A Proposal for Cloud Based E-Learning Architecture for Higher Education System in India and its Impact

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ABSTRACT

The inadequate ICT infrastructure (power supply, hardware and Internet access) in many Indian cities and most Indian towns/villages can prove to be the biggest hindrance in adoption of modern education delivery through e-Learning services hosted on cloud platforms. One other problem that faces many institutions in large cities where physical infrastructure is adequate, is the lack of awareness about the benefits of the cloud based services and absence of a intermediary to assist students/learners, educators/teachers, and other resource partners.

In this paper we have elaborated the organizational, technical and conceptual architecture of an e-Learning service system that is centrally hosted and managed and has its resource centres and service providers distributed over a large geographical area. The approach is unique to Indian circumstances where the vast geography, regional differences and lack of connectivity pose a unique set of problems. The paper discusses about the covering the gaps in infrastructure, organizational setup, and resource availability for enabling the benefits of advances in higher education reach the farthest students through a cloud based service.

KEYWORDS

Cloud Computing, e-Learning, Higher Education, Benefits of Cloud Computing, Impact of Cloud on Education.

I. INTRODUCTION

In our previous papers [1] and [2], we have described how a cloud based e-Learning solution is best placed for effective and efficient dissemination of knowledge, learning and information. In [2] we discussed about the deficit of quality facilities for higher education and presented conceptual model architecture for implementing a cloud based system that will be governed centrally by a government agency, like UGC in India. In this paper we elaborate various organizational components needed for such a setup and how their interactions are governed, how are students reached and how are they benefitted from the services provided.

II. PROPOSED ARCHITECTURE

The proposed system will primarily consist of resource partners (RP), local service providers (LSP) and central cloud-based e-learning system (CCELS). Multiple services that will be offered via this medium are shown in figure 1. The system must allow a vast variety of devices (like PCs, laptops, smart-phones, tablets, notebooks, etc.) connect to itself. A large pool of people will access CCELS in different roles – as class-room students, home students, self-learners, teachers/instructors, content designers, education administrators, systems administrators, programmers and security personnel.

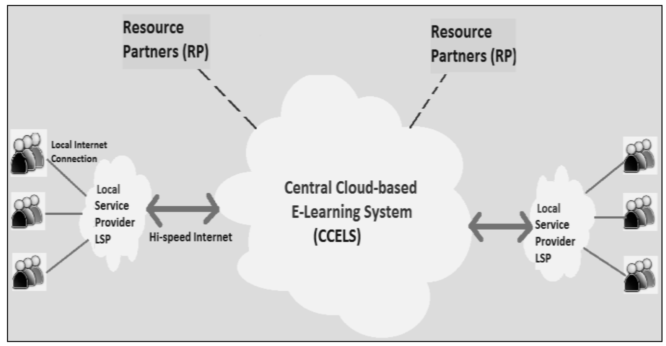

Figure 1: A Top-view of the Interactions among End-Users, CCELS, LSPs and RPs

At local level in a campus, or community, or city a partner educational institute will manage a local server connected with high-speed Internet access to connect to the central system and act as the local service provider (LSP) to its catchment area, much in the same way like regional ISPs. These LSPs will monitor course progress, student requests, content generation in local language, arrangement of video conferencing facilities for virtual classrooms, etc.

The resource partners (RPs) can provide their services in the area of content generation & monitoring, establishing & maintaining hardware and network resources, implementing security and privacy policies, customization of content as per local needs, and development of necessary software support. The RPs can be private corporations, government agencies, universities, local schools, and even individuals with certified credentials. The figure 1 clearly shows the role of the CCELS, the RPs, and the LSPs in offering the cloud based e-Learning resources to users at the far end of the spectrum.

A. Client Request Initiation Process

As per our proposed scheme each end-user through her terminal communicates directly with the local service provider or LSP for accessing services from the cloud. The LSP is the single point of contact (SPoC) for all end-user requirements. The hand-shaking and actual communication is depicted in figure 2. The steps of the procedure are described below:

1. The user initially register with the LSP, by providing

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personal details and creating a User ID with password to access services later.

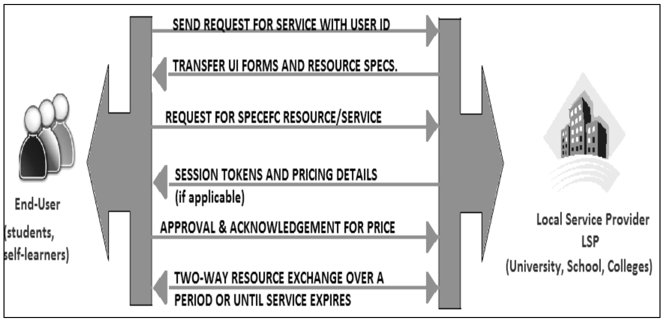

Figure 2: Steps of Communication between End User and Local Service Provider (LSP)

2. The user request is sent to LSP with User ID information for authentication purposes.
3. After, authentication the LSP sends a basic user interface, or the dashboard, as the starting point of service consumption and to see various reports and assessments related to her.
4. The end-user chooses the services to avail like learning a course, posting a query/question/reply/answer, submitting an assignment, taking a test, or certificate generation. The system can have user blogs, jobs postings, resource sharing, etc.
5. The user request is forwarded by the LSP to different servers based on category and service sought. The web-server at the LSP simply acts as a proxy or intermediary. Before sending the request forward locally cached resources are checked if they can fulfill the requirement. It also applies the billing rules, encrypts data, and generates authentication tokens for remote servers.
6. In case the user accepts to use a paid/premium service then LSP offers various payment options. Premium or paid services are necessary as certain highly advanced content can become sustainable only if costs are covered and an incentive is available for resource partners (RPs) to produce quality content. The prices can be brought down eventually with increased number of subscriptions.
7. Finally, the LSP contacts the central cloud (CCELS) for exchange of service for the duration of the session.

B. Resource Monitoring Procedure

One of the biggest advantages of using the cloud is its innate ability of resource monitoring, load-balancing and distributed hosting [5], [6]. The proposed architecture has provisions for sharing the under-used resources. To identify the under-used resources at the LSP level so that they can be reclaimed or assigned to an overloaded LSP the following process of resource identification is carried out, as depicted in figure 3.

1. The central cloud system (CCELS) sends a periodic ‘control packet’ to each server located at different LSPs to query status of their resources acquired by their clients.
2. Each server, at LSP, replicates several copies of ‘control packet’ and forwards to each of the active clients.
3. The clients upon receiving the control packet, prepare their ‘status packet’ and send it back to the server at LSP.
4. The LSP servers wait until all status packets are received within a specified time-limit. Upon either receipt of all expected ‘status packets’ of expiry of timeout, it collates the status report of each client into a ‘LSP Status Packet’.
5. The LSP server sends back the collated status packet to the CCELS or the central cloud for further action.
6. If the central cloud load balancing module finds an under-utilized server at one LSP, it can ask the server to share the resources with other neighbouring LSPs for faster access by the end-users. The data can be replicated in neighbourhood LSPs or only the processes can be virtualized, depending on network capabilities, LSP server capabilities and security policy in force.

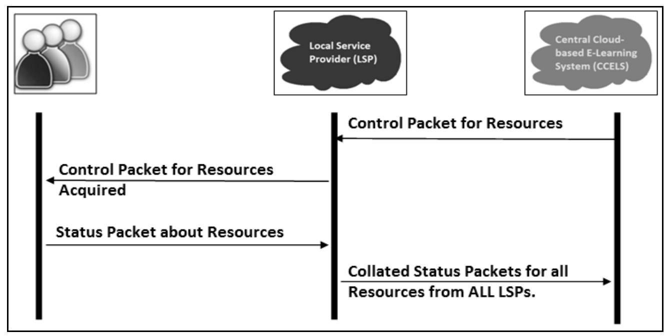

Figure 3: Flow of Information Exchange for Resource Monitoring

C. Allocating Resources to LSPs and End-Clients

The server at LSP polls each client at a fixed time-interval for any requests. Thereafter, the LSP server multiplexes all requests into multiple groups of services, based on the service requested. At this juncture it is possible that a single client’s request are separated and made part of multiple service bundles. For example, one LSP server receives two requests from two distinct clients – one client requests commissioning of a new course on “Web Design & Development” and to an antivirus software for limited time (say 6 hours); on the other hand the second user demands 5 GB of storage on the cloud to upload her projects, online C++ IDE for a team of 4 users for 48 hours, and access to anti-virus software for 7 days.

For example, as shown in figure 4, the LSP server will bundle the two requests for the anti-virus software into a single request for the anti-virus application with timing, pricing and location information of the clients. The request for the new course will be bundled as second request, while requests for storage and IDE will be sent as bundles 3 and 4. The CCELS upon receiving requests will put them in the batch of appropriate services for further processing.

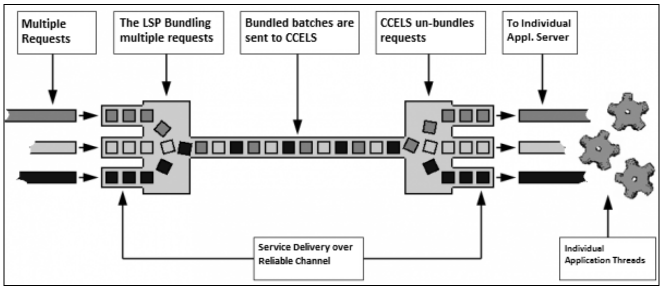

Figure 4: Bundling of Multiple Requests from End-Users to CCELS

The actual delivery time will depend on many factors – availability, connectivity, load on the server and service duration.

D. Security, Authentication, Billing and Load-Balancing Mechanisms

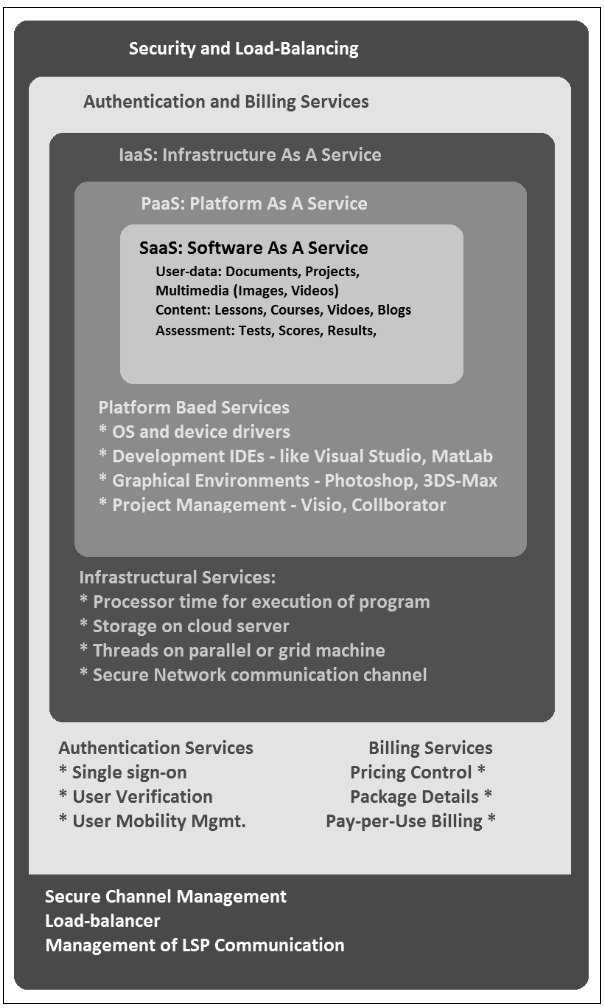

Figure 5: Multi-ring Security, Authentication and Load-balancing

The proposed architecture of CCELS is divided into multiple sub-layers, as shown in figure 5. The outermost sub-layer is implemented in network layer and transaction management services dynamically manage load on multiple servers. They also maintain redundant communications channels with LSPs. The second layer provides authentication and billing services to all kinds of users – LSP, students, RP, content generators, teachers and researchers. This layer along with the first layer will be responsible for confirming the access of the users to the internal systems that contain not only expensive resources but also confidential data and credentials. The inner three layers are the actual cloud layers that provide different types of cloud services falling into the category of IaaS, PaaS and SaaS, respectively. These layers are described as follows:

1. *The Outer Shell*: major responsibilities include managing network connections, keeping the communication channel state up-to-date for management, introducing redundancy in network paths as fail-safe, load-balancing and request dispatching, secure connection and firewall.
2. *Authentication and Billing Management Layer*: the authentication of user - including single sign-on for multiple services; user authentication and authorization into multiple roles; role management; users' migration. Billing services handle credit and debit transactions, allowing to charge users for services actually accessed, package management, course fee, as well as making payments to resource providers (RPs) and content generators.
3. *The IaaS Layer*: infrastructural services of the cloud include assigning storage space, allocation of process threads, allocation of processing elements (PE/ALUs) for heavy processing requirements, and secure network channel.
4. *The PaaS Layer*: platform oriented services comprise of OS and device platforms, system calls and daemon processes, IDEs, DBMS instances, project collaboration tools, etc.
5. *The SaaS Layer*: provides core educational content on a on-demand basis. Productivity modules like document editors, spreadsheets, presentation software, and customized software for e-learning, assessment, testing, course management; lesson scheduling, blogs, forums etc.

III. COMPARISON WITH EXISTING SYSTEMS

There are many points of reference against which the proposed architecture can be compared with the existing systems including the traditional chalk-board system, distance learning systems and use of Internet based e-learning facilities. These differences and similarities are elaborated as follows:

A. Portability of Data

Data portability refers to making data available across platforms, and independent of software used to process it [7]. It has become a major problem as a vast variety of data formats are popular for similar data processing requirements [11]. Therefore, portability of data and its conversion from one format to another is a non-trivial problem [7], [13]. The proposed architecture will propose common formats for similar documents and will benefit from the open library of format interpreters and convertors, allowing the users to access the data in the best suitable format for their use.

B. Resource Monitoring

In case of any existing systems, monitoring of resources is either not possible in real-time or it is very expensive as the resources are scattered over a large number of resource providers [8], [11]. Challenges range from costs, to spotting of under-utilised or over-loaded resources, from allocation of resource to movement and seamless discovery, from dynamic addition and removal of resource to change in resource related usage policies [5], [9]. The proposed system with help of multi-layered architecture and division of services across multiple participants ensures that resource distribution, allocation, management and monitoring do not suffer.

C. Reporting

Reporting related to content generation, content usage, student activity, student progress, course enrollment and drop-out ratios, test scores, online competence/proficiency certificate generation and verification, popularity of courses, feedback on courses and trainers/teachers, etc [12]. These reports will be produced in graphical, and summary formats as well as with details, these reports will allow ad-hoc query submission to view the data from multiple angles and spot trends. Tools like data analytics, data mining and Big Data tools will be used for faster and better reporting [14].

D. User Monitoring

Real-time monitoring of users, especially of students, is a big challenge as a timely input can help in not only more enrollments but also more engagement [12]. If the problems are identified and addressed timely it can help make the system more popular and acceptable. The problems can relate to data location, cost, sharing, unavailability of resources/contents, problems in access, problems with LSP, etc.

E. Flexibility of Learning

The traditional e-learning provides contents that the user can go through at her pace [11]. The similarity with a cloud based system ends there [13]. The monitoring and inter-linking of contents with blogs, forums, tests, assignments and results, make the overall experience for the user similar to that of a real classroom [3]. There will be competition, interaction and understanding, which lacks otherwise in the conventional e-learning systems.

F. Scalability

Scalability will ensure that the system does not degenerate with increase in user traffic [11]. In the Internet hosted e-Learning courses scalability is hard to achieve and service delivery starts deteriorating rapidly for all users [10]. The cloud based system with load-balancing and mirroring of local resources at the LSP can solve this problem effectively and will scale gracefully.

G. Cost

The costs of a system like education delivery that does not form a part of a government’s immediate concerns practically, though in theory it is accorded high priority, can prove to be an impediment in its adoption and timely roll-out [4], [7]. As per the press release of the PIB, Government of India and various news reports, the set-up costs of a University project is estimated in the range of Rs. 500 to Rs. 1,500 crores.

1. *Setup Costs*: the setup cost of a cloud based e-Learnig system would be negligible as a major part of real-estate development can be avoided. Making use of open-source technologies can reduce licensing costs. The Internet and network backbone are already in place providing high-speed connectivity. The average cost per user (beneficiary) of such cloud based system would come down with its growing usage and reach.
2. *Resource Development Costs*: these can be controlled by multiple modes – voluntary contributions by teachers, universities and research organizations; creative commons licensing; industry associations and brandings etc.
3. *Maintenance Costs*: the maintenance cost of physical infrastructure has come down over the years due to development of efficient hardware, enabling environments, and proper monitoring.

H. Security

Security has many aspects like security from threats and security against system failures. Hardware or network infrastructure failure rates have gone down but the threat from terrorist attcks have gone up [10. The security of physical systems is directly related to the overall law and order situation in the region and can be kept at minimum [13]. Security against intusion and malware is built-in to the proposed architecture using multiple layers of security devices and policies.

I. Central Policy Control

The central nodal agency must be able to exercise control over the standard and quality of education [8]. It must restrain itself from implementing overarching controls, but should certainly be able to block the content that goes against the national interests [9]. As most of the content would be available centrally hosted on the cloud and on the LSPs under the supervision of cloud administrator, the education department can easily appoint experts and event deploy automated scripts to check the content for violation of standards, morals, ethics and constitutional principles.

V. CONCLUSIONS

Regardless of criticisms and drawbacks, Cloud Computing is going to be adopted by businesses, governments and education sector in a big way to provide commonly hosted services. The growing costs of education and shortage of competent faculty will compel governments and universities to consider cloud based solutions. Many universities have started to adopt this initiative and there is substantial evidence in favour of such systems due to reduced cost of education delivery and anytime-anywhere nature of such courses.

The aim of this paper was to identify the key resources and partners with their respective roles in the CCELS. Chiefly, the paper considers the risks involved, costs associated and benefits derived from such a system if adopted. A proper adoption strategy for the central government and participating universities is also highlighted.

The primary intention of our proposed architecture is to use our limited resources in a most efficient way. Since many shared resources remain underutilized for most of the time, the proposed architecture can allow for their optimal sharing. Additionally, some serious drawbacks of current e-Learning system in their management and their administration of resources have been addressed. Piracy and plagiarism can be checked by providing users with cheap but quality resources as per their needs. We believe that this architecture can prove to be effective in balancing the demand and supply of resources and eliminate the role of third party while keeping the whole system secure.

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