

## Potentials of Fog Computing in Higher Education

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Arumugam Raman  
Universiti Utara Malaysia, Sintok, Malaysia  
arumugam@uum.edu.my

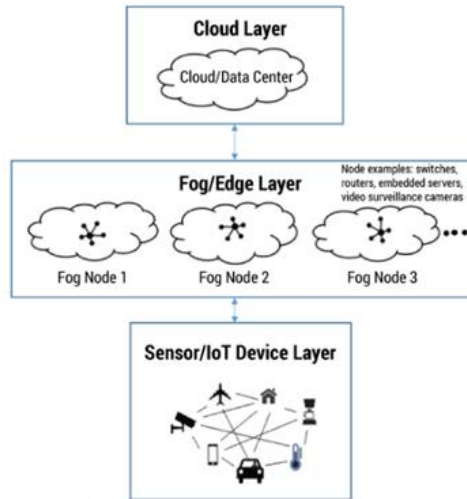
**Abstract**—This paper is documenting the potential of Fog Computing in Education. First, this study explores the difference between cloud computing and Fog Computing. Then the features of computing explained briefly. A tremendous increase in Internet usage among the people does not allow the sustainability to continue depending on Cloud Computing as a centralized web server, due to the truth that Cloud Computing system allows access to internet data as well as therefore making it feasible for users to availability, share along with store information in remote servers. With Fog Computing, multiple users, gadgets such as automobiles, wearable gizmos, sensing units, wise gadgets, an organization can accept one another utilizing their very own Fog facilities. In the educational sector, Fog computing technology boosts educational operations and provides a platform with agility, versus slowing them down or quitting them. Fog computing is a modern technology that is set for high development in the future, as well as will substantially improve day-to-day procedures for many sectors, including education. Finally, security issues and challenges of implementation Fog computing discussed.

**Keywords**—Fog computing, cloud computing, internet of things, higher education

### 1 Introduction

The introduction of the IoT brings 50 [1] billions of tools to the Internet, and most of these gadgets are resource-constrained. To get rid of the challenges of these tools as well as meet the demands of the application domain, the demand for an intermediate computer layer becomes obvious. The idea of Fog computer is the most recent offspring in the line of physical separation of functional units. It is a computer layer closer to the perception layer, where the sensing units and also actuators stay, and also provides computer, networking, and storage services. Fog computing is a dispersed computer atmosphere that expands the Cloud Computing standard to sustain the Internet of Things (IoT) vision. It intends to push the intelligence, processing and also storage space of information closer to the Edge of the network to supply computer-related solutions much more instantly and also near to the interconnected wise things that form a component of the IoT [2]. Because of this, Fog computing is occasionally likewise referred to as Edge Computing. The two terms are commonly made use of interchangeably; nevertheless, there are refined differences. The Fog Computing mar-

ket is currently valued at \$22.3 million in 2017 and is expected to expand at an explosive rate and grow to \$203.5 million over the next five years [3]. It is expected to increase at an eruptive rate to expand to around \$205 million over the next five years. With such a high level of connection of wise tools, Fog computing seems the next massive thing for the IoT vision. Figure 1 shows a graphic of Fog computing.



**Fig. 1.** Overview of fog-based computing

Source: <https://www.cutter.com/article/fog-computing-new-space-between-data-and-cloud-497871>

Although the Cloud paradigm is very appealing for data-intensive handling requirements, there are several fundamental limitations that the Fog vision aims to solve. For example, minimizing the Internet/service latency, enhancing the context awareness, saving the network bandwidth, enhancing the quality of stipulation, boosting the operational efficiency, supplying the enhanced user experience and accelerating the real-time processing as well as keeping of sensitive information near where the data are generated.

Fog paradigm offers better support for flexibility and also the use of mobile communication whereas, in Cloud Computing, feedback times remain in minutes as well as typically days, data storage space periods are longer time and usually permanent, and area coverage is too broad as well as often worldwide. By contrast, in Fog Computing response times are in nanoseconds or sub-seconds, information storage periods are short-term, as well as area insurance coverage is regional and also with enhanced awareness. Table 1 shows a comparison of Fog versus Cloud computing.

**Table 1.** Fog versus cloud computing

Requirements	Fog computing	Cloud computing
Latency	Low Latency	High Latency
Location of servers	Servers on the edge of the network	Servers within the Internet
Security	Safe from attack	No-user-defined security
Location awareness	Yes	No
Geographical Distribution	Distributed	Centralized
Data storage period	Milliseconds	Minutes

These benefits are primarily due to the localization of nodes in the Fog design that sustains vertically and down isolated latency-sensitive applications by offering ubiquitous, scalable, layered and federated network connection. Whereas the Cloud atmospheres are frequently geographically a long method away from the end-user gadgets as well as rely greatly on the larger Internet data transfers, the Fog solutions are much closer to end-users with dense geographical circulation. Fog Computing is presently being successfully deployed in countless industrial and also industrial application situations that require both Fog localization and Cloud globalization, including: smart grids, smart houses as well as cities, smart campus, connected automobiles, self-drive autos as well as trains, traffic light system, medical care administration and also countless various other cyber-physical systems.

## 2 Literature Review

Both Fog Computing as well as Edge Computing provide the same functionalities in terms of pressing both data and also intelligence to analytic systems that are located either on, or near where the information originated from, whether that is screens, speakers, electric motors, pumps or sensing units

The benefit of Fog Computing is the amount of time in supplying feedback from the information center. When the reaction is quicker especially with tools that have the 5G ability, the advantage that Fogging materials are the minimized latency in addition to jitter. Fog Computing can for that reason provide much better or enhanced results, increase service levels as well as safety in various environments such as transportation, mining and also the public sectors. In establishing nations such as Malaysia, the federal government has noticeable interest in supplying accountable along with clear civil service delivery where the workout of ICTs is exceptionally expected.

Organizations focusing and planning on dependable service agility can benefit with Fog Computing by taking care of the organizational applications properly because Fog application program allows the gadget to work according to the individual's needs. Fog Computer offers enhanced understanding and action to occasions by removing a round trip to the Cloud for evaluation. It avoids the need for pricey transmission capacity enhancements by offloading gigabytes of network traffic from the core network. It likewise secures delicate IoT information by analyzing it inside business walls. Eventually, organizations that adopt Fog Computing gain deeper and also

much faster insights, causing enhanced company dexterity, higher service levels and boosted security.

According to International Telecommunication Union (ITU), in industrialized countries, slow as well as constant growth enhanced the percentage of the populace making use of the Internet, from 51.3 percent in 2005 to 80.9 percent in 2018. In developing countries, growth has been far more sustained raising from 7.7 percent in 2005 to 45.3 percent at the end of 2018. Of all ITU regions, the toughest growth was reported in Africa, where the portion of people making use of the Net increased from 2.1 percent in 2005 to 24.4 percent in 2018. According to the quotes, the areas with the lowest growth prices were Europe, with 79.6 percent, and the Americas, with 69.6 percent of the populace making use of the Web. In the Commonwealth of Independent States (CIS) area, 71.3 percent will be using the Internet; 54.7 percent in the Arab States and also 47 percent in the Asia-Pacific region [4].

The increase of Internet people does not allow the sustainability to continue depending on Cloud Computing as a centralized web server, due to the truth that Cloud Computing system allows accessibility to internet data as well as therefore making it feasible for users to availability, share along with store information in remote servers. The difficulty of a centralized Cloud internet server cannot be reliable any longer, due to the fact that they are typically situated not near the people which causes high ease of access latencies, hence the suggested option is to move towards a decentralized atmosphere such as Fog Computing which is in some cases referred to as Edge Computing. Cloud Computing obtained its allure when it comes to information taking care of as well as reliable high computation power ability [5].

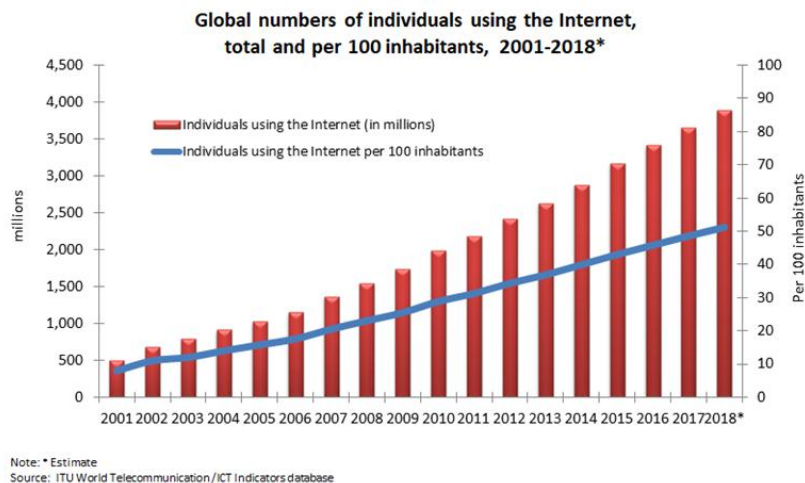


Fig. 2. Global numbers of individuals using the Internet

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With Fog Computing, multiple users, gadgets such as automobiles, wearable gizmos, sensing units, wise gadgets, and organization can accept one another utilizing their very own Fog facilities. The existing paradigm of Big Information created daily, and the strong entrance of IoT are refined by devices such as smart phones sent at the edge of the network or close to terminal gadgets and also allow regional data to be easily accessible. Also, various mobile phones can additionally connect directly to every other. The information does not have to be transferred to the Cloud and even the base terminal.

Fog nodes are extremely vibrant as well as heterogeneous at various degrees of networks hierarchy for reduced latency and scalability needs. The Fog Computing atmosphere is released in various kinds that can be online or physical [6]. The Fog computing such as routers on the Edge, access factors as well as gateways have computational and storage capabilities that can operate on numerous OS as well as procedure information application in various location. Azaan and also Huh [7] conclude that because Fog Computing is very virtualized in nature "digital computer nodes and online network nodes," these nodes are seen to be used as Fog nodes as a result ending up being heterogeneous.

### **3 Fog Computing in Education**

Education Industry encounters a variety of obstacles in giving rich understanding experiences for students, among which is technology--particularly, staying on par with technology developments to provide the most effective learning devices offered. Students throughout all phases of education and learning need accessibility to modern-day technology to help prepare them for the digital-focused and affordable job market. Merely replacing chalkboards with interactive screens or smartboards is no more the only remedy required to prosper. Alongside the pressure of offering the best for trainees, institutions are under remarkable pressure to keep limited IT budget plans.

There is a shift towards presenting job assignments online via students portals where data is stored in the cloud. Higher institutions are implementing usual office applications, messaging services and also online desktops, while holding web solutions for students and also parents, along with supporting even more specific educational applications. Regardless of the record development in Fog computing, several Higher Institutions are not aware of the innovation behind the scenes that makes this advancement possible. Below are three methods that side computing is affecting the class [8].

First, Fog computing enables microdata facilities to provide modern on-site technology that can scale up and down with the college's needs. The system capacity might have a surge of website traffic because of an increased number of both staffs as well as students accessing the Learning Management System (LMS). One of the most typical applications used in these circumstances is PowerSchool (Oracle 12 Database), Skyward as well as Procure. During this moment, the facilities required to scale as much as deal with traffic and also make specific efficiency does not go down, however after that downsize down when everyone is logged off. To operate efficiently, connection as well as networking requirements to be the number one top priority. Nevertheless, this can be a challenge for lots of distributed institutions, like schools-- particularly those expanded across numerous branches. By bringing information locally on-site, latencies can be gotten rid of for a constant as well as a much better individual experience.

Additionally, some universities might not have IT personnel on site. The advantage of fog computing is that trained IT personnel can do remote management of jobs. Having the ability to do most, otherwise, all, of these jobs remotely is essential not just because of the cost of traveling to these sites yet also for reducing downtime due to delayed reaction times because of travel. Secondly, Modern technology in the class has come to be the new regular as teachers want to new ways to utilize computer systems and online sources in education and learning. The worldwide market for education technology is expected to grow from \$193 billion in 2016 to \$586 billion in 2021 [9], according to Research AND Markets. Colleges with several campuses are touching Fog computing as a viable service to support universities, due to the simplicity of use and its impact on user experience. Fog computing is local computing, away from the main information facility where efficiency and integrity are necessary, which can be deployed rapidly as well as quickly. When Higher Institutions use side computer, they focus on connection and networking throughout numerous campuses to eliminate slow-moving rates, which substantially improves the experience of students and also educators.

Finally, a raising variety of Higher Institutions (HI) are making use of tools in the classroom, with more than 5.8 million mobile Computers offered in Q1 of 2018, according to a Future Source record [10]. Much more HIs' are giving students exterior access to digital libraries as well as online application sites throughout the day. Again, connectivity and also networking are important to make certain the performance of these technology initiatives. His', expecting a simple, inexpensive, localized computing option, like Fog Computing. Fog computing uses the dexterity to operate successfully as well as properly far from the major site as well as throughout several gadgets-- as an example, on-line research websites as well as gain access to throughout multiple schools. Fog computing technology boosts educational operations and provides a platform with agility, versus slowing them down or quitting them. Fog computing is a modern technology that is set for high development in the future, as well as will substantially improve day-to-day procedures for many sectors, including education.

### **3.1 Security Issues in Fog Computing**

No doubt Fog paradigm is appealing; it is necessary to note and understand the various issues that come with the usage as well as the implementation of the Fog computing strategy. Besides the problems inherited from Cloud Computer, several of the Fog-specific concerns describe the complying with such as security and privacy. According to the OpenFog consortium [11], there are five ways that fog computing can uniquely improve endpoint security. Since fog computing deals with the cloud and also not outside of it, it acts as an added layer of protection between IoT devices and the web server past. The fog network can monitor the smaller sized, less complex devices that were not necessarily built with their cybersecurity abilities. This suggests that tiny IoT sensors can count on the fog network to take care of the mass of the security duties [12].

Fog gadgets are made to manage updates on a multitude of devices at the same time, unlike cloud networks, which call for tools to link to the cloud each time. Fog networks can properly keep an eye on the safety and security condition of dispersed systems on campus.

Fog networks use real-time incident reports for linked IoT systems and also allow for IT teams to react to breaches without shutting down vital system aspects. Specialists claim haze computing is even more away from widespread fostering than side computer. Nevertheless, universities are excited at the prospects this new computing framework might bring.

## **4 Conclusion**

Lam [13] indicates that there is a need to understand the reasons why there is usually resistance by users and the employees when new technologies are introduced in any organization. One of the most likely general cause of hesitation is the desire to avoid the changing world modules and moving away from the comfort zones by employees.

Therefore, in order to avert such scenarios, it is important for users to receive support from the start and during the implementation of any new technology [14]. Government and top management in organizations must provide in-depth knowledge of Fog Computing, and they should deepen the understanding of legal issues, strategic alignment, and factors that affect the adoption of Fog Computing in order to be more flexible when confronting new governance challenges in the Cloud Computing environment. Users that have subscribed to mobile devices are deepening their cries when it comes to cost, bandwidth size, reliable connectivity and the security concerns about adoption of Fog Computing. According to Kannabiran [15], lack of ICT infrastructure, poor communication infrastructure, and ICT skills affects the adoption of technology.

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## **6 Author**

**Arumugam Raman** The researcher is a faculty member in the school of Education and Modern Languages, College of Arts and Sciences in Universiti Utara Malaysia. His research interests include Educational Technology, Instructional Technology, Computers in Education, Educational Research Methodology, Technology and ICT, Statistics for Educational Research and Partial Least Squares Structural Equation Modeling (PLS-SEM). The researcher is better known as an Educational Technologist and currently teaching ICT in Education, Research Methods and Statistics in Education. Besides, he has written International articles and books which have been published in national and international levels. He is a member of few Editorial boards for International Journals such as Journal of International Education Studies, International Journal of Education and Development using ICT, and Journal of Studies in Education. Furthermore, he is also a member of professional bodies namely International Association of Science and Technology for Development (IASTED), Internet society (ISOC), and Qualitative Research Association of Malaysia.

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