. The goal of optimal coverage is to cover the whole area or all of the target sites using the fewest possible sensors. One of the most crucial characteristics of a sensor's coverage in a WSN is its shape. In real life, the sensing region's geometry is irregular and complex, which introduces a new problem of overlapping zones. Hence, the key difficult challenge in this problem domain is to minimize the overlapping sensing zones without a coverage hole.

Energy Efficient Clustering and Routing

Since the energy amount that may be used by sensors is limited, energy efficient infrastructure is crucial. For which, the transmission of the detected data uses up the majority of the sensor's energy. The energy required for data transmission rises exponentially as the transmission time lengthens. Hence, grouping sensor nodes into clusters is an effective topology control strategy for attaining long-term operations of WSNs. It has been shown that, network designs based on clustering are the most efficient in terms of power utilization (Elhabyan & Yagoub, 2015). An effective clustering enables load balancing between the cluster heads (Singh & Kumar, 2019). In order to establish communication between the sensor nodes and the base station, optimal routing strategies are required (A. Sarkar & Senthil Murugan, 2016). Thus, the main concerns in this field are essentially the data maximization with extended network lifespans, finding the optimal routing path for each cycle and minimizing the communication distance.

Sensor Localization

The goal of the sensor localization in WSNs is to identify each sensor node's location inside the network. Where, optimization algorithms aim to establish the location information of each sensor node without employing the global positioning system (GPS), as it consumes a lot of energy (So-In et al., 2016; Han et al., 2013). With the aim of localizing the sensor nodes in the WSN, several optimization algorithms are used. For which, the major challenge in this problem domain is to increase the accuracy of the unidentified node position by minimizing the localization error. Whereby, the localization error is the estimate difference between the approximated node position and the actual node position.

Sink Node Placement

The main objective of WSN applications is to optimize the network life span by using the energy effectively, since the energy available in the sensor nodes utilized in WSN is limited. In WSN, all the data gathered by the sensors are forwarded to a sink node. Consequently, the placement of a sink node greatly influences the energy consumption and lifespan of WSNs (Eva et al., 2018; Alageswaran et al., 2012). Hence, finding the optimal position for sink node is important in WSN application.

Data Aggregation

Data aggregation is an energy-efficient strategy in WSN and is a second way of minimizing the redundant information detection. When sensors monitor a region, they collect local data and transfer it to a data aggregation center completely or partially processed. The data aggregation center decides specifically to extend the lifespan of the sensors by removing the sensing of overlap or common locations based on the data it has received. Based on the logical topology of the WSN, five different kinds of data aggregating methodologies exist: flat, tree-based, grid-based, cluster based and chain based (Ramachandran & Perumal, 2018). The major concerns in the data aggregation problem domain focus on addressing the challenge of determining the minimal number of aggregate points while routing the data, optimizing the optimum power allocation and ensuring consistency for complex and extensive scale WSNs.

6. APPLICATION OF BIO-INSPIRED ALGORITHMS IN WSN

Numerous WSNs are utilized for different applications due to the low cost and small size and of sensor nodes, which is essential to the existence of Internet of Things (IoT) technology. As a result, improved models and algorithms are always required to facilitate on-demand wireless sensor network deployment. Though various obstacles might arise while developing wireless sensor network, including those related to deployment, power allocation, localization, communication, and routing.

The proposed solution methods come from adapting different recent bio-inspired optimization algorithms. Searching for the optimum solutions in the optimization space is one of the major characteristics of bio-inspired systems. The deployment, power allocation, localization and routing problems with wireless sensor networks are characterized as NP-hard optimization problems in comparison to traditional optimization problems (Efrat et al., 2005). Hence, the wireless sensor network is composed of a set of sensor nodes, the bio-inspired optimization approach simulates each sensor node in the wireless sensor network as a single search agent. For which, the bio-inspired optimization algorithm's goals during iterations include locating the sensor nodes in the optimal location or reducing the given wireless sensor network's energy consumption. Table 2 investigates the key aspects influencing the WSN as well as come up with bio-inspired algorithms to resolve various wireless sensor network challenges.

Single-objective optimization algorithms are used to handle single objective problems, and their primary goal is to or maximize or minimize a single objective while taking into account a variety of constraints. Whereby, single-objective optimization algorithms select the most essential performance metric to be optimized. Since single-objective optimization algorithm prioritizes one measure above the other dominant ones, this optimization algorithm type may be biased in real-world applications (Fei et al., 2016; Iqbal et al., 2015). Thus, in real WSNs applications, it could be unreasonable and inappropriate because it selects the most important performance parameter to be improved.

Hence, multi-objective optimization algorithms have attracted the attention of researchers to solve a variety of multi-objective optimization problems (MOPs), in which numerous objectives are considered simultaneous according to a set of constraints (Lanza-Gutiérrez et al., 2019) (Hasson & Khudhair, 2018). Whereby, multi-objective problems are more often solved by bio-inspired optimization algorithms. In WSN, simultaneous achieving many objectives is a more feasible optimization, such as the longest network lifetime, the maximal energy efficiency, the highest reliability, the shortest delay or the trade-offs among the previous objectives (Tharmarasa et al., 2013).

Saad et al proposed a realistic coverage model for 3-D WSNs. The authors re-formalize the deployment problem for 3-D WSNs while taking into account a realistic spatial representation of the surroundings. For which, multi-objective genetic algorithm with novel adaptive and directed genetic operators is then used to tackle the deployment problem (Saad et al., 2020).

Cao et al investigate the problem of heterogeneous wireless directional sensor network deployment in 3-D smart cities. Using 3-D urban terrain data, authors restructure the deployment issue into a multi-objective optimization problem, taking into account the reliability and connectivity constraints as well as the connectivity

Table 2. WSNs application with bio-inspired optimization algorithms in the literature

Algorithm	Optimization Area	Objective	Reference
Artificial bee colony-based	Deployment	minimizing the number of deployed sensor nodes maximizing network lifetime	(Dananjayan et al., 2022)
Improved moth flame search	Coverage and Connectivity	Repair coverage holes minimize energy consumption	(Yao et al., 2022)
Immune plasma algorithm	Deployment	maximize coverage, and lifetime minimize consuming energy	(Tasdemir et al., 2022)
Elephant herding optimization + Tree growth algorithm	Localization	minimize the errors in finding the location of the sensor nodes	(Strumberger et al., 2019)
Vampire bat algorithm	Deployment	Repair coverage holes minimize energy consumption	(Wen et al., 2022)
Glowworm swarm optimization	Deployment	minimum number of nodes, multi-hop transmission, and sleep-wake mechanisms	(Chowdhury & De, 2021)
Grey wolf Optimization	Coverage and Connectivity	maximizing coverage and connectivity minimizing overall network cost	(Jaiswal & Anand, 2021)
Biogeography-based optimization	Deployment	minimize the number of sensor nodes minimize interference with efficient connectivity	(Naik & Shetty, 2021)
Shuffled frog leaping algorithm + whale optimization algorithm	Coverage	Improve network coverage with a minimum number of nodes	(L. Zhang et al., 2021)
Grey wolf optimization	Localization	minimize the errors in finding the unknown sensor nodes location	(Rajakumar et al., 2017)
Artificial Bee colony + whale optimization algorithms	Coverage and Connectivity	maximize the coverage and connectivity	(Vishal & Babu, 2020)
Enhanced grey wolf optimize	Deployment	maximize the WSN coverage minimize the deployment cost	(Wang & Xie, 2020)
Particle swarm optimization	Deployment	maximize the network coverage and connectivity	(Yanmin, 2020)
Discrete particle swarm optimization	Deployment	Improved field monitoring	(Xia et al., 2020)
Improved flower pollination algorithm	Deployment	maximize the coverage area of WSN deployment in an urban area minimize the energy consumption rate and the node radiation overflow rate	(Wang et al., 2019)
Artificial Fish Swarm Algorithm	Sink Node Placement	maximize the performance of sink moving in WSN	(Mechta & Harous, 2017)
Ant-lion optimization	Deployment	maximize coverage rate	(Liu et al., 2018)
Grey wolf optimizer +sunflower optimization	Energy Efficient Clustering	Find the optimal cluster head selection (CHS) under certain factor constraints such as energy spent and separation distance	(Nagarajan & Thangavelu, 2021)
Social spider algorithm	Deployment	Improve the WSN coverage	(Zhou et al., 2018)
Bacteria foraging	Deployment	Improve WSN coverage and connectivity	(Nagchoudhury et al., 2015)
Bat algorithm	Localization	maximize the precision of node localization.	(Goyal & Patterh, 2016)
Cat Swarm Optimization algorithm	Sink node placement	minimize the transmission paths from the sink node to rest of the sensor nodes	(Snasel et al., 2016)
Firefly algorithm + particle swarm optimization	Energy Efficient Clustering	minimize the energy and also prolongs the lifetime of the network by finding the optimal cluster head selection	(Pitchaimanickam & Murugaboopathi, 2020)
ANT Particle Swarm Optimization	Data aggregation	minimizing the routing disturbance finding a safe and efficient routing in wireless sensor networks	(Chandnani & Khairnar, 2022)

quality, coverage,, and lifetime objectives. Whereby, a novel distributed parallel multi-objective evolutionary algorithms (MOEAs) is proposed to solve the optimization problem (Cao et al., 2019).

Hajjej et al studied the localization issue for sensor nodes in WSNs. First, a restricted multi-objective optimization problem is used to frame the problem. Then, a multi-objective Flower pollination algorithm (MOFPA) innovative technique was proposed to solve the optimization problem. The goal of this novel approach was to estimate the best trade-offs between multi objective functions, including improving coverage, decreasing network energy dissipation, network lifespan maximizing, and sustaining connection (Hajjej et al., 2019).

Storn/multi-objective Price's and Differential Evolution (DE), two methods that improve WSN coverage while using less energy, were implemented by Céspedes-Mota et al. The proposed algorithms maintain network connection by optimizing the placement of nodes randomly into various shapes. Additionally, a Hungarian technique was used to determine the shortest distance between the positions of the first and last node. For which, DE offers a solution with the best precision possible (Céspedes-Mota et al., 2018).

Controlled Deployment Algorithm (CDA) was proposed by Hajizadeh et al based on multi-objective Bee swarm optimization taking behavior of honey bees into account. There are two key components of the proposed algorithm: coverage and WSN connection (Hajizadeh et al., 2018). While, Y. Y. Hao suggested an improved Glow-worm swarm optimization (IGSO) algorithm to improve the performance of multi-dimensional problems and convergence rate (Y. Y. Hao et al., 2018).

7. CONCLUSION

The employment of bio-inspired algorithms has propelled next-generation computing into a new stage. For solving optimization problems in the real world, bio-inspired algorithms provide a variety of benefits, including reasonable processing time, the potential to find global optimal solutions, and applicability. Traditional algorithms, on the other hand, frequently produce unsatisfactory results, mostly due to the size and complexity of the structure problem. Hence, bio-inspired algorithms are perfectly adapted for solving multi-objective real-world optimization problems. This Chapter, listed various inspirations of bio-inspired algorithms, and provide a comprehensive review of the use of these algorithms in WSNs and the associated challenges. For which, bio-inspired algorithms have demonstrated a strong competence in solving WSN issues in terms of deployment, energy efficient, data aggregation and localization.

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Chapter 3
Digital World of Cloud Computing and Wireless Networking:
Challenges and Risks

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ABSTRACT

Today's world is a new digital world where most of the things have moved online. As the digital world is enhancing, advancing, and evolving every day, various new and unique innovations and developments are rolling out in the IT industry. These innovations and developments are helping humans overcome existing problems, improve processes, and enhance the user experience by providing specific and personalized solutions to users. User needs are the main reason behind all this digital change and innovation. One such important innovation which has changed the digital world's face is known as cloud computing. Cloud computing is an internet-based service, which enables on-demand network access to share a collection of all configurable computational resources (such as servers, repositories, networks, applications, resources). As the amount of data is increasing day by day, the security of users' data has become a major and crucial concern to provide protected communication between users and the cloud service provider.

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INTRODUCTION

It is evident that technology has integrated itself into our daily lives. We must confess that going without technology for a day would be challenging. Our lives are made simpler, more convenient, and more effective by technology (Hussain et al., 2018). Therefore, it is not surprising that many of the valuable businesses with the greatest global growth potential are technology firms.

Cloud computing is a term that involves the use of the internet and central distant servers for maintaining and storing and sharing data, resources, and applications. Therefore, before going to start the concept of cloud computing let's first discuss the internet and some other important aspects which are used before cloud (White, 2012) computing.

Apart from this, Investors from all over the world have their eyes on stocks in the technology industry. The Nasdaq Composite Index shows that from August 2020, the index has increased by a remarkable 37.5%. Additionally, the technology sector has produced 5–6 times the returns on investments. Here we are describing the concept of the role of the internet.

Internet is the concept where a network of networks is interconnected to transfer information from one end to another. It's a globally available system that uses the standardized communication protocol suite called TCP/IP to provide services to billions of users worldwide. It is a network of interconnected networks that (Sagiroglu & Sinanc, 2013) consists of public, private, academics, educational institutes, businesses, and government networks. The whole world is connected via the internet to exchange data, news, interest, and opinion (Leung & Zhang, 2016).

Definition of Cloud Computing by NIST

Cloud computing by NIST is a model for enabling ubiquitous convenient, on-demand network access to a shared pool of configurable computing resources (e.g., servers, storage (Cappa et al., 2021), networks, applications, and services) that can be rapidly provisioned and released with minimal management efforts or service provider interaction.

Our contribution is to establish the scope of digital market in cloud computing and wireless networking so in this article; we also compared the difference between the factors of cloud computing techniques and the era of wireless interface.

A total of five sections are discussed in this article. The first section is about the introduction of cloud computing. The second section is based on features of cloud computing (Yang et al., 2017). The information and data of big cloud companies and their services are described in the third section. The fourth section describes the challenges and risk of cloud computing and last section explored the conclusion through this article.

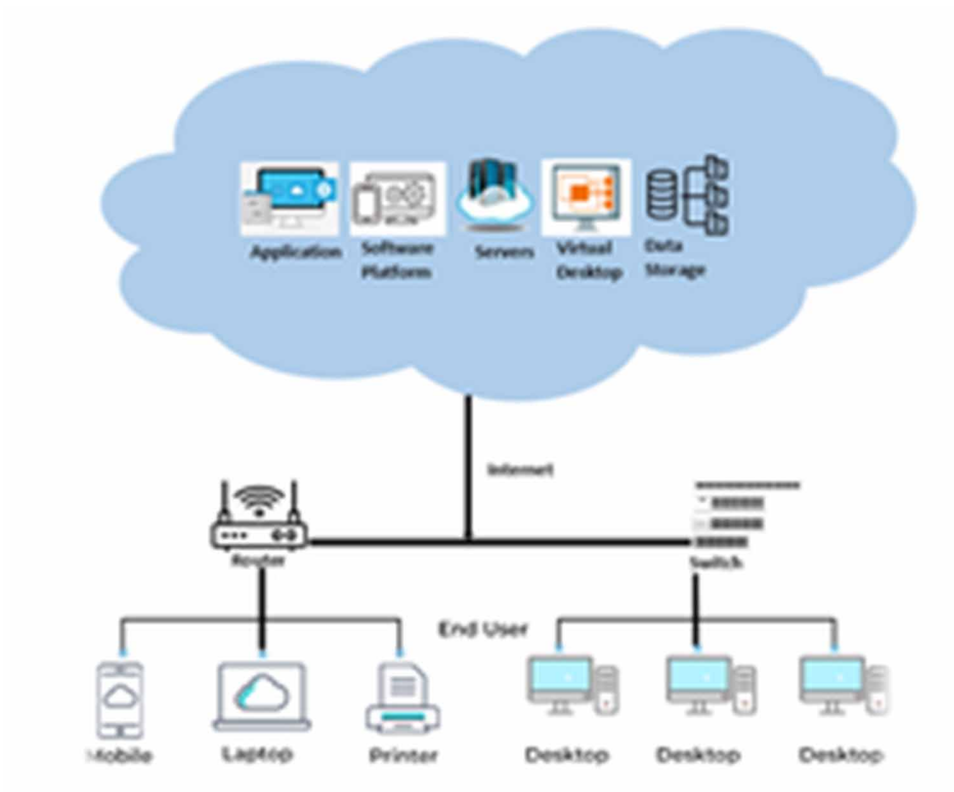
Cloud Computing

Simply put together cloud computing is using the available resources and services provided over the internet. Cloud resources are assigned or used from the available data centers worldwide. Cloud computing made it easier for users to (Zhao et al., 2014) access computer-generated resources using the internet on a demand basis. As the use of cloud computing increased rapidly it grabbed popularity in a few years. A few cloud service classifications are Google Engine, Oracle Cloud, and Office 365 (Elshawi et al., 2018). Nowadays the use of cloud computing has increased so fast as a maximum number of people are taking interest in the development of the cloud and using the cloud. Cloud computing is not a new concept to us although it's a fresh package of old foundations with advancements.

Most people are aware of iCloud through Microsoft OneDrive or Apple's iPhone, both of which simply provide data storage. Cloud computing, however, does more than merely offer data storage. Cloud computing is a set of services that allows both individuals and companies to store, manage, and access huge amounts of data generated online (Khajeh-Hosseini et al., 2012).

The business of cloud computing is growing rapidly, famous and well-formed IT companies like Google, Amazon, Salesforce.com are offering computing services such as storage, computation, and applications as on pay as per usage with the service models Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). Cloud computing one day may be managed as an open or public utility. Presently electricity is organized as an open or public utility. We need the concept of cloud computing because IT (Low et al., 2011) companies have to come across to meet the business needs to serve customers all-inclusive, by 24*7*365 round the clock and as data is increasing, we also need to upgrade the technology by replacing the old data center concept, because old data center infrastructure is not providing the better accommodation for such rapid data growth. And the other important and major reason for moving towards cloud computing is that as business demands are increasing, the cost of buying new equipment (Singh et al., 2021), power, cooling support, etc., so we need to search for a way that can fulfill customers' business needs at a very low cost and the answer to this is cloud computing (Singh, 2004). The cloud computing architecture is illustrated in Figure 1.

Figure 1. Cloud computing architecture
Source: White (2012)



Cloud Data Center

In a basic and simplest language, a data center is a physical service that many organizations use to store their critical applications, software and data. The main and important component of a data center design includes routers, switches, firewalls, storage systems, servers, and application delivery (Diwakar et al., 2021) controllers. Data centers are important for different purposes for business such as email and file sharing, the productivity of software, CRM, ERP, Databases, etc.

Classic Data Center

A classic data center is a service that provides IT resources to process data. Applications, Storage, Networks, and Database Management Systems (DBMS) are the core elements of the classic data center. Here these IT resources are typically

(Iyappan et al., 2022) viewed and managed as a separate entity, but all these elements must work collectively as a single unit to address data processing requirements. Power supply and environment controls like air conditioning and fire suppression are also other important entities of the classic data center (Sidhu et al., 2022).

Virtualized Data Center

Virtualization is the method of creating a virtual version or image of the available physical resources or hardware to make it appear as a logical resource or entity. Virtualization may be implemented at computing, storage, network, and application layers which refer to as a virtualized data center. Virtualization provides the facility to utilize IT infrastructure, helps in reducing cost and managing complexity, decreases the deployment time, and improves flexibility.

FEATURES OF CLOUD COMPUTING

As we know, cloud computing has become quite famous nowadays and the reason behind this is that it offers countless benefits to clients and has a number of important features (Shah et al., 2022) which make one's life easy.

On-Demand Self-Service

This feature makes it possible for the consumer to use the services as and when required without communicating with the service provider. This service gives you the facility to access your information immediately as required without any difficulty. Some of the services are (Vaqur et al., 2022) freely available and for some, you must pay with a monthly subscription or pay for what you use.

Broad Network Access

Cloud computing offers you the facility to access the network from anywhere worldwide. What you need is just to log in to your account with an internet connection.

Usage Fee

The most important thing with cloud computing is that it has the pay-per-use facility feature. This is the most prominent reason why several companies are deciding to opt for it for the purpose of storage. The usage fee option gives you the facility to use the services on pay per use, which means you have to pay for what you use and for what period of time you want to use that service. You just need to pay for that period only (Lakshmi, Saxena, Koli, Joshi, Abdullah, & Gangodkar, 2022).

Scalability

Cloud computing also has the power to scale the resources for your immediate business needs. You can immediately and simply add or delete users, software features, and other additional resources.

Measured Services

As cloud provides the pay-per-use service (pay only for that what you use) as we know that it is an affordable nature of the cloud. With the measure services feature cloud allows you and your cloud provider to measure storage level, processing, and bandwidth and also can monitor and control the number of resources that you may use which makes a crystal-clear image of cloud computing.

Large Network Access

By using a device and the internet, data from the cloud can be accessed and uploaded from anywhere by the user. These services (Lakshmi, Saxena, Koli, Joshi, Abdullah, & Gangodkar, 2022) are used and accessed using the internet.

BIG CLOUD COMPANIES AND THEIR SERVICES

Cloud computing nowadays is widely used by small to big organizations to improve or revamp their core operations. Due to this increased demand for cloud computing services, there has been a massive increase in the number of cloud service providers which we are going to discuss as follows:

AWS

Amazon web services are one of the topmost, growing, and innovative cloud services providers. AWS is an all-in-one service provider that can be used to use compute power, database storage, content delivery, or other functionalities therefore because of all these toolsets, AWS stands out from the rest. Preferably, AWS provides the opportunity for big and slow-moving companies to move from traditional old data centers to cloud-based technology (Sharma et al., n.d.).

Microsoft Azure

Microsoft Azure is one of the leading competitors to Amazon Web Services. Microsoft Azure is used by IT partners for deploying, managing, and supporting customers' existing solutions (Gui et al., 2023). Study shows that around out of 500 companies, 95% rely on Azure for trustworthy cloud services. The other important benefit of Azure is that it supports open-source technologies and it is the one consistent hybrid cloud that provides comprehensive multi-layered security.

Google Cloud Platform

It is the publicly available cloud service provider by Google. It runs on the exact infrastructure, which Google uses internally for its end-user products such as Gmail, Google Search, Google Drive, and YouTube (Ke et al., 2023). GCP is leading when talking about AI, Machine Learning, and Data Analytics.

Table 1. AWS versus Azure vs. GCP cloud services comparison

AWS	Microsoft Azure		Google Cloud
File Storage	S3 Storage Service	Azure Storage	Cloud Storage
App Hosting	Elastic Beanstalk	Cloud Services	App Engine
RDBMS	Amazon Relational Database Service	SQL Database	Google Cloud SQL
Containers	Amazon Elastic Compute Cloud Container Service	Azure Kubernetes Service (AKS)	Google Kubernetes Engine
Serverless Functions	AWS Lambda	Azure Functions	Google Cloud Functions
Backup Options	AWS Glacier	Azure Backup	Cloud Storage
Data Management	AWS Redshift	SQL Data Warehouse	Google BigQuery

Now let's wrap up the comparison and discuss which one is the best. So, if we talk about it from the establishment, Availability Zone, Market Share, Number of Services, integration with open (Sehgal et al., 2023) source and on-premise system perspective AWS is the winner and with growth rate and pricing models, Google Cloud is the winner.

CLOUD COMPUTING CHALLENGES AND RISK

Cloud computing has gained a lot of popularity because of the benefits it provides to users and all types of small, medium, and big businesses. Due to this reason, we can say that cloud has become an integral part of our life today therefore it is also important for us to look at the issues, risks, and challenges that come with cloud computing (Alqahtani et al., 2023). Let us deep-dive into some of the important challenges, risks, and issues of cloud computing (Wang et al., 2020).

Data Security and Privacy Issues

Security risk is the topmost major and very important concern when we talk about cloud computing and the reason for same is the availability of data publicly as the data is stored and processed by some third-party vendors which make the data more vulnerable to identity theft, malware infections, cyber-attacks, data breaching, account hacking and compromised credentials which eventually decrease the trust among the users of the applications.

Cost Management

When there is under optimization of resources or when the servers are not being used to their full capacity/potential then this adds up (Rana et al., 2022) to the hidden costs or we can say that unused resources make the cost group.

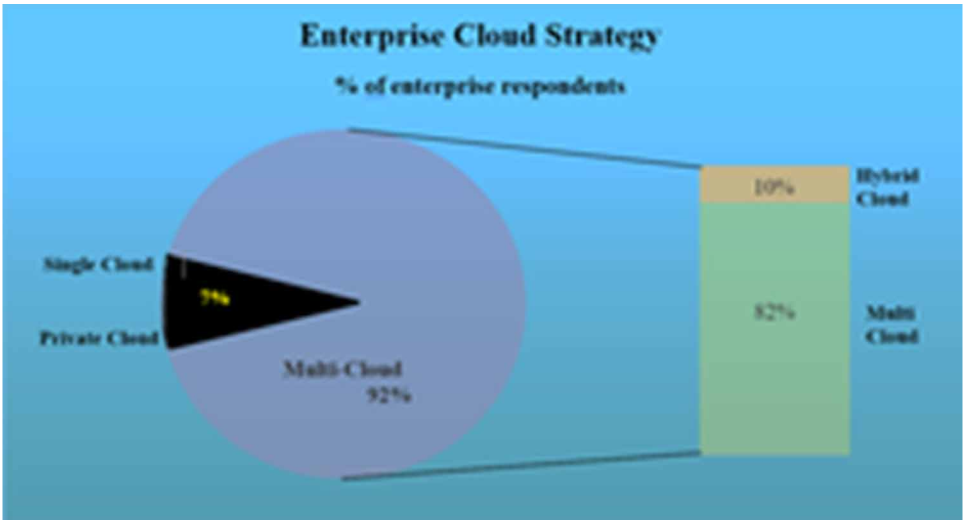
Multi-Cloud Environment

As many different types of cloud service options are available businesses have the opportunity to use multiple cloud services and due to this reason almost 84% of companies are dependent on multiple clouds. Multi-cloud usability often leads to difficulty in managing the cloud due to the differences between multiple cloud providers (Roy et al., 2023) as we see in Figure 2.

Performance Challenge

Performance plays an important role when considering cloud (Vashishtha et al., 2018) computing. Performance-wise if the cloud is not satisfactory, it can make users disinterested and decrease the profit. Even a little delay while loading any app, website, or page can increase the bounce rate or huge drop in the percentage of users (Dayoub et al., 2021).

Figure 2. Enterprise cloud strategy
Source: Yang et al. (2017)



Interoperability and Flexibility

The cloud faces the challenge of not being flexible when one shifts from one cloud environment to another, difficult to handle data movement, and setting up the security from scratch when shifting cloud solutions (Wardianto et al., 2020).

High Dependence on Network

Cloud's high dependency on the network makes it vulnerable to being hacked and it is difficult for small businesses to maintain a particular bandwidth which comes at a high cost.

CONCLUSION AND FUTURE SCOPE

Finally, we would say that cloud computing is a very good platform and has many advantages for small to big organizations who want to grow and excel but we also don't have to ignore the security issues while adopting cloud computing services. We must be very careful while choosing a cloud service provider, we should look into all the compliance policies they follow and check if they have a proper plan to tackle the risks and challenges which come with cloud computing. Funds value can be raised in stock market and share market for future perspective.

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Chapter 4
Influence of Artificial Intelligence on Cognitive Radio Applications

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ABSTRACT

Cognitive radio networks (CRNs) promise to meet device-to-device communication requirements for effective spectrum utilization and power control in a distributed environment for industrial applications. The architecture of the CRN must maintain a high data rate (throughput) at low power consumption, which requires both radio spectrum efficient and energy efficient system design. In order to attain these objectives, the architecture adopts a CRN model needs to operate in an interweave mode that allows spectrum sensing followed by opportunistic secondary user (SU) data transmission over the unused bandwidth of the primary user (PU) in an operating structure. It improves the usage of the radio spectrum intelligently. Cognitive radio works in tandem with artificial intelligence (AI) techniques to provide an intelligent allocation of resources for its users. This chapter aims to highlight the various AI techniques used in cognitive radio operations to enhance cognition capabilities in CRNs and present a review of the subject.

INTRODUCTION

Cognitive Radio Network (CRN) based technology deployment is a promising new application area of wireless mobile communication to provide many industrial

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services. Historically CRN technology is deeply rooted in early cellular and personal communication systems. Cognitive radio research and applications were envisioned in the late 1990s (Mitola, 2000). The regulatory bodies (e.g., Office of Federal Communications (OFCOM) Commission in the United States of America) regulate technical communications issues for commercial applications. For example, some well-known industrial applications include public safety systems (e.g., fire control, flood-related disaster management, earthquake relief operation service, transport network management, and healthcare service operations). In these applications, a large portion of certain licensed frequency bands often remain unused. Therefore, to address the new radio spectrum issue, a new policy would allow devices that can sense and adapt to their spectral environment, such as cognitive radio to become secondary users. Such users are wireless devices that opportunistically use the spectrum already licensed to the primary users. The primary users are generally associated with the primary radio spectrum licensed holder and thus have a higher priority right to the spectrum. The intuitive objective behind secondary spectrum licensing is to improve the spectrum use efficiency of the network, depending on the type of licensing, without affecting higher-priority users.

Spectrum sensing, spectrum decision, spectrum sharing, and spectrum mobility are the four main characteristics of cognitive radio systems. Spectrum sensing helps to observe the spectrum occupancy status and recognize the available ability, while cognitive radio users dynamically access the available channels through the regulation processes of spectrum decision, spectrum sharing, and spectrum mobility. In order to mitigate the processing delays required in these four functions and to improve the efficiency of spectrum utilization, spectrum prediction for cognitive radio networks has been extensively studied in the research literature (Neel, 2007) (Haykin, 2005) (Mitola, 2000). Besides, one of the essential characteristics of CRN is opportunistic spectrum access (OSA) to mitigate the mobile communication spectrum scarcity-related issues. In CRNs, opportunistic spectrum access relates to the wireless communications paradigm in which the communicating parties dynamically exploit the radio spectrum band not utilized by the primary service licensed to operate over such a band.

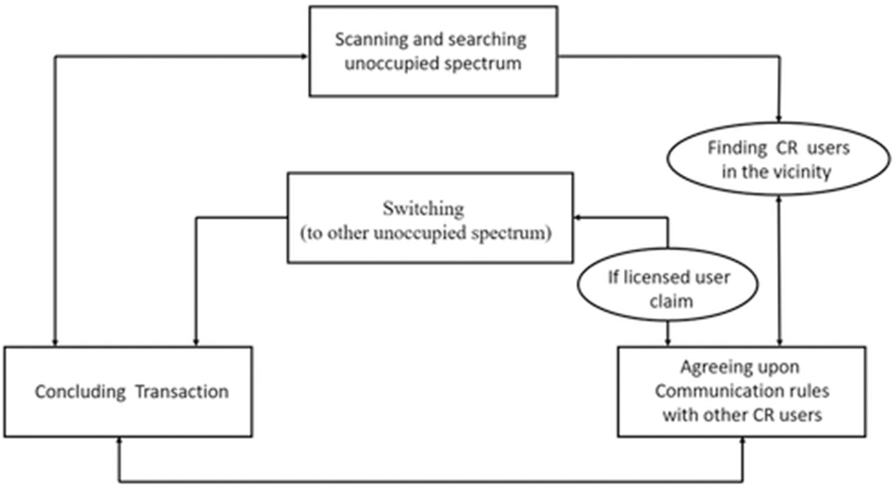
The central component of CRNs, hence OSA, is the cognitive radio transceiver. In a cognitive radio operating environment, a wireless device senses the surrounding radio environment and opportunistically accesses the unutilized spectrum band(s), relying on examining the activities of the primarily licensed networks. In this way, to enhance the usage of the radio range, a cognitive radio hub detects the weather, evaluates the open-air qualities, and then makes certain decisions and distributes the executives' space assets. The cognitive radio works in tandem with artificial intelligence (AI) techniques (e.g., fuzzy logic, neural networks, genetic algorithm, genetic programming, case-based reasoning, Bayesian network-based learning paradigm) to provide a flexible and intelligent allocation of resources for its users. The central objective of this chapter is to highlight the various artificial intelligence techniques used in cognitive radio operations to enhance cognition capabilities in CRNs and present a review of the subject, which includes the typical learning challenges emerging in cognitive radio systems.

Cognitive radio (CR) can support the increased need for networked communications and situational awareness by observing and understanding their environment, applying appropriate policies and behaviors, and learning from their experiences. The primary objective is to make more efficient use of the spectrum in terms of accessing un- or under-utilized bands and effective resource management. In this way, it presents an opportunity for radios that are agile and intelligent enough to use allocated bands where and when they are unoccupied by the assigned users. The sensing ability of cognitive radio requires, at a minimum, adaptive capability: the ability to sense occupancy and to react by changing carrier frequency. With additional intelligence, the radio might *'figure out'* suitable operating parameters based on sensing its environment, for example, altering its bandwidth and packet length to fit within unoccupied frequency blocks at different times. While all of these attractive driving characteristics are recognized in the domain of *cognitive radio*, there is much disagreement on precisely what is and what is not a cognitive radio, with seemingly everyone having their definition (Mitola, 1999). A communication model for cognitive radio is presented in Figure 1. However, the following characteristics are primarily expected from a cognitive radio and form an initial set of assumptions for the remainder of this chapter.

- **Observation:** Application-specific information about the operating environment, capability, and radio characteristics is collected.
- **Reconfiguration:** Alter the operation parameters of the radio.
- **Cognition:** Cognition can be understood as a process of collecting knowledge and understanding through thought, experience, and the senses. It encompasses tasks like attention, memorizing, learning, judgment and evaluation, reasoning, problem-solving, and decision-making. This is existing knowledge and may generate new knowledge.

In CRNs, nodes are powered with *cognitive radios* (CRs) that can sense, learn, and react to changes in network conditions. Mitola envisioned that CRs could be realized by incorporating high computational capability or AI techniques, particularly machine learning (ML), knowledge-based reasoning (KBR), and natural language processing (NLP), into software-defined radio (SDR) hardware. In present days, it is accomplished by using a cognitive engine (CE) incorporating different AI techniques through which the CR adapts to the network conditions to satisfy some notion of

Figure 1. Communication model for cognitive radio systems



optimality (Moon & Gulhane, 2016). In addition, CR promises to dramatically enhance spectrum access, capacity, and link performance while incorporating the requirements and the context of the user. As a result, CRs are increasingly being viewed as a critical component of next-generation wireless networks and their communication capability.

The primary agenda of this chapter is to weave together briefly the AI techniques-based research carried out on problems of spectrum sensing, power control, and other activities in CRNs. The remaining chapter is organized as follows. Next section describes the overview of CRNs. Followed by the fundament operations in CRNs and applications of AI techniques. Finally, the chapter presents a graph based dynamic spectrum sensing methods and conclude with concluding remarks.

BACKGROUND INFORMATION ON COGNITIVE RADIO NETWORKS

Cognitive radio has much potential applicability because of its compelling, affordable, unique features. Also, cognitive radio is a promising technology to enhance the existing software-defined radio (SDR) techniques and utilize the flexibility of spectrum access policy. However, wireless communications are generally governed by a fixed spectrum access policy in which spectrum bands are assigned to licensed users for exclusive use. Even though such a policy simplifies the protocol and hardware development of the devices in use, the policy is causing a significant problem of inefficient utilization of precious spectral resources. Paradoxically, as it seems that there is a problem of spectrum scarcity and over-crowdedness in some bands, others are showing poor utilization levels. For example, the unlicensed industry-science medical (ISM) band and the Global System for Mobile communications (GSMC) band are already exhausted due to the explosive growth of the bandwidth-demanding wireless services and applications utilizing these bands. Meanwhile, according to the Federal Communications Commission (FCC) reports, a large portion of the spectrum in UHV and VHF ranges and the licensed bands allocated for public safety and military radio systems are sporadically used even in crowded areas. This paradox strongly indicates that spectrum shortage results are mainly caused by the spectrum management policy rather than the physical scarcity of usable frequencies.

Consequently, a flurry of exciting activities in engineering, economics, and regulation communities has been stimulated in searching for better spectrum management policies and techniques to use the underutilized spectrum. Many of these research efforts were directed towards a new dynamic access paradigm instead of the conventional static policy (Moon & Gulhane, 2015).

Dynamic Spectrum Access

As a concept, Dynamic Spectrum Access (DSA) is not new. An already established model using DSA is the spectrum commons model (also called the *open sharing model*) (Moon & Gulhane, 2015) applied in the unlicensed ISM band. In this model, all users obey a certain spectrum etiquette and share the spectrum. However, generalizing the model to other bands meant significant changes with high costs in the already well-established legacy systems. So, to keep these well-established legacy systems without significant changes, two models were proposed to share the spectrum with the primary systems (Figure 2); the *negotiated-sharing model* and the *hierarchical-access model* (Moon & Gulhane, 2015). In the negotiated sharing models, negotiations between the primary systems and the unlicensed secondary users occur.

These negotiations can be in the form of trading the spectrum for temporal use, cooperation from the primary system side (e.g., announcing the times of accessing or leaving the spectrum), or cooperation from the secondary users (SUs) side (e.g., working as relays for primary users (Saleem et al., 2015)). However, in the hierarchical access model, the secondary users are considered transparent to the primary system, and it is the secondary users' responsibility to coexist in the spectrum without causing harmful interference to the primary users.

The hierarchical access model can be further classified into two major schemes; the *underlay approach* and the *Opportunistic Spectrum Access (OSA) approach*

Figure 2. Classification of dynamic spectrum access models

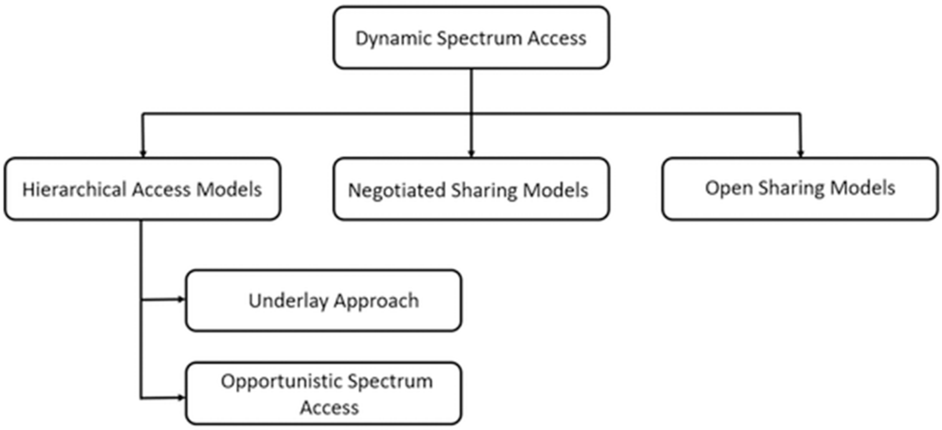
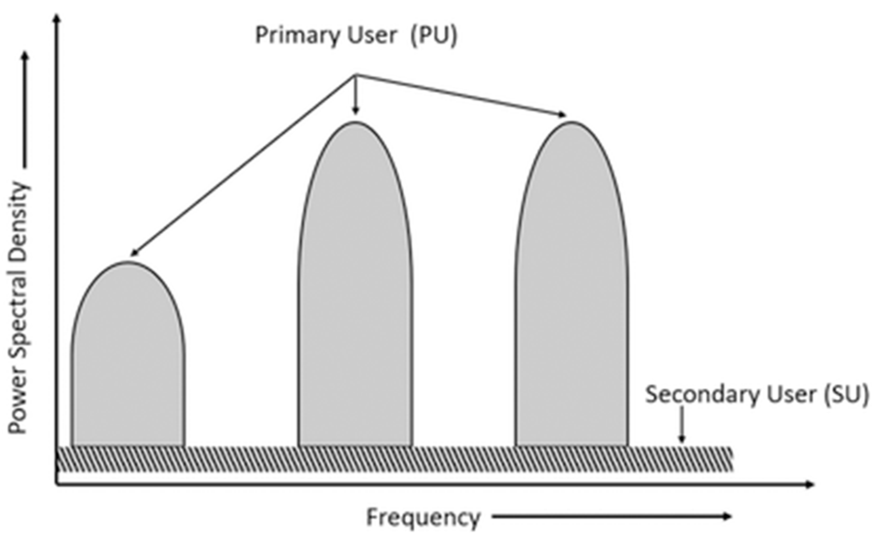


Figure 3. Characteristics of primary users and secondary users transmitted signals



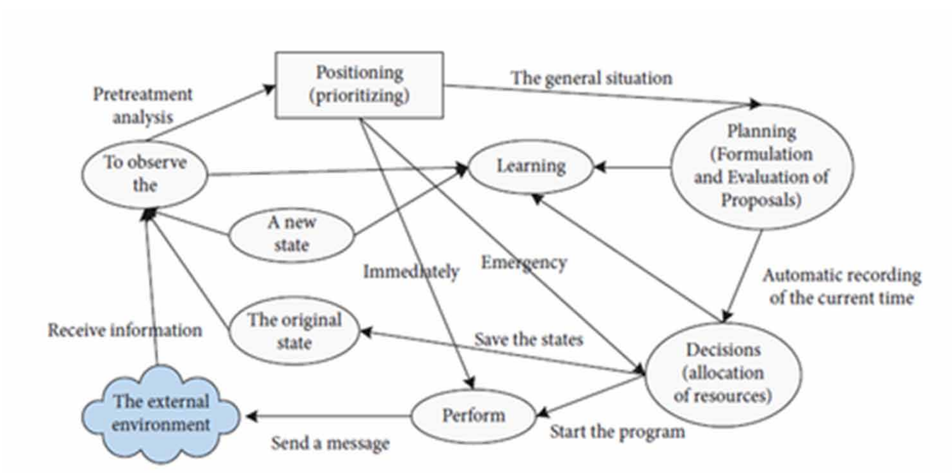
(also called the *interweave approach*) (Moon & Gulhane, 2015). In the underlay approach, secondary users can simultaneously transmit their signals over the primary spectrum with the primary users. However, to do so without harmful interference to the primary users, secondary users spread their transmitted signals over a wide frequency band (UWB) but with power below.

Cognitive Wireless Network

Cognitive radio has some special abilities to automatically extract operational environment data that can improve system functions based on historical results and environmental changes. The initial ideas of cognitive radio networks were introduced by Mitola (2000) in his doctor of philosophy dissertation. The cognitive cycle model he mentioned can well reflect the concept of cognitive radio. The presented cycle model mainly consists of six parts: (i) environmental observation, (ii) self-positioning, (iii) planning, (iv) intelligent training, (v) deployment, and (vi) implementation.

The central objective of the 'environment observation' stage is to deploy the collection and storage of neighboring wireless environment data. The vital purpose of self-positioning is to determine the level of excellence related to the urgency of communication services, sort users according to the main functions of the planning stage, prepare decision-making plans, evaluate the plan's feasibility, and plan the learning stage based on relevant information. The learning occurs continuously, and decision-making activities of the scenarios around the wireless network occur. The deployment phase is the computation and distribution of wireless spectrum resources. The essential activity of the implementation phase is that the cognitive radio allocates its work according to the resources. Figure 4 describes a diagrammatic representation of the cognitive cycle model. Awareness, reasoning, and learning are the essential components of a CR discussed and artificial intelligence-based techniques play important role in design and development of CRNs. For example, AI learning techniques (e.g., artificial neural networks, multilayer linear perception networks, radical networks, genetic algorithms, fuzzy logics, rule-based reasoning,

Figure 4. Cognitive cycle model diagram

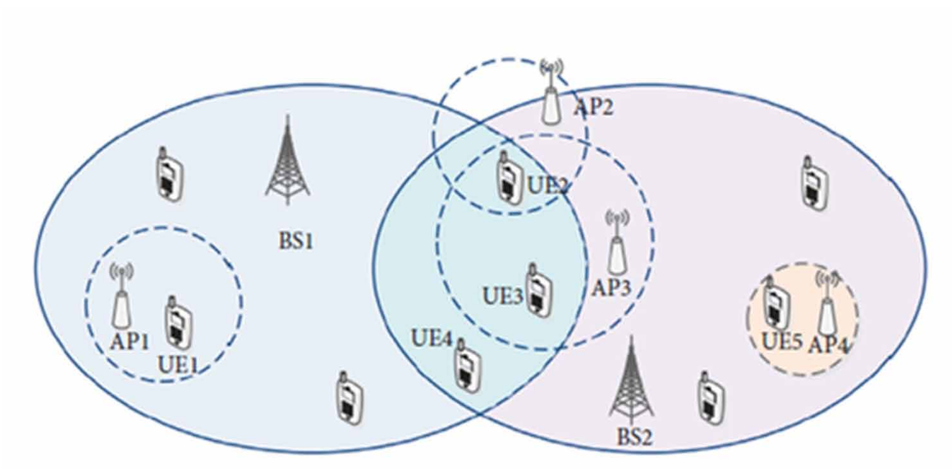


case-based reasoning, and graph-based decision analysis) are used in CRN industrial applications. The following section presents a dynamic graph-based decision analysis method for CRN application.

Heterogenous Network Model

In the heterogeneous wireless convergence system, different wireless networks use different frequency bands and communication methods, making the channel leasing of the heterogenous network no longer applicable, and the load balancing of the heterogenous network must be solved by transferring the load. In addition, regarding access speed and resource types, the burden-sharing of heterogeneous wireless systems requires unified management of wireless resources and load and planning in a large-scale manner.

Figure 5. Heterogenous convergence system of UMTS and WLAN



In designing and modelling sensing networks, a network model with C channels, M primary users, and N secondary users is considered. The primary user occupies some licensed channels, while the secondary users try to access the licenses that the primary user does not. The access matrix of the network is formed as shown below:

$$A = \{a_{n,c} \mid a_{n,c} \in \{0,1\}\}_{N \times C}$$

where $a_{n,c} = 1$ when n^{th} secondary user accessing c^{th} channel and vice versa. The idle channels' hidden terminals and exposed terminals may cause variations from different secondary users. The idle matrix of the network is defined as:

$$I = \{i_{n,c} \mid i_{n,c} \in \{0,1\}\}_{N \times C}$$

where $i_{n,c} = 1$ when n^{th} secondary user accessing c^{th} channel and vice versa. When the secondary user intends to operate in the licensed spectrum, it needs to follow the observation of the primary user occupancy. The observation status of the secondary user is shown in Table 1.

Table 1.

I =	C_1	C_2	C_3	C_4	C_5
SU_1	1	1	0	1	0
SU_2	0	1	1	0	1
SU_3	1	0	1	0	1
SU_4	1	1	0	0	1
SU_5	1	0	1	1	0

In CRN, the primary users and secondary users coexist in the same spectrum band, but they are unknown to each other. It is difficult to identify the presence of a primary user when the secondary user is located outside of the primary user range. The interference between the secondary user and the primary user is defined as:

$$D = \{d_{n,m,c} \mid {}_{n,m,c} \in \{0,1\}\}_{N \times M \times C}$$

where $d_{n,m,c} = 1$ when n^{th} secondary user and m^{th} primary user accessing c^{th} channel simultaneously. The performance of a CRN is maximized by reducing the interface to primary users and reducing the interface among secondary users. It affects both the sender and the receiver in terms of reduction in the transmission rate, spectrum utilization, and higher packet delay. So, energy-based spectrum sensing techniques are used to avoid the interface between them.

Spectrum Sensing

In cognitive radio networking (CRN), spectrum sensing plays an enormous role for its users. It helps to make the most of the unused spectrum portion adaptively to the radio environment. In CRN, a source node and the destination node determine the spectrum availability in the communicating environment. For spectrum sensing, this chapter has adopted energy-based spectrum sensing to identify an idle channel for the secondary users. It senses the unknown signal based on the available noise power. The energy of the received signal is compared with the system threshold. Depending on the result of this comparison, the secondary user identifies the presence or absence of the primary user (Lin et al., 2009).

The hypothesis test for identifying the presence of a primary user is described below by two equations:

$$\beta_{pu}\left(t\right) = \gamma_i^g \theta\left(t\right) + \delta\left(t\right)$$

$$\beta_{su}\left(t\right) = \delta\left(t\right)$$

where:

β_{pu} = received signal by the primary user

β_{su} = received signal by the secondary user

γ_i^g = channel gain

$\theta\left(t\right)$ = primary signal

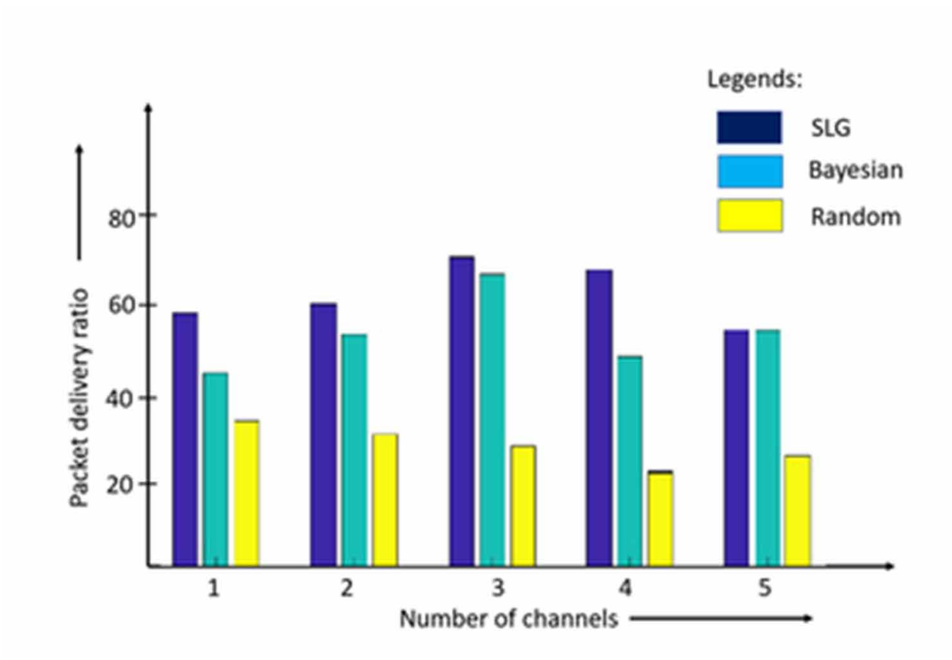
$\delta\left(t\right)$ = represents Gaussian noise, and t refers to the varying time interval of the spectrum.

The solution to the above equations is as shown below:

$$r\left(s\right)=\begin{cases}1\ primary\ user\ is\ exist\\0\ primary\ user\ is\ not\ exist\end{cases}$$

where r(s) is the signal received by the secondary user, and if r(s) = 0, the primary user is absent; otherwise, the primary user is present. Figure 6. shows the basic structure of the spectrum sensing method diagrammatically. The secondary users (SU) access the licensed spectrum through the secondary user base (SUB) station. The primary user base (PUB) station has primary users (PU), allowing the SU to access the spectrum without causing interference to the primary user.

Figure 6. Packet delivery ration



The commercial world is heavily dependent on the efficient use of communication channels. With the increase in the number of communication devices, the utilization of the electromagnetic spectrum efficiently is an important challenge in regular business operations. However, recent advancements in wireless communication are creating a spectrum shortage problem regularly. Cognitive Radio Networks (CRNs) consist of intelligent wireless devices which can efficiently sense the medium and effectively utilize the vacant or under-utilized spectrum. Secondary Users (SUs) are enabled by cognitive radios to opportunistically access the spectrum unused by the Primary Users (PUs). There are two basic objectives of Cognitive Radio Medium Access Control (CRMAC): controlling interface and avoiding collision between SUs, Medium Access Control (MAC) has a vital role in several cognitive radio functions such as spectrum sensing, mobility, resource allocation, and spectrum sharing. The MAC layer manages and coordinates communication over wireless channels. In the presence of dynamic radio surroundings, the CRN access protocol shall create a variety of choices in real time. These requirements make the realization of CRN a challenging task compared to standard access protocols in the present static spectrum policies.

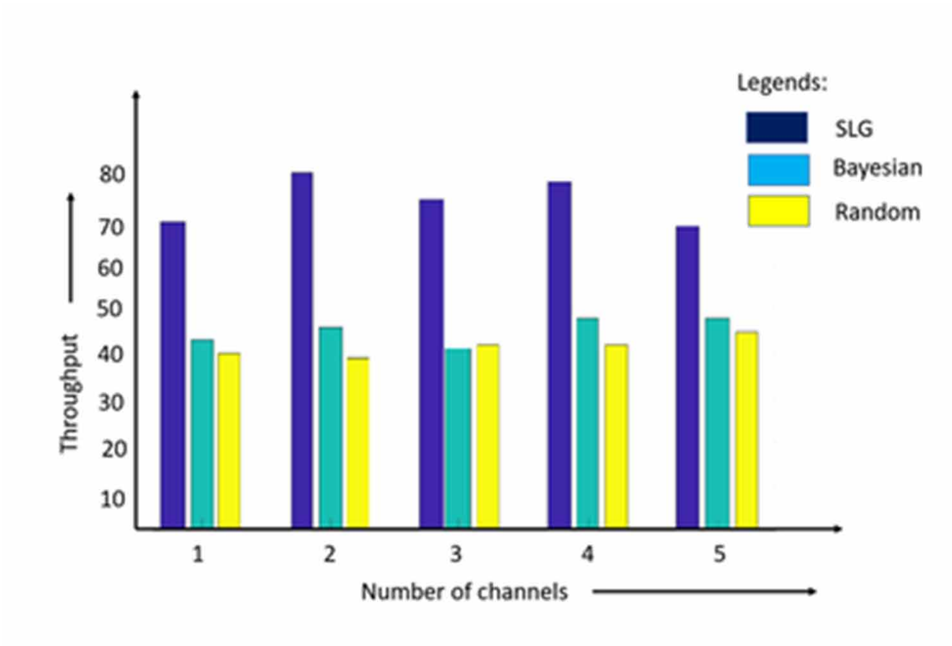
In recent decades, Opportunistic Spectrum Access (OSA) has emerged to increase spectrum utilization considerably. For this, the SUs ought to have the flexibility of dynamically searching and utilizing the opportunities within the authorized spectrum in numerous dimensions like time, frequency, and code. Therefore, the OSA protocol needs to integrate spectrum sensing and access functionalities. In essence, spectrum sensing, spectrum allocation, spectrum access, spectrum sharing, and spectrum quality determine the critical parts of the economical OSA protocol style. Cognitive radio has helped to improve spectrum scarcity. Earlier, spectrum was allocated in a fixed manner in which fixed users could only use licensed spectrum, but with the concept of cognitive radio, SU can broadcast data on the unlicensed spectrum without creating any interference with the licensed operational spectrum. This type of intelligent spectrum sensing enables the network to perform sensing securely.

Performance Evaluation

The proposed SNG-based prediction's performance evaluation has been done using Mat Lab. The three parameters, throughput, packet delivery ratio, and channel utilization, are considered to show the performance of the secondary users. The Figure 6 represents packets delivery patterns. This network assumes five primary user channels and fifty secondary users. The source and destination are modelled by a wireless channel Rayleigh fading with additive white Gaussian noise.

The secondary user senses the channel at a specified observation time and displays the availability status in a binary format, as shown in Figure 7. If it is 0, the channel is free; otherwise, it is busy. So, the secondary user can access only these free channels. Out of ten channels, 1,4,5,8,10 are idle channels. These idle channels do not exist for a longer time. When the secondary user tries to access these channels, it must switch over the spectrum when the primary user arrives. This will degrade the performance of the secondary user. So, estimating the primary user usage in

Figure 7. Throughput



each channel is most important. In this paper, the SNG-based prediction is used for the identification of the usage of the spectrum.

In the SNG-based prediction, the secondary user senses the spectrum and frequently updates its PCL list. Figure 7 shows the prediction result of ten channels. In which 1,4,5,8,10 is had minimum primary user usage that is referred to as LP channels. Each secondary user maintains its LP list, which helps to select the channel randomly. The random selection of the channels leads to a collision between the secondary users. The collision probability can be reduced if a user senses the channel before trying to use it. To minimize the collision, CSMA/CA follows three strategies: the interframe space, the contention window (CW), and the acknowledgment (ACK).

The CSMA/CA protocol decides on an accessing channel. During packet transmission, a secondary user works with RTS/CTS mode. First, it sends an RTS signal to the destination station and reserves the channel. Now the destination station acknowledges the RTS with a CTS signal. After the successful packet transmission, the destination station responds with ACK, which means the receiver may receive the packet. When two or more users try to send an RTS signal simultaneously, they may collide, and the lack of CTS response detects it. The RTS/CTS mechanism always reduces the collision and increases the system's performance.

CONCLUSION

The chapter briefly overviews cognitive radio networks and some of the most critical technical challenges. These networks are expected to be part of the future generation of wireless networks. They offer enormous promises for users regarding the ability to freely move among different networks, obtaining cheap services and new advanced services and business models. At the same time, this technology demands solving very complex research questions regarding dynamic spectrum access, multi-dimensional routing, optimization, and security. Finally, the chapter briefly presents the importance of artificial intelligence techniques in designing CRNs and describes a dynamic network-based model for spectrum sensing purposes. Altogether, there is a high expectation that new technical solutions will appear to allow the advance and acceptance of new technology.

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Chapter 5
Metaverse:
Interdependent Architecture and Applications

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ABSTRACT

Metaverse is the future of internet and an amalgamation of VR, AR, blockchain technology, AI, and 5G, and beyond. Metaverse can be seen as a self-sustaining system with its economy, structure, and trade of virtual items. Currently, there is no common platform for this in a decentralized manner. Thus, there is a need for an interdependent architecture that can provide interaction amongst layers. This chapter focuses on a seven-layered architecture that is simple to comprehend theoretically but cannot represent the true essence of all aspects of Metaverse. Hence, a novel interdependent architecture that includes physical and virtual world interaction is proposed in this chapter. Next, some potential applications and services of Metaverse are discussed. Later, two case studies, that of a virtual city and a virtual university campus using Metaverse, were analyzed based on the proposed architecture. Finally, the chapter is concluded with the open issues and challenges faced while dealing with Metaverse.

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1. INTRODUCTION

Metaverse is not a new concept, but it has come into the limelight due to the advent of Blockchain, the Internet of Things (IoT), and Artificial Intelligence (AI) (Yang, et al., 2022). Many big companies like Facebook (now Meta) (Yang, et al., 2022), have been major contributors to popularizing Metaverse.

Metaverse has emerged as a mammoth networking system due to the major fact that the current generation feels their online presence is almost, if not more, as important as their real-world presence. Needless to say, the Covid pandemic became an accelerator for the virtual. The rise of cybernetics, the evolution of physical devices, and improvement in AI and blockchain technologies are important factors in the evolution of Metaverse as an immersive and shardless virtual ecosystem (Lim, et al., 2022). It is just a larger version of the Massive Multiplayer Online (MMO) games (Lim, et al., 2022) (Duan, et al., 2021) (Díaz, Camilo, & Camilo, 2020) but it has still time to get implemented because of the real-time computations, scalability and ubiquitous implementation (Mystakidis, 2022). The privacy issues of users also pose a serious concern.

Metaverse can be seen as a self-sustaining and complete system with its economy, structure, and production-consumption of virtual items. But creating this economy is a challenge because of the difference in production and consumption of physical and virtual world assets (Yang, et al., 2022). Currently, there is no common platform to trade digital items in a decentralized manner. However, the emergence of Blockchain as a decentralized ledger has brought new opportunities for the Metaverse. Recent developments in AI also have brought fresh promises to overcome challenges such as big data analytics, AI-empowered content generation, etc. Fusing blockchain and AI with Metaverse brings with it many solutions as well as challenges (Yang, et al., 2022).

The organization of this chapter is as follows. Section 2.1 discusses a common seven-layered architecture conceptualized by the author and game designer, Jon Radoff. This is then followed by the proposed, novel interdependent architecture in section 2.2. After section 2, the third section consists of some future applications of Metaverse. This is then followed by Section 4, where two case studies – that of a virtual city and a virtual university campus, are discussed and analyzed based on the proposed architecture. Section 5 discusses some open issues and research challenges and in the end, this chapter is concluded.

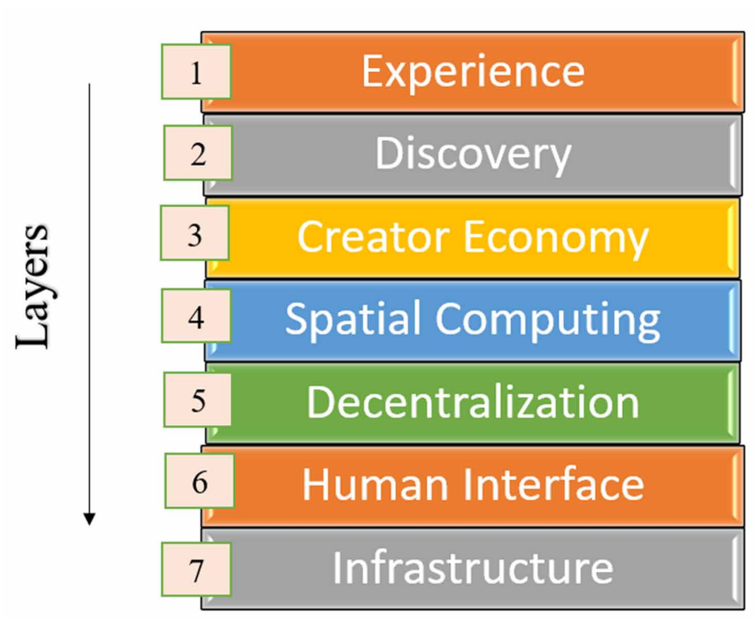
2. ARCHITECTURE OF METAVERSE

Since Metaverse is in its nascent stage, there is no particularly defined architecture of Metaverse (Duan, et al., 2021). The architectural divisions of Metaverse are based on the interaction between the virtual and physical worlds. The most common, seven-layered architecture (HoloNext, 2022) (Takyar, 2022) conceptualized by Jon Radoff, has been discussed in section 2.1. In this section, its architectural divisions, or simply, its layers are introduced in brief. This architecture is common and simple to comprehend theoretically, but it cannot truly represent the essence of all the aspects of the Metaverse. Hence, a novel three-component, interdependent architecture is proposed in section 2.2, outlining its advantages over the first. Its components include the virtual world, hereby named anatomy; the physical world, named ecosystem and the interaction between the two, named convergence. All of its components are explained in detail, including the technologies used in each.

2.1. Seven-Layered Architecture

This is the most common and layered manifestation of the Metaverse architecture, proposed by Jon Radoff (HoloNext, 2022). It consists of seven layers which are built upon each other. These layers, as depicted in Figure 1, starting from top to bottom are the experience layer, discovery layer, creator economy layer, spatial computing layer, decentralization layer, human interface layer and infrastructure layer (Takyar, 2022). All these layers are briefly explained below.

Figure 1. Seven-layered architecture of Metaverse



Layer 1: Experience

The experience layer derives its name from the English language semantics. It simply means what the user feels in the virtual world of the Metaverse while interacting in the digital environment. It will include a replica of the physical world using 3D and 2D models, but without boundaries (HoloNext, 2022).

The biggest brands are focusing on the experience in massive interactive live events (MILEs) (HoloNext, 2022), which are being hosted on platforms like Decentraland (Decentraland, 2020) and Roblox. Failed to get a front-row ticket to test match? Don't worry. In the Metaverse, all seats are front-row seats, without even leaving the comfort of home. Metaverse will provide life-like experiences in almost all fields, ranging from shopping to theatre to sports and many more.

Layer 2: Discovery

The Discovery layer refers to the concept of "push and pull" of information (Takyar, 2022). In layman's terms, it means how users discover new experiences, either by clicking on ads or via search engines or community messages etc. (Goldston, Chaffer, & Martinez, 2022). Push is the method of sending messages to people whether or not they have asked for it. These outbound messages include display advertising, e-mails, notifications etc. Pull represents the messages that people get when they are actively looking for information. Some examples of inbound messages are search engines and community-driven content. This layer is mostly used by businesses as a marketing tool.

Layer 3: Creator Economy

Due to the ease of content creation using clicks and drag-n-drop, users are just bombarding the virtual space with data, without learning to code. The market is overflowing with user-generated content (HoloNext, 2022). Social media like YouTube, TikTok, and Instagram reels, have created a new market for the consumer as well as content creators. Millions of people can make videos or vlogs and share their knowledge about a variety of subjects, no matter what the size of their audience is. It is believed that the creators will capitalize on the growing Metaverse, thus creating a multibillion-dollar industry.

Layer 4: Spatial Computing

Spatial computing merges virtual, augmented and mixed reality. Instagram filters, Microsoft's HoloLens, Snapchat's Landmarker, and the most famous Pokémon

GO game (2016) are common examples of spatial computing (HoloNext, 2022). It allows you to interact with a digital, three-dimensional, virtual universe against your immediate real-world surroundings. Voice and gesture recognition, the Internet of Things along with user biometrics, geospatial mapping, and 3D engines that display geometry and animation (Goldston, Chaffer, & Martinez, 2022) are some aspects of spatial computing that run the Metaverse.

Layer 5: Decentralization

Decentralization explained in layman's terms will be, whether the Metaverse will be ruled by a single authority or will it be open and distributed. Major corporations may play on a major chunk of Metaverse data but this will create privacy and data protection issues which are so common with the internet today. They may use the data for the benefit of advertisers and businesses which may harm the user. Hence, storing data centrally will be a big hindrance in making the Metaverse popular among naïve users. Decentralization might be the solution to this problem, in which Blockchain technology, crypto assets, and open-source platforms will play a major role. When the market is decentralized and distributed, it becomes competitive, resulting in experimentation and major growth (HoloNext, 2022).

Layer 6: Human Interface

The human interface layer refers to the hardware that Metaverse users will need to truly experience the immersive virtual world. As the technologies are getting smaller, they are coming closer and closer to the human body. For example, smartwatches, smart glasses, and haptics. With haptics, one would be able to transmit the feeling of touch over the virtual universe. One might even be able to feel the texture and shape of a virtual object (Takyar, 2022).

Layer 7: Infrastructure

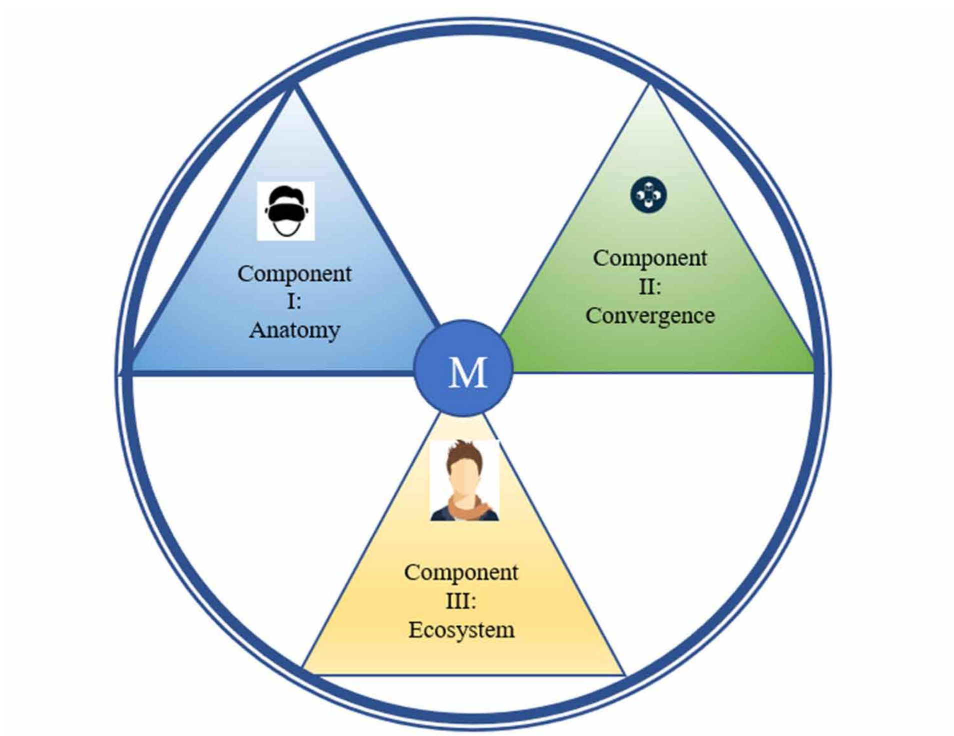
The infrastructure layer is the heart of the Metaverse. This can be made possible due to the improvements in technology. From 5G and 6G computing (which increases bandwidth and reduces latency) to edge computing to artificial intelligence, to display technologies using AR, VR, MR, and XR, all will be needed to create a fully functional and interoperable Metaverse. As more and more users are entering this field, scalability needs to be addressed on a regular review basis (Goldston, Chaffer, & Martinez, 2022).

To conclude this section, this architecture consists of seven layers namely, infrastructure, human interface, decentralization, spatial computing, creator economy, discovery, and experience (from top to bottom). Although simple, it cannot truly represent the interaction and all the aspects of the layers in the Metaverse. In the next section, a novel and more relevant architecture is proposed.

2.2. Proposed Interdependent Architecture

The above seven-layered architecture is based on commercial and trade divisions of the virtual world. These divisions are based on the value chain of the expected market (HoloNext, 2022). Contrary to this, a more applicable view of Metaverse at a broader level is proposed here. This architecture consists of three major components, namely, anatomy, convergence and ecosystem. It is based on the premise that the components of Metaverse are not distinctly layered, but interdependent, which is shown in Figure 2. These three major components are interconnected and are explained below in detail.

Figure 2. Interdependent Architecture of Metaverse



2.2.1. Component 1: Anatomy

This component refers to the physical world consisting majorly of hardware, edge intelligence-empowered infrastructure (Yang, et al., 2022), network and storage. This component may be seen as encompassing layers 6 and 7 of the 7-layered architecture. The major role players in this component are explained next.

- **Hardware**

Although hardware provides an immersive experience for Metaverse users, it is a huge barrier in terms of technology and cost (Park & Young-Gab, 2022). To truly realize the Metaverse, head-mounted displays (HMDs) or physical auxiliary devices (for eye and head tracking, voice input, etc.) are needed. The images are shown through a display and the sound is through speakers. A bit on the expensive side, these HMDs are very popular among gamers. The MMO game Roblox works well with Oculus Quest 2 and HTC Vive, whereas PlayStation 5 VR is compatible with Quest 2 (Duan, et al., 2021). Quest 2 has a single LCD with 1832x1920 resolution per eye, which is a vast improvement over its older generation model. The HTC Vive Pro also has a good resolution display of 1400 x 1600 per eye, with in-built headphones (Park & Young-Gab, 2022).

Virtual and Augmented Reality (VR/AR) help in visual experience, whereas haptics help in touch experience, e.g. handshake over the internet or remote surgery. The innovations in haptics, which include a combination of vibrations and motion, are increasingly becoming available to users. Many companies like Ultraleap have built haptic gloves that support hand-tracking and mid-air haptic feedback (Saddik & Abdulmotaleb, 2018).

Another futuristic piece of technology is a full-body haptic suit that can deliver a full-body sensory experience. It is being developed by VR electronics and is still in the developmental stages (Saddik & Abdulmotaleb, 2018). Innovation of a more complex device can be done to expand the immersive experience to smell and taste also. Physical infrastructure for high network bandwidth and secure connections should also be there for each person conversing in Metaverse.

- **Edge-Intelligence Empowered Infrastructure**

Edge intelligence systems allow decisions to be made locally instead of putting all the burden on the cloud. It is used in communication, networking and computation, not to mention, storage. For example, in the virtual world, one avatar, the virtual self of a user, is interacting with another, and due to a network glitch, there is a disruption and the user is aware of the real world, then this break is not acceptable. To enable the seamless transfer of VR and haptic data across Metaverse, ultra-dense networks can be deployed in B5G networks at the edge level. Also, local computations can be performed on end devices, thus reducing the burden on the cloud (Lim, et al., 2022). The foreground scene rendering requires fewer graphical details, and lower latency but is costlier to implement on the cloud. This service can be shifted to Edge servers and more computation-intensive tasks like background rendering can be executed on cloud servers, thus reducing the bottlenecks and overload.

Complex tasks can also be divided into subtasks and can be performed by edge servers. The disadvantage here is the stragglers (the slowest processing nodes) which affect the computation time very much, which can be eliminated by algorithms that utilize worker selection schemes (Yang, et al., 2022). Also, pre-trained model caching can be done at the edge for faster response to users. One of the most important advantages of edge computation is local machine learning model training. When many people are connected to the Metaverse, data leaks tend to increase. For this, users can carry out AI model training on their local device before transmitting it to Metaverse, thus taking care of privacy and data leak issues. Resources like VR/AR at the edge can also be optimized to maximize user satisfaction.

- **Network and Storage**

The Metaverse, along with low latency and secure networks, requires a very important aspect i.e. accessibility. It needs to be accessible at any time and place, depending upon the user's need. Every person in the world can be connected, so the amount of data generated will be voluminous. It is different from the current scenario. E.g., people generate YouTube content, which is huge, but in the Metaverse, the people *are* the content. Their eye movements, body movements, facial emotions, dialogues, recommendations, and each motion is data. The basic need here is mass storage to handle this unfathomable amount of data. How to effectively store and retrieve this data, is an open challenge.

2.2.2. Component 2: Convergence

For Generation Z, the physical and virtual worlds are almost the same. The fast development of visual and language recognition techniques along with accurate capture of natural body movements may make this immersive experience more real. To interact in the virtual world, users need head-mounted displays or AR goggles to navigate and communicate with each other using avatars (their virtual selves). Another thing needed for this physical and virtual world interaction is the 'sensor network' which will send live data feed to the virtual world. The sensor network may be owned by Sensing Service Providers (SSPs) who send the live data to Virtual Service Providers (VSPs) (Lim, et al., 2022). The VSPs develop and maintain the virtual part of the Metaverse. Another stakeholder is the Physical service provider which operates in the real world, e.g. to deliver the physical goods which were transacted in the Metaverse.

Convergence is the interconnection between anatomy and the ecosystem. In simpler words, it is the interaction between the physical and virtual world and comprises of immersive user experience, digital twins, Blockchain (Park & Young-Gab, 2022), content creation interface (Duan, et al., 2021), and computation software. This component may be seen as roughly equivalent to layers 3, 4 and 5 of the previous architecture and is discussed below.

- **Immersive User Experience**

Immersive user experience refers to the multi-sensory experience for the user by letting them get into their avatar and interact with one another in the same way as they would do in the real, physical world (Metaverse Events, 2021). It combines virtual content with the actual world and provides greater appeal and realistic projections of real-world objects.

To make this possible, the collaboration of hardware with the software (to receive real-time data from the physical world and render their duplicates) should be as seamless as possible. The existing technology is not only cumbersome but also not up to the mark to provide an immersive thrill. The participants need to be active to completely enjoy the immersive feel. Along with the hardware, the network and storage capabilities must also be shardless for a ubiquitous experience.

- **Digital Twin**

Digital twins are virtual objects, the counterpart of physical things in the real world. They have to be modeled in real-time, just like the 3D projection of an object. They add to the realism of Metaverse. AI can be used to generate life-like digital characters quickly. All these are just for improved immersive user experience. IoT and sensor networks deployed in the physical world collect data from the environment which can be used to feed information to a digital twin (Lim, et al., 2022).

Naïve users, who are not that familiar with Metaverse, confuse digital twins with avatars, which are two completely different concepts. Avatars (explained in the next component) are the virtual representation of the user or player in the Metaverse. There are other Non-Player Characters (NPCs) also, which are computer-operated characters such as ones offering assistance or support. Some researchers suggest using Bayesian networks and Reinforcement Learning (RL) to make the avatar intelligent by interacting with smart objects (Yang, et al., 2022) (Lee, et al., 2021). Some others say to precompute the avatar behavior from unlabeled motion data (Lee, et al., 2021). Most of the research is based on RL techniques.

- **Blockchain Technology**

Blockchain is a very important component of Metaverse which is needed to preserve the 'value and universality' of virtual goods. Right now, there are different platforms for different virtual games, and the goods used in one platform can't be used or traded in another. So blockchain is needed for making these goods universal as well as for secure trading of data. The conventional blockchain architecture has different layers including data, network, consensus, incentive, contract and application layers (Yang, et al., 2022). Without blockchain, it will be difficult to identify the value of the resources and goods traded in Metaverse, especially when these elements will interact with the real-world economy.

Just as the real world needs fiat money, the Metaverse will be built on cryptocurrencies. Blockchain implements the creation, recording and trading of cryptocurrencies. Traditionally, Bitcoin adopts the Unspent Transaction Outputs transaction model (UTXO) and Ethereum records the balance of each account address, to track the usage of cryptocurrency (Park & Young-Gab, 2022) (Yang, et al., 2022). Transactions in Metaverse will include some, if not all of the purchase-sale scenarios of the real world also.

In some research, blockchain is merged with the Industrial Internet of Things (IIoT) and a hierarchical structure is proposed, where old information is stored on the cloud and the latest block is stored on IIoT devices. Various authors have proposed various protocols for cryptocurrency transactions including the Repulay protocol and virtual channel protocol based on UTXO (Park & Young-Gab, 2022). Initially, blockchains only supported token transferring. Existing solutions such as DEX on Ethereum, and Cybex need to be empowered with decentralized finance frameworks for Metaverse. Non-fungible tokens (NFTs) which are unique can be stored permanently on blocks for historic purposes. Thus, they can be used to prove the uniqueness of the avatar and its creations.

The existing blockchain protocols have various issues such as latency due to the need to store all the historical transactions, creating huge and bulky data. Thus, new blockchain mechanisms need to be devised (Yang, et al., 2022).

- **Content Creation Interface**

To maintain an almost perfect environment and immersive experience, a storyboard that handles Non-Player Characters (NPCs) and various user interactions, is also needed rather than turn-by-turn dialogue delivering. This will result in some organization to a large number of unorganized teams in Metaverse. Environment design includes scenes, colour, lighting, audio, digital twins, etc. relations between avatars and the events happening to them are linked together using graph models (Park & Young-Gab, 2022). Authoring or creating tools will greatly affect the efficiency and intelligence of Metaverse.

- **Computation Software**

Computation software is a very important part of the Metaverse engine. It receives inputs from users, SSPs, etc., and generates and maintains the virtual world. Along with this, low latency and fast rendering of the scene, which the user views, are also needed. The 360-degree view along with all the user-generated content (dialogues, emotions, body movements, NPCs, data of obscure objects) need a large capacity processing software. The gap between hardware and software performance, according to user expectations is huge, which is a hindrance to the ubiquitous and immersive experience for the user.

2.2.3. Component 3: Ecosystem

The ecosystem is the breathing, parallel, virtual world which might comprise everything that a physical world can. It will have its advantages and limitations. This is the virtual world that consists of avatars (Duan, et al., 2021), economic systems, User Generated Content (UGC), and AI fusion (Park & Young-Gab, 2022) with Metaverse. All these components are discussed next.

- **Avatars**

These are user-controlled representatives of the players in the virtual world. Their movement and positioning are determined by the computational software. These avatars can have desired skin colour, gender, physiological features and hence help in reducing social discrimination (Park & Young-Gab, 2022). They may play a vital role in the simulation of social problems and finding their solutions. Virtual NPCs help these avatars in the introduction and various events throughout the lifetime of the avatar (Yang, et al., 2022). For example, a traffic controller NPC may guide an avatar to a nearby police station. Users can then control their avatar to finish their corresponding action.

- **Economic System of Metaverse**

Ideally, Metaverse should be interoperable so that users can trade virtual items from one platform to another. The Metaverse economic system is composed of the following four parts, namely, digital creation, asset, market and currency. Digital creation is similar to the production of things in the real world. So, the number of creators (producers) decides economic development. So, there can be drag-and-drop tools for creating content or more detailed Software Development Kits (SDKs).

Digital assets have a hidden property which is the precondition of trade, for example, the 'skins' in the game counter strike. They can be exchanged, traded, or bought at the platforms. But this incurs privacy issues hence blockchain and encryption algorithms are needed. Digital Market is a place where avatars can trade to generate income. The Metaverse market will be different from the current digital market. Digital currency is used because the fiat currency or digital-based currency will be of no use here. To enable a secure and intelligent Metaverse, blockchain fusion, as discussed earlier, is an important part of the economy of Metaverse.

- **User-Generated Content (UGC)**

UGC refers to the content generated by, or rather of the user. Just like the example discussed earlier, each motion of the user is user-generated content. It is not created by the developers. Since, people from different backgrounds, ethnicities, cultures, and countries come together in one place, the UGC is also diverse and heterogeneous. This makes the data huge as well as needs standardization of this content to make it interoperable and achieve liquidity.

- **Artificial Intelligence**

Artificial Intelligence (AI) and machine learning algorithms are making machines learn and gain human comprehension by learning from experience and data. Mathematical solutions like Support vector machines and convolutional neural networks (used in facial recognition or image search etc.) may be used (Yang, et al., 2022). Along with this, Reinforcement Learning will be a step towards establishing an autonomous system.

It is seen that all the technologies and features of Metaverse are truly interconnected. For an immersive, life-like experience of this magical virtual world, the hardware and network are as important as the UGC and crypto-economy. Table 1 shows a comparison between the proposed architecture and the seven-layered architecture. The next section presents all the areas where Metaverse will be used in the recent future.

Table 1. Comparative analysis of the two architectures of Metaverse

Factors	Seven-Layered Architecture	Proposed Interdependent Architecture
No. of components	Seven layers built upon each other (as explained in section 2.1)	Three major components with each one of them connected with each other (as explained in section 2.2)
Basis of divisions	Commercial and trade divisions of the virtual world	No distinct divisions. Components are all interconnected and interdependent.
Complexity	Simpler to understand	Novel and interdependent components may take time to comprehend.
Names of the components/ layers	Infrastructure layer, Human interface layer, Decentralization layer, Spatial Computing layer, Creator economy layer, Discovery layer, and Experience layer.	Anatomy component, Convergence component, Ecosystem component
Sublayers	Each layer has a distinct function	Each component may be seen as a loose combination of two or three layers of the seven-layered architecture.
Advantage	More common and thus simple to comprehend	A more applicable view of Metaverse and presents its actual representation
Drawback	Cannot represent the true essence of all aspects of Metaverse	Difficult to understand for a beginner

3. APPLICATIONS OF METAVERSE

Although Metaverse is a virtual world, most of the work done in Metaverse focuses on its social utility. As mentioned earlier, avatars can help in simulating social discrimination problems or fire evacuation drills with zero risk factors. Thus, the vast number of applications of Metaverse can be broadly classified into the following categories.

3.1. Entertainment and Adventure

This is the most common and well-known application of Metaverse. VR and Haptics will help in immersive social interactions as well as better gaming and entertainment experiences. Things that are difficult in ordinary life such as parachute jumping, skiing on the slopes of mountains, swimming with the whales, etc. can be experienced in

Metaverse. One popular example is Decentraland (Decentraland, 2020) where one can buy and sell land, meet friends and go to virtual concerts etc.

3.2. Social Applications

Counselling psychological problems, without revealing one's true identity will be a major benefit of avatars (Park & Young-Gab, 2022). Simplification of digital interfaces can be done in the Metaverse so that elderly people can understand and use it in a better way. People from various backgrounds and ethnicities come together in Metaverse which will reduce social discrimination and promote democratic equality. For example, in Decentraland (Decentraland, 2020), the participants can propose new policies and vote on them. They can have a say in how the world behaves, thus facilitating equality. Along with this, Metaverse will help people gain emotional closure and mental stability. For example, there may be some life moments that can't be brought back, but users can revisit these memories in Metaverse for emotional stability and personal happiness.

3.3. Pilot Testing

People can pilot test the yet-to-be-launched products, directly in the Metaverse. This will be low cost and will have fewer safety considerations. For example, cars can be test-driven on highways with real traffic conditions. New and innovative fighter jets or planes can be virtually flown and tested with zero risk factors.

3.4. Gig Economy and Creative Industries

The gig economy in the creative industry means contract-based or per-job income. The piracy of these creative pieces creates an adverse effect on the gig labour market. Due to the Metaverse, piracy will be reduced because of blockchain technology, thus alleviating its effects on the labour's income. The content created by the user can be accurately authenticated using NFTs and thus purchased from the owner directly (Lim, et al., 2022). In third-party transactions, some commission can be forwarded to the owner/creators thus discouraging piracy.

3.5. Virtual Retail, Marketing, and Advertisement

Metaverse will significantly reduce the physical space and objects needed for the retail and marketing segment. The store display, big billboards for advertisement, virtual screens, displays and trial of IoT devices are just a few examples of what can be done in this virtual world. Metaverse has unlimited extension space, so markets from all over the world can create a diversified scenario, which will benefit both the consumers as well as the producers (Shen, Weiming, Jingzhi, Linshuang, & Peng, 2021). It will create a virtual space for shopping by consuming goods provided by producers, thus creating an economic system (Park & Young-Gab, 2022).

3.6. Office

After the pandemic, working from home has become a part of office culture worldwide. But there are some well-known limitations to zoom or google meetings. In Metaverse, employees sitting at distinct places will also appear to be part of an organizational team. Nonverbal cues in the meetings will not get lost. (Park & Young-Gab, 2022) states some representative examples of office applications such as Branch and Teamflow. Real-life examples can be Microsoft Mesh and Horizon Workroom which allow you to have shared virtual workplace experiences, hold meetings and meet teams etc. (Ziaul, 2022).

3.7. Simulation

Simulations can depict real-world problems in an enclosed, relatively safe environment, with multiple users and low-risk factors. It can also be used in academia, for education and for museum visits. It is different from real-world simulations in the sense that, it can be more exaggerated based on the creator's will and also it is not that solution-dependent. Complex surgery can be practiced in this simulated environment. Fire safety evacuation drills can be performed in a game, with people engaging from remote locations, through their avatars, with the option of real-time supervision. (Park & Young-Gab, 2022) states that simulation ranges from games to social phenomenon research and marketing. It can be also used for education and museum visits.

3.8. Education

Online classes are a one-way teaching method. With Metaverse, this drawback will be removed and students can have a hands-on and better interactive environment almost similar to real-world teaching. Similarly, users can visit virtual museums, situated far across the globe or they can feast their eyes on digitally reconstructed, restored ancient relics which can only be seen in textbooks or photographs physically. Audio-visual (AV) aids are an important application of Metaverse (Park & Young-Gab, 2022). The case study of the Chinese University of Hong Kong, Shenzen (CUHKSZ), analyzed in section 4 is powered by blockchain to provide a virtual campus to students.

3.9. Healthcare

This will be the most beneficial application of the Metaverse. Accessibility of healthcare to even the remotest areas of the world, the ability of kin to virtually visit patients with infectious diseases, 24x7 virtual nurses, medical education and training across the world are some of the few happy possibilities in the Metaverse (Ziaul, 2022). DeHealth (DeHealth, 2022) is the first Metaverse in healthcare and allows patients and doctors to interact in a full 3D virtual world (Ziaul, 2022).

3.10. Smart Cities

Smart cities are technologically advanced cities that use IoT, social media, sensors etc. to acquire information about their residents (Ziaul, 2022). Metaverse Seoul is one such digital twin (Lim, et al., 2022) of the physical capital of South Korea, which is analyzed in section 4. It became the first local government to join Metaverse at the end of 2021.

In the future, Metaverse will be as much part of our day-to-day lives, as the internet now is. Education to work, health to entertainment, everything will be enjoyed via Metaverse. In the next section, two simple case studies are taken and analyzed using the interdependent architecture. The first case study is of a virtual city of Seoul and the second one is of a university campus in Hong Kong.

4. ANALYSIS OF CASE STUDIES OF METAVERSE

Metaverse science fiction has developed many UI designs such as Jarvis in Ironman, various wearables in Minority report, Avengers, Oblivion, and Ready Player One, which provide a visual insight into the framework of Metaverse.

In this section, two case studies i.e., prototypes of a virtual city and a virtual campus, have been analyzed and discussed based on the interdependent architecture proposed in section 2.2. Lim W. et al have given a skeleton of the virtual city 'Metaverse Seoul' for the edge-assisted rendering of the virtual world. Duan H. et al have presented a Metaverse prototype of a university campus in Hong Kong.

4.1 Case Study 1: Analysis of a Skeleton of 'Metaverse City Seoul'

The urban, virtually developed city of Seoul can help people experience various perks of real-world cities using VR/AR or other head-mounted devices (Lim, et al., 2022). This virtual city will provide many municipal services as a one-stop service including education, administration, construction, tourism, etc. For example, the tourist can scan the target building or road and he/she will be provided with map guidance or information about the building.

4.1.1 Anatomy

This virtual city uses HMDs for online services planned in the virtual city. This means AR/VR glasses will help access business and consulting services. Users can use mobile, AR and VR helmets and glasses to scan the target scene and interact with each other.

To alleviate the burden on the cloud, Lim W. et al propose that only those images should be rendered in the virtual city, which is in the viewport of each eye. Panoramic VR rendering is to be avoided to save battery usage of HMDs. So, if users don't want to render much background information, edge servers may be used. In addition to this, a Double Dutch Auction (DDA) scheme is used for the incentives.

4.1.2 Convergence

As mentioned earlier, for immersive user experience, virtual tourism in this Metaverse will be encouraged and major tourist attractions like Deoksugung Palace and significant markets will be reproduced virtually. Retail stores, popular restaurants, and traditional festival celebrations will be available for an out-of-the-world experience.

The authors also derived the user valuation of VR rendering services (Lim, et al., 2022) based on the user's perception of streaming quality (Video Multi-method Assessment Fusion or VMAF) and the VR image quality (Structural SIMilarity or SSIM value). Edge server valuation was also derived based on energy cost and the available computation and storage resources. To find a perfect match, the users adjust their bid upwards and the edge servers adjust their sell price downwards. According to the authors, this will in turn motivate the users to participate in the auction rationally.

For the physical-virtual world interaction, the authors Lim W. et al devise a resource allocation method to create the virtual world in real time through collaborative sensing. There are sensing service providers (SSPs) and Virtual Service Providers (VSPs). For the real-time virtual city, to reflect the physical city, sensors and IoT are needed; which will send live data feed to the digital counterparts i.e., digital twins. A resource allocation algorithm has been used in which drone-like SSPs hover over different physical areas of a real city and send their feed to VSPs which in turn develop the corresponding parts of the virtual city. A certain specific amount of reward is kept for that area and is distributed among all the SSPs manning that area. More the SSPs, the better the feed, but the less the reward.

4.1.3 Ecosystem

Due to multiple people interacting online, at the same time, the Content and vivid scenarios are created as well as used by residents, businessmen, academicians, tourists, and medical practitioners from all over the world, including the city's government, virtual gaming, retail industry, etc. This content and storyboard can be created on the AR cloud. An open communication space can be created where common people, as avatars, can contact the government, and give their opinions and suggestions. Each virtual city can have its economic system and its virtual currency. Residents can create and sell goods using that currency. To maintain its interoperability a standardization procedure needs to be devised.

The authors discuss that VSPs need to utilize both virtual and physical resources, which are often owned by separate entities. All these resources are based on the reservation or on-demand plans. However, VSPs need to decide which plan to choose before the actual demand. Over-provisioning and under-provisioning may happen so they need to choose wisely. The authors propose a resource allocation scheme Stochastic Integer Programming (SIP) for the VSPs so that they can allocate the resources optimally, using historical data of user demand.

The analysis of this virtual city developed by Lim et al., 2022, shows that the hardware required for realizing this Metaverse is not limited to VR/AR glasses or helmets. This can be further extended to include haptics as a means for communicating gestures and touch to some extent. The use of edge intelligence is done extensively so that only the images which are in line with the viewport of each eye are rendered, the background may not appear with high-definition clarity. Thus, the demand for data traffic and computation workload will be much reduced. The authors have focused on edge intelligence, which in turn makes networks glitch-free and prevents latency by reducing the load. Although there was no mention of the storage requirements, the authors evaluated edge servers based on energy cost and the available computation and storage resources, which means that the results of actual implementation might be satisfactory.

Using the continuous streaming of data and syncing it, the authors aim at the virtual city reflecting the physical city in real-time, promising an immersive user experience. The SSP-VSP mechanism used by them also makes sure that computational software is distributed via the allocation algorithm. The evaluation of the association between edge server valuation and user valuation shows that the incentive mechanism that the authors use, gives a satisfactory result to the user and provides a good immersive experience. Software Development Kits may be provided for content creation so that the residents can create their avatars and other products easily and their copyright can be protected using NFTs. Blockchain may be used to preserve the values of goods created in this Metaverse. This prototype focuses more on the anatomy and the edge-assisted computation than the content creation and economic system.

4.2 Case Study 2: Analysis of 'The Metaverse Campus of Hong Kong University'

The education sector is offering services in the new, integrated learning paradigm. Blended learning, mobile learning, social networks etc. have enabled a dynamic and interactive educational approach. Duan et al., 2021, have developed phase I of the Metaverse campus of a university in Hong Kong, named The Chinese University of Hong Kong, Shenzhen (CUHKSZ). This system is a prototype of an interactive Metaverse that provides the students access to information that can be converted from the real or virtual world to the other (Duan, et al., 2021). In this section, the authors' Metaverse is analyzed on the interdependent architecture proposed in section 2.2.

4.2.1 Anatomy

This proposed, virtual campus CUHKSZ is developed on a platform called Unity (Unity, 2022) which is used for real-time content creation. It is mostly used by game developers for creating 3D and 2D games. Thus, CUHKSZ can be used on various platforms, including mobile, laptop, and tabs. So, any student or faculty member can communicate with each other via any device. The 3D models in this Metaverse are built using Blender. (blenderbasecamp, 2022). (Duan, et al., 2021) have used Solidity (ethereum/solidity, 2022) as the contract-oriented programming language. "Solidity is a statically-typed curly-braces programming language. It has been designed for developing smart contracts that run on Ethereum Virtual Machine" (ethereum/solidity, 2022). This network is peer-to-peer and thus anybody can contribute, execute or implement tokens of value (ethereum/solidity, 2022). This language is still in the development phase.

Duan et al., 2021 have not mentioned any hardware like VR glasses that must be used by the students to access this Metaverse, nor have they used any edge intelligence in their program. They plan to use the built-in cameras, GPS and sensors of smartphones which are easily available to the users. They have used readymade platforms to design and code their virtual campus and aim to provide students with an immersive experience. Their software uses a peer-to-peer network and is platform-independent.

4.2.2 Convergence

The authors (Duan, et al., 2021) have applied blockchain with the smart contract and they have selected FISCO-BCOS (FISCO BCOS, 2022) for this virtual campus. FISCO-BCOS is an open-source, secure, reliable and high-performance financial-grade association blockchain platform in China, started in 2017 (Fisco-Bcos, 2022). It provides copyright protection in trading and protection along with pluggable consensus mechanisms. Solidity programming language (ethereum/solidity, 2022) provides support for this blockchain-based ecosystem. The blockchain-based token system has been proposed by the authors, to represent fair monetary transactions in the campus. All residents can claim and use the tokens based on their actions and performance.

The authors have built a ‘Metaverse Viewer’, which can provide first and third-person perspectives. Currently, they have used this editor with smartphones because they make it easy to acquire physical data with built-in cameras, GPS and sensors. A naïve user can also learn to make imaginary 3D items in this editor. But mobile devices are not ideal for providing immersive user experience, which is an important aspect of the Metaverse.

The author’s theme is to promote social good in university. They incentivize the students by giving them tokens based on their GPS location (sensing mechanism). For example, a student studying in the classroom physically will get more tokens for use in the virtual world. This sensing mechanism is at a very nascent stage and needs to be improved, maybe by facial recognition or hand-eye movement tracking. For this, good, large-capacity computation software will be needed, which the authors seem to lack.

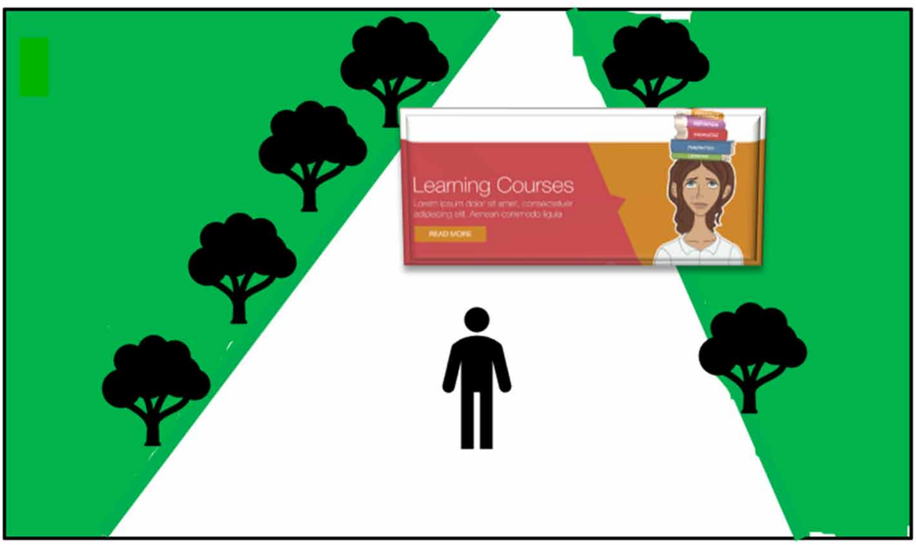
They plan to adopt other devices in the later stages. UGC is a fundamental element in Metaverse. The 3D items created or designed by the users will have that particular user’s ownership and copyright and they can be built as NFT for trading and transferring. The authors have designed and implemented an easy-to-use UGC editing tool (Duan, et al., 2021), which can be used by beginners also to create their 3D models and digital twins. Then generative algorithms have been used at this level to generate 3D digital twins based on the elements designed by the user. This content creation interface seems easy to use and is an important part of the convergence component.

4.2.3 Ecosystem

The economic system of CUHKSZ employs a token-based system where the tokens can be used in various activities in the virtual world. Users will be able to buy-sell and vote among other things. A location-based incentive mechanism has already been explained before, where a favorable location on GPS will ensure earning of more tokens.

Avatars of students will physically study in the university in the virtual campus. They can chat with each other while earning tokens in high-speed modes. The UGC creator (discussed before) is used to create and display content according to the needs. The avatars can display the UGC or wear them as ornaments, in this version of CUHKSZ (Duan, et al., 2021). A customized billboard can be displayed outside every room or faculty cabins to display information or their personalities. Virtual billboards as seen in Figure 3, may be put up in the campus according to the inclinations of the student.

Figure 3. A virtual billboard at university campus



AI is fused with the content editor where generative algorithms can create 3D items designed by the user. An AI-driven Metaverse observer is also developed by the authors, which can recommend ongoing events to students. This recommender system is based on the number of users in an event or official approval. Along with this, the authors also propose a Delegated Proof of Stake (DpoS) protocol for voting and raising motions, to ensure fair and democratic governance.

Analysis of the above case study shows that the virtual university Metaverse CUHKSZ is still in a budding stage and is just a prototype. It seems promising if some of the aspects such as VR/AR hardware, and immersive user experience using different sensing mechanisms are used. The blockchain-based token system and the voting mechanism seem fair enough for ensuring equality but need to be more refined. The content editor for creating digital twins and avatars is easy enough for untrained users. This prototype doesn't take advantage of edge intelligent computation, maybe because heavy-duty computations are not being done here.

The next section brings up the future challenges, which need to be addressed to create a seamless, immersive user experience with all the security measures that should be taken care of.

5. OPEN CHALLENGES

There is no doubt that the Metaverse will be the next internet but, there are some challenges and issues which will be faced when dealing with Metaverse. It can significantly contribute to various applications and use cases, but for the Metaverse to have sustainability, issues like a large volume of data, interoperability, governance, blockchain-related issues, ethics and security need to be considered (Park & Young-Gab, 2022). Some of the common challenges faced while dealing with Metaverse are listed below.

- **Interoperability Standards**

To make Metaverse seamless, different platforms, although developed by different companies, must have interoperability standards, so that user-generated content can easily populate the Metaverse. Users would be easily able to transfer their digital assets, teleport their avatars and resources across Metaverses (Challenges in metaverse, 2022). Interoperability standards can be seen as semantic interoperability, syntactic interoperability and organizational interoperability, as shown in Figure 4.

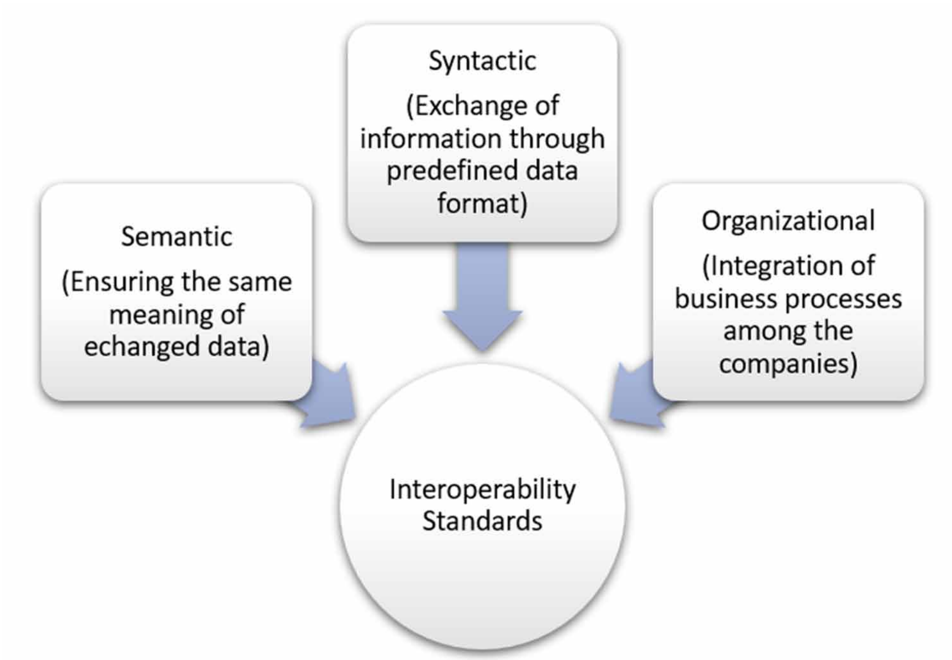
- **Artificial Intelligence Issues**

Current AI technologies use Deep learning models which incur a high burden for resource-constrained devices such as mobiles (Yang et al., 2022). Also, at this stage, people tell machines to do specific tasks instead of enabling the machine to learn things automatically. Meta-learning may emerge as a promising learning paradigm, to achieve auto-machine learning in future years, but it is a challenge at present.

- **Blockchain-Related Issues**

The real-world NFT that exists now, may or may not be able to adapt to the high transaction volumes (Yang, et al., 2022). Some protocols need to be devised to deliver

Figure 4. Interoperability standards



a healthy blockchain-empowered market in the Metaverse. Blockchain-empowered game finance, meaning currency exchange between fiat money and cryptocurrency is legal only in some countries. Future Metaverse should embrace a more open, fair and rational physical world.

- **Governance Issues**

Currently, Roblox and Meta are some of the few big companies propagating the concept of Metaverse. Large companies need to cooperate to have a unified Metaverse instead of having some applications in tiny Metaverses and other ecosystems of large companies. Measures need to be in place to incentivize these giant companies and make uniform governance rules (Yang, et al., 2022).

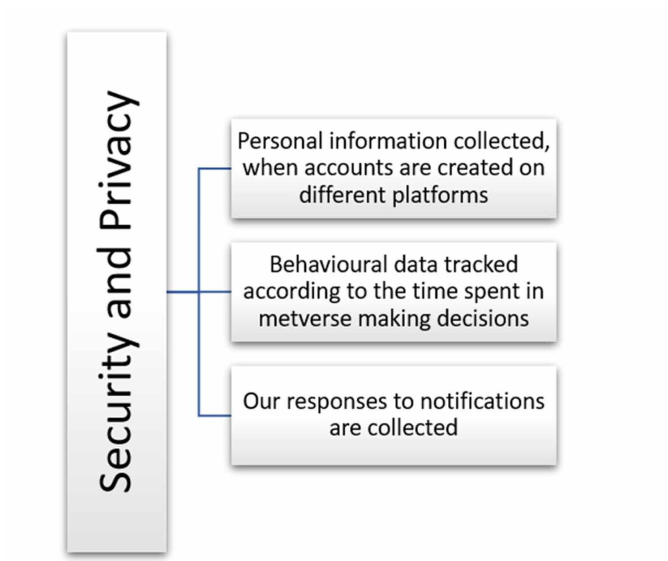
- **Refining User Quality of Experience**

Quality of Experience (QoE) metrics for users require redefining with interdisciplinary efforts (Lim, et al., 2022), e.g., finding the relation between network requirements and user visual perception can be used as a QoE metric. In addition, the traditional focus of the video is not that important here. Instead, eye tracking can be used to render important scenes and reduce the image quality of scenes in the periphery.

- **Security and Privacy**

Personal information fed into any app might be used by tech giants for their gain (Challenges in metaverse, 2022). There might be many security and privacy issues in the Metaverse, some of which are shown in Figure 5. Metaverse doesn't only collect this personal information but it also collects behavioural data which is as easy to collect as user conversation and internet history (Park & Young-Gab, 2022). Along with this, malicious smart contracts or finger-tracking of VR users can cause security concerns. Hence, new dimensions of user data, e.g., eye tracking can be collected and used for more personalized advertising. Cryptography which can protect the digital assets of users and two-factor authentication present novel challenges to user data privacy.

Figure 5. Issues in security and privacy of users



However, these challenges include all the major open issues in Metaverse but are not limited to the above-mentioned list.

6. CONCLUSION

Metaverse is not a new term. It has been used in science fiction for over two decades but it gained popularity when the giant Facebook changed its name to Meta in 2021. Metaverse is the evolved version of the Internet, or one can say, a virtual world where your digital self can move about, connect with physically distant relatives, play, work, learn and shop. Almost all the things which one can do in real life can be done in Metaverse. It will be possible through an amalgamation of virtual reality (VR), augmented reality (AR), blockchain technology, edge assistance and networks like 5G and 6G. Digital identities and digital assets will be easily created, allowing the users to create a digital economic system and have an immersive virtual world experience.

For Metaverse to be interoperable, scalable and secure, its underlying architecture has to be carefully designed. In this chapter, a seven-layered architecture of Metaverse has been discussed and is then contrasted with a proposed three-component, novel interdependent architecture. All the major technologies included in each interdependent component are presented in detail. Focus has been on the blockchain, artificial intelligence and edge-assisted computing which will be essential elements to the future Metaverse, where anyone can freely and safely engage in social and economic activities. After that, some applications of the Metaverse and the benefits it will have for society, have been discussed. This has been followed by two case studies, the virtual city Seoul and the virtual university campus CUHSZK, which have been discussed in brief and analyzed according to the proposed interdependent architecture. Later on, some open-ended challenges have been discussed, since the Metaverse is still in a very early stage and these challenges have to be met to create a shardless virtual world. The purpose of this chapter has been to understand and draw more attention to Metaverse, by the industries as well as the academia field, so that together a better society can be built.

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KEY TERMS AND DEFINITIONS

Augmented Reality: Augmented reality is the superimposition of a simulated image over the user's view of the real world. This composite view can enhance the perception of the user. The most common example is the Pokemon Go game which became popular in 2016.

Avatar: An avatar is the user's identity or the digital self in the entire Metaverse. Users will be able to create and use an avatar just like his/her real self in the physical world. The avatar will be able to wear clothes according to the user's choices, can change skins and learn, play, and work as the digital counterpart of the real user.

Blockchain Technology: Blockchain, as the name conveys, is a list of blocks where each block is a record of transactions made in cryptocurrency over a shared system. This list keeps on growing and can safely store information. These blocks give viewing access but no editing access to the users.

Digital Twin: Digital twins are the digital replicas of any physical object in the physical world, in terms of its physical properties and its behaviour. They are modelled by acquiring information about their characteristics using sensors.

Metaverse: A simulated virtual-reality space in which users can interact with other users, using their digital selves, called avatars. They will be able to shop, learn, play and work without any physical boundaries or space limitations. Metaverse environment is computer-generated. It can be achieved by the amalgamation of Virtual, Augmented and Mixed Reality, along with blockchain and networks with 5G and beyond.

Non-Fungible Tokens (NFT): NFTs are cryptographic assets on blockchain having unique identification codes and metadata that distinguish them from each other. The difference between them and cryptocurrency is that they cannot be traded or exchanged at equivalency. The most popular example of NFT is crypto kitties, launched in 2017 using the Ethereum blockchain.

User-Generated Content (UGC): UGC is the combination of all types of content, such as images, videos, text and audio that has been posted by users on online platforms. These platforms may include social media, discussion forums, blogs etc.

Virtual Reality: Virtual Reality is the computer-generated simulation of the physical environment. This is accomplished with the use of IoT sensors which send and receive data from the real world in real-time. The use of special equipment like smart glasses or screens, makes the user perceive virtual scenes as real ones.

Chapter 6
Monitor Cloud Performance and Data Safety With Artificial Intelligence

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ABSTRACT

Artificial intelligence (AI) techniques, particularly those in machine learning (ML), have been successfully applied in various areas, leading to widespread belief that AI will collectively play an important role in future wireless communications. Risks associated with the utilisation of cloud components during service delivery can be mitigated through the implementation of safety measures. Protection and efficiency are the two pillars upon which the security and scalability of cloud computing rest. AI is the study of algorithmic enhancements to the real world. The issues and worries associated with utilising one or more AI algorithms in the cloud are outlined, including supervised, unregulated, semi-controlled, and enhanced cloud safety issues. In the future framework, cutting-edge algorithms usher in a new era of cloud data security. Specifically, it is the aim of improving cloud security and privacy. Computers with AI are particularly keen on voice recognition technology, ML systems, decision-planning systems, and problem-solving systems.

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INTRODUCTION

Massive amounts of dynamic data, including as semi-structured and unstructured data, must be processed, maintained, exchanged, and analysed in a secure manner in order to recognise patterns and trends. Improve health care while simultaneously making the country safer and developing alternate energy sources (Hiran & Doshi, 2013; Ramasamy et al., 2020). The exceedingly sensitive nature of the programmes necessitates ensuring the security of the clouds. The most serious security vulnerability of cloud computing is that the owner of the storage cannot monitor where the information is located. This is because, even if you choose not to take advantage of the benefits of cloud computing, you may still use cloud planning and resource distribution. As a result, we must protect the security of records even when our systems are inefficient (Choubisa et al., 2022).

Cloud storage poses a variety of security problems since it necessitates more modern technology. Networks, servers, web browsers, application development, infrastructure planning, information retrieval, memory management, and storage location tracking are all examples of this. With all of these varied ideas and techniques, cloud computing provides its own set of distinct data security issues (Peprah et al., 2020). For example, the network that connects the numerous devices that comprise a cloud must be secure. Furthermore, the virtualization strategy utilised in cloud computing contributes to a variety of security issues. Our technology and a fundamental principle for constructing a secure grid were used on a reliable server. To ensure that cloud computing is risk-free, a secure virtual machinery layer, an encrypted cloud layer, a data storage layer, and a private web special network layer have all been built. Cloud computing refers not only to the applications that Internet service providers make available in the datacenters where these services are stored, but also to the hardware and software that comprise these systems (Hiran, 2021; Hiran and Doshi, 2014). The NIST defines four basic architectural types for cloud distribution, each of which is determined by the type of cloud provider. Firms will either use a single model or a combination of several different models to create efficient and ideal apps and commercial services.

The following are the four models of distribution:

- A private cloud is a type of cloud computing dedicated to a single organisation and managed by that organisation or a third party. These facilities can be accessed outside of the main building (Mahrishi et al., 2021a, 2021b).
- Cloud infrastructure, also known as cloud data, is information that is stored in the cloud and distributed to users via cloud-based services, such as those provided by a cloud provider.

- The collaborative cloud is a cloud ecosystem in which different businesses employ cloud resources to serve a common audience. These facilities are located off-site and are either maintained by the corporation or provided by a third party. The government cloud, colloquially known as the G-cloud, was a subset of the group cloud. One or more organisations provide this type of cloud computing services to the vast majority, if not all, public bodies (service provider role).
- A hybrid cloud is one that is built by integrating several cloud architectures. A hybrid cloud is data that is stored in a cloud service connection committee but is subsequently used by a cloud computing programme (Hiran & Henten, 2020; Lakhwani et al., 2020).

IN THE CLOUD, ARTIFICIAL INTELLIGENCE (AI)

The purpose of Artificial Intelligence (AI) is to sensitise the working environment of IoT and Fog nodes and continuously adjust them in order to provide enhanced service features, minimise total energy usage, and reduce infrastructure costs. AI employs a wide range of search and machine learning methods (Hiran et al., 2021; Vyas et al., 2021), as well as improvements to school scheduling and organisation. In the modern world of data-intensive jobs, with a rising number of fog and cloud implementations, particular detail at individual processes is necessary to ensure optimal task allocation choices, VM migrations, and so on. Even though there are various constraints, this is required to permit optimization, as previously indicated (Dadhich et al., 2021; Mehul Mahrishi et al., 2020). These constraints will include everything from compute and bandwidth restrictions to service level agreements and mission timetables. Several attempts have been made to improve the performance of fog and cloud networks by utilising AI methods. Numerous studies have been conducted on a variety of issues, including successful cloud planning, application development technologies, and delivery network configurations, to name a few (Singh & Hiran, 2022). They maximise their optimal solution by using a number of analysis methods such as genetic algorithms, controlled machinery education, and profound strengthening education, among others. AI offers a profitable strategy for optimising large networks with massive amounts of data by simplifying and productive engineering using automated decision-making rather than human-coded heuristics to produce very quick and efficient choices. As a result, AI is an appealing alternative for optimising complicated networks (Barua et al., 2020; Khazanchi et al., 2021).

REVIEW OF LITERATURE

Many neural networks have been defined in Dongwen (Cui, 2019) work to assist researchers in achieving their objectives. These networks include single-layer activation functions, layered perceptions, Grnn, RBF, and others. This little neural network was found to be useful in a few of the more fundamental runtime data and structures. However, advances in digital technology have limited the amount of data that can be collected as well as the time that can be spent on device architectural implementation. Following that, several scholars had the idea to redesign standard neural networks so that they could accommodate much more information and reach conclusions in a shorter amount of time. Neural networks have the potential to represent or generate the effect of data that is both complex and untrustworthy.

Zhang et al. (2019) put out the idea that confidence-based issues and challenges associated with cloud models be investigated. They described CC as an appropriate processing environment that allows registration assets to be hosted from any place. This ensures that the knowledge is consistent, effective, and easily accessible. The authors recommend a trust-based access control mechanism as an efficient and effective technique for ensuring the safety of distributed systems. The key source of inspiration for their concept was the decision to base it on providing access to an authorised cloud client and selecting a resource for the measurement. Consumer and cloud properties are both examined, and their results are based on an evaluation of their level of confidence.

In Kochovski et al. (2019), AI algorithms that are utilised in CC to tackle data and security concerns posed by malware have been put through their paces. An artificial intelligence (AI) algorithm-driven barrier architecture that is geared for high malware finding has been developed by the investigators.

Syed Arshad Ali (2020) presented a methodology for the administration of cloud-based information that is secure for end-user consumption. This procedure permits municipal environmental protection assessments. In order to generate an effective review report, this method employs both linear verification and random masking. It only supports monitoring by a single party at a time and will not tolerate audits by multiple parties.

A fragmented method was suggested by Bulla (Bulla & Birje, 2021) in the text. During the process of data processing, this technique improves the methods for data aggregation and increases the storage requirements for data protection. The protection of sensitive information is its primary concern.

A research proposal on the security of cloud-based information was presented (Sadam et al., 2021). To determine the motions and delink the places, use the idea of heterogeneity as well as the practise of including connections in connection databases. The data is encrypted before the final user saves it to the cloud storage service. This ensures that the information is kept secret. This splitting is repeated until independent fragments on both the vertical and horizontal planes are formed.

Bhatt (Bhatt et al., 2021) published their findings in an investigation on the disruption recognition systems that make use of a device intuition strategy in a mobile cloud environment. Their investigation resulted in a schematic depiction of the CC and MCC concepts and management styles, in addition to a survey of the safety concerns that are associated with these particular conditions.

Hussein (Abdou Hussein, 2021) discussed a security-resolving method with the purpose of improving the effectiveness of cloud systems. Because an outsider collects, manipulates, and modifies the data, the database loses trust in the information it contains as a result of the knowledge volatility of the outsider.

Peng Sun (Sun & Boukerche, 2021) provided an explanation of how AI templates can improve data safety. The concept of distributed computing has been proposed because it carries the potential to expand essential momentum and virtualized cloud farms, which, when developed sufficiently, can serve both as a functional platform and a solution to enormous enterprise applications.

In order to mitigate potential threats to the safety and security of cloud applications, researchers have implemented a paradigm known as assist. It examined the most important risks, safety concerns, and different cloud application configurations already in use, as well as the strengths and weaknesses of those configurations (Chauhan et al., 2019).

CLOUD'S ACTIVITIES AS EXHIBITED

Power is a component of any electronic system. An output concept was proposed, with a particular emphasis on ISO 25010 (*ISO - ISO/IEC 25010:2011 - SQuaRE*, 2011), which measures the performance characteristics of a stable and efficient process to meet the demand specified below and within the total boundary condition of the distributed ledger to determine the reliability of cloud services. Consumers, sellers, and executives will all be held to standards and regulations. The quality of the network is affected by the many decisions that go into making each programme; these decisions range from providing the intended benefit to outright rejecting the product (Saini et al., 2021; Wireko et al., 2021). A cloud strategy is essential for both users and providers since cloud computing is an embedded environment that manages dispersed resources, depends on the administration of massive amounts of data, and necessitates the development of tools to boost productivity. Knowledge and efficiency measures are included in cases where such performance affects cloud services' general appeal. Customers and government organisations can both benefit from the efficiency and increased productivity that cloud computing offers (Lakhwani, 2020; Niemi, 2021). Multiple factors, such as the predicted mean per unit time and total time to wait per unit time, must be analysed to determine the implications of the quality of cloud services on the success of cloud projects.

- Their performance, responsiveness, technical support, and usability are all evaluated in an open and transparent manner by the users.
- Consumers rely on performance indicators to make explicit or implicit judgments about the technologies, quality measurements, effectiveness indicators, and middleware capabilities.
- Metrics for success are determined by the infrastructure's quality, power, durability, availability, and scalability (Hiran et al., 2014).

WHAT IS THE CONNECTION BETWEEN EFFICIENCY AND SAFETY?

The automated system's scope is determined by how well the programme runs, but the connection between effectiveness and security has been mapped out. Performance is a metric measuring how quickly information can be transferred and processed, whereas security refers to the absence of risk. Device operating system components are at the heart of the problem and must be addressed by the consumer and service provider. One of the measures of productivity is safety, but the most important indicator of success is performance, and safety is merely a by product of the technology (Frempong & Hiran, 2014; Tyagi et al., 2020). Consequently, the performance-security alliance is a necessary condition for the development of the gadget. More and more data providers are making their services available through cloud computing, wherein the client initiates service requests and the vendor carries them out. However, the process hinges on an agreement between the parties involved to facilitate communication and usage. Agreement on Support Quality is the Present (SLA). Other issues, such as security and service efficiency, between the client and the service provider also affect the user's decision to move to the cloud (Acheampong et al., 2018). Since the user has no idea where their data is being processed and no say in the matter, it is the responsibility of the customer to make protection and performance transparent, and the freedom of the software platform to ensure it is available to the provider. However, security is crucial if the cloud customer is not applying a security protocol, i.e., if he has a low level of safety that impacts the efficiency of the service. In the cloud, security is irrelevant. In addition, the network operator's protection will be based on the performance scale, which will change depending on whether the low safety level affects efficiency and quality.

COMPUTING IN THE CLOUD, WITH THE HELP OF AI, HAS MANY ADVANTAGES

Due to the increasing intelligence of computers, it is essential that human interaction with these systems be reduced to a minimum. Everything from Siri to Google's Self-Driving Car is based on AI's core concepts and algorithms. These applications typically fall under the category of "bad Ai" or "limited AI" due to the limited set of tasks they can complete. The ultimate goal of AI is to create a robust AI system capable of performing a wide range of jobs. A significant consideration in the evolution of artificial intelligence is the impact these Machines will have on people and the world at large (Lee, 2020; Zohuri, 2020). All throughout the world, researchers are hard at work on this front, with the ultimate aim being to design next-generation computers that won't get in the way of people's lives. The true promise of AI in the future years is now clear, and it is no longer a matter of intense scrutiny. Since the introduction of cloud computing and AI, the market landscape has shifted dramatically, making it essential for businesses to use these technologies if they want to succeed financially (Kakish et al., 2022). As AI aids devices in more accurately interpreting information and facts about the world and data patterns, the performance can be honed for making swift and effective decisions, ultimately guaranteeing the satisfaction of the end user. All human error has been eliminated from this process, making it perfect. This means there has been a fundamental shift in the way information is compiled, stored, and ultimately used across a wide variety of online services (Shi et al., 2014). In light of recent innovations in the cloud and AI industries, it is safe to say that highly educated and skilled professionals in these fields are in high demand. Different benefits and advances can be made to your business or service by implementing cloud computing and artificial intelligence techniques (Parreno-Centeno et al., 2020).

CLOUD ARCHITECTURE

Smart clouds offer secure cloud storage. Cryptographic procedures are employed to protect information and infrastructure in the cloud. With this approach, stable clouds may be created quickly. The shift from shallow to deep learning will accelerate. In this scenario, AI cloud systems and computing algorithms use previous analytics to plan for the future. Otherwise, machines and robots will mimic human behaviour in real-world settings by using sophisticated data and cloud-based expertise. A user's risk exposure for data stored in the cloud may vary depending on the user's architecture (Alkhater et al., 2014). Cloud computing is susceptible to a wide range of potential security threats. Risks posed to network users by the protection

CIA (Cloud Security Model) are outlined in Table 1 and highlight why a Cloud security model is crucial for any Cloud service. Three relative analytical attacks are determined by the components of their network-centric, VM-based space and device-type attacks (Ogunlolu, 2017).

ELECTRONIC ATTACKS

Besides the aforementioned port access and Trojans, malicious software is another major source of danger for electronic gadgets. Software developers can use a vulnerability scanner to investigate a target and secure official approval for a widespread campaign. Because regular channel scans are part of most system security measures, defenders can't reliably hide their identities while hackers probe the system. With the help of preexisting worm infections on social media computers, hackers are able to create a network of infected machines to launch attacks. When malicious software or hackers successfully pose as another user, they have launched an attack known as malware. This happens when an attacker is assumed to be present on a channel in order to exploit or reveal sensitive information about other computers, equipment, or individuals (Kshetri, 2013).

ASSAULTS THAT RELY ON STORAGE

If there was a strict control mechanism in place, hackers wouldn't be able to steal the valuable data stored on any given piece of hardware. Due to the data scavenging, the attacker will be unable to access any data stored on discs. Picture versions are removed from duplicates when dealing with numerous metadata sets. It protects against this kind of attack by replicating the vast majority of data in files. Threats to the cloud framework's performance, such as malicious data theft, are not the only ones it faces. The three most common types of software package risks include malicious software injection and stenographic threats, collaborative models, network servers, and traditional threats (Qasem et al., n.d.).

CRYPTOGRAPHY FOR SAFEGUARDING AND IMPROVING CLOUD DATA PERFORMANCE

Mathematical study of the encryption and decryption processes for use in secure communication; uses mathematical transformations of common phrases and devices. Greek "cryptos" means "reading," "secret," and "graphin," which is where the word

Table 1. A threats checklist for the Cloud

Menace	Outline
Insiders are vulnerable to the following user risks: o Fraudulent smog from dishonest clients. o Unauthorized third-party use (fraudulent use).	Each supply model may need a large number of authorised partners, making insiders who have access to relevant cloud-stored data especially vulnerable. One cloud-based feature that could be useful for client and dealer management is collaboration. Developers and managers of the software and infrastructure that support the research community. Third-party consultants to the system.
There are a few possible causes of information loss: o The absence of cloud-based data and backup solutions for vehicular and mechanical transport. o The failure of multi-domain protected control rights.	Multiple organisations who are in direct competition with one another yet use the same private cloud run the danger of a systemic security compromise, which could result in lost data or malfunctioning hardware.
Assaults on potential attackers include: o The onslaught of improved cloud-based apps. o A coordinated assault on gadgets hosted online. o Upgrading a cloud service.	In data centres where client data points have been compromised, however, hackers employ a wide variety of Cloud monetization tactics. More opportunities for hackers to strike exist on the open cloud web. Credit card numbers, personal information, and other sensitive data are stored in an upgraded database. Information gatherers would focus on highly valuable public or intellectual property.
Virtue	
Data isolation o Incorrectly defined defensive borders o Misleading cloud service and OS installation.	Developers of software and managers of the research infrastructure must ensure reliability in cloud-based storage systems. Which is meant to track concentrations in data centres may provide a problem for user authentication if assets on individual devices cannot be readily identified.
Information delivery: o Improperly installed software or hardware components	The likelihood of a data quality effect is increased when cloud providers host data for several customers. If another user of the cloud adds a faulty or erroneous item, it could affect the data integrity for all users.
Inherence	
Management of the Transformation: o Adoption testing for a large number of cloud customers; o Enhanced cloud vendor, customer, and third-party services for customers in the cloud.	Due to the cloud provider's increased responsibility for controlling changes in both models, enhancements may end up being counterproductive. Advances in the cloud's hardware and software can set these in motion.
Threat of service denial: o Bandwidth in networks with dispersed access refusal. o Because of high demand and inadequate supply,	The risk of being denied access to a cloud storage provider's available resource is an external risk. However, both domestic and international malevolent hackers can develop programmes or physical hardware that will create a system rejection, which could harm any cloud infrastructure architecture.
Inadequate recovery procedures: o endanger the ability of businesses to fully recover from calamities.	There is a higher risk of incomplete maintenance and emergency response methods when cloud customers explore consolidating their own in-house networks with all of those maintained by third-party cloud providers. The healing process could be greatly impacted if these methods aren't re-evaluated.

"cryptography" comes from. This "cached content" was the true heart of its cypher. Plaintext, symmetric encryption, a decryption technique, a decryption key, and a set of keys are the building blocks of any cryptography. In its normal, unencrypted form, cypher text is a document or piece of information that can be read and understood by its intended audience (Priyadarshinee et al., 2017). Information encryption is the process of using a code to convert a symmetric key into an encrypted script.

ADVANCED ENCRYPTION STANDARD (AES)

Two main authentications, both cryptographic procedures, are used in cyber security, making it one of the most prevalent and successful methods of protecting data from hackers. The goal of cryptography is to make it difficult for unauthorised parties to obtain transmitted information. In this stage, the document itself can be converted into unreadable representations known as chip code. The key to decryption is not hidden. That's the method used to decipher encrypted information into plain text without using any of the phrases found in the source material. Without a hint, this method uses mathematics to carry out the entire cryptographic process, including substitutions and combinations. When it comes to the AES algorithm, AEA is among the most well-known and widespread block-symmetric chippers in the United States. Encrypting and decrypting private data using this architecture is done on devices and networks all over the globe (Alassafi et al., 2019; Doshi, 2018; Fung, 2014). It might be very challenging for certain people to have correct information while encoding using the AES method. There has been no conclusive evidence that such a method can be broken. Each cryptographic technique has a capacity of 128 bytes, and AES can deal with three different weights (AES 16 bytes, AES 24 bytes, and AES 32 bytes). The research of AES's cloud-computing applications is highly sought after. There have been many recent studies on AES algorithms, many of which aim to increase the difficulty of using them for encryption and decryption.

Each assault on the procedure consists of four distinct phases.

- First, the bytes are changed out for new ones; this is the stage where the block code's bits are swapped with those defined by the S-boxes.
- When rows are shifted to the second phase, the result is a derivation. As can be seen, throughout this stage, we will be shifting everything but the first two lines.
- Third, we confuse the pattern by combining the columns of both frames using the Hill chip, which is being employed in the third phase.
- The fourth step is to incorporate the rounding key, at which point the text is XOR'd primarily with the appropriate rounding keys. Such precautions

establish the repeatability of an encrypted procedure without compromising its security.

Before authentication and encryption, 128-bit CBC mode uses XOR on the entire first unencrypted frame and an initialization vector (b_1). For CBC to work, all blocks must be chained together, and the only way to encipher a frame's plaintext is to XOR it with the ciphertext of the frame

Regardless of the manner this strategy is summarised in, it appears to include:

$$c_t = e_k\left(b_t \oplus c_{t-1}\right) \tag{1}$$

Block encryption with key k is denoted by e_k, while the matching cypher to b_{t-1} is c_{t-1}.

$$b_t = d_k\left(c_t\right) \oplus \left(c_{t-1}\right) \tag{2}$$

There is no tolerance for block losses in the encryption process when using CBC mode, despite the fact that it is the more secure option. This is due to the fact that encrypted blocks rely on their predecessors in order to function.

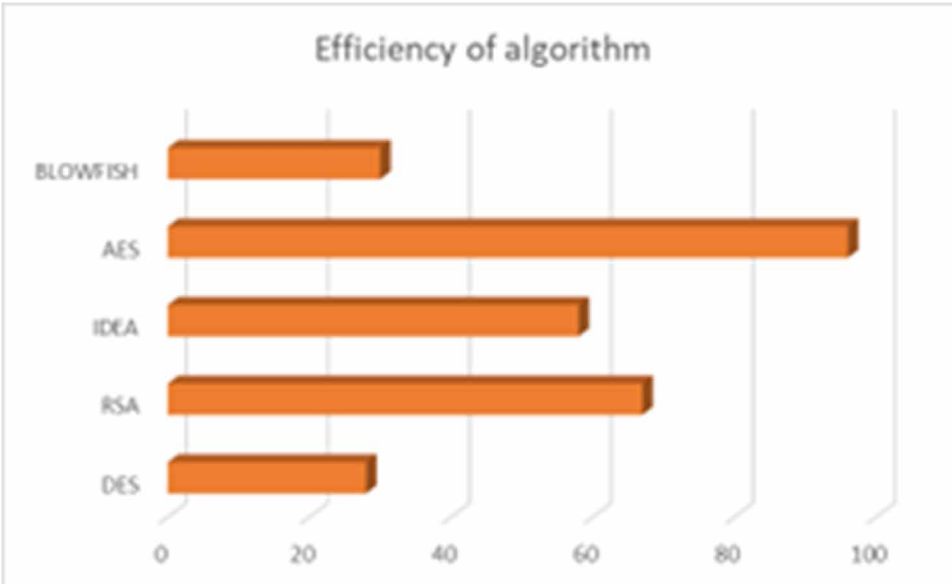
DISCUSSION AND RESULT

Table 2. Performance evaluations of various algorithms

S No.	Name of Algorithm	Efficiency of Algorithm
1	DES	28
2	RSA	67
3	IDEA	58
4	AES	96
5	BLOWFISH	30

According to Table 2, the data efficiency of DES in the cloud is 28%, that of IDEA is 58%, that of BLOWFISH is 30%, that of RSA is 67%, and that of AES is 96%.

Figure 1. Comparison of efficiency algorithms



CONCLUSION

Initially, in this work, we focused on cloud security issues. Safety measures for discs, virtual machines, data, networks, and software are all part of this. The main goal is secure data storage and management that is independent of the data owner. Businesses of all sizes can now go in a promising new path, made possible by cloud computing and artificial intelligence. After many more years of research and analysis, this course of action will mature. Organizations can maximise system capabilities and costs by adopting cloud and AI initiatives. With the help of AI algorithms, companies will be able to expand their reach in the market, and their employees will be able to operate in an environment that is both conclusive and exact. Using this method, businesses of all stripes will become more productive, resulting in increased earnings and longevity.

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Chapter 7
Novel Design of Deep Learning and CNN Approaches for Wireless System Applications and Services

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ABSTRACT

In trendy wireless communication networks, the inflated shopper demands for multi-type applications and top-quality services became a distinguished trend and placed hefty pressure on the wireless network. The standard of expertise (QoE) has received a lot of attention and has become a key performance measuring for the appliance and repair so as to fulfill the users' expectations. The management of the resource is crucial in wireless networks, particularly the QoE-based resource allocation. One amongst the effective ways for resource allocation management is correct application identification. In this chapter, the authors propose a unique deep learning-based technique for application identification. It explores QoE for wireless communication and reviews the restrictions of the standard identification strategies. After that, a deep learning-based technique is projected for mechanically extracting the options and characteristics.

INTRODUCTION

In this chapter, we will discuss the novel design of deep learning and CNN approaches for wireless system applications and services.

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The research presented in this chapter is focused on developing a novel deep learning and CNN approach for wireless system applications and services. The proposed approach can be used to improve the performance of wireless system applications and services, which are currently plagued by limited bandwidth, high latency, poor reliability, and unreliable quality of service (QoS).

The proposed deep learning and CNN approach leverages the advantages of deep learning to perform better in wireless system applications than traditional approaches based on conventional techniques such as Bayesian belief networks and reinforcement learning. The proposed approach is also scalable since it does not require any changes to the existing components; instead, it can be easily integrated into existing systems without requiring additional hardware or software modifications.

LITERATURE SURVEY

The literature survey has been conducted to provide a comprehensive understanding of the current state of deep learning and CNN techniques in the area of wireless system applications and services. In this report, several advantages and disadvantages in the existing deep learning and CNN techniques are discussed. It is important to note that these techniques are not yet mature enough to be used in real-world applications. However, some researchers have shown promising results by applying them on real-life data sets.

WIRELESS SYSTEMS AND SERVICES

In this paper, the author will discuss the advantages and disadvantages of using wireless systems and services (Raj & Bhattacharyya, 2020). He will also describe how these advantages can be used to improve communication systems.

DISADVANTAGES OF WIRELESS SYSTEMS

Wireless systems have some disadvantages; however, they can still be used to solve many problems in wireless communication. These problems include:

- **Limited Range:** Because there is no wire connecting two devices, the range for a wireless signal is limited by the distance between them. The farther apart two devices are, the more difficult it becomes for them to communicate with each other.

- **Low Bandwidth:** In a wired connection, information travels through wires at high speeds; however, in a wireless connection, information must travel through air at much slower speeds. This means that sending large amounts of data over wireless connections is very time consuming and costly.
- **High Cost:** Wires are much less expensive than radios or other wireless technology because they can transmit signals quickly and efficiently across long distances without requiring any extra equipment or power supplies. Therefore, if you need to send large amounts of data over long distances (such as when sending images over hundreds of miles), then you should probably use wired connections instead of wireless.

PROPOSED SYSTEM

Deep learning and CNN approaches for wireless system applications and services.

A novel deep learning and CNN approach is proposed to address the problem of the data inconsistency in a wireless system. The proposed approach uses a deep learning model that takes into account both spatial information and temporal information. It also uses a CNN to identify which type of data is more likely to be corrupted (Dhanapal & Gokulakrishnan, 2021). The proposed approach is tested on real-world data sets collected from a wireless sensor network.

Advantages

Complexity

As we know, the wireless systems are more complex than their wired counterparts. This is because of the need to support a wide range of wireless protocols across different hardware platforms.

Security

The wireless system is less secure. It does not offer any security mechanism for protecting information and its users from being hacked or stolen.

Interoperability

The interoperability of the wireless systems and services is limited. For example, a corporate user may not be able to access his/her email through a mobile app from outside the company's premises unless he/she has set up an account on that app first.

Wireless systems and services are becoming more and more important in our day-to-day lives. From home to work, to entertainment, wireless is everywhere. With the increase of wireless technology and the growth of mobile devices, it has become critical that wireless systems and services maintain their reliability and efficiency. However, with the rapid growth of the technology, there are many challenges that must be addressed in order for these systems to achieve their full potential.

The use of deep learning models can help improve performance by reducing the amount of data required by a system at any given time, as well as provide a wider range of responses than traditional neural network models. For example, CNNs have been shown to be able to recognize objects in images much more quickly than traditional convolutional neural networks (CNNs) while using less power.

Wireless System and Service

Wireless systems have several uses in security, as well as retail loss interference, proximity access cards, vehicle tag readers, wireless alarm transmitters/receivers, and digital infrastructure for entire security systems. Understanding the capabilities and limitations of those systems is that the key to success or failure as a RF system designer.

A wireless system uses associate in and of itself open and unsecure radio channel for transmission of user signal and traffic between the bottom station and mobile stations. As such, reliable and strong security and encoding procedures should be used in order to shield confidentiality, privacy, and integrity of user traffic and credentials, and to stop security breaches and thieving of service in cellular networks (Liu et al., 2020).

This chapter describes the safety aspects of the IEEE 802.16m normal. As shown in Figure 1. The safety sub-layer of IEEE 802.16 is found between the mackintosh and also, the physical layers. the safety functions give users with privacy, authentication, and confidentiality by applying cryptological transforms to mackintosh PDUs transported over the connections between the MS and also the BS. additionally, the safety sub-layer allows the operators to stop unauthorized access to information transport services by securing the associated service flows across the network as shown in the Figure 2. The safety sub-layer employs associate etches client/server key management protocol within which the BS (the server) controls distribution of keying material to the MS (the client). additionally, the essential security mechanisms are strengthened by adding digital-certificate-based MS device-authentication to the key management protocol.

Figure 1.CNN neural network

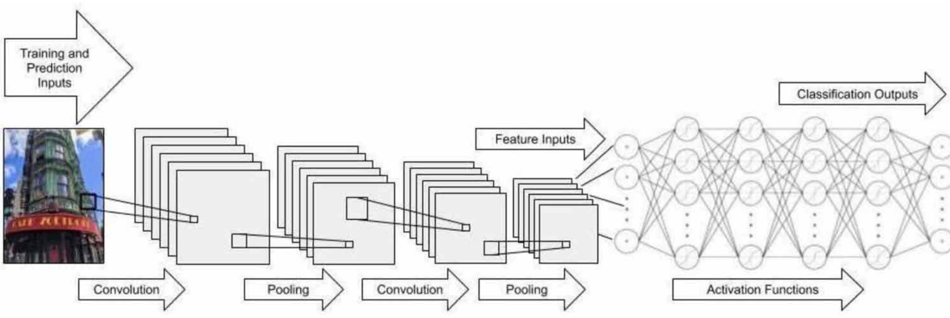
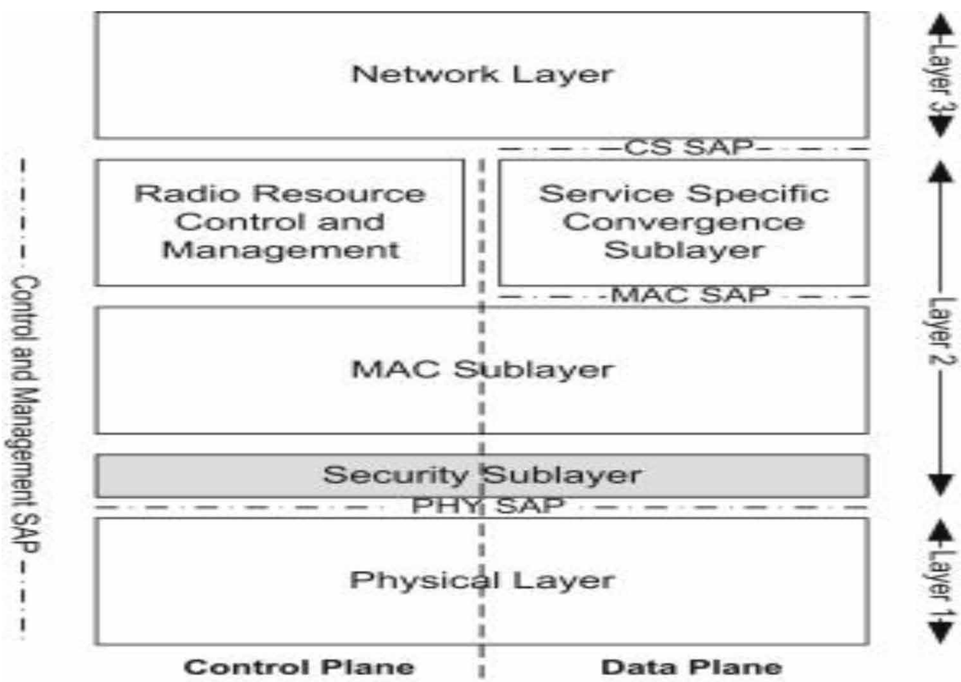


Figure 2. Network layer



If, during capability negotiation, the MS indicates that it does not support the IEEE 802.16m security protocols, the authorization and key exchange procedures are skipped and the MS will not be provided with any service (except emergency services). The privacy function has two component protocols:

1. An encapsulation protocol for securing packet data across the network, i.e., a set of cryptographic suites and the rules for applying those algorithms to a MAC PDU payload;
2. A Key Management Protocol (PKM) providing the secure distribution of keying data from the BS to the MS. The MS and the BS can synchronize keying data via the key management protocol.

The BS can use the protocol to enforce conditional access to network services, as well.

Figure 3. Key management protocol

Learning technique	NB - KNN	Distribution Analysis	HMM	RF fingerprinting	RF fingerprinting	Distribution Analysis	SVM	FL	CNN - DNN	CNN	Neural Network	Neural Network	CRP Clustering	Heirarchical clustering + KNN
MAC Layer	✓	✓				✓	✓							
PHY Layer		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓

A CNN architecture was developed to train and classify recorded signals. Power-frequency values obtained from ognitive radios rely on information gathered during spectral sensing to foster communication between protocol-disparate devices. Clearly, an essential requirement is accurate service discovery. To this end, several approaches have been explored spanning processes like matched ðlter, cyclostationary and energy detection techniques. Methods can also be grouped into one of two types based on the information.

Wireless System Applications

Wi-Fi communication is nearly an equivalent as alternative communication varieties, because it is additionally a wireless network. It acts as a two-way communication system. It uses radio waves and works on IEEE standards like 802.11g and 802.11n

(Singh & Sinha, 2021). The process of transmission of signals relies on routers that send data to the wireless network through cables, and also the same happens at the receiver's finish.

Applications

- **Internet:** Wi-Fi provides high-speed net to users. The speed depends on the standard of the cables.
- **Video Conferencing:** It makes video conferencing less costly than cellular knowledge with wonderful quality.
- **Common Access Points:** In universities or faculties, it provides one purpose of the net from wherever everybody will use the Wi-Fi with their provided credentials. If got Associate in Nursing ethernet-only device, then you'll conjointly connect it to your Wi-Fi.

This planned model will be used for the detection method for any wireless communication system like single input single output (SISO), ancient multiple input multiple output (MIMO), SS-GSM MIMO, or MS-GSM MIMO. additionally, a changed CV-CNN model is planned for the constant enfold signal constellation to cut back the procedure quality in terms of the amount of real valued multiplications. Figure shows the most design of the planned AE-CNN for any wireless MIMO systems.

The novel style of deep-learning and CNN approaches for wireless system applications and services is applicable for the physical layer of MIMO wireless networks and achieves vital quality reduction particularly for single image generalized abstraction schemes. The planned model is ready-made to cut back the procedure quality for the detection method that may be a price intensive on the prevailing detection algorithms. The minimum reduction of the procedure quality is 73.95% for single image generalization abstraction modulation systems victimization MPSK schemes. As a result, the facility consumption at the receiver is reduced which suggests increasing the energy potency. In terms of the spectrum energy, because the spectrum potency is raised, the reduction on the procedure quality with reference to the quality of the most chance detector is raised. For instance, for an abstraction size of 8 the procedure reduction is 70.45% whereas for the abstraction size of 16, the procedure reduction is 73.86%. With the employment of abstraction modulation, the spectrum potency in terms of the number of transmitted bits per second per Hertz is raised while increasing neither the transmission information measure nor the transmission power.

CONCLUSION

This concludes by summarizing the main Points and Conclusions of the topic discussed. The novel design of deep-learning and CNN approaches for wireless system applications and services, discussed the novel design of deep-learning and CNN approaches for wireless system applications and services, decompose deep learning into two main components: Convolutional Neural Network (CNN) technology, which is a type of machine learning technique that works by converting information into numerical form.

This Topic aims to propose novel approaches of deep-learning and CNN approaches for wireless system applications and services, they have been applied respectively in the network design of distributed systems. The research results showed that the proposed deep-learning and CNN approaches are based on the data mining layers, which constitute a new layer of deep-learning, identify different types of patterns within large volumes of data by applying CNNs or other neural network methods; to solve the numerous problems in wireless link detection, channel model adaptation and traffic classification tasks, which are very complicated in real networks.

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Chapter 8
Optimized Storage and Resource Management in Fog Computing Paradigm

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ABSTRACT

Fog computing reduces network usage and latency. The fog layer connects IoT users to the cloud by executing applications or processing data in network infrastructure devices. Cloud-based IoT can provide communication, computing, and storage. Offloading computer-intensive apps with fog is promising. Fog computing expands IoT roles at the network edge and supports cloud platforms. Clients can send control signals using fog computing and cloud services. Offload latency-sensitive user experiences to broken fog nodes at the network's edge. This makes real-time cloud management of sensors, actuators, and wi-fi routers difficult. Most cloud efforts allocate communication and computational resources. Fog computing emphasizes communication or computation. Fog computing can improve service quality and manage network challenges caused by real-time, latency-sensitive applications and IoT bandwidth and user resource limitations. This chapter examines computing and communication resource allocation. In this chapter, the author also discusses service delay, link quality, and mandatory benefits.

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OVERVIEW

The computing paradigm known as “fog computing’’ is a method of computing that provides access to connected, customized computer resources that are suited for use all over the globe and may be initiated on demand. This refers to networks, storage, servers, applications, and services that can be quickly obtained and shared while requiring only a small amount of work or time from the service provider. Cost analysis, resource management, and getting the most out of the resources you have are the three hardest parts of centralized fog computing. Fog computing systems are getting better because computer programmers, data, and services are moving from central nodes, also called the core, to the edge of the Internet, which has a direct physical connection to the outside world. The performance of cloud computing systems is also improved via edge computing. The Internet of Things (IoT) and cloud computing are both important parts of the conceptual framework for the cloud of things. Computing in the fog focuses on the problems and main concerns of IoT devices and applications on a centralized platform, while also taking cloud computing and computing at the edge into account for effective resource management.

The Internet of Things (IoT) is a development that has been very helpful to the world of technology in recent years. By linking everything in the real world to the internet, customers may be able to use technologies that were once out of their reach. The Internet of Things (IoT) is a new idea that uses resources in the real world to connect, interact with, and do computing. It is also known as the Internet of Things. Kevin Ashton is credited as being the one who first introduced the term “Internet of Things” in the year 1999. The Internet of Things (IoT) is a concept that refers to the seamless networking of real-world items that each have their own unique address and are connected together via the use of standard communication protocols (Atzori et al., 2010).

Cloud computing is a fairly new technology that uses the internet to deliver its services. It is sometimes referred to as the internet of things. The Internet of Things (IoT) owes its success to cloud computing and storage. Using the cloud has many benefits, like a virtualized platform and an unlimited amount of storage space. However, it does change latency and performance, and this change depends on having an internet connection. End devices like sensors and actuators are unable to connect directly to the cloud because the cloud depends on the internet for everything. Due to their proximity to end-user edge devices and the use of resources to reduce latency, fog nodes have a wider range and closer proximity than cloud nodes. Cloud computing is easy to use and expands the cloud’s capabilities by using a network device’s processing and computing power (Ab Rashid Dar, 2016).

Recent problems and issues in cloud computing include providing and allocating resources, being able to change, having long wait times, bottlenecks, network congestion, managing privacy, and managing security. These are all facets of network administration. Cisco came up with the concept of fog computing as a natural progression from cloud computing. The term “fog computing” refers to a new model in which data is stored and processed locally on devices called “edge devices” “fog” is a highly virtualized platform where data is stored and processed on “edges.” When a network terminal asks for a service, the fog first filters, preprocesses, and analyzes the data (Tordera et al., 2016). When a network terminal asks for a service, the fog first filters, preprocesses, and analyzes the data. The processed data is then sent to the cloud computing system, which makes the cloud data center less busy.

As IoT technologies get better, the number of mobile devices at the edge of the network is growing quickly. To meet the different needs of users, huge amounts of data need to be processed and stored. Even though cloud computing’s main servers are far away from end users, which can cause big delays, the technology is very good. Because of how fluid the fog environment is and how volatile and unpredictable it is, resource scheduling is an important technology that needs to be taken care of as soon as possible. Because of how fluid the fog environment is and how volatile and unpredictable it is, resource scheduling is an important technology for the fog as soon as possible. Fog computing addresses the issue of large amounts of data by scheduling resources (Al-Fuqaha et al., 2015).

INTRODUCTION

The Internet of Things (IoT) technology was made possible by the rise in the number of consumer devices and the improvement of distributed computing power. As IoT technology advances, new computing paradigms such as fog computing emerge. The idea behind fog computing is to bring processing and storage capabilities closer to consumers, who can either create or use them. To do this, computing resources are built into intermediate infrastructure parts (fog devices) to make this happen. This gives users and the cloud a continuous computing experience. Fog devices make this possible because they allow data to be stored locally and services to be run on nodes that are close to the user. This reduces latency and network load.

The market for mobile terminals for fifth-generation (5G) mobile radio systems is growing quickly, which will put a lot of pressure on the current network topology and communication infrastructure. The Internet of Things (IoT), social media, and real-time video communications are just a few examples of mobile applications that place additional demands on network capacity and transmission speed. Because of this, the amount of sensory data created by technologies like monitoring devices, security, and pollution control has grown by a huge amount. To do this, computing resources are built into intermediate infrastructure parts (fog devices) to make this happen. This gives users and the cloud a continuous computing experience (Ngu et al., 2016). But other methods, like fog computing, have been made to speed up the processing and management of sensor data in real-world situations like smart grids and the Internet of Things, where service quality and security are very important. IoT technology has made it possible for billions of objects, like sensors, actuators, and other things, to connect to the Internet and talk to each other.

These devices produce enormous amounts of process-able data, which may put a limit on available computational and storage resources. With the development of cloud computing, limitations on storage and processing have been eliminated. Over the past ten years, cloud computation loads and data volumes have grown. Routinely, the results of these computations and control data are sent to network cores and centralized data centers. The result is that cloud computing now faces new difficulties, like increased workload latency. Cloud computing can easily be replaced by fog computing (Niewiadomska-Szynkiewicz et al., 2020).

Fog computing can do more processing than edge computing, but it can't do as much as cloud computing. Fog computing can do more processing than edge computing, but it does as much as cloud computing. However, the cost of the electrical energy needed to perform the calculations is out of the question. By connecting everyday things to the wider Internet, the Internet of Things (IoT) enables more significant interactions between people and the things around them. During the connection, devices for detecting, actuating, and regulating are frequently coupled (Chiang & Zhang, 2016). Also, these devices follow the essential communication protocols that support the goal of intelligently recognizing, finding, tracking, and managing objects, which the IoT can do in a number of useful and exciting ways (Gantz & Reinsel, 2012). As a result, the Internet of Things is gaining traction across a wide range of industries, including healthcare, logistics, retail, and industrial automation, which are all examples of smart industries.

Airports, for example, might function much more efficiently. The Internet of Things can keep track of the quantity of people as well as their movement around the airport. It could be used in smart lighting systems for airports, which would save fuel and cut down on the need for routine maintenance (Mijuskovic et al., 2020). RFID tags and smart sensors could be used at airports to improve the way luggage is moved from one place to another. It is possible to do this in order to make sure that the luggage gets to the right person at the right time and place. These are just a few examples of how the technology behind the Internet of Things may be used to boost airport operating efficiency. IoT could also help make other industries more reliable, like supply chains, healthcare, and the monitoring of water pipes, roads, and bridges (Saad & Shahid, n.d.).

Cloud computing does not come without its drawbacks, one of which is the need for data to be sent from each sensor to a data center over a network, where it is analyzed and then used to control actuators. Because sensors and actuators are often on the same piece of hardware, this is a serious problem for two main reasons: (a) communication takes a lot longer, and (b) control information may be out of date. To address these limitations, cloud computing may benefit from fog and edge computing.

The cloud and each individual end device may be connected via the use of the Fog Node, which serves as a connecting point between the two. Computing in the fog is not a good substitute for cloud computing because it can't store or process the huge amounts of data that end devices send. Every day, Fog just gathers all the information and data from the different end devices and sends it to the cloud. The cloud and the fog layers may be able to communicate with one another using this method. By strategically placing proxies and access points along highways and trains, Fog will be able to talk to each other and provide high-quality streaming to moving nodes like cars. (Aazam & Huh, 2016).

As seen in Figure 1, fog computing may be used in an Internet of Things setting (Shanthan & Arockiam, n.d.). This figure has three levels: the IoT Device Layer (sometimes referred to as the device at the end of the chain), the Fog Layer, and the Cloud Layer. It has been pointed out that both the fog layer and the edge devices are geo-distributed. It has been pointed out that both the fog layer and the edge devices are geo-distributed. One of the most major differences that can be made between fogs computing and edge computing is the location of the intelligence and processing capacity. This is because fog computing takes place in the cloud. Computing in the fog makes use of a great number of nodes, and each one of these nodes is a computer.

It has intelligence and is located between the cloud and the end devices. Access points or base stations are what we call these intelligent nodes. Since it takes intelligence out of the cloud, fog computing can look at data from the internet of things locally. So, when the need comes up, it may be more efficient to use cloud resources than to use specific pieces of equipment. For example, fog computing could send intelligence to a local area network (LAN), which could then help a fog node or an Internet of Things gateway process data. Computing at the network's edge is a way to quickly spread the intelligence, processing power, and ability to talk to other devices from an edge gateway to the devices that are connected to the network.

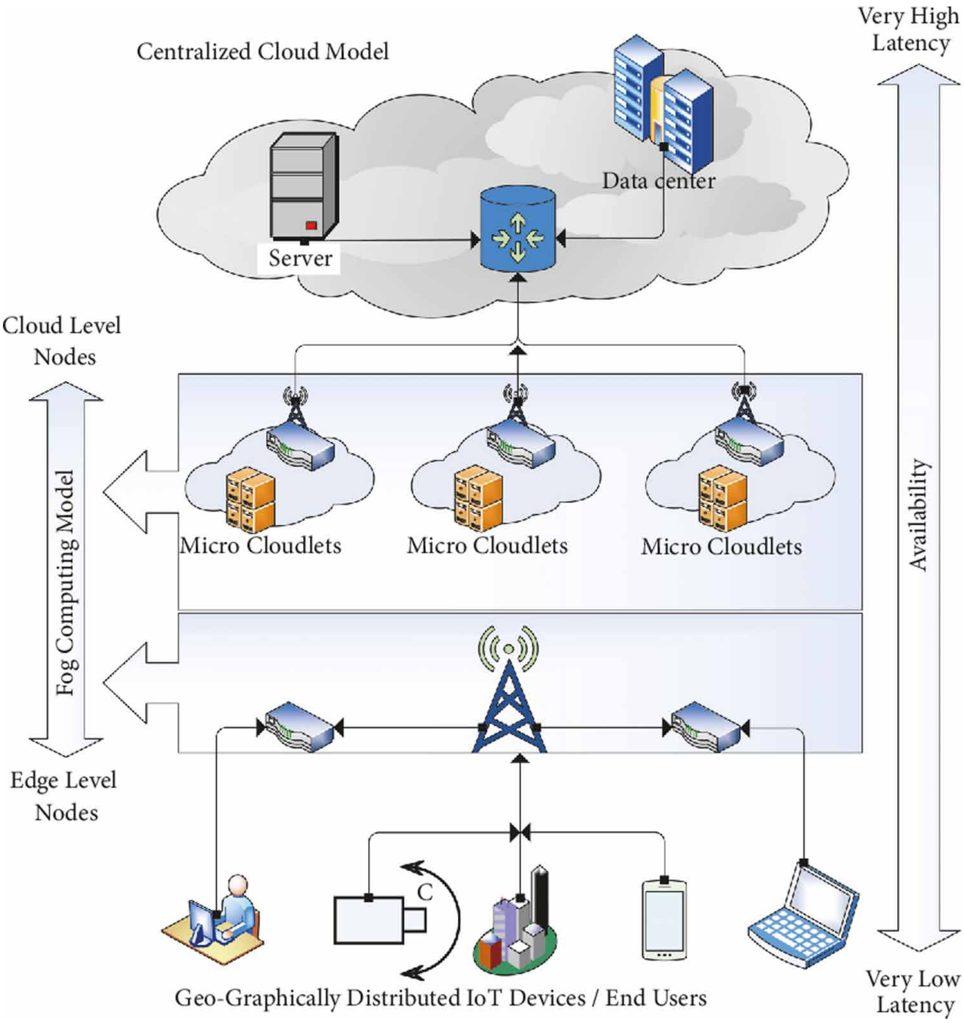
Intuitively, computing at the network's edge is a way to quickly spread intelligence. In this approach, integrating Internet of Things devices is often given more cloud-based services. In this approach, integrating Internet of Things devices is often given more importance than offering cloud-based services. Access to a radio network in real time and very low latency are important parts of, for example, a mobile service provider. The term edge computing refers to the act of transferring computing and resources for communication sent from the cloud to the physical location where they are used. By getting rid of delays, this lets services work and gives customers the chance to get messages faster (Fan, 2016).

Figure 1. Fog computing in an IoT platform

FOG COMPUTING PARADIGM ARCHITECTURE

As the number of IoT devices at the network's core grows, more and more data is created. So, if necessary, a basic structure could handle all the data related to traditional community-based systems, such as micro data centers, cloudlets, and the role of fog computing in the Internet of Things, which has been studied in the

Figure 2. Fog computing structure



past (Agarwal et al., 2015). This idea might not always be helpful for processing data gathered at the edge of the network. This section defines "fog," describes "fog computing architecture," and highlights various relevant research initiatives. It will also explain why fog computing will outperform other technologies, with a network structure divided into three distinct tiers, as depicted in Figure 2 (Anawar et al., 2018).

IoT device layers and end users include smartphones, tablets, smart cars, and lots of smart home gadgets. Using technologies like 3G, 4G, and Wi-Fi, sending sensor data across this layer also makes a connection. In the fog computing layer, technologies like 3G, 4G, WiFi, and WiBro are used to set up a connection when sending sensor data across this layer and devices like access points, routers, switches, and gateways.

Fog Architectural Design and Implementations

Researchers thought that the sense-process-act cycle could affect apps that know where you are because they have feedback loops. To put it another way, a large proportion of IoT devices are too far away from the cloud to support low-latency applications. Here is a quick explanation of how the design and architecture of fog computing work. The mathematical expansion of processing, communication, and storage at the edge for maximum effective information system capacity is called computation, data transmission, and storage (Deng et al., 2020). To get a good idea of an information system's overall capabilities, it must be able to handle relevant data, even "big data," and be able to process data at the edge of the network based on its capacity for data analytics.

Fog Interfaces With Cloud, IoT, and Other Fog Nodes

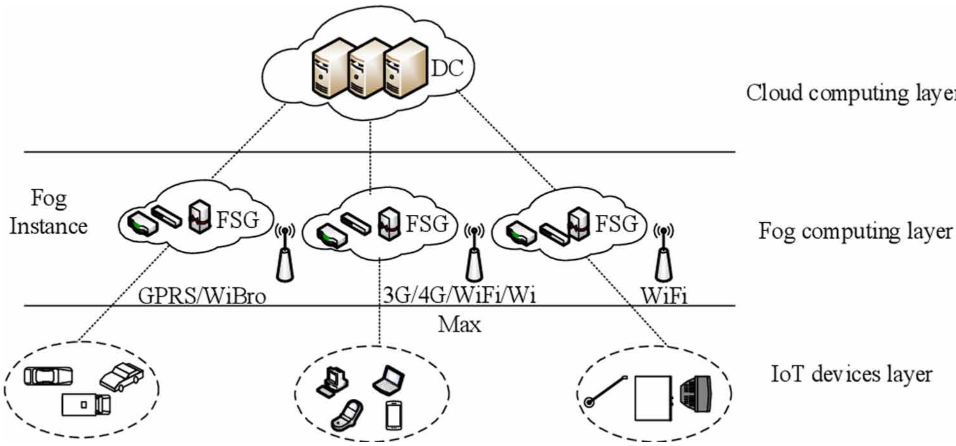
As was already said, fog computing uses the same processing techniques and features (virtualization, multi-tenancy, etc.) as cloud computing in order to offer scalable, non-trivial computing services. Fog computing is becoming more important because it already does some transformative things, like high-speed roaming applications (like smart connected vehicles and connected trains), low-latency requirements for applications, large-scale distributed control systems (like smart grids, connected rail, and STLS), geologically distributed applications (like sensor networks to monitor different environments), and large-scale distributed control systems (like smart grids, connected rail, and STLS).

Nodes in the fog, cloud, and continuous IoT can use the architecture of fog computing to move their processing, networking, and storage resources. On the other hand, for the cloud to work, the interfaces that the fog uses to talk to other clouds, objects, or people must allow for the flexible and dynamic transfer of processing, storage, and control functions between all of these different things. It managed the quality of services in a smart and effective way and helped end users evaluate fog computing services correctly.

Fog Node Paradigm

Fog nodes are important parts of fog computing's architecture. They can be either virtual, like virtual switches, cloudlets, and computers, or physical, like gateways, routers, switches, and servers. They are closely linked to access networks and smart

Figure 3. Fog computing architecture



end devices, and they give the devices listed above the computing power they need. One thing that fog nodes have in common is that they know both where they are logically and where they are physically in the fog. In a fog computing system's architecture, the fog nodes the nodes that connect the different user devices and resources to each other are the nodes that are responsible for providing the necessary communication services and data management. Fog nodes can be set up to talk to each other so that services can be offered, or several fog nodes can be linked and set up as decentralized fog nodes to implement a certain computing capability using fog computing. Single fog nodes may be For example, several fog nodes can be set up to talk to each other so that services can be delivered, or several fog nodes can be connected and set up as decentralized fog nodes so that a certain computing capability can be implemented using fog computing. They may also be coupled to create clusters, which, when used with methods such as extension or mirroring, make it possible for horizontal scalability across geographically disparate sites.

Fog Computing Architecture

Fog nodes are important parts of fog computing's architecture. They can be either virtual, like virtual switches, cloudlets, and computers, or physical, like gateways, routers, switches, and servers. Due to the IoT, fog computing might also be closely linked to access networks and smart end devices, and they give the devices listed above the computing power they need, seen as a three-tiered network structure, as depicted in Figure 3 (Li et al., 2019).

Smart phones, tablet computers, intelligent automobiles, and a range of smart home devices may all be found on the Internet of Things (IoT) device layer. With the help of many sensor devices, the Internet of Things can keep an eye on its surroundings and gather data in real time. This layer also connects to upload the sensor data it has collected after talking to the fog computing layer using 3G, 4G, WiFi, and WiBro technologies. The fog computing layer is made up of different types of devices, such as routers, switches, gateways, access points, and a number of edge servers.

RESOURCE MANAGEMENT IN FOG COMPUTING

Many researchers have looked at different ways to manage resources in fog computing based on things like resource allocation, workload balancing, resource provisioning, resource scheduling, and other things. The main goal of solutions for managing resources in a fog computing environment is to cut down on power use, communication costs, and latency. Different evaluation frameworks have been used to try out different ways to measure how well resource management algorithms work. Depending on the deployment scenario and the standards used for resource management, power management, and service quality, different assessment metrics are used. Fog computing devices need careful management of resources, so one of the problems with fog computing is managing the resources that are available.

Traditional cloud servers can't manage the resources of devices connected to the Internet of Things, but fog machines can store and analyze data from end-user devices. Fog computing devices need careful management of resources, so one of the problems with fog computing is managing the resources that are available. Getting control of the resources created by IoT devices takes time and requires the creation of new methods and approaches. Fog is a conceptual framework for resource management using fog. The fog layer has six resource management features. The resource as well as a coordinator, scheduler, request handler, resource allocator, and task load analyst are among them.

Internet of Things devices are too much work for traditional cloud servers to handle, but fog devices can store and analyze data from end devices. One of the issues with fog computing is resource management. Because fog computing devices require careful resource management, IoT resource management takes a lot of time and requires more and more complex procedures and ways of thinking. Fog is a theoretical paradigm for resource management utilizing fog. As previously stated, this architecture is composed of three levels. Six resource management capabilities are available in the fog layer.

The Workload Analyzer, Request Handler, Resource Allocator, Scheduler, and Resource Co-Coordinator are the components. Resource coordination is the process of putting together the resources that many IoT devices provide. IoT devices are incapable of managing a large quantity of available resources. Collecting tiny resources from Internet of Things devices requires coordinating resources and adding them up so that they can be stored in the cloud. This approach relies heavily on fog-to-cloud resource synchronization. In a smart home, for example, small amounts of money are gathered in a number of ways, such as through video monitoring in the kitchen, room, hallway, etc. All of these resources are coordinated by the fog node. A fog node is a cloud node that summarizes resources or data.

CHALLENGES IN RESOURCE ALLOCATION FOR CLOUD, FOG, AND EDGE COMPUTING

Use of 5G, server-less computing, resource allocation, optimization, power consumption, data management, use of federation principles in fog computing, trust models, business models, and services, mobility, and industrial IoT are all examples of cloud, fog, and edge architectures. One of the problems that 5G needs to solve is getting people to accept the idea of "network shredding," which lets a group of services work according to certain performance requirements. Cloud domains, fog nodes, wireless transmission, and optical packets are all terms used in cloud computing, and network-wide resource management are some examples. They do not, however, offer a comprehensive and uniform collection of materials across several areas. Recent advances in network virtualization provide possibilities for network destruction. Table 1 shows the difficulty in distributing resources for cloud, fog, and edge computing.

In server-less computing, it may be hard to move services across cloud, fog, and edge computing devices so that micro services can be managed across the cloud, fog, and edge hierarchy. The hierarchy of clouds, fog, and edges is to blame for this. The automated management of the micro services needs to check the deployment's location, context, and any possible limits on resources. Also, the large number of systems in an IoT cloud-fog environment could make it hard to deploy and reconfigure micro services.

Also, because devices are portable and applications' needs are always changing, it is reasonable to expect that network structures will change often. Because IoT devices are so different and their environments are so flexible, it is necessary to have active and dynamic system management based on allocating resources based on a large number of parameters. Resource management systems and multi-criteria schedulers can help quickly improve resource allocation when dealing with behaviors that are always changing. This could prove to be difficult due to the fact that the number of variables expands the search region, which in turn slows down the scheduler and makes it take more time to complete its tasks.

Table 1. Challenges in architecture for cloud, fog, and edge computing

Sr. No.	Challenges	References
1	Load balancing	(Chen et al., 2014)
2	Security and efficiency issues	(Chen et al., 2014)
3	Data integrity and availability	(Chen et al., 2014)
4	Cloud-based synchronization	(Taneja & Davy, 2017)
5	Dynamic scalability	(Taneja & Davy, 2017)
6	Efficient network processing	(Taneja & Davy, 2017)
7	Challenges References	(Bittencourt et al., 2018)
8	Server less computing	(Bittencourt et al., 2018)
9	Energy consumption	(Bittencourt et al., 2018)
10	Data management and locality	(Bittencourt et al., 2018)
11	Orchestration in fog for IoT	(Bittencourt et al., 2018)
12	Business and service models	(Mijuskovic et al., 2021)

RESOURCE-CONSTRAINED DEVICES

The Internet of Things is a network that connects billions of objects and gadgets, each of which has a finite amount of data storage (memory), power, connectivity options, and computational capabilities. Because of these limits, it is hard for devices with limited capabilities to do all of the necessary tasks at the same time. Also, they don't have enough resources to meet all of their computing needs with just what they have. Because of the related sophisticated protocols and resource-intensive processing, it will also be prohibitively expensive and impracticable for the devices to connect direct communication with the cloud some limited medical equipment, like insulin pumps and blood glucose meters, must do things like identify the user and give permission to use the equipment (Zeng et al., 2016). Similarly, most resource-constrained IoT devices cannot participate in block chain techniques of reaching a consensus. These include Proof-of-Work (PoW) and Proof-of-Stake (PoS) protocols, which demand massive computing power for the mining process.

RESOURCE SCHEDULING PROBLEM IN FOG COMPUTING

The majority of the time, scheduling resources is a problem with task scheduling, in which resources are allotted to the tasks that users are working on. It's possible that large-scale data transfer will use up a lot of capacity on the network and load cloud data centers if resource allocation is done in the cloud. Also, the type of service request from a user affects how resources are planned in fog computing. Delay sensitivity and tolerance are both service needs. Fog computing is different from cloud computing because it is close to the end users. Cloud computing is far away from the end users, which slows down transmissions. User requests that are delay-tolerant are often handled at the application layer, and user requests that are delay-sensitive are typically handled at the fog computing layer.

FOG COMPUTING FUTURE DIRECTIONS

Scalability: Offers services that may be scaled up or down depending on factors such as demand, traffic, and cyclical peaks; The use of fog makes it more interactive and dynamic; at any given moment, a company's resource demand may be at its greatest or lowest peak; thus, the costs of unused services may be handled at the edge of the network. In addition, the peak in resource demand for one's company can be the greatest or lowest in the industry.

Business Agility and Flexibility: One of the primary aspects of fog services that is drawing in an ever-increasing number of customers is its ability to provide business agility and flexibility, both of which are reliant on the elasticity of the underlying infrastructure.

Mobility Support: Smart watches, cellphones, and connected automobiles are all actively contributing to the formation of the fog edge layer that is now taking place. Edge devices have the capability to communicate with other devices either directly or they function properly by means of fog-smart gateways, which allow them to function properly to connect and move around more readily.

Improved User-Experience: Between the edge devices and the cloud is where the fog intimidator layer is positioned, there is a significant reduction in long distance, jitter delays, and communication noise.

Speed: It is essential for any service to be run on a cloud platform if the business wants to maintain its customers' engagement and satisfaction levels. Fog serves as a The IoT the IoT consists of an intermediary layer that quickens the processing of communication between the many edge devices that make up the IoT.

Maximize Network Bandwidth Utilization: The majority of the channel bandwidth is used for fog computing, which also partially replaces idle time. However, communication between the presence of fog nodes and edge devices in edge networks makes available more bandwidth that was previously used for fog computing.

The Localized and Decentralized: Communication between it's because of fog nodes and edge devices in edge networks that idle bandwidth is created accessible (Mahmud et al., 2018). To some extent, fog computing consumes the bulk of the bandwidth channel and replaces idleness.

Security and Risk Management: As a result of the possibility of direct connections between devices and edge devices, a number of nodes are actively participating in the fog environment. If one of the nodes in the system fails, the operation of the system will be continued by the other nodes. Security and risk are both reduced in an area characterized by fog.

Handling Natural Disasters: The data is safe and sound even in the event of natural disasters like hurricanes, storms, or earthquakes. The use of fog computing has the potential to make data processing and storage in the automotive industry significantly quicker, more secure, and superior to anything that has come before it. This will reduce the likelihood of data loss and open the door to new opportunities for the automotive sector.

Better Interconnectivity: However, with fog, only trimmed data is communicated to the network through edge devices, resulting in efficient, elegant, and uncongested connectivity (Jalali et al., 2016). Bottlenecks develop as a consequence of the centralized allocation of computer resources.

Distribution by Location: However, only the trimmed data are sent to the network via the edge devices when fog computing is used. This results in a network that is efficient, elegant, and uncongested interconnectivity. This is in contrast to the centralized allocation of computing resources, which generates bottlenecks.

Interactive Cabin Systems: Because only a decreased amount of data is delivered to the network through edge devices when fog is used, the resultant interconnection is efficient, beautiful, and free of congestion.

Heterogeneity and Interoperability: Because of the centralized distribution of computing resources, bottlenecks are created. However, only the data that has been trimmed is sent to the network via edge devices when fog computing is used, which results in an interconnection that is efficient, elegant, and free of congestion (Hassan et al., 2015).

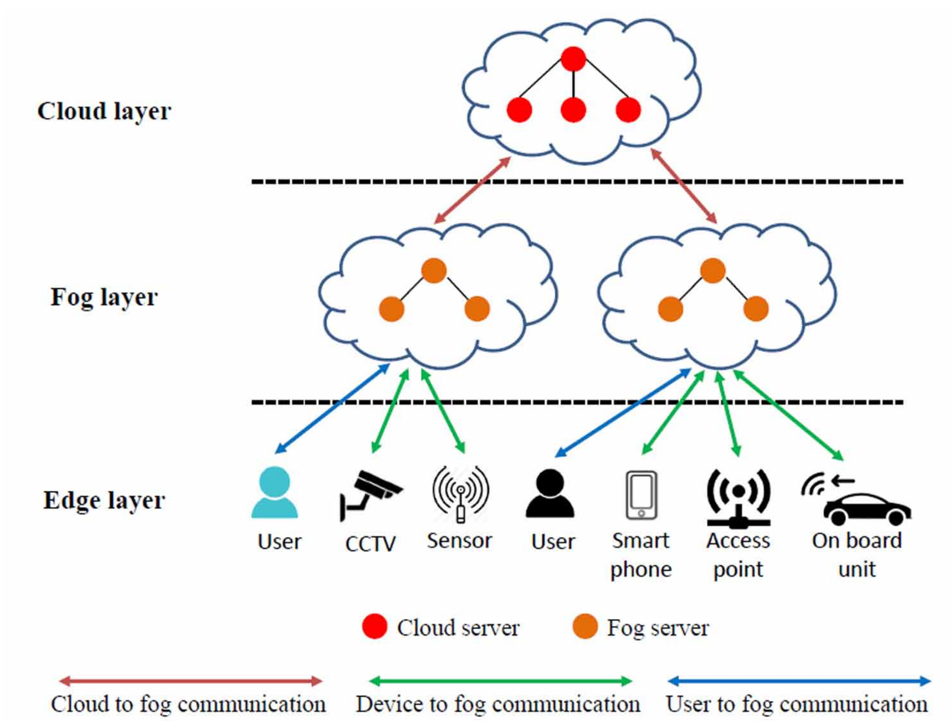
NEW HORIZONS IN CLOUD COMPUTING AND FOG-LAYERED ARCHITECTURE

Edge and Fog Computing

"Fog computing" is a term for a computer infrastructure that is everywhere and everywhere else. This infrastructure is the most modern way to spread out data, processing power, storage, and applications. It does this by using the right network configuration to expand the capabilities and services of cloud computing. This brings the advantages as well as the processing power of the cloud to devices used by end users, which is the location where real-time data is generated. Despite the fact that fog computing is sometimes called edge computing, its major purpose is to improve cloud computing capabilities at the network's edge. IoT makes IoT technology more useful by letting end-user devices like cell phones, everyday objects, and traffic surveillance systems be accessed and managed remotely (Shi et al., 2016).

Edge computing is a way to make cloud computing better and more efficient at the edge of the network, where end-user devices are controlled and accessed. By combining cloud and edge computing with fog computing, it makes it easier to get to resources. Since the latency is shorter, response times are about the same as when requests are handled at the edge (Rahman & Wen, 2018). In Figure 4, the Fog Nodes are seen acting as a connecting mechanism between the Edge devices and the cloud platform (Weng et al., 2021).

Figure 4. Fog computing: An intimidator layer



Fog Architectural Layers

Fog computing is the most recent and cutting-edge innovation in the information technology industry. It is rapidly gaining popularity and is considered an alternative to centralized cloud computing. Cloud computing brought all the way out to the edge of the network is what Cisco refers to as fog computing. Technology also allows for the rapid processing of massive volumes of data. Because it is a novel technology, the fog platform helps edge network company owners. It makes sure that IoT devices work well in a network that is spread out over a large area. It includes cloud capabilities and provides cloud users with a better real-time experience.

Real-time information delivery is a must for businesses that depend on speed, such as healthcare, transportation, connected cars, smart grid systems, and windmills. The concentrated and diffused fog reduces the issues associated with cloud computing latency. At the preprocessing stage, calculations are also done before the information is sent to the cloud data center to be stored in a permanent way. Because of storage issues, Fog's tiny data center is unable to keep up with substantial demand, which results in storage concerns for the company. The fog relies on data created in real time by edge devices; these devices get intelligence and computational capabilities from the rest of the network in order to be able to react rapidly. To make sure that a method works, people at all three levels need to work together. The process is broken down into very small parts, which are then sent from the edge device to the fog nodes in order to be processed, where they are temporarily held in cloudlets of fog. This helps to reduce the amount of latency experienced by the mobile edge. It can't keep and save data permanently because the storage device has a limited amount of space. It can't keep and save data permanently because the storage device has a limited amount of space. The fog clouds are sent to the datacenter of the cloud so that they may be kept there for an extended length of time.

CONCLUSION

The goal of this chapter is to explain an evaluation method, how to classify assets, and how a user should use them in situations like fog and edge conditions. People who make fog, haze, and edge situations should know a lot about the problems that CEOs have to deal with. Such as fog and edge conditions. Consider that cloud, haze, and edge thinking may be the basis of a worldview that could help with Internet of Things applications that need a solution for time-critical Internet of Things applications and inactivity while reducing the cost of communication and inactivity. The higher limits on how much information it can handle and how much it can store, which can be used to improve performance while reducing costs for communication and inactivity, In this chapter, the author divides calculations into six groups so that readers can judge the cutting-edge calculations used in many research papers.

Following that, the author considers how assets may be managed across clouds, haze, and edge devices. Fog computing should be summarized as a distributed and hierarchical system with scheduled storage, virtual cache and temporary storage built into virtual machine images and the deployment of network resources. Even though fog computing has a lot of benefits in terms of cost savings, efficiency, and business continuity, industrial data management still has a long way to go. The bulk of studies on IoT applications have linked fog computing, particularly in growing industries like manufacturing or the oil and gas sector.

On the other hand, most current or speculative research on the development and growth of smart cities may use planned combinations of sensor monitoring networks, smart buildings, and sensor traffic light systems. In the not too distant future, one city will Cloud services provide wide-area connectivity, global coordination, heavy-duty computing, and a lot of storage space, while fog allows user-centric services, edge resource pooling, rapid innovation, and real-time processing. Cloud services offer wide-area connectivity, global coordination, heavy-duty computing, and a lot of storage space, while fog allows user-centric services, edge resource pooling, rapid innovation, and real-time processing. Cloud services offer wide-area connectivity, worldwide coordination, heavy-duty computing, and massive storage capacity. Cloud services also make it possible to collaborate with people all around the world. During this transitional time, which is a great window of opportunity, it is interesting to do a lot of research on what fog might look like and what differences will carry over to the field of virtual computing in the next ten years.

In an IoT scenario, the cloud is paired with a relatively new technology called "fog computing." Edge devices manage storage and processing in fog computing. As a result, end-device latency is reduced. One of the most important aspects influencing fog performance is resource management. The resources that are collected from the end points are sent to the fog nodes, which add them up and send them to the cloud. The cloud and the endpoints are connected by the fog layer, which acts as a connecting medium. The proposed framework is meant to achieve goals like making the best use of resources while also lowering the costs that service providers have to pay. This architecture gives an overview of the different ways that resources can be managed in a fog computing setting. This idea may one day be used in an Internet of Things setting that operates in real time.

The Fog computing platform, which has been effectively implemented in healthcare, smart cities, and other fields, will manage data-intensive services and applications in the future, since long-term analysis data may be performed with lower cloud storage and transmission power requirements. The fog computing paradigm, including its features, possible uses in many different fields, and a full analysis of the security problems that both centralized and decentralized computing paradigms are currently facing, to make data storage and security measures work better in the future, people will also look at how to manage, use, and optimize costs and resources. These are three areas that will get attention in the time to come. Recent technological advances include the Internet of Things (IoT), linked cars, the Smart Grid, cyber-physical systems, wireless sensor and actuator networks, and software-defined networks. Fog computing can't do all of these complicated tasks by itself, so it needs to work with cloud computing to offer the best services for managing and optimizing resources.

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Chapter 9
Use of Machine Learning Approaches in 5G Applications

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ABSTRACT

The rapid development of 5G technology has led to a proliferation of smart applications and the need for efficient network interoperability. To address the challenges associated with 5G applications, machine learning approaches have emerged as powerful tools for predicting network characteristics and optimizing resource allocation. This chapter explores the integration of advanced algorithmic techniques and distributed computing resources to enhance the performance of 5G networks. This chapter explores the integration of advanced algorithmic techniques and distributed computing resources to enhance the performance of 5G networks. It provides an overview of the integration of artificial intelligence (AI) with 5G technology, including logistic regression, support vector machines (SVM), artificial

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neural networks (ANN) such as MLPs, and clustering techniques like K-means clustering, Gaussian mixture model (GMM), and expectation maximization (EM). It also investigates the integration of 5G with existing mobile networks, emphasizing the importance of seamless connectivity and efficient handover mechanisms. Overall, this chapter provides a comprehensive analysis of the use of machine learning approaches in 5G applications. It highlights the potential of these techniques to address the unique challenges posed by 5G networks and enable the realization of their full potential. By leveraging advanced algorithmic techniques and integrating AI, network operators and service providers can optimize network performance, improve user experience, and unlock new opportunities in the era of 5G technology.

INTRODUCTION

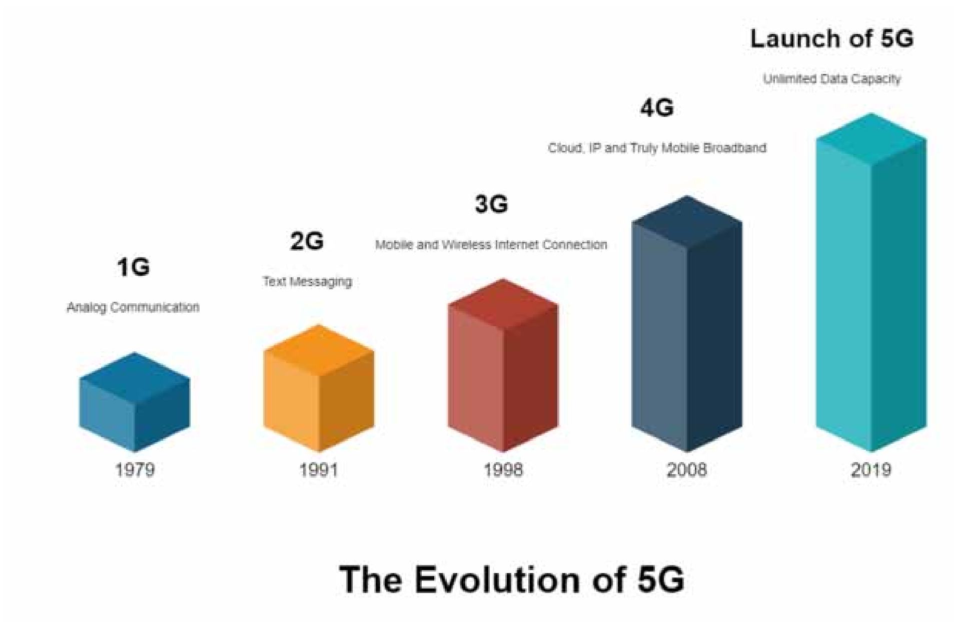
The introduction of the 4G mobile network has addressed the major obstacle of high capacity, allowing for the construction of real broadband Internet. It was primarily designed by a flexible physical layer. New ways have been opted to develop bandwidth requiring services such as VR (virtual reality), AR (augmented reality) etc. Innovations in applications, like vehicle communications or Internet-of-Vehicles, raise a great demand on stability of mobile networks. 5G has overcome some of these obstacles by employing a new radio interface based on massive MIMO.

Furthermore, the rise of Software-Defined Networks (SDN) and Network Function Virtualization (NFV) has provided operators with greater flexibility. It also allows them to serve the services which are highly demanding from various vertical markets. Furthermore, operators are being compelled to think about inclusion of intelligence on higher level networks, as well as the behaviors and requirements of their users, in depth and precisely. In order to establish a proactive and efficient updatable network, it is also necessary to foresee their evolution. In this chapter, authors discuss how Artificial Intelligence (AI) and Machine Learning (ML) helps in designing a cost-effective and adaptable higher level mobile network in 5G.. The usage of AI/ML in the network life cycle is described in some detail.

The abbreviation 5G refers to fifth-generation cellular communication. Its criteria were initially established in late 2017. Low-band, mid-band, and high-band are the three fundamental forms of 5G service. Which are incompatible and perform differently in current scenario? Even all US carriers have 5G at the moment; it will be few years before meaningful improvements are noticed as a outcome. 4G arrived in 2010, but it was not there till 2012/2013. Key apps that are necessary for 4G to function became popular. However, Ericsson, predicts that by 2024, 5G will have connected 40% of the world (Malhan, 2019).

In 5G "G" stands for *GENERATION*. The cellular service's first generation was analogue. The Second generation was digital cellular technologies. The Speed increased from 200 kbps to several mbs per second, credit to 3G technology. Currently, 4G technologies gives speed rates of hundreds of Mbps and even gigabits/ second. It provides bigger channels for faster speeds, lower latency for better responsiveness, and the ability to connect more devices at once are all features of 5G (*How Artificial Intelligence Improves 5G Wireless Capabilities* n.d.).

Figure 1. Evolution of 5G

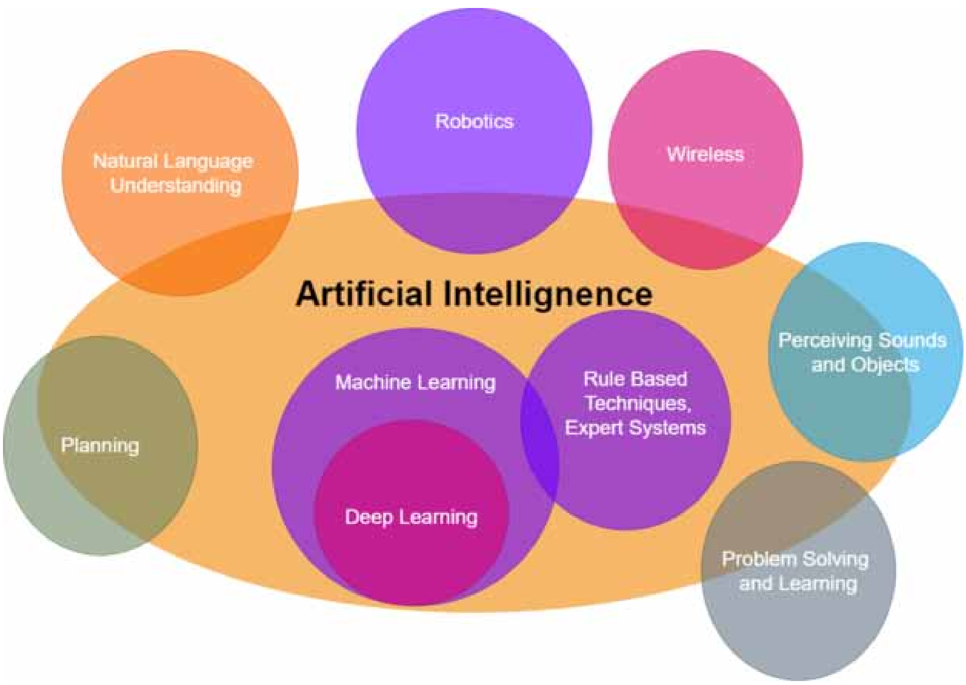


OVERVIEW OF AI AND ML

AI is a branch of science concerned with training robots to exhibit behavior of human beings in order to solve tasks that people excel at (speech, image recognition, natural language etc.). The interaction of various areas of computer science & engineering as well as applied mathematics is at the heart of AI. AI takes the position that we, as humans, have a perceptive knowledge of intelligence so that we can thus judge whether or not the machine is quite intelligent. Alan Turing, who introduced his famous "Turing test" in 1950, endorsed this practical concept of AI. The Turing test determines whether a machine is intelligent if machine can communicate like a human so that interrogators are unable to detect the difference between it and a human (Turing, 2004).

Today, Artificial Intelligence (AI) is a set of technologies which work together to enable machines to learn, then sense, then interpret, and finally act like human being. The early efforts to AI were expert system that use rule based algorithms. Figure 1 shows the AI landscape, which includes technologies that are well known like Machine-Learning (ML), Deep-Learning (DL) and Big Data. People sometimes confuse AI and machine learning since the greatest recent developments in AI have been in machine learning. The ambition to construct AI is to learn and acquire information eventually spawned the discipline of MML.

Figure 2. Relationship between machine learning, deep learning, and AI



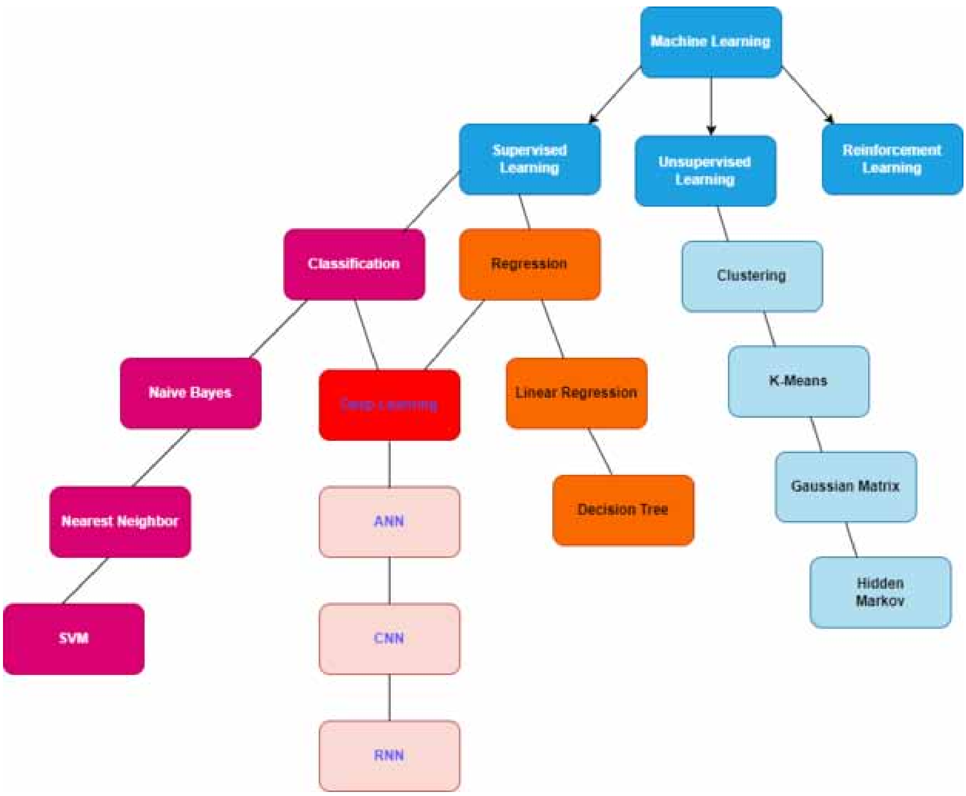
Different ML techniques are classified as follows:

Learning using a labelled training set is referred to as supervised learning. Classification and regression tasks are included in this category.

Unsupervised Learning is related to the process of training a model with unlabeled training data. It discovers patterns in unlabeled data. It works for Clustering.

Reinforcement Learning is related to the process by which we train a model on the basis of a series of various actions which leads to specific outcomes, where benefits are for performing well and penalties for performing poorly. This Learning is used in robotics as well as in games.

Figure 3. Classification of different ML approaches



ROLE OF AI AND ML IN COMMUNICATIONS

Machine Learning is a technique which is being implanted into networks, where primary focus is on reduction of capital's expenditure, optimization of network's performance and creation of revenue streams.

In future it will help to recover the investments done by CSP (communications service providers) during switching to 5G. It will lower the operational costs and ensure the return on network investment. Network intelligence and automation are very important parameters that contribute to the evolution of 5G. With the help of 5G-compatible technologies operators will help in boosting the network's capacity.

One of the major profitable integrations of ML with networking is to provide elevated performance and effective computation resources. This 5G seeks to provide ultra-low latency with high throughput for communication services (Moltzau, 2019; Ericson, 2023).

ML models use large amount of data for training. Model learns from characteristics of data. They may be like traffic, management, etc. This helps in enhancing the accuracy of analysis, and realizes the intelligent services provided by communication networks.

At the time when ML models are transmitted respectively to the network management system, sometimes the information state of resources may change. The network management knows the local information of the state. It doesn't know the system's internal state. Machine Learning can be covenant with such kind of uncertainty in reasoning and fuzzy logic.

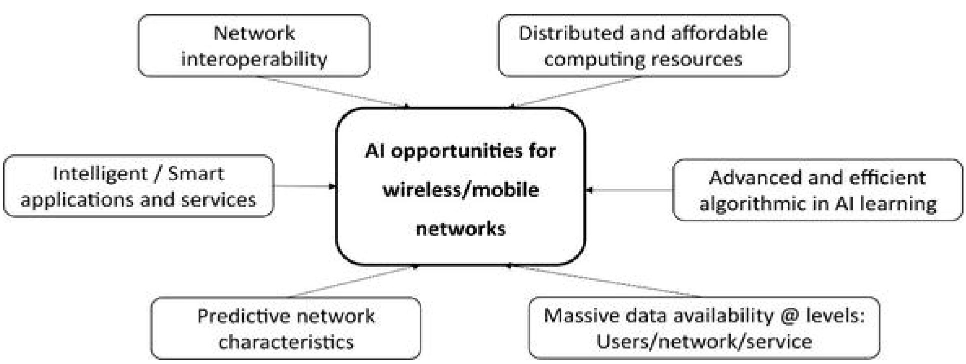
The multi-agent association with ML into the respective network will provide the ability to have association between network managers.

Such an association requires interoperability between the networks which are heterogeneous and creates the communications infrastructure (Haidine et al., 2021).

Network interoperability defines one of the numerous factors which must be satisfied by the surrounding environment, in order to utilize above-mentioned advantages of Machine Learning.

Figure describes various AI opportunities for mobile networks (Haidine et al., 2021)-

Figure 4. AI opportunities for mobile networks



MACHINE LEARNING APPROACHES IN 5G

Machine Learning approaches can be described into three categories (Ericson, 2023).

1. Supervised Machine Learning
2. Un-Supervised Machine Learning
3. Reinforce Learning

Supervised Machine Learning: It is a type of machine learning technique where machines get trained using well "labeled" training datasets, and then machines help to predict the output. The labeled or tagged data means input data (training data) is already tagged with the correct results and it is passed to machines in the training phase. In the testing phase only, input is passed to machines and machines predict the results. Finally, this result is compared with the actual result to find the accuracy of the model (Morocho-Cayamcela & Lim, 1970).

Table 1. Mapping of learning model and applications

Learning Models	Applications in 5G
Logistic Regression	With the help of Logistic Regression supervised technique, dynamic frequency as well as bandwidth can be allocated in self-organized LTE systems (Haidine et al., 2021)
Support Vector Machines (SVM)	It is one of the classification techniques which helps in prediction of Path loss in urban environments (ved kafle,2021).
Neural-Networks	It helps to infer unobservable Channel State Information (CSI) from one of the observable channels (Mao et al., 1970).
Artificial Neural Networks (ANN), and Multi-Layer Perceptrons (MLPs).	With help of ANN & MLPs, modeling of objective functions for link budget can be approximated as well as propagation loss for next-generation wireless networks can be predicted (Haidine et al., 2021) (Ericson, 2023)..
K-means clustering, Gaussian Mixture Model (GMM), and Expectation Maximization (EM).	These are probability-based clustering approaches that helps in Supportive spectrum sensing. It also helps in Relay Node Selection present in vehicle networks (Haidine et al., 2021).
Hierarchical Clustering.	Anomaly detection / Fault detection /Intrusion detection is one of important applications in various services of mobile wireless networks and HC plays an important role in it (Haidine et al., 2021).

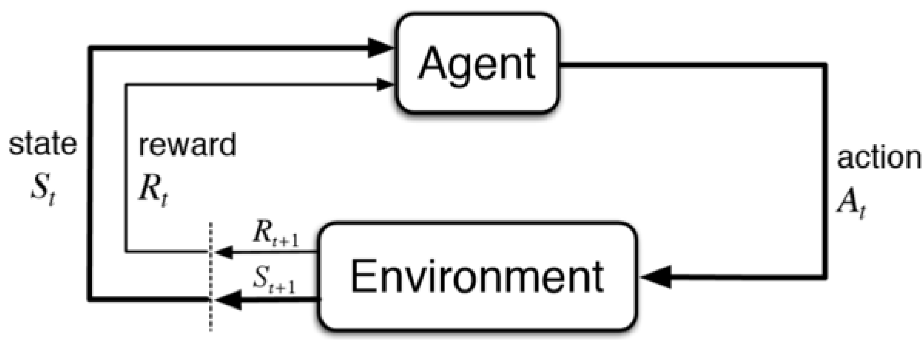
Advantage: It is a type of Software-centric security for heavily software-driven networks. It provides adaptive security management and automation.

Unsupervised Machine Learning: It is a type of machine learning mechanism where models get trained using the unlabeled dataset and models are permitted to act on unseen data without having any supervision. Here models find the concealed patterns as well as insight from the given data. Models based on unsupervised machine learning do not have a training phase; instead, they perform grouping of data and find similarities among data items and represent them in terms of clusters (Moltzau, 2019; Morocho-Cayamcela & Lim, 1970; Flores et al., 2021).

Advantage: It provides automatic grouping of data sets which are highly dynamic. Also gives association mining of various features on the basis of common traits. It consists of Real-time implementation. It helps the user to determine unusual data points (Moltzau, 2019; Turing, 2004).

Reinforcement Learning: It is a feedback-based machine learning technique, based on agents and its actions. It uses an action reward feedback loop.

Figure 5. Reinforcement learning



1. **Environment:** Surroundings where the agent operates
2. **State:** Current state of the agent
3. **Reward:** Feedback from the surroundings
4. **Policy:** Mapping of agent's state to actions
5. **Value:** Long term reward, to be received by an agent by taking an action in a particular state

Advantage: They are extremely robust and skilled agents used for decision making in a timely fashion. They are proved as efficient for mission-critical applications and delay-sensitive applications in digital infrastructure. They are very much adaptable in a diverse set of threats for tackling (Moltzau, 2019).

5G TECHNOLOGIES

5G systems are deployed to provide high throughput and ultra low latencies while communicating. This improves the user's experience quality. To fulfill these requirements new application fields are matched with three axes i.e. Requirement, desired value and application areas. This requirement can be data rate, data volume, latency minimization, high battery life, a good number of devices to be connected and high reliability.

Table 2. Major requirements for 5G

Requirement	Expected Value	Examples
Data Rate	1 to 10 GBPS	Virtual Reality Office
Data Volume	9GB/h (busy period) 500 GB/month/user	Stadium, Dense Urban, Information Society
Latency	Less than 5 MS	Traffic efficiency and safety
Battery Life	10 years	Enormous deployment of sensors & actuators
Connected Device	300,000 devices / AP	Enormous deployment of sensors (with massive IoT)
Reliability	99.999%	Traffic safety and efficiency, Tele-protection in smart grid n/w

5G technology helps in mobile broadband, machine type communications also. It helps in allowing high bandwidth required applications providing high data rates. It helps in expanding the number of wireless devices as per the requirements. It allows smart homes, IoT and delivery via drones who supports small data amounts over extended coverage areas. It also helps in providing mobility, high reliability and very low latency in healthcare, UAVs(unmanned aerial vehicles), remote surgeries, autonomous driving, smart industry application etc.

5G technologies can be explained into two levels i.e., system level and Network level. In system level system related issues are handled and network level takes care of network issues. System level takes care of Spectrum utilization, spectrum efficiency related issues, network Densification and energy efficiency. Network level deals with network architecture, NVF/SDN, Network slicing, Mobile edge

Computing, self-organizing Networks (SON), device to device communications and fog computing.

5G systems use various advanced technologies like PHY, NFV, MAC, SDN. to integrate ML and AI with 5G simultaneous connections are required with various IoT devices which will generate massive data to be processed with AI and ML. While integrating AI and ML with wireless providers following actions may happen:

1. Wireless providers can act to identify dynamic changes to forecast the distribution of users by historical data analysis
2. After forecasting peak traffic, utilization of resources and types of application, it can fine tune and optimize network parameters for capacity enhancement
3. after measuring interference and inter site distance, elimination of coverage holes can be done
4. Automation can be done using AI and ML architecture at n/w edge
5. Steering and aggregation of application-based traffic across the network which is heterogenous
6. Slicing of network to address different use cases with different QoS requirements
7. AI and ML services for end users.

INTEGRATION OF AI AND ML WITH MOBILE NETWORKS

Fame of Artificial intelligence & Machine Learning is growing day by day in various fields. Wireless communication and networks are not also untouched from it. Machine learning has impacts on various aspects like physical layer, security, radio resource management etc. Impact of ML on 5G can be categorized in two categories: General ML and Deep learning based.

In the general ML category all possible ML approaches fall and deep learning is in focus in the second category. Deep Learning is very helpful in the case of 5G as it is good in handling complexities of 5G. General ML consists of three classes: supervised, Unsupervised and Reinforcement learning. All these general ML classes provide different types of support in 5G applications. Table 3 can be used to understand the relation between learning classes, models and their application area in 5G.

Except this ML can be used in 5G for wireless communication in various other sectors like feature extraction, bigdata exploitation, unsupervised learning, multi task learning and geometric mobile data learning.

Table 3. Mapping of learning classes, models and their application area in 5G

Class	Model Technique	Application Area in 5G
Supervised Learning	ML & statistical logistic regression	Allocation of bandwidth and dynamic frequency in LTE densed cell deployments
	SVM (Support Vector Machines)	Prediction for path loss in Urban environments
	Neural Network based Approximation	Transfer of channel learning information from an observable to unobservable channel
	Supervised frameworks	TDD uplink and downlink configuration in maximizing network performance in hybrid optical Wireless n/w.
	ANN and MLPs (multi-layer perceptron)	To model and approximate objective functions for propagation loss in wireless n/w.
Unsupervised Learning	K-means clustering, GMM (Gaussian Mixture Model) and Expectation Maximization (EM)	In sensing of spectrum and Relay Node Selection Process
	Unsupervised soft Clustering ML framework	Latency reduction by clustering fog nodes. It is done using upgrading LPN (low power node) to a HPN (High Power Node) in heterogeneous cellular n/w
	Hierarchical Clustering	Detection of Anomaly, fault or intrusion detection in mobile wireless n/w
	Affinity Propagation Clustering	Used in resource management applications based on Data driven methods for Ultra Dense cells
Reinforcement Learning	RL-LSTM (RL algo on long short-term memory cells)	Used in allocation of proactive resources in LTE-U n/w to enable SBSs
	GF (gradient follower), MRE (modified Roth-Erev) and MBM (modified Bush and Mosteller)	To enable femto cells to reduce inter intra tier interference
	RL with network assisted feedback	RATs(Radio access technologies) selection

ADVANTAGES AND DISADVANTAGES OF 5G TECHNOLOGY

A lot of advantages are there for 5G technology:

- It collects all the networks on single platform.
- It is manageable, effective as well as efficient technology.
- It can also provide connection in uninterrupted manner.

This technology also suffers from disadvantages like:

- It is very difficult to achieve its claimed speed.
- It needs high cost from infrastructure point of view.

- Some old devices are not compatible with 5G technology.
- Security and privacy issue are yet to be solved.

CONCLUSION

It was experienced that 4G networks are to be improved with more capacities. So, network operators proposed real time broadband mobile Internet up to capacity of 600 Mbps. This requirement asked for high demand for quality of service. Very high requirements of capacities, reliabilities and speed have been evolved due to VR (virtual reality) and AR (augmented reality). Such a requirement of reliabilities and capabilities with extreme low latency pushed network operators to move into 5G, which increased day by day so finally operators decided to increase intelligence in the network to make it concise about the environment. This involvement of intelligence tuned up into evolution of forecasting, optimization, adaption and automatic configuration of networks to variety of services.

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Chapter 10
Utilizing Artificial Intelligence Techniques to Improve the Performance of Wireless Nodes

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ABSTRACT

Advances in wireless systems have encouraged the growth and improvement of tiny, low-cost, efficient, and multi-tasking smart sensors. Wireless sensor networks are employed for sensing, collecting data and information, analysing it, and sending it to the main center to be considered quickly. During the performance, a wide range of issues appear, and the existence of some restrictions on the movement of sensors, reliable data collection mechanisms and transferring them properly and securely to the main center, and issues in the sensor network topology. In fact, all traditional

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methods need more ability to deal with and solve these situations. In this regard, the authors decided to highlight the importance and role of artificial intelligence technologies in designing wireless sensor networks by proposing a hybrid model that helps to construct a more practical sensor network and solve all the situations it faces. These techniques significantly improve network performance, extend battery life, develop smart nodes, and improve network functionality.

INTRODUCTION

Artificial intelligence techniques are characterized by the growth of approaches that simulate the intellectual and interactive capabilities of the human brain in facing challenges (Aggarwal et al., 2022; Paul et al., 2021). Artificial intelligence is significantly concentrating on one dream is the human mind (Peprah et al., 2020; Jarrahi,2018; Wireko et al., 2021; Shukur, et al., 2023). These techniques depend on their job on the concept of multi-agent systems. This system consists of intelligent systems called agents that can be executed as a software program, as an active computer, or as a robotic machine. The agents in the system interact with each other to systematize a proper situation for them and exchange knowledge and information safely and soundly. Smart sensor networks are distributed in a way that can be noticed from a multi-factor perspective that contains sensor nodes that work collectively in an organized manner (Gou, et al., 2020; Khan et al., 2022; Dhillon and Kalra, 2018). Its primary function is to gather data from the environment in which it lives. In other words, wireless sensor networks are multi-agent systems as well as artificial communities with an intelligent ability to absorb data of any size and transmit it to the main center or receive it from the same center as it works through sensor nodes (Shin and Lee, 2020; Ramesh et al., 2021).

Artificial intelligence techniques execute mechanisms within the borrowing device to enable it to interact with the systems that collect data from it, as a group of agents is designed and devised and interacts between them in a stable and updated manner (Mijwil et al., 2022; Osamy et al.,2022; Vanitha et al., 2022; Sharma et al., 2021; Priyanka et al., 2021; Majid et al., 2022). Through artificial intelligence techniques, algorithms can be utilized and executed to enhance the role of the wireless sensor network and enable it to work in an intelligent and autonomous manner at the same time. Moreover, these networks must be distributed in an effective way to achieve the critical goals of the environments in which they live because the data collection process requires borrowing devices that are distributed in an organized manner and work individually, with the presence of artificial intelligence techniques that contribute particularly to data transfer (Chandnani and Khairnar, 2022; Srinivasulu et al.,2022).

A sensor network (SN) is a procedure consisting of tiny devices called sensor nodes whose primary function is to monitor a specific environment and record all cases and conditions that occur (for instance, temperature, wind direction, humidity, chemical concentrations, the spread of viruses and pollutants, and many others) in different locations and send them immediately to the concerned centers. Moreover, they are fundamental devices in that their components are tiny, have excellent processing capabilities, and work as a group in collecting and transmitting data.

All sensors are generally equipped with a radio transmitter and receiver, a controller, and a power source (battery). These devices rely on smart algorithms to help them complete the tasks required of them. In addition, it must be ensured that the sensor network is subject to more stringent energy restrictions than computers and smartphones. The current development in electronic devices has made wireless sensors the ideal and best solution in monitoring, tracking or controlling, for example, tracking fires, controlling nuclear reactors, following up the spread of viruses such as COVID-19, where infected people are monitored through smartphones and know their health status, vehicle traffic monitoring and many more (Mijwil, 2021; Masud et al., 2021; Fagbola et al. 2022; Mijwil et al., 2022). The main purpose of this article is to see the role of artificial intelligence techniques in wireless sensor networks and how to make a high-level sensor network that acts intelligently as a multi-factor system and according to the environments in which it lives.

Artificial Intelligence in SN

Artificial intelligence techniques seek to simulate the mental and intellectual capabilities of humans inside computers through the use of a set of algorithms that have the ability to carry out a bunch of operations that are challenging for humans to execute (Mijwil et al., 2022; Song et al., 2022; Šumak et al., 2021). The modern strategy for artificial intelligence techniques revolves around the concept of an agent that can perceive its surroundings through sensors devices and collect the required data from that environment through actuators. In addition, this agent seeks to improve and update the performance scale of sensors, with measuring the performance of human factors, automated factors, and software applications. From this viewpoint, artificial intelligence techniques can be considered as a mechanism for designing artificial factors that contribute to improving agent performance. Agents work and interact with other agents in a variety of ways, including web programs, football-playing robots, e-commerce negotiating agents, social media agents, machine vision agents, computer vision agents, and considerably more. This type is called multi-agent systems, which consists of a group of factors that interact with each other. Also, it is anointed Distributed AI, which is the subfield of artificial intelligence that deals with the principles and design of multi-agent systems.

Sensors based on artificial intelligence are characterized by the ability to modify their internal behavior to improve their practical ability to collect data from the physical environment and deliver it in a rapid manner to the main centers. The function of these devices includes self-standards at work, self-verification in collecting data, and compensation or work in place of other devices in the event of their stop working. The smart sensors contain self-standards in monitoring the conditions within the physical environment and monitoring the measurement status to determine and know the type of measurement required to be carried out within the same environment. Self-verification is valuable in determining mistakes in mathematical operations or programming, isolating these mistakes, and sending the type of mistake present within this sensor. In the same devices, compensation is employed to make the available devices work instead of the blocked devices, even by a small percentage in data collection. The most critical techniques of artificial intelligence employed are machine learning, which is used in data classification, artificial neural networks and fuzzy logic, as they play a significant role in building smart sensor structures. The most critical issues faced by sensors are:

- Coverage (the extent of the network).
- The lifetime of the network (the battery).
- The accuracy of data collection from the physical environment.

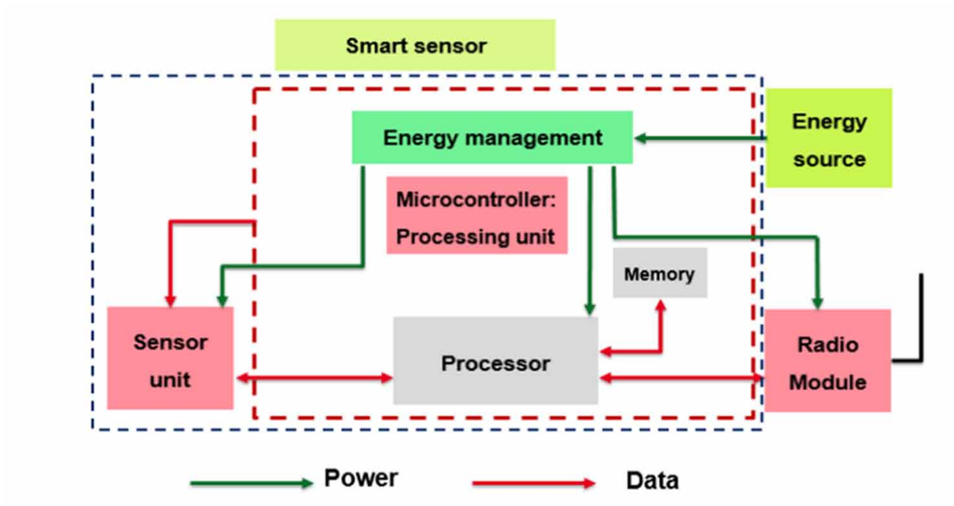
Artificial intelligence techniques are of fundamental significance in solving all the limitations that wireless sensors face by equipping them with updated and new algorithms and applications that develop over time and benefit them in many things. It should be taken into consideration that resource management is a significant and necessary component of a middleware solution within sensors, as tasks to be performed include runtime and allocated resources (bandwidth and network lifetime). It is mainly preferred to use reinforcement learning in controlling resources within the wireless network, with the addition of smart networks and collaborative systems to improve the quality of work of smart sensors. In addition, machine learning methods have an effective role in preserving the network from hacking and data theft, as it contributes to maintaining workflow, classifying data according to its categories, and not allowing unauthorized persons to enter wireless network management systems, whether fixed or mobile (Mijwil et al., 2022; Loukas et al., 2017).

SN System Architecture

Smart sensors are miniature computers that are very simple in terms of their components, interfaces, systems, and applications (Sofi et al., 2022; Akhtar et al., 2021; Sinha and Dhanalakshmi, 2022). These devices have a small capacity, but they contain a large processing capacity when performing within a group of sensors in the same environment. In fact, the sensors are variable in size, as they could be a dust cloud or the size of a shoebox. In addition, there are devices connected to each other, where they work to pass data among themselves through a specific protocol, and then it is delivered to the main center. The distinction of these devices is that they can be installed in a required location, even in the most difficult places (for instance, volcanoes), and in all seasons, they work continuously without stopping. Smart sensors have a flexible structure so that if other nodes within the same environment stop, a network continues to generate obtained information and send data to the main center continuously as long as there is energy. Moreover, the sensor nodes have sufficient components to transmit data over the radio signals array. The main weaknesses of these devices are the limited power and communication resources. Therefore, using a large group of sensors within a large environment is preferable. So, thanks to artificial intelligence techniques that seek to create more innovative sensors and save energy used.

The smart sensor node used in wireless sensor networks is a node with computing capabilities that seeks to collect data perceptually and communicate with other nodes within the same environment. It contains a microcontroller, transceiver, power supply, external memory, and one or more sensors (see Figure 1). It is recommended to add an extra battery to the diagram below. With the addition of this battery, it will be intended to take preventive measures against the possible depletion and deterioration of the current energy source during the flow of vital data and reduce the risk factor. The effect is that the load generated by processing codes will be reduced and the life of the sensors will be extended. In addition, the microcontroller processes all incoming data and controls the functions of other components in these devices. Also, the transmitter and receiver use the industrial, scientific, and medical radio band (ISM radio band) at work to ensure that data is transmitted between the sensors and the main center (Yang et al., 2022). By this practice, free broadband radio broadcasts and global availability are ensured. More energy is required for data communications at the sensor node, but the energy consumption for sensing and data processing is less. For instance, the energy needed to transmit one kilobyte of data over a distance of 200 meters is equivalent to the energy needed to process 3 million instructions on a processor processing 200 million instructions per second. AI sensors are devices that can build measurable responses to physical adaptions such as temperature and geographical. These sensors estimate or notice the physical data of the zone to be monitored.

Figure 1. SN architecture
Source: Bouguera et al. (2018)



New Model Proposal

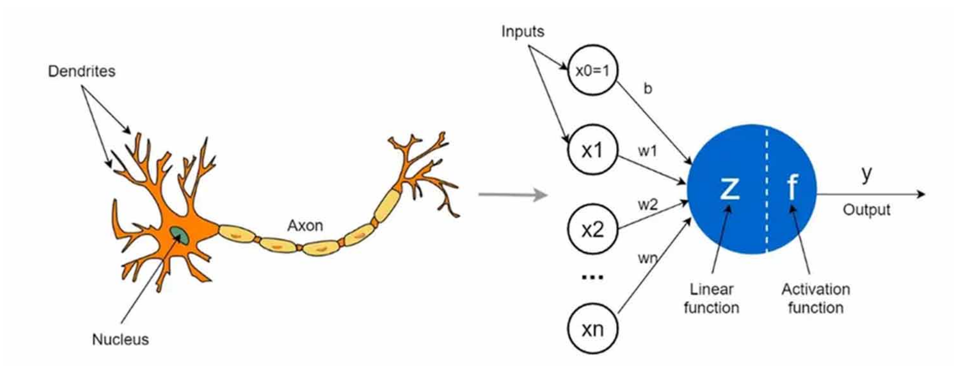
In this section, new models will be proposed to develop the work of sensor nodes and differences in execution. The current models need higher efficiency in implementation, as these models will be mixed with artificial intelligence techniques. The proposed models have the ability to extend the life of the sensor nodes by addressing matters such as data security (saving the data correctly), real-time data, similar data, and data extraction are unnecessary and not practical because this data aims to consume the battery and may lead to the sensor stops working. Artificial intelligence techniques work on inventing a hybrid model for sensor nodes with agents that simulate the distribution of software agents on it. It is preferable to use agent-based models to evaluate various approaches during work because data requires time to be collected and sent to the main center. Agents can communicate in an application to control network resources and enable support through artificial intelligence techniques. Consequently, there must be protocols that contribute to the process of communication between agents. It must be recognized that the current models can be used in the development of the proposed models and can only be dispensed with once the wireless sensor network becomes more practical and can be implemented sufficiently. The operation of the proposed models depends on the state of the platform in the physical environment, the measurement devices, and a model that connects the node to the real world through the radio channel, one physical channel, and more, depending on the location in which it will be located. Besides, battery models must be responsible for verifying the nodes' energy consumption by calculating the battery consumption and completing alerts to the main center of the operating status of this node.

The proposed hybrid model is multi-agent to simulate the deployment of software agents in a wireless sensor network and seeks to operate mobile agents to control network resources and facilitate the transfer of information to the main center. These models illustrate the node platform and its characteristics in terms of uptime, energy consumption, radio channel, physical media, and memory capacity. Moreover, variables must be added in the structure and physical variables that simulate the smart sensors as if they were in a natural environment. Also, use software agents to perform all the required assignments in collecting and removing unneeded data. As for the suggested system, it consists of detection nodes, where these nodes consist of smart borrowing nodes located within a physical environment to carry out tasks such as perception, understanding, doing business, and communication between nodes. In fact, a single node cannot employ all the sensors, so it is preferable to have multiple sensor nodes. Therefore, when applying artificial intelligence techniques to sensor nodes, the physical conditions of the environment in which they are installed are taken into account in order to function properly. Whatever artificial intelligence technique is needed in any environment, moderated or unmoderated technology is employed depending on the data to be collected. For instance, a sensor that is about to run out of power will connect to the nearest node in the environment in which it is located, and it will be ensured that it quickly transmits important data by itself without analyzing it. In situations such as danger (emergency), urgency, and safety (security), artificial intelligence technique is automatically designated according to the significance and priority of the data. The speed of decision-making and information delivery to the main center characterizes these techniques. One of the most well-known of these techniques is the artificial neural network (ANN) (Xu et al.,2021; Faieq and Mijwil, 2022).

ANN in New Model

This section will address the essence of artificial neural networks in the proposed hybrid model. Artificial neural networks are designed employing chains of decision units through their learning algorithm to distinguish nonlinear and complex functions and find practical solutions. It works in a similar way to the human brain, and its structure is characterized by processing information and distributing it in parallel, as it assists the computer in learning, knowing the type of issue and finding solutions. It is considered one of the most influential techniques of artificial intelligence. It has great importance in many areas because it follows the method of learning by samples instead of programming. Therefore, this technique is perfect and does not have the negatives that other technologies possess. The use of an artificial neural network is not accessible due to its high computational requirements for learning network weights. Fortunately, there are central solutions in which the artificial neural network can learn multiple parameters for output and decision making at the same time. Moreover, its architecture provides a simultaneous solution to many issues faced by the wireless sensor network. This technique can analyze the data received through the sensor nodes, as it has the ability to deal with data, whether it is from a linear environment or not, and it can deal with complex issues, as this procedure assists the sensors to do more work in collecting data and saving energy. The artificial neural network is characterized by having artificial neurons connected to each other in a consistent way, where the network is arranged in the form of layers (input, hidden, and output layer) with a complex and non-linear processor to collect information after the learning period and store it with the weights of connecting cells and generalizing the effects obtained. Figure 2 illustrates the layers of the artificial neural network.

Figure 2. Artificial neural network layers and simple neuron
Source: Pramoditha (2021)



The artificial neural network approach in the investigation follows the active convergent path of the nodes, as this path is characterized by reducing the energy consumed and the lack of delay in the exchange of data. This approach assists in facilitating the work of the proposed model by providing a computational tool to solve the issue of optimizing the performance of the sensors. In addition, it enables the process of making a high-speed routing algorithm in execution to converge nodes with each other and gain a very high response rate. In general, sensors have little memory and low processing capacity to use. Therefore, the proposed model requires a large amount of training groups and can only be applied in the presence of high resources and a proper environment. An artificial neural network consists of hundreds or thousands of nodes, and it works in a logical manner in executing procedures within the work environment. The data collected is extensive in size and leads to minimal energy consumption. In the proposed model, a wireless sensor network is formed from several sensors integrated into the same sensor so that each node becomes a data source. The raw data cannot be sent to neighboring nodes or the main center after a specific time to complete this process. To implement this, an agent must be formed, where each node transmits data to this agent, which in turn collects data and sends it to the main center. Therefore, the data collection and classification process are one of the essential steps in the proposed model. The data collection process seeks to eliminate duplication or unnecessary data and reduce the obligation on sensor performance. In short, artificial neural networks are characterized by small units called neurons (see Figure 2) within different layers through which simple mathematical calculations are performed to meet the requirements of sensors by providing parallel computing, storing and distributing data between these devices, and reducing communication and memory costs.

CONCLUSION

In this article, a hybrid model is prepared to solve the current issues of sensor nodes employing artificial intelligence techniques. These techniques have been confirmed to have incredible practices, more efficiency, guaranteeing data integrity, and a significant improvement in reducing energy consumption. The proposed model supports to grow and improve the performance of the wireless sensor network by proposing a new design for smart sensors and relying on artificial intelligence techniques to provide a mechanism that addresses all obstacles and can organize itself while working in parallel with neighboring nodes. Likewise, this model seeks to eliminate redundant and unnecessary data and send accurate raw data to the main center. Machine learning will provide complete data security and prevent unauthorized persons from entering and manipulating data. In order to facilitate the integration of artificial intelligence techniques into the wireless sensor network, it is preferable to use supervised and unsupervised learning to create an architecture that contains layers that operate in an orderly manner. Provide the essential protocols and tools to face challenges and obstacles, as this model can be configured according to environmental conditions and transmit data in real time. Eventually, the proposed model is characterized by the fact that it contains a mechanism that increases the work of sensor nodes for a period of at least 2 to 3 years, collects the required data and sends it to the main center while providing a mechanism for managing energy consumption. In the future, more studies will be conducted on applying this model to large virtual environments and comparing the performance of artificial intelligence techniques.

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Chapter 11
Campus Information Dissemination System Using Short Message Service Technology

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ABSTRACT

One of the main causes of learners getting poor grades is a communication problem between the instructors and students. There are times when students miss tests and proposal due dates, which results in poor grades. Short messaging service (SMS) is an efficient way to remind and disseminate information among students within and outside the school campus. The aim of having no verbal communication between students and teachers would be helped by this feature. When a student is registered in the departmental information dissimilation portal, their mobile phone will be updated with any academic related information at any point in time. We employed web technology to achieve this goal, which enables each registered student to have access to updated information from the department within and outside the institution campus. The proposed system achieved an efficiency through the various menu implemented on the system by reducing the stress and printing cost of notifying the student.

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INTRODUCTION

Technologies advances have made world wide area information sharing in common place (Yovanof & Hazapis, 2009). User gain easy access to information, but at the same time, they are faced with an information overload. It is difficult to stay informed without shifting through huge amount of incoming information. A mechanism, called information dissemination, helps user cope with the problem. Information dissemination system to describe system that deliver individual copies of the same data from one source computer or a cluster of computer to client computer (subscriber's) via the internet (Gundu et al., 2022). Although we concentrate on developing method for efficient delivery of data from one source to multiple receivers, our results can be applied in cases where more than one group member can be transmission sources (Abbasi et al., 2021). For example, a straight forward extension to multiple sources is to contract a dissemination system for each sources separately, and then use a combination of these system, assigning each sources to the corresponding dissemination system. The typical application that use group communication can impose different, and sometimes connecting, requesting on the information dissemination system (Hacker et al., 2020). Devising method for designing efficient and reliable content disseminating system that can satisfy these requirements is crucial for the development of the future generation for internet communication. The requirement typically presented to the content dissemination system may demand to keep system performance above a fixed threshold, or may require the system to achieve best possible performance. Further, the requirement may impose constraints on reliability and other aspect of system behavior

Information retrieval (IR) is the activity of obtaining information resource relevant to an information need from a collection of information resources (Jakutienė & Civilkienė, 2021). Searched can be based on metadata or on full-text (or other content based) indexing. Information retrieval (IR) is also concerned with the structure, analysis, organization, storage, searching and dissemination of information. An IR system is designed to make a given stored collection of information items available to a user population (Brik & Touahria, 2020). At one time that information consisted of stored bibliographic items, such as online catalogs of books in a library or abstract of scientific articles. However, in today's world, the information is more likely to be full-length document either stored in a single location, such as newspaper archives, or available in a widely distributed form, such as the World Wide Web (WWW).

Automated information retrieval systems are used to reduce what has been called "information overload". Many universities and public libraries use IR system to provide access to books, journals and other documents (Mooketsi, 2020). Web search engine are the most visible IR applications. An information retrieval process begins when a user enters a query into the system. Queries are formal statement of information needs, for example search strings in web search engines. In information retrieval a query does not uniquely identify an object in the collection. Instead, several objects may match the query, perhaps with different degrees of relevancy. In an information dissemination, a user submits a long-term profile consisting of a number of standing queries to represent his information needs. The system then continuously collect new document for underlying information sources, filters them against the user profile and delivers relevant information to him.

Communication is crucial since without communication messages or information could not be delivered. With the birth of information technology and telecommunication media rapidly expanding from time to time. What started as "fixed" information technology has expanded itself becoming mobile thus enhancing the dissemination of information directly and more instantly (Asharf et al., 2020). Existing development in mobile and wireless technology has greatly assisted in establishing the business and service management sector (Ibrahim et al., 2020). The education sector is also not left behind whereby the use of mobile technology is not merely an extension of online learning process that relies on networking but it can also activate the dissemination of information on teaching and learning to happen anytime, anywhere and anyhow. The use of mobile technology in education is also known as "m-education or mobile-education". The use of mobile technology began with the use of SMS (short messaging system) and until now many thing rely on this technology (Hilty et al., 2020). This statement is further established by the total number of studies conducted on the use of SMS especially in the dissemination of information as one of the tools in mobile learning involving education.

Notification refers to the action of informing the user of something. An information dissemination system will therefore facilitate the process of informing the user that an event has occurred. In the deliverable, a distinction will be made between the system that processes and delivers the information to the user and the event of which a notification was sent. This system is a software component that will enable the Head of Department or Admin to send notification to the students. These system remain however unaware of the type of event that the notification is sent for. An event can be for example, the availability of a new data collection task or the arrival of a new message.

This study makes notification convenient and reduces stress in the sense that notification is delivered to the student at that time it being announced because student carry phone with them wherever they go instead of queuing up at the notice board. And this study makes information to be effective and accurate to the student in a way that student receive up-to-date information even when the information changes.

BACKGROUND

Information Dissemination

Diffusion of knowledge has long been an essential social function, but it has taken on new significance in today's information-driven cultures. Commercial communication infrastructures have been established during the last 30 years primarily to transport various information (Bharany et al., 2021; Kaur et al., 2022). Human cultures, mainly those reliant on computer and communications networks, disseminate knowledge in various ways. There are a wide variety of categories, including academic, educational, healthcare, gossip, financial, and military information, as well as vital information (e.g., confidential, noise-sensitive, and public) (e.g. beneficial, harmful, and indifferent).

Recent networking infrastructure and service advancements have been spurred in part to handle the rising trends of increasing quantities and service needs of disseminated information in combination with the diversity of information kinds, as mentioned above. When it comes to how human beings receive a piece of information, it may be divided into three distinct categories: helpful, malevolent, or indifferent. In the following sections, each category is examined in further detail (Bharany, Kaur, Badotra et al, 2022; Bharany, Sharma, Bhatia et al, 2022; Bharany, Sharma, Khalaf et al, 2022).

End consumers anticipate a wide range of data types to be included in helpful information, all of which are expected to be immediately or later applicable. All of the above may be included in a single piece of information. People are eager to receive and save such material, such as e-books and health examinations, for future reference. As a result, when it comes to relevant information, a user goes from not having it to having received and stored it, all in the space of a single state transition.

In contrast, dangerous information, most notably malware, may be delivered to individuals over the Internet. User acceptance and usage of this sort of information is generally discouraged. E-mail viruses are an example of dangerous material disguised as beneficial or neutral information to gain some users' trust. There are several novel ways in which harmful information is conveyed, such as employing hybrid diffusion methods and alternating transmission channels to propagate their dangers and developing new well-hidden strategies for enticing their victims. Because of this, harmful material has a repeated pattern of activity, as stated in the previous chapter's SIS diffusion model. Users can remove malware that is presently spreading at some point. However, depending on their level of familiarity, they may become vulnerable to the same or different malware that may spread in the network later. End users who are harmed as a result bear the financial and time burden (Bharany, Kaur, Badotra et al, 2022; Bharany, Sharma, Khalaf et al, 2022; Shuaib et al., 2022).

It is important to note that the term "indifferent information" refers to a wide range of information that the user does not want to follow but which is also not considered detrimental to him or her by the user. Spam emails (usually unwelcome adverts, etc.), pop-up advertisements on various websites, pamphlets in general, and other emails designed for broad promotional goals are typical examples of indifferent information. Relevant communications are frequently repeated to achieve their aim; the user usually discards such information, yet relevant messages are recurring. However, most of the time, the user has little choice but to deal with recurrences of inconsequential information that annoy him or her. Phishing email messages and promotional/discount pop-ups on numerous electronic retail websites are two instances of characteristics. It is important to remember that while malevolent and neutral information is fundamentally different, their dissemination is often the same or quite similar. As a result, we will use the same SMS methodology to disseminate campus information later in this paper.

LITERATURE REVIEW

A study on the use of asynchronous online platform was conducted by Salleh (2006), it was found that students want to be updated and like to update others on not just academic but non-academic matters often, if not every day. In this instance, most students have become more interested to receive information through short message service.

Permana et al. (2020) developed a tracer study information system based on sms gateway to support career development in cibiru campus. The study provides information directly to graduates quickly and sustainably in accordance with the needs of graduates. Rapid Application Development as an information system design method was used to implement the system. This system was built by using the HTML Programming Language, PHP, and Bootstrap as a CSS framework to send an information related job vacancies in accordance with the scientific fields of UPI Kampus Cibiru alumni.

Koshy et al. (2017) worked on IoT based information dissemination system in the field of education. Beacon technology which allows mobile applications to listen for signals from beacons in the physical world and react accordingly was used. The study aimed to bridge the barriers of communication in the student-teacher relationship.

Noguchi et al. (2015) employs an Android application in combination with Beacons to manage the attendance of a class. It illustrates how Beacons can be used within a classroom to emit signals through which students can mark their attendance. Similarly, this paper aims at using Beacons in a classroom setting. The Bluetooth

Low Energy (BLE) signals emitted are detected by the user's Android application and triggers a Content-Management notification.

Thobias and Kiwanuka (2018) developed m-health information dissemination in rural environments to remind mothers to attend antenatal care through the use of mobile technology. The study was conducted in a low resource setting, mobile network coverage was good and thus SMS technology could be used. Research should be conducted on how to disseminate similar information in remote areas without mobile coverage.

Setiaji and Paputungan (2018) employs telegram bots for campus information dissemination. The study used webhooks method for the communication which was able to provide zero latency and handle requests concurrently during communication within the Telegram bot. The Telegram bot prototype shows that even though Webhooks is able to provide information as requested, Webhooks setting is difficult and trickier.

MATERIAL AND METHODS

This study used various method web technologies to design the dissimilation software in which JavaScript is considered for both the frontend and backend. This is used because of the flexibility and mobile facilities provided with the stunning graphic user interface (GUI). It is good because it's secure and object oriented in nature. It can run any multimedia phone with a little amount of energy. It is also very easy to amend for any programmer for future and it is self- documented. Laravel PHP is also used for backend while frontend will be carry out using Web Technology with the following scripts and programming language such as HTML, CSS, JavaScript. SMS API to link the system to SMS technology. Figure 1 shows the data flow diagram of the proposed system.

Login: This place is where admiration will supply the username and password to gain access to the server.

Post Information: This module gives administration access to dissemination information to the user's mobile phone.

View Post Information: All the information posted can be found in the module.

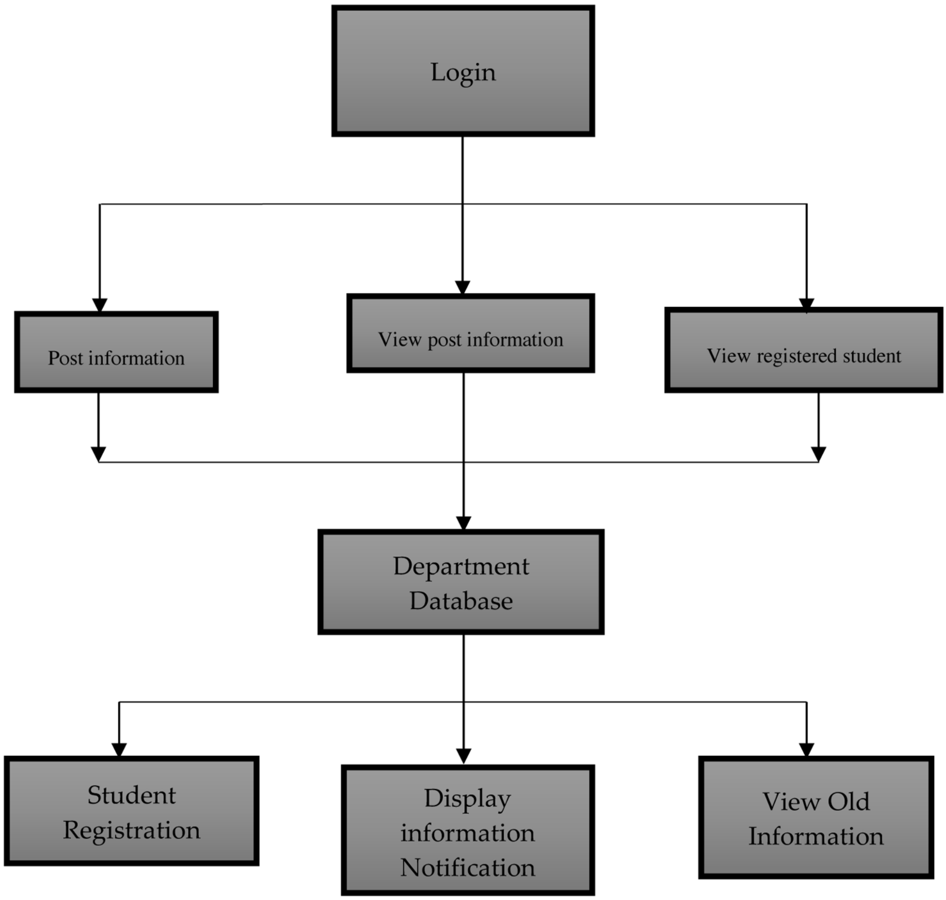
View Register Student: This is where the administration can see the entire registered student.

Student Registration: This module will be found in mobile platform where student entire their information.

Display Information Notification: This is where the recent information posted by the administration will be displayed to the users.

View Old Information: This is where the old information will be displayed to the user.

Figure 1. Data flow diagram of the new system



RESULTS AND DISCUSSION

The study developed a program that will enable users of phone to receive department notification anywhere and anytime and as well provide a way of delivering such information to user that does not use multimedia phone through Short Message Service. The software comprise of two part (1) Administration End (Server) by HTML, CSS and JavaScript (2) Website developed by JavaScript and Laravel PHP with MySql database. Figure 2 displays the administrator login interface by supplying the necessary details. Figure 3 displays the interface where the administrator can send vital information directly to individual student mobile phone.

Table 1. Algorithms

Algorithm 1.1: Algorithm for Home
1. Input operation
2. If operation is post information then
2.1 load post information page
3. If operation view posted information then
3.1 load view posted information page
4. If information is view registered student then
4.1 load registered student page
5. Stop
Algorithm 1.2: Algorithm for posting information
1. Input content of information
2. If any field is empty then
2.1 Display message al field are required
3. Else
3.1 Open database file
3.2 Insert information to the database
3.3 Send information to the student mobile device
3.4 Display message information sent successfully
3.5 Close database file
4. Stop
Algorithm 1.3: Algorithm to view posted information
1. Open database file
2. Display all the posted information
3. Close database file
4. Stop
Algorithm 1.4: Algorithm for student registration
1. Input your detail
2. If any field is empty then
2.1 Display message all field are required
3. Else
3.1 Open database file
3.2 Insert record to the database
3.3 Display message registration successful
3.4 Close database file
4. Stop

SYSTEM EVALUATION

The system is sub-divided into two. Firstly the web application that will be hosted on the server, thereafter; the administrator will type the URL of the server, login into the server then post available information to the learner, user can receive SMS notification posted on the mobile phone, students/user can receive information as text message so as to be aware of various activities and events such as lecture time, change of lecture time, meeting with the Head of Department, meeting with the Dean of college, seminar presentation among others.

Figure 2. Admin login interface

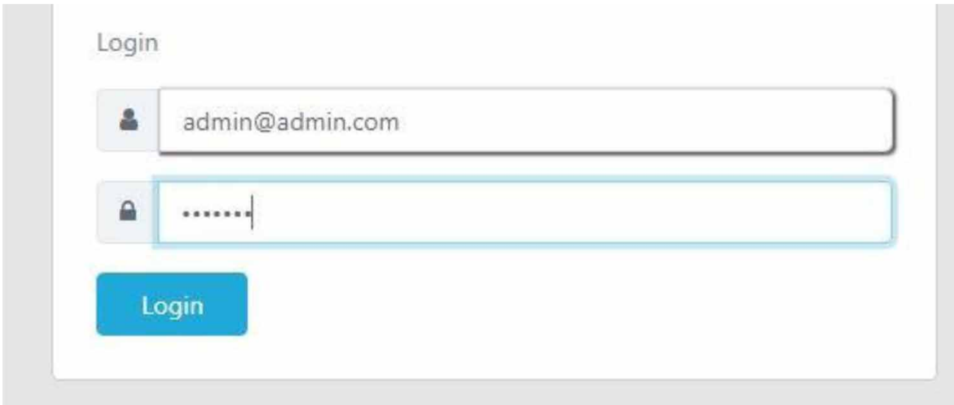


Figure 3. Message posting information page

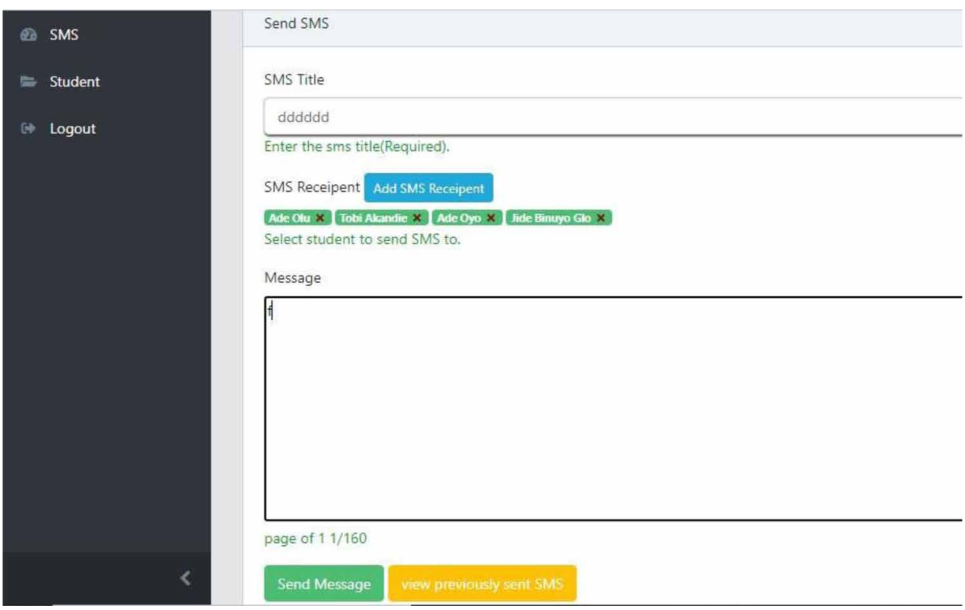


Figure 4. Student database information page

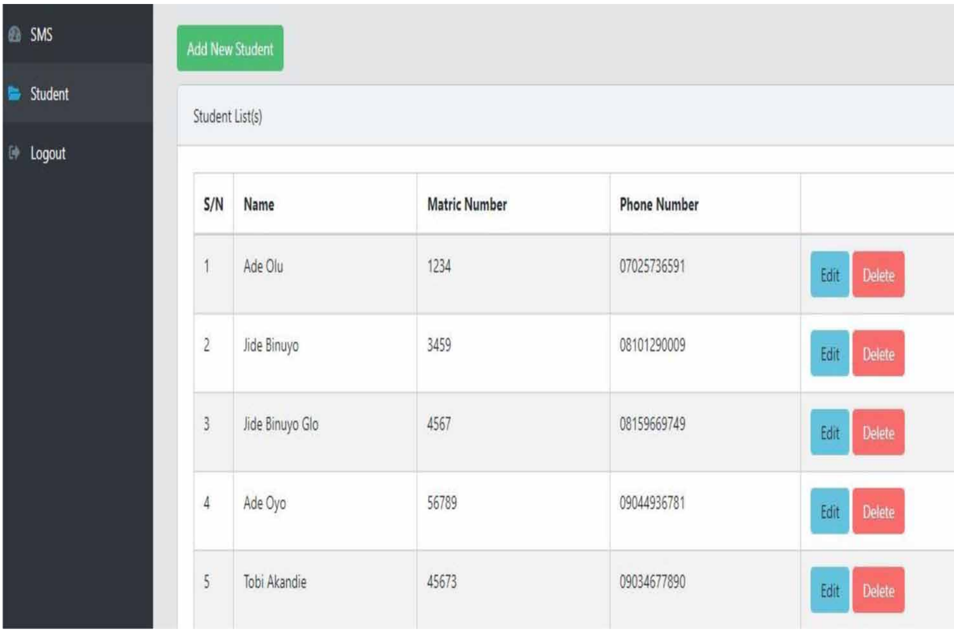


Figure 5. Adding student's information page

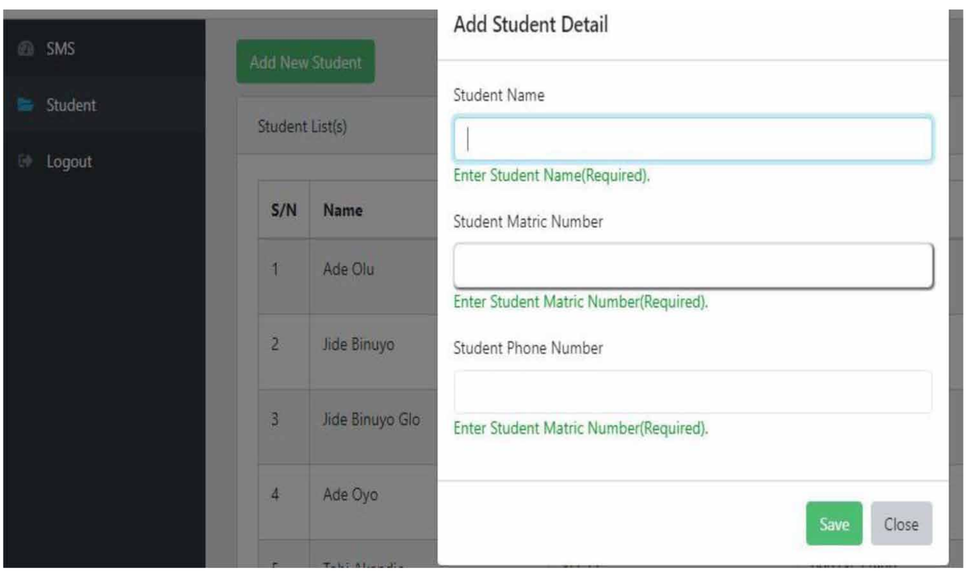
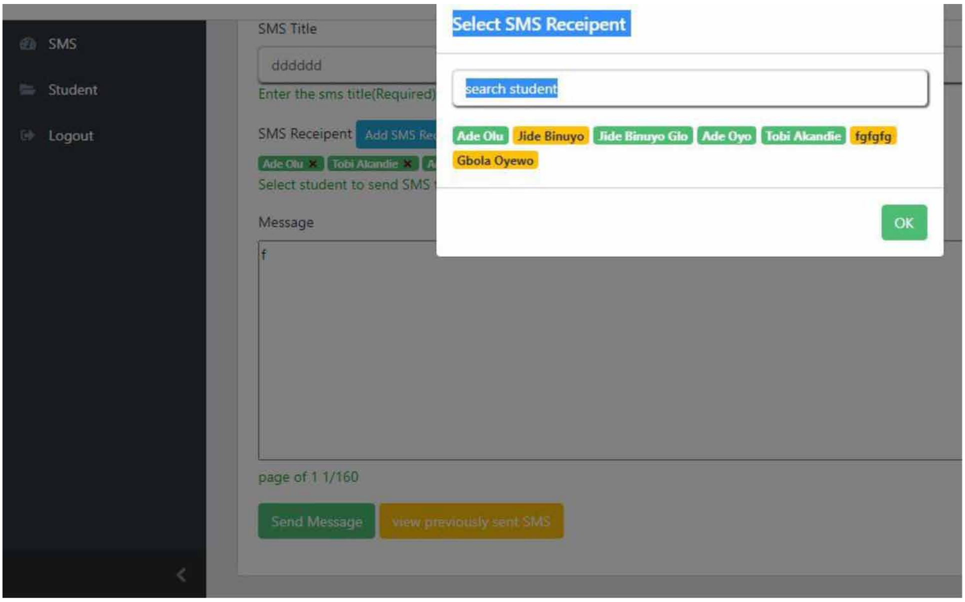


Figure 6. Interface to select recipient of the information



CONCLUSION

Information Dissemination System portal using short message service was develop to solve some of the problem that may be encountered in the school activities while using manual methods of posting information on notice board. The system allows the Head of Department (HOD) or Administration of the software to send notification to students, user without multimedia phone can register online so as to receive SMS notification of any information posted. The proposed system is able to reduce the paper method of notification and cost of printing paper all the time when there is available information. This proposed system makes notification convenient and reduces stress. It also makes information to be effective and accurate to the student in a way that student receive up-to-date information even when the information changes.

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Chapter 12
Artificial Intelligence and Wireless Communication Systems in the Health Industry

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ABSTRACT

Artificial intelligence (AI) is not very prevalent in the healthcare sector. It will promote and enhance automation in various aspects of patient care by promoting diagnosis of disease at a subclinical stage which can be otherwise missed by human clinicians. There is a rapidly increasing interest in machine learning (ML) applications in medical care. Precision medicine, neural networks, and deep learning methods of ML have gained importance in the healthcare domain. Based upon the patient attributes, the prediction about the prognosis of disease is possible through precision medicine approach of ML. Likewise, neural networks and deep learning methods are sufficiently capable of predicting the outcomes of the patient disease, which is otherwise less predictable due to the lack of prediction models in the clinical practice. WSN, IoT, IoMT have gained popularity among all the stakeholders in the hospital settings. Monitoring of the patients has become more viable with an application of wireless communication, which is more cost effective and energy saving for the patients.

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1. INTRODUCTION

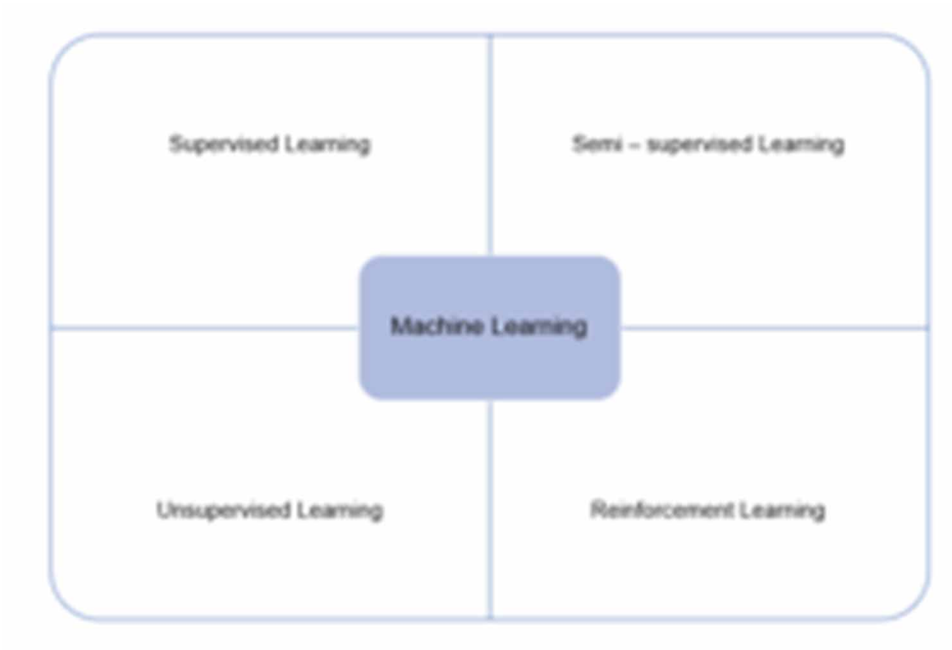
Artificial Intelligence (AI) is the ability of the intelligent computer programming to adopt machine algorithms based on human intelligent processes of cognition, meta-cognition, learning and auto-correction, for the decision making related to diagnosis and prediction of outcomes of various bodily system diseases. The modernization of the clinical development process has been outlined by the integration of AI and machine learning (ML) based algorithms and digital methods (Ahmed et al.,2020). It can be quite useful and popular in the health care industry due to rapid rise in data complexity and it has been noticed in published literature that the demand of inclusion of AI has increased at many instances. The use of AI- & ML- have been explored in the following major areas –

1. Drug discovery using machine-based learning.
2. Diagnosis at sub-clinical stage and monitoring of progression of disease; preparation of algorithms for computational expansion of prevailing datasets (clinical and imaging).
3. Detection of new prediction model using Deep learning methods.

Wireless sensor networks (WSN) have gained an importance as a major connector of all key stakeholders of the hospital. Internet of Things (IoT) has become popularized among healthcare sector due to its cost effectiveness and characteristics of autonomous sensor operations methods to monitor vitals such as blood pressure, temperature, heart rate etc. and to take an emergency action when required (Nogueira, 2019). Wireless Body Area Network (WBAN), through low powered biosensor modes monitor the health status of patients, thereby preventing the consumption of energy and costs of communication. WSN will allow patients to live independently in their homes and for longer periods with family members and will enable to improve the quality of life of patients.

The organization of the chapter is as follows. Section 2 highlights an overview of various ML methods. Section 3 presents an overview of wireless communication networks with a special emphasis on Internet of things/Internet of Medical Things (IoT/IoMT), WBAN and Bluetooth Low Energy (BLE). Section 4 delineates the emerging trends and applications of ML and WSN. Section 5 addresses the challenges and ethical implications of AI and WSN. Finally, the conclusion highlighting the key points and future aspects of AI and WSN in the healthcare.

Figure 1.



2. OVERVIEW OF MACHINE LEARNING METHODS

Machine Learning (ML) is a broad muti-disciplinary specific technique of AI which has proliferated in the healthcare industry. It is the method of procuring information from the training data. It is omnipresent and is used widely in the various fields like finance, IT industry, security and medical care science. The important characteristics attributed to ML which has made it popularized in the health industry are higher precision, scalability, adaptability and robustness. In the last decade, the application of ML has been accelerated in the healthcare settings due to significant improvement in resources of data, computational analysis, innovative methods. Handling of large and heterogenous data, revealing of complicated and mystical forms and forecast of complex outcomes is possible these days due to availability of various ML methods. In the clinical trials, ML is efficient and capable to enhance the patient – centeredness, external validation, success of results. As a specific AI technique, it has proven to be intelligent in processing the multi-sensor data in the hospital settings, to augment better care to the geriatric population; to optimize and monitor the physical condition of the children, and in the prediction of various life – threatening cardiovascular diseases at a very early stage and thus contributes in the early prevention and treatment plan. ML can be categorized under the following categories as shown in Figure 1.

Supervised ML (SML) trained algorithms can make outcome predictions in the form of either discrete (e.g., positive, negative, benign or malignant) or continuous (e.g., numerical scores). Algorithm obtained using discrete SML model is called classification algorithm and using continuous SML model is called regression algorithm. Non – Supervised ML (NSML) do not involve predefined outcome and are thus exploratory in manner, able to trace clusters or undefined patterns within datasets. NSML algorithms are known as dimension reduction techniques as synonymous to data reduction tool in statistical analysis i.e., factor analysis. Commonly employed ML algorithms methods used to develop, evaluate and to sensitize healthcare professionals are – the regularized logistic regression (LR), Support Vector Machine (SVM), K-Nearest Neighbour (KNN), Decision Tree (DT), ensemble Random Forest (RF), Naïve Bayes, AdaBoost in the detection of diseases associated to brain (Lamba et al., 2022), heart (Rani et al., 2021), kidney, diabetes, COVID-19 (Jain et al., 2022), breast cancer using data types as image, tabular, speech, sound, mixed dataset.

OVERVIEW OF WIRELESS COMMUNICATION NETWORKS

WBANs

Wireless body area networks (WBANs) work with the help of radiofrequency communications and is probable of optimizing healthcare delivery and monitoring system. WBANs comprises of several number of heterogenous biosensors, which can be placed in wearable or implantable form under the skin by user in different areas of the body. These sensors can detect human emotions and measure vital parameters of a patient. The architectural communication of WBANs is usually three – tiered namely, Tier 1 (Intra WBANs); Tier 2 (Inter WBANs) and Tier 3 (Beyond WBANs) respectively as shown in Figure 2.

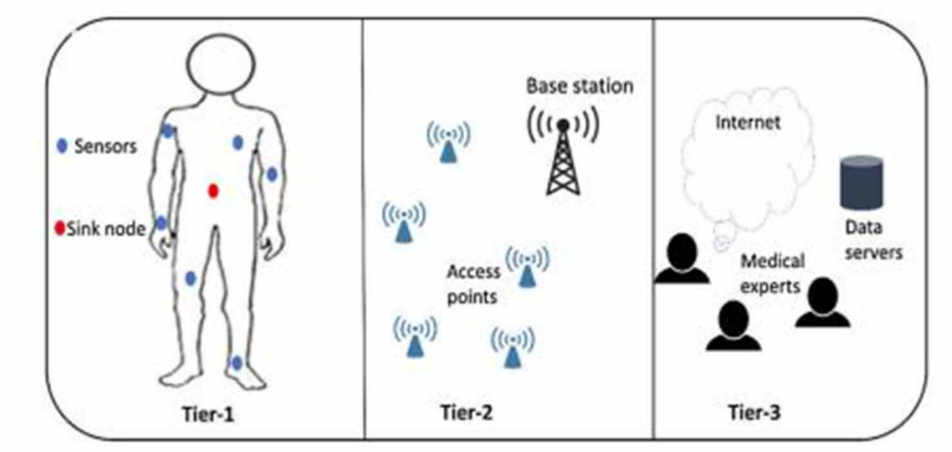
Tier 1: Intra-WBANs signifies communications among wireless body sensors and the master node of WBAN.

Tier 2: Inter-WBANs contains communications between master node and personal devices such as robots, notebooks etc.

Tier 3: Beyond WBANs connects the personal device to the Internet.

The following technologies have been enabled by the WBAN (Negra et al., 2016):

Figure 2.
Source: Saba et al. (2020)



1. **Bluetooth Low Energy (BLE):** It has an excellent suitability for WBAN. Power consumption is less and it operates in wireless mode in mobile devices at a data rate of 1Mbps.
2. **ZigBee:** Its characteristic features are low power consumption, lower data rate (20 – 250 kbps) and with higher levels of security. It can operate without charging batteries for longer time with the activation of the sleep mode. Transmission range varies from 10 – 150 m.
3. **IEEE 802.15.6:** It is the first medical WBAN which serves inside and outside the human body. It uses narrowband, ultra-wideband, and human communication band for data transmission. This technology boosts the research environment by designing the wearable sensors of higher frequency range, low battery consumption and abundant quantity of nodes per body and priority nodes.

The following security methods are used in WBAN (Panhwar et al., 2019):

1. **Bilinear Pairing:** It uses public key for session management and private key for encryption of data in normal manner.
2. **Biometric Security:** In this approach, behavioral and physiological patterns of the individual are identified and authenticated.
3. **Hidden Markov:** Model Authentication and Selective Encryption Approaches.

IoT/IoMT

Internet of things (IoT) is an innovative technology which allows smarter and safer lives to its users, with a capability of transferring information at various location, time, media and atmosphere. The various advantages and disadvantages of IoT in healthcare settings is described in the Table 1.

Table 1. IoT in healthcare settings

Advantages	Disadvantages
Enhances remote monitoring of patients and enable the physicians to diagnose and treat illnesses and diseases in an efficient way.	Due to its complexity, any failure in the power, bugs in the software/hardware may have a serious consequence.
Enhancement in the quality of life and prevention of recurrence of disease with IoT based intelligent medical sensors.	The compatibility problem may lead to monopoly in the market.
Cost -effective in a manner to reduce the patient visits to doctors.	Bringing data from millions of things may pose threat to security and privacy.
Enable flexible and real time access from anywhere to the healthcare provider to access and plan for treatment regime based upon patient information.	Blowing out of things or devices which are producing massive amount of health data.
Unified information by means of an automated collection of data.	
Improvement in the quality of the healthcare management.	

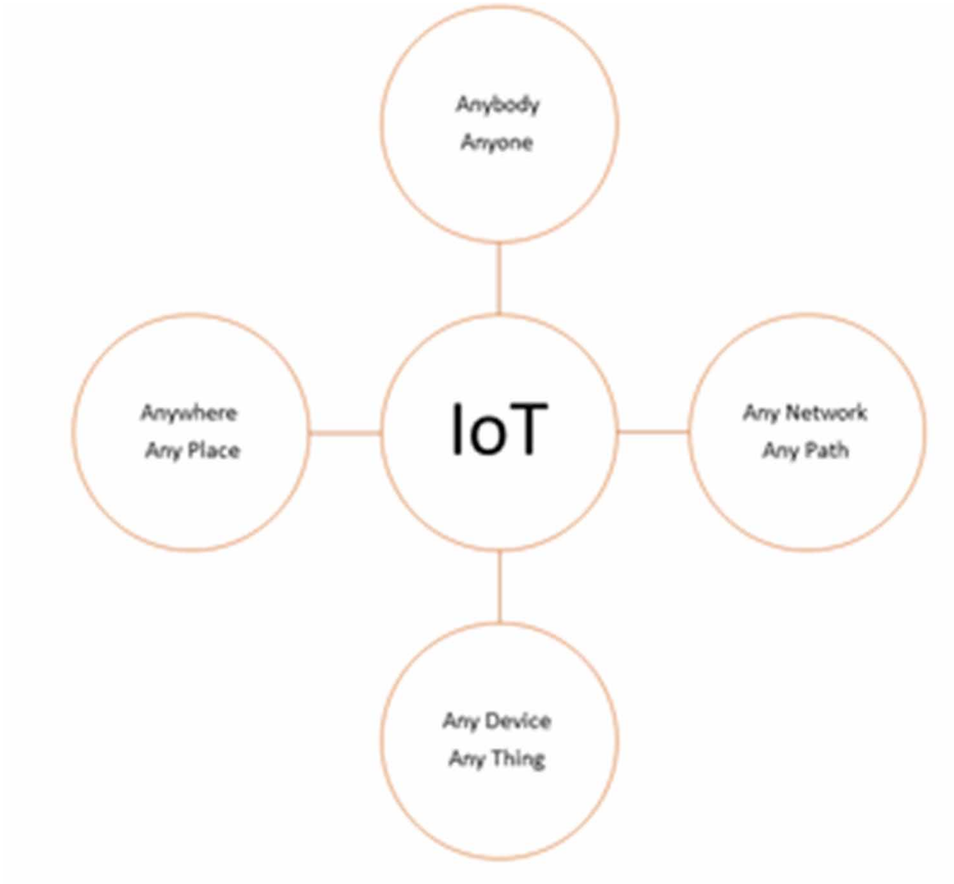
Figure 3 represents the dimensions of IoT, beneficial to both patients and providers in the health care fields.

IoMT has proven to be of utmost importance in the current pandemic situation to monitor the daily record and health status and thereby, prevent the risk of infection. Figure 4 delineates the architectural layers of IoMT namely, perceptual layer i.e., bottom layer, network layer, and application layer respectively.

IoMT framework is made of several phases.

Phase 1: Patient medical data is recorded using implantable or wearable sensors from patient's body that are connected together through WBANs.
Phase 2: Transferring, prediction and analysis of data.
Phase 3: AI based data transformation and interpretation.

Figure 3.



Data Collection Techniques in an IoMT-Based Smart Healthcare System

1. **Electronic Health Record:** On the basis of requirement in research, an optimal approach can be considered for practical application. It is only applicable to specific environment and no new suggestion about any technique.
2. **Rule-Based Approach:** With the help of mechanism proposed in this approach, speed of data gathering can be improved. However, more work can be done to improve its accuracy.
3. **Support System for Clinical Decision:** There is a precision in collection of data but with no proper handling of missing values of data.
4. **Correlation-Based Ratio Analysis:** Gathering of healthcare information is possible with this technique but have not considered missing values.

Figure 4.
Source: Srivastava et al. (2022)

5. **Open Dataset:** Due to graphical user interface, there is better visualization with a disadvantage of not considering missing values.

EMERGING TRENDS AND APPLICATIONS IN HEALTHCARE SETTINGS

Table 2 highlights the list of sensors and their applications in smart healthcare settings.

CHALLENGES AND ETHICAL IMPLICATIONS

The points to be considered during IoMT network designs are as follows (Gerke et al., 2020; Kaimian et al., 2022):

Table 2.

Sr. No.	Sensor Name	Description	Uses	Domain of Belongingness
1.	Gyroscope (Jalal et al., 2020)	Senses angular velocity	Detects tilting of human body and provides an alert mechanism during problem.	Acute care
2.	Magnetometer (Jalal et al., 2020)	Senses relative orientation and detects magnetic field	Detects falls in elderly along with gyroscope and accelerometer.	Acute care
3.	Accelerometers (Jalal et al., 2020)	Measures acceleration	Detects human body movement and motion.	Home care
4.	DHT11 (Feresu et al., 2022)	Detects humidity and temperature	It is useful in measuring environmental conditions with humidity between 20% - 90%; temperature between 0 degrees - 50 degrees Celsius.	Selfcare/Homecare
5.	LM35 (Babu & Jyothsna, 2020)	Senses body temperature	Used for measuring body temperature in centigrade.	Selfcare
6.	ADXL335 (Radha et al., 2021)	Senses position of body	Useful in ensuring proper body position and preventing of complications such as pressure sores, pain or breathing issues.	Selfcare
7.	MAX 30105 (Garcia et al., 2018)	Monitors heart rate	Optical sensor with 2 LED's monitor heart rate between 1.8 V to 3.3 V.	Selfcare/Homecare
8.	AD8232 (Mishra et a.l, 2018)	ECG sensor	It senses heart signals irrespective of body state of person under examination.	Home care/acute care

1. **Body Movements:** The routing protocol of IoMT must be adaptable to changes in the topology of network because of the user movement under observation with on body sensors or medical devices.
2. **Change in Temperature:** The increase in the temperature of the IoMT device due to the power consumption by nodal circuit may damage the body tissues or organs of the user under observation.
3. **Energy Efficiency:** It determines device size, usability and lifetime. The battery life of the implantable sensor should be minimum of 10 to 15 years to make it cost effective for the user.
4. **Range of Transmission:** The disconnection and repartitioning among the sensor nodes are possible when the range of transmission is low and short.

5. **Heterogenous Environment:** The smart healthcare system routing protocol must be capable of handling challenges due to heterogeneity of body sensor network applications.
6. **QoS:** The routing protocol should adopt the QoS measures to deal with data loss, and implantable sensors must have computational abilities and fixed memory.
7. **Security:** Storage of data in the cloud for more precision and swift responses to the patients under observation with IoMT devices can lead to the security of stored data.

Ethical principles: Human autonomy, Explicability, Algorithms Fairness, Patient privacy, Prevention of harm

CONCLUSION

Inclusion of the applications of AI in the health industry will enhance the greater precision in making the diagnosis and boost the efforts of human clinicians towards the optimum patient care. The development of health care system like smart devices, implantable body sensors have enabled the smart adoption of IoMT and contributed significantly in the screening, detection and monitoring of the diseases at sub clinical levels also.

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Chapter 13
Computation-Oriented Communication:
Computation-Based MIMO Radar Communication for Debris Detection in LEO

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ABSTRACT

Debris are human-made objects in earth orbit that have no usefulness but create hazards for the valuable space assets. The space activities are considerably huge in low earth orbit (LEO), and hence, most orbital debris resides within the orbital altitude of 500 – 1000km from Earth's surface. This is the region where the highest concentration of debris is detected. The ground-based radars are in practice globally to detect and characterize the LEO debris environment with the help of collected statistical data. Radar systems used for the monitoring and tracking of space debris will help in generating alert messages for avoiding a collision between operational spacecraft and debris. Multiple input multiple output (MIMO)-based radar has the potential to provide optimum solutions for space debris tracking. It provides wider illumination area, clutter reduction, and hence improvising the object detection capabilities. This chapter provides a study of performance estimation for MIMO radar and comparing the detector performance for signal-to-noise ratio (SNR) improvement.

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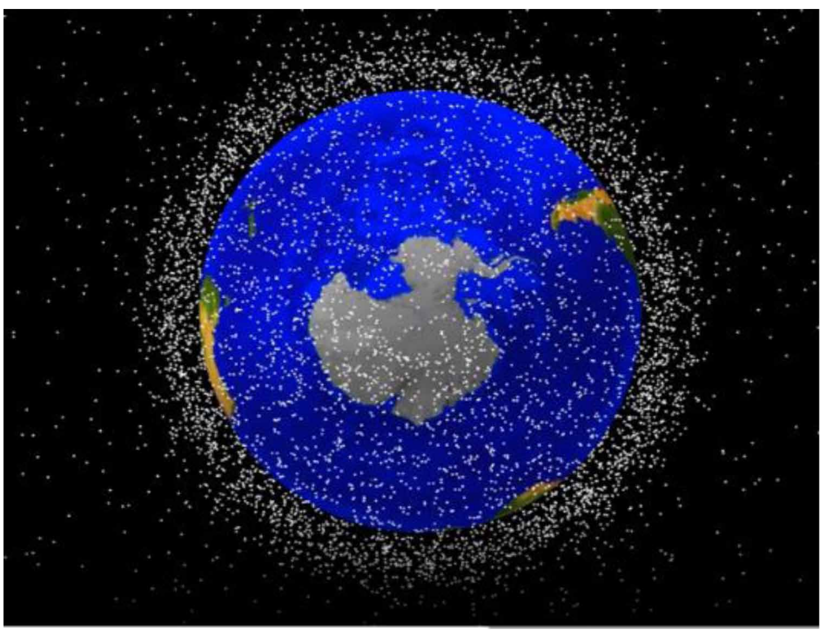
INTRODUCTION

Currently around 25,000 objects are greater than 10cm size and amount of material orbiting in earth's orbits are around 9,000 metric tons. Debris size > 10cm, tracked routinely through space surveillance radars. The dots in the below animation image represent actual catalog objects (payloads and debris) in the Earth orbit as shown in Figure 1. and the number of debris which changes in huge amount with altitude. The orbiting speed of the debris ranges from 7 to 8 km/s, while the average impact speed of orbital debris can range between 10 and 15 km/s, which is 10 times faster than the speed of a bullet. Hence even a tiny size of debris moving at this speed contains sufficient amount of energy to damage the space assets if collides. At higher altitude, more the chances of debris to intact in the Earth orbit and debris left in orbits below 600 km normally fall back to earth atmosphere after considerable amount of time (NASA, n.d.). Low Earth Orbits extends from 200 km to 2000 km above the Earth's surface, and collisions of objects larger than 1 cm in diameter are declared as mission-critical. According to the European Space Agency, a 10 cm object hit will almost certainly result in the target's catastrophic disintegration (ESA).

Figure 1. Debris representation in the Earth orbit
Source: NASA (n.d.)



Hence it is highly desirable to monitor the debris to protect space assets from serious damage. The concept of conventional phased array radar for debris detection is not new and it is being widely used for space surveillance and tracking (SST). The challenge in a design of a surveillance radar is the ability of the sensor to detect unknown, small sized object at high altitudes. In radar surveillance terminology, FOR (field of regard) is referred as area under illumination. Uniform and Continuous illumination of target area is highly desirable but it is quite challenging to achieve with conventional Radars. Target detection ambiguity is another problem when received beams are synthesized with antenna side lobes and MIMO Radar have potential to mitigate both the problems. Unlike conventional beamforming in phased array radar, the concept of MIMO radar for debris detection is still evolving. ESA is using Radar surveillance system for its SSA (Space Situational Awareness) program and for debris detection (Chen, Zheng, Wang, Li, & Wu, 2017).

MIMO radar works by sending various orthogonal signals from different antenna, which may then be separated and processed separately at the receiver using filters. Using the MIMO approach, a number of orthogonal waveforms delivered in different directions from the antenna array may be utilized to light the whole Field of regard (FOR) (Misiurewicz et al., 2019; Rogers, 2019). In comparison to before, this opens up new options in signal processing compared to traditional approach in which the FOR is scanned by a tiny light beam. To cover the target region with high angular precision, several narrows receive beams are synthesized.

In this chapter, a study of MIMO Radar system model and MATLAB simulation of signal processing algorithm at the receiver end is done. The performance evaluation of MIMO receiver in terms of achieved BER (Bit-Error-Rate) against the estimated SNR (Signal to Noise Ratio) values are also shown. This study provides a roadmap for MIMO channel modelling and performance estimation which may lead to an innovative technique for debris detection if suitably implemented on hardware set up / proper test bed.

LITERATURE STUDY

The literature is started with the identification of the manuscripts. In the literature study it is found that the researchers have reported debris detection in many of the related works.

However, in few of the condition the researchers have reported many other issues. We have focused our screening on MIMO Radar Communication for Debris Detection in LEO. In initial search, 88 manuscripts are identified. The keywords are identified and based on exclusion and inclusion criterion, the manuscripts are filtered in the screening process as shown in Figure 2. For the literature study, we have identified closely linked manuscripts related to proposed topic. Exclusion and inclusion criteria are also identified for the filteration of the relevant manuscripts. Few of the keywords have taken in consideration for exclusion criteria as shown in Figure 2. After careful consideration, total 29 papers identified for full review in screening process. Out of 29 papers, 14 papers are selected for the complete literature study. The detailed literature study report is discussed below.

Figure 2. Screening and Identification of the manuscripts

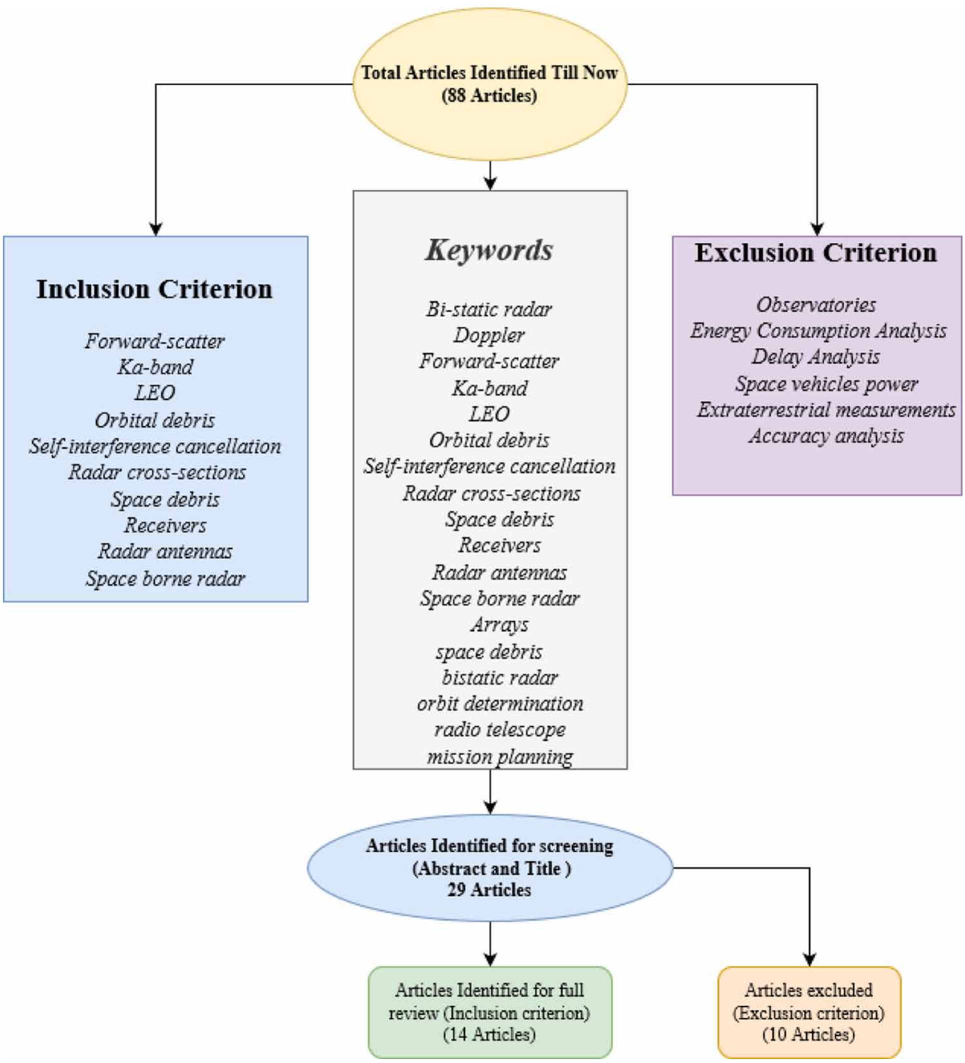


Table 1. Objective, contribution, and conclusion of the works

Objective	Contribution	Conclusion
Detection of orbital debris using self-interference cancellation residual signal (Jayasimha & Jyothendar, 2013)	Higher frequency signals can spot and range debris as small as 5cm in diameter.	The paper provides new insights into the influence of weather and orbital debris on self-interference canceller performance.
SIMO radar design for small space debris detection in the LEO (Agaba et al., 2015)	The use of available radio telescope receivers in a radar system that performs space debris detection and monitoring is becoming popular. In this paper, the author discussed the feasibility test results of one of the Square Kilometre Array precursors, KAT-7 for space debris detection.	Using the SIMO radar equation, the L-band KAT-7 radar system is able to detect debris with a radar cross section (RCS) of 10.5 dBsm up to a maximum range of 800 km with a signal to noise ratio (SNR) of approximately 35 dB and a range resolution of approximately 0.6 m.
MIMO Radar Waveform Design Method for Target Detection in Heterogeneous Clutter Zone (Jiu, Liu, Wang, Zhang, Wang, & Chen, 2015)	On the basis of maintaining the output target signal, a new optimization cost function is developed by minimizing the output clutter peak level and peak side lobe level of the correlation function.	Two subproblems are created from the original optimization problem. Convex programming and CA can be used to find a suboptimal solution based on prior knowledge of clutter in the spatial and temporal domains.
Moving Target Detection Using Colocated MIMO Radar on Multiple Distributed Moving Platforms. (Chen, Zheng, Wang, Li, & Wu, 2017)	A novel radar system with numerous moving platforms is proposed. Each moving platform has several colocated antennas that can be used as either a transmitter or a receiver. An innovative two-step OMP algorithm is proposed to address the off-grid clutter issue. A unique waveform optimization technique has been presented to optimise the SCNR of the echo waveform in each moving transmitter platform in order to further improve the target detection performance.	The suggested reconstruction algorithm and waveform optimization can both further enhance the detection performance. Simulation findings show that the proposed radar system outperforms existing distributed and colocated MIMO radars in detecting moving targets.
Multi-Target Angle Tracking Algorithm for Bistatic Multiple-Input Multiple-Output (MIMO) Radar Based on the Elements of the Covariance Matrix. (Zhang, Zhang, Zhou, & Li, 2018)	Proposed method was able to track the moving object with non-uniform speed. At SNR = 10 dB, the proposed approach closely matched the target's actual trajectory, and it performed better than the existing angle tracking algorithm. The number of transmit/receive antennas gradually improved the performance of the proposed algorithm. Due to diversity gain, several transmit/receive antennas enhanced angle tracking performance.	The study presented in this article offers technological foundation for the practical use of MIMO radar. In this paper three approximation procedures were proposed and with the help of that the suggested approach was able to determine the linear relationship between the covariance matrix difference and the angle difference. The suggested algorithm simplified computation and enabled automatic linkage of DOA and DOD.
A Compressed Sensing MIMO Radar System for Extended Target Detection is proposed (Rogers & Popescu, 2021).	In this paper, a compact representation of the radar scene is produced using transmit-receive beamforming in conjunction with a shortened frequency domain representation of the radar signals. The radar waveforms used to detect the presence of numerous extended targets with known impulse responses and the receiver filters used to rebuild the radar scene are both designed using compressed sensing (CS) techniques.	By examining a set of related reflection coefficients acquired from a sparse picture reconstruction problem, the proposed system can identify the presence of numerous extended targets. When the radar waveform and receiver filters developed using the proposed algorithm was applied, reduced mutual coherence, fewer reconstruction errors, and better ROC performance were seen.
Probabilistically Robust Radar Waveform Design for Extended Target Detection (Xu et al., 2022).	It is proposed to resolve the Peak-to-Average Ratio (PAR) constraint radar waveform design problem for extended targets. The distribution of the output Signal-to-Interference-Pulse-Noise Ratio (SINR) is obtained using the Target Impulse Response (TIR) stochastic model.	The stability of detection performance against the stochastic TIR is improved by the proposal of a novel waveform design metric called Probabilistically Robust Detection (PRD).
A Parametric Moving Target Detector for Distributed MIMO Radar in Non-Homogeneous Environment. This work's major goal is to address the non-homogeneous clutter that distributed MIMO radar inevitably produces because of multi-static TX-RX antenna setups and the environment's azimuth- or direction-selective backscattering of the radar signal (Wang, Li, & Himed, 2013).	A parametric approach is used to represent the non-homogeneous disturbance signals by using a collection of unique auto-regressive (AR) models, one for each TX-RX pair. The MIMO-PGLRT detector is developed as a parametric generalised likelihood ratio test (PGLRT) for MTD in distributed MIMO radars.	The proposed technique uses a series of unique AR methods for clutter modelling, estimation, and cancellation to solve the non-homogeneity in clutter reported from various TX-RX antennas.
Space based TDM-MIMO radar debris ladder array second order compensation method for multi target tracking in short time (Liang, Duan, Wang, & Li, 2021).	For a space-based TDM MIMO radar space debris array, a second order compensation solution is given in this research. The fractional Fourier transform is then used to concentrate the energy after first using the keystone transform to rectify the relative uniform motion. It can focus energy and eliminate the effects of acceleration.	This technique may achieve non-uniform array correction and compensation without knowing the preceding velocity, enabling the detection of targets with uniform acceleration and improving detection performance.
Mission Planning Tool for Space Debris Detection and Tracking with the MeerKAT Radar (Dhondea & Inggs, 2019).	To identify and track space debris, a bistatic radar system with the MeerKAT radio telescope in South Africa as its receiver network has been proposed. This paper covers the Mission Planning Tool created to schedule sensors and forecast MeerKAT radar performance in terms of orbit determination precision.	The proposed MeerKAT radar system for space target observation is demonstrated using the results of numerical simulations.
Feasibility Study on a PCL Radar for Space Debris Detection (Ochi & Tanaka, 2019).	A PCL radar system feasibility assessment for space debris detection is described in this research. A receiving system that is located on the ground is part of the PCL system that is being suggested. It consists of satellites that circle the Earth and emit radio waves.	It was demonstrated through modeling that this proposed PCL radar is capable of detecting space debris from LEO to GEO. At an altitude of 400 km, the detectable size was transformed using the JCSAT-3A technology into a physical silhouette area of 0.70 m2. The observable size with the NOAA-19 system was 0.93 m2 at an altitude of 800 km.

The contribution of the previously reported research works are explained in Table 1. The contribution of the researchers and conclusion are explained.

MIMO RADAR SYSTEM

The following categories of MIMO radar systems may be made based on the spacing between antennas:

Distributed MIMO Radar

In this system, the antennas are spaced far from each other, so it is possible to use the spatial diversity of the target's radar cross section (RCS) to enhance target detection performance (Belfiori et al., 2014). Spatial diversity, or simply diversity, refers to the different propagation paths due to many antennas in a system. We may decide to broadcast the same data through several propagation (spatial) pathways in an effort to increase system reliability. Based on radar movement, distributed MIMO radar are of two types:

1. Static Distributed Radar
2. Moving Distributed Radar

Colocated MIMO Radar

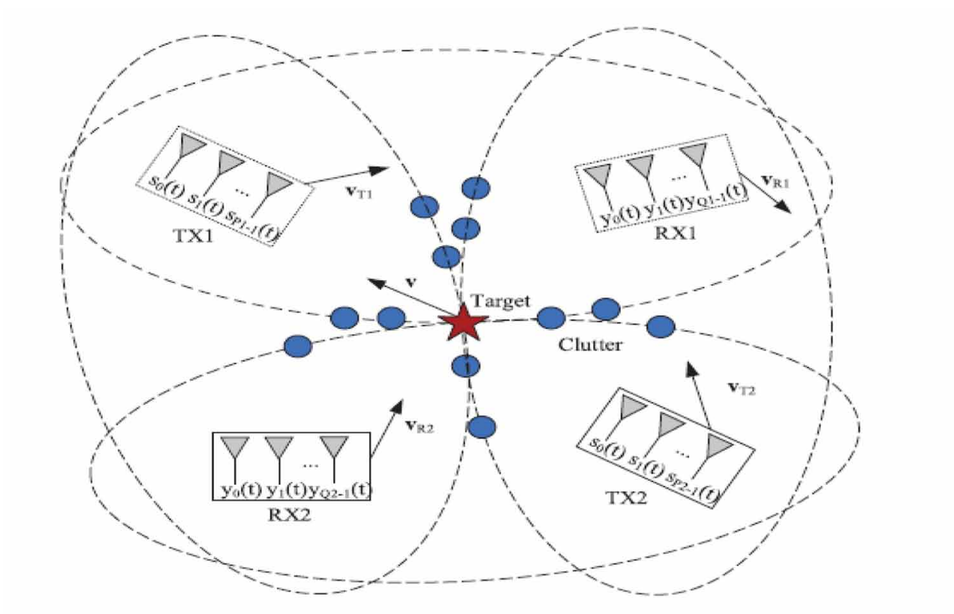
In this radar the antennas are closely located, due to this the adaptive array processing, such as waveform and beam-pattern optimization (Haimovich et al., 2008; Li & Stoica, 2007), may be used to utilize the waveform diversity. Based on the transmitter and receiver position, collocated MIMO radar is categorized as follows:

1. **Monostatic MIMO Radar:** All antennas are closely located, and the Transmitter (TX) and Receiver (RX) are near to each other. Then, more reliable target identification and beam-pattern generation are feasible (Davis et al., 2014).
2. **Bistatic MIMO Radar:** The Transmitter and Receiver are located far apart and the antennas are either closely located within the transmitter or receiver. Then, using various view angles from TX and RX, greater target localzation performance may be obtained (Willis & Griffiths, 2007; Willis & Griffiths, 2007).

Multiple Moving Platforms-Based Colocated MIMO Radar

In this system, many widely spaced moving platforms are placed with MIMO antennas on each moving platform More waveform variation can be introduced, and transmitted waveforms can be modified to enhance target detection performance even more. Therefore, this system is having some of the benefits of both colocated and distributed MIMO radar and provide a tradeoff between these two systems. Since TXs and RXs are widely separated, this radar system is also an extended version of the bistatic MIMO radar.

Figure 3. Colocated MIMO radar system on multiple moving platforms
Source: Chen, Zheng, Wang, Li, & Wu (2017)



WAVEFORM DESIGN ALGORITHMS FOR TARGET DETECTION IN MIMO RADAR

Orthogonal MIMO Radar Waveform Design

The fundamental of MIMO radar waveform design is orthogonal MIMO radar waveform design, which focuses on the properties of auto-correlation and cross-correlation. For optimizing the above said properties such as minimization of auto-correlation sidelobe level and cross-correlation level, many multiphase waveform design methods have been suggested like cross entropy technique (Zhang et al., 2010), the simulated annealing algorithm (Deng, 2004; Khan et al., 2006), statistical genetic algorithm (Liu, 2006), cyclic algorithms (Liu et al., 2007), etc. However, the main problem with orthogonal MIMO radar is that it has isotropic transmit beam which produces a low main-lobe gain. Due to this, the signal to clutter plus noise ratio (SCNR) of received echo is reduced which later deteriorate MIMO radar performance in target detection. This is the limitation of orthogonal MIMO radar system.

Transmit Beampattern and Waveform Design

In this method, a transmit beampattern with main-lobe and sidelobe can be generated using a non-orthogonal waveform. To improve the performance, researchers have focused on optimizing the transmit waveform's cross-correlation matrix. The focus of the majority of existing MIMO radar transmits beampattern design algorithms is primarily on main lobe maintenance and on sidelobe level minimization. The transmit waveform matrix can be optimized under total transmit energy constraints by maximizing the target signal energy, minimizing clutter energy, or maximizing the system output SCR (Stoica et al., 2009). In general, these algorithms perform well in the zones of homogeneous clutter and noise. When the surrounding environment clutter is heterogeneous, the existing transmit beampattern design algorithms cannot achieve maximum output SCNR.

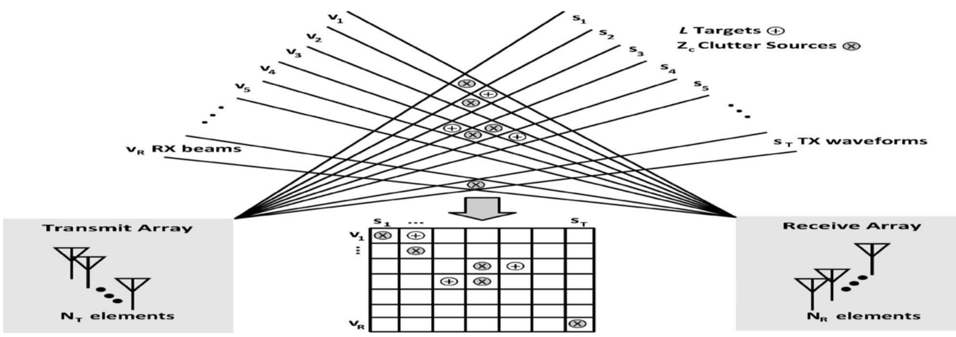
Knowledge-Based MIMO Radar Waveform Design Method

This method is useful mostly in heterogeneous clutter zone for target detection. For the heterogeneous clutter, the clutter response may vary substantially in the peak-to-average power ratio (PAR) and the clutter response could be quite large. The peak clutter in this case may exceed the detection threshold, increasing the false alarm rate. The main focus of KB spatial-temporal hierarchical MIMO waveform design method is to effectively increase detection probability and decreasing the false alarm rate. The output clutter peak level (CPL) is a key optimization metric.

Compressed Sensing (CS) Methods

In this method, Compressed sensing technique is used for the design of radar waveforms and receiver filters that are customized to known target impulse responses. The received radar signals that have been interfered by noise and clutter are then processed using the designed waveforms and receiver filters to restore the radar scene. Then the complex approximate message passing (CAMP) algorithm is applied for restoration. When reconstructing the scene, the radar system looks for the presence of multiple extended targets that are contained within a single transmit and receive beam pair cell and are thought to have an extended range.

Figure 4. Schematic representation of the CS based MIMO radar system
Source: Rogers (2019)



PERFORMANCE PARAMETERS IN MIMO RADAR DETECTORS

Signal-to-Clutter Noise Ratio (SCNR)

Unwanted echoes in radar systems are referred to as clutter. These echoes can seriously impair the effectiveness of radar systems and are typically produced by the earth, the sea, rain, animals/insects, chaff, and atmospheric turbulence. Since the accumulation in the detection can significantly reduce the noise, the clutter has the biggest impact on the detection performance. The transmit beampattern can be optimized by optimizing the sent waveform with different techniques. As a result, the received signal's SCNR can be raised.

Target Velocity

The target may be separated from the clutter by the different velocity. Hence target velocity is one of the important parameters in MIMO radars. In co-located radars, increasing the target velocity can enhance target detection performance; however, this is not the case with distributed MIMO radar. It is possible to attain greater ROC performance for a given target velocity.

Number of Antennas

Better ROC performance can be attained by increasing the antenna count because it can increase the degree of freedom in waveform optimization. Therefore, a radar system with multiple antennas is desirable.

MIMO RADAR BASED DETECTORS

In multiple-input multiple-output (MIMO) communication systems have several antennas, transmitters and receivers which will provides high gains, power, and energy efficiency in contrast to conventional Radars systems (where both the transmit and receive chain have only one antenna each). Hence, MIMO system improves multipath propagation and also provides high signal-to-noise ratio (SNR) at detector end without additional bandwidth requirement. However, this system demand complex signal processing algorithms and also complex hardware implementation solutions. Hence designing of energy efficient and reliable detectors for MIMO System is quite challenging where large number of interfering sub-streams needs to be handled. The main objective of designing MIMO receiver is to minimize detection errors using perfect channel state information (CSI) at the receiver (Trotobas et al., 2020). The following MIMO detectors are available in the literature:

Maximum Likelihood Detector (MLD) or Sphere Decoding (SD) Detector

These are perceived as non-feasible detectors (Yu et al., 2014; Zhang et al., 2016; Zhang, Zhang, Zhou, & Li, 2018) and may be used for specific application because of their high computational complexity. In fact, as the number of transmit antenna and constellation size increase, the number of vectors to be examined also increases exponentially. Consequently, an irrational amount of resources are needed to compute the cost of evaluation.

Linear Detectors

Zero Forcing (ZF) Detectors:

The simplest techniques for tackling the detection problem are linear detectors. In terms of the signal-to-interference ratio (SIR) requirements, the ZF detector is the best linear option. Problem with the ZF detector is that performance of the ZF detector is compromised by ignoring the noise and concentrating only on the interference.

Minimum Mean-Square Error (MMSE) detector:

A Bayesian estimator that takes into account the receiver's knowledge of the noise level can offer a better detection. The minimum mean square error (MMSE) detector, which relies on a Bayesian detection matrix and quantization, is known to maximize the signal-to-noise plus interference ratio (SINR). The MMSE detector performs better when the signal-to-noise ratio (SNR) is low, limiting both the interference and the noise.

Interference Cancelation Detectors

These nonlinear detectors operate under the concept of cancelling signal interference.

Successive interference cancellation (SIC) detector:

The SIC detectors works with two-step iteration: first, a judgement is made on the first transmitted location x1, and then the detector corrects the received vector y by reducing the interference that would have been produced by x1 assuming that the decision was correct. Even though the performance is greater than with linear detectors, the SIC process is particularly error-prone because each iteration's assumption affects all subsequent iterations.

Parallel interference cancellation (PIC) detector:

The SIC algorithm's primary issue is that iterations increase exponentially with the number of antennas. Because of this, a PIC detector that could eliminate interference from all antennas simultaneously was created. The fundamental goal of the PIC method is to assume interference on all antennas at once and then cancel it using a linear simple detector with low performance as a starting point. The following three instructions can be repeated as many times as necessary if improved performance is desired by changing the assumption to use the newly discovered symbol.

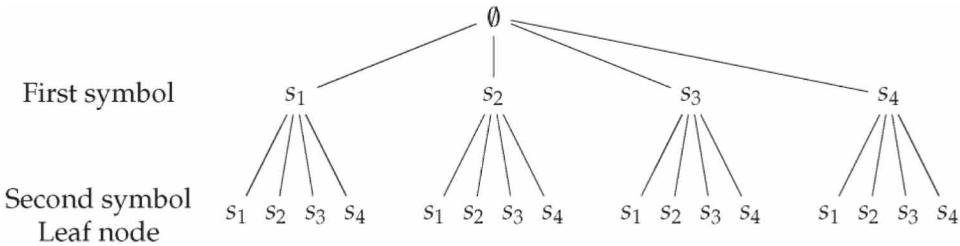
Tree-Search-Based Detectors

The detection problem is depicted by the tree-search detector as a search for the best possible path in a tree. Figure 5 depicts a tree interpretation for a constellation comprised of four symbols and two data streams. This procedure is analogous to locating the path in the tree that leads to the best goal function. The first symbol corresponds to the first tree level, and so on for each level.

Bioinspired and Geometrical Detectors

The two most researched bioinspired decoders are ant colony optimizations (ACO) and particle swarm optimizations (PSO), which comprise the firefly algorithm (FA). When compared to previous procedures, these are very complex.

Figure 5. Tree view of the detection problem
Source: Trotobas et al. (2020)



Geometrical detectors work in two stages: exploration to locate a limited set of interesting solutions and exploitation to improve this set at a low cost.

PROPOSED METHODOLOGY

Two transmitter (2T) and three receiver (3R) architecture of MIMO Radar channel model is selected. This architecture could be a very large in number (for e.g. 100T x 100R also) but for channel modeling and analysis simplicity the lower scaled version of MIMO architecture is selected as shown in Figure 3.

Transmitter RF Chain:

DAC+ Filter + Mixer + High Power Amplifier

Receiver RF Chain: LNA + Filter + Mixer + DAC

MIMO Radar Channel Model Equation

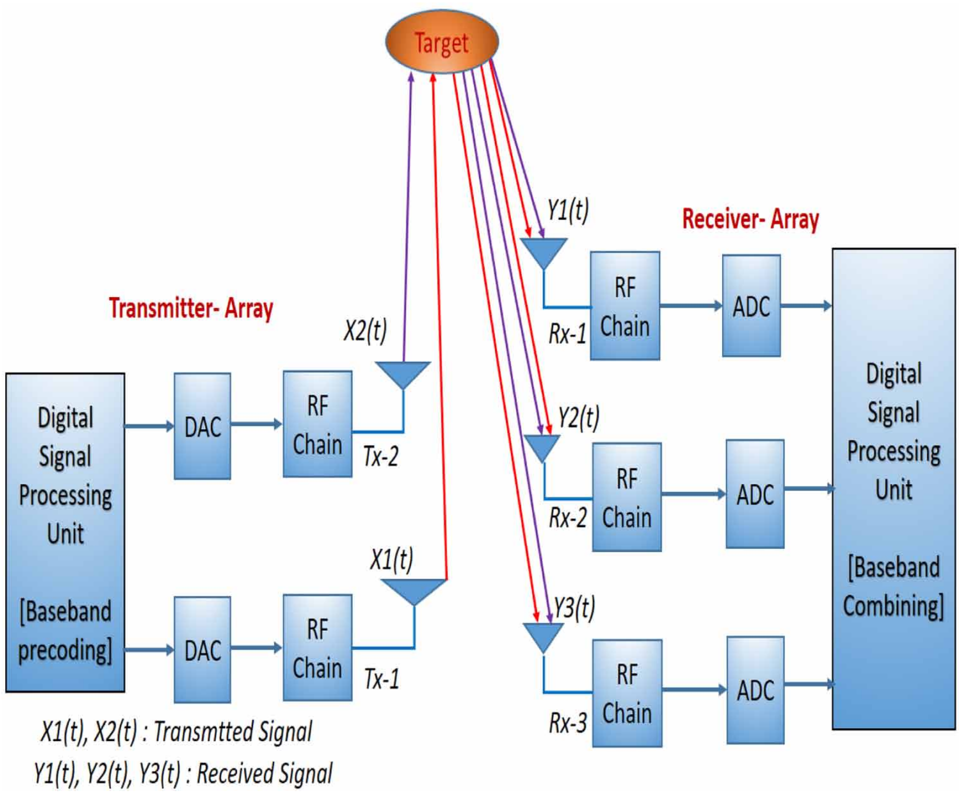
Following is the channel model equation for MIMO

$Y(t)=H*X(t)+n(t)$

Where,

Y(t): Received Signal
H: Channel Matrices
X(t): Transmitted Signal
n(t): Detector Channel Noise

Figure 6. Application scenario of 2T x 3R MIMO radar model architecture



End-to-End Link Estimation

Free space EM wave propagation will not have meaningful reflections in case of satellite communications and there will be only one major path for signal transmission. However, for terrestrial systems signal may reach to the receiver via multipath reflections from buildings, trees etc. which enforces variations in signal strength. Hence link budget estimations are the essential steps in RF communication system design to meet the operational requirement with sufficient margins.

Typically, the below equation shall be used for Link budget estimations for radar communications in LEO:

Cumulative Received Power (PR) from all the three receivers = Transmitted Power (PT1+ PT2) + Transmit Antenna Gain (dB) + Receive Antenna Gain (dB) – Path Loss (dB) + 228.6 (Boltzmann Constant).

There are two major types of receiver ZF & LMMSE which is primarily used in the MIMO systems because of their simplicity and optimum performance:

Zero Forcing (ZF) Detector

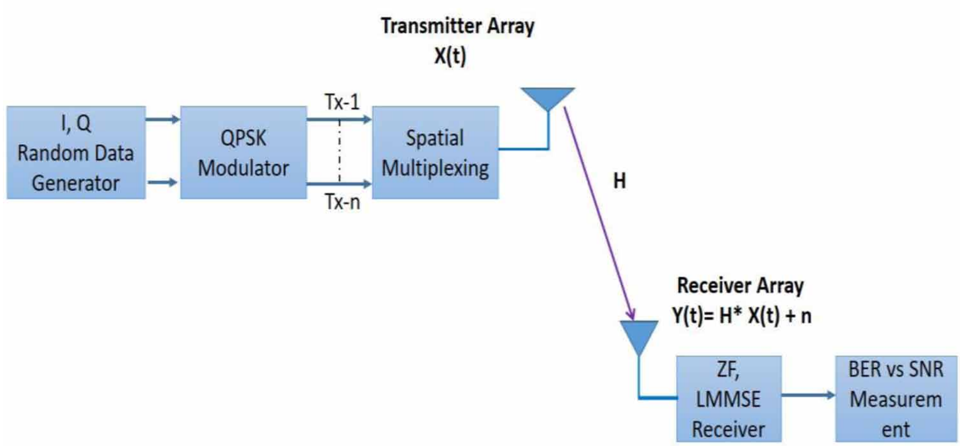
This is a Linear detector preferred due to its simplicity in algorithm writing and hardware implementation. It does not demand very complex hardware circuitry and selected based on specific application.

Linear Minimum Mean-Square Error (LMMSE) Detector

ZF receiver mainly focuses on the interference and its performance suffers from not taking the noise into account. Nevertheless, if the noise level accounted properly at receiver (a Bayesian estimator including this information) it can provide a better detection. LMMSE uses Bayesian estimator to minimize the mean-square error using the orthogonality principle.

Block diagram of the MATLAB Simulation model is depicted in the below Figure 4. Algorithm is written in MATLAB Editor Tool for ZF & LMMSE detector and performance was compared for BER (Bit Error Rate) vs achieved SNR (Signal –to-noise ratio).

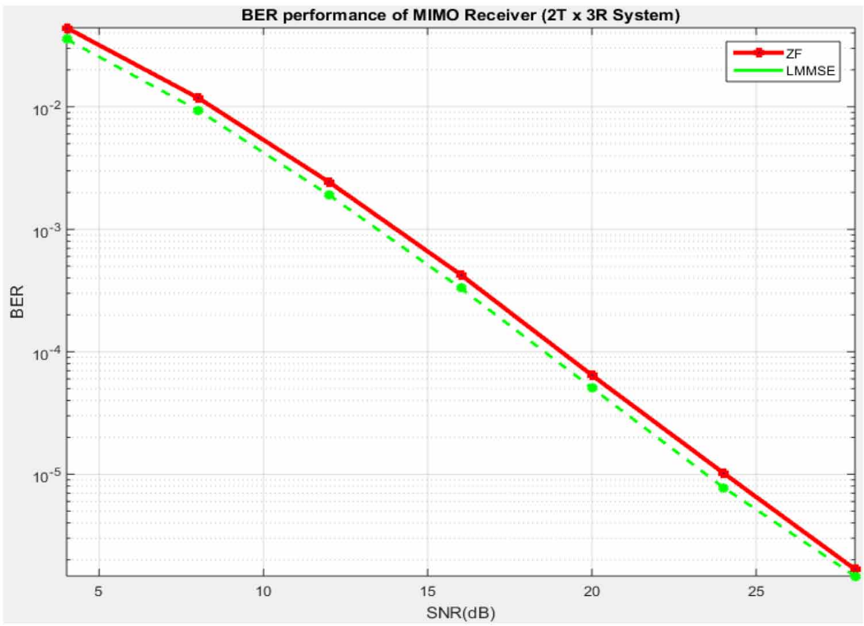
Figure 7. Block diagram of MATLAB simulation model



RESULTS AND DISCUSSIONS

Algorithm written in MATLAB Software tool for ZF receiver and LMMSE receiver. Simulation carried out with 1000 no samples size for 2T x 3R MIMO Radar model. The simulation result compared between ZF receiver and LMMSE receiver. The obtained result shows that as SNR values are increasing, the BER performance of the detector system is improving in both the cases as shown in Figure 5. However, the bit error rate performance of the LMMSE receiver is better than ZF receiver for the same SNR values.

Figure 8. ZF and LMMSE receiver performance



CONCLUSION

The scope of this work is to bring out the importance of debris detection to protect the space assets against serious damage. Literature shows the best ways to mitigate the debris threat is through proper surveillance. Radar is being used widely for this purpose; however MIMO radar is the promising technology (evolving slowly for this purpose) which has ability to reduce the drawbacks of phased array radar and improve the target detection capability. There are various MIMO receiver exists in the theory but from implementation and optimum performance point of view, ZF and LMMSE are the suitable choices. The performance comparison of both the receivers are shown in the simulated result in Figure 5. Future scope of activity includes the hardware implementation /test bed development for these algorithms.

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Chapter 14
Rigorous Study of Core Concepts and Technologies of AI-Based Wireless Networking and Cloud Computing With Their Role in Smart Agriculture During Pandemics

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ABSTRACT

Today's cloud is a frequently used global technology that shifts local network content to network centric content, where huge quantities of data processing are performed on powerful computational farms and accessed via the internet. This technical reality uses the metered service for accessing the resource and distinct data centres. The purpose of this work is to present a fundamental review concept of cloud computing where we have mentioned its key characteristic, services, and deployment models. The authors have also looked into how quickly COVID-19 accelerates the market. They attempted to decipher the concept of virtualization approach through the chapter, which is widely acceptable. How cloud computing technology is beneficial over conventional farming is also highlighted. Here they have also focused on cloud computing applications, trends, and the most recent adoption challenges employed in different sectors.

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INTRODUCTION

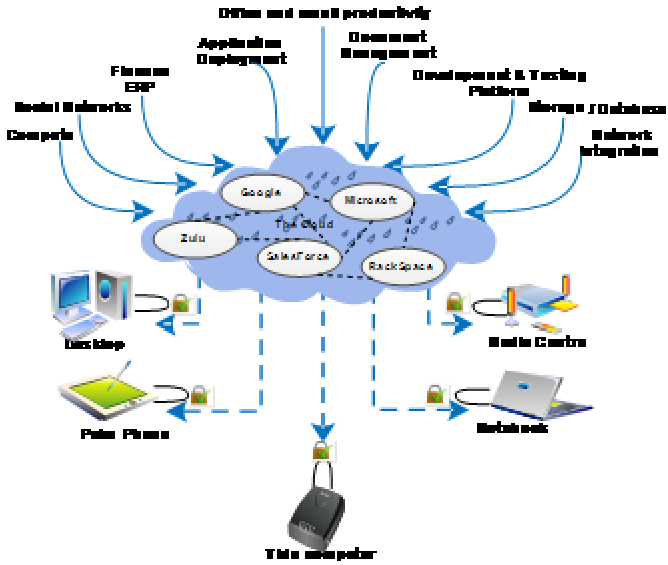
Technology arrives with perfect timing get favourable outcomes and success, on the other side innovation pop up at the wrong time leads failure for example in 2001, Microsoft tablet PC was launched with extremely high hope but didn't get commercial success as like Apple's iPad which get runway success because its touchscreen technology was so natural and worked smoothly with almost every app. Apple designed its touchscreen OS when everything was already in place and succeeded the tablet market as its timing was not too early nor too late. Everything in this planet has its time to evolve, grow, get mature, terminate or replaced by novel or younger, same things happen to technology also (Gralla, 2021). Many IT firms, small and medium-sized digital organizations, industries, academic institutions, and government agencies are now selling, utilizing, and satisfying the needs of users by providing a wide range of cloud-based services. As per modern context, the term "cloud computing "was firstly coined on August 9, 2006, by Eric Schmidt, then Google CEO (MIT Technology Review, 2021). On September 2011 NIST (National Institute Of Technology), Gaithersburg, published a report on computer system technology where it stated the definition of cloud computing (CC) as "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Samarati et al., 2016). Cloud computing's primary concept is to process a vast amount of data quickly and efficiently using enormous farms having storage and computing resources, and then internet can be used to access these resource pools (Doras.dcu.ie, 2021). Figure 1 depicts The basic cloud computing notion is that various remote computer resources or cloud services applications are accessible via secure internet connections and can be accessed through the cloud.

Essential Characteristics of Wireless Networking

1. On demand self-service

The end user selects and uses the desired resource or services like network storage, server time, network node, licensed software etc. according to its requirement with the help of interface, without relying on human interaction or expertise.

Figure 1. Cloud computing idea and networking components
Source: Chandrasekaran (2014)



2. Broad network access

It makes the availability of resources on cloud so that it can be accessed by multiple devices like PCs, Tablets, thin -thick client, and smart phones. There is necessity of appropriate network because resources are geographically distributed.

3. Resource pooling

Multiple clients can use cloud computing environment, which provides temporary and scalable services and dynamically assigns virtual and real resources based on user demand.

4. Measured services

Cloud computing has metering capabilities to control and monitor the resource usage. Any type of services are measured services, users pay what they use.Cloud computing has capacity to scale resources up and down in response to user demand. Cloud should be competent to satisfy the demand of customer weather its necessity is little or immense. For an instance, to run a particular simulation user requires 4 GB RAM, later requirement enhances up to 8GB when while running the things, so user should be able to provision it rapidly.

5. Multitenancy

In cloud computing, shared resources are pooled somewhere and multiple consumers called tenants can use the same resource from there.

There are various computing trends that make CC a reality. It's nothing like cloud computing exist from day one or all of sudden. As we find that all the inventions or any kind of technical development primarily come up because of some requirement or necessity of scientific community and general citizen at large. Earlier, computing was systematized for public usage like water and electricity, etc. There is different computing paradigm (specially embraced by many IT companies like Oracle, HP, IBM, Google, Apple, Amazon, Microsoft) these are the driving force for CC. In upcoming section different computing stages have been discussed very precisely (Chandrasekaran, 2014).

BACKGROUND

Distributed Computing

The mother of all computing is distributed computing, then we have different other computing. In early days computing generally performed using single processor, also known as Uni-processor computing or centralized computing, were different terminals submit their jobs to mainframe computer system (logically single processing). Centralized computing is not out of picture even today it is still very much useful for several purposes like mission critical applications, payroll, account transactions etc. Other computing which was evolved is distributed computing based on peer processes, where computational problems can be solved using several computational systems (e.g., Workstations, server, PDA) which are distributed over specific geographical area with seamless network connectivity. Each entity has its own memory (local) and they use message passing system for communication. Intranet, ATM machines, Internet is example of distributed computing. Distributed system has some properties like fault tolerance, resource sharing, load sharing, scalability, parallel computing, robustness.

Grid Computing

Another common computing method is grid computing (GC). According to IBM, this type of computing allows for the virtualization of distributed computing (DC) and data resources such as computing, communication bandwidth, and depository to create different system images and provide users and applications with better accessibility to IT capabilities. Grid computing infrastructure, according to Sun Microsystems, provides reliable, durable, ubiquitous, and low-cost access to computational power. The most known thing we have in our day today life is Electrical power grid analogy. Here, user utilizes the computing resources as per need without knowing much about the technology, hardware, operating system, and location of the resources. GC's main goal is to make effective and efficient use of resources across multiple organizations, connect different communities (grid resources are used by local communities such as biological sciences and genetic research, for example), and create a dynamic environment where users can share computing power as well as data. Today's research or science really demands simulation and modeling techniques rather than conventional experimental practice because user wants precise and more accurate results to their scientific and engineering problems within a time. Therefore, data virtualization and exploitation of recourses are needed. Grid computing has been used for different scientific paradigm like reactor Applications, crystallography, weather forecast, detection and modeling natural disasters etc., so various types of grids fulfil or used for different purposes for example we have computational grid used for high throughput.

Intensive computing applications, data grid provides storage for heterogeneous database and file systems, collaboration grid helps in collaborative projects, network grid provides fault tolerant communication facility and here grid node act as a data router between two communication ends to speed up the communication. Utility grid is one of the most essential form of computing which supports sharing of software resources for example an application running on a single machine which is shared by other users either by sending their data to that machine or retrieve result from that machine.

Cluster Computing

Cluster computing is another significant part of computing, with components such as PCs, SMPs, OS, high-performance interconnects, middleware, parallel or distributed settings. There are several types of clusters like failover clusters, load balancing cluster and parallel cluster for different purposes. The key benefits of clustering are availability of system, fault tolerance, high performance, network scalability and application and operating system reliability.

Utility Computing

The above-mentioned computing motivated to a system called Utility computing, the typical meaning of utility is where end user is only concern about the presence of utility and its usage and least bother about the nitty-gritty of resource maintenance and its production. Utility approach also termed as pay-per-use. Utility computing is a kind of virtualization where the availability of huge computing power or storage exists in comparison of single system sharing computer. Utility computing has enormous scope of automation and more focused to service driven architecture. On demand cyber infrastructure can be considered as its example. In utility computing there are two perspective one is consumer and another is service provider and different management issues like pricing, security, service level agreement, application sizing ties them together. The other side of utility computing have some risk also like data backup: data resides somewhere or at third party, if there is crash what will happen or if service provider itself goes out of the business. Data security, competency, defining SLA and getting value from charge back is also an issue.

The following section discusses several cloud service models, with acronyms such as (SaaS), (IaaS), and (PaaS) being extensively used in the cloud sector.

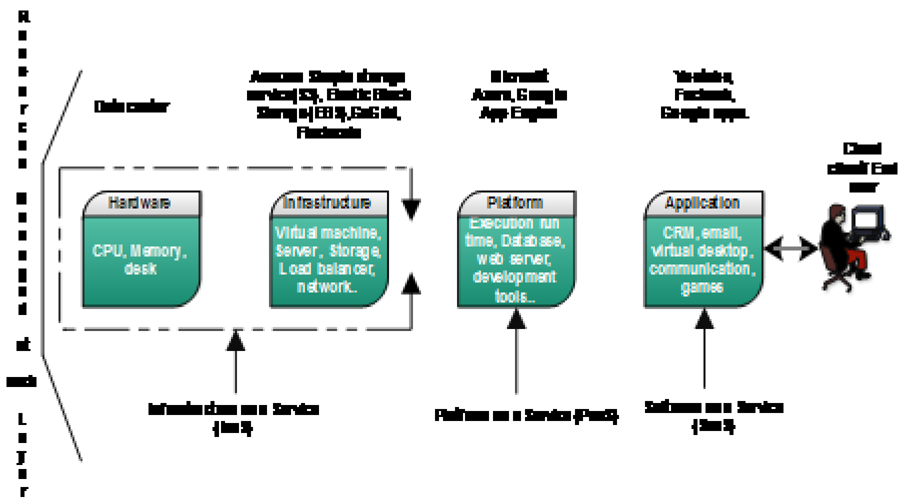
CLOUD SERVICE MODELS

Cloud computing offer cost-effective corporate solutions while also enhancing IT capacity and performance. These models are distinct in several ways, despite some overlaps (Aldeen, 2018). These basic cloud service model is depicted in Figure 2 along with some examples, let discuss each of them one by one.

Software as a Service (SaaS)

SaaS offers the applications that runs on cloud. SaaS is also known as software cloud where cloud vender host the application and provide it as a service throughout the committed network and also relieves the users from the trouble like maintenance, upgrading hardware and software .Now a day’s user using different type of aspects like word-processing, Google spread sheet, webmail, Force.com CRM, NetSuite’s Business Software Suite, tool like lattice available on the internet, for technical communication. All these applications are somewhere on the cloud and user hook to that application and either store its data on its own local machine or at times the data is stored in some other data service provider so, that means, user requires the basic minimal way of interfacing to the external cloud and get SaaS, Here, The foundational cloud infrastructure, comprising processors, space, networks, operating system, and specific application capabilities, has no jurisdiction over the user.

Figure 2. Basic service model of cloud



Infrastructure as a Service (IaaS)

This model realizes the consumers about the dynamic scalability and availability of huge volume of raw computer infrastructure at their end. The out sourced services like storage, servers, CPU, network equipment, data centres, run arbitrary software are there for the users when they need them. These services are billed as per its consumption or duration. Amazon Elastic Compute Cloud (EC2), Amazon Web Service, Flexi Scale, and GoGrid are all examples of (IaaS).

Platform as a Service (PaaS)

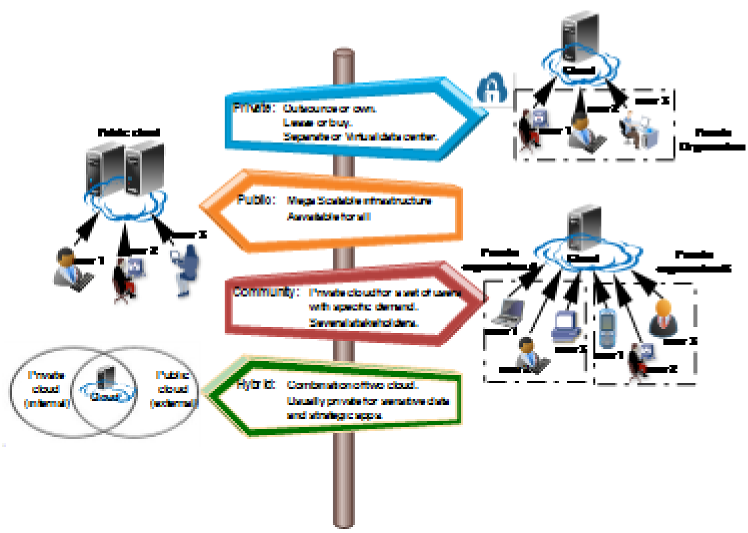
In between the above-mentioned two service models, there is another model known as PaaS. It serves as a foundation for several development and test cases.

The vendor supplies the majority of the tools and resources requisite for developing and conveying services and applications, such as web service applications, application versioning, application development, testing, and hosting. The consumer has control through the provided application and perhaps configuration setting for the application –hosting environs. Examples of PaaS consists: Sun Microsystems NetBeans IDE, Google App Engine, and Microsoft Azure, etc. (Default, 2021). Other than these(SaaS, IaaS, PaaS) three primitive cloud services, conveyers uses some more services in order to tackle other factors like compliance requirement, security and privacy, business continuity, user access management etc. More than this, service providers has to satisfy the specific requirement of adopters by creating cloud based system. Here, some other cloud support services are Identity and Access Management as a Service (IAMaaS), Monitoring as a Service (MaaS), Data Storage as a Service (DaaS), etc.

CLOUD DEPLOYMENT MODELS

User prefer cloud environment as per its specific requirement. A cloud is categorized into four forms based on the interaction between the client and vendor, as shown in Figure 3 (Default, 2021; GarcíaZaballos & Iglesias Rodriguez, n.d.).

Figure 3. Cloud deployment models



Private Cloud

It is designed to be used by a solitary organization composed of various consumers or entity. This model can be hosted in house or externally. e.g Window Server "Hyper-v'.

Pros: Security level upgraded, More control over the server and amiable.

Cons: Difficult to retrieve data from remote areas, need of IT experts.

Public Cloud

The public cloud environment is managed by an outsourced cloud provider, and it is accessible to a wider of businesses via the online on a metered basis. Cloud infrastructure is dedicated to public and exists on the cloud service provider's (CSP's) premises. Individual, businesses, academic institutes, government organizations-own, manage and operate it. E.g.Google Doc, Spreadsheet.

Pros: Easily scalable, topographically no restriction, cost effective, highly consistent, convenient to manage.

Cons: Not suitable and safest for sensitive data.

Community Cloud

This cloud infrastructure supports collaboration of different community that has common interest like specific job, security requirements, agreement consideration, guiding principle, etc.

Pros: Security-protect IP, legal/compliance, strong adoption in healthcare and financial areas.

Cons: It is more expensive than using the public cloud, group of people share a set sum of bandwidth and storage arrays.

Hybrid Cloud

This cloud infrastructure is a combination of two above mentioned models while maintaining their distinctive entities in order to provide more adapted IT solutions.

Pros: Extremely adaptable and flexible, it is economical, security has been improved.

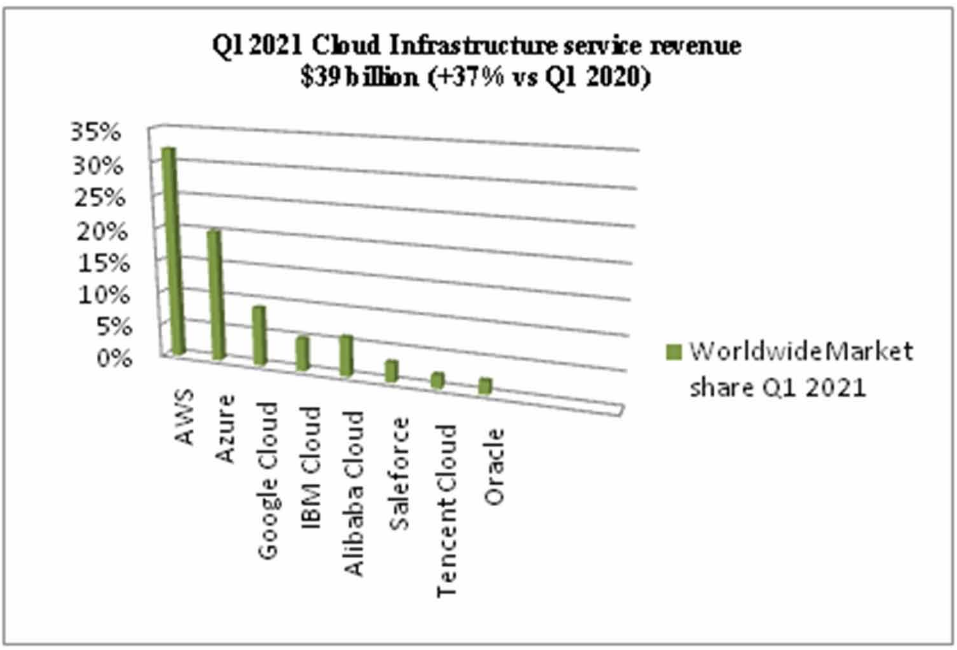
Cons: Network communication may be incompatible because it is used in both cloud environments.

CLOUD COMPUTING DURING PANDEMIC COVID-19

Prior to the COVID 19 outbreak, the worldwide cloud computing market was valued at USD 266.0 billion in 2019, with a CAGR of 14.9 percent expected from 2020 to 2027. However, the CAGR is only expected to be 17.5 percent by 2025 as a result of the epidemic. All throughout the globe, cloud computing is in tremendous demand.

According to the IDC Worldwide Semi-annual Public Cloud Services Tracker, which gives overall market size and seller's share for over 70 sectors of the worldwide public cloud service market. The revenue generated by all major cloud services projected in Figure 4, including IaaS, SISaaS (System Infrastructure Software as a Service), PaaS), and SaaS, is the parameter on which this tracker is based (Gartner, 2021; WPOven Blog, 2021).

Figure 4. Cloud market share 2021



Most latest technological disruptions, like configurable business, are now powered by the cloud, which has demonstrated its durability, adaptability, elasticity, and rapidity during periods of uncertainty. Heterogeneous, multi-cloud, and edge environments are now more common, paving the way for new distributed cloud models. New wireless networking breakthroughs, such as 5G R16 and R17, will also accelerate technology acceptance to a new level of breadth, depth, and pervasiveness. The use cases that will develop include improved mobile banking experiences and healthcare change.

Cloud usage will continue to grow fast over the world. Companies migrated assets to the cloud 24 times faster during the pandemic than before. As per Gartner, end-user investment in public cloud services will reach $396 billion by 2020 and rise 21.7 percent to $482 billion in 2022. (As seen in Table 1) public cloud spending will account for more than 45 percent of overall company IT spending by 2026, up from less than 17 percent in 2021.

Table 1. Worldwide public cloud services end-user spending forecast (millions of U.S. dollars)

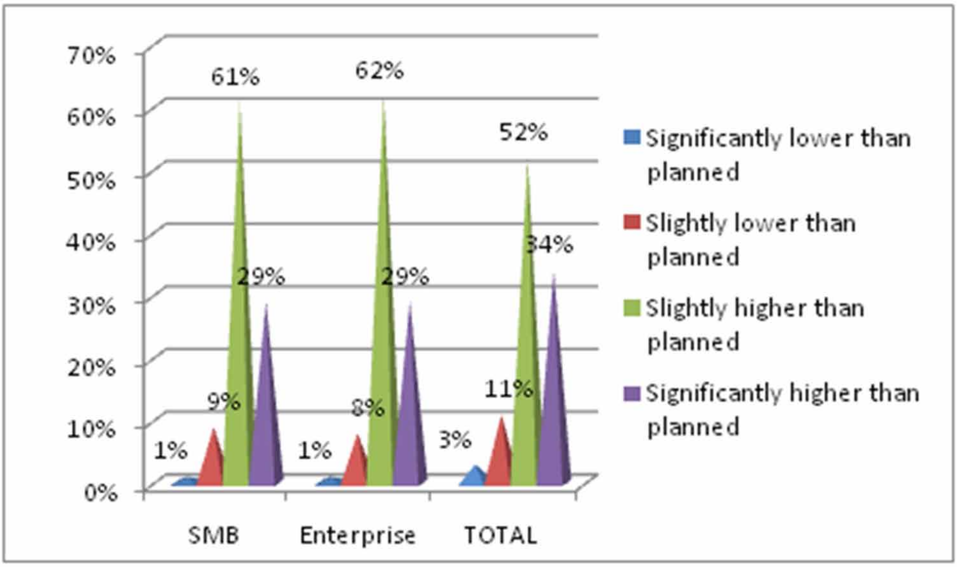
Service	2020	2021	2022
Cloud Business Process Services (BPaaS)	**46066**	**51027**	**55538**
Cloud Application Infrastructure Services (PaaS)	**58917**	**80002**	**100636**
Cloud Application Services (SaaS)	**120686**	**145509**	**171915**
Cloud Management and Security Services	**22664**	**25987**	**29736**
Cloud System Infrastructure Services (IaaS)	**64286**	**91543**	**121620**
Desktop as a Service (DaaS)	**235**	**2079**	**2710**
Total Market	**313853**	**396147**	**482155**

COVID-19's appearance inspired Flexera to include a question in its 2020 survey that assesses how the pandemic might affect cloud strategy. As a result of the epidemic, cloud plans and adoption have definitely evolved. COVID-19 is expected to have an impact on cloud plans, according to the results of the current poll. As seen in Figure 5, 90% of respondents said cloud utilization is more than expected. Some of the growth is due to the additional capacity required by present cloud-based apps to fulfil rising demand as online usage develops (Info.flexera.com, 2021).

CLOUD COMPUTING LAYER ARCHITECTURE

Technological model of cloud has an architecture which defines its working structure. It comprises the expectations on which it works and the elements that work over it. This computing technology relies on internet for its working. Figure 6 gives the picture of cloud architecture consisting four layers.

Figure 5. Change from planned cloud usage due to COVID-19 (% of respondent)



Layer 1

All the users whether it is thin client, thick client, and mobile belong to this lowest layer from where they commence connection to the cloud. In some way user's device should support basic functionalities to ingress web applications. Thin Clients are lightweight computer system that has low potential to process something, therefore also known as lean clients without any local storage, hard drive. Thin clients basically used to establish remote connection with servers in computing environment. Thick client, also known as heavy client as they are able to execute software application independently.

Layer2

This layer offers the various services to the user and act as an interface between user and the cloud. Local Area Network, i.e., LAN. Cloud provider defines the requirement of minimum bandwidth in case of public or private cloud.

Connection, where in instance of private cloud, connections are assigned by the cloud infrastructure is completely depends to this connection i.e. internet. The Public cloud (location unknown to user) can be accessed by the users through the internet Layer 2 doesn't come under the concept of Service Level Agreements (SLA).

Figure 6. Layered architecture of cloud

Layer 3

This layer software (operating system) manages the cloud. Operating system acts as an interface between users and actual resources like data centre. All the activities like scheduling, provisioning, virtual servers, memory load consolidation, and private cloud governance.

Layer 4

This layer fall under SLAs purview. Therefore, any disparity in service or any process suspension may be considered as SLA violation .In case of any SLA violation, service provider has to pay penalty as per agreement or rule. In order to avoid any flaw related to SLA provider's uses high speed connection and effective algorithms to transfer data from data centres to the manager.

CLOUD COMPUTING REFERENCE ARCHITECTURE BY NIST

The conceptual reference model of cloud computing is proposed by NIST having major actors along with their functions and activities. Figure 7 Describes a high-level architecture for understanding cloud computing's requirements, uses, attributes, and fundamentals (Liu et al., 2011; Vacca, 2016). This reference architecture shows five major actors and, these entities having their own ability to perform, participate and process in cloud computing environment. Let's define them briefly. Conceptual reference model explains the job of each stakeholder within the CC field, a list of would-be recipients from reference model is given below. Each beneficiary makes the make use of cloud in their own way to solve their purposes:

Standardization Bodies

Industry consortiums and organizations that form the cloud standards.

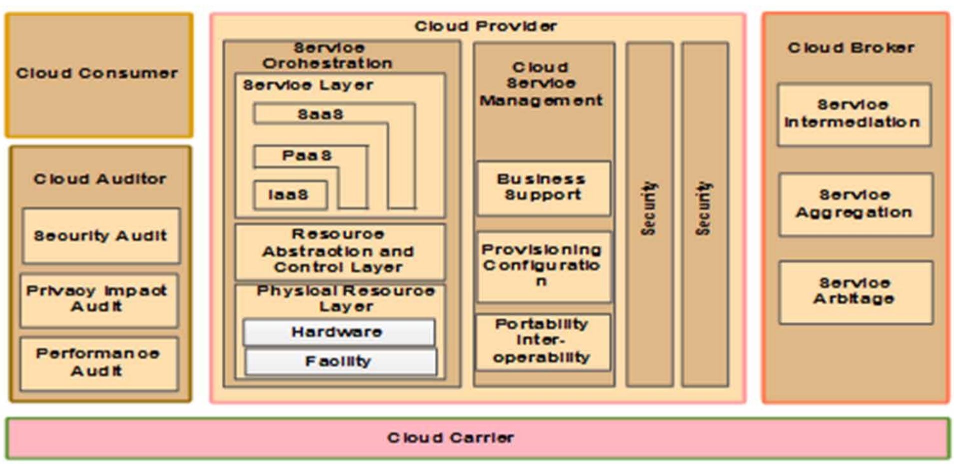
Cloud Creator

Group or individual who build services cloud maker isn't always a cloud provider.

Cloud Consumer

Cloud consumer is a client who has subscribed to the cloud services.

Figure 7. NIST referenced architecture of cloud computing



An organization, object, or entity liable for creating a service accessible or available to interested parties based on SLA.

Cloud Auditor

A third party that can undertake an unbiased review or assessment of cloud services, data operational considerations, functionality, and privacy.

Cloud Broker

This group handles service usage, manages performance and conveys cloud services. It also negotiates relationship between consumers and providers in cloud. Cloud Carrier: This is an arbitrator, which delivers connectivity and transfer of cloud services from cloud vendors to cloud users.

Cloud Carrier

This is an arbitrator, which delivers connectivity and transfer of cloud services from cloud vendors to cloud users.

Cloud Educators

Institutes or individual who provide education materials and teach other about cloud computing.

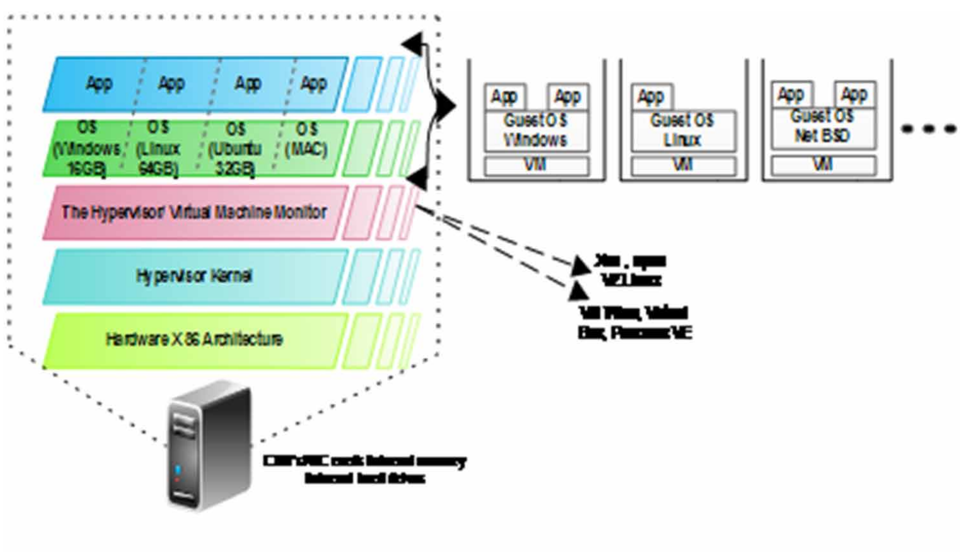
Cloud Learners

Developers, learners, or anyone who is interested in learning about cloud computing. Cloud computing reference architecture is required since it provides a uniform, coherent architectural representation as well as the essential concepts that must be understood while planning and implementing various projects.

VIRTUALIZATION APPROACH AND TYPES

Cloud and its virtualization is somewhat that comes hand –in – hand. Virtualization is a broad term in sense of memory, storage, network etc. Virtualization allows a single system to perform the functions of numerous systems by distributing the resources of a single piece of hardware across multiple environments. "The most apparent and long-standing use scenario is system consolidation, but virtualization is like a Swiss army knife." said Raghu Raghuram, VMware's Chief Operating Officer for Products and Cloud Services. It can be applied to a variety of scenarios. "Virtualization avails extended life of the technology with low cost that's why it is quite famous for small to medium business. It also generate efficacious utilization of resources and enhance return on investment. Let understand it with the help of a virtualized stack Figure 8 (ZNetLive Blog, 2021). As shown in figure, at bottom, there is bare metal of the hardware, over that a middleware that allows to create virtual things. We can have different hardware like different systems across different networks. Here, end goal is to realize different virtual machine like 16 GB of machine running windows, 64 GB RAM machine running some variant of Linux etc. In between the hardware and VM there is a need of Virtual Machine Monitor (VMM) or Hypervisor which allows the ambulation of these different types of machines. Here, .Various application runs on their Guest OS, which resides over the VM present in some geographical location. So, individual consumer has its machine for their purpose. On the same hardware, a user can run different operating systems and apps. In a nutshell, virtualization provides the foundation for a cloud environment's increased agility and adaptability. Hypervisor are of two types: First and foremost, it is used on server market. Various Hypervisors has been made, few of them are shown below with the help of Figure 9 and Figure 10. At bottom, there is bare metal of the hardware, over that a middleware that allows to create virtual things.

Figure 8. Virtual machine concept



- **Hypervisor-Type 1:** Type 1 hypervisor also known as bare-metal hypervisor, which proceeds (Run) openly on the hardware of host computer so that it could govern and handle the hardware resources and guest OSs respectively.
- **Hypervisor-Type 2:** Hypervisor operates (Run) inside a formal OS environment, also known as hosted hypervisor which runs as a separate second layer whereas the guest OS runs on third layer which is over the hardware that means, here hypervisor situated between hardware and virtual machine (Chandrasekaran, 2014; Singh & Singh, 2018).

Figure 9. Type 1 "baremetal hypervisor"

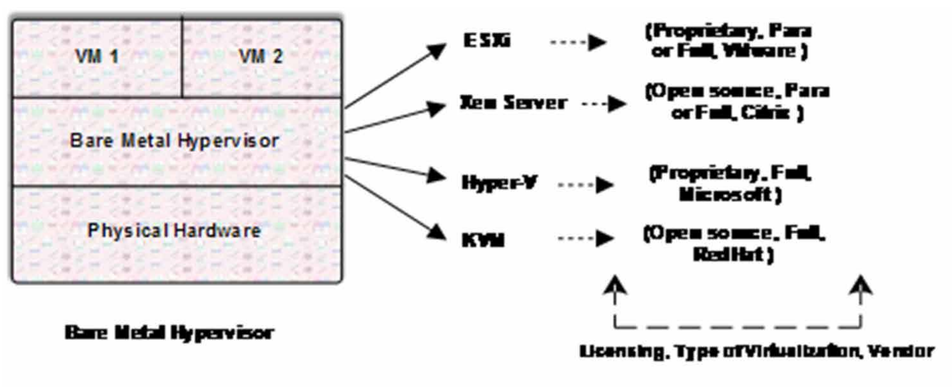
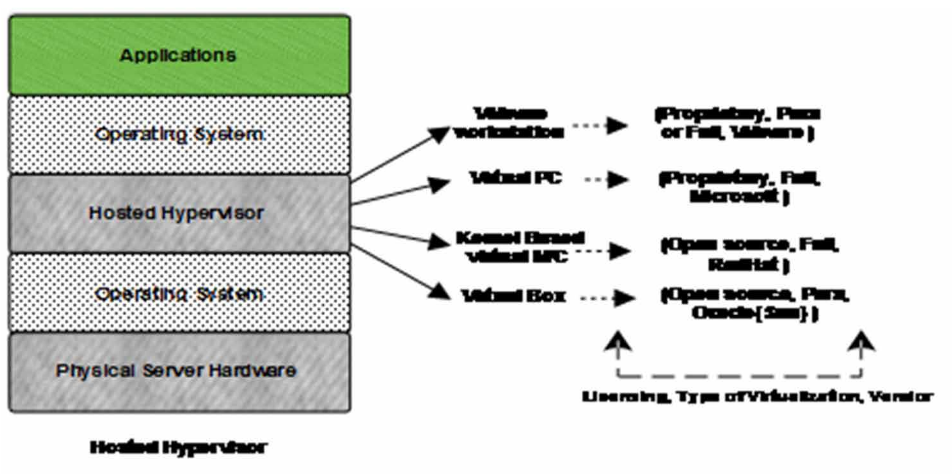


Figure 10. Type 2 "hosted hypervisor"

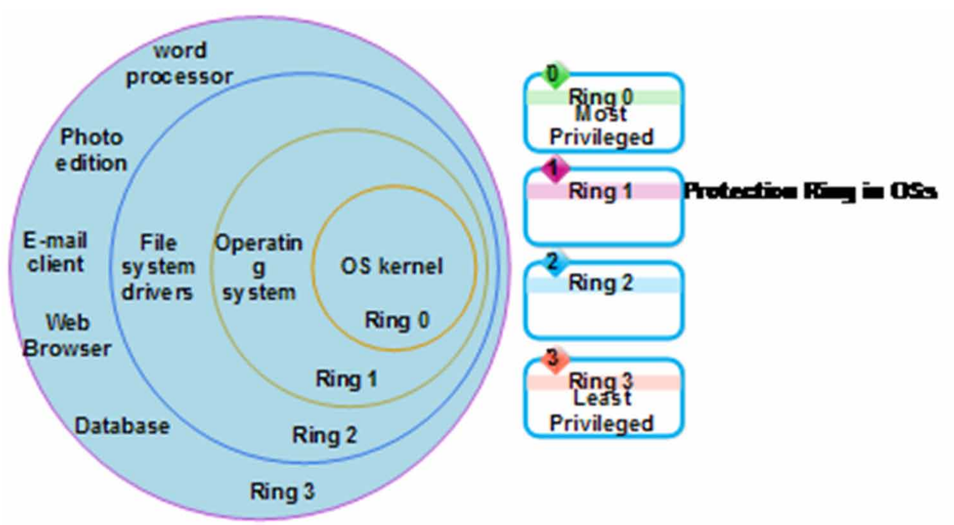


APPROACHES TO SERVER VIRTUALIZATION

Various virtualization techniques have been introduced by Popek and Goldberg for withdrawing the problem encounter with Type 1 architecture (bare metal). Before proceeding towards virtualization techniques let understand the concept of protection ring. In OSs protection rings has its own significance in virtualization approaches. It is specially used to segregate operating system from false user's applications. Protection ring architecture illustrated in Figure 11, consist privileged levels and rings from 0 to 3 as shown in figure. Ring 3 consists least privileged programs whereas ring 0 comprise of most privileged programs as per Goldberg's Theorem 1 (Hamdaqa & Tahvildari, 2012).

The most trusted instructions of OS runs inside Ring 0 and access the physical resources openly. Ring 3 consists false or doubtful applications, bounded to access physical resource. Rest of the ring 1 and 2 are assigned for device drivers. These Protection rings control or stop all the untrusted user level programs having hostile nature and try fraud access to resources. Different virtualization technique adopts different type of privilege levels let discuss them one by one.

Figure 11. Protection rings



First Generation Technique: Full virtualization relies on binary conversion to virtualizes and capture some sensitive and non-virtualizable instructions, as well as new sequences of instructions that have a substantial impact on the virtual hardware.

During runtime, Binary image of OS is used and the processor directly executes the User level code for high performance virtualization. Combination of both binary translation and direct execution delivers Full Virtualization. As illustrated in Figure 12, the guest OS resides in ring 1 is entirely segregated from the underlying hardware by the virtualization layer.

Virtual machine passes 75% of CPU requests directly to the host CP for execution that advances the speed of today's modern virtualized systems.

The hypervisor settled at ring 0, provides virtual infrastructure to all needy virtual machines (VMs). Full virtualization examples are Microsoft Virtual Server, VMWare ESXi.

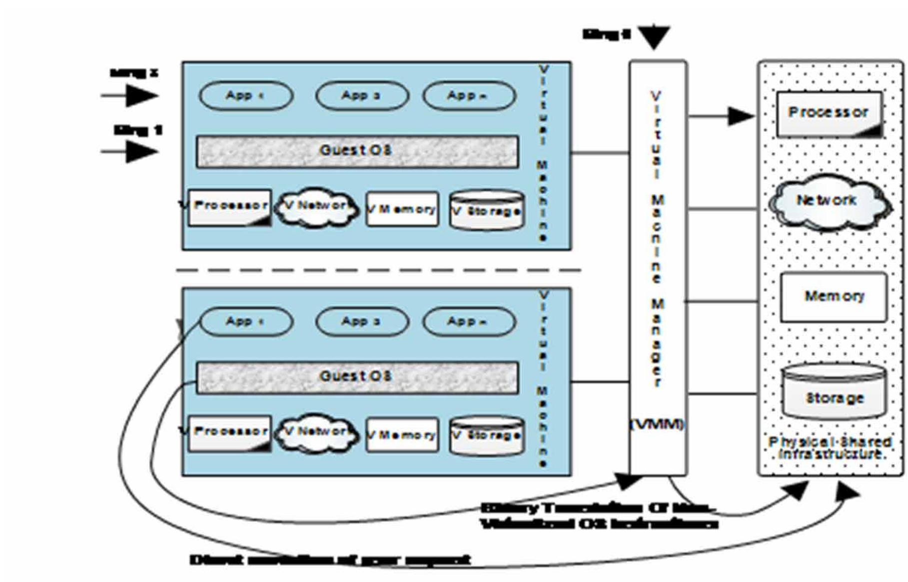
Advantages:

- Gives best separation and security for the VMs.
- Various OSs can run concurrently.
- Ease of migration of virtual guest OS in primitive hardware.
- Without affecting the OS, it is easy to install and use.

Disadvantages:

- System's overall performance got affected as the binary translation is an additional burden.
- Proper fusion is required between hardware and software.

Figure 12. Concept of full virtualization



Second Generation Technique: Para primarily refers communication between hypervisor as well as guest OS to increase efficiency and performance. It also implies the alteration of OS kernels to exchange non-virtualized instructions with hypercalls which transmits directly with the virtualization layer hypervisor. Figure 13 shows that modified guest OS situated at Ring 0 (privileged state) whereas Users applications placed at Ring 3. Guest OS establish direct communication with virtualized layer without any translation by means of hypercalls. This direct communication enhances the efficiency and performance of system.

Here, hypervisor renders "hypercall" interfaces for other critical kernel operations like interrupt handling, memory management and time keeping. In para virtualization Operating system aware of its running in virtualized environment.

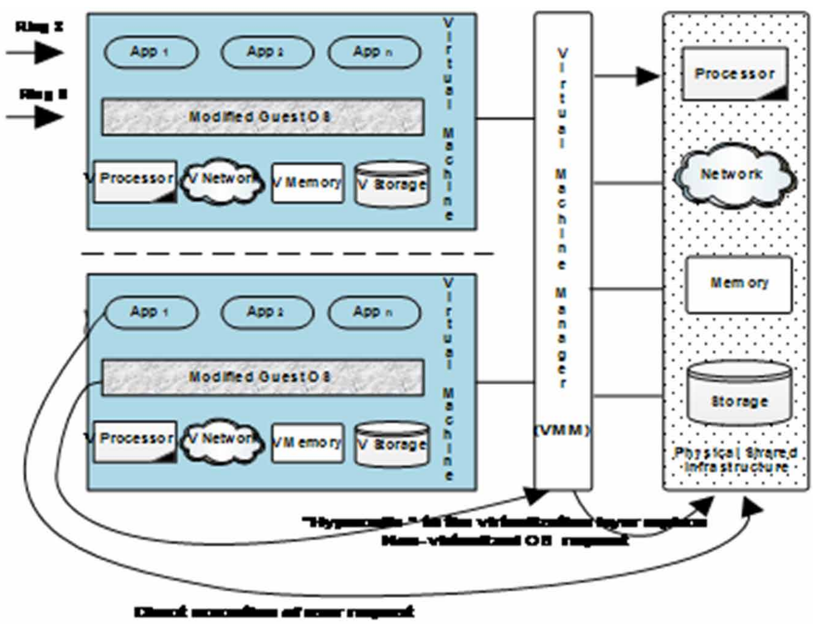
Advantages:

- There is no overhead related to binary translation, so system performance gets improved.
- Easy to implement and eliminates the special hardware need.

Disadvantages:

- Guest OS kernel modification produce cause overhead.
- It is infeasible to migrate modified guest OS, to run on physical hardware.

Figure 13. Concept of para virtualization



Third Generation Technique: The third virtualization technique is Hardware Assisted, Vendors like Intel's Virtualization Technology (VT-x) and Advance Micro Devices AMD's both target the privileged instructions along with new feature of CPU execution mode. This feature concedes VMM to run in a new root mode as shown in Figure 14. In spite of working below Ring 0, VMM still owe Root privilege level. All user's applications and Guest OS carry non-root privilege level.

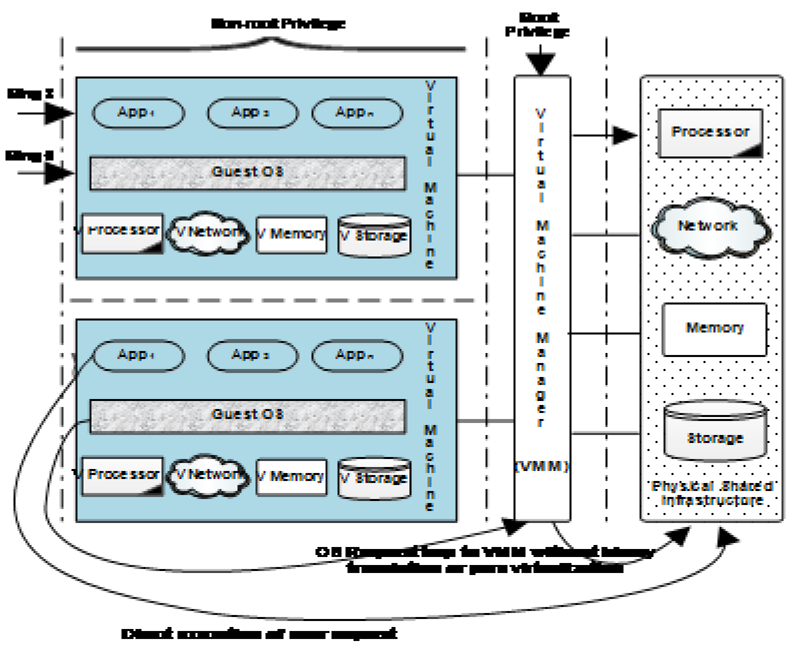
Advantages:

- Ability to use any OS without modifying it.
- Easy to obtain better performance.
- Further decreases binary translation overhead in full virtualization.
- Dispose of OS modification in para-virtualization.

Disadvantages:

- In order to grace hardware assisted feature all x86/x86_64 processors requires explicit support in the CPU (Kumar & Charu, 2015; Singandhupe & Sethi, 2016).

Figure 14. Concept of hardware-assisted virtualization



TYPES OF VIRTUALIZATIONS

As per resource utilization, virtualization process can be classified into subsequent ways:

OS Virtualization

In OS virtualization, the system of Service consumers present at their desk while the system's main OS is hosted somewhere else server (virtual environment). In an operating environment for application having OS, libraries', specific system's data structure, or other environmental settings are kept intact so that application will not observe any disparity from that of real-world scenario. Virtualization layer on top of the OS creates a separation for each virtual machine on demand (Nanda, 2005; Pearce et al., 2013).

Memory Virtualization

In memory virtualization, to achieve expended contiguous memory we aggregate physical memory across different severs into a individual virtualized memory pool. For example, Microsoft Windows OS permits some chunk of disk storage to server in a form of RAM extension. Modern x86 Processor supports main memory virtualization.

Storage Virtualization

It is a kind of large single combined amount that extent multiple devices, which gives a different logical view of physical storage. The most common example is Storage Area Networks (SANs), often used for disk images from system virtualization. In a Single virtualized storage environment, different users get private and public cloud storage offered by company like DropBox (hosted outside).

Network Virtualization

Network virtualization can be of two types, one is External network virtualization: It impose a logical view of a physical network used in Virtual Private Networks and in Virtual Local Area Network i.e. (VPNs) and (VLANs) respectively. Another network virtualization type is Internal: where pseudo network devices has been used in a "network in a box", this network devise act as physical devices which controls communication between virtual machine software.

Application Virtualization

Essential server installs single virtualized application and the requesting users obtain different virtualized components of application. Application has its own copy of component like own registry files global objects which is non-sharable. Each user has a virtual copy of its application so doesn't require to install individually and modify it as per its necessity (Chandrasekaran, 2014; Pearce et al., 2013; Ruest & Ruest, 2009).

DOCKER-CONTAINER DEVELOPMENT

So far we have discussed that how the cloud computing is evolved, importance of its different deployment and service models and also put some light on core architecture and associated technology like SOA and Virtualization in cloud computing. This segment is referring to another approach i.e. Docker container, which is a management service initially release in March 2013. The most fundamental feature of DOCKER is (Develop, Ship, Run anywhere) to facilitate the developers to develop an application, ship them into a container so that they can be deployed anywhere (desktop, android, iOS, openstack, Bluemix, cloud).

As we have seen there are challenges in infrastructure, platform and software build-up that's why we try to migrate from our in-house installation to some service provider installation, another issue is which is coming-up now a day due to the development of software and other thing are redeployment, reconfiguration or recompilation of the software when we want to ship one package to another environment. Therefore, this motivation actually brings the devices that are available now a day in market which are much resourceful to run an application. Other side of this is that we have different collection of applications development across the thing. So, achieving the portability to migrate these applications from one surrounding to other is becoming a major challenge. When Container technology came into the picture, we get able to bundled-up the applications along with its associated dependencies into a container and push it as a single container to the other type of environment. Once the container prepared, application get started working. In such cases cloud is appeared as a platform to host this container.

Though in some literature or in forum people says that container is a technology is something which is contented to the cloud, but this is not actually true, actually cloud is enhancing its capability by adopting this container technology. Docker is one such container that becomes so popular. Docker becomes slang for modern world development, specifically in the face of Agile–based projects (Nptel.ac.in, 2021; Ruest & Ruest, 2009).

Docker-Features

- Docker reduces the size of development, gives smaller footprints of OS system through the container.
- Software team can develop and operate the applications seamlessly with containers.
- It can be deployed anywhere, whether it is physical or virtual machine or even in the cloud.
- Scalable as it is light weighted.

Usage

Developers consider Docker as a world's software container platform used to knock out "work on my machine" problem while cofunction code with co-workers. Engineers use this technology to manage and run the applications in parallel fashion in an isolated container to attain better computing density. In business, docker is used specially for delivering agile software's more securely.

ADVANTAGES OF CLOUD COMPUTING

Toady CC delivering very trendy services in our day today life, like any picture upload on our Facebook account or knowing the bank account status using smart phone. These entire new common computing services take place with the help of internet connection. There are several advantages that attract so many businesses towards it in order to improve their cash flow, efficiency and many more (Idexcel.com, 2021; SearchCloudComputing, 2021).

Less Cost

There is no capital expenditure on the services. Hardware also doesn't cost much in cloud computing, user just have to pay as per subscription plan. Traditional servers need expensive upgrades that cost much upfront. Cloud service provider gives us the facility to buy more gigs when it is needed and save when we don't.

24x7x365 Availability

Most of the cloud service provider's uptime is about 99.9% which helps users to get applications from anywhere as the cloud is always on.

Security

cloud computing delivers better service than local servers so user not worry about losing data because of any natural disaster or any system damage. User can remotely delete out data from the lost system.

Environmental Protection

Cloud computing offers various organizations to reduce their carbon footprint as they require less physical servers or resources used. This helps companies to downsize their data centres. Cloud computing saves waste of resources and energy.

Automated Updates on Software

A regular update of software including security is provided by server to avoid wasting time on maintaining the system.

Enhance Collaboration

As per the Cloud Security Alliance, most of the users' requests or buy cloud applications with file sharing and collaboration. This collaboration authorizes many groups to virtually exchange information through shared storage.

Easy Control of Document

Document control leads secure business, as we know documents on untrained hands can bring trouble. Cloud computing provided central file storage and real-time collaboration which eliminates 100 versions of single file so it become easy to control one copy.

Streamlined Work

Cloud service providers manages underlying infrastructure, which enables organizations to emphases on priorities like application development.

Better Work-Life Balance

Employee is free to work either from tropical vacation or anywhere and complete their work quickly so that they can spend enough time with family. Employee is not chained to a specific location and device.

HOW CLOUD COMPUTING SUPPORT SMART AGRICULTURE?

We've seen a consistent pattern in the loss of agricultural land and ecosystems around the world.

Climate change-induced extreme weather and a growing global population competing for limited resources are painting a bleak view of the future. Using technological tools, we may be able to change this tendency. Technologies like CC have the potential to be a very useful tool. AgJunction proposed cloud-based system that shares and store data from a variety of precision agricultural controllers on a farm in order to cut expenses and environmental impact. Fujitsu has also launched the "Akisai" cloud for the agri food industries, which employs information systems to assure future supplies of food.

Farmers might also obtain data from predictive analytic organisations through the cloud, able to make exact forecasts as to which harvests are in demand in market segments and adjust production appropriately. They can also get information on climate conditions and other factors that strongly impact production. This well-known technique has the potential to offer agriculture-based knowledge, as well as natural resource management and expertise, directly to consumers not just in a small area, such as in nonstop marketing or shops, but also in a larger area. It will really transform the overall supply chain, which is driven primarily by large businesses but could be turned towards a more transparent and faster network between companies and consumers. The growth of (IoT) and fifth generation wireless network is expected to take farming methods toward the next level. COVID19 has recently garnered more public attention to food safety, which has a favourable influence on market share of sustainable farming. The issue of confidentiality and protection in sustainable farming, on the other hand, is now more important. Because smart agriculture necessitates working with vast volumes of data, many of which are delicate, and some of which are even confidential, a data breach could jeopardise user privacy. To obtain detailed information about a plot, soil composition, acceptable cultivars, watering, and fertiliser demands, big data analytics software (SaaS) such as robotics, drones can be employed Cloud computing technology can be used to enhance agriculture growth, food, grain, product, and market circumstances, as well as to guarantee safety of food, increase the nation's Revenue, and disseminate information on agriculture (Choudhary, 2016).

Table 2.

S. No.	Application of IoT	Sensors Used	Measurement (In Values)	Usage
1	Monitoring system for climate/weather conditions	CO sensor and temperature sensors	20.32	Ease of time, reduce the cost of labour
2	Crop management	Ultrasonic sensors	45.66	Increase the demand of water supply on various plants
3	Agriculture based Drones	NDVI sensors	20.56	Increase crop prediction
4	Smart Greenhouse	Light sensors	33.99	Better plant growth
5	Livestock Monitoring	Multiple Connected Sensors	23.34	Save time

CHALLENGES IN CLOUD ADOPTION

Security and Privacy

Security is the primary responsibility while working in or on the cloud. When clients moves in the cloud, many cloud providers convince their customers that their data is safe and won't be accessed and shared with anyone and for they apply state-of-the-art security measurements. Despite that, 100% guarantee can't be achieved. It is obvious to recognize the amount of risk involved while sharing the same infrastructures with others, even though the cloud providers guarantees privacy and security and their logical separation of data and application (Choudhary, 2016).

In cloud computing model, each level whether it is network, host, application or data level has to deal with security issue and also face the dispute of security uncertainty. In order to avoid uncertainty, information entrepreneurs put security issue as a prime concern in cloud computing (Voorsluys et al., 2011; Wease et al., 2018).

Changes in the IT Organization/Changes to IT Policy

The technological shift towards CC and others affects the IT organization in some way There are two aspects in technology shift, first is the occurrence of new skill sets to expand the technology to solve business problem, and the other dimension is that how the technology impact the IT performance. It is necessary to mention that during COBOL era, the versatility and flexibility of the solution was poor, users hardly program and the expectations of the user interface was also assorted. Separate non-automatic training was provided at the time, and users were instructed to tackle the problem using established paths. The speedy changes in technology affect the adoption of cloud technology in IT. Technical revolution also the decomposed old solutions from plugging to give real benefit of cloud technology. It is also needed to manage IT risk in the business (Voorsluys et al., 2011).

Compatibility With Existing Applications/ Integration With Existing Systems

Most of the clients are bounded while using various service models provided by the cloud providers because cloud providers have some limited capabilities that makes application migration quite difficult in some cases, as it demands change in currently stable, on premise applications. Therefore, stepping towards the cloud is less fascinating in this scenario (Wease et al., 2018).

Governance and Compliance Policies

The governance policy, vague compliance policies around cloud computing become roadblock for those companies who want to make investment for adopting cloud but they are afraid of more restricted, confined regulations that might affect their future journey towards cloud (Wease et al., 2018). All major global technological and political powers that have a detrimental impact on the growth of the global cloud should quit exerting political pressure in order for cloud computing to evolve as a universal heritage. For example, Through the Patriot Act, under the anti-terrorism investigations, the US government has certain rights to access information and can issue a “gag order” so that the cloud provider isn’t allowed to tell you that your data is transferred or being accessed.

This US policy affect Canadians in several ways so in the interest of their people, Canadian government ask to stop using computers in the global network that are operating within U.S. borders (Avram, 2014; Mather et al., 2009).

Lack of Cloud Expertise

Cloud computing is fast improving and being embraced, resulting in a significant demand for IT skills in this industry, yet there aren’t enough qualified workers to meet it (Wease et al., 2018).

Justifying Return on Investment (ROI)

ROI measures effectiveness of any investment (Misra & Mondal, 2011) for a cloud ROI is defined as

ROI= (Increaseinprofit+reductionincost-cloudcosts)/cloudcosts (1)

The definition of ROI defined in above equation is based on the cloud capability and different properties of cloud like scalability, flexibility, elasticity etc. Mathematically ROI is function of increase in profit and different cost invested in cloud. Justifying ROI is measure challenge in cloud computing.

The success of cloud computing is determined by the cumulative return on investment. It is necessary to weigh the long and short-term costs, as well as the benefits, of cloud computing (Avram, 2014). Various obstacles encountered during cloud computing adoption (Default, 2021).

Vender Lock-In

In Vendor lock-in state, the user is unable to withdraw, switch, or jump to any other alternate because of some technical or non-technical ledge, this trapping situation also known as provider lock-in (O'Hara & Malisow, 2017). Because of current CC pettiness environment, data, applications, and services are defenceless to the hazard of lock-in (Conway & Curry, 2012). In common, with CC architectures, the risk of vendor lock-in is proportional to the number of hardware and software components offered by the vendors.

Learning Curve

The learning curve depicts the improvement in learning or skill advancement that occurs as a result of experience (Time). The cost of learning is the expense of acquiring new skills and knowledge. According to the conclusions of this survey, it is a big issue for managers when considering cloud adoption. Although the majority of engineers interviewed expressed an interest in learning cloud computing skills, they and their employers will need to invest time and money in training. Learning CC takes time and money, depending on how sharp the learning curve is (Lin & Chen, 2012).

Transition From Legacy Systems

Shifting a traditional style of application to the cloud is not an easy job and come up with several objections. The amount and the complexity of this task can be discouraging for small and medium project aspired to achieve benefits from the assured advantages of the cloud (Aubert et al., 2012; Da Silva Filho et al., 2018). The evolution of the cloud is not limiting the growth of existing legacy systems. Although it helps to modify the way these systems run, deliver services, and maintained (Gholami et al., 2017) there is no common standard for cloud service development (Toosi et al., 2014). Many of the intricacy (Diwakar et al., 2021) lies in the migration process (Shah et al., 2022) are because of: (1) wrong understanding of CC requirements, (2) not enough planning (Gholami et al., 2017).

CONCLUSION

It is true to say that CC is evolved from existing technology paradigms and abolished the problems with the technologies that it developed from, cloud computing includes desired characteristics by integrating various technologies. The potential CC had greatly impact and change the way in which earlier computing was working. Today's new computing paradigm make the users burden free from all logistic findings or administrative work (hardware infrastructure capacity) and rather facilitate them with utility services to focus their innovation. Many business organizations are already providing cloud services and giving momentum to this data intensive computing. During Covid-19, companies unquestionably looked to cloud computing as a reliable method to survive and develop, ushering in a new era of digitization. It is also evident that virtualization amalgamation with cloud providing interoperability, flexibility, scalability also reduces the overall cost and enhances the efficiency of cloud environment. Despite of all that there are number of challenges associated with its adoption like security, social ethical issues, incorporation with existing systems, learning curve, vender lock-in and many more that is figured out and highlighted through this paper.

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