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LETISA: Latency optimal Edge computing Technique for IoT based Smart Applications

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ABSTRACT

Internet of Things is a technological change which is not only "connected" but it is "smart", connected is not equal to smart. The switch from connected to smart is the ability of performing analytics at device level, which implies moving beyond, means not just only sensing the data but also processing the data. IoT in "smart" sense also called as Internet of Everything (IoE) or Internet of Anything (IoA). Edge Computing is used as an intermediary layer between the cloud and end users to reduce the latency time and extra communication cost that is usually found high in cloud based systems. The transmission time of cloud based computing is intolerable almost for every smart application. In this paper the existing system is studied and also the drawbacks of system are highlighted and problems associated with it are discussed. Keeping existing system in view a novel and efficient system is proposed**,** which tries to eliminate the drawbacks of the existing system. The LETISA is based on edge computing, which is a new and emerging technology that brings the services close to the proximity of data sources, as IoT devices are not only used as data gathering devices but are also acting as data consumers. The LETISA improves the efficiency of IoT based applications by deploying some of the computational capabilities at the edge devices. Finally the performance of the system is compared with the existing system, which shows the LETISA can significantly overcome the end-to-end latency.

Keywords: Cloud Computing, Edge Computing, IoT, LEC, LETISA.

I. INTRODUCTION

The World Wide Web (www) is the most important invention of the 1990's and cellular communication of 2000's. Now the third biggest achievement in the field of information and communication technology is disruptive technology that has revolutionized the world, i.e. "Internet of Things". The phrase "Disruptive Technology" was first introduced in [1], means a technological change often renovating the previous technology. The IoT describes a new way of linking the real world objects to virtual world, where each and everything or even virtual data environments can interact with each other in same space and time [2]. Developments and flexibility in embedded systems-on-chip (SOC's) with in centimeters or millimeters in size had made it possible for many commercial devices to run full-fledged operating systems and more complex algorithms. These types of embedded systems are powerful enough and are configured by set of different sensors such as camera, GPS, microphones, actuators with more than one communication technology such as Bluetooth, Wi-Fi or Ethernet. The advances in technology giving rise to new devices with different technologies and more capabilities. The potential of IoT is extended to the novel trends, earlier IoT concept was simply used for collecting data from things as in WSN and analyzing it elsewhere such as in cloud. In IoT scenario things are data producers as well as data consumers so it is better to perform computations on site without leaving physical world. Now-a-days IoT devices are more powerful than before with more computation capacity that made it possible to think about to compute on devices. According to Cisco data produced by beings, machines and things will be 500 zettabytes, and connected devices will be 50 billion by 2020. Number of applications is growing exponentially, some are private which implies private data, some are producing huge amount of data that can cause network load, and some requires very short responses etc. depending upon nature and type of the application [3].

Cloud Computing is the efficient way to process the sensed data as there is more computing power in cloud and can give all types of services on demand [4]. But where response time and low latency is of interest, cloud computing surrenders here which implies this is inefficient enough to support such kinds of applications. In cloud computing environment the processing is done in cloud which gives late responses due to network load, longer latency and other parameters that reduces the user experience. Keeping the latency and fast responses in view it is better to go for another technology: Edge Computing. Edge Computing is novel technology that allow computation near to the data sources that is at edge of network. Edge Computing functions for both the types of services which implies on downstream on request of cloud and for upstream on request of IoT services. Edge Computing is a platform of accelerating and improving the performance of cloud computing for mobile users [5]. Edge Computing promises the quicker responses, reduced network load in terms of bandwidth, reduces energy consumption and latency etc., security and privacy are additional benefits of edge computing because processing occurs close to data source [6]. The goal and objective of edge computing is to minimize communication latency and energy consumption of resource and energy constrained devices to attain high throughput. There are lot of applications which requires real time processing such as autonomous vehicle that has lot of sensors embedded on it produces at least 1 Gigabyte data per second to take correct decisions [7].

The rest of this paper is divided into following sections: Section II describes the detailed summary of cloud model, explains the working of it and give tabular view of hot applications and technologies. Section III presents novel architecture for IoT based Smart Application which is based on edge computing. The aim of proposed architecture is to reduce the network delay and maximize throughput or in other terms low delay and quick responses. In Section IV the results of both the existing model and proposed model is compared, it shows proposed model is better than Existing model. Section V concludes by summarizing the paper.

II. Existing Technologies

Cloud Computing plays vital role in the concept of modern internet technology and is building block of future internet. Cloud computing has enormously changed the way of living, work and study since the interception around 2005. Cloud computing provides the three basic services Application as a Service (AaaS) [8], Platform as a Service (PaaS) [9] and Infrastructure as a Service (IaaS) [10]. These services of cloud computing have greatly reduced the cost of ownership management of virtual resources, new services. The evolution of cloud computing and internet of things have enabled a lot of unprecedented opportunities in the IoT services arena. Most IoT applications are based on cloud processing [11], that are sensing the data then sending that data to cloud [12]. In this existing model that is based on cloud uses the services that are at remote location through the traditional network or internet connection [13]. Table 1 shows various IoT applications with the searching score and various technologies [14].

Table 1: IoT Applications and Search Score on Internet

Applications	Search on Internet (1000)	Wi-Fi	Bluetooth (BLE)	Mobile Network	Edge Computing
Smart Home[15]	64.730	Yes	Yes	Yes	Optional
Wearables[16]	35.320	No	Yes	Yes	Optional
Smart City[17]	41.580	No	No	Yes	Yes
Smart Grid[18]	41.160	No	No	Yes	Yes
Industrial Internet [19]	11.730	No	Yes	Yes	Yes
Connected Car [20]	6.250	Yes	No	Yes	Yes
Connected Health [21]	2.505	Yes	Yes	Yes	Yes
Smart Retail [22]	1.201	Yes	Yes	Yes	Yes

There are various cloud based models available [23], one is with gateway between the different entities. This model also known as Device-to-Gateway model, IoT devices basically connected to gateway to access a cloud service [24]. Gateway acts like an intermediary between the cloud services and IoT devices. The gateway runs application software which is responsible for data or protocol translations to provide the solution for interoperability gap between devices that communicate on different standards. For example smart devices, Z-Wave and ZigBee transceivers can communicate with both families of devices. Another model is device to cloud, in this model communication involves an IoT device connecting directly to an Internet cloud service like an application service provider to exchange data and control message traffic. There is no gateway, so no conversion is done in this model, it uses already available internet connections (wired Ethernet or Wi-Fi connections) and can also use cellular technology. By this type of connectivity the user and an application obtain remote access to a device. A use case for cellular-based Device-to-Cloud would be a smart tag that keeps track of any device or thing which is at remote location [25]. Hybrid Model is combination of both device to cloud and device to gateway model. Diagrammatic representation cloud model is given below in Figure 1.

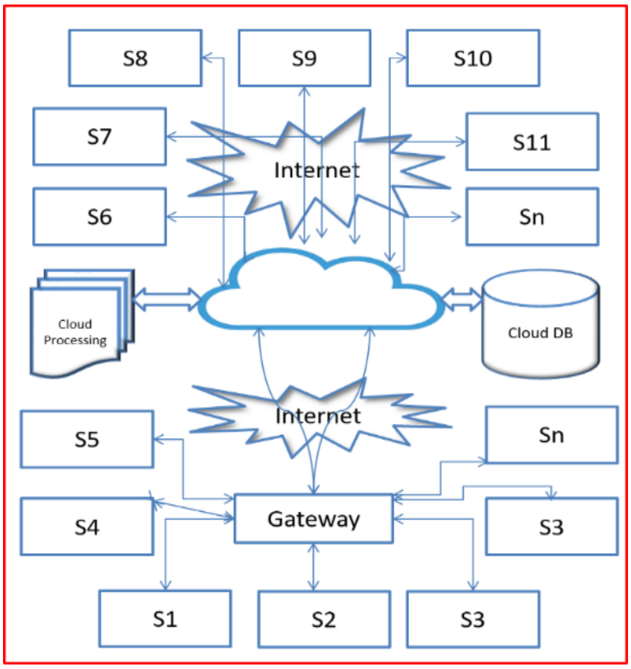

Figure 1. Cloud Model

III. Proposed: Latency optimal Edge Computing Model (LEC)

The integration IoT and Cloud is known as edge computing, edge computing is a way allowing computation to be performed at the edge of the network near to data sources. Edge refers to the huge number of devices and sensors that are distributed across any geographical area are embedded in a system such as car, plane etc. and are generating data for the functioning of specific device or sensor. The edge computing is the extension or forward step of cloud computing, in edge computing end devices are not only generating data but are also consuming the data. At the network edge, devices not only requesting services from the cloud but also can perform tasks such as processing, storage, caching and analytics etc. Edge device also responsible for computation offloading to the cloud, in simple terms it acts as a gateway between cloud and physical devices and taking decisions whether to offload or process locally. Figure 2 gives diagrammatic representation of the Latency optimal Edge Computing Model (LEC).

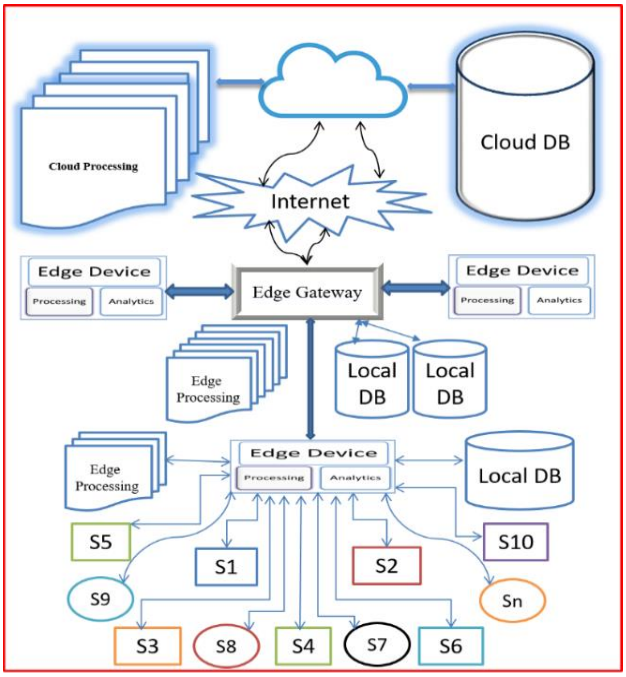

Figure 2. Latency optimal Edge Computing Model (LEC)

Mobile Edge Computing is novel concept in which some of the computation capabilities or shifting of the some computation power from cloud such as analysis, pre-processing and decision-making capabilities to the edge of the network. Mobile edge computing offers greater responses and reduces latency by deploying the computation and storage capacity at the edge of the network. Mobile Edge Computing gives real time Radio Access Network (RAN) information that is within the range of RAN such as network load, location. This real time data can be used to give the context aware services to the mobile users thereby to improve or enrich the user's satisfaction.

The real world is divided into physical locations or areas. The area is geographical unit where one or more IoT devices are deployed. In an edge computing environment devices can be of three types depending on their role. The architecture of mobile edge computing is divided into three basic components or layers in the edge computing architecture: 1) Devices which includes all types of devices such as mobile phones, sensors, actuators and RFID tags etc. These are special purpose devices that do not have general purpose processors or operating systems. These devices are connected to edge devices or edge gateways directly or via low power radio technologies. 2) Edge device or Edge Gateways are general purpose devices which have the capability of running the full-fledged operating system and are often battery powered. Edge devices can perform computation on data, received from sensors and send commands to Actuators. Edge Gateway acts as mediator for connecting edge devices to the cloud or edge devices can be connected directly to cloud. Edge Gateways are different from edge devices in a way that edge gateways have unconstrained power supply, more CPU power, Memory and storage. Edge Gateways offer location management services in addition of acting as intermediator. 3) Edge Gateways as well as Edge Devices can forward selected of raw or pre-processed IoT data to the services running in cloud like storage or analytical services. They both can receive commands from the cloud, like configurations, data queries or machine learning models against which to locally score IoT data.

IV. Performance Analysis

The proposed technique is compared with traditional cloud based processing. The parameters taken for calculation are as under, the range of Edge device is 500 meters, the physical layer protocol is BLE for device to edge communication, the transmission power is same for all devices that are 24 dBm and the bandwidth is 10MHz for device to edge communication. The adoption and deployment of cloud computing is critical to evaluate the performance of cloud environments. Modeling and simulation technologies are suitable for evaluating performance and security issues. Cloud simulators are required for cloud system testing to decrease the complexity and separate quality concerns. There are several cloud simulators that have been specifically developed for performance analysis of cloud computing environments and CloudSim is a one of them Cloud simulation application. CloudSim enables seamless modeling, simulation, and experimentation of cloud computing and application services. Now a days there are various versions of CloudSim such as CloudAnalyst, GreenCloud, Network CloudSim, EMUSIM and MDCSim. Most of them are open source and are based on java language and some are based on C++ also, the simulation type is either event based or packet level.

The execution time for most of IoT based application is less that is in range of milliseconds as compared to time duration of channel block. The transmission delay also known as packetization is the amount of time required to push all the packet's bits into the wire or caused by the data-rate link. In other words transmission delay is the time take by a unit of data to reach from one device to another. Response time is an amount of time that a system takes to respond to a request for service or in other words the response time is the total elapsed time from when a request is made to the time it is completed. The figure 3 below shows the results with respect the number of devices in cloud and as well as in edge. In figure x-axis shows the number of devices and y-axis shows time in milliseconds.

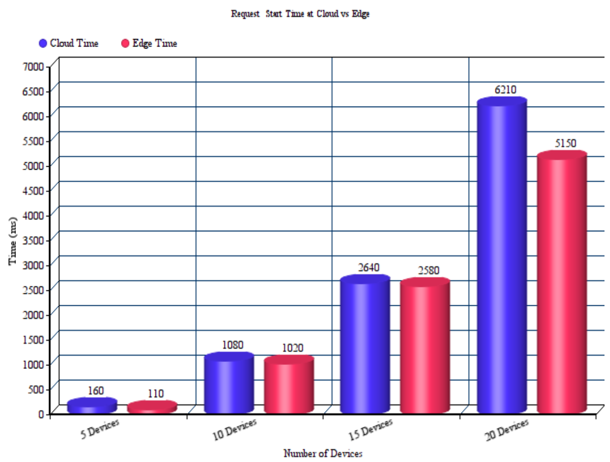

Figure 3. Transmission Delay [Edge vs cloud]

Delay is most important characteristic of any system which is not to be for granted. Delay and latency are sometimes used interchangeably, it is the amount of time taken by a unit of data transmitted from one device to other device. In terms of networking, it is a time that a data packet takes to reach or get from one designated point to another. The Figure 4 below shows the delay in milliseconds for processing a unit of data in edge and in cloud. For analysis different number of users are taken 5 users, 10 users, 15 users, and 20 users respectively. The column represents the total delay and line represents the process start time. End to end delay is total delay that is processing time and transmission time of a process. The graph shows that edge processing is better than cloud processing, as the delay is low and response time is also lower than of cloud. In this the x-axis shows the number of devices and y-axis shows the time in milliseconds.

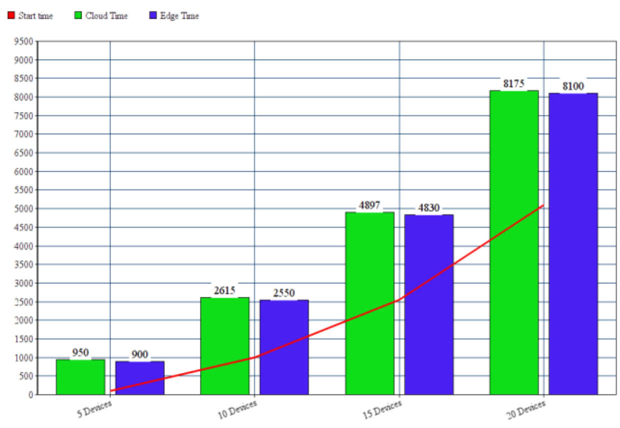

Figure 4. End to End Delay and Response Time with respect to Number of Devices

V. Conclusion

Internet of Things make it possible to collect information from the physical world and analyze it in virtual reality. The IoT can be used almost in every field of the modern era because there are already devices present with capabilities that can be used in smart application systems. The latency and response time are the most important characteristics of novel applications which requires real time processing for better and efficient results. Edge computing is promising area for low latency and high responses. Edge devices are close enough to proximity of sensor nodes and edge gateways can exploit by its unique strategic position to handle many challenges in edge based application systems such as mobility, efficiency, energy, interoperability, scalability, and reliability. The detailed drawbacks of existing system are highlighted with different models. Studies have shown that existing system is not good enough for those applications totally depend on computed results. Smart Trafficking, Smart Healthcare system etc. cannot tolerate the long latency and high responses. In this paper, the novel architecture is proposed, LEC Model promises low latency and high responses which can be used for every smart application that needs the above features. The LEC Model is explained with the devices as well as their communication technologies. Finally, the performance analysis of the new system is compared with the existing system and results have shown that proposed system is better than existing system. The analysis shows the proposed framework performs better when number of devices does not exceeds the capacity of edge device. This issue can be addressed by proposing scalable edge computing in future. Scheduling and scalability are the two main issues which can be taken as future work.

VI. References

[1] Flavin, Michael. "Free, Simple and Easy to Use: Disruptive Technologies, Disruptive Innovation and Technology Enhanced Learning", Disruptive Technology Enhanced Learning, 2017, pp. 19-52.

[2] Weber, Rolf H., and Romana Weber, "Internet of things. Vol. 12, Springer, 2010.

[3] Shi, Weisong, et al. "Edge computing: Vision and challenges." IEEE Internet of Things Journal, Vol. 3, No. 5, 2016, pp. 637-646.

[4] Mell, Peter, and Tim Grance. "The NIST definition of cloud computing." 2011, pp. 1-7.

[5] Cloud Computing Tutorial for Beginners, https://www.guru99.com/cloud-computing-for-beginners.html.

[6] Varghese, B., Wang, N., Barbhuiya, S., Kilpatrick, P., & Nikolopoulos, D. S., "Challenges and opportunities in edge computing", IEEE International Conference, 2016, pp. 20-26.

[7] Bonomi, F., Milito, R., Zhu, J., & Addepalli, S., "Fog computing and its role in the internet of things" In Proceedings of MCC workshop on Mobile cloud computing, 2012, pp. 13-16.

[8] Buyya, Rajkumar, Rajiv Ranjan, and Rodrigo N. Calheiros. "Intercloud: Utility-oriented federation of cloud computing environments for scaling of application services." International Conference on Algorithms and Architectures for Parallel Processing. Springer, 2010, pp. 13-31.

[9] Gong, C., Liu, J., Zhang, Q., Chen, H., & Gong, Z., "The characteristics of cloud computing", IEEE Conference, 2010, pp. 275-279.

[10] Moreno-Vozmediano, Rafael, Rubén S. Montero, and Ignacio M. Llorente. "Iaas cloud architecture: From virtualized datacenters to federated cloud infrastructures." Computer, Vol. 45, No.12, 2012 pp. 65-72.

[11] Hassanalieragh, Moeen, Alex Page, Tolga Soyata, Gaurav Sharma, Mehmet Aktas, Gonzalo Mateos, Burak Kantarci, and Silvana Andreescu, "Health monitoring and management using Internet-of-Things (IoT) sensing with cloud-based processing: Opportunities and challenges." IEEE International Conference, 2015, pp. 285-292.

[12] Shinde, Tejaswinee A., and Jayashree R. Prasad. "IoT based Animal Health Monitoring with Naive Bayes Classification." IJETT, Vol. 4, No. 2, 2017, pp. 1-4.

[13] Tao, Fei, Ying Cheng, Li Da Xu, Lin Zhang, and Bo Hu Li. "CCIoT-CMfg: cloud computing and internet of things-based cloud manufacturing service system." IEEE Transactions on Industrial Informatics, Vol. 10, No. 2, 2014, pp. 1435-1442.

[14] IoT Analytics https://iot-analytics .com/10-internet-of-things-applications/, Accessed on 24-07-2017.

[15] Hou, Enxing, Long Dai, and Zhenwei Wen. "Method, apparatus and electronic device for controlling smart home device." U.S. Patent No. 9,691,272. 27 Jun. 2017.

[16] Chan, M., Estève, D., Fourniols, J. Y., Escriba, C., & Campo, E., "Smart wearable systems: Current status and future challenges", Artificial intelligence in medicine, Vol.56, No. 3, 2012, pp. 137-156.

[17] Sheng, Zhengguo, Shusen Yang, Yifan Yu, Athanasios Vasilakos, Julie Mccann, and Kin Leung., "A survey on the ietf protocol suite for the internet of things: Standards, challenges, and opportunities." IEEE Wireless Communications, Vol. 20, No. 6, 2013, pp. 91-98.

[18] Kurt, S., Yildiz, H. U., Yigit, M., Tavli, B., & Gungor, V. C., "Packet size optimization in wireless sensor networks for smart grid applications", IEEE Transactions on Industrial Electronics, Vol. 64, No. 3, 2017, pp. 2392-2401.

[19] Da Xu, Li, Wu He, and Shancang Li. "Internet of things in industries: A survey." IEEE Transactions on industrial informatics, Vol. 10, No. 4, 2014, pp. 2233-2243.

[20] BJ Hubert Shanthan, A. Dalvin Vinoth Kumar, and L. Arockiam. "Filling Fuel Quantity Measurement Systems Using Internet Of Things.", International Journal of Innovative Research and Advanced Studies, Vol. 3, No. 13, 2016, pp. 152-154.

[21] Lin, Zhicheng, Pui-In Mak, and Rui Paulo Martins. "A sub-GHz multi-ISM-band ZigBee receiver using function-reuse and gain-boosted N-

path techniques for IoT applications," Ultra-Low-Power and Ultra-Low-Cost Short-Range Wireless Receivers in Nanoscale CMOS. Springer International Publishing, 2016, pp. 81-103.
[22] Dacko, Scott G. "Enabling smart retail settings via mobile augmented reality shopping apps." Technological Forecasting and Social Change, 2016.
[23] Armbrust, Michael, Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., & Zaharia, M., "A view of cloud computing." Communications of the ACM, Vol.53, No. 4, 2010, pp. 50-58.
[24] Using an IoT gateway to connect the "Things" to the cloud, John Treadway, http://internetofthingsagenda.techtarget.com/feature/Using-an-IoT-gateway-to-connect-the-Things-to-the-cloud. Accessed on 1st July 2017.
[25] Chen, Min, et al. "Cloud-based wireless network: Virtualized, reconfigurable, smart wireless network to enable 5G technologies." Mobile Networks and Applications, Vol. 20, No.6, 2015, pp. 704-712.

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