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Edge Computing an Initiation Towards Internet of Things

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ABSTRACT

Edge computing is a revolutionary computing architecture that processes data quickly and effectively close to the source, bypassing network bandwidth and latency issues. By moving computing capacity to the network's edge, edge computing reduces the processing and transmission strain on cloud computing centers while simultaneously reducing the time it takes for users to provide input. As a result, access latency could become a bottleneck and the benefits of edge computing, particularly for data-intensive services, could be overshadowed. We face some issues in edge computing like security, incomplete data, investment and maintenance cost. In this paper we conduct a comprehensive survey of Edge Computing and how Edge device placement makes better performance in IoT networks and we have made a comparative study of different Edge Computing Implementation and have discussed about various challenges faced in implementation of Edge Computing. This paper aims to inspire new edge-based IoT security designs and allow the dynamic placement of edge devices by providing a complete review of IoT security solutions at the edge layer.

Keywords: - Edge Computing, Internet of Things (IoT), security, edge server, incomplete data.

I. INTRODUCTION

The notion of network-based computing dates to the 1960s, but many believe the first use of “cloud computing” in its modern context occurred on August 9, 2006, when then Google CEO Eric Schmidt introduced the term to an industry conference. It enabled information to be stored and processed on remote servers, which meant our devices could offer services beyond their technical capabilities. Using the cloud, a device with only a few gigabytes of memory can effectively host an infinite amount of data. As time has gone by, though, the cloud has started to impede certain technologies, especially IoT. The scope of IOT is so vast that cloud computing alone cannot be a means of data processing. The data sent by IOT over a Wi-Fi or cellular network can slow down the entire network. Without the access to the central cloud IOT devices are useless because of the devices not having an internet connection. This is where edge computing comes in.

Edge computing is an open platform based on edge nodes, which integrates network, computing, storage, application and other core capabilities of distributed computing. The United States is the birthplace of the concept of edge computing. In 2003, AKAMAI began collaborating with IBM on "Edge computing", providing edge-based services on Web Sphere (IBM & AKAMAI, 2003). In 2011, Cisco was the first one to proposed the concept of fog Computing, which extends the concept of Cloud Computing (BONOMI, 2011). Compared with Cloud Computing, it is closer to the place where data is generated. Data, data-related processing and applications are concentrated in devices at the edge of the network. From fog computing to edge computing, mapping along the edge cloud network hierarchy. It makes possible for a variety of computing tasks to achieve different levels of intelligence at different costs and energy budgets (Martin and Diaz, 2018), as shown Figure 1. In May 2016, a team of professors at Weisong Shi state university in the United States came up with a formal definition of edge. Edge computing is a new network computing mode that performs edge computing.

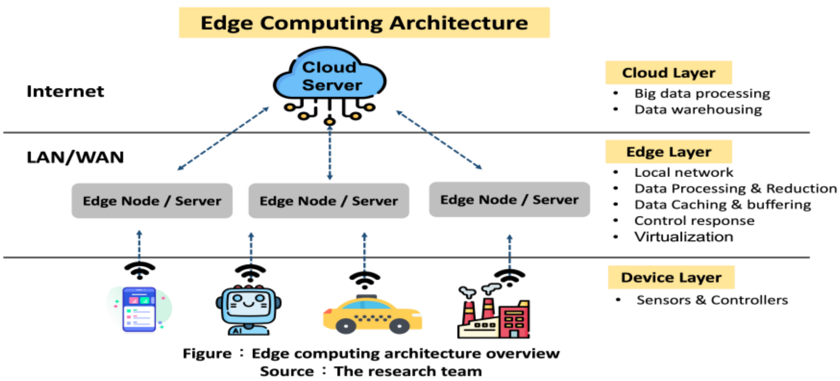

Figure 1: A simplified architecture of edge

II. INTERNET OF THINGS

The Internet of things (IoT) describes the network of physical objects “things” that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet. The idea of adding sensors and intelligence to basic objects was discussed throughout the 1980s and 1990s (and there are arguably some much earlier ancestors), but apart from some early projects -- including an internet-connected vending machine -- progress was slow simply because the technology wasn't ready. Chips were too big and bulky and there was no way for objects to communicate effectively. Processors that were cheap and power-frugal enough to be all, but disposable were needed before it finally became cost-effective to connect up billions of devices. The adoption of RFID tags -- low-power chips that can communicate wirelessly -- solved some of this issue, along with the increasing availability of broadband internet and cellular and wireless networking. The adoption of IPv6 which, among other things, should provide enough IP addresses for every device the world (or indeed this galaxy) is ever likely to need -- was also a necessary step for the IoT to scale.

Kevin Ashton coined the phrase 'Internet of Things' in 1999, although it took at least another decade for the technology to catch up with the vision. In IoT, with the help of edge computing, intelligence moves to the edge. Like if you have massive amounts of data and for this, you have to leverage in such end to endways or highly sensor intensive or data-intensive environments where data is generated at the edge, which is due to IoT as data sensing at the edge. And also, with real-time information, the increasing unstructured data of which sensor and IoT data are part, traditional approaches don’t meet the requirements which are needed. There are various scenarios where speed and high-speed data are the main components for management, power issues, analytics, and real-time need, etc. helps to process data with edge computing in IoT.

III. BENEFITS OF EDGE COMPUTING

Low Latency:

For many companies, speed is absolutely vital to their core business. The financial sector’s reliance upon high-frequency trading algorithms, for instance, means that a slowdown of mere milliseconds can have expensive consequences. In the healthcare industry, losing a fraction of a second can even be a matter of life or death. And for businesses that provide data-driven services to customers, lagging speeds can frustrate customers and cause long term damage to a brand. Speed is no longer just a competitive advantage it is a best practice.

The most important benefit of edge computing is its ability to increase network performance by reducing latency. Since edge computing devices process data locally or in nearby edge data centers, the information they collect doesn’t have to travel nearly as far as it would under a traditional cloud architecture. It’s easy to forget that data doesn’t travel instantaneously; it’s bound by the same laws of physics as everything else in the known universe. Current commercial fiber-optic technology allows data to travel as fast as 2/3 the speed of light, moving from New York to San Francisco in about 21 milliseconds. While that sounds fast, it fails to consider the sheer amount of data being transmitted. With the world expected to generate up to 44 zettabytes (one zettabyte equals a trillion gigabytes) of data by the end 2020, digital traffic jams are almost guaranteed.

There’s also the problem of the “last mile” bottleneck, in which data must be routed through local network connections before reaching its final destination. Depending upon the quality of these connections, the “last mile” can add anywhere between 10 to 65 milliseconds of latency. By processing data closer to the source and reducing the physical distance it must travel, edge computing can greatly reduce latency. The end result is higher speeds for end users, with latency measured in microseconds rather than milliseconds. Considering that even a single moment of latency or downtime can cost companies thousands of dollars, the speed advantages of edge computing cannot be overlooked.

Security:

While the proliferation of edge computing devices does increase the overall attack surface for networks, it also provides some important security advantages. Traditional cloud computing architecture is inherently centralized, which makes it especially vulnerable to distributed denial of service (DDoS) attacks and power outages. Edge computing distributes processing, storage, and applications across a wide range of devices and data centers, which makes it difficult for any single disruption to take down the network.

One major concern about IoT edge computing devices is that they could be used as a point of entry for cyberattacks, allowing malware or other intrusions to infect a network from a single weak point. While this is a genuine risk, the distributed nature of edge computing architecture makes it easier to implement security protocols that can seal off compromised portions without shutting down the entire network. Since more data is being processed on local devices rather than transmitting it back to a central data center, edge computing also reduces the amount of data actually at risk at any one time. There's less data to be intercepted during transit, and even if a device is compromised, it will only contain the data it has collected locally rather than the trove of data that could be exposed by a compromised server.

Even if an edge computing architecture incorporates specialized edge data centers, these often provide additional security measures to guard against crippling DDoS attacks and other cyberthreats. A quality edge data center should offer a variety of tools clients can use to secure and monitor their networks in real time.

Scalability:

As companies grow, they cannot always anticipate their IT infrastructure needs, and building a dedicated data center is an expensive proposition. In addition to the substantial up-front construction costs and ongoing maintenance, there's also the question of tomorrow's needs. Traditional private facilities place an artificial constraint on growth, locking companies into forecasts of their future computing needs. If business growth exceeds expectations, they may not be able to capitalize on opportunities due to insufficient computing resources. Fortunately, the development of cloud-based technology and edge computing have made it easier than ever for businesses to scale their operations. Increasingly, computing, storage, and analytics capabilities are being bundled into devices with smaller footprints that can be situated nearer to end users. Edge systems allow companies to leverage these devices to expand their edge network's reach and capabilities.

Expanding data collection and analysis no longer requires companies to establish centralized, private data centers, which can be expensive to build, maintain, and replace when it's time to grow again. By combining colocation services with regional edge computing data centers, organizations can expand their edge network reach quickly and cost-effectively. The flexibility of not having to rely upon a centralized infrastructure allows them to adapt quickly to evolving markets and scale their data and computing needs more efficiently. Edge computing offers a far less expensive route to scalability, allowing companies to expand their computing capacity through a combination of IoT devices and edge data centers. The use of processing-capable edge computing devices also eases growth costs because each new device added doesn't impose substantial bandwidth demands on the core of a network.

Versatility:

The scalability of edge computing also makes it incredibly versatile. By partnering with local edge data centers, companies can easily target desirable markets without having to invest in expensive infrastructure expansion. Edge data centers allow them to service end users efficiently with little physical distance or latency. This is especially valuable for content providers looking to deliver uninterrupted streaming services. They also do not constrain companies with a heavy footprint, allowing them to nimbly shift to other markets should economic conditions change.

Edge computing also empowers IoT devices to gather unprecedented amounts of actionable data. Rather than waiting for people to log in with devices and interact with centralized cloud servers, edge computing devices are always on, always connected, and always generating data for future analysis. The unstructured information gathered by edge networks can either be processed locally to deliver quick services or delivered back to the core of the network where powerful analytics and machine learning programs will dissect it to identify trends and notable data points. Armed with this information, companies can make better decisions and meet the true needs of the market more efficiently. By incorporating new IoT devices into their edge network architecture, companies can offer new and better services to their customers without completely overhauling their IT infrastructure. Purpose-designed devices provide an exciting range of possibilities to organizations that value innovation as a means of driving growth. It's a huge benefit for industries looking to expand network reach into regions with limited connectivity (such as the healthcare, agricultural, and manufacturing sector).

Reliability:

Given the security advantages provided by edge computing, it should not come as a surprise that it offers better reliability as well. With IoT edge computing devices and edge data centers positioned closer to end users, there is less chance of a network problem in a distant location affecting local customers. Even in the event of a nearby data center outage, IoT edge computing devices will continue to operate effectively on their own because they handle vital processing functions natively. By processing data closer to the source and prioritizing traffic, edge computing reduces the amount of data flowing to and from the primary network, leading to lower latency and faster overall speed. Physical distance is critical to performance as well. By locating edge systems in data centers geographically closer to end users and distributing processing accordingly, companies can greatly reduce the distance data must travel before services can be delivered. These edge networks ensure a faster, seamless experience for their customers, who expect to have access to their content and applications on demand anywhere at any time.

With so many edge computing devices and edge data centers connected to the network, it becomes much more difficult for anyone failure to shut down service entirely. Data can be rerouted through multiple pathways to ensure users retain access to the products and information they need. Effectively incorporating IoT edge computing devices and edge data centers into a comprehensive edge architecture can therefore provide unparalleled reliability.

IV. APPLICATIONS OF EDGE COMPUTING IN INTERNET OF THINGS

Power Monitoring System:

The power monitoring system is composed of the control center at all levels, such as substations, power line surveillance, and so on (Tao et al., 2017). The system applies modern control technology, visualization technology, modern communication technology and Internet of things technology to intelligently monitor power equipment hot spots, power, and environment. It intelligently analyzes data, and realizes comprehensive visualization display and intelligent linkage alarm, at the same time, it effectively assists power equipment informatization, overhaul, and operation. Overall, it serves for smart grid overhaul, operation, and whole life cycle management (Li, 2019). It mainly describes the two service applications of transmission lines and the intelligent substation in the power monitoring system based on edge computing.

Smart Energy Systems:

The smart energy system is an integrated management system, which is made up of a distributed generator, energy storage devices, flexible loads, and energy conversion devices. The integrated energy management platform coordinates the electrical energy interactions in the power network and uses a microgrid central controller, a distributed power grid connection interface device, and an intelligent control terminal to implement the basic functions of the smart energy system.

The architecture consists of three layers: device layer, edge layer, and cloud layer. The cloud layer takes the cloud platform as the core and provides various cloud services. For different scales, the cloud layer can deploy the public cloud, private cloud, or hybrid cloud. The equipment layer consists of various types of power devices, including uncontrolled distributed power sources such as photovoltaic and wind turbines, controlled distributed power sources such as diesel generators and power conversion devices such as inverters, energy storage devices such as electric vehicle charging piles and batteries, and various types of loads.

The edge layer is the core of the entire architecture; it consists of edge gateway, edge platform, and edge services. The edge layer provides computing, storage, application deployment, and other functions at the edge side near the data source of the device. The edge gateway is the core device in the edge computing architecture, which collects the operation data of distributed power supplies, loads, power conversion devices, and energy storage devices in real-time and then uploads them to the edge platform. Under the coordination of the edge platform, each edge gateway executes the control commands derived from the calculation results at the edge side to control the dispatchable power devices (Xu et al., 2020). We will analyze the typical applications and the related advantages brought by the architecture based on the EC-IoT smart energy systems, including identification of malicious behavior of electricity consumption and Real-time perception of distributed energy power generation status, efficient data processing, and fast reactive voltage response.

Advanced Metering Infrastructure:

Advanced metering infrastructure (AMI) consists of smart meters, data concentrators, data centers, and communication networks. AMI is interconnected with the communication network to achieve two-way communication of power data. In the AMI, the smart meters are uploading their power usage information to the data concentrators through wired and wireless communication in the Neighborhood Area Network (NAN). And then the data center actively requests power data from data concentrators through the wide area network (WAN), or data concentrators pass through the WAN at a preset time interval, and they centrally upload power consumption data to the data center, then the data center distributes electricity price information to users and implements related measures such as load management, demand response, and meter control commands to improve customer service (Liang et al., 2021).

With the rapid development of the smart grid, the data generated by smart meters and other power terminal devices has exploded. Facing the computing demand of massive data, traditional cloud computing solutions face huge challenges in

transmission bandwidth, transmission delay, data storage, and real-time response. The introduction of edge computing
technology and the introduction of edge computing modules in the data concentrator constitute the AMI edge computing framework. The data collected by the terminal is processed locally in the concentrator, and only the calculation results are uploaded to the cloud, thus reducing the network burden, lowering transmission costs, and meeting users' real-time response needs, etc.
We will present the typical applications and the related advantages brought by the architecture based on the EC-IoT advanced metering infrastructure, including real-time power forecasting and efficient abnormal detection.

V. CONCLUSION

Edge computing integrates network, computing, and storage on the edge of the network. The introduction of edge computing can solve the problems of cloud computing architecture facing the IoT, which is unable to handle massive heterogeneous data, communication delays, high computing pressure, data privacy leakage, and difficulty in satisfying user demand response and other issues. First, this article introduces the edge computing technology and the framework of the IoT, and gives the architecture of the combination of edge computing and the IoT and the internal architecture of the edge computing layer. Moreover, one of the contributions of this paper is to analyze the technical application of edge computing in the three
power Internet of Things scenarios: power monitoring system, Frontiers in smart energy system, and power metering system. It also gives the architecture of the edge computing in the three scenarios. Furthermore, the major contribution is putting forward the policy challenges, market challenges, and technical challenges of the application of edge computing in IoT, meanwhile, the technical challenges and outlooks in four major areas are analyzed in detail. This paper aims to obtain more attention from other researchers in edge computing in the IoT, and make power industry development more rapid and convenient.

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