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An Edge based Offloading Scheme for Universities

Mir Sajjad Hussain Talpur[1], Azhar Shaikh[1], Hadi Bux Khokhar[1], Anzar Ali Shah[1], Noor Ul Ain Abbasi[1], Arif Hussain Magsi[1], Fauzia Talpur[2], Asadullah Kehar[3], Abdul Samad Memon[4]

[1]*Information Technology Centre, Sindh Agriculture University, Tando Jam.*

[2]*University of Sindh @Laar Campus Badin*

[3]*Department of Computer Science, Shah Abdul Latif University, Khairpur*

[4]*Benazir Bhutto Shaheed University Lyari, Karachi*

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Abstract: Edge computing has been a dominant infrastructure for both content offloading and computational offloading. The most prominent advantage of edge computing over cloud computing is to alleviate the network burden, save battery life, and so forth. Edge computing is locally managed in the proximity of end-users. The edge provides the same functionalities as a centralized cloud, but edge computing enables end-users to cache or offload content in the proximity of the end-user. By exploiting edge computing, users can download, upload, or cache content at a high speed. Current literature explores edge computing in several areas, such as education, entertainment, vehicular networks, e-health systems, and so on. However, this has not yet been thoroughly investigated at the university level. Our research contribution is all about the placement of edge computing at a university, which facilitates the stakeholders of a university to store and offload their important work at a nearby data center. The simulation results validate our findings and show a very small delay as compared to the traditional cloud computing architecture.

Keywords: Edge, cloud, offloading, caching

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1. Introduction

Managing the network resources has been a great challenge for network operators [13]. Many applications are hosted on remote servers, which overburdens the backhaul network. According to a report, network bandwidth is consumed twice each year [12]. On the other hand, the way of interaction with computers has been dramatically changed since 2005 due to the implementation of cloud computing [1]. Edge computing has the same infrastructure as cloud computing. However, the only difference is their geographical placement, which makes edge computing a promising network architecture. In edge computing, the powerful machines are placed in the proximity of end-users [7], whereas the centralized cloud computers are far away from User Equipment (UE). Edge computing has several advantages over traditional cloud computing, such as speed, security, and privacy, which are the major problems in cloud computing which are mitigated by edge computing. Edge computing has been hailed as a game-changing architecture for content and computational offloading. Rather than managing heavy and expensive computing machines and physical space, edge computing enables end-users to offload their heavy computational tasks over edge computers. Edge computing offers different services such as Software as a Service (SaaS), IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and so forth. Some of the renowned cloud applications are Apache Spark [2], Apache Hadoop [3], MapReduce [4], One Drive, Google cloud [5]. It enables end-users to offload their content to locally managed, powerful edge computers rather than faraway, centralized clouds. Edge computing drastically saves the UE battery life, maintains privacy and security, and saves the network bandwidth and so forth. Edge computing has been widely exploited in several fields, such as education, health, business, banking, industry, smart cities, smart logistics, smart security systems, and so on. However, edge computation has not been explored in universities. Edge computing can play a magnificent role in universities, where the edge can offer different services to students, teachers, and other officials. These services include heavy and costly simulations to be performed over edge computing, storing and accessing heavy datasets which can be useful for other stakeholders. Furthermore, the Learning Management System (LMS), active directory of emails, video library, and many other services can be offered by edge computing at high speeds. Fig. 1 depicts the network architecture of edge computing.

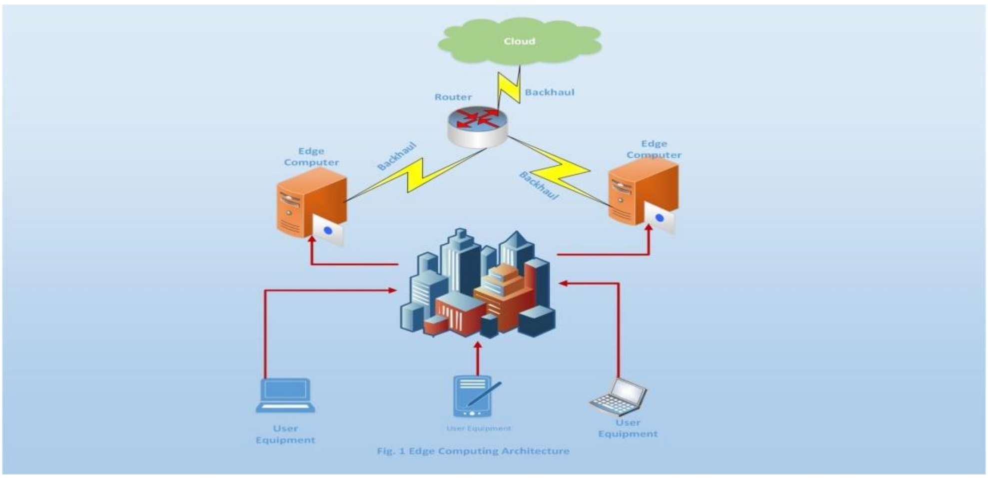


Fig. 1: Mobile Edge computing Architecture

The contribution of our research can be summarized as follows:

a. We propose smart computation and content offloading at the university level, in which universities can manage their email systems and other applications locally rather than through remotely managed data centers.

b. We designed two (2) different networks having different hop counts between UE and server machines.
c. Using CISCO packet tracing simulation, we assess the performance of those five (5) networks architectures.

The rest of the paper is organized as follows. Section II outlines the related work. In section III, we present the basic architecture of our proposed scheme, and experimental results through extensive simulations that verify the effectiveness of our proposed system are presented in section IV. Section V concludes the research work.

2. Related Work

During last few years, the edge computing has emerged as the new disruptive technology to change the world. It has facilitated different eras such as IoT [8], Vehicular Networks [9], machine learning [10], software defined networks [11] and so on. In [15], li et al,. proposed a mobile edge-based computation offloading scheme in for the detection of heart rate in video form. According to authors, the combination of both edge computing and cloud computing, also named as multi-layer offloading provides best performance. The authors in [14] proposed an offloading strategy on mobile edge computing where most suitable edge is decided to unload computation. The offloading choice is based upon three different parameters where the first task checks the task size, computation requirements, the computation capabilities of corresponding server and bandwidth of network. Secondly, authors design a task scheduling model which estimates the time requirement for offloading. Finally, the computation offloading performance of edge server is analyzed to investigate the best host for content offloading. The proposed technique is useful to select a reliable edge node to offload the content. However, analyzing the computation capability of every edge server and measuring the networking performance before sending a raw material for offloading consider an unnecessary overhead. The proposed scheme neglects the time constraints that is very important in offloading. Authors in [16] solved the distance education problem through artificial intelligence in Mobile Edge Computing (MEC) infrastructure. In this paper, authors solved different problem of universities and college such as distance based engineering talent training, the problem of the unintelligent experimental curriculum system and fragmented curriculum content, the problem of backward experimental teaching platform and teaching off the mobile network , the problem of inconsistency between experimental teaching and the demand of mobile network, the problem of poor portability of experimental teaching in distance education. By the implementation of Artificial intelligence over MEC, the ability of students can be evaluated and improved.

3. Proposed Architecture

A. Network Architecture

In our proposed network architecture, we assume two network infrastructures according to the hops. The network – 1 is assumed to be edge computing while network – 2 having 5 hops is a cloud computing host.

Network	Hops
01	01
02	05

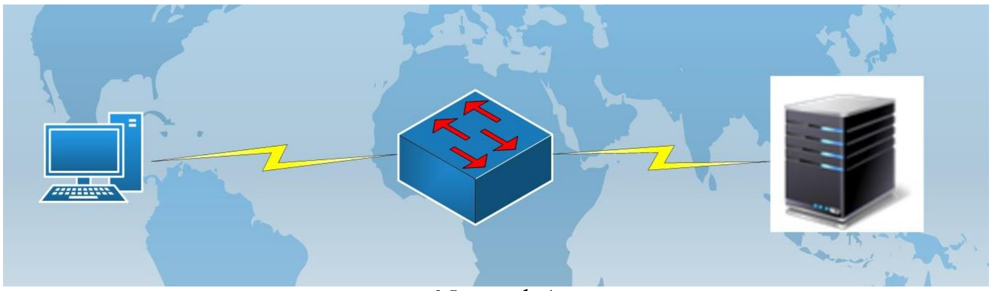
Table 1 Network Architecture

It is noteworthy to mention that the performance of each above network topology will be measured in simulation environment and their results will be presented.

3.1.1 Network 01

Network 01 contains one end-user that is directly connected to switch. On the other side, switch is connected to server. Figure 2 illustrates network 01.

Fig 02:

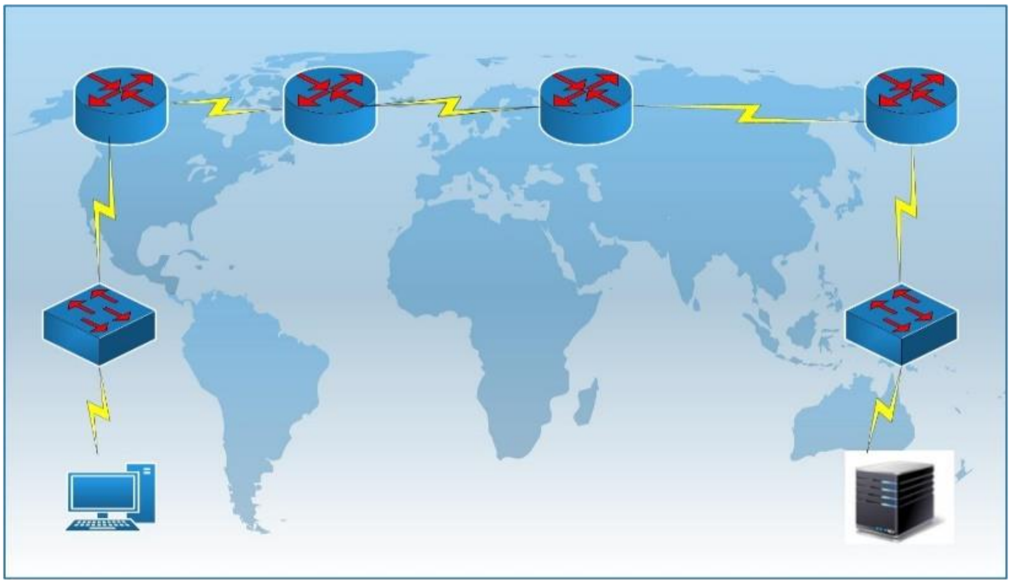


Network-1

3.1.2 Network 2

This network is more enhanced by adding more routers in it. In this network, total 4 routers and two switches are included in this network.

Fig 03:



Network 02

3.2 Network Performance Analysis

We analyze the performance of both networks individually. In order to evaluate the performance, we use CISCO owned network simulator called packet tracer version 7.2 for windows operating system. In every network, a server holds 5 text files as shown in table 2. To measure the delay and throughput in every network, every end-user device access and get the file from server. Table 1 illustrates the delay and throughput.

S. No	File Name	File Size (KB)
01	File 1	45
02	File 2	135
03	File 3	452
04	File 4	549
05	File 5	995

Table 2 File Size

3.3 Content offloading Policy

In traditional cloud computing architecture, an end user offloads their content on centralized cloud server. Offloading content on centralized cloud occurs privacy and speed issues. When a user wants to offload their content on centralized cloud, they have to agrees with terms and conditions of that corresponding cloud, after agreement, the cloud owner can access their content, he/she can use it, sell it. In such situations a user cannot offload their sensitive content due to privacy issues. Every time requesting to cloud for offloaded content can also overloaded the backhaul network. Speed is another issue that is faced in traditional cloud computing architecture, as the centralized cloud server is far away from the end user, so when the end user request to centralized cloud for their offloaded content, it takes some time to process the request due to huge space and hops between end-user and cloud. In our proposed mobile edge computing architecture, the pressure upon backhaul is released, thus privacy and speed problem is resolved. To elaborate our proposed content caching methodology lets assume case-1 and case-2 as following:

Case-1: In an organization, the employees offload their heavy content on cloud, when several employees requests for their offloaded content, the backhaul network can overload and speed can suffer due to huge space and hops between user and centralized cloud.

Case-2: In a bank, customer's accounts and transections details are offloaded on centralized cloud, this details / content is accessible by cloud owner which may causes privacy issue, and due to huge space between user and cloud, the bank employees cannot get their content quickly.

Case-1 and Case-2 Solution: In our proposed solution, the data will offload on edge server which is on proximity of end-user that will decrease the spaces between end-user and server and ultimately speed will increase. If the content offload on edge server, the end-user does not need to request the cloud so the backhaul network will also improve.

It is noteworthy to mention that the performance of each above network topology will be measured in simulation environment and their results will be presented.

4. Results

The experimental results are gained using a packet tracer simulator. Every result given below shows the network number, the delay in file access, and throughput in Kbps.

4.1.1 File 1 Results

File 1 is a text file. Its capacity is 45 KB. This file was accessed on both networks as depicted in table 3 and figure 4 respectively. Moreover, Network 1 shows lowest delay due to 1 hop between end-user device and edge server.

Network	Delay (ms)	Throughput (Kbps)
01	400	179.1
02	292	153

Table 3 File-1 Results

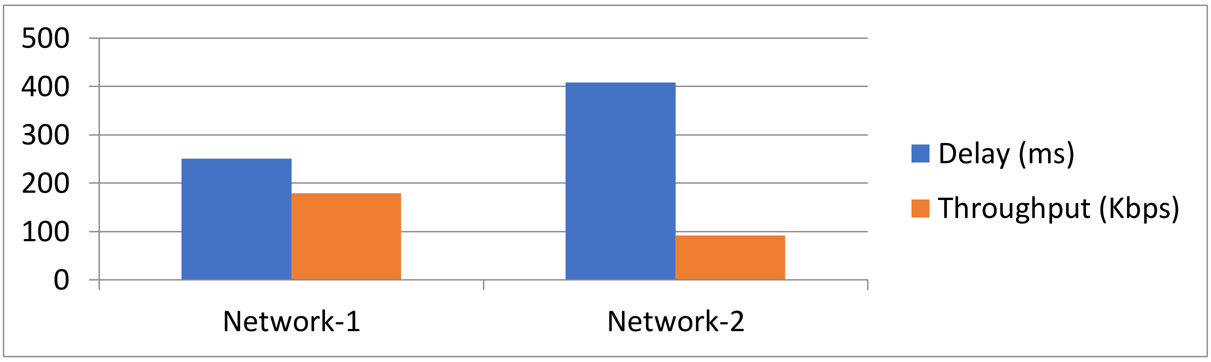


Fig 04: File-1 Results

4.1.2 File 2 Results

File 2 contains a text file that occupies 135 KB. Following table and figures shows simulated results.

Network	Delay (ms)	Throughput (Kbps)
01	547	247
02	1011	98

Table 4 File 2 Results

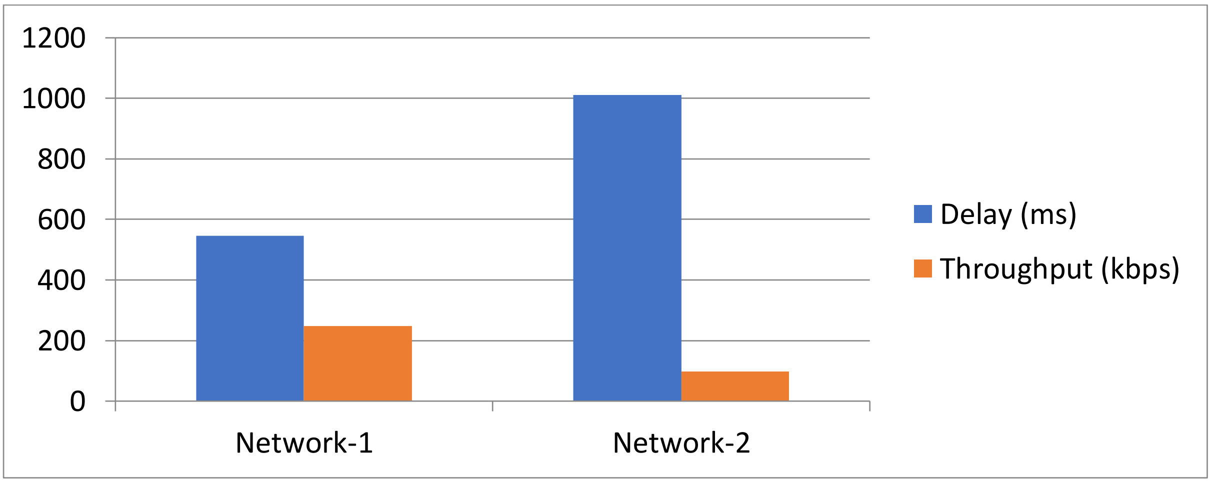


Fig 05: File 2

4.1.3 File 3 Results

File 3 contains a text file that occupies 452 KB. Following table and figures shows simulated results.

Network	Delay (ms)	Throughput (Kbps)
01	1590	257
02	2200	119

Table 5 File 3 Results

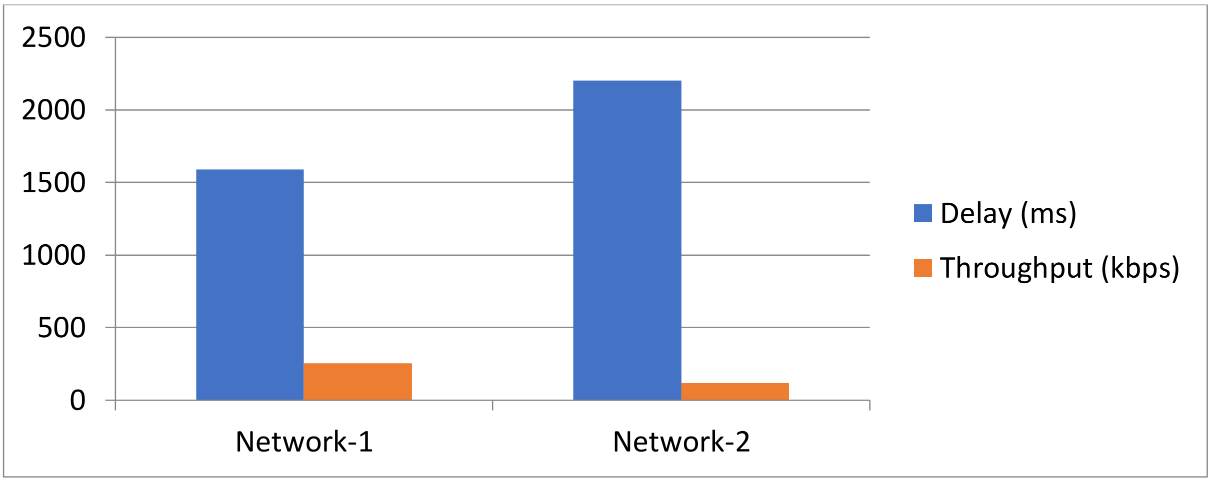


Fig 6: File 3

4.1.4 File 4 Results

File 4 contains a text file that occupies 549 KB. Following table and figures shows simulated results.

Network	Delay (ms)	Throughput (Kbps)
01	2023	374
02	2832	90

Table 6 File 4 Results

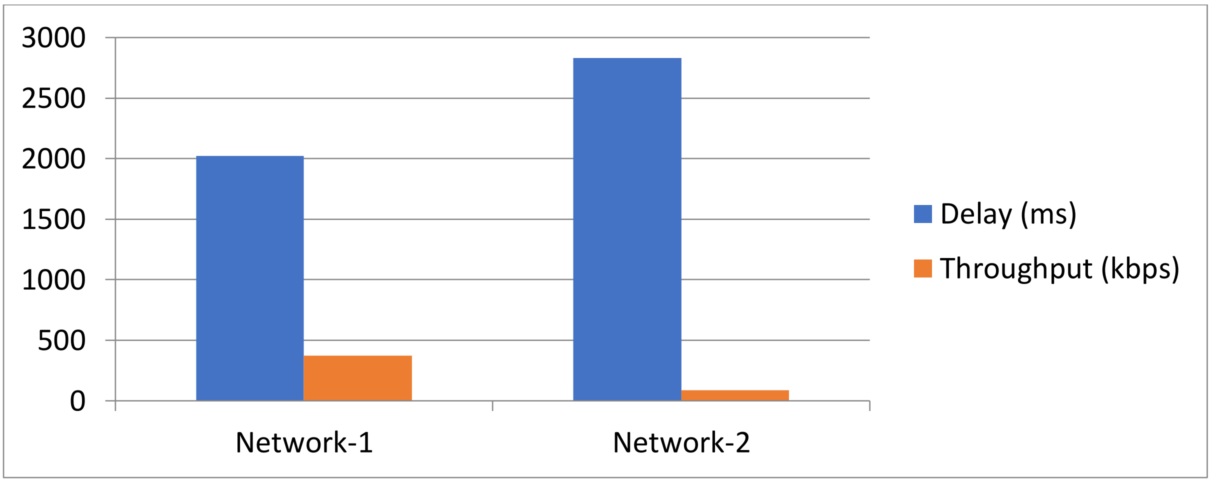


Fig 7: File 4

4.1.5 File 5 Results

File 5 is a text file having 995 KB storage space. Following table shows delay and throughput on all five networks.

Network	Delay (ms)	Throughput (Kbps)
01	3979	641
02	5463	291

Table 7 File 5 Results

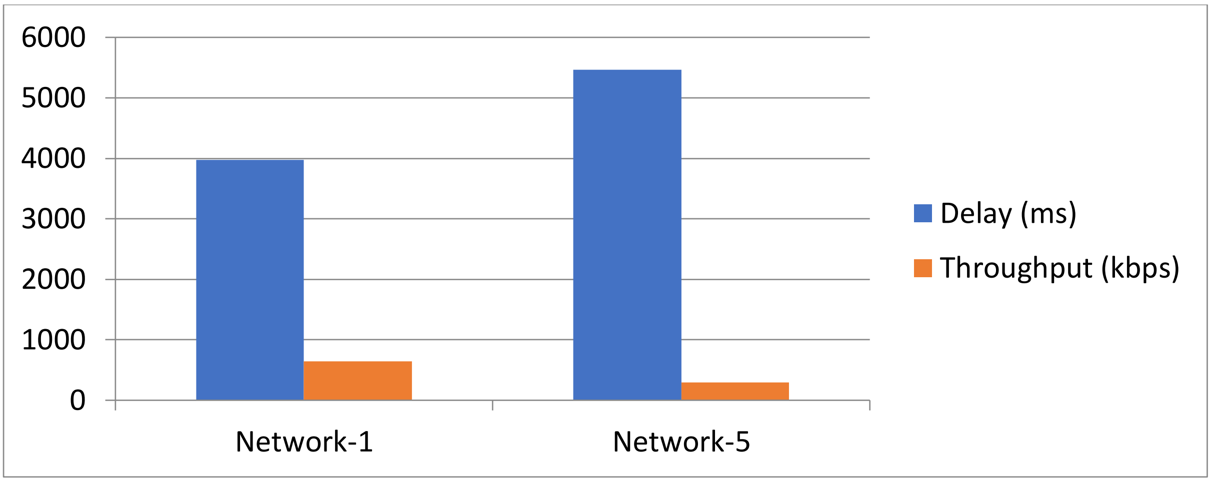


Fig 8: File 4

5. Conclusion

The proposed study is all about content offloading in mobile edge computing. Rather than approaching a faraway centralized cloud, in our proposed mechanism, we initially create 6 different networks in packet tracer version 7.2 for the Windows operating system. The networks contain end-user devices, switches, routers, servers. In every network, a server holds five text files, and we increase the hops between end user and server in each network to check which network performance indicator is in use. To measure the delay and throughput on every network, every end-user device access and gets the file from the server. We discovered that the network with the fewest hops between the user and the server has the shortest delay.The security is also enhanced due to having a server in close proximity to the end-user, and if content is offloaded onto an edge server, the burden on the backhaul network will also be overcome. The results of the proposed research work reflect the superiority over traditional cloud computing, which is very slow as compared to mobile edge computing.

References

[1] M. Armbrust et al., "A view of cloud computing," Commun. ACM, vol. 53, no. 4, pp. 50–58, 2010

[2] Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. IEEE internet of things journal, 3(5), 637-646.

[3] M. Zaharia, M. Chowdhury, M. J. Franklin, S. Shenker, and I. Stoica, "Spark: Cluster computing with working sets," in Proc. 2nd USENIX Conf. Hot Topics Cloud Comput., vol. 10. Boston, MA, USA, 2010, p. 10

[4] K. Shvachko, H. Kuang, S. Radia, and R. Chansler, "The hadoop distributed file system," in Proc. IEEE 26th Symp. Mass Storage Syst. Technol. (MSST), Incline Village, NV, USA, 2010, pp. 1–10.

[5] J. Dean and S. Ghemawat, "MapReduce: Simplified data processing on large clusters," Commun. ACM, vol. 51, no. 1, pp. 107–113, 2008

[6] S. Ghemawat, H. Gobioff, and S.-T. Leung, "The Google file system," ACM SIGOPS Oper. Syst. Rev., vol. 37, no. 5, pp. 29–43, 2003.

[7] Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. IEEE internet of things journal, 3(5), 637-646.

[8] Khan, U. Y., & Soomro, T. R. (2018, November). Applications of IoT: Mobile Edge Computing Perspectives. In 2018 12th International Conference on Mathematics, Actuarial Science, Computer Science and Statistics (MACS) (pp. 1-7). IEEE.

[9] Luo, G., Yuan, Q., Zhou, H., Cheng, N., Liu, Z., Yang, F., & Shen, X. S. (2018). Cooperative vehicular content distribution in edge computing assisted 5G VANET. *China Communications*, *15*(7), 1-17.

[10] Shakarami, A., Ghobaei-Arani, M., & Shahidinejad, A. (2020). A survey on the computation offloading approaches in mobile edge computing: A machine learning-based perspective. *Computer Networks*, 107496.

[11] Baktir, A. C., Ozgovde, A., & Ersoy, C. (2017). How can edge computing benefit from software-defined networking: A survey, use cases, and future directions. *IEEE Communications Surveys & Tutorials*, *19*(4), 2359-2391.

[12] Ericcson, "Ericcson Mobility Report – June 2013."

[13] Y. Saleem, F. Salim, and M. Husain Rehmani, Resource Management in Mobile Computing Environments, Springer Verlag Handbook. Springer, 2014, vol. 3, ch. Resource Management in Mobile Sink based Wireless Sensor Networks through Cloud Computing, pp. 439–459.

[14] Jinfang Sheng, Jie Hu, Xiaoyu Teng, Bin Wang * and Xiaoxia Pan "Computation Offloading Strategy in Mobile edge computing" School of Computer Science and Engineering, Central South University, Changsha 410073, China; jfsheng@csu.edu.cn (J.S.); 174712017.

[15] Li, X., Ding, R., Liu, X., Yan, W., Xu, J., Gao, H., & Zheng, X. (2018, December). Comec: Computation offloading for video-based heart rate detection app in mobile edge computing. In 2018 IEEE Intl Conf on Parallel & Distributed Processing with Applications, Ubiquitous Computing & Communications, Big Data & Cloud Computing, Social Computing & Networking, Sustainable Computing & Communications (ISPA/IUCC/BDCloud/SocialCom/SustainCom) (pp. 1038-1039). IEEE.

[16] Hou, C., Hua, L., Lin, Y., Zhang, J., Liu, G., & Xiao, Y. (2021). Application and Exploration of Artificial Intelligence and Edge Computing in Long-Distance Education on Mobile Network. *Mobile Networks and Applications*, 1-12.