FUTURE IMPLICATIONS OF CLOUD COMPUTING

GYANTI THAKUR*

Abstract:

Cloud computing, a style of computing where scalable and elastic IT-related capabilities are provided as shared assorted services (IaaS, PaaS,SaaS, DaaS), metered by use, to customers using internet technologies built on top of diverse technologies like virtualization,distributed computing, utility computing, and more recently networking, web infrastructure and software services. It represents a paradigm shift in how we think about our data, the role of our computing devices and on managing computing resources. Being an emerging service technology with promising novel and valuable capabilities it attracts industrial research community with main focus on standardization and customized implementation in every segment of society. Cloud powered higher education institutions also gain significant flexibility and agility. This paper examines and discusses the concept of cloud computing from the perspectives of diverse technologists, services and models available, cloud standards, cloud in government, enterprises and higher education, along with opportunities, challenges and future implications.

Keywords: cloud computing; services; models; standards; higher education; government enterprises; present status; future implications.

* Computing and Information Technology, Engineering and Technology, Kenyatta University, Nairobi ,Kenya.

1. Introduction

The revolution in internet and email applications along with the higher user acceptance is an all new concept that humanity ever show since the invention of wheel. This has led to the networking of every works and personal lives started moving online .today's , internet has become a platform to mobilize the entire human society .Enormous data require to be processed every day and therefore it requires to many hardware and software at every individual level. This leads towards high cost and increase in pollution. To reduce cost and inculcate green environment concept, attention is required to hold the pool of data accessed and process the same. Hence, reshaping the data centre and evolving into new paradigms to perform large scale distributed computing is the need of the hour (Magoules et al., 2009). An infrastructure for storage and computing on massive data and to pay for what you want, advance into a realistic solution, to centralize the data and carry out computation on the super computer with unprecedented storage and computing capability . Gartner, Inc., defines the solution as cloud computing , a style of computing where massively scalable IT-enabled capabilities are delivered 'as a service' to external customers using internet technologies (http://www.gartner.com/). The common perception of infrastructure that must be bought, housed, and managed has changed drastically. Companies are now seriously considering alternatives that treat the infrastructure as a service (IaaS) rather than an asset and, are not bothered about where the infrastructure is located and who manages it. A key differentiating element of a successful information technology is its ability to become a true, valuable, and economical contributor to cyber infrastructure (Kaufmann, 2004). Cloud computing embraces cyber infrastructure, and builds upon decades of research in virtualization, distributed computing, grid computing, utility computing, and, more recently, networking, web and software services (http://cloudcomputing.qrimp.com/portal.aspx). Cloud computing is a next natural step of integration of current diverse technologies and applications. The literature asserts that cloud computing is different and it is important. Information technologists are skeptical about hype. Most of the people in this segment have heard of, tried, used service bureaus, application hosts, grids, and other sourcing techniques. But what is different about the cloud? The first key difference is its technical aspects. The maturity of standards throughout the stack, the widespread availability of high-performance network capacity, virtualization technologies are combining to enrich the sourcing options (Geelan, 2009). As service providers and users are quite different, the generation raised on broadband connections, Google search, and Face book community are likely

to grip the idea of cloud-based services in their enterprise roles. Such users, who are raising the sales of net books, are likely to move towards lower cost lightweight computing, web delivered services, open-source operating systems and applications. According to Gartner, The consumerisation of IT along with the emergence of software as a service (SaaS) and other web-based service options will force way for enterprise services. At the same time, the focus on managing IT costs and return on investment are driving commercial enterprises to move swiftly. The top two trends identified by Enterprise Software survey were SaaS and web services/SOA (Enterprise Software Customer Survey, 2008).

Finally, recognizing these technical, generational consumer, and enterprise economic trend s, developer communities and system integrators are shifting away from established software vendors, and the established vendors are working to 'cloud-enable' their products (Enterprise Software Customer Survey, 2008). McKinsey and Company suggests that using clouds for computing tasks promises a revolution in IT similar to web and e-commerce (Clearing the Air on Cloud Computing, 2009). Burton Group concludes that, IT is finally catching up with the internet by extending the enterprise outside of the traditional data centre walls (http://www.burtongroup.com/research/). According to Nicholas Carr, the 'big switch' is ahead, wherein a great many infrastructure, application, and support tasks no w operated by enterprises will be handled by very large-scale, highly standardized counterpart activities delivered over the internet (Carr, 2 008). As the topic on cloud computing has become the central focus point among researchers we felt a dire need towards a review of the topic (Rewatkar and Lanjewar, 2010). In this paper, we discuss the concept of cloud computing, cloud services, cloud models, cloud standards, cloud in India, the present status and the future implications with a special emphasis on higher education.

2 Cloud computing

2.1 What is cloud computing?

In recent times the most discussed topic and the next emerging revolutionary application anticipated is all about cloud computing and it's utility, However a thorough search over the web portals about cloud computing leaves us highly excited as well as equally confused (http://www.google.co.in/).These are common phenomenon observed with things that are new,

things that promise to transform, and things with ambiguous names. McKinsey and Company uncovered 22 distinct definitions of cloud computing from well known experts (http://www.mckinsey.com/). But one of the biggest problems we have in IT is the vagueness and lack of precision in all of our work around these complex topics. A better accepted definition of cloud computing is of Gartner's (http://blogs.g artner.com/) that defines it as a style of computing where scalable and elastic IT capabilities are provided as a service to multiple customers using internet technologies. This characterizes a model in which providers deliver a variety of IT-enabled capabilities to consumers. Cloud-based services can b e exploited in a variety of ways to develop an application or a solution. Using cloud resources one can rearrange and reduce the cost of IT solutions. Enterprises will act as cloud providers and deliver application, information or business process services to customers and business partners. According to NIST cloud computing is a model for enabling 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 provider interaction (http://www.n ist.gov /). This looks to be a clear definition as it is internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, just like the electricity grid existing today. In general, the concept of cloud computing can incorporate various computer technologies, including web infrastructure, Web 2.0 and many other emerging technologies. The key technological hype about cloud computing are:

On-demand self-service: a consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

Broad network access: capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs).

Resource pooling: The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided

resources but may be able to specify location at a higher level of abstraction (e.g., country, place, or data centre). Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

Rapid elasticity: capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.

Measured service: cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported providing transparency for both the provider and consumer of the utilized service.

McKinsey and Company presented a typology (http://www.mckinsey.com/) of software-as-a-service (SaaS) depicting it through delivery platforms like managed hosting contracting with hosting providers to host or manage an infrastructure (for example, IBM, OpSource), cloud computing using an on-demand cloud-based infrastructure to deploy an infrastructure or applications (for example, Amazon Elastic Cloud), development platforms like cloud computing – using an on-demand cloud-based development environment to provide a general purpose programming language (for example, Bungee Labs, Coghead), application-led platforms like SaaS applications –using platforms of popular SaaS applications to develop and deploy application (for example, Salesforce.com, NetSuite, Cisco-WebEx). It implies a service-oriented architecture, reduced information technology overhead for the end-user, greater flexibility, reduced total cost of ownership, on-demand services and many other things. As per Wikipedia, (http://en.wikipedia.org/wiki/) cloud computing describes a new supplement, consumption and delivery model for IT services based on internet, and it typically involves the provision of dynamically scalable and often virtualized resources as a service over the internet. The evolution of on-demand information technology services, products based on virtualized resources have been around for some time now (Averitt et al., 2007), but the term became popular in October 2007 when IBM and Google announced a collaboration in that domain (Bell, 2008;Blakeley, 2007). This was followed by IBM's announcement of the 'Blue Cloud' effort (Kirkpatrick, 2007). Since then, everyone is talking about 'cloud computing'. Certainly, there are many ways to look at

cloud computing but the benefits need to be qualified in order to be quantified. Recently, the iPhone has become very popular since it is in essence a cloud computing oriented device.

2.2 Cloud computing services

Cloud computing services vary depending on the service level via the surrounding management layer. It may be SaaS, platform as a service (PaaS), IaaS, or data storage as a service (DaaS).

Cloud SaaS:

The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based e-mail). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. This will lead to end o f traditional, on-premises software. The functional interface makes End user interaction with the Application's function management Metering and Billing based on number of users (e.g., application services like SalesForce.com).

Cloud PaaS:

The capability provided to the consumer is to deploy onto the cloud infrastructure consumer created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations. This provides an independent platform or middleware as a service on which developers can build and deploy customer application. Common solutions provided in this tier range from APIs and tools to database and business process management system, to security integration, allowing developers to build applications and run them on the infrastructure that cloud vendors owns and maintains. Examples ,Microsoft Windows azure platforms services, Google apps. The functional interface interacts with application development and deployment environment management, manage scale out of application, metering and billing based on application QoS (e.g., application infrastructure services like Force.com).

Cloud IaaS:

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls). This primarily compasses the hardware and technology for computing power, storage, operating systems or other infrastructure, delivered as off premises, on-demand services rather than dedicated as on-site resources. Because customers can pay for exactly the amount of service they use, like for electricity or water, this service is also called utility computing. Examples, Amazon elastic compute cloud (Amazon EC 2) or Amazon simple storage service (Amazon S3), eucalyptus open-source cloud computing system. The functional interface makes virtual machine for hosting OS-based stacks management: manage life cycle of guest machines.

Cloud DaaS:

Delivery of virtualized storage on demand. By abstracting data storage behind a set of service interfaces and delivering it on demand, a wide range of actual offerings and implementations are possible. The only type of storage that is excluded from this definition is that which is delivered, not based on demand, but on fixed capacity increments. Storage as a service is a business model in which a large company rents space in their storage infrastructure to a smaller company or individual. Storage as a service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure. The functional interface includes data storage interfaces used by any of the other type's management, data requirements and storage usage.

2.3 Cloud computing models

The cloud computing models are categorized based on the targeted group using the cloud service .They can be grouped as:

Private cloud: the cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise (cloud enterprise owned or leased).

Community cloud : the cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

Public cloud: the cloud infrastructure is mad e available to the general public or a large industry group and is owned by an organization selling cloud services. The resources are dynamically provisioned on a fine-grained, self-service basis over the internet, via web applications/web services, from an off-site third-party provider who shares resources and bills on a fine-grained utility computing basis.

Hybrid cloud: the cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary tech no logy that enables data and application portability (e.g., cloud bursting for load-balancing between clouds). A hybrid cloud environment consisting of multiple internal and/or external providers 'will be typical for most enterprises'.

3 Perspectives of cloud computing

People may have different perspectives from different views. For example, from the view of end-user, the cloud computing service moves the application software and operation system from desktops to the cloud side, which makes users be able to plug-in anytime from anywhere and utilize large scale storage and computing resources. On the other hand, the cloud computing service provider may focus on how to distribute and schedule the computer resources. Enterprises will act as cloud providers and deliver application, information or business process services to customers and business partners. A user of the service does not necessarily care about how it is implemented, what technologies are used or how it's managed. Only that there is access to it and has a level of reliability necessary to meet the application requirements. In essence this is distributed computing. An application is built using the resource from multiple services potentially from multiple locations. But the difference is, the endpoint to access the services has to be known to the user whereas in cloud it provides the user available resources. Behind this service interface is usually a grid of computers to provide the resources. The grid is typically hosted by one company and consists of a homogeneous environment of hardware and software

making it easier to support and maintain. Once you start paying for the services and the resources utilized it becomes utility computing. Cloud computing really is accessing resources and services needed to perform functions with dynamically changing needs.

4 Standards

In this section we explore the readiness of various standards, gaps and opportunities for improvement. The standards must cover many areas such as interoperability, security, portability, governance, risk management, compliance, etc. National Institute of Standard and Technology (NIST), USA (http ://www.nist.gov/)

has initiated activities to promote standards for cloud computing. To address the challenges and to enable cloud computing, several standards groups and industry consortia are developing specifications and test beds.

Some of the existing standards and test bed groups are:

- Cloud Security Alliance (CSA)
- Distributed Management Task Force (DMTF)
- Storage Networking Industry Association (SNIA)
- Open Grid Forum (OGF)

There is an urgent need to define minimal standards to enable cloud integration, location and data portability. It is required to avoid specifications that will inhibit innovation and need to separately address different cloud models.

5 Cloud computing in India

India is globally known for its strengths in innovation in IT services and associated models and cloud computing is an emerging opportunity in this space. India has always been a playground and a test bed to pilot IT strategic adoption techniques. Indian Subcontinent is a very unique and a potent geography for platform vendors. No other geography will give the platform vendor access

to the whole ecosystem. This market has a huge, untapped potential at every level, b e it enterprise or public sector. System integrators such as Microsoft, IBM, Wipro, Infosys and TCS are busy assessing the opportunity and creating the relevant service offerings.

5.1 Opportunities

By 2030, the population of India will be largest in the world estimated to b e around 1.5 3 billion. India's current population is about 1.15 billion and about 70 % of it resides in the rural areas and villages. Thus India has a great potential to make it an economic as well as an IT superpower http://www.indiaonlinepages.com/population/). Obama Administration recently termed India as a great and emerging global power. Also global economic fortunes and global ambitions make it a potential power. But the major hindrance in this direction is the lack of infrastructure for the development of the technical know-how amongst the people living in the rural areas and the villages. With the introduction of the new cloud computing paradigm these problems can be easily eliminated because it doesn't require the end users to have any type of infrastructure, as all of them are delivered as services (whether it be IaaS, PaaS, SaaS) on a pay per-cycle basis (utility computing) virtually which makes it easier and cheaper for the people living in rural areas to actively involve themselves in the IT sector.

5.2 Present status

Indian businesses are definitely adopting cloud computing, but it's still in a budding phase. The decision makers have to understand the need of IaaS, PaaS and SaaS for their organization and then adapt to either public, private or hybrid clouds. Cloud vendors take India seriously as India hasn't hit the saturation levels yet. It is understood that TCS, Infosys and Wipro amongst others are taking steps towards making cloud-based services available to their customers. With India poised to achieve massive growth in cloud computing, mature markets in the region are nurturing early adopters while developing markets are presenting many green field opportunities for cloud vendors. We need to work on evaluating the business case for public, private and hybrid cloud models; developing an enterprise integration and migration strategy towards cloud provisioning; optimizing the management of virtualized environment and cloud implementation; tracking

developments in cloud security, governance and standards; and learning lessons from recent SaaS, PaaS and IaaS implementation.

5.3 Government and enterprises

Cloud computing holds the potential for the Indian government to offer better services while adding a green touch to its e-governance enabled transformation. Cloud computing holds the promise to transform the functioning of governments. In http://www.apps.gov, the US administration has taken a definitive stride to infuse cloud computing paradigm into its enterprise architecture. The government (both central as well as state) and the public sectors have to understand the benefits of the cloud in a right direction . By setting up a private cloud, state governments can gain access to virtually unlimited, centralized computing. Through this, they can save cost by limiting the servers and maintenance in the local data centers. Cloud printing has qualitative advantages such as reduced worker frustration and productivity loss resulting from searches for enabled network printers; increased productivity, especially for mobile and remote workers; the ability to deliver anywhere and then print the latest file version at the last minute; enabling non-employees to print to selected corporate printers, etc. The small and medium enterprise (SME) may use public SaaS and public clouds and minimize growth of data centers; Large enterprise data centers may evolve to act as private clouds; Large enterprises may also use hybrid cloud infrastructure software to leverage both internal an d public clouds; and Public cloud may adopt standards in order to run workloads from competing hybrid cloud infrastructure.

5.4 Challenges

To realize the full potential o f cloud computing and to be mainstream member of IT portfolio and choices, the challenges has to be met. There is a lot of challenges to be tackled related to privacy and security and associated regulations compliance, vendor lock-in and standards, interoperability , latency, performance and reliability concerns, besides supporting R&D and creating specific test beds in public-private partnership. It further enhances scientific and technological knowledge on all related foundation elements of cloud computing. The role of academic institutes to subscribe to cloud services that provide student/teacher/parent collaboration on subscription, is a massive and

important transition needed at this hour. Cloud computing could add a new dimension to India's ongoing e-governance program me. Certain preparatory steps could be initiated by the Government of India to launch cloud computing as a model for e-governance programs. These are as follows: Setup a nodal agency for cloud computing; create pilot solutions and demonstrate their success; develop a legal framework and risk management program me; and creating a solution portfolio for cloud migration. State governments and their departments are at varying levels of e-governance maturity. As a result, citizens and businesses get varying degrees of accessibility and quality of government services across India. Usage of cloud computing can ensure the reach of citizen services in all states irrespective of their present e-governance readiness.

5.5 Cloud in higher education

The major hurdle for development of IT-related education in the rural areas is the lack of institutes with proper infrastructure. To tap the maximum potential of the rural India it is very important that these IT study institutes be located in the rural areas itself with proper tools such as proper applications, infrastructure and development platforms. The difficulty lies in the huge amount of money spent on buying software licenses, setting up proper infrastructure required for computation, storage, etc. The evolution of cloud computing can change the facets of rural area, through the three fundamental concepts namely IaaS, PaaS and SaaS. Expenses on software licenses shall be reduced by pay-per cycle basis whether it would be software development packages or working platforms. Instead of setting up huge and expensive infrastructure such as high speed processing computers or huge data storage devices, they can use these resources from the cloud providers.The cloud computing environment will lead to better skilled people in rural areas and villages. These technocrats from the rural areas will involve themselves in the IT sector to empower the technology development. Hence, the maximum potential of the rural India can be utilized. The spread of rural technologies will be facilitated if they are also employment generators. This scenario will surely lead to the increase in the standard of living of the rural people and convert a simple and poor economy into modern and high-income economy. Economic development is the social and technological progress of any nation. Cloud computing may give an extensive growth to the Economy of rural areas by providing IT opportunities to the people which will lead to efficient business management. The income from the business will provide better funds for the development of technical institutes in the rural areas which will result into more number of technical people. For academia, cloud computing lets students, faculty, staff,

administrators, and other campus users access file storage, e-mail, databases, and other university applications anywhere, on-demand.

***Cloud class room*:** cloud computing also finds applications in the classroom teaching-learning process. Tools like Google Docs, Microsoft Office Live Workspace, and Zoho Office Suite are already in usage. Online office suites like these typically include word processor, spreadsheet, and presentation functionalities which users can utilize to create and edit documents completely online with collaboration capabilities between geographically separated users. Cloud computing may just be a buzzword today, but classroom experience with Google docs, it was shown that it offers a new and better tool for teaching and collaboration. On the other end IBM and Google are each shelling out between $20 million and $25 million to start college programs focused o n cloud computing. The vision goes like this: run multiple data centers in parallel and allow users to share resources. Microsoft, Sun Microsystems, Hewlett-Packard and others all have a similar vision of computing in the cloud. IBM and Google will at first offer 400 computers to teach cloud computing techniques. The duo plans to expand to 4,000. So far, six universities – University of Washington, Carnegie Mellon, MIT, Stanford, University of California at Berkeley and the University of Mary land – are participating (Young, 2008).

***Cloud library*:** we also view on these new services at increasing the value of the subscriptions it offers to library members. It eliminates many of the redundancies inherent in the current patterns of library automation and allows libraries to take advantage of Web-scale efficiencies. Visits to libraries, focus groups, and over a decade of engagement in the library automation world have convinced us that libraries require less complexity in their management systems. Libraries spend a great deal of time on repetitive tasks, such as cataloguing best-sellers, while ignoring the most valuable aspects of their collections: the archives, the rare items, the unique collections. Libraries must transfer effort into higher value activity and embrace the web as the primary technology infrastructure.

5.6 Benefits of cloud in higher education

The prospect of a maturing cloud of on-demand infrastructure, application, and support services is important as a possible means of driving down the capital and total costs of IT in higher education; facilitating the transparent matching of IT demand, costs, and funding; scaling IT;

fostering further IT standardization; accelerating time to market by reducing IT supply bottlenecks; countering or channeling the ad hoc consumerisation of enterprise IT services; increasing access to scarce IT talent; creating a pathway to a 24 × 7 × 365 environment; enabling the sourcing of cycles and storage powered by renewable energy; increasing interoperability between disjointed technologies between and within institutions; and facilitate inter-institutional collaboration. In 2009, National Science Foundation (NSF), USA announced $5 million grants to 14 leading US universities through its cluster exploratory (CLuE) program me to participate in the IBM/Google Cloud Computing University initiative. Indian Universities should also be given such grants to enable cloud computing in higher education. This may lead to usage of scarce resources as services by institutions.

6. Future implications:

Cloud computing, from becoming a significant technology trend in 2010, there is a wide spread consensus amongst industry observers that it is ready for noticeable deployment in 2011 and is expected to reshape IT processes and IT market places in the next three years. This implies that in the near future there would be a requirement for professionals in this field. As companies increasingly depend more on blogs/online document storage or other web-based applications, enterprising youngsters can actually set up a business to help people set-up these applications. Thus while there would be bigger players like Amazon, Google, IBM, Microsoft, Yahoo, who would need such professionals in the field of cloud computing, the smaller players too would need fresh talent. While these companies invest heavily to make cloud computing mainstream, it is the nimble start-ups like Nivio who rush to take advantage to ever cheaper cloud computing infrastructure to deliver innovative applications. The undeniable consensus is that cloud computing is going to be with us for a number of years. One thing that stands as a testament to the financial industry is that it is able to work in every industry and translate problems and obstacles into bridges towards success. Future will be filled with services either at management level or at functional level. Users will be at one end, service providers at others end and the service managers or the middle layer dealers will help out gluing both. Despite its possible security and privacy risks.

7 Conclusions

Cloud computing overlaps some of the concepts of distributed, grid and utility computing. However it does have its own meaning if contextually used correctly. The conceptual overlap is partly due to technology changes, usages and implementations over the years. Cloud computing built on decades of research in virtualization, distributed computing, utility computing, and, more recently, networking, web and software services. It imp lies a service-oriented architecture, reduced information technology overhead for the end-user, great flexibility, reduced total cost of ownership, on-demand services and many other things. But cloud computing has become the new buzz word driven largely by marketing and service offerings fro m big corporate players like Google, IBM and Amazon. As information becomes even more on-demand and mobile, cloud computing is likely to grow. Is cloud computing limited by the availability of internet? Will cloud computing actually work for the 'unconnected'? This has to be made very well comprehensible. The clear concept and definition of Cloud Computing by the experts have paved the way for people to explore the giant transition. The services that shall be provided by cloud, the models on which it can be deployed, the different dimensional requirement for the user and the service provider will lead to a contemporary era. The outlook for cloud computing in India and more particularly in higher education, needs a make shift to the cloud. Definitely the future implications are scalable and expansive, and this cheap , utility -supplied computing will ultimately change the society as profoundly as cheap electricity did in the past.

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