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A Study of Edge Computing and its Impact on Network Services in Nigeria

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Abstract: ***Edge computing is a distributed computing paradigm where client data is processed as close as feasible to the source at the network's edge in the twenty first century, Due to the rapid growth in the amount of data exchanged globally especially in smart city applications like autonomous vehicles. In Nigeria a lot might have experienced a slight lag now and then when watching a sporting event live in Nigeria, It can be a little unpleasant when a player's video freezes right before he is about to shoot and then resumes to show him celebrating with his teammates and also most of the Nigerians pictures themself driving a self driving vehicle through a hill's winding curves. they most likely would feel much more than just dissatisfaction if the car turned away from a cliff's edge a second too slowly, They may feel a little on edge in each situation to varied degrees. However, both of these scenarios are possible due to a phenomenon known as "latency," which to that advancements in this area can hasten the economic progress of a country. In this case, this review article is focused on highlighting the study of edge computing and the key attributes of Edge computing that can be used to address emerging markets use cases, the impact, the crises of network service on businesses in Nigeria, and most recent trends on edge computing in the research field.***
Keyword: Edge computing, Cloud computing, Mobile edge computing, Industrial Internet of Thin, Latency .

I. INTRODUCTION

The proximity to the end user is referred to as edge in this context. The ability to process data at the device where data creation and consumption are occurring is the definition of edge computing. This is utterly different from cloud computing, which involves processing and storing data in a single site that may be thousands of kilometers distant. The device itself does the computation as it examines the produced data. Edge computing sorts the created data and determines which ones require an instant reaction, as opposed to sending all of it to the cloud and data center[1]. Such features prevent the widespread use of cloud computing, primarily because it experiences WAN delays, traffic jams, and expensive large bandwidth allocation. Due to these difficulties, edge computing brings a new paradigm, were it was adopted. Edge computing uses equipment such wireless routers, base stations, and gateways to create an intermediary layer between the cloud and the edge of the network in an effort to solve the problems associated with cloud computing. Edge computing nodes (ECNs) are the technical term for these gadgets, which provide cloud services like processing, storage, networking, and management. By handling some processing requests locally, edge computing aims to limit the amount of data that is transferred to the cloud for processing and calculation. This data just needs to be stored locally, not in the cloud. The edge layer enhances Geo distribution, mobility support, and latency for real time applications[2]. In mature countries like the US and the UK, edge computing usage has become standard, while in emerging economies with a concentration on South America, it is becoming increasingly popular. Edge is viewed as having the potential to contribute to economic progress in emerging nations like Nigeria. This pledge to serve the emerging market with new development services. The majority of emerging market use cases cannot be used in Nigeria due to certain restrictions. Constraints on driving are typically caused by economic issues. But cost effective approaches brought forward by edge computing are encouraging emerging markets to adopt it. This study investigates edge computing strategies that can be used to handle use cases in emerging markets.

Edge computing can reduce costs, increase speed, and prevent latency in the operations of the devices in which it is installed by bringing this processing closer to the IoT device. Utility, mining, and manufacturing are just a few where IIoT is beginning to play a bigger part in improving industrial operations. Agriculture is among the oldest businesses in the world, but it is quickly embracing IoT as a tool for automation and process management. Smaller, less effective implements are being replaced by larger, more powerful machines with GPS based autonomous steering, and high tech precision equipment sensors convey information to help enhance agricultural output, lower operating costs, and secure both resources and assets[3].

However, highlighting the recent use of edge computing in some companies such as Apple, Dell, Amazon, and many others, besides showing how the existing platforms in the market use edge technology, is also important, with the aim of exploring the business related benefits which can be achieved using edge technology.

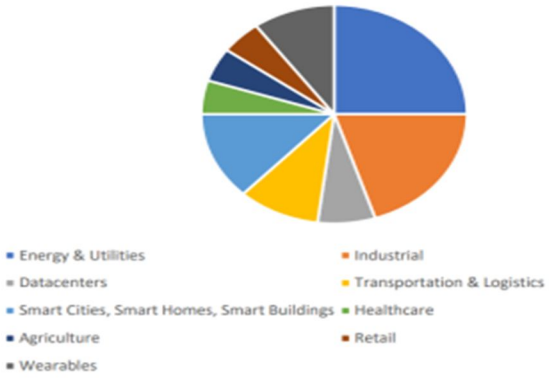

Figure 1. Global edge computing market share by industry vertical, 2020

II. EDGE COMPUTING

At the edge of the network, which is where the data is generated it enables computations to be carried out close to the location where the data was produced. It has both upstream and downstream streams. Upstream refers to the direction were the data is traveling in from the IoT device (the data source) to the cloud. The IoT services are served by this stream. By downstream, it mean that the IoT devices are receiving data from the cloud. The cloud services are served by this stream. For the Edge and cloud paradigms to function, both of these streams are essential. Any network resource having processing power in the line of sight between an IoT device and the cloud is referred to as a "edge." How edge computing actually operates in practical situations?. In cloud computing, the data produced by IoT devices is quickly transported to a centralized database that is located in the cloud, where it is analyzed and stored[4]. The central server responds back to the device appropriately if an action is necessary as a result of the received data. The time it takes to send the data and receive the response is normally under a second, but there may be occasions when the response from the cloud is interrupted or delayed because of network anomalies or a glitch, a sluggish internet connection, or because the data center is far away.

III. EDGE COMPUTING PARADIGM

The Internet of Things (IoT) and end user devices are both data consumers and creators. These include all currently available smart products, such as smart phones, watches, automobiles, parking systems, smart lights, smart speakers, homes, and TVs. Computer systems, smart cameras, etc. The edge can be made up of devices like gateways, routers, tiny servers, and micro data centers[5]. They can use the cloud to obtain information and services while simultaneously working on computer chores. Service delivery, computational offloading, IoT administration, data storage, data caching, and data processing are all performed at the edge. The Edge must be built with dependability, security, and privacy protection in mind in order to efficiently meet the criteria.

IV. OVERVIEW OF RESEARCH WORKS CITED

The following subsections provide a summary of current cutting edge developments in research, business, and technical platforms. It becomes apparent that a variety of edge platforms are currently in use on the market, and many businesses have begun to move their operations to the edge by utilizing stronger servers, gateways, and other technologies. The selection of these use cases is influenced by emerging market factors that facilitate deployments. The purpose is to highlight how edge computing technology may be used to address social challenges in emerging markets. In order to increase business benefits, our goal is to emphasize important requirements and crucial concerns that edge computing in emerging markets may answer. The most frequently referenced contributions among works included in the following which are:

A. Agriculture with Intelligence and Precision

By the year 2050, the world's population is expected to reach an astounding 9.7 billion people, according to UN forecasts. A population of this size presents many difficulties, particularly in light of the current food production problem. In order to prevent famine in the near future, the UN Food and Agriculture Organization estimates that global food production must increase by at least 70% over the next few decades [6].

In addition, the UN estimates that despite the use of around two million tonnes of pesticides each year, about 20–40% of the world's crop harvests are lost to pests and illnesses [7]. However, the emergence of farming methods made possible by cutting edge technology like the internet of things (IoT), edge computing, machine learning (ML), and artificial intelligence (AI) allows problems with the UN projected study to be addressed. About 70% of the agricultural produce is used as intermediary goods in the sector in emerging economies like South Africa where agriculture is important. As a result, agriculture is a vital industry and a significant driver of economic growth [8][9]. Because of this, adopting the concept of smart farming is essential to increasing the contribution of agriculture to the national gross domestic product (GDP). With smart farming, farmers may be able to use less agrochemical by spotting crop competitors earlier to enable precise chemical application or pest extermination. Intelligent technology like robots and drones may help farmers do this. Aside from that, IoT cameras can be put on drones, which can then be used to monitor farms in real time, spot issues, and alert the farmer[10]. These techniques make it simpler for farmers to manage crops and identify fungal illness. Small holding farms can benefit from the adoption of edge computing technologies by having access to powerful technical analysis tools for generating field based recommendations and decisions. All this intelligence can be achieved at low cost IoT solutions[11]. This makes even possible for well established farmers to share their data analysis to emerging farmers. This analysis could be provisioning of understanding of the appropriate conditions for an efficient yield of crops. By these techniques, even small farm business will be well established, and improve the agriculture economy to contribute more to the country's GDP.

B. Optimal Server Positioning for Mobile Edge Computing

The difficulty of executing mobile edge computing away from the primary central system design, as well as of reducing message latency and transmission response times across the network, has lately begun to receive research attention. In [12], vLi and Wang examine the issue of placing edge servers and offer a sophisticated method in which the edge server placements are optimized to increase server usage while also lowering the number of servers operating in the idle state. The authors use the assumption that the mobile edge network operates as an un directed graph G = (V, E), where V is the collection of edge nodes that may serve as the locations of edge servers, and E is the communications between them.

C. Data Transfer Security Through Edge Networks

The security of data transported across edge networks is a key new research area[13] investigates the security of data transferred between domains utilizing edge computing technology. The major security ideas that should be taken into account when protecting edge computing networks are introduced by authors Alrowaily and Lu u. Since all components of edge computing networks speak with one another and exchange large volumes of data, protecting users' personal information is one of the most serious difficulties that has arisen. The following concepts should be taken into account when managing edge network privacy, according to this paper: anonymity, pseudonyms, unobservability, and linkability

V. WHY AND THE BENEFITS OF EDGE COMPUTING

many people asked why using edge computing, in a nutshell is because the edge computing have (a) Low bandwidth demands (b) low energy demands (c) improved privacy (d) Smart device transformation from data consumers to data creators.The advantage of edge computing is that it offers a number of benefits over traditional cloud based computing by placing the calculation power close to the data source, To encourage the wider use of edge computing, particularly for use cases related to emerging markets, rather than just as a technology to alleviate the limits of Cloud computing. To demonstrate why edge computing is a better choice than cloud for emerging markets and also to identify technological aspects that might affect edge computing's uptake in emerging markets.

1) *A Shorter Response Time Lag:* Running Facial Recognition at the edge rather than the cloud has assisted researchers in completing the recognition of any face with a response time that was reduced by 169 to 900ms, meaning that the system was able to recognize the face on a time range that was between 169 and 900ms shorter than that of a cloud system [14].
2) *Less Energy is Needed:* Researchers moved computing activities for wearable technology using cloud lets The response time was cut in half in this instance, to 220 milliseconds. Additionally, it was noted that employing edge lowered energy usage by 30–40% [15].
3) *Greater Data Security:* It is challenging to target each device in order to steal data since with edge computing, the data is only distributed to the devices or at the closest node [16].

4) *Improved app Functionality:* Applications like Facebook, Instagram, and the pictures app provide users greater performance because the data is processed at the edge. Users experience less app browsing while the images and videos are still being uploaded because to the decreased lag time.
5) *Lower Operating Costs:* Edge assists in lowering the cost of data traffic as well as the need for cloud data storage. It aids in cost savings. However, since the gadgets are capable of operating independently, connection problems won't be too problematic
6) *Limitless Scalability:* Contrary to cloud computing, edge computing gives users the flexibility to scale up their IoT networks as needed, thus it is not necessary to refer to the user's available storage.

VI. CHALLENGES OF EDGE COMPUTING

We will talk about a few of the problems and challenges with the edge computing paradigm in this section which are[18].

1) *Programmability:* Is the primary factor determining where computing will take place in cloud computing is the cloud itself. All programming and codes are on the cloud, which is accessible to all devices, and the devices upload their data to the cloud. However, with edge computing, each IoT node or device has its own code or program to analyze and produce the data. They may even have a variety of programs that are incompatible with one another. Therefore, a global programming standard for IoT devices should be established and used.
2) *Naming:* The number of IoT devices that are connected to the edge will grow constantly. Since naming is concerned with identification, data transfer and communication, addressing, etc., identifying these devices is of utmost importance. Therefore, it is necessary to create a consistent and effective naming scheme for edge computing. A dynamic network topology, data security, and privacy protection should all be supported by the naming system in addition to handling the movement of objects back and forth. Scalability should be a further issue that the system addresses because there will be a lot of unpredictable things.
3) *Abstraction of Data:* Although data abstraction has been addressed in cloud computing, it remains a difficult problem in edge computing. Abstraction of data becomes vital and challenging due to the vast number of IoT devices and data sources. A smart thermometer, for instance, would record and report the temperature virtually every minute, but at most, this information would be used a few times each day. Second, although though a security camera records continuously throughout the day, the data is only kept in the database for a short period of time when no one is really utilizing it, after which it is deleted.
4) *Differentiation:* The edge should be able to distinguish between devices with the highest priority and those with the lowest because the number of IoT devices will be enormous. By "high and low priority," we imply that in a smart home setting, essential services like healthcare devices (fall detection, heart rate detection), failure alert, trespass alarm, fire detection, smoke detection, followed by entertainment services like smart lights, should have the highest priority.
5) *Flexibility:* Generally speaking, extensibility refers to expanding the network or integrating new intelligent devices with the existing infrastructure. The addition of new devices to the network ought to be simple and trouble-free for the user. Failure of a device and replacement should be simple and hassle-free.
6) *Seclusion:* The same devices may be controlled by many apps, or we may say that they share the same data resource. For instance, the user may have several applications loaded specifically for controlling smart lights. However, the user should still be able to control the lights via alternative means if a particular program stops working, crashes, or the server is unavailable. In other words, the entire system shouldn't go down.
7) *Trustworthiness:* The main obstacle for the edge computing paradigm is this. Every technological gadget must malfunction. Failure can have a variety of causes, but they are frequently very difficult to identify. For instance, a broken compressor, a faulty power line, or a damaged battery in the temperature controller could all contribute to an AC not working properly. The AC's failure can be detected by the edge network, but finding the root of the problem will be crucial to treating it. EdgeOS should be able to keep track of the system's overall topology, which will facilitate network administration and problem identification.
8) *Security and Privacy:* Every day, enormous data is produced by IoT devices. The loss of the data collected by these devices could result in privacy invasion if they are used in homes or the healthcare industry. For instance, one can quickly determine if a house is empty or occupied based on the readings of its water and electricity meters. If this data get into the wrong hands, theft or a break-in could happen. We use the example of securing a residential Wi-Fi network. Over 80% of the 43,90,000 home Wi-Fi routers still have their default passwords set, and 49% of those routers are unsafe [19][20]. The immediate requirement is to find and use more effective tools. which will help protect data privacy and secure the data.

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VII. HOW DOES EDGE COMPUTING WORK?

We can use any smart device currently on the market as an example to demonstrate how it functions in real life. Every IoT sensor generates enormous amounts of data each second. The data is immediately sent to the centralized, uniform cloud database in the event of cloud computing, where it is processed and stored. After receiving and reviewing the collected data, the central server will determine whether any action is necessary and send its response back to the device. Even though the entire procedure usually takes under a second, there may be times when the response is interrupted or delayed[21]. This could occur as a result of a network issue, a shaky internet connection, or just the fact that the data center is too far away from the device with edge computing, you are no longer required to transfer the data collected by IoT sensors anywhere. Data processing is done by the device itself or the closest network node (like the router), which is also capable of acting appropriately if something has to be done.

VIII. ADVANTAGES OF EDGE COMPUTING AND REAL TIME CASES

A. Enhanced Information Security

Edge computing can assist you in securing your networks and enhancing overall data privacy while IoT technologies are an ideal target for cyber attacks. It's challenging to bring down the entire network or compromise all of the data in a single attack due to the decentralized nature of the data, which is scattered across the devices where it is produced. Regarding GDPR compliance, this strategy is likewise preferred: the less sensitive data that is sent across your network and stored in your cloud, the better.

B. Improved app Functionality

The data must travel back and forth between the device and the data center, as was already established. You can decrease lag time and enhance the overall performance of the program by storing and processing the data close to its source. As a result, you may instantly and without delays study the data.

C. Lower Operational Expenses

You don't require a lot of cloud storage when the majority of the data is stored and processed "at the edge." Additionally, you can filter out the extraneous data and backup only the pertinent information. Your infrastructure costs will consequently unavoidably decrease delays.

D. Enhanced Business Dependability and Efficiency

More effective business operations are the result of less data flow and cloud storage. Additionally, unlike with other IoT items that rely on the cloud, connection problems won't be as troublesome. This is because your devices may operate independently, without an internet connection.

E. Endless Scale Ability

With edge computing, as opposed to cloud computing, you may extend your IoT network as necessary without taking into account the available storage (or its costs). Edge computing truly shines when it comes to time-sensitive operations as a result of the aforementioned advantages. According to McKinsey, the sectors having the greatest edge computing use cases are energy, retail, healthcare, and utilities, as well as travel, transportation, and logistics.

IX. HOW EDGE COMPUTING CAN HELP NIGERIA

A. Autonomous Vehicles

Self driving cars represent one of the important IoT edge computing use cases. In Nigeria most of the people having alot of problems with internet when trying to make used of there autonomous vehicle and its a big issues.

A moving vehicle simply cannot rely on a remote server to decide if it needs to stop when there’s a pedestrian crossing the road in front of it.

The decision needs to be made immediately. The data has to be processed on the spot, regardless of the internet connection. Plus, vehicles (while on the road) can communicate with each other more efficiently because they don’t need to send data about accidents, weather conditions, traffic or detours to the remote server first. If this can be address the market for self driving vehicles will increase in Nigeria as a result of edge computing.

B. Healthcare Devices

One more practical case for edge computing lies within the domain of health monitors and other wearable devices. When used in tel medicine for keeping track of the patient's chronic conditions, they can become real life savers. But Nigerians hospital don't even used the healthcare devices because of the respond of the machines and devises is very low the heart beat of a person can go down without the devices notify the doctors due to network issues. For example, a heart rate monitor capable of analyzing health data independently, can instantly provide the necessary response to alert caregivers when a patient needs their help. Robot assisted surgery is another use case for edge computing in healthcare, especially when every nano second can mean the difference between life and death. These robots need to be able to analyze data on their own in order to provide assistance in surgery safely, quickly and accuratel.

C. Security Measures

Any security system should have quick response times to security risks. For these reasons, edge computing for surveillance systems makes sense. Because Each year, $450 million is spent by companies, banks, and other financial organizations, as well as government bodies, to store or host data abroad. However, Nigeria's major problem now is terrorism and other forms of lawlessness, Every element of economic, social, cultural, and political life is overshadowed by terrorism. It creates instability and shatters the calm and harmony. It is detrimental to commercial and economic growth, making it one of Nigeria's largest problems. Boko Haram, the train bomb that occurred on the Abuja Kaduna line, the massacres in Borno, etc. are examples of these criminal acts in Nigeria. According to the World Bank, entails the hardware, software, networks, media, and services for gathering, storing, processing, transmitting, and presenting information (speech, data, text, and images). According to Mustapha Ibrahim Danbirni, the use of ICT tools has helped several nations combat terrorism and other criminal issues. These methods, however, can only aid Nigeria as a whole in reducing criminal activity if its network is sufficiently strong. Security agencies in Nigeria can set up a surveillance system using ICT to keep a close eye on the activities of people, groups, organizations, and institutions suspected of engaging in illegal activity or capable of causing a breach of security. Some of these tools include closed circuit television (CCTV) cameras, surveillance cameras, social network analysis, biometric surveillance, and others.

As a result, cameras with on device video processing may detect motion, identify trespassers, and alert users to such activity right away. In order to reduce bandwidth and cloud storage while improving response speed and accuracy, these cameras use less raw data to process instead of transmitting vast amounts of data to the servers. Traffic lights and wind turbines don't need to constantly connect with the cloud, and they may even have the option of becoming completely independent, which is another use case for edge computing. Streetlights are able to create a self sustaining, autonomous system cloud by communicating with one another directly as opposed to via a separate cloud.

D. Precision in Agriculture

Agricultural production can be improved in terms of quality, quantity, sustainability, and cost efficiency through farming. With the aid of these tools, farmers can determine the best seeds to use, the quantity of fertilizer they need to apply, the best time to harvest, and the anticipated crop yields. Farmers can monitor sensors that can be used to determine soil moisture, crop growth, and livestock feed levels, among other crucial tasks, by implementing IoT. Furthermore, connected harvesters and irrigation equipment can be remotely managed and controlled by the sensors. Farmers can use certain IoT platforms in the agriculture sector to smart sensors in agriculture don't need to turn to the central server to decide when they need to water the plants nearby or add fertilizers. They can easily perform the routine tasks on their own and sync with the main cloud once in a while.When deciding when to water neighboring plants or add fertilizer, agricultural smart sensors don't need to consult a central server. They can easily complete the usual activities on their own and occasionally sync with the main cloud.

X. DISCUSSION

The primary learning from the review of the presented are summarized in this Section. It is evident that the ETSI defined network architectural idea of mobile edge computing is evolving as paradigm that will enable cloud computing capabilities and an IT service environment to go to the edge of cellular networks and, more generally, to the edge of any network. The theory behind this is that network congestion may be greatly minimized and application performance can be much improved by running apps and carrying out relevant processing chores close to the end user. In this situation, the best server placement enables up to a dozen percentage points better data traffic management and a considerable decrease in power usage. Edge computing, which allows client data to be processed as near to the original source as feasible, is essentially a distributed information technology architecture.

By 2023, the Business Insider Intelligence Service predicts that 12 million agricultural sensors will have been installed worldwide, with a 20% annual increase (Meola, 2021). In the age of IoT, clients are becoming lighter in nature. The market for "smart agriculture" was projected to be valued USD 13.8 billion in 2020 and increase to USD 22 billion at a CAGR of 9.8%. 2025. (Meola, 2021). High-speed wired networks are progressively replacing robust wireless connectivity in IoT devices and the network environment. Due to users' demand for real time and context aware service delivery in IoT applications, the emphasis is gradually shifting from the cloud to the edge (Ren et al., 2017). Furthermore, centralizing resources increases processing lag times, bandwidth consumption, and average network latency. In fact, because a single server point may handle so much data, backbone networks and cloud servers may become overloaded (El-Sayed et al., 2017). Nigeria's network is currently too slow for users to even call or chat, which affects many business owners. However, the implementation of edge computing will improve the country's economic situation. Now Doctors are increasingly using electronic records in place of paper patient notes, and the availability of electronic records makes it possible to analyze this data in order to improve healthcare delivery. Hospitals and HMOs can use edge computing to support the collecting and analysis of patient information, with the resulting data directing both patient care and budgetary planning. Patients can also receive healthcare information to promote better lifestyles and lessen the need for frequent or protracted hospital stays.Edge computing can be used in manufacturing to monitor operations, utilizing real-time analytics and machine learning to spot production mistakes and improve product quality. Edge computing can make it possible to add different kinds of sensors to the plant that will collect and analyze data about the production procedures, the output of the various production stages, the quality of the final product, and the stock levels for production inputs. This information can assist enterprises in producing accurate production supply and output forecasts as well as in streamlining the manufacturing process to reduce waste and boost efficiency. According to recent data, the agriculture industry would continue to make up a sizable portion of Nigeria's GDP, or over 25% of GDP in 2021. Therefore, it continues to be the foundation of the Nigerian economy, and edge computing can aid in raising the sector's output, profitability, and GDP contribution. Farmers may track soil quality, crop development, weather and climatic fluctuations, input usage and stock, crop yield, crop quality, and water usage, among other things, with the aid of edge computing technologies. By enhancing planning, farming practices, and output, this information can assist farmers in increasing production. In addition to continuously enhancing crop growing algorithms, the data can assist farmers in anticipating and addressing environmental conditions and ensuring that crops are in top condition when harvested.

Nigeria must give indigenous ICT firms with competitive advantages, such as Internet Service Providers (ISPs), the freedom to deliver dependable and high quality services if it is to improve service delivery. Additionally, there is a need to enhance the development of Nigeria's digital infrastructure through the use of services like data storage and management, edge computing, data backup, help desk IT services, network security, IT consulting, social media consulting, as well as increased socioeconomic education reform and research development. The growth of digital skills and innovation in the ICT entrepreneurial environment will both significantly enhance service delivery.

XI. CONCLUSION

Many Nigerian businesses now keep a fleet of automobiles for use as executive status cars, operational vehicles, and staff buses. By collecting information about vehicle location, speed, road and traffic conditions, weather, and servicing cycles, edge computing can dramatically improve fleet planning and management. Edge computing may significantly increase workplace safety by analyzing data from cameras, sensors, and safety equipment in real time and alerting firms to prospective or existing safety hazards that can then be proactively rectified to reduce accidents. Monitoring compliance with safety rules and establishing a foundation for their revision, as needed, can both be accomplished by enterprises through the tracking and analysis of workplace safety data. The multiple ways in which edge computing can greatly enhance business operations and profitability in Nigeria are vast, and the applications of edge computing in Nigeria mentioned above are just a few of them.

A new technology called edge computing can help with many daily problems related to smart services and time sensitive applications. In order to show whether Nigerian organizations should move their operations to the edge in order to improve business performance and successfully satisfy customer expectations, we present in this article a thorough assessment on edge computing technology from recent research subjects. With the justification that data processing should take place close to the data sources, we attempted to describe the edge computing paradigm and contrast it with the well known cloud computing paradigm. The necessity of edge computing was also discussed. We talked about the advantages and some real world applications of the technology. Finally, we talked about a few obstacles to the technology's adoption. The edge computing models appears as an optimized solution for improving rural local and urban businesses. The key role of edge computing can work better for business who intend to share best practices as to improve their economies.

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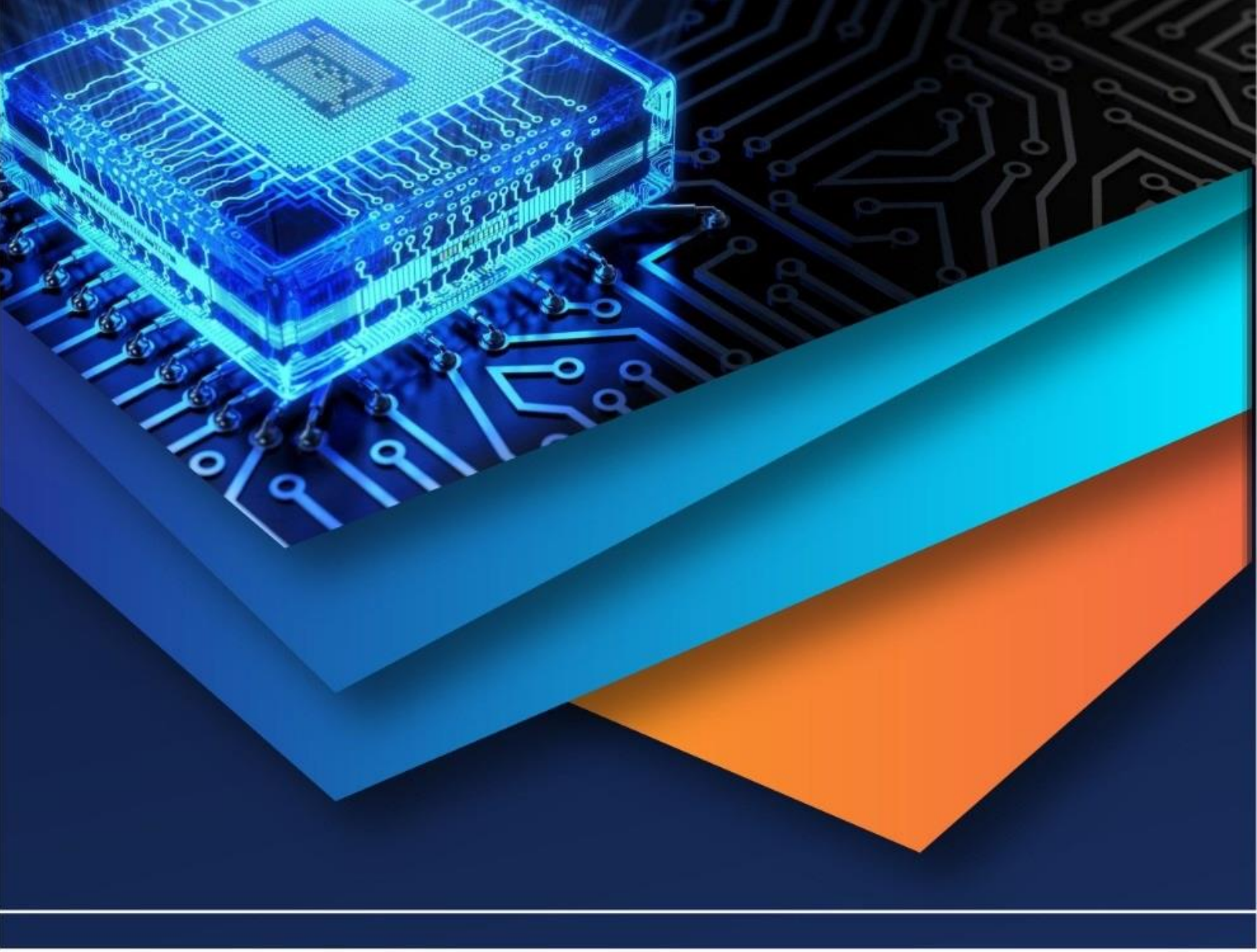

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