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Edge Computing for IoT: Challenges and Solutions

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***Abstract*— Edge computing is a promising paradigm where resource processing is close to the edge of the Internet. Due to an increasing number of devices forming an interconnected network of devices in the Internet of Things (IoT) leading a huge amounts of data are produced. Internet traffic usage has been significantly increased over the years. In this paper, we examine the current edge computing architectures, their challenge associativity availing respective current state-of-the-art solutions. Formerly, we state the enabling features of edge computing in IoT development and some edge computing challenges with respect to their IoT applications. We conclude the paper by summarizing solutions in both IoT and edge computing in the tables, regarding the identified challenges.**

Keywords*— *Internet of Things; Edge computing; Quality of Service; 5G

I. Introduction

Edge computing decentralizes data processing and storage by carrying them out on network edges rather than cloud servers and centralized points, closer to Internet of Things (IoT) users. Edge computing drives application, data and computing power away from integrated points to locations closer to user in interacting with edge from centralized cloud, this leads to distribution of power and storage leading to better performance.

IoT extends networks including physical objects that own Internet Protocol (IP) addresses for internet connectivity although they are not limited to IP networks. They are utilized in different technologies including smart cars, smart home, and entertainment systems. Commercial and industrial IoT concerns itself with issues like, inventory controls, connected medical devices, connected electrical meters, flow gauges, pipeline monitors, manufacturing robots, and other types of connected industrial devices and systems.

Local processing supports real-time business systems and alerts, and it manages the data sent back to the cloud. Consider an autonomous vehicle traveling down a busy road, in case the car needs to stop immediately to prevent an accident, sending data to and back from the cloud, its likely to take too long. As an alternative, number of sensors that assess the status of every piece of equipment in the vehicle, interacting with each other have been introduced.

This study clearly sought to provide a view of Edge computing mainly on the architecture, challenges and state-of the-art solutions proposed. The following are the contributions of this paper.

- Analyze the current challenges affecting edge computing as a paradigm.
- Provide a review of state-of-the-art solutions.

The rest of this paper is structured as follows: In section 2, we state the related work in this area, while section 3 illustrates the edge computing and IoT architectures. Section 4, discusses the challenges of IoT and edge computing and introduces respective state of the art solutions noted in tables 1, 2, 3 and we concluded the paper in section 5.

II. Related Work

In this section, we discuss previous studies on edge computing which were an attempt to solve some of the mentioned challenges of edge computing. Since cloud computing performs weaker compared to edge computing because of its centralized nature on processing, storage and security which is caused by the clouds' distance from IoT users and the possibility of data theft along the way to the clouds [1].

IoT edge devices solve problems associated with the centralization of cloud architecture; by bringing cloud computing capabilities to local devices, IoT, edge computing can process data faster its main applications in real life scenarios where response time is an essential requirement for many of these applications [2].

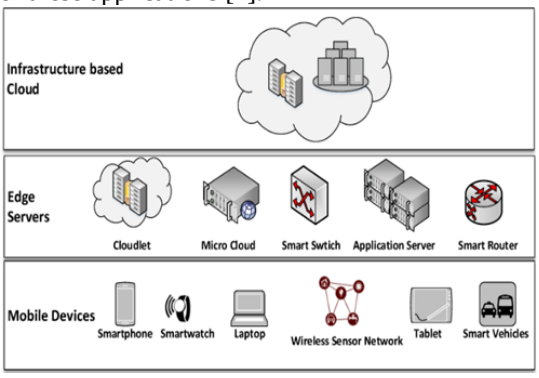

Figure 1: Fog computing architecture

III. IoT and Edge computing Architecture

In this section we mainly discuss architectures of edge computing and edge computing-based IoT devices and technologies. While these devices vary in capabilities and services, there are core features that differentiate these systems

Including complex event processing, artificial intelligence model, offline support, data management and their various applications. In the next generation, a key aspect of IoT edge devices should be the flexibility to rapidly change device configurations through remote tools and increased security in transmission of packets and updates as well as some other capabilities.

Fig. 1. Illustrates the edge computing architecture in different levels where the first level refers to the IoT devices that can communicate with each other remotely by the use of resource pooling techniques before being transferred to edge servers like micro clouds and cloudlets as well as some smart routers and switches, for further data processing or in some cases, data preprocessing before the final cloud processing occurs.

The second level of this architecture is the edge server platform that can be an access point of the network resources like storage and computation; close to a demanding IoT client, which causes reduction of latency and improved load processing. The third level refers to the infrastructure-based cloud, where the main processing and computation on data occurs and all generated data by the IoT devices and sensors is stored and can also be accessed virtually or online by any other device of any level.

A. 3-1 Edge computing characteristics

Edge computing solves some of the issues in cloud computing like providing closer processing units to users, less delay and no bandwidth limitation. Edge computing-based IoT overcomes some of the challenges of IoT applications, since data coming from IoT devices are processed in edge devices rather than going all the way to the central clouds, preventing costly delays and security risks along the way their way to clouds.

3-2 Characteristics of IoT in Edge computing

The IoT consists of resource-constrained devices such as sensors, smartphones, wearable devices and machines connected to the Internet. IoT is any machine-friendly device that digitalizes the data. Edge computing provides low latency, location awareness, wide-spread geographical distribution, mobility support and consists of a large number of nodes.

Edge computing allows enterprises to operate independently using a public or private cloud and local computing in a specific area, region, domain or required local security boundaries. Edge computing is the practice of processing data near the edge of your network, where the edge computing is a distributed and open information technology architecture. That may span from end users, to the edge, to core and up to the cloud [3].

IV. Common challenges in Edge computing and IoT

In this section, we discuss some identified challenges from some of the state-of-the-art studies in this area. The edge is no longer sufficient to promptly process and evaluate the data generated by IoT devices like connected cars and other digital platforms. Edge computing introduces quite a number of challenges in IoT as depicted in Table 1 where we illustrate each challenge and its respective state-of-the-art solution.

TABLE I. Edge Computing challenges

Challenges	Focus	Reference
Cyber and physical security	Cyber Threats, Attacks and their effects on various IoT parts	[4]
Privacy	privacy-aware task offloading scheduling algorithm	[5]
Maintenance support	framework for proactive maintenance	[6]
Access	Multi-access edge computing (MEC) for good performance	[7]
Latency	Long distance between edge devices and cloud data center	[8]
Reliability	Management well be supported in management layer	[9]
Power Consumption	Optimal time allocation for best power consumption	[10]
Remoteness	Smart urban surveillance for instant decision making at the edge	[11]

4-1 Challenges of Edge computing in IoT

Edge computing introduces quite a number of challenges in IoT as noted in table 1. where we illustrate each challenge and its respective state of the art solution. Below we explain more About each of the challenges in edge computing stated in table

Privacy

Privacy in all aspects is a challenge in edge computing since user's data must undergo through security routines and data encryption before transmission to guarantee user data privacy, some traditional methods like plaintext keyword search and some others will be obsolete and replaced with more secure mechanisms [12].

Maintenance and support

Predictive maintenance comprehended in detection failure, intrusion detection and device mal-functionalities. A predictive program is needed in Edge computing therefore to simply detection, by management systems such as service

Systems. Edge computing enables to connect multiple data sources to the machine data sources to get a more accurate data overview [13].

Power consumption

Energy efficiency reduces the quantity of energy required to provide a product or service. Edge devices are used for different functions in resource allocation and power management on energy backups. Edge computing manages the resource flow to the resource centers and the edge node is responsible for handling the computations in the Edge.

4-2 IoT Challenges in Edge computing

In this section, we are to illustrate the IoT challenges in list in a table 2 and we look for its effect on IoT.

We denoted the current solution for these identified challenges and each solution for each challenge in respectively. The data encryption and decryption ensures data privacy maintenance and the chances of data theft are reduced to the bare minimum, ensure communication protection, secure the network, ensure device authentication during IoT communications.

Data analyze

By applying advanced analytics to these incoming streams of data, organizations gain new insights that can support them make more informed decisions about which actions to take positions and the environmental conditions in which systems operate [29]. We provide a summarized table 3 showing the current solutions to the challenges.

TABLE II. IOT CHALLENGES

Challenges	Focus	Reference
Security	Data safety	[14]
Privacy and protection	Environment perception System based on an industrial IoT network	[15]
Reliability	Reliability of emergency applications under IoT technology	[16]
Maintenance	Predictive maintenance technique	[17]
Management	Edge process management	[18]
Synchronizations and connectivity	Synchronization optimization algorithm	[19]
Trust	Trust connectivity of the domain	[20]
Scalability	Translation of the only extracted date to cloud	[21]
Data analysis	Location-awareness and latency-sensitive monitoring and intelligent control	[22]

Security

The increasing security threat to IoT underlines the importance of finding practical solutions that may address the issues and drastically reduce the rate at which IoT devices are attacked by criminals operating from the cyberspace like Use IoT Security Analytics, Thus, there is a need for multi-dimensional security analytics apart from monitoring IoT gateways alone.

TABLE III. STATE-OF-THE-ART SOLUTIONS

Challenges	Solutions	
	IoT	Edge
Effect on resource	On-demand provisioning and elasticity	Maintenance of the resources from threats
Security	Protection at the physical and media layer of the network	Cryptography-based technologies for solving data security and privacy
Control access	Configure operating conditions, criteria, sensitivity and authority in core management	Setting policies for resource access, controlling devices and user access
Management	An automated connection of devices within the smart word	Management systems should be designed to cope with intermittent network
Scalability	System's performance and advancing reengineering of the whole connectivity.	Dynamic resource scalability infrastructure
Latency	Shorter geographic distances between Edge nodes and end user	Resource allocation improving the quality of services by reducing communication latency
Bandwidth Issues	Analyze captured data to transmit.	Recourse management for bandwidth
synchronization	Establishing consistency among data	Drive the IoT network to global time and carrier frequency synchronization

V. CONCLUSION

In this paper, we carried out a comprehensive study on edge computing and IoT based on architecture, its challenges and suggested current state-of-the-art solutions. Our categorization was presented in three tables, where in table 1 we summarized the recent issues in common challenges, under table 2 briefly summarized the recent IoT challenges in edge computing where we further illustrated the current solutions in the table 3. The purpose of this paper is to provide new ideas to the research community to tackle the challenges in the supreme way. We are working on currently at simulation model within the domain of wireless and mobile computing that advance proper performance and controlled delay in the 5G.

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