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Edge Computing in IoT: An Overview and Applications

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***Abstract*: The sudden boom of IoT and the success of cloud services have pushed to a new cloud computing paradigm, edge computing, which tells to process the data at the edge. Edge computing has the potential to address the concerns of response time, bandwidth, cost, as well as data safety and privacy. In this paper, we have discussed the definition of edge computing and how Edge Computing is being used in IoT, also discussed is how other technologies enable Edge Computing. Section I gives a brief introduction, in Section II – V we talk about what Edge Computing is, benefits of using Edge Computing, applications of Edge Computing, and technologies that enable Edge Computing.**

***Keywords*: Cloud Computing, Edge Computing, Internet of Things.**

1. Introduction

Cloud computing has changed the way we do things and perform everyday tasks since its beginning. Edge Computing bring data closer to the destination. The need for faster data processing is more important than ever. Billions of smart devices can now connect to the Internet in the form of the IoT due to developments in networking technologies. Due to progressions in technology and the need for higher processing power, especially in IoT, it helps to bring the data and the necessary processing near the destination.

2. What is Edge Computing?

More and more data are produced near the destination in the network; hence, it would be more efficient to also create the data near the destination in the network. Even though the older technologies were groundbreaking, they were a bit inefficient. Edge Computing describes a computing topology in which data is composed and handled closer to the edge.

A. Need of Edge Computing

Pushing away from Cloud: Having all the computing of data on the cloud can prove to be efficient. But with current technological growth trends and the expansion of IoT devices, large amounts of data are created. To put all this data on the cloud and wait for it to process will take a lot of time. This is where edge computing can play a useful & an important role by taking the data near the source and processing it near the edge. This also reduces the bandwidth used by the data.

Use in IoT: Eventually all kinds of electronic devices will become part of IoT, and they will play the role of data producers as well as consumers, such as health monitors, smart assistants, LED bulbs, microwave oven, etc. It is safe to conclude that the number of things at the edge of the network will develop to more than billions in a few years. This reduces the current systems inefficient and incompetent of the upcoming demands.

Change from a data consumer to producer: In the cloud computing model, the end devices at the edge usually play the role of a data consumer, for example, watching a YouTube video on your smartphone. But people are also producing data these days from their mobile devices. The change from a data consumer to data producer/consumer requires more function placement at the edge. For example, it is very normal that people today take photos or do video recording then share the data through a cloud service such as YouTube, Facebook, Twitter, or Instagram. Moreover, every single minute, YouTube users upload 72 h of new video content; Facebook users share nearly 2.5 million pieces of content; Twitter users tweet nearly 300,000 times; Instagram users post nearly 220,000 new photos. However, the image or video clip could be fairly large and it would occupy a lot of bandwidth for uploading. In this case, the video clip should be demised and adjusted to a suitable resolution at the edge before uploading to the cloud. Another example would be wearable health devices. Since the physical data collected by the things at the edge of the network is usually private, processing the data at the edge could protect user privacy better than uploading raw data to cloud [1].

3. Technologies that enable edge computing

Edge Computing is made possible by a few key aiding technologies, which are also critical in the evolution of current mobile networks to their fifth-generation (5G). To be specific, 5G includes many new technologies which address the underlying critical issues, for example, low latency and reliable communications, radio band insufficiency, and an increasing amount of data from various devices. Edge computing isn't only about enabling faster experience to consumers but could serve as a base for some other bigger technological

development. These are some of the important technologies that enable Edge Computing as a technology,

A. Virtualization

In Virtualization, cloud computing providers can run multiple independent software instances on a single physical server. These instances can access the primary physical resources while being isolated from each other. This isolation enables instances to run without interfering with other instances running on the same server. Other than sharing physical resources, virtualization also allows the relocation of Virtual Machines or Containers. More specifically, relocation consists of moving the resources needed from one physical server to another. This is very useful for quite a few scenarios, including the merging of virtualized instances to reduce data center energy consumption.

B. Network Function Virtualization and Software-Defined Networking

The use of network functions as software modules that can run on general-purpose hardware is under Network Function Virtualization. It separates the software from the primary hardware by using the previously described virtualization technologies to its advantage. Taking this approach, different network functions no longer need to run on dedicated hardware. It also offers improved flexibility, as virtualized network functions can be brought into action in the location most suitable for efficient delivery of mobile applications and services.

Software-defined networking complements network function virtualization by separating the management or control plane from the data plane over which data packets are moved. Software-Defined Networking enables easier and more flexible management of networks through abstractions and a logically centralized controller that handles policy and forwarding decisions. Moreover, the introduction of software of the controller allows for faster deployment of new services. Software-Defined Networking, together with Network Function Virtualization, enables flexible and programmable deployment of software-based modules, thereby simplifying network configuration and management.

C. Computation Offloading

Typically, computation and storage are offloaded from resource-constrained mobile devices to the cloud, i.e., processing-heavy tasks are sent for execution in the cloud which, in turn, sends the results back to the devices. Offloading can involve edge computing platforms instead of (or in addition to) the centralized cloud. In either case, end-devices access cloud resources as a thin client or through a Web browser. Offloading computation from devices has several benefits. For instance, the battery life of resource-constrained end-devices can be extended by avoiding complex local processing. Offloading to the edge instead of the cloud results in even lower energy consumption at the end-device. Moreover, offloading computation enables several types of applications to run on resource-constrained devices, including mobile gaming, mobile learning, natural language processing, and mobile healthcare.

4. Applications in IoT which use Edge Computing

A. Smart Homes

Homes would really benefit from automation. It reduces the total workload on us humans. Just a quality of life change. Some products have already been developed and are available such as Smart bulbs, Smart TV's, automated vacuums, Smart assistants, may more. However, just adding a wireless module to the existing electronic devices and connecting it to the IoT is not enough for a smart home. In a smart home, it is also required to have multiple sensors, wires, etc. to help in adding devices.

B. Healthcare

In healthcare, there are some really specific and precise needs. Edge Computing can help in these applications by providing low latency, higher processing speed, etc. Edge Computing can also help by storing important files and reports nearer rather than storing and retrieving it from the Cloud again and again.

C. Smart Cities

Similar to smart homes, here an entire city is connected on the cloud network. Some common examples are city surveillance apps, traffic alerts app, weather update app, etc. These applications require high speed data processing, and it is better to use a more localized processing solution such as Edge Computing, rather than using a remote cloud server.

There are many more applications in IoT that already exists and other are under development waiting to cross some important technological barriers and even maybe some government regulations.

5. Key Requirements of Edge Computing in IoT

A. Latency

In interaction services, latency is one of the most important metrics to measure the performance. Latency is the time taken for receiving a response from the server (Cloud or Otherwise). Latency plays a very important role in all network related applications. Generally, latency defines the quality of the network/service. Hence, because Edge Computing is near the end consumer, it has a lower latency than cloud computing.

B. Reliability

Almost every section talks about how Edge Computing is fast and powerful. But all this power can be justified only if the results are consistent and the system is reliable. Reliability is an important factor in heavy-duty, precision based, systems/ services/networks. Edge Computing can be really only proved to be the "ultimate solution" if it is reliable.

C. Security

With all the application specific and highly sensitive data, security is of the utmost importance in Edge Computing networks. With hackers getting smarter day by day and user data being worth millions, attacks are imminent and we have to make sure there is top class security implemented.

These were some of the key requirements of edge computing. there are more application specific requirements which may be defined while implementing the systems.

6. Conclusion

In this paper, we have discussed how edge computing can play an important and useful role in IoT. Edge Computing will not only improve the user experience but also help in managing data better. This will not only make IoT applications faster and efficient but also help the providers in understanding the problems and come up with solutions quicker. This is not only a right step in the direction of improving speed and efficiency but also a huge leap in end-user experience. There is still a lot of room for improvement in Edge Computing. In this day & age, security, privacy and availability is very important and Edge Computing can provide that given the right deployment and development.

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