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CLOUD COMPUTING IN EDUCATION

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CONTEXT AND OUTLINE OF THE PROBLEM

Educational institutions throughout the World have become highly dependent on information technology to service their business requirements. Procuring and maintaining a wide range of hardware and software require substantial, ongoing investment and the skills to support them.

The economies of scale and other features of cloud computing are likely to mean an increasing shift away from institutionally-hosted services. These services are increasingly provided using Internet technologies to staff and students and accessed from web browsers. The services are offered cheaply or freely to education, often with much higher availability than can be provided by the educational institution.

Are we therefore facing a future where the majority of educational services will be hosted in the cloud and institutions no longer host their own data centres with expensive hardware, power bills, staff salaries and computing resources which are rarely fully utilized?

This policy brief has analyzed some of the emerging benefits and challenges of cloud computing for the educational sector.

There are various definitions of cloud computing but most commentators agree on several key characteristics:

Remote data centres

Cloud services are delivered via the Internet from high-specification data centres in locations remote from the end user and their institution. The server farms have features such as the latest cooling systems and service optimization techniques which individual educational institutions are unlikely to be able to afford. The data centres are often located near cheap sources of electricity. Their locations are not necessarily known to the user, though in some cases users require services to be located in specified countries due to data protection legislation.

Pooling of resources

Resources such as data storage, processing, memory and bandwidth are shared between multiple customers and can be allocated dynamically depending on demand. Individual hardware components can be replaced without impacting on performance or availability. Resources may even be spread across multiple data centres to provide better security and resilience.

"Infinite" scalability

A key feature of cloud computing is its rapid elasticity, allowing for sudden peaks in demand and giving the customer the impression that the services are infinitely scalable. If the institution wishes to increase use suddenly there is no need to purchase additional hardware which could take weeks and may later be underutilized.

Pay per use

Customers simply pay for the services they use while providers bear the costs of hardware and software provision. Pricing may vary depending on the time of day due to peaks in demand or varying electricity costs and institutions may therefore carry out certain activities when costs are cheaper. However distributed cloud networks may enable providers to smooth out demand globally and offer uniform pricing strategies not dependent on timing.

Self service

Customers can decide what resources they wish to use, and increase or decrease these without discussion with the provider. Reporting facilities are provided so that customers can monitor resource usage.

TYPES OF CLOUD COMPUTING

Cloud computing services are generally regarded as falling into three separate categories or levels (Johnson, Levine and Smith, 2009). The lowest level is sometimes known as **infrastructure as a service** (IaaS). Here customers can rent basic computing resources such as processors and storage, and use them to run their own operating systems and applications. Amazon's Elastic Compute Cloud is a one example; organisations can use this infrastructure to run Linux servers on virtual machines and scale up usage as required.

Platform as a service (PaaS) is the next level up. This enables customers to install their own applications using a platform specified by the service provider. An example here is the Google Apps Engine where developers can write and install applications using the Python language.

The highest level of cloud computing service is known as **software as a service** (SaaS). This is currently of most interest in education. Not only is the data stored in the cloud but the application is too, with the user requiring only a web browser. The best known examples of this are Google Apps for Education and Microsoft Live@edu which provide communication and office applications such as email and spreadsheets.

THE DIFFERENCE BETWEEN CLOUD COMPUTING AND WEB 2.0

Some educators have wrongly assumed that cloud computing refers to any services provided over the Internet which are not hosted by their institution. In addition there is confusion between the terms Web 2.0 and cloud computing.

As with the term cloud computing, there is disagreement about what exactly Web 2.0 means. Blogs, wikis and social bookmarking are generally regarded as Web 2.0 applications. They allow users to alter the content of web pages and interact with others. Such software can be hosted by an institution itself or accessed over the Internet. It may or may not be provided from the cloud with features such as rapid elasticity, pay per use and the other key features noted above. Putting it simply, Web 2.0 can be regarded as a particular type of application while cloud computing is a method by which applications and data are hosted and delivered.

HOW IS CLOUD COMPUTING BEING APPLIED IN EDUCATION?

Many educational institutions have begun their movement to cloud computing by outsourcing their student email provision (Sclater, 2010). Email is a basic, fairly standardized service, can be provided easily by third parties, and is arguably not core to the educational mission. Both Google and Microsoft offer email services for free to the educational sector in many countries.

These two companies provide email as a part of larger application suites which are usually made available to students alongside email. Google Apps for Education and Microsoft Live@edu contain other communication tools such as instant messaging along with contact management and calendar software. There are also document creation applications allowing the production of word processed documents, spreadsheets and presentations as well as the ability to create websites. These can all be edited collaboratively with other users. Significant storage space for documents of all types are offered to users who can continue to use these once they leave the institution.

Why are the services provided for free to educational institutions? There are a number of advantages to companies who are currently competing for market share. Software has always been provided at a discount to the educational sector and vendors seek to build relationships with the institutions which provide their future employees. In addition they are building brand awareness and loyalty which may lead to the selling of other or premium services to institutions and users in the future. A student seeing the benefit of these tools may persuade a future employer to invest in the commercial equivalents which provide a more revenue source to the cloud providers.

Educational institutions are also beginning to use lower level cloud services for purposes such as data storage. This may be attractive where data security is of lower concern such as where video and audio is provided as open educational resources.

Another use of cloud computing which is beginning to emerge in education is for the hosting of institutional learning management systems (LMSs) in the cloud. Outsourcing the provision of LMSs such as Blackboard or Moodle to a third party makes sense for institutions who cannot justify the costs of purchasing, maintaining and supporting hardware and software themselves.

BENEFITS OF CLOUD COMPUTING FOR INSTITUTIONS AND STUDENTS

By now it will be clear that there are some major potential benefits to institutions deploying cloud services.

Economies

The primary advantage for many institutions is economic. This is particularly clear where services such as email are offered for free by external providers. Hardware for such services can be redeployed or removed, potentially freeing up valuable real estate – increasingly at a premium in settings such as city centre university campuses. Personnel costs can be cut or staff redeployed.   The fact that institutions pay per use rather than for often underutilized hardware is appealing.

Elasticity

A second major benefit is the elastic facet of cloud computing discussed earlier. This allows institutions to begin with small-scale services and build them up gradually without significant up-front investment. It also allows for rapid escalations in demand at peak times such as at the start of the academic year or during exam periods. There is therefore no need to plan usage levels in advance.

Enhanced availability

A further benefit is that availability may be higher with less downtime due to the superior resources and skills available to cloud providers. Whereas a university computing service department may aim to achieve 99.5% availability for its educational services such as the LMS, Google offers 99.9% availability for its educational application suite and appears to outperform this target. Students increasingly dependent on online services for learning and assessment should be given the best possible availability.

BENEFITS OF CLOUD COMPUTING FOR INSTITUTIONS AND STUDENTS

Lower environmental impact

In some countries there are now "green" targets for reductions in power usage by organisations. Cloud computing enables educational institutions to reduce their own electricity consumption and, in theory, cloud providers should be able to optimize power usage over a group of customers. However it is not easy to obtain figures for power usage from cloud providers and it is likely that their power consumption worldwide is growing significantly.

Concentration on core business

Another claimed advantage of cloud computing is that it allows institutions to concentrate on their core business of education and research. Schools and universities do not normally have their own sewage plants and power stations; similarly it can argued that computing services are becoming commoditized and are handled better by organisations with specific expertise and economies of scale.

End user satisfaction

For end users, apart from better availability, there are other clear benefits of cloud-based services, particularly evident with the range of new applications being provided. These contain the latest tools and features from innovative companies such as Microsoft and Google. Students can use office applications for free without having to purchase, install and keep these applications up to date on their computers. Possibilities for collaboration are greatly enhanced. They do not have to worry about backing up or losing data as it should be safely stored in the cloud - with large storage capacity provided for free. Their data is accessible to them from any location or from a range of devices such as their mobile phone. Technologies such as HTML5 will increasingly allow users to work offline when Internet access is intermittent.

RISKS OF CLOUD COMPUTING

Cloud computing is a new paradigm which is threatening to some individuals in institutions. It challenges computing service personnel who may fear the consequences of their roles being outsourced. In addition, senior managers may feel uncomfortable about transferring the hosting of business-critical data and services outside the institution. Thus some risks may be more to do with perception than reality.

Data security

A major concern is around the security of data. Institutions may consider that their data is more secure if it is hosted within the institution. Transferring data to a third party for hosting in a remote data centre, not under the control of the institution and the location of which may not be known presents a risk. Strict data protection laws in the European Union restrict the storage of personal data to certain countries with which agreements have been signed. Some cloud providers now provide guarantees in their contracts that personal data will only be stored in particular countries. The primary risk here is that there will be a breach of confidentially which involves a student (or member of staff) suing the institution, leading to high costs and adverse publicity.

While high service availability is one of the main benefits of cloud computing there is a possibility that particularly high profile providers are at greater risk of threats such as denial of service attacks than individual institutions. It has been suggested that the provision of cloud services through a single provider is a single point of failure and that it would be better to contract more than one cloud provider in order to minimize risk.

Unsolicited advertising

Another risk is that cloud providers will target users with unsolicited email or advertising. This is illegal in areas such as the European Union, and institutions must take steps to ensure this does not happen as there are high penalties for breaches. In addition the accumulation of usage data by the providers may be of value for onward selling to third parties, though it may be anonymised. The inclusion of appropriate clauses in the contract may minimize the risk of abuse.

Lock-in

Companies such as Google and Microsoft allow institutions to co-brand their cloud products. There may be a risk in associating an institution too closely with these companies whose popularity is variable with users. Probably of greater risk however is that an institution will become "locked-in" to the products of a particular provider. There are significant costs in migrating from any widely-used system. While some providers make claims about the inter-operability of their products it is rarely easy to transfer content from one system to another.

Institutions which start to integrate business or educational processes with the cloud systems will find it even more difficult to migrate. If a better rival product emerges or the cloud provider decides to impose or increase charges on institutions it may be too late to change.

GUIDELINES FOR SELECTION AND DEPLOYMENT OF CLOUD SERVICES

Institutions wishing to procure cloud services will find it helpful to develop a list of selection criteria and present these to competing providers for their response.

Functionality

The list should include the functionality required by users. In the case of email for example this may include the use of a POP client instead of the web-based software or out of office messages for display when on holiday. For document storage, issues to consider may include the total allocation per user and the types of files that can be stored. For office applications, file compatibility may be of concern, particularly if documents created using the cloud software may later be viewed using different providers' applications. It is also helpful to assess the level of integration between the different applications provided within a product suite.

Platform

The platforms on which the applications are provided should be assessed. Ideally the software will function the same on all devices, operating systems and web browsers but this is unlikely to be the case. It may be necessary to advise users to use particular platforms. Access from mobile devices is becoming increasingly important for many students.

Technical issues

The institution may have to carry out some technical integration work such as automating the creation of user accounts on the cloud system based on data held in student information systems or facilitate single sign-on across systems. There may also be a necessity to monitor usage, remove accounts or perform other systems management activities.

GUIDELINES FOR SELECTION AND DEPLOYMENT OF CLOUD SERVICES

User experience and accessibility

Some systems may provide a better overall user experience than others. Usability is important – a necessity to install any software additional to the web browser may make the software less attractive, for example. Use by disabled users is one issue that requires to be considered for ethical and legal reasons. Organizations wishing to deploy cloud services should therefore ensure that the software conforms with web accessibility guidelines and standards.

Contract

The provider will have a standard contract which should be studied closely. Larger institutions are at greater risk and may wish to seek legal advice before signing the contract. Issues which should be examined include the initial term of the contract, penalties for early withdrawal, costs and future potential costs.

The service level agreement may provide institutions with compensation in the event of breaches of service. In the case of free services, compensation may be restricted to the provision of extensions to the contract and consequently may provide little reassurance to customers who may be advised to consult with other users of the services in advance of deployment.

Support is another issue. For cheap or free services an institution is likely to have to provide the direct user support itself, escalating issues to the provider only via a limited group of institutional staff. Most high level cloud services are however easy to use and either require minimal support.

Costs

While costs for cloud services may appear minimal or even non-existent, the real costs to institutions can be considerable. It is helpful to estimate costs for any legal advice associated with the contractual negotiations, project and change management, technical integration and staffing an institutional helpdesk.

POLICY IMPLICATIONS

There are significant policy implications of cloud computing in the context of education at institutional, regional, national and even international levels. At a local level, as has been noted earlier, the roles of computing personnel may evolve from providing services to procuring and monitoring cloud services and relations with cloud computing providers. Staff will have to monitor the rapidly evolving landscape of cloud computing and plan ahead for renewal of service contracts.

To make full use of the cloud, institutions will need to put aside their fears about data security in particular and manage the risks by ensuring appropriate contractual arrangements with providers. They will also have to accept that users will increasingly be able to by-pass institutional policies over computing provision and live in an environment where applications are subject to rapid upgrades outside the control of the institution.

The ownership of data needs to be clearly established within the contract. Contracts for cloud services should assert that ownership of the data stored in the cloud is retained by the customer. Educational institutions may then wish to re-assign ownership to the user who uploaded the content. Where any educational materials are being stored in the cloud, new intellectual property rights clearance may have to be carried out.

Contractual negotiations for cloud computing services may be better carried out by regional or national education authorities than by individual schools, colleges or smaller universities who do not have access to expensive legal services. There may be additional advantages here in that multiple institutions become part of one "cloud", facilitating cross-institutional data sharing and collaboration.

FUTURE SCENARIOS

The inertia of educational institutions and their risk averse nature means that they are likely to be slower than business to migrate key services to the cloud. They also have unique requirements relating to their teaching methods, examination regulations, funding regimes, government policies and legal issues which necessitate bespoke applications less suitable for migration than generic services such as email.

It seems likely that it will no longer be economically viable for institutions to host their own email systems, though in certain circumstances, such as defence research, this may continue to be necessary. As bandwidth increases globally and increasing numbers of students have adequate access to the Internet, many through mobile devices, they will become more comfortable with using rapidly evolving web-based applications and storing their data online rather than on their own storage devices which are more likely to be lost or corrupted. Demand for cloud applications may therefore be driven by users rather than by institutions.

Complex educational applications such as LMSs will be slower to move to the cloud, however LMS-like functionality is increasingly found in applications such as Google Apps and Live@edu and some users and institutions may decide that this functionality is better than that of their LMS. Education-specific software for course calendars and assessment which can be integrated with these suites of tools in the cloud is beginning to emerge which may ultimately make the LMS redundant. The Microsoft and Google systems are already being used as e-portfolio systems by some institutions, though there are issues such as the preservation of student work for assessment purposes which are currently problematic.

It is not yet clear whether institutions will find these systems adequate for all the purposes to which they currently put their LMSs. There is however already integration between some cloud applications and popular LMSs with single sign-on and cloud functionality integrated on screen within the LMS. Applications such as Moodle and Blackboard are themselves available in the cloud and it seems unlikely that most institutions will wish to host these systems locally in the future if cloud provision provides secure, higher-availability and cheaper systems than they themselves can deliver.

The increased use of lower level cloud services in education such as for data storage seems inevitable, particularly for services where security is less of an issue such as for repositories of learning content. While some universities will wish to maintain their expertise in hosting computing resources for research and teaching purposes, this may incur costs which most educational institutions prefer to do without.

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This policy brief discusses the phenomenon which has become known as cloud computing, analyzing the benefits and risks for educational institutions and examining some of the legal and contractual issues. It provides guidelines for the selection and deployment of cloud services and suggests some policy implications and future scenarios for their use in education.

Author: Niall Sclater