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The Integration Of Edge Computing Into Iot Application Using Advantedge Platform, Case Study: Connection Technology (Wi-Fi, 4G, 5G)

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As the number of Internet of Things (IoT) devices that access the internet increases, generating data has correspondingly increased. As a result, the need to improve Internet speeds to facilitate data transmission is increasing, along with growing requirements for computing resources and storage capacity in centralized servers. In response to these challenges and to facilitate real-time data processing while reducing network bandwidth consumption, the integration of edge computing has emerged as a promising avenue. This research paper focuses on merging edge computing with IoT applications, using a simulation platform called AdvantEdge. In this context, we delve deeper into the use of connectivity technologies such as Wi-Fi, 4G and 5G by user equipment (UE) to establish connections with edge infrastructure. The main goal is to solve problems related to latency and network bandwidth usage inherent in IoT applications.

Key words and phrases: Multi-access Edge Computing (MEC), Internet of things, IoT application, Wi-Fi, 4G, 5G.

1. Introduction

Multi-access Edge Computing (MEC) emerges as a feasible method to mitigate useful resource constraints in the IoT domain. MEC environments deploy servers endowed with specific computational capabilities at the network periphery, proximate to IoT devices, thereby furnishing computational services tailored to the needs of said devices.

The Cisco Annual Internet Report (2018-2023) [1] predicts that the number of internet connected IoT devices will proliferate, reaching 30.9 billion by 2023. By 2025, these devices are expected to generate 73.1 zettabytes (ZB) of data, a significant increase from his 18.3 ZB collected in 2019. This includes data from a variety of IoT devices such as sensors, cameras, and interconnected peripherals. The increasing amount of data being generated and the expansion of the IoT device environment are creating a simultaneous demand for low-latency applications and high-bandwidth networks. MEC technology has proven to be an essential solution to meet the needs of IoT applications, and this is the central argument of this article.

Traditional cloud computing offers benefits such as extensive computing resources, scalability, and cost efficiency, but it also suffers from single points of failure and significant latencies (hundreds of millimeters) between end users and the centralized cloud infrastructure. Conversely, countless IoT applications require distributed systems that integrate location awareness, reliability, and minimal latency. Latency thresholds for time-critical IoT services require compliance with sub-millisecond benchmarks and reliability standards of no less than 99.99% [2].

2. Main section

IoT edge computing refers to the processing of data originating from data sources or IoT devices in close proximity to the data sources, as opposed to the traditional approach of transferring all data to a central server. point. This strategy allows for faster analysis and action on collected data while reducing the amount of data transferred. Traditional IoT architectures typically include three different layers: the perception layer, the network layer, and the cloud platform layer [3]. The sensing layer is primarily responsible for collecting field data and monitoring system operation, while the network layer facilitates the transmission of sensing data and control instructions. The platform layer handles various functions such as device and connectivity management, application facilitation, and business analytics. Integrating edge computing into IoT frameworks can effectively complement traditional IoT systems. Compared to traditional IoT architectures, IoT edge architectures include an additional layer, the edge layer, between the sensing layer and the platform layer,(see Fig. 1).

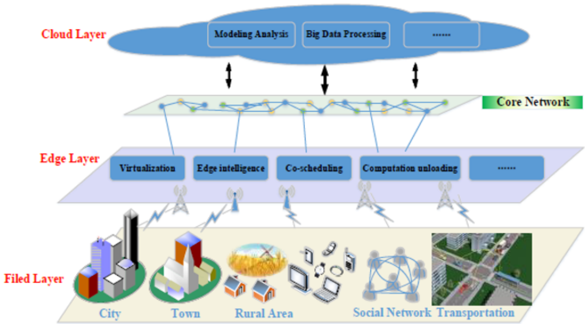

Figure 1. IoT Edge Architecture

The edge layer acts as a central interface between the cloud platform and the operational infrastructure, allowing for instant data analysis and processing. Additionally, it enables real-time control and decision-making processes within the system, reducing unnecessary data transmission and saving network bandwidth. This operating paradigm also helps reduce system latency and energy consumption associated with data transmission. Additionally, edge-centric IoT systems operate as closed systems, which greatly enhances system resilience and reliability [4].

Our system has three main parts, which are the IoT sensors, the Edge computing platform and the cloud (see Fig. 2).

This process involves deploying IoT applications to edge computing platforms. Data transmission from IoT devices is sent to both the edge and the cloud through three different connectivity technologies: 4G, 5G, and Wi-Fi, followed by data processing. To implement this scenario, we use AdvantEDGE [5], a mobile edge emulation platform (MEEP) based on Docker and Kubernetes. This platform provides an emulation environment that makes it easy to test and experiment with edge computing technologies, applications, and services.

Performance evaluation involves measuring several parameters such as latency, bandwidth, and error rates. AdvantEDGE allows comprehensive measurements of these parameters. A comparative analysis is then performed between scenarios where IoT applications operate in the cloud and at the edge, comparing the performance of three different connectivity technologies.

In the first development phase, a network model for the planned scenario is designed, (see Fig. 3). The network consists of three main components: three UEs, an edge server, and the cloud. In addition, additional network elements are integrated, including zones and their three PoA for each technology, namely the operator and the Internet.

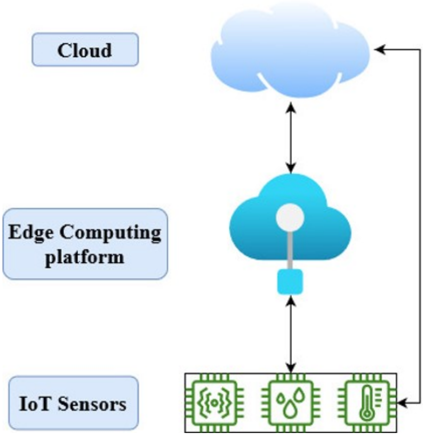

Figure 2. The Schema of the IoT Edge Application

In our network components we set the Uplink/Downlink throughput to 1000/1000 Mbps, and the latency between each two components as recommended from the platform as shown in Fig. 3.

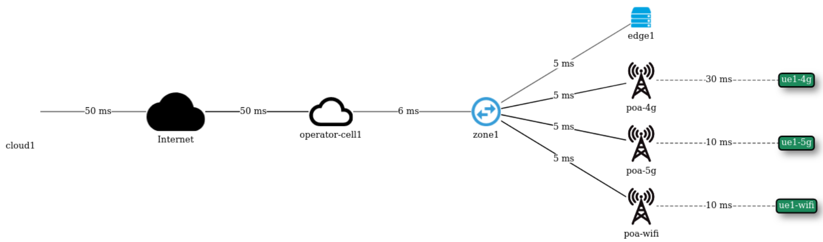

Figure 3. Network Design

After designing our network, we added the application that will simulate the IoT application and for that we will use iPerf which is a tool for network performance measurement and tuning. iPerf is a versatile tool that is compatible across multiple platforms, capable of generating standardized performance metrics for any network. This tool offers both client and server functionality and can establish data streams to measure the throughput between the two endpoints in one or both directions. The typical output generated by iPerf includes a time-stamped report that provides information on the volume of data transferred and the measured throughput [6]. Technically we will have three applications for each UE with iPerf, which works as clients and the other two work as servers (see Fig. 4).

The applications that run on the UEs work as a client and send the data to the server and the edge server, it uses UDP protocol, and it sends 20 Mbps. The applications that

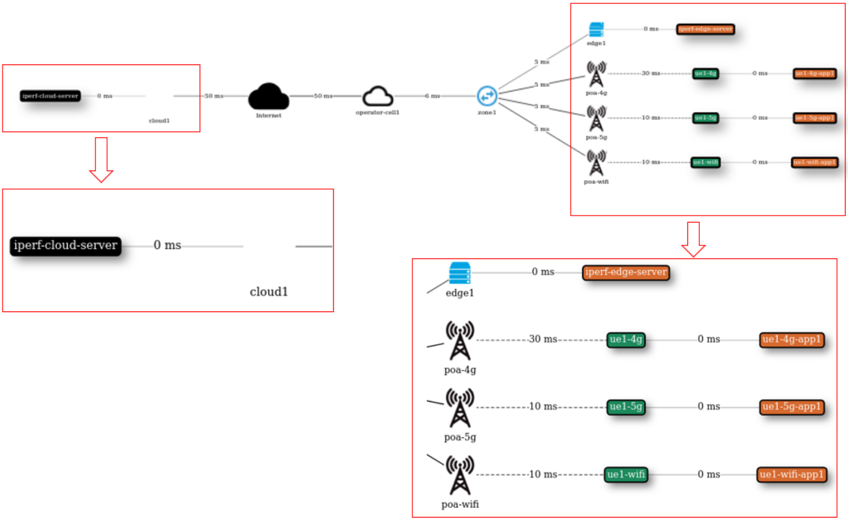

Figure 4. Network Design with the iPerf Applications

run on edge and cloud work as a server and receive the data from the clients, it used UDP protocol and listen on port 80.

After the design of the network and the configuration of the network elements and the applications. The results of the deployment are measured from the edge and the cloud side so we can see them in one chart. In Fig. 5 we can see the latencies from the edge side, the latency is bigger when it comes to 4G technology around 100 ms, and the variation of latency is bigger than the others. For the 5G and the Wi-Fi the latency is around 50 ms and the variation is less than 4G.

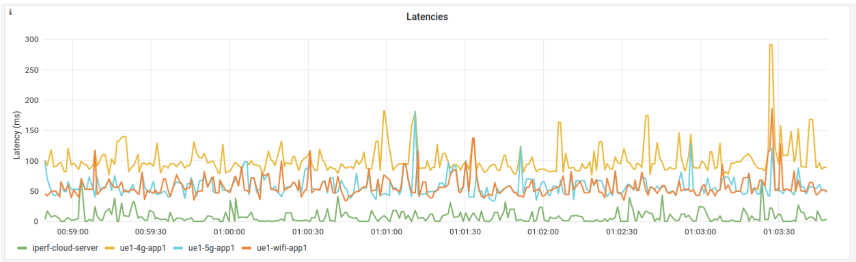

Figure 5. Latencies from Edge to the UEs and the Cloud

In Fig. 6 we can see the latencies from the cloud side, the latency is much greater than the edge side for all technologies, it is around 300 ms and the variation for technology is clear for 4G and 5G more than when using Wi-Fi, and that's related to the wide range of area that 5G and 4G cover whish may lead to such variation.

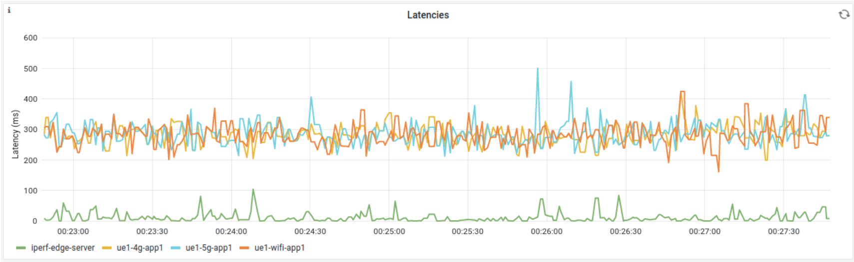

Figure 6. Latencies from Cloud to the UEs and the Edge

3. Conclusions

This study presents a simulation model of an IoT application deployed on an edge computing platform and shows that integrating of MEC and IoT can significantly reduce latency leads. Specifically, we achieved latency values of approximately 50 ms for Wi-Fi and 5G and 100 ms for 4G, as opposed to the 300 ms latencies observed with cloud infrastructure alone. Additionally, this integration reduces the data load on the network. The results of this model provide valuable insights into the potential of using MEC in IoT application development and position MEC as a core enabling technology in the IoT ecosystem. Subsequent research efforts can build on this model and explore further ways to integrate MEC into IoT application architectures. Based on our observations, we propose to deploy edge servers for critical applications and reserve cloud resources for non-critical applications, thereby optimizing resource allocation and improving overall system performance.

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Интеграция краевых вычислений в приложения интернета вещей с использованием платформы AdvantEdge: кейс-исследование технологии подключения (Wi-Fi, 4G, 5G).

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По мере увеличения числа устройств Интернета вещей (IoT), получающих доступ к Интернету, объем генерируемых данных увеличивается. В результате возрастает необходимость повышения скорости Интернета для облегчения передачи данных, а также требования к виртуальным ресурсам и объему хранения на централизованных серверах. В ответ на эти вызовы и для облегчения обработки данных в первое время при снижении потребления пропускной способности сети появилась интеграция локальных компьютеров как многообещающего направления. Настоящая научная статья сосредотачивается на слиянии локальных вычислений с приложениями IoT с использованием платформы симуляции под названием AdvantEdge. В этом третьем мы рискуем использовать такие технологии связи, как Wi-Fi, 4G и 5G пользовательского оборудования (UE) для управления связью с региональной инфраструктурой. Основная цель - решение проблем, связанных с задержкой и использованием пропускной способности сети, существующими приложениями IoT.

Ключевые слова: Мультидоступные краевые вычисления (MEC), Интернет вещей (IoT), приложения IoT, Wi-Fi, 4G, 5G.