Impact and Challenges of Cloud based E-Learning in the Indian Education Sector

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Abstract

Web based learning has taken a new turn over the years. With the proliferation of Cloud computing and similar paradigms like Mobile Cloud Computing, e-learning technology has created waves in the education sector. However, in India this has been low due to lack of infrastructure and incorrect allocation of resources. Over a period of time it has been observed that although a bounty of cloud resources are available, to a large extent accessing these resources has become a major challenge. To this end, in this manuscript we look at some of the foremost challenges of a cloud based service and its direct impact on the growth of E-learning in the Indian Education Sector.

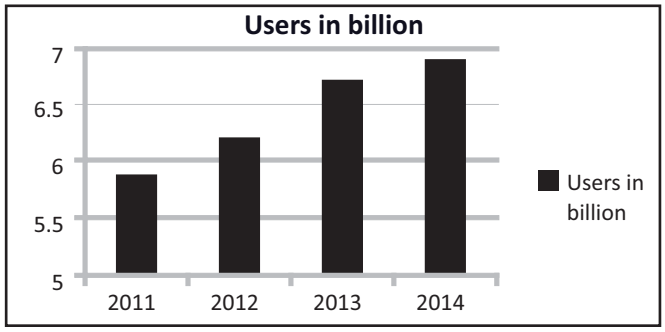
Keywords: Cloud Computing, E-learning, Indian Education Sector, Mobile Cloud Computing

I. INTRODUCTION

Theoretically, Moore's Law posits the exponential increase in the growth of device hardware and its processing speeds with time. Inevitably, over the decades a practical resemblance can be clearly observed. Statistically [1] shows that devices have not only yielded powerful computation platforms but have also shown significant quantitative growth in their storage capacities and in device usage. This statistic is for mobile usage alone. Intuitively, desktop usage can be pictured to be much more.

Although, both mobile and desktop devices have grown in their physical characteristics, the application level growth has also seen a tremendous increase. For example, applications aiding educational purposes like Duolingo, Kgeography, CrypTool etc. sometimes crash or fail to load as they seem to have out-grown device capabilities for processing. This increase has overshadowed the growth in hardware to an extent that an external assistance is considered primal for application execution. A very essential commodity for this purpose is the **Cloud computing paradigm**.

Fig 1. Statistical growth of mobile device usage



Mell and Grance [2] defined Cloud computing paradigm as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service or service provider interaction".Various studies like [3] and [4] provide ample justification for requesting a cloud resource in times when application execution becomes a constraint in the native device.

Nevertheless, the reliance on cloud data-centre resources does not come without its drawbacks. The data-centre resources are located far away from the consumer. Thus, the time taken by the consumer request to reach the data-centre resources affects the overall user

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experience. This has in many ways led to a negative impact on the usage of the cloud resources. To tackle some of these limitations and improve the performance in the Indian market, Amazon [5] began shifting five of its datacentres to Mumbai for better service provisioning and user experience.

As the key enabler of e-learning technology is the need for an infrastructure to run the aforementioned computation intensive applications and a crisp interactive response, Cloud Computing began its emergence [6]. Many articles like [7][8][9] provide analytical studies regarding the same. Additionally, various forms of Cloud computing with added features to maintain seamlessness have been developed like in [10]. Further, as the mobile applications began to grow and the companies providing e-learning technology began producing newer resources for faster and easy accessibility, these applications started relying on another paradigm that brings together the mobile computing aspects with the Cloud Computing paradigm, called Mobile Cloud Computing. To this end, we analyze the effects of e-learning technology and also posit how the cloud infrastructures augment these technologies by making the following contributions:

❖ The impact of Cloud Computing paradigm on E-learning technology.

❖ The growth of heavy duty mobile applications which aid in education that have supplemented the e-learning domain.

❖ The convergence of cloud computing, mobile computing and e-learning, can re-define Mobile e-learning or M-learning and has the potential to revolutionize the Indian Market.

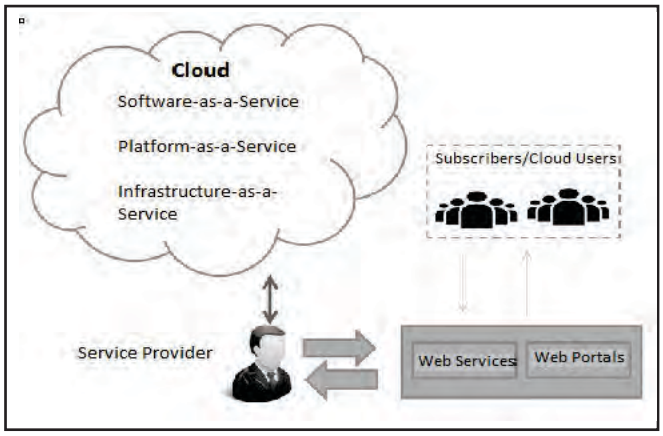
The remainder of this paper defines e-learning and the advantages of e-learning applications in section II, followed by how the convergence of cloud computing with e-learning is beneficial for the service providers in section III. We look at the emergence of mobile cloud computing in Section IV and discuss some of the challenges that needs to be addressed in the future in section V. Eventually, in section VI we conclude with some future directions for this research work.

II. E-LEARNING

An educational aid that can augment the process of learning anytime/anywhere at the same time not curbing the traditional learning ecosystem using the internet is known as e-learning technology. Aruna and Prakasam [7] defined the need for e-learning to chalk out the diversification caused by this technology. Through this technology, wide spread use of computers and computer-based application processes network together for skill and knowledge transfer. Some of the processes like computer based training, virtual learning environments are involved in engendering the e-learning process as a whole.

A major benefit of such a process is that students can participate in a lecture at their own convenience at any place of their choice. There have been many studies in the past like [8,9] that show a massive impact on the students who were put under test to evaluate this form of learning. The delivery of content to consumers and the quick access to resources is in itself a primary challenge that we analyze in the following sections.

Fig 2.Convergence of Cloud Computing and E-Learning[17]



III. CONVERGENCE OF CLOUD COMPUTING AND E-LEARNING

Recent studies like [12][13] show the impact of e-learning in a developing country like Nigeria. They show how the reliance of e-learning technology on cloud computing provides astounding results in terms of content delivery and faster interaction. As shown in fig.2, when cloud computing is put to proper use with e-learning technologies, results can be beneficial for the service provider in terms of optimization of cost as well as better customer satisfaction. The fundamental concept of cloud computing begins with its dependence on service oriented architecture. Service oriented architecture comprises of the following entities [2] [17] :

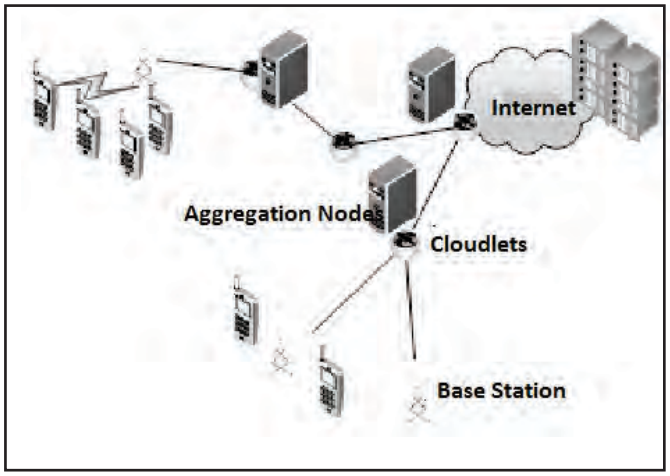
❖ **Software-as-a-service (SaaS)** – This layer offers limited power to the consumer in terms of customizing ability. The SaaS model fundamentally allows hosting web services and computer software application for

users. A simple resource poor mobile device can potentially access SaaS via a web browser or any other vendor specific web based application. However, a SaaS user does not get the privilege to configure the underlying infrastructure such as a server, an operating system to name a few.

❖ **Platform-as-a-service (PaaS)** – This layer provides services to host application, tools for development and other libraries to cloud infrastructure. Subscribing to this service means the user receives an API from the provider to access platform application or software development. However, even with this service layer, users do not have the privilege to configure or modify the underlying infrastructure. Nevertheless, a PaaS user can configure the applications developed or the ones that are run on the platform.

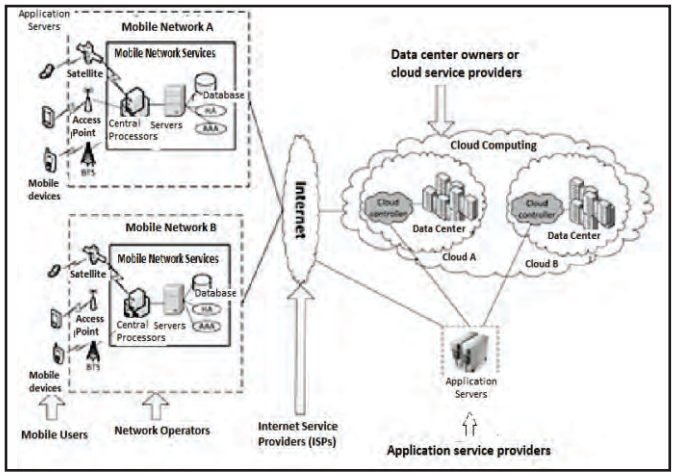
❖ **Infrastructure-as-a-service (IaaS)** – This is the most integral layer that provides the processing, storage, networks, and other computing resources that are provided according to the service characteristics of the cloud. IaaS users have the freedom to configure and migrate workload between resource provisioning entities. For instance, Amazon AWS provides virtual server instances and storage via an API which allows users to move workload to Virtual Machines within a datacentre. Additionally, users can choose the operating systems and what type of VMs they need for the task etc. Here, users get a portion of cloud control privilege with which they can customize the operating systems, processing, and storage on demand. The key enabler is the virtualization technique. Different providers make use of hypervisors for provisioning. For instance, Amazon makes use of the Xen Hypervisor. Sun's Sun grid makes use of virtualization for Job Management System (Sun Grid).

Fig. 3. Cloudlet based Approach [15]



These paradigms together allow a service provider to first look at consumers request and deploy a service that is made available to the customer at a low cost. Further, this paradigm has opened up more innovations in the field of computing. One such innovation is the computation of intensive mobile applications in cloud data-centres. This is known as Mobile cloud computing. In the next section we discuss the impact of mobile cloud computing and the various innovations that have emerged in recent times.

Fig. 4. Mobile Cloud Computing [18]



IV. EMERGENCE OF MOBILE CLOUD COMPUTING AND A TWO TIER HIERARCHY

As the computation intensive applications began to grow in number, it was hard to execute even the e-learning applications executed locally inside a device. This led to the emergence of a new paradigm called Mobile Cloud Computing as shown in fig. 4. Dinh, Lee, Niyato, and Wang [18] defined mobile cloud computing as:

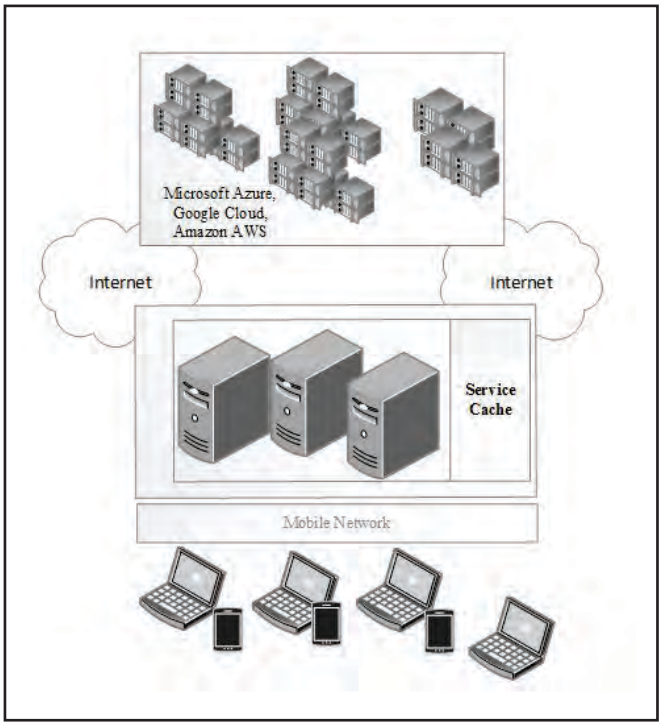
"*Mobile Cloud Computing at its simplest refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smartphone users but to a much broader range of mobile subscribers*".

Therefore, as there was a rise in the heavy duty e-learning applications, the scalability of the cloud computing platform was investigated further. However, a major limitation of relying on the cloud data-centre was the time of delivery of the service. Hence, not only it is necessary to find a resource entity that can provide a

satisfactory service but there is a need to re-affirm that the service is provided well within the requested time. For instance, if a student requests for a service to study a math class at 10 a.m. in the morning, the expected time of delivery should be close to human cognition so that there is a crisp interactive response. Otherwise, without being said, the interest in the service is lost,and in this case a student would obviously lose interest in learning. To this end, Satyanarayanan, Bahl, Caceres, and Davies [15] put forth the Cloudlet based approach.

With this strategy a small server/computing entity can be deployed at the closest one-hop distance from the consumer that can not only act as a cache but also provides other proxy services. For instance, places like coffee shops, airports etc. are locations that have enough space and can be used as sites for cloudlet deployments. Hence, if we look at a similar scenario like the student's request for an e-learning course, the closest cloudlet (deployed at the nearest coffee shop) could play a role of caching service where the request can be processed much faster than what happens in a cloud based data-center. Fig. 3 explains the notion of cloudlet and its deployment.

Fig 5. Two Tier Hierarchy [19]



As shown in fig. 5 a two tier hierarchy was proposed by Ha, Lewis, Simanta, and Satyanarayanan [19] that took both into consideration: the cloudlet and a cloud wherein the service cache can alleviate the time taken for providing a service. For instance, if a consistently used service such as an e-learning service from a company, a regularly used application for mobile based training etc. is considered, the middle entity or the cloudlet can take off the load from a data-centre and act as a processing cache. In this way the cloudlet itself performs a very dominant feature of load balancing. To further investigate this timeliness of a service and deployment of a resource entity, the concept of computing at the networkedge was proposed in [11] [16]. Roman, Rodrigo, Lopez, and Mambo[11] proposed a data-centre deployment at the edge which is also known as Edge Cloud as shown in fig. 6. Owing to word count limitation we do not delve into the Edge Cloud paradigm.

However, ETSI, MEC[16] defined a more proximal service deployment called Mobile Edge Computing. It is defined as the new platform that "provides IT and Cloud-Computing services within the Radio Access Network which is in close proximity to mobile users". Similar to this is the concept of Fog Computing [11]. Although, there is another definition of MEC that considers base stations used for offloading computation from devices. Nevertheless, the areas of Fog Computing and Mobile Edge computing are overlapping and the terminologies are used interchangeably [20].Mobile Edge Computing is a culmination of three technologies namely, Network function virtualization, Information centric Networks, and Software Defined Networks.

In contrast to the Edge Cloud Paradigm as shown in fig. 6, where the Edge Data-centre and the virtualization infrastructure are both far away from the subscriber, the MEC brings the resources closer to the user. It is clear from fig. 6 how the location of a user from A to B changes and the service migration takes place with respect to the infrastructure that is deployed in the core network.

Fig 6. Edge Cloud Paradigm [11]

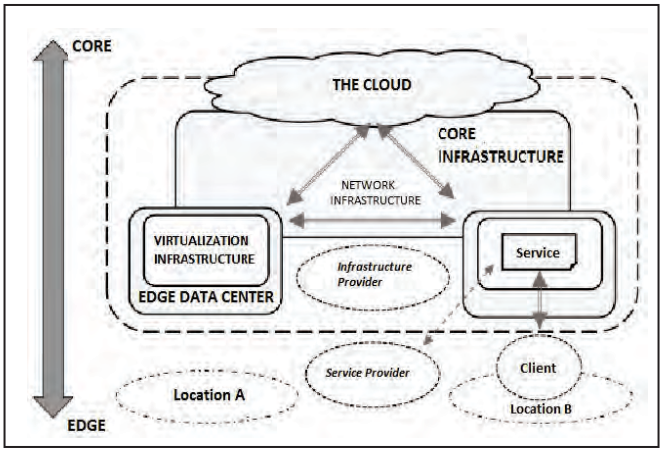
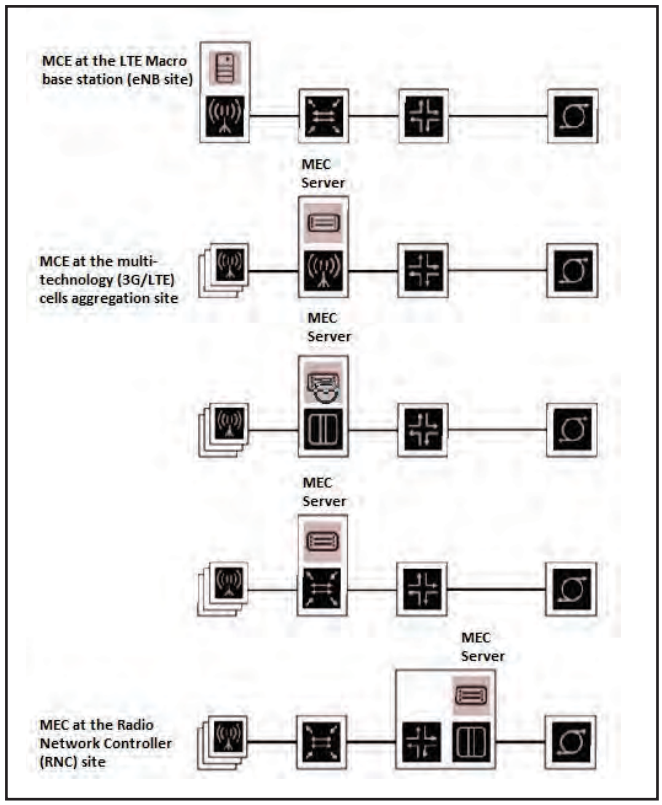


Fig 7. Mobile Edge Computing, ETSI architecture [16]



To take this approach to a milli-second latency environment and deploying a quicker service the European Telecommunications Standard Institute (ETSI) defined the Mobile Edge Computing (MEC) standards. Fig. 7 shows the MEC architecture as provided by ETSI.

This shows the different deployment scenarios of the MEC server at the eNodeB level, at different other technologies and the network controllers site. Ostensibly, MECs can have a metamorphosing impact on the Indian market in terms of providing better service infrastructure as well as optimal gains for service providers. However, there are some key challenges that need to be taken into consideration before the deployment that will be discussed in the next section.

V. LIMITATIONS AND CHALLENGES

The usage of mobile phones and the dense Indian population can have a detrimental effect on the mobile network which in-turn plays an integral role in providing seamless e-learning service.

Now we discuss the major challenges projected by Mobile Computing and E-learning domains combined.

A. M-learning

Moura and Carvalho [21] defined m-learning as a new form of learning that is different from the traditional pedagogical model of teacher and student present inside a class-room. Authors refer to this as an integration of wireless technologies with learning. Mobile learning i.e. making use of smart-phones and laptops can itself lead to a ubiquitous form of learning environment, however, it has its drawbacks. Primarily, the study materials have to be designed in a way that the students can understand while learning remotely from a location where the mobile and internet are the only points of contact. This needs to be further explored as the materials for this tudy need to be prepared by intellectuals and scientists who have prior knowledge unlike the traditional type and print system, where the presence of an intellectual is not necessary once the typing of the content has been completed.

B. Indian Mobile Networks

As the growth of the Indian Mobile Networks have been observed recently i.e. the move towards 4G based networks, there has to be proper and reliable infrastructure to tap these resources. This development caters only to needs of specific people and does not in any way provide essential services to rural and less developed areas. Further, the deployment was not as successful as it was proclaimed [22] where the companies could not provide sufficient reasons for the failure in the network. A plethora of reasons are available [23] that point towards the lack of stable infrastructure for deployment of a cornucopia of resources such an MEC or a cloudlet for instance. Therefore, such limitations have to be further investigated before a milli-second latency service deployment for an interactive course based e-learning technology is manifested.

C. Indian Education Sector and Awareness of E-learning in the Market

India is the second largest market for e- learning after the US. The sector is currently pegged at US $2-3 billion and is expected to touch US $40 billion by 2017. This country has more than 1.4 million schools with over 227 million students enrolled and more than 36000 higher educational institutions. The education market is worth US $100 billion and higher education constitutes 59.7% of market and within a decade this can reach around 70% [24, 25].

❖ Some major investments and developments which have taken place show the importance of e learning in India. Byju's, an education technology start-up, has raised US $50 million from the Chan Zuckerberg Initiative, founded by Facebook founder Mark Zuckerberg, and existing investors Sequoia Capital, Sofina SA, Lightspeed Venture Partners, and Times Internet Ltd. Byju's raised another Rs.100 cr from World Bankarm International finance corp. Byju's has about 8 million registered students, including400,000 paying subscribers. This start-up also launched a maths focused app for students in classes four & five.

❖ Tata Trusts, part of the Tata Group, has entered into a strategic partnership with web-based free learning portal, Khan Academy, and seeks to use technology to provide free education to anyone, anywhere in India.

❖ Venture capital fund Acumen has invested in two Hyderabad-based education start-ups—Ignis Careers (US$ 250,000) and SEED (US$ 650,000)—working in the low-cost school education space.

❖ Infibeam Inc., India's first listed e-comerce entity plans to provide a wide range of services to students as well as educational institutions as a single vendor.

VI. CONCLUSION AND FUTURE SCOPE OF RESEARCH

Even though India has a huge market potential for cloud computing, the awareness is limited among the higher education institutions. Various government initiatives are being adopted to boost the growth of distance education market. Cloud computing provides cheaper, faster as well as greener options with agility and scalability. This can improve the prospects of e-learning as well as m-learning in India. India's e-learning market has huge potential since education sector is speeding up digitilization. India should invest in content development for e learning which should be customized along with the local language support.

Furthermore, with online modes of education being used by several educational organizations, the higher education sector in India is set for some major changes and developments in the years to come with emphasis on sustainable development.

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