Role of Edge Computing in IoT

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Abstract: ***Edge computing has emerged as a new paradigm to address IoT and localised computing needs as a technique to mitigate the escalation of resource congestion. Compared to the well-known cloud computing, which has some drawbacks, such as latency, bandwidth, protection and lack of offline access, robust, safe and smart on-site edge computing would migrate data computation or storage to thenetwork ''edge,'' near the end users .Thus, the computational burden can be discharged away from the centralised data centre by a variety of computing nodes spread across the network and can greatly minimise the latency of message exchange. In addition, the distributed framework will balance network traffic and prevent IoT network traffic peaks, minimising the latency of transmission between edge/cloudlet servers and end users, as well as reducing response times for real-time IoT applications in comparison with traditional cloud services.***

Keywords: IOT, Edge computing, Cloud computing, Software Defined Networking

1. Introduction

Through the progressive growth of information technology, the Internet of Things (IoT) has come to play an important role in our daily lives. Via modern communication network infrastructure linked by millions of IoT nodes, interconnected sensors/devices can collect and share different data between themselves [1][2]. In this scenario, through IoT techniques, more and more sensors and devices are interconnected, and these sensors and devices can produce massive data and demand more processing, providing both service providers and consumers with information. All data must be transmitted to centralized servers in traditional cloud computing and the results must be sent back to the sensors and devices after computing. A more critical situation arises for IoT applications that are time-sensitive, meaning that very short response times are non-negotiable (the smart transportation [3], smart electricity grid [4], [5], smart city [6][7], etc.) and conventional cloud computing-based service definitively cannot satisfy the demand. This is because it is important to upload the computing processes to the cloud, and large data transfers occupy the limited bandwidth and network resources, on top of the cloud being already far from the end users. In addition, most IoT devices have limited resources and it is important to balance power usage by preparing computation for devices with higher power and computational capacities in order to increase the lifespan of devices. In addition, transmission time would be minimized by processing data in computing nodes with the shortest distance to the user. Data transmission speed can be impacted by network traffic in cloud computingbased services, and heavy traffic contributes to long transmission times, raising the cost of power usage. To address the above problems and issues, in this paper we summarize existing efforts and previous work [8][9], and present our view on edge computing for the IoT.

2. Review of Literature

The core concept of edge computing is a distributed computing form that places computing resources and data storage at the edge nodes of the network [10] and supports new human-centric services by providing users with lowlatency service awareness and controllable network transmission costs [11]. Facing heterogeneous resources and system sharing in edge computing environment, we need to consider factors [12] as matching of resource performance, behavior trust, identity trust and resource providing ability trust to effectively face the challenge of interaction and sharing between ubiquitous terminal nodes in the network. Although trust computing is relatively new in edge computing, much research work has been developed and explored in edge computing. In [13] a trust management scheme, studied how to calculate the reputation of edge data center, and allowed mobile users to use cloud computing through mobile cloud providers.It designed a set of trust metrics computed in an autonomous and distributed way to evaluate and manage trust in computing edge data centers. They proposed and applied a trust management framework based on measurement theory, which can evaluate the trust in applications and computing resources. Although the feedback mechanism is undoubtedly a basic requirement of the trust system, the recent research ignores the collusion problem caused by the feedback mechanism itself, which will greatly reduce the reliability of the trust system. In addition, the previous studies mostly used subjective methods to assign weights to trust decision-making factors, which cannot reflect the adaptability of trust decision-making process, and may lead to misjudgment of trust calculation. This paper proposes a multi-source trust fusion mechanism based on time decay for edge computing, which guarantees the security of edge computing environment.

3. What is internet of things?

Internet of Things played an important role in our daily lives. IoT based Smart city project activities taken by Government of India builds the city the executive's productivity and improves the personal satisfaction by including and interfacing numerous public utilities like administration of water, power, traffic, stopping, fire assurance, gas supply associations and other different administrations through a wise stage.

IoT is changing into the key driver for digital transformation that is making additional and additional innovations in product, improvement and automation of information analysis, new applications, R&D investments, new business, and revenue models across all sectors. [14]. Figure 1 and 2 shows IOT utilities and the trend of IOT usage over time.

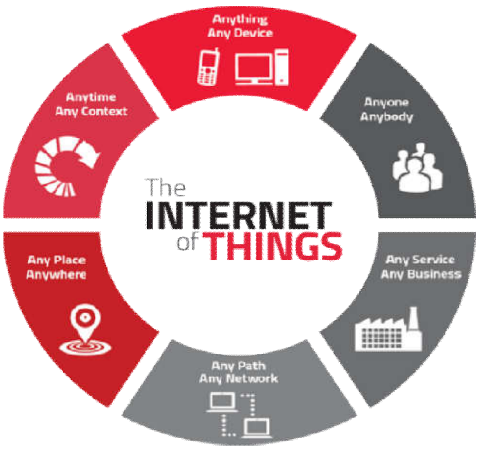

Figure 1: IoT Utilities

IoT is on the cusp of radically dynamical the technology landscape. Ericsson predicts that there'll be 29 billion web connected devices by 2022, and 18 billion of these are associated with IoT. Cisco has prompt that figure could also be nearer to 50 billion.

The amount of knowledge expected to be in transit between IoT devices and therefore the cloud is ever increasing. Our thirst for period analytics means that unessential latency may be a drawback we will sick afford. The Growth of net of things variety of devices obtaining connected, from computers to house devices to enterprise and industries has mature in last 6 years at an annual rate of 23.1%, touching 50.1 billion things in 2020 [15]. Worldwide defrayment on IOT can cross $1 trillion in 2022 and $1.1trillion in 2023 as per IDC report [16].

IOT is primarily comprised of mobile devices and consumer-oriented things but lately industrial automation is increasingly capturing larger share in IOT market.

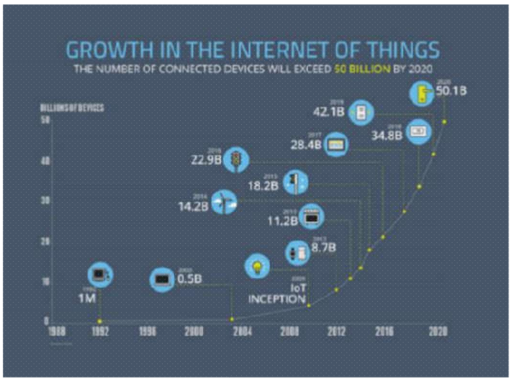

Figure 2: The trend of IoT usage over time

4. Edge computing in IoT

Edge computing is a "mesh network of micro data centers that process or store critical data locally and push all received data to a central data center or cloud storage repository, in a footprint of less than 100 square feet" according to research firm IDC [21]. Any devices that produce data can be the edge device. In RAN, mobile edge computing provides real-time RAN information. By using the real-time RAN information, the network providers can improve Quality-of- Experience (QoE) for end users, because real-time RAN will offer context-aware services [22]. As we mentioned before, the edge computing platform allows edge nodes to respond to service demands, reducing bandwidth consumption and network latency. Architecture of edge is shown in Figure 3 and 4.

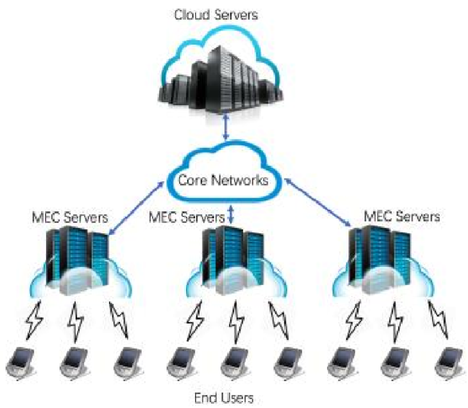

Figure 3: The basic edge computing architecture.

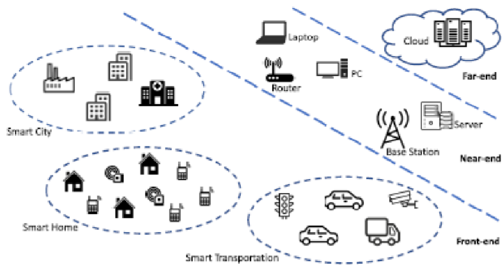

Figure 4: A typical architecture of edge computing networks.

4.1 Edge Computing Architecture

Figure. 4 illustrates the basic architecture of edge computing. Note that servers on edge computing are closer to the end user than servers on the cloud. Therefore, even though edge computing servers have less computing power than cloud servers, they still provide end users with better QoS (Quality of Service) and lower latency. Obviously, edge computing integrates edge processing nodes into the network, unlike cloud computing. The edge computing nodes are called edge/cloudlet servers in this paper.

4.1.1 Front-End

At the front-end of the edge computing structure, the end devices (egg: sensors, actuators) are deployed. Edge computing can offer real-time services for certain applications, with the computing power provided by the multitude of nearby end devices. Nevertheless, most specifications in the frontend setting cannot be met due to the limited capacity of the end devices. Thus, the end devices must forward the resource requirements to the servers in these situations.

4.1.2 Near-End

Most traffic flows on the networks will be served by the gateways deployed in the near-end environment. There may also be different resource requirements for edge/cloudlet servers, such as real-time data transmission, data caching, and computing offloading. The majority of data computation and storage in edge computing will be migrated to this near-end environment. In doing so, with a slight increase in latency, end users can achieve much better data computing and storage efficiency.

4.1.3 Far-End

Since the cloud servers are deployed farther away from the end devices, the latency of the transmission is essential in the networks. Nonetheless, cloud servers will provide more processing power and more data storage in the far-end environment. For example, the cloud servers can provide massive parallel data processing, big data mining, big data management, machine learning, etc. [19].

4.2 Edge Computing Implementation

To implement the aforementioned architecture of edge computing, some research efforts have already focused on the design of edge computing models. Typically, the following two models dominate:

(a) Hierarchical model

The edge architecture is split into a hierarchy, describing functions based on distance and resources, given that edge/cloudlet servers can be deployed at various distances from the end users. in proposed a hierarchical model, which integrates the Mobile Edge Computing (MEC) servers and cloudlet infrastructures. in proposed a hierarchical edge cloud model, which can be used to serve peak loads demanded from mobile users. Cloudlet servers are deployed at the network edge in this model and the regional edge cloud is created.

As a tree hierarchy, which consists of edge servers deployed. The computing abilities of edge servers can be further aggregated to meet the need for peak loads by leveraging this planned hierarchical structure.

(b) Software-defined model

Software Defined Networking (SDN)can be a viable solution to deal with the complexity of edge computing management. In their model, the paradigm of softwaredefined data plane is considered in a Mobile Virtual Network Operators (MVNOs) network. Manzalini and Crespi in proposed an edge operating system, which leverages available open-source software to achieve powerful network and service platforms. In proposed an integration of three new concepts, including MEC, Software Defined Network (SDN), and Network Function Virtualization (NFV). in proposed a Smart Applications on Virtual Infrastructure Software-Defined Infrastructure (SDI) Smart Edge architecture, which can be used to support the construction of various distributed network services and applications.

5. Advantages of Edge computing in IoT

As you'll be able to see, the most purpose of edge computing is to change information handling. This results in variety of benefits over the normal cloud. Namely, there square measure 5 main benefits of edge computing for IoT:

(a) Increased Data Security

While IoT solutions represent an ideal target for cyberattacks, edge computing will assist you secure your networks and improve overall information privacy. Because the information is decentralized and distributed among the devices wherever it's made, it's tough to require down the entire network or compromise all of the information with one attack. This approach is additionally most popular in terms of GDPR compliance: the less sensitive info is shipped through your network and hold on in your cloud, the better.

(b) Better App Performance

As mentioned above, it takes some time for the data travel back and forth between the device and the data centre. By storing and process the info on the point of its supply, you cut back the lag time and improve the app performance. As a result, you'll analyse the data in real-time, while not delays.

(c) Reduced Operational Costs

When you store and process most of the data "at the edge," you don't need an abundance of cloud storage. Plus, you can filter out the unnecessary information and backup only the relevant data. As a result, your infrastructure costs will inevitably go down.

(d) Improved Business Efficiency and Reliability

Lower information traffic and reduced cloud storage, in turn, results in a lot of economical business operations. Additionally, association problems will not be very problematic as they're for alternative IoT product that suppose the cloud. This is due to the fact that your devices can work autonomously, without an Internet connection.

(e) Unlimited Scalability
Unlike cloud, edge computing allows you to scale your IoT network as needed, without reference to the available storage (or its costs).

6. Challenges of Edge computing in IoT

Edge computing is that the addition of more ‘smart’ devices into the edge servers and IoT devices that have robust built-in computers, there are new opportunities for malicious actors to compromise these devices. Below we explain more about each of the challenges of edge computing in IOT.

(a) Privacy
Privacy altogether aspects may be a challenge in edge computing since user’s information should bear through security routines and encryption before transmission to ensure user information privacy, some ancient ways like plaintext keyword search and a few others are going to be obsolete and replaced with safer mechanisms [20].

(b) Maintenance and support
Predictive maintenance understood in detection failure, intrusion detection and device mal-functionalities. A prognosticative program is required in Edge computing thus to easily detection, by management systems like service Systems. Edge computing allows to attach multiple information sources to the machine information sources to urge a additional correct information summary [20].

(c) Power consumption
Energy potency reduces the number of energies needed to produce a product or service. Edge computing manages the resource flow to the resource centres and also the edge node is answerable for handling the computations within the Edge.

(d) Cost
From the service providers’ perspective, e.g., YouTube, Amazon, etc., edge computing provides them less latency and energy consumption, potential raised output and improved user expertise. for instance, supported most residents’ interest, we will place a well-liked video on the building layer edge. the town layer edge will free from this task and handle additional complicated work. to totally utilize the native information in every layer, suppliers will charge users supported the information location.

7. Application

“When we take the power of the cloud down to the device – the edge – we provide the ability to respond, reason and act in real time and in areas with limited or no connectivity it’s still early days, but we’re starting to see how these new capabilities can be applied towards solving critical world challenges.” – Kevin Scott Microsoft CTO [19]

(a) Smart Homes
Some merchandise like good TV, good light-weight, automaton vacuum area unit offered in market nowadays. In good home surroundings, the devices area unit connected and might be controlled by a wise phone, or by a wise device. Besides that, an oversized quantity of information being created and it ought to be transmitted over network. The cloud has got to method these whole information and therefore time interval are high, likewise as information measure and latency. the info area unit being processed domestically and there by releases the burdens for web information measure and high privacy and security is given to the info [20].

(b) Smart City
The edge computing paradigm can be flexibly expanded from a single home to community, or even city scale. Edge computing claims that computing should happen as close as possible to the data source. 1) Large Data Quantity: A city populated by 1 million people will produce 180 PB data per day by 2019, contributed by public safety, health, utility, and transports, etc. In this case, edge computing could be an efficient solution by processing the data at the edge of the network. edge computing is also an appropriate paradigm since it could save the data transmission time as well as simplify the network structure. 3) Location Awareness: For geographic-based applications such as transportation and utility management, edge computing exceed cloud computing due to the location awareness. In edge computing, data could be collected and processed based on geographic location without being transported to cloud.

(c) SMART TRANSPORTATION
To achieve safe and effective autonomous driving, a cloudbased vehicle control system is needed, because it can collect information from the sensors via a vehicle-to vehicle network.

8. Conclusion

With IoT growth, edge computing is becoming an emerging solution to the difficult and complex challenges of managing millions of sensors/devices and the necessary resources they require. Edge computing, similar to the cloud computing model, will transfer data computing and storage to the' edge' of the network, near the end users. In order to minimise traffic flows, Edge computing can also reducetraffic flows to decrease the IoT requirements for bandwidth. Moreover, edge computing would decrease the latency of transmission between edge/cloudlet servers and end users, resulting in shorter response time for real-time IoT applications compared to traditional cloud services. In addition, the lifespan of limited battery nodes can be extended along with the lifetime of the entire IoT system by reducing the transmission expense of the workload and migrating the overhead of computing and connectivity from nodes with limited battery resources to nodes with substantial power resources. We have examined the edge computing architecture for IoT, the performance targets, task offloading schemes, and security and privacy risks and related edge computing countermeasures to sum up our work, and have highlighted typical IoT applications as examples.

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