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An Edge Computing Tutorial

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Abstract

Edge Computing (EC) is an emerging technology that has made it possible to process the large volume of data generated by devices connected to the Internet, through the Internet of objects (IO). The article provides an introduction to EC and its definition. The integration of EC in those contexts would imply an optimisation of the processes that are normally executed in a cloud computing environment, bringing considerable advantages. The main contribution of EC is a better pre-processing of the data collected through devices, before they are sent to a central server or the cloud.

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Edge Computing

The Internet of Things is a network or an interconnection of devices, sensors, or actuators that share information through a unified protocol. The devices use ubiquitous sensing, data analysis, information representation and the same framework to achieve this. A standard IoT network consists mainly of radio frequency identification devices (RFID) and Wireless Sensor Networks (WSN). This type of IoT network have an important number of challenges that are difficult to overcome in smart scenarios, such as: logistic, home, city, Industry 4.0 or finance-realted challenges.[1-3]

Until very recently, cloud computing was considered the traditional approach to meeting the requirements of the Internet of Things.[1,4] Cloud computing is defined as a model that allows for ubiquitous, convenient, on-demand access to a shared set of configuration computing resources (e.g., networks, servers, storage, applications and services) that can be quickly provisioned and released with minimal

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interaction between the management center and the service provider.[5,6] The approach of using cloud computing as a centralized server, generally geographically distant, increases the frequency of communications between the peripheral devices used by users (tablets, computers, wristbands or smartphones) becoming a limitation for applications that require a real-time response.

This challenge has given rise to Edge Computing (EC) as an emerging technology that allows applications to run on network nodes.[7] In EC, the nodes can be centralized, distributed (core) or at the end of the network, in this last case they are called "edges", allowing for a more distributed processing of all the information generated by the peripheral devices. The widespread interest in this technology is due to its association with the Internet of Things (IoT) and its disruption in diferent scenarios, as a result of the number of devices that can be connected to the Internet, generating data and requiring organizations to improve their productivity through the administration and analysis of these data.[8]

Consequently, lines of research have emerged to address edge computing, its challenges, oportunities and application scenarios. EC is defined by several authors as a set of devices, sensors, computer resources and computers that produce and collect data that are then sent to cloud centers. They approach the concept of edge computing in terms of its architecture, challenges, software technologies, benefits and capabilities.[9-11] Some of the most commonly used edge computing concepts are presented as follow:

- Edge Computing is a technology that allows to perform computation at the network edge so that computing happens near data sources. In Edge Computing, the end device not only consumes data but also produces data.[12]
- Edge Computing is a new paradigm in which substantial computing and storage resources, also referred to as cloudlets, micro datacentres or fog nodes, are placed at the Internet's edge in close proximity of mobile devices or sensors.[13]
- Edge computing, refers to the enabling technologies that allow for computation to be performed at the network edge so that computing happens near data sources. It works on both downstream data on behalf of cloud services and upstream data on behalf of IoT services.[14]

In authors opinion, the most precise definition of Edge Computing is that established by the Edge Computing Consortium: Edge Computing is a distributed open platform at the network edge, close to the things or data sources, integrating the capabilities of networks, storage, and applications. By delivering edge intelligence services, Edge

Table 1: Difference between Edge and Cloud Computing[16]

	Edge	Cloud
Advantages	· Real time response. · Low Latency. · Edge can work without cloud and improve data security. · The EC distributed structure reduces: network traffic, storage and bandwith cost.	· Scalable. · Big Data processing. · Unlimited storage capacity.
Disadvantages	· Storage capacity is limited · EC needs proprietary networks. · IoT devices have a high power consumption. · Difficult to maintain the security of data. · High costs of data storage and transmission.	· Response time is slow. · High latency. · Cloud does not have an offline mode.

Computing meets the key requirements of digitisation for agile connectivity, real-time services, data optimisation, application intelligence, security and privacy protection.[15] This definition establishes what organizations currently demand: "platforms capable of processing data in a secure and private manner, providing answers to users in real time".

IoT applications and services must be able to support heterogeneous devices that generate large volumes of events and data. This feature makes it difficult to find the development specifications that would take advantage of all IoT potential. Considering these concepts, Edge Computing increases IoT performance with its distributed structure, likewise network traffic can be significantly minimized; latency transmission between the edge node the cloud and end users can be improved; and therefore the real-time response of IoT applications compared to cloud and fog computing.

Table 1 resumes the main differences between EC and Cloud Computing, dispite with all the advantages mentioned above, it is important to clarify that the process of increasing the processing or computing capabilities of IoT devices located at the edge of the network, using EC, does not replace the functions performed by Cloud services. In this regard, is important to note that cloud and edge computing are very different technologies which complement each other making it possible to deploy resources with ubiquitous accessibility. However, even when working together, they face the challenges of mobility, scalability, reliability, security, privacy or limited energy.

Figure 1 shows an edge computing ecosystem, based on the work of W. Yu, F. Liang, X. He, Hatcher, W G., Lu, C., Lin, J., Yang, X. (2017).[16] It supports how these two technologies complement each other by integrating to more efficiently manage this flow of information. In this sense, the devices need to be managed and the data collected needs to be analyzed and this requires a coordination of the cloud with the network.

The Figure 1 components are described as follows:

- Devices and sensors: responsibles to generate and collect data. This group of devices interact directly with the end user (sensors, smartphones, tablets, smart bracelets or laptops) and although some offer services and answer in real time, most of them have a limited capacity. Therefore, they need to send requests to equipment located on the Edge infrastructure.
- Edge infrastructure: there are distributed data centers to provide realtime data processing, data visualization, analitycs, filtering, optimizacion. They being located closer to

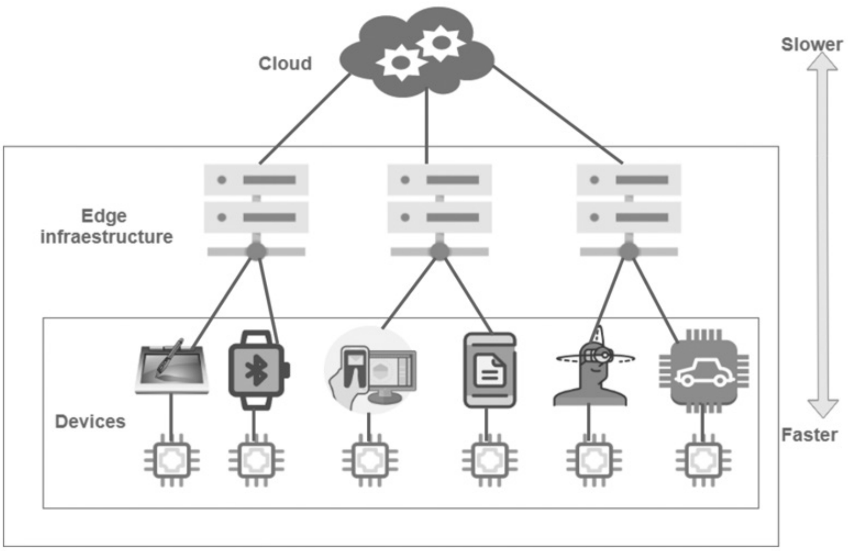

Fig. 1: Edge and Cloud Computing[16]

end users, they process, cache storage, and perform calculations for a large volume of data. With this capability, the edge reduces data flow and costs of using cloud services, as well as reducing end-user response time and latency.

- Cloud: It offers a greater density of compute, storage, networking resources. Cloud servers host applications for automatic learning, big data analysis and business intelligence.

Finally, edge computing is a new paradigm that promises to provide the required computing and storage resources with a decrease in delays due to its "proximity" to end users or devices. This tutorial included a state of the art in the field of EC with the objective of guiding readers towards current trends, challenges and future research opportunities in the area of edge computing.

Conclusion

This work is an edge computing state of the art review, which is a disruptive technology driven by the development of the Internet of Things and the devices of our environment permanently connected to the Internet. IoT devices generate data in real time and constantly. The growing number of sensors, connected machines, geographic heterogeneity for data storage, requests for real-time response have given rise to Edge Computing. The main advantages of edge computing as following: real-time analysis of data at the level of local devices and edge nodes and not necessarily in the cloud; reduction of operating costs, traffic and data transfer between the Edge and the cloud; increase the performance of applications for IoT scenarios by reducing network latency; and finally allows integration with Blockchain technology for security. As future lines of research, the authors propose the design of an edge computing reference architecture for IoT scenarios.

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Conflict of Interest

We dont have conflict of interest including any financial, personal or other relationships with other people or organizations that can influence in our work.

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