AIoT WITH EDGE COMPUTING IN THE 5G ERA

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Abstract

Internet of things (IoT) and Artificial Intelligence (AI) are separate technologies that are changing the way things work in the industry today. However, when combined, their benefits are enormous. IoT connects devices with one another and receives signals like a nervous system while AI acts as like a human brain; data is received, processed and used to make informed decisions that control the whole system. In today's world we have interconnected systems that are emerging from the combination of many aspects such as infrastructure, manufacturing, embedded devices, smart objects, humans, and physical environments.

IoT and AI combined may emerge as the next 'smart revolution'. We are heading to a huge 'Internet of Everything' in today's smart data-driven world. The problem is how to handle the huge data that is generated with a system that consist of a weaker power of computation. IoT with AI can become a huge breakthrough to address this problem. With advancements in 5G and Edge computing, AIoT systems will open doors to a new era of a data-driven world. This is not just about saving money, making things smarter or reducing human effort. This is much more than that – it is about easing human life.

There are also issues like security, privacy of data and ethical issues which will go hand in hand with 'AIoT'. The big picture is not in knowing or understanding how amazing and helpful AIoT can be; rather, it is to see how people perceive it – beneficial or as a threat?

Introduction

5G Era

What is 5G?

The fifth-generation mobile network (5G) is the newest wireless standard. Designed to enable high speeds, superior reliability, and negligible latency, 5G was created to connect everyone with everything and has revolutionized the way machines, objects, and devices will function in the future. Several companies are contributing to bring 5G to life.

5G wireless technology delivers high data speeds with ultra-low latency and is designed for increased availability and leads to a more uniform user experience connecting new industries.

The previous generations of mobile networks are:

- 1G (First generation): Invented in 1980s & mainly delivered analog voice
- 2G (Second generation): Invented in the early 1990s & introduced digital voice
- 3G (Third generation): Invented in the 2000s & introduced mobile data
- 4G (Fourth generation): Invented in 2010 & paved the way for the mobile broadband era

Is 5G available now and how fast is it?

5G is available in plenty of countries now. Compared to 4G, it is being adopted and rolled out due to high speeds and low latencies which have piqued the interest of consumers. Moreover, 5G enables mission-critical applications with much better mobile broadband in terms of 5G and the huge power of Internet of Things (IoT). More countries are expected to deploy 5G networks in 2022 and beyond.

5G is built to handle peak data speeds of up to 20 Gbps. It's about 500% faster when compared to 4G LTE when downloading a full 8K movie.

Advantages of 5G over 4G

5G is must faster

5G can handle much more capacity

5G has significantly lower latency

Artificial Intelligence (AI)

What is AI?

Artificial intelligence is replication of human intelligence in a way that a machine could simply duplicate it and carry out activities, from the most basic to the most complex.

Some applications of AI

1) **Speech recognition:** Converting audio signals to valuable data that can be read and understood by humans. It is also called automatic speech recognition (ASR), speech-to-text, or computer speech recognition. Voice searches are conducted using this technology.

2) **Customer service:** Virtual chat bots are gradually replacing human agents in call centers. Virtual bots provide answers to frequently asked questions, can cross/up-sell products, and suggest/recommend solutions to users. This changes how we think about customer support and engagement across the world. Some applications of chat bots are on e-commerce sites, social media sites, hospitality & travel sites and so on.

3) **Stock trading:** Trading platforms these days are AI-driven, which is then designed to optimize stock portfolios per individual, making customized suggestions to help close millions of deals every day without the need for human participation. This reduces human effort involved while providing accurate data based on previous trends.

IoT

What is IoT?

Internet of Things (IoT) is a network of gadgets connected to the internet that can collect and transmit data over wireless networks without requiring human interaction.

IoT Applications

1) **Manufacturing industry:** From supply chain through delivery, IoT plays an integral part in all stages of Manufacturing. Advanced IoT sensors in manufacturing machines or warehouse shelves, combined with Big Data analytics and predictive modelling, can reduce warranty costs, increase production output, and improve customer experience.

2) **Healthcare:** Data from the Internet of Medical Things (IoMT) – such as wearables and other medically connected devices that track exercise, sleep, and other health habits – is captured in real time using IoT technology. This IoT data enables more precise diagnosis and treatment plans, as well as improved patient safety and results in more efficient administration of care.

3) **Transportation industry:** For transportation and logistics organizations, IoT with geofence-enabled location information and AI implemented across the value chain may bring increased efficiency and dependability. This technology can raise customer satisfaction while also improving

service quality and reducing downtime. The transportation industry also benefits from improved safety and lower costs by controlling and tracking vehicles that are linked and other mobile assets in real time.

4) **Energy:** IoT enables service and product providers to deliver dependable, cost-effective services and goods. Problems are predicted by IoT-connected devices and equipment before they arise. IoT enables distributed grid resources such as solar and wind to be incorporated. Data on behavior, such as that acquired from smart homes, promotes convenience and security while also guiding the creation of personalized services.

5) **Government:** Many real-world challenges, such as traffic congestion, city services, economic development, citizen involvement, and public safety and security, are addressed via IoT applications. IoT sensors are frequently embedded in physical infrastructure, such as streetlights, water meters, and traffic signals in smart cities.

AIoT (Artificial Intelligence of Things)

What is AIoT?

AIoT combines AI with IoT to achieve more efficient operations. It also improves human and machine interactions enhancing both data management and analytics. This integration between AI and IoT is now improving the overall growth of various industries and verticals.

By leveraging all the data from smart connected devices through learning and collective intelligence, AI can augment the value of IoT. Machine learning, deep learning, natural language processing (NLP), and computer vision are some of the key AI approaches to achieve this.

Edge Computing

Data can help deliver valuable business insights and real-time control of critical business processes and operations. Sensors and IoT devices communicate large volumes of data in real time, which is gathered, processed, and analyzed in a single place. In regard to edge computing, it's all about the location. It basically means moving resources such as storage and compute closer to the data source. This mitigates latency as well as bandwidth limits by minimizing the distance between data and resources that support them and reducing network hops. Growing demand for real-time computing and the rapid increase of IoT devices have prompted computing from the cloud to the edge.

Convergence of AIoT and Edge Computing with 5G

Imagine the possibilities if we combine 5G, AIoT and Edge computing; we can unleash the true potential of data. Let's explore how these technologies work when converged with each other.

As discussed above, IoT is a collection of sensors that collect data. Today, the era of digital transformation, each business is motivated to gain an advantage from the data insights that add value to the business by opening efficiently and utilizing machine learning to obtain analytics to drive more revenue.

Post being collected, data is sent to big data centers for further processing, analysis and storage. Data centers have a huge supply of computing resources and high-capacity storage which makes it easier to process data at the data center. AI methodologies such as Deep Learning, Machine Learning, Image Recognition, Predictive Analysis, etc. require huge computational power and capacity. One of the drawbacks of processing data at the data center instead of the source is latency, which manifests in time lost to the business. Organizations need a solution that can help deliver insights much faster.

IoT devices were simple in the beginning, e.g. a temperature monitoring system with a sensor, will trigger an alarm when a temperature rise is detected above the set threshold or limit. As technology evolves, IoT systems have become complex and more intelligent. Now these systems can recognize data patterns and make decisions to maximize outcomes and productivity. Converging AI with IoT integrates AI algorithms with IoT devices to enable automation and machine intelligence without human involvement. These new intelligent devices can deliver new levels of optimization and efficiency in many edge computing applications.

Deep learning models are becoming more precise and efficient using fewer computing resources. AIoT will be beneficial in two ways. First, having intelligent sensors and IoT devices makes the telemetry data process much more efficient. Second, AI enables mission-critical and complicated applications to do stream (real-time) and batch (Big Data) processing at the edge.

To lower the latency required to reach the cloud, companies are transferring their computing workloads from the data centers to the edge. Edge architectures make use of edge computers that are placed near sensors and IoT devices to collect data. Because the data is created locally, the backhaul to the centralized data center is reduced, allowing local apps to function in real-time with remarkable performance. Furthermore, edge computing minimizes the quantity of data transmitted to the data center by filtering raw data before sending it away for extra processing. This procedure reduces bandwidth use and saves workloads that rely on data center resources.

While 5G promises to drastically reduce network latency, edge computing eliminates backhaul latency associated with central data centers by placing computation and storage resources at the edge.
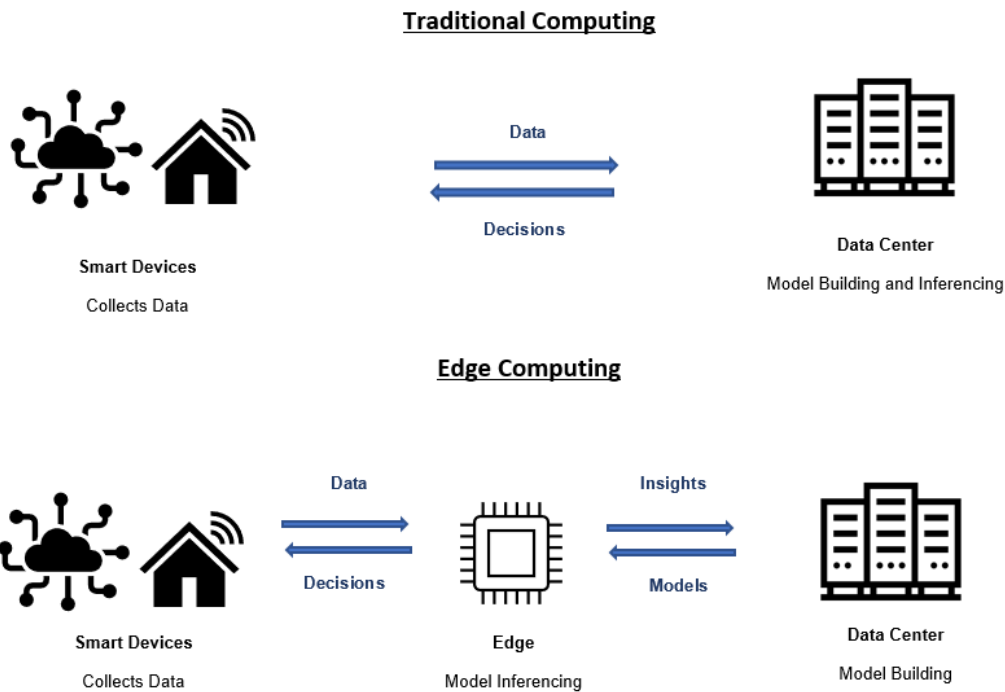
Figure 1: Traditional Computing vs. Edge Computing

Relevant Industry Use Cases

Manufacturing

The edge is the production environment for Manufacturing Industries where sensors, actuators, machines and assembly lines generate data. Edge computing with AI enables them to analyze and act on data to achieve better outcomes. AIoT and Edge computing simplify data management to help improve production operations, and also lets them modernize and scale across various locations. Data obtained from AIoT and edge computing enables manufactures to accelerate decision making with accuracy to increase performance of the machines and business continuity.

With AIoT & Edge computing, manufacturers can turn data into insights to anticipate future trends based on previous data and improve overall efficiency. In the future, AIoT and Edge computing can help manufacturing industries expand locations as well, as they have the ability to consolidate data from their various locations around the globe.

Healthcare

AIoT plays a critical role in healthcare industry. Recognizing patients that require immediate attention is difficult when doctors and nurses have to cater to hundreds of patients' daily. Fortunately, AI and IoT systems can assist in these circumstances. New AI-powered virtual assistants are being used by hospitals to save data of some of their sickest patients. Smart devices or wearables will alert doctors with real time analytics if a patient's health deteriorates. These AI healthcare systems were able to

detect abnormalities that doctors overlooked in some circumstances and enable doctors to remotely monitor patient health and identify which patients require immediate attention, even when they are not on premises.

Transportation

The goal of smart transportation is to improve passenger comfort while increasing safety. The advantages of smart transportation in highways, railways, aviation, and sea transportation has become increasingly evident. For instance, staff can be warned of weather conditions, road conditions, vehicle issues, etc. and take proactive measures to calculate a new route or locate the nearest service station to reduce/minimize delays.

This can prove advantageous to businesses in saving time and money. AIoT with Edge computing improves quality of service, reduces costs, increases safety, and drives overall efficiency.

Sports

AIoT can be leveraged in sports to improve performance, for instance, Motorsports, e.g. Formula 1. AIoT with Edge computing creates new opportunities for sports teams as it provides deeper, real-time insights from data. This enables faster response to events, safety issues, structural changes and real-time decision-making to outperform other teams. Data collected at the edge can also be captured and analyzed later to improve overall performance in the long-term.

Benefits and Threats of AIoT with Edge computing in the 5G Era

Benefits

1) **Low Latency:** Since data doesn't need to be sent to the server and back, there is practically ultra-low latency
2) **Privacy & Security:** Since no data leaves the edge computing device, it reduces the risk of a possible threat, hence maximizing privacy and security
3) **Connectivity:** The introduction of 5G is an added advantage for edge computing due to high reliability and speed of 5G
4) **Automated action**: The device acts by analyzing data and previous trends

Threats/ Disadvantages

1) **Security**: While Edge computing enhances security by reducing the amount of data that has to be safeguarded in data centers, it also creates security risks at each edge network location. Furthermore, because not every edge device has the same built-in authentication and security capabilities, certain data is more exposed to breaches.

2) **Infrastructure costs**: Networking technology is always a significant investment whether you use clouds or scattered edge devices for computing. While a more robust edge network saves money on data center bandwidth, it comes with its own set of expenditures to build and manage edge devices. For maximum performance and local storage demands, edge devices may require additional hardware and software, and costs can quickly climb when they are dispersed across numerous local geographies.

3) **Data Loss:** Sifting through all the data in a cloud data center might be arduous, but the data's central storage offers you the assurance that it will be there when you need it. On the other hand, while edge computing saves space and money on storage, crucial data could be misinterpreted and accidentally lost on an edge device.

Conclusion / Future of AIoT

The number of businesses adopting AIoT-powered solutions is rapidly growing, ranging from manufacturing, healthcare, security, banking, retail and insurance.

AIoT combines the power and efficiency of AI and IoT to solve specific issues with distributed, intelligent systems. Intelligence at the edge will thrive and flourish with the appropriate mix of computers, AI accelerators, storage, and networking.

Businesses can use these cutting-edge technologies to break new ground, identify new growth opportunities, improve their competitive position, and achieve more efficiency and productivity.

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