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The Investigation and Challenges of Advanced Applications Using Artificial IoT on Edge Computing

Ara Zozan Miran
Department of Information Technology, College of Engineering and Computer Science, Lebanese French University, Erbil, Kurdistan Region, Iraq
ara.zozan@lfu.edu.krd

Halmat Ayub
Department of Information Technology, College of Engineering and Computer Science, Lebanese French University, Erbil, Kurdistan Region, Iraq
Halmat@lfu.edu.krd

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ABSTRACT

The rapid development of Internet-of-Things (AIoT) systems that assess and respond intelligently to environmental stimuli without human participation has been substantially facilitated by the combined integration of AI and the IoT. However, the volume, velocity, and validity of data and catastrophic transmission latency make it difficult or impossible to process huge volumes of data on the cloud. Edge computing is a viable solution for these pressing problems. In the beginning it defines certain broad terms like "Internet of Things," "artificial intelligence," and "edge computing." Informed by these ideas, it investigates the broad architecture of AIoT, provides a real-world AIoT example to show how AI can be implemented in the real world, and analyzes promising AIoT use cases. In the other side, a general look at the state of the art in AI model inference and training at the network's edge have been showed. At the end, the remaining problems and potential future developments in this field are discussed in details. AIoT will also be accompanied with concerns such as security, data privacy, and ethical difficulties. The purpose of this research is to conduct an in-depth analysis of edge computing and the impact that AI has on the Internet of Things, a machine learning program determine how much data can be sent to the cloud with little loss of quality, AIoT architecture and provides a practical AIoT example to show how AI can be

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implemented in real-world. The analyzing results shows the uses, outcomes, and difficulties associated with AIoT and edge computing.

1. Introduction:

Internet of Things is a term used to describe the practice of electronically connecting commonplace objects to the web. In theory, the IoT necessitates the presence of sensors and communication to other devices; in practice, however, IoT devices need not have their own processing capabilities. (AI) is a system built on statistical models that enables "learning" through feedback. “The purpose of artificial intelligence is to give inanimate objects the ability to evaluate their surroundings and make autonomous decisions based on that evaluation " (Ghosh, 2018). The IoTs serves as a digital analogue to the human central processing unit of the brain and spinal cord, while AI performs the role of the brain. Appliances, wearables, sensors, digital helpers, and freezers all, and other internet-connected devices are examples of IoT "Things.". The IoT is rapidly expanding in today's smart cities, regular households, and numerous businesses. The Internet of Things helps build smart environments by facilitating the development of technologies like smart home automation, smart wearables, smart security systems, and smart healthcare (Din et al., 2019). "Artificial Intelligence of Things" (AIoT) describes the Improvements Integration allows for the achievement of human-machine interactions, as well as data analytics and management, in Internet of Things operations. of AI with the IoT's underlying infrastructure. AIoT mergers (IoT) and (AI) for improving IoT acts. But there are obstacles that must be overcome before the sector can reap the full benefits of AI and the Internet of Things. Some examples of these difficulties include: massive quantities of IoT-based data processing, collection, and mining; all IoT devices' security and privacy; protocols and algorithms; for transmitting data; the state of smart sensing today; and the development of new smart hardware platforms and software frameworks (Deng et al., 2020). A new trend, AIoT, is emerging as a result of the integration of IoT and AI, opening up promising new frontiers for the furtherance of digitalization. (AI) and the (IoT) share some similarities, but there are also key differences. There is an almost infinite number of ways in which AIoT can be put to use; basically, wherever that data analysis can be utilized to provide insight, automate, or improve a procedure. However, a robust network is required to support effective AIoT systems. Edge computing is one of the most promising developments in the field of artificial intelligence and internet of things systems due to the fact that "the old cloud computing paradigm is under tremendous strain as a result of network capacity restrictions and communication delay concerns."(Cui, 2018). Since edge devices process critical information close to its point of origin,, they reduce latency and improve reliability, making them a crucial part of any AIoT system. Since AI models, especially deep learning models, require a great deal of computing and storage resources, They are a viable alternative for the "AIoT" because of their divisibility and the ability to offload compute-intensive tasks to edge servers. This ensures that all the moving parts can function without any hiccups. Data transport across the network backhaul can be aided by AIoT systems., lower network processing and maintenance costs, and enable rapid decision making by co-locating computation with end devices (Mohammadi et al., 2018). The "IoT," "AI," and "EC" technologies are presented in this research, the major goal is to analyze how well cloud-managed EC can facilitate the integration of IoT and AI technology and investigate the challenges well. Seven "AIoT application scenarios" are examined, with an emphasis on tactics that facilitate the efficient deployment of "AI models" in a "end-edge-cloud" collaborative paradigm. In the following section, the research describes theoretical background; third section describes the related works in the same area. The fourth section, followed by the methodology then the Results of Contrasts between Cloud and Edge Computing also the implementation of edge computing . At the end, the paper finalized with conclusion, and references.

2. Theoretical Background:

There are various factors that led to the adoption of new technologies, but one of the most cited by researchers is that consumers' needs prompted new developments. The term "cloud computing" refers to the practice of storing and processing information without relying on a single device or physical location, is useful in some industries and has its own benefits. Over the past decade, cloud has gone from starts a novel business idea to one of the most rapidly expanding industries in the information and technology sector. One of the most alluring features of the cloud paradigm is that it eliminates the need for a company to own and operate a physical location in order to deploy apps and provide services. Cloud computing's ability to scale computing capacity in response to fluctuating demand is also noteworthy (Gillam & Antonopoulos, 2017). By activating this function, resources can be reallocated in response to changing demand. This quality is essential to companies that experience significant seasonality in their customer demand and frequent demand spikes.

In addition, there is leeway in how bills are made. In the past, only well-funded businesses were able to afford the expensive up-front costs of implementing an IT platform or offering some sort of Internet-service to their customers. To accommodate new businesses that may not have the capital to invest heavily at the outset, the cloud now offers pricing models that are more reasonable (Wang., 2017, Dhuria, 2017). Cloud computing is replacing centralized resource access with a distributed, decentralized architecture. When it comes to the traditional "building blocks" of CC, such as "processing," "storage," and "networking," edge computing is a new paradigm that brings these capabilities as close to the end users as feasible. Another option is "edge computing," which is still in its infancy and being promoted in a variety of ways by vendors from different industries. Market participants in the present day include cloud computing service providers, networking organizations, and manufacturers utilizing automation technology. Solutions for "edge cloud computing" can be broken down into "fog computing" and "edge computing" for the sake of simplicity. As a quick recap, the former distributes processing of data to a fog node at the local area network level of the network architecture. A device can then take advantage of the intelligence, processing power, and connectivity features of an edge gateway or appliance. However, it's important to keep in mind that the terms "edge computing" and "fog computing" are frequently used interchangeably. If the computing nodes can be placed geographically close to the data's origin, then the latency of the data's journey to the cloud will be reduced. Use of this benefit is already widespread; some examples include the video game, healthcare, IoT, and streaming media industries. Most clouds are built on top of virtualized infrastructure, which allows for higher hardware utilization densities. When it comes to deployment speed, auto provisioning variability, and overall cloud management, this is one of the technologies that enables elasticity. Now, several vendors offer virtualization environments. In this particular cloud environment comparison, the live migration features were the deciding factor.

3. Related Works:

In the recent decade, cloud computing has emerged as a leading option for deploying applications. “In most cases, this aids in the development of a streamlined, unified infrastructure for storing and processing data” (Zeadally., 2018). Currently in the midst of the fourth wave of digitalization, commonly referred to as the IoT. Devices near the network's periphery, which are part of the IoT system, produce a flood of data. Cloud solutions face new challenges in meeting the unique requirements of these devices for service content. For instance, many safety applications necessitate millisecond-level rendering in real-time. Recently, there has been a push towards edge computing, which is the practice of utilizing dispersed resources at the network's "edge" to move potential points of failure nearest to the data-source. Edge computing has the potential to alleviate some of the problems associated with using the cloud to host Internet of Things applications by reducing the time it takes for data to be transferred, minimizing power consumption, and protecting user privacy. In addition, a hybrid edge architecture that incorporates the benefits of edge-computing and cloud-based centralized processing is possible. However, compared to conventional cloud architecture, this has an effect on the processing of data in IoT applications, making their development even more challenging. In research paper (Sodhro, Pirbhulal, and De Albuquerque 2019) the authors focused on finding the challenges of portable IoT-based devices is the hardest issue with today's industrial evolution and this done firstly by offers FCDAA (Forward Central Dynamic and Available Approach) by adjusting the duty-cycle and transmission power levels of mobile IoT devices while performing sensing, processing, and broadcast duties while taking into account a significant amount of real-time facts. Second, a proposed system-level battery model for portable

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IoT devices is made. Third, an industrial platform with AI-driven edge computing proposes a data reliability model for IoT devices. They suggested FCDAA improves energy efficiency and battery longevity at acceptable reliability (0.95), according to experimental test data. After that in (Makkar, Ghosh, and Sharma 2021) proposed a framework of considers three separate layers, including data gathering services, edge intelligence for web data filtering, and web spam detection. cloud services as well as edge computing services. The goal is to find harmful images. An image's features, such as its mean, image gradient, and entropy, are first retrieved, and the retrieved data is then processed using the suggested framework. The suggested system is validated using deep learning methods. It was evaluated using a real-time dataset that was obtained, and the accuracy figure was 98.77%. By delivering correct information in (D. 2019) about the soil moisture, temperature, humidity, and other factors specific to the field, the suggested model with AI enabled edge computing for smart computing is an on-premises solution for the agriculture field. The AI-enabled Edge provides a practical means of reducing the unexpected failure of the gadgets that provide correct information with very low latency, enabling continuous monitoring and a boost in productivity. According to the data, smart farming with AI enabled edge has a lower power usage and faster delivery times than conventional approaches. The research will continue with an assessment of AI-enabled automation techniques for plowing, sowing, harvesting, and supply chain management in the future. (Fragkos, Tsiropoulou, and Papavassiliou 2020) they proposed enabled artificial intelligence and distributed edge computing framework. By demonstrating that the game is submodular, showing that there is a Pure Nash Equilibrium (PNE) point. In addition, several alternative reinforcement learning approaches (e.g., gradient ascent, log-linear, and Qlearning algorithms) are studied to determine the users' stable data offloading strategies. These approaches explore and learn the environment based on the results of the Best Response Dynamics (BRD) algorithm. Modeling and simulation are used to compare these methodologies' matching results and intrinsic characteristics with one another. Furthered more, (Debauche et al. 2020) the research article suggest AI and edge computing architecture for smart chickens that uses the latest Nvidia

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Jetson Nano features to analyze, verify, and aggregate readings from the Environment Sensing Node and the Nutrition Sensing Node.. Additionally, the Jetson Nano can process images and video captured with a USB HD webcam. In next projects, we'll use video editing and animal chicken analysis to find anomalies in the flock, like abnormal mortality and stress. Lastly, In an intelligent edge, they first explain the security difficulties, then the privacy issues computerized setting. They also give a thorough overview of the ongoing works that help in comprehending how intelligent edge computing maintains security and privacy. Consideration should be given to safeguards against falsifying the training dataset, deriving private information, and attacking learning agents in particular (Nguyen et al. 2021).

4. Methodology:

The (IoT) is becoming increasingly ingrained in our daily lives as a result of recent advances in information technologies. It all begins in the realm of digitization. The first wave was the introduction of computers and related items, the second was the introduction of internet-enabled computers, and the fourth is the introduction of mobile internet and the internet of things. IoT entails the interconnection of everyday objects like smartphones, home electronics, automobiles, and a wide variety of sensors and actuators, allowing for the collection and exchange of a wide variety of data via state-of-the-art communication network technology (Kirsch, C. F., & Ho, M. L, 2021). Sensors and devices in the Internet of Things can be deployed in a wide range of scenarios that don't always match the use cases of conventional computers. Their unusual characteristics help them perform their particular roles and accomplish their distinct goals.

In cloud computing, either information was sent to a hosted service over the internet or information was requested from a hosted service over the internet in order to complete a task. Cloud is the practice of using the network to access and manipulate data (whether it be for storage, perusal, download, or reception) housed in a virtual cloud. The provision of the infrastructure required to analyze and store data acquired from end devices is a significant obstacle faced by the

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IoT (Jain, R., & Paul, S, 2013). It has been proposed that one useful way to host IoT services is through cloud computing. Users benefit from cloud computing because it simplifies their access to shared computing, storage, and communication resources. This is a concept for providing users with quick and easy network access to a shared pool of configurable computing resources on demand, as described by the National Institute of Standards and Technology (such as communications, hardware, software, data, and service delivery) that can be rapidly provisioned and released with minimal management effort or interaction from the service provider. The main purpose is to examined a machine learning program to determine how much data can be sent to the cloud with little loss of quality. Our argument relies heavily on work done at the network's periphery; at the beginning the discussion will be on how edge computing has been defined in the literature. Examining edge-related generic business model variables requires in-depth knowledge of Edge-computing (Verago , Ghaddar., Premsankar ., Di Francesco., 2018). With these ideas, it is better to grasp the complexities of Edge-computing in IoT use cases. The following is a working definition of edge computing and its subsequent description. References to works that attempt to define "edge computing" This is because the definition shifts depending on the context and application, therefore various scholars come to different conclusions. Most academic studies lack even a basic definition of what "edge computing" entails. The benefits of edge computing include reduced demand for costly long-haul connections to data centers and improved response times for latency-sensitive applications (Qi, Q., & Tao, F,2021). It is crucial to have a firewall device in IoT linked to edge devices as data is gathered and processed there. When used, the cloud's storage and network components can provide invaluable assistance to other Internet of Things (IoT) devices, which themselves contain vast troves of useful information. Given the growing importance of edge computing, it's crucial to prevent "edge devices" from becoming a single point of failure. In the event of a primary node failure, network architects must design redundancy and failover mechanisms to prevent catastrophic outages. The market has come a long way in meeting the

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needs of edge computing, and it is quickly becoming standard. As the utilization of real-time applications increases, its significance will increase as well.

4.1 Contrasts between Cloud and Edge Computing:

As a refined form of cloud computing, edge computing shares several characteristics with its predecessor. In addition to its central role in "non-real-time" details preparation, like trade deciding and another area, the most notable features of "cloud computing" are its ability to manage the whole, to prepare a large amount of information, to conduct in depth analysis, and to handle a large volume of data (Bangui, H., Rakrak, S, 2018). To meet the immediate demands of local businesses, "edge computing" concentrates on the area and may play a far better; role in "small-scale," "real-time" brilliantly investigation. Edge computing, on the other hand, might be used for "small-scale" cleverly inquiry and local administrations, making "CC" the more practical option in creating programs for centralized management of massive data sets. In order to better manage assets, edge computing can deliver data closer to the point of origin. Instead of sending everything to the "cloud," information can be stored and managed on-premises. Reducing load on an arrangement greatly improves its utilization efficiency and thus, its transfer speed. The development of intelligent "IoT" relies heavily on "cloud computing" and "edge computing" in the future (Ren et al., 2017). The primary distinctions between "cloud computing" and "edge computing" are listed in Table 1.

Table (1): Major differences between Edge and Cloud Computing

	Increasing demands on network bandwidth	**Real-Time**	**Computation Mode**	**Situation\involved**
EC	Less	Low	Analysis using Intelligence, Scaled Down	Local
CC	More	High	Computational centralization used on a massive scale	Global

Despite this, "edge computing" will not replace "cloud computing" anytime soon (Satyanarayanan, M, 2017). Both should coexist, supplement one another, and grow in an efficient manner so as to facilitate the industry's computerized shift from the perspectives of arrangement, commerce, application, and management. and insights.

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All edge node data must still be abstracted in the cloud for thorough inquiry and better investigation results. That's why "cloud computing" is so crucial to the progress of increasingly sophisticated "Internet of Things" devices.

4.2 Implementation of Edge Computing:

In the following paragraph, the authors compared and contrast three "EC" implementations with respect to their underlying architecture, the nature and location of the hubs that serve as the layer of infrastructure between the cloud and client devices, the services they promise to provide, and the types of applications they are designed to support. Table 2 depicts the "N-tier" architecture, which consists platform of cloud, endpoint devices, and various "Edge Computing" implementations.

Table (2): Edge computing comparison Implementation and End Points

	Edge mobile	**Fog**	**Cloud-let**
Node Locations	Macro Base Station/Radio Network Controller	Differences in the Cloud and in the End Devices	Local/Outdoor installation
Devices of Node	In base stations, there are servers functioning	Switches, Routers, Gateways, Access Points	Data Center in a box
Software Architecture	Mobile Orchestrator based	Fog Abstraction Layer base	Cloudlet Agent based
Situational consciousness	High	Medium	Low
Methods of Entry	Networks for Mobile Devices	The Three Big Ideas in Wireless Technology: Bluetooth, Wi-Fi, and Mobile Networks	Wi-Fi
Proximity	One Hop	Any Number of Jumps	In a Single Jump
Internode Communication	Partial	Supported	Partial

5. Conclusion:

Data explosion and heterogeneity are just two of the problems that arise with widespread IoT deployment. The development of increasingly sophisticated AI technologies offers promise as a means of overcoming these obstacles by facilitating the discovery of crucial data, the creation of reliable forecasts, and the implementation of prompt corrective actions inside the Internet of Things (IoT). Clouds' end-of-the-millennium edge coordination In order to meet the needs of its many customers, AIoT can guarantee varied quality-of-service parameters depending on their needs, such as providing services within a range of delay times or making highly precise predictions. Although the edge-2004cloud coordination Furthermore, incorrect functioning or the occurrence of previously unanticipated problems are two ways in which AIoT could pose a threat to human life. On the other hand, having Internet-connected household appliances (smart lights, automobiles, etc.) makes life more convenient, but hackers have an easier time breaking in. This research paper investigated the challenges of advanced applications using Artificial IoT on edge Computing, the results analyzes how well cloud-managed Edge Computing can facilitate the integration of IoT and AI technology and investigate the challenges well as well as a comparison, Implementation and End Points of edge computing showed in this research paper.

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لێکۆڵینەوە و تەحەددیاتی بەرنامە پێشکەوتووەکان بە بەکارهێنانی IoT دەستکرد لەسەر کۆمپیوتەری لێوار

پـوختـە:

گەشەسەندنی خێرای سیستەمەکانی ئینتەرنێتی شتەکان (AIoT) کە بە شێوەیەکی زیرەک هەڵدەسەنگێنن و وەڵامی هاندەرە ژینگەییەکان دەدەنەوە بەبێ بەشداریکردنی مرۆڤ بەهۆی یەکخستنی تێکەڵاوی AI و IoT ئاسانکارییەکی بەرچاوی بۆ کراوە. بەڵام قەبارە و خێرایی و ڕەوایەتی داتا و کاتە شاراوەکانی گواستنەوەی کارەساتبار وا دەکات کە پرۆسێسکردنی قەبارەیەکی گەورەی داتا لەسەر هەورەکە قورس بێت یان مەحاڵ بێت. کۆمپیوتەری لێوار چارەسەرێکی بژاردەییە بۆ ئەم کێشە پەستاندارانە. لە سەرەتاوە هەندێک زاراوەی فراوانی وەک "ئینتەرنێتی شتەکان"، "زیرەکی دەستکرد" و "کۆمپیوتەری لێوار" پێناسە دەکات. بە ئاگاداربوون لەم بیرۆکانە، لێکۆڵینەوە لە تەلارسازی فراوانی AIoT دەکات، نموونەیەکی جیهانی ڕاستەقینەی AIoT دەدات بۆ ئەوەی نیشان بدات کە چۆن دەتوانرێت AI لە جیهانی ڕاستەقینەدا جێبەجێ بکرێت، و کەیسە بەڵێندەرەکانی بەکارهێنانی AIoT شی دەکاتەوە. لە لایەکی دیکەوە، سەیرێکی گشتی لە دۆخی هونەر لە دەرئەنجامدانی مۆدێلی AI و ڕاهێنان لە لێواری تۆڕەکەدا نیشان دراوە. لە کۆتاییدا بە وردی باس لە کێشەکانی ماوەتەوە و پێشهاتە ئەگەرییەکانی داهاتوو لەم بوارەدا دەکرێت. هەروەها AIoT لەگەڵ نیگەرانییەکانی وەک ئاسایش، نهێنی داتا و کێشە ئەخلاقییەکان دەبێت. مەبەست لەم توێژینەوەیە ئەنجامدانی شیکارییەکی قووڵە بۆ کۆمپیوتەری لێوار و ئەو کاریگەرییەی کە AI لەسەر ئینتەرنێتی شتەکان هەیەتی، بەرنامەیەکی فێربوونی ئامێر دیاری دەکات کە چەند داتا دەتوانرێت بنێردرێت بۆ هەور بە لەدەستدانی کەمی کوالیتی، بیناسازی AIoT و نموونەیەکی پراکتیکی AIoT دەخاتە ڕوو بۆ ئەوەی نیشان بدات کە چۆن دەتوانرێت AI لە جیهانی ڕاستەقینەدا جێبەجێ بکرێت. ئەنجامەکانی شیکاری بەکارهێنانەکان، دەرەنجامەکان و کێشەکانی پەیوەست بە AIoT و کۆمپیوتەری لێوارەکان نیشان دەدەن.

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التحقيق والتحديات المتعلقة بالتطبيقات المتقدمة باستخدام إنترنت الأشياء الاصطناعي على الحوسبة المتطورة

الملخص:
تم تسهيل التطور السريع لأنظمة إنترنت الأشياء (AIoT) التي تقيم وتستجيب بذكاء للمحفزات البيئية دون مشاركة بشرية إلى حد كبير من خلال التكامل المشترك بين الذكاء الاصطناعي وإنترنت الأشياء. ومع ذلك ، فإن حجم البيانات وسرعتها وصلاحيتها والتأخير الكارثي للإرسال يجعل من الصعب أو المستحيل معالجة كميات ضخمة من البيانات على السحابة. تعد الحوسبة المتطورة حلاً قابلاً للتطبيق لهذه المشاكل الملحة. في البداية تعرف بعض المصطلحات العامة مثل "إنترنت الأشياء" و "الذكاء الاصطناعي" و "الحوسبة المتطورة". بناءً على هذه الأفكار ، يبحث في البنية الواسعة لـ AIoT ، ويقدم مثالًا حقيقيًا للذكاء الاصطناعي AIoT لإظهار كيف يمكن تنفيذ الذكاء الاصطناعي في العالم الحقيقي ، ويحلل حالات استخدام AIoT الواعدة. في الجانب الآخر ، تم عرض نظرة عامة على أحدث ما توصلت إليه التكنولوجيا في استدلال نموذج الذكاء الاصطناعي والتدريب على حافة الشبكة. في النهاية ، تتم مناقشة المشاكل المتبقية والتطورات المستقبلية المحتملة في هذا المجال بالتفصيل. سيصاحب الذكاء الاصطناعي للأشجار أيضًا مخاوف مثل الأمان وخصوصية البيانات والصعوبات الأخلاقية. الغرض من هذا البحث هو إجراء تحليل متعمق للحوسبة المتطورة وتأثير الذكاء الاصطناعي على إنترنت الأشياء ، ويحدد برنامج التعلم الآلي مقدار البيانات التي يمكن إرسالها إلى السحابة مع فقدان قليل للجودة ، وبنية AIoT ويقدم مثالًا عمليًا للذكاء الاصطناعي AIoT لإظهار كيف يمكن تنفيذ الذكاء الاصطناعي في العالم الحقيقي. تُظهر نتائج التحليل الاستخدامات والنتائج والصعوبات المرتبطة بـ AIoT والحوسبة المتطورة.