INTERNET OF THINGS (IoT)

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Internet of things (IoT) with cloud computing

1. Introduction

A new era of data management and communication has been brought about by the convergence of two breakthrough technologies in recent years: cloud computing and the Internet of Things (IoT). This paradigm change has created a wealth of potential for efficiency and creativity in addition to changing the way we view and use technology. This essay examines how cloud computing and the Internet of Things work together harmoniously, examining their mutually beneficial relationship and the combined effects they have on our globally networked society.

2. Internet of things (IOT)

The term "IoT" was first used in 1999 by British tech pioneer Kevin Ashton to refer to a system in which sensors are used to link physical items to the internet. Any physical object on Earth, whether or not it's a communication device, can be considered a "thing". Even while IoT is widely accepted, it lacks a common definition. Various definitions exist, including one stating it involves devices creating, exchanging, and using data without a central computing device. The Oxford Dictionary defines it as an internet-based architecture connecting electronic devices in real-world objects. The RFID groups defines it as a global network of networked objects that a single entity can access via pre-established communication protocols.

At the core of this partnership are three layers of IoT architecture, each playing a vital role in smoothly connecting physical devices to the virtual world.

- **Perception Layer** : This layer acts as a bridge between the physical and digital realms. This layer collects data from various sensors and devices like temperature sensors, cameras, and RFID tags. It serves as the initial point where IoT devices interact with and gather real-time information from the physical environment.

- **Network Layer** : This layer serves as the central communication hub for the IoT ecosystem. This layer facilitates the exchange of data between connected devices, ensuring that information flows securely and efficiently. In this case, cloud computing is crucial because it

offers scalable infrastructure to manage the massive volumes of data produced by IoT devices.

- **The Application Layer** : This layer is the brain of the IoT architecture. Here, collected data is analyzed, leading to valuable insights and informed decision-making. Cloud computing resources are used extensively in this layer for complex computations, storing and processing large datasets, and deploying advanced algorithms that contribute to the automation and optimization of various processes.

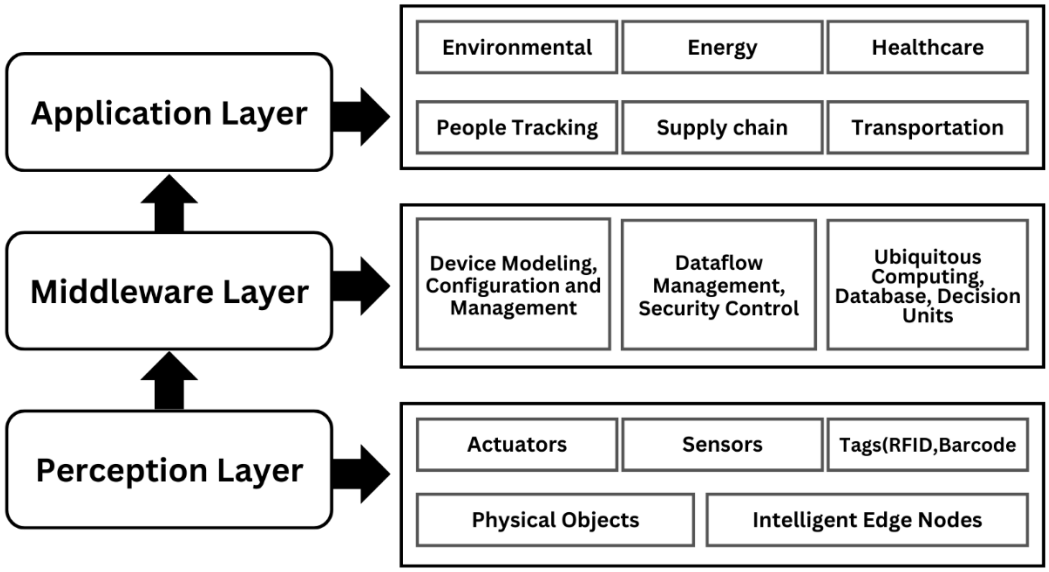

Figure 1. IoT's three-layered architecture

3. Cloud Computing

Cloud computing serves as a centralized hub for managing and evaluating the enormous amounts of data generated by networked devices within the context of the Internet of Things. The cloud serves as a potent backend, offering the processing power and storage required to manage the varied and dynamic types of data created by IoT devices. This section will examine cloud computing and the fundamental features that make it work so well with the Internet of Things.

Some of the primary characteristics of cloud computing are as follows:

- **On-Demand Self-Service :** This type of cloud computing allows users to provision and use computer resources, like processing power and storage, as needed. Because of its scalability and adaptability, IoT systems may adjust to changing workloads without having to make large upfront infrastructure investments .

- **Broad Network Access:** The wide range devices— including laptops, cellphones, and Internet of Things sensors—that may access cloud services over the internet highlights this property of broad network access. This feature improves IoT device connectivity to the cloud, enabling real-time data transfer and teamwork.

- **Resource Pooling:** Cloud companies maximize efficiency by pooling computing resources to serve several consumers. Because it enables devices to dynamically access shared resources, this resource pooling feature is very advantageous for the Internet of Things (IoT) and improves system performance.

- **Rapid Elasticity:** Depending on demand, cloud resources can be quickly scaled up or down. Rapid elasticity guarantees that the infrastructure effortlessly adjusts to fluctuations in the context of IoT, where data influx might fluctuate dramatically, preserving a responsive and effective ecosystem.

- **Measured Service:** Platforms for cloud computing keep an eye on and quantify resource utilization, offering accountability and transparency. This feature encourages cost-effectiveness and appropriate resource management by enabling Internet of Things users to pay for the resources they use.

4. Fusion of IoT and cloud technology

The idea of the Internet of Things (IoT) allows physical objects to be connected to the internet so they may collect, share, and use data. In addition, cloud computing offers resources in a service-oriented fashion via the internet. Combining IoT with cloud computing has resulted in revolutionary applications that leverage the cloud's storage and analytical capabilities. This integrated paradigm, also known as Cloud of Everything, IoT Cloud, CoT , or Web of Things , lacks a commonly recognized term. IoT's capacity to transcend technological constraints by utilizing limitless cloud resources is one of its main advantages. In turn, cloud computing affects IoT by bringing new installations and applications for practical uses. IoT devices send data straight to the cloud, typically because of low processing capability. An intermediary layer in the cloud computing environment makes it easier for apps and physical things to communicate with one another.

IoT and cloud computing integration is the subject of ongoing study, with particular attention on applications like linked cars, smart cities, sustainable buildings, and industrial automation. Future directions for this integration will need tackling issues related to data security, privacy, scalability, energy efficiency, and interoperability. The quest of a successful integration emphasizes the development of important applications and highlights the significance of overcoming these obstacles.

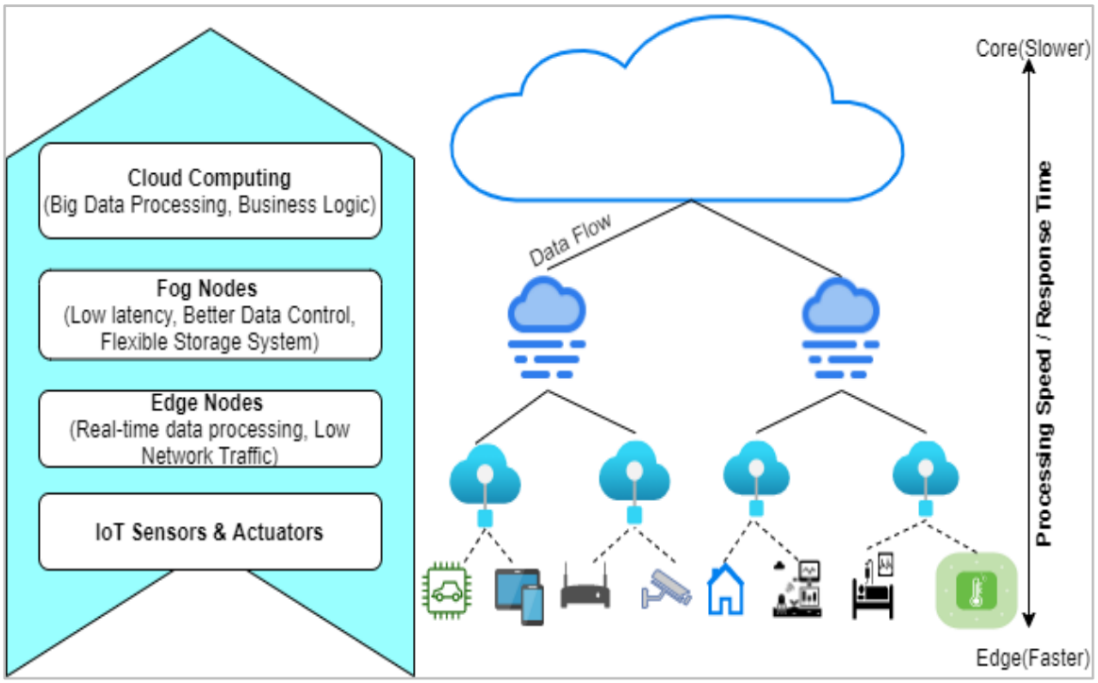

Figure 2. IoT, Edge, Fog, and cloud architecture

5. IoT architecture based on cloud

To establish a cloud-based Internet of Things (IoT) architecture, it is imperative that it can support a diverse array of devices and sensors, along with the data they collect. The architecture should demonstrate proficiency in managing real-time data generated by these devices, offering the necessary processing and analytical capabilities. Moreover, it must meet the security and privacy prerequisites integral to IoT applications.

The structure of an IoT-based cloud ecosystem typically comprises three layers: the physical layer, the networking layer, and the application layer. At the foundational level (the physical layer), the responsibility lies in gathering the requisite data from the surroundings, which is then passed on to the subsequent layer, the network layer. This network layer, in turn, accesses a spectrum of valuable services from the physical layer. Figure 3 illustrates the infrastructure of the cloud-based IoT , highlighting the interplay between these layers.

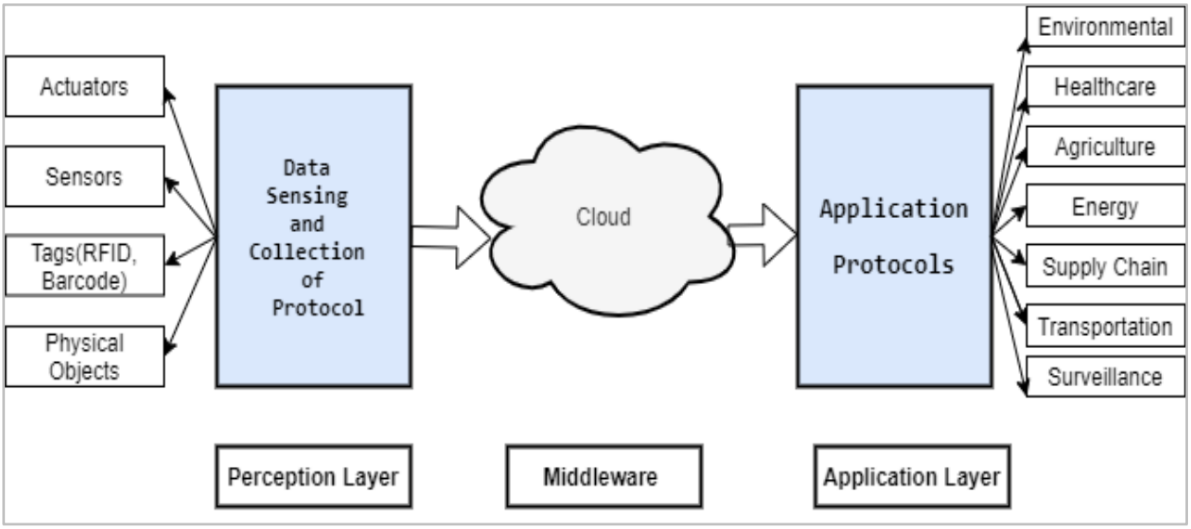

Figure 3. architecture of IoT with Cloud

6. Challenges in IoT Cloud Space

The issues in the world of connecting gadgets to the internet mostly revolve around things like gathering data, linking devices, and storing information. Let me break it down: The data that gadgets collect needs to be sent to the internet (the cloud) so it can be looked at and decisions can be made. To make this happen smoothly, the gadgets and the internet (cloud) need to talk to each other in a reliable way. Also, the place where the internet stores this data needs to be super safe and secure, especially because it's info gathered by gadgets.

7. Real World Examples

Many businesses are taking advantage of the convergence of cloud computing and IoT to transform a range of industries in the quickly changing technology landscape.

1. **Smart Home Automation:**

- IoT devices integrated with cloud computing enable homeowners to control and monitor various aspects of their homes remotely .
- Security cameras, lighting systems, and smart thermostats utilize cloud connectivity for seamless control and data storage.
- Amazon's Alexa and Google Home use IoT devices with cloud integration for smart home automation, allowing users to control and monitor devices through voice commands.

2. **Industrial IoT :**

- Factories and industrial facilities implement IoT sensors and devices connected to cloud platforms for real-time monitoring of machinery and production processes.
- Cloud-based analytics provide insights into equipment performance, predictive maintenance, and overall operational efficiency.
- General Electric (GE) utilizes IoT and cloud computing for its Predix platform, offering industrial solutions for monitoring and optimizing machinery performance.

3. **Healthcare Monitoring:**

- Wearable devices equipped with IoT sensors collect health data, such as heart rate and activity levels, transmitting it to cloud-based platforms.
- Healthcare professionals can remotely monitor patient health, enabling timely interventions and personalized care.
- Fitbit, a company now part of Google, integrates IoT devices with cloud platforms for fitness tracking and health monitoring.

4. **Smart Agriculture:**

- IoT devices like soil sensors and drones in agriculture are integrated with cloud platforms to collect and analyze data on soil conditions, crop health, and weather patterns .
- Cloud-based applications offer farmers actionable insights for optimized crop management and resource allocation.
- John Deere employs IoT devices and cloud solutions for precision agriculture, enhancing farming efficiency and productivity.

5. **Environmental Monitoring:**

- IoT devices deployed in environmental monitoring stations collect data on air quality, water levels , and weather conditions.
- Cloud platforms process and store this data, enabling researchers and authorities to analyze trends and respond to environmental changes.
- IBM's Green Horizons project utilizes IoT devices and cloud computing for environmental monitoring to address issues like air pollution and climate change.

6. **Energy Management:**

- IoT devices in smart grids and energy systems transmit real-time data to cloud platforms for monitoring and optimization.
- Cloud-based analytics help utilities balance energy supply and demand, leading to more efficient and sustainable energy use.
- Siemens uses IoT and cloud solutions for energy management, helping utilities optimize energy distribution and consumption.

7. Benefits of integration IoT and cloud

IoT services include various devices like embedded devices, sensors, communication devices, and mobile devices. If the IoT system doesn't have enough storage and processing power, it struggles to handle large amounts of data from sensors. That's where cloud computing comes in. Cloud computing offers lots of storage, powerful computing, and network capabilities, which help the IoT system deal with these challenges. Cloud resources can adapt to the needs of the IoT system, expanding or shrinking as necessary. Cloud-based Big Data analytics also help in analyzing sensor data.

When cloud computing is integrated with IoT systems, it makes them more efficient and reliable. Combining IoT with cloud computing brings many benefits, such as improved data management and system performance.

1. **Data transmission**
   Sending data between devices becomes easier with cloud-based IoT systems. These systems allow for efficient and low-cost data transmission among different points. Cloud computing plays a role in making the connection, control, and data exchange cost-effective and efficient through integrated applications**.**

2. **Storage**
   The world of IoT involves many devices and sensors that produce a huge amount of real-time data. The storage capacity on individual IoT devices isn't enough for all this data. Moreover, many IoT devices generate different types of data, both structured and unstructured, which regular databases can't handle well. Cloud computing comes to the rescue, providing a solution to the storage challenge. In simple terms, cloud computing consists of a bunch of regular computers with a lot of built-in storage. With cloud-based IoT systems, users can store their data and access it from anywhere via the internet. This extensive storage can also be used to improve the performance of devices by enabling analytics and system enhancements that consider the diversity of devices.

8. Conclusion and future directions

There's a growing need for reliable and efficient ways to connect stuff to the internet (like your smart gadgets) with computer systems in the cloud. This becomes more important as more and more of these gadgets show up. People have been looking into the advantages of linking these gadgets to apps in the cloud, and this article digs into the tools and systems we have right now for this internet-gadget-cloud connection thing.

Even though connecting gadgets to the cloud is pretty useful, there are still some problems. First, there are not-so-good tools and systems for doing this. Second, making these things work usually needs a lot of manual effort, which can lead to mistakes. This study is checking out a bunch of things about using computers on the internet and connecting gadgets, looking at both the good stuff and the not-so-good stuff. We did a careful review of existing studies using a special approach. We looked at a lot of papers using cool techniques that show how words and authors are connected. The idea is to understand what everyone else is saying about this gadget-cloud connection stuff.

When we mix gadgets and cloud computers, it opens up new chances for businesses and researchers. We think that as gadgets become better, connecting them to apps in the cloud will become more common. This appears to have a bright future, especially with the introduction of new technologies like edge computing, Big Data, blockchain, industrial 5.0, 5G, and AI . There are numerous options for gadgets with each of these.

We expect to see more gadgets and apps that are connected to the cloud soon. This will make it easier to gather and manage more data, helping things run better and decisions be smarter. According to our study, there might be new chances for people working in this field because of these technologies coming together.