International Journal for Infonomics (IJI), Volume 5, Issue 1/2, March/June 2012

Education Beyond the Cloud: A platform for 21st Century Education

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Abstract

With the advancement in technologies, the last decades have seen a sea change in the way people interact and communicate. For instance, contents, services and applications previously executed locally or on a local network are gradually finding its way to the cloud. As people and environment changes, so must education in order to be able to adapt to and embrace this paradigm shift in the educational landscape. Cloud-based education has thus arisen and has since gathered a lot of interests in the recent years. This paper describes the issues that need to be solved in order to arrive at cloud education, including integration, ownership, security and assessment, and offers a holistic approach to cloud education.

1. Introduction

Societal changes have increased in pace during the last fifty years or so. This phenomenon applies world-wide, but even more so to countries like the UAE, which has developed from a nomadic culture to a high-tech society in time-lapse. As a result, the way people approach education, particularly in terms of learning and teaching, have changed accordingly. The challenge within education is to adapt to this change, rather than to resist to keep a status quo, so as to suit the new educational landscape and enable students to take advantage of new technologies and the skills they acquired with them [1].

The focal point where many of these new technologies come together is cloud computing. Cloud computing is one of the major drivers of change in the industry. While many different definitions exist, it generally denotes the transition from local computing offerings to external ones. These offerings can be fairly simple services such as virtualised desktop, data storage, and email, or whole applications such as an office application suite, security package, and collaboration tools.

The move from locally hosted offerings to cloud computing has many consequences. Large one-off setup costs for infrastructure are replaced with regular monthly fees. This means that small schools and universities can make use of these offerings, that otherwise would be impossible to run due to the large initial cost. This is especially true in regions like the UAE where many of its schools and universities are relatively small in size, which consequently could not justify the return-on-investment in the high initial setup cost. Furthermore, as cloud hosted offerings are shared across different schools and universities, novel applications and services can be implemented, such as collaboration tools between students of different institutions, social communities, and more. In fact, this has complementary synergies with the UAE National Research and Education Network (NREN), called Ankabut[1], whose aim is to connect not just the local academic institutions, but also link with the global research and education communities.

A number of online only services such as blogs, micro blogging and social networks are coming of age and strongly influence the way people and businesses interact within and with each other. As a result, opportunities arise to not only "do the same online" but also to exploit the inherent advantages of cloud computing, in particular with respect to collaboration and interaction between services and people. However, several issues need to be addressed before such a cloud education proposition could become a reality:

- Integration - Incorporation and mobility of different tools/services/data.
- Assessment and Learning - Within a networked class, assigning who did what, who learned what becomes more difficult.
- Identity and Ownership - New definitions are needed for what constitutes original work, individual work, and plagiarism.
- Security and Privacy - Preserving means to protect data, identity, and means to distinguish between professional and private data that is on the cloud.

This article is an extended version of [2]. The rest of this article is structured as follows. We first give an overview over cloud, cloud education, and mobile cloud education, and its role within the campus of the future in Section 2. We then address each of the above-mentioned issues individually in Section 3. Note that the intention here is not an attempt to provide a working solution, but instead point to methods and technologies that could allow us to address these issues in the near future. In Section 4 we will detail some of the concrete steps toward achieving the vi-

[1] http://www.ankabut.ae

sion. Finally, we offer our take on the state of mobile cloud education in Section 5.

2. Mobile Cloud Education

In order to put forward the issues and concepts described in this paper, we first give an overall view of the main elements relevant to this work.

2.1. Cloud Computing

While there are several definitions in what constitutes cloud computing (e.g.[3], [4]), they generally agree on a number of key aspects. First of all, three service models can be identified. *Software as a Service* (SaaS) is the most abstract model, where the consumer uses web-based applications that are hosted by the cloud provider. The consumer has no control over the underlying infrastructure. Examples are Google Docs[2] or Microsoft Office 365[3]. Closer to the metal is *Platform as a Service* (PaaS), where the cloud provider, instead of providing fully functional applications, provides a set of services and functionalities together with a development environment which allows the consumer to develop applications using the provided services. While this gives the consumer more control, the provider still dictates where and how the services are run on the servers. Scalability is generally relegated to the services. Examples are the Google App Engine[4] or Microsoft Azure[5]. Finally there is *Infrastructure as a Service* (IaaS). There, the cloud provider essentially allows the consumers to run virtual machines on their infrastructure, in addition to further core provisions such as storage. The consumer has full control over their virtual machines, including the computing resources provided to each instance of a machine. Scalability and elasticity is in the hands of the consumer who has to ensure that enough instances of his/her system runs, and that the deployed system is actually able to take advantage of replication of virtual machines. Examples are Amazon Elastic Compute Cloud (EC2)[6] and Rackspace[7].

Apart from that, there is generally a distinction in deployment. With private clouds, the infrastructure that hosts the cloud is owned and operated by the consumer. Public clouds are independent companies that offer to run software on their infrastructure. Most of the examples above are public cloud offerings. Finally, hybrid clouds combine private and public clouds - either by running a small private cloud that has “spill over” capabilities, or by outsourcing some of the services to public clouds while keeping, for example, services that are operationally-critical or deal with sensitive-data on site. Depending on the needs of the consumers, such consideration essentially forms part of the trade-off evaluation in determining which and how much of the services that can be hosted on the cloud.

In addition to these aspects, cloud computing is characterized by properties such as elasticity and resource pooling. Elasticity means that resources can be quickly and often automatically scaled up, horizontally or vertically. Resource pooling means that a cloud infrastructure can run various (independent) services. In the case of multi-tenancy models, these can belong to different consumers, while single tenancy models only allow one consumer on a given resource. Such resources can either be computing, storage, memory, specific services or virtual machines. Note also that, as cloud computing virtualizes the actual location of the used services, they can generally be used at any place and at any time (at least in the case of public cloud installations).

It is also worth noting that a simple web-based installation cannot automatically be considered a cloud offering (even though the consumer might not be able to tell), because it lacks the elasticity and scalability inherent to cloud computing.

2.2. Mobile Cloud Education

Mobile cloud education is a relatively new and leading edge research and innovation --- a term coined to signify the novel unification of two main domains of educational research fields, namely cloud learning and mobile learning, so as to be able to realise and extract its holistic cross-synergies between the two. The former is the introduction of cloud computing in education, in its delivery of the appropriate cloud contents, services and applications for learning purposes; the latter, on the other hand, focus on anytime-anywhere context-aware learning via portable devices, such as mobiles, tablets and laptops, by harnessing the smart contextual capabilities of the devices. Figure 1 depicts an overall view of the concept.

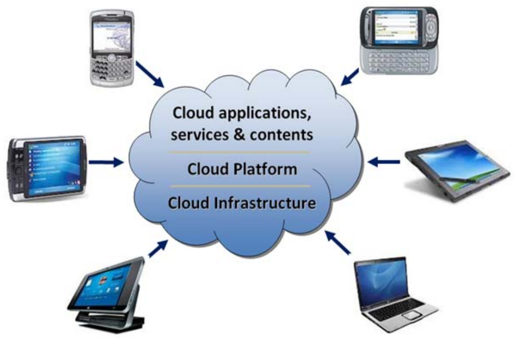

Figure 1. Diagrammatic illustration of mobile cloud education concept

[2] http://docs.google.com/
[3] http://www.office365.com/
[4] http://code.google.com/appengine/
[5] http://www.microsoft.com/windowsazure/
[6] http://aws.amazon.com/ec2/
[7] http://www.rackspace.com/

The application of cloud computing in education have already been discussed in numerous publications, focusing on the different aspects of learning (see e.g. [5], [6]). Also several companies have seen opportunities in the changing and emerging market for cloud based educational offerings. For instance, a number of large software enterprises offer some versions of cloud computing for education, for example IBM [7] and Microsoft [8], as well as more specialized firms, for example LoudCloud[8] which offers a cloud based learning management system. Related are efforts by BT who is presently conducting a cloud-education pilot field trial among a small group of schools in the UK. Furthermore, many researchers develop tools that take advantage of the various features of the cloud, often focussing on either specific properties like collaboration [9], specific technologies such as wikis [10], specific applications, for example creative writing [11] or argumentation [12], or specific tools such as learning management systems [13], for example the Cloud Learning Environment[9] that is based on Google Apps.

2.3. The Campus of the Future

The global educational landscape is changing; some have termed it as the “climate change” in education. This paradigm shift in education is imminent and has since gathered a lot of interests, among the academics and the industry, in an attempt to bridge the technological gap in the educational sector. To cope with the changing education environment, Etisalat BT Innovation Center (EBTIC)[10]-a joint research centre between British Telecom and Etisalat, in partnership with Khalifa University of Science Technology and Research- has put forward an international iCampus initiative [14] which is aimed to create/adapt a holistic next-generation intelligent campus environment that is suited for the 21st century. A holistic intelligent campus framework has also been derived, encompassing comprehensively all aspects of a smart campus environment (see

Figure 2).

A number of pillars have been defined in the iCampus framework, namely the iLearning, iSocial, iGreen, iHealth, iManagement, and iGovernance aspect of the campus. Each of which serves to ensure the proper operation of each function of the intelligent campus environment, which briefly covers the following aspects:

iLearning supports the students and faculty in their task of acquiring knowledge. This includes providing means in the preparation and delivery of contents, but also (and maybe more importantly) providing means for the students to learn, individually or collaboratively, and access to pertinent contents from anywhere and at anytime. Mobile cloud education has a great impact on this pillar.

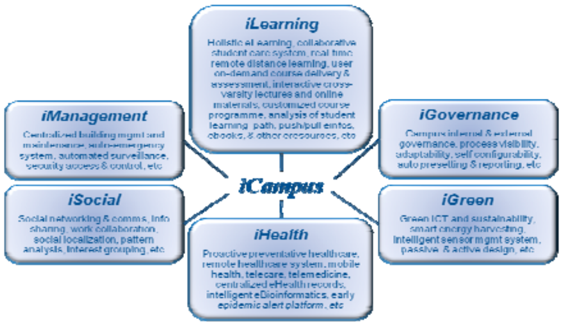

Figure 2. Pillars of the iCampus

iSocial focuses on social networking and communities within the campus, hence enabling informal social interactions between people. In here, there are three main areas of concern: campus's core curriculum, extra curriculum, and general social activities.

iManagement encompasses more physical aspects of a campus, such as smart building management, student access and control, security and surveillance, as well as emergency response.

iGreen covers aspects of green ICT and sustainability, smart energy harvesting, and resource management

iGovernance takes care of the organizational aspects of the campus, providing process management, change management and adaptability, and administration aspects.

iHealth finally provides preventive healthcare, remote healthcare and monitoring, and epidemic alert systems.

All of the above pillars, while looking at (more or less) the distinct aspects of a campus environment, come together synergistically under the iCampus umbrella for a holistic approach to the intelligent campus. An iCampus platform (see

Figure 3) connects the distinct elements to enable higher-order functionalities that draw from aspects developed or provided by the different pillars.

For example, localization information (from sensors managed by a building management system in the iManagement pillar) can be used in conjunction with the student enrolment data and class locations (coming from a student management system under the iGovernance pillar) to automatically send personalized reminders, to students enrolled in classes, that are timed such that it allows adequate time for the student to get from their current position to the class (or are not sent if the student appears to be close to the classroom or moving towards it). Course materials can automatically be downloaded to the notebook of the student, together with a unified list of relevant bookmarks and notes that fellow students

[8] http://loudcloudsystems.com/
[9] http://gcloudlearn.appspot.com/
[10] http://www.ebtic.org

have collected. Attendance can automatically be logged when a student enters a smart classroom, and students can join remotely using any available device (such as mobile phones or desktop computers). These are just some of the scenarios that can be easily implemented within a holistic intelligent campus environment.

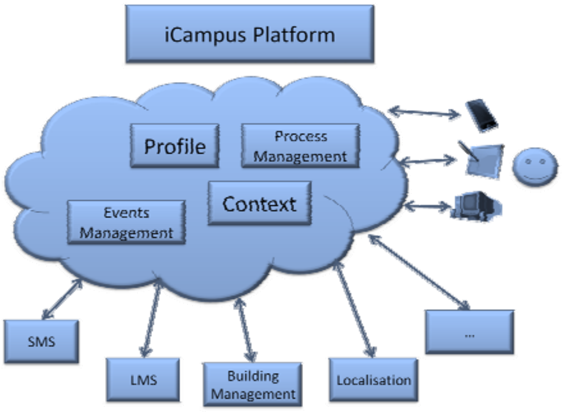

Figure 3. The iCampus platform

3. Challenges

As noted above, there are a host of offerings that could provide (parts of) an intelligent campus. The challenge is to integrate the different services together and make them communicate with each other. For example, many universities offer email, file storage, and learning management systems like Moodle or Blackboard. Additionally, there are student information systems such as Banner, content management systems, and many others on the network. More often than not, each of these typically has different authentication mechanisms, and information needs to be entered multiple times. For instance, one has to re-enter courses that exist in the student information system in the learning management system, including the enrolment of students and the relevant materials for each course. These examples, of course, only scratch the surface, but it should be apparent to the readers that the scenarios, as sketched, require the integration of not only the software but also the hardware and localized services which hence necessitate a different approach.

Two different aspects of integration need to be addressed - services (or functionality) and data (or information). The integration and interoperation of services is generally approached using service oriented or agent oriented approaches. Essential aspects of service orientation are decoupling of interface and implementation as well as composability [15]. Many software packages provide interfaces to their functionalities that can be accessed by other services, using, for example, WSDL (Web Services Description Language) or RESTful (REpresentational State Transfer) services.

However, for services to interact, they first and foremost need to "understand" the data that they have to consume and process. The semantic web augments data with semantic information. While originally, data was semantically described using logic-based ontologies like OWL: Web Ontology Language (see e.g.[16]), more recently the linked data initiative advanced a less formal approach where items in databases are interlinked, thereby essentially creating a huge distributed database [17].

Similarly, the semantic web not only aims at adding meaning to data, but also augments services with semantic annotations, thereby enabling intelligent service usage, automatic service lookup and autonomous orchestration. Where services are generally either used in isolation or by rigidly defined processes, agents add some flexibility to the mix [18] through the concept of goal orientation and the use of semantics [19], [20]. In the context of education, agent technology has been used in various settings, for example in [21].

For the campus of the future, the interplay between different services and the availability of these anytime-anywhere services from any devices is clearly a requirement. Additionally, students and faculty expect not only to have access to these services, but that data is available and usable by different services, so that it is left to the user to combine and mix data and services, rather than having to follow a fixed and limited set of processes. Cloud computing thus plays a vital role in enabling the availability of these data and services within the next generation campus environment.

3.1. Assessment and Learning

In terms of learning and teaching, new models need to be considered. On the one hand, the wealth of information and the ease with which data can be found requires new skills for analyzing the relevance of sources and identifying the original research. Also, the sheer amount of data makes it harder for students to actually produce original writing without falling into the plagiarism trap, particularly within the traditional teaching and assessment environments [22].

On the other hand, the production of knowledge and its dissemination is greatly simplified using tools such as blogs, twitter, and other social networking tools. These allow the student to participate in the academic discourse from an early onset, presenting his or her work to peers (classmates and outside researchers), and enabling a form of apprenticeship where students can follow the thoughts and developments of ideas of more senior researchers, in order to try and emulate it - be it within a formal school setting or within an informal outside-school setting [23].

There are a number of different theories of learning, but recently the social learning view [24], [25] has gained much attention. It is based on a constructionist view, whereby we learn by actively creating knowledge based on experience, as opposed to passively receiving it from the teacher. This notion is then refined with learning by observing and modelling the behaviour of others in social learning. Collaborative learning assumes that knowledge can be created by interacting and sharing experiences. It allows the learners to assume various roles including one of a teacher, which is deemed to be another effective method of learning [26]. As such, the authors in [27], for example, have designed teaching agents so that the students can teach in order for them to learn.

As we encourage and promote social interaction and collaborative learning, we need to ensure that the necessary adjustments are reflected in the way that the student assessments are carried out, as well as the tools that we have provided [28]. Take for instance, additional care has to be taken to assess not only the final product but also the process of collaborating [29], or additional means has to be taken to ensure that the individual student's work can be identified within a collaborative assignment setting [30].

As data and services are moved to the cloud, it not only enables new ways of interaction with data, learning objects, and services (as well as fellow users), but it also allows tracking of students' behaviour and information's usage. This in turn opens up the ability to conduct in-depth analysis of each individual student's learning behaviour. Any abnormal deviation can hence be identified and brought to the attention of the relevant parties-of-concern, thereby providing the students with more personal support and assistance. Novel ways of assessment can also be implemented based on the students' usage of learning objects or their interaction pattern with one another.

3.2. Identity, Ownership, Privacy and Security

On a more abstract level, the move from conventional paper and blackboard based learning and teaching methods towards the use of computers and internet-based (cloud) applications poses a whole new set of opportunities - but also a new set of challenges.

As discussed in the previous section, although the availability of information enables the students to quickly access a wealth of information, it also becomes harder to identify original thought. Related to this is the question of ownership of derivative works. Widely publicized examples where copyright owners took down private videos on YouTube because they used copyrighted songs as background music (See e.g. Lenz vs. Universal[11], a legal dispute about a video showing a little child dancing to a song) to questions of where original research ends and plagiarism starts.

Further, through the continuing integration of social networks and the expansion of the internet into more and more areas of one's personal lives, it becomes harder to separate relevant (professional) and irrelevant (private) data and interaction. While the issue of separation is beginning to be addressed by social networks such as Google+ and also Facebook with its lists feature, it still puts the burden on the user, especially when various tools are increasing in many contexts (professional and private), where it is not easily possible to just create numerous online personae or use different services for each context. Approaches like web of identities [31] or federated identities [32], amongst others (for an overview see e.g. [33]) can help to alleviate this issue. There, users have different aspects of their digital identity hosted by various identity providers. Each contains information such as the user's identity and personae (profile data, social graph, files, presence information etc.). Connections between different providers are under the control of the user, so he can manage which information is shared and with whom. While this is a very powerful solution, the challenge lies in the manageability from a user perspective, as these interactions could become increasingly complex.

In certain regions, cultural aspects have to be taken into consideration as well, such as the use of video transmission, or the interaction between males and females. Any viable system needs to ensure that such cultural sensitivities are taken into consideration. This can be done by completely obscuring the identity and gender whenever possible, or by allowing for gender-based selection criteria.

Closely related is the issue of security and privacy. Generally, these have a number of objectives, such as integrity, confidentiality, authentication, authorization, and non-repudiation [34]. It is beyond the scope of this paper to go into each in detail. But to demonstrate how these objectives interact, consider the following instance: for any exam session, it must be ensured that the person taking the exam can be identified to be the one supposed to take the exam (authentication), be able to access the exam (authorization). Further it cannot be doubted later that it was indeed that person doing the exam (non-repudiation), that the answers have not been changed or modified (integrity), and that the results are kept private (confidentiality).

In the context of interaction between users, especially within the education context, the notion of trust and reputation is also important. Trust denotes the ability of users or machines to make statements about the probability that the information is correct,

[11] https://www.eff.org/cases/lenz-v-universal/

or that a digital ID is correlated to a certain person, while reputation is generally what is said about an object's or a person's standing [35].

Any holistic approach to the campus of the future will have a myriad of services and applications that store various bits and pieces of information about the students and faculty. Some of them are under the control of the university, while others are provided by third parties. Any such system needs to ensure that the data is protected and can only be accessed by authorized users. Federated identities and similar approaches are hence a requirement for the next generation campus environment. Cloud computing, while currently often closed, can support shared ID concepts and allow the providers as well as the users to control access to services and data.

4. Towards the iCampus platform

In Section 2.3 we have detailed in broad strokes the way we envision the platform of the future to look like. Now, we want to discuss concrete steps that we are taking in order to get there.

Figure 4 shows an overview over a number of different projects that we are currently executing and which all contribute towards a learning platform that will be part of the iCampus platform. The projects are designed to develop stand-alone tools that contribute modules towards the platform.

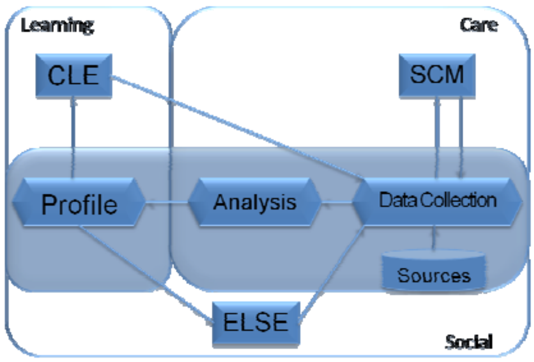

Figure 4. The learning platform

4.1. Collaborative Learning Environment

The Collaborative Learning Environment (CLE) is a tool that supports collaborative assignments in a formal classroom setting [36]. On its face, it is mainly an integration of various technologies that support the student in its collaborative work, such as a shared collaboration area, audio, video and chat communication, shared bookmarks, and easy access to course data. (See Figure 5 for a number of modules.) It is designed as an extension to the learning management system Moodle, though the concept is easily adaptable to other frameworks.

Behind the scenes though, the CLE offers a number of innovative features. First, it provides educators an insight in the way the student's work was created, by means of usage statistics as well as a playback feature that shows how the assignment text was derived. This information can be used to inform on strengths and weaknesses of the students, and provide data for individual grading of group assignments.

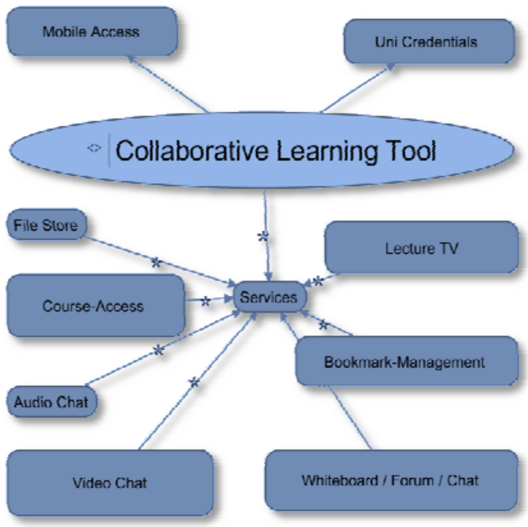

Figure 5. Modules of the CLE

Second, the data about the student is fed into the platform's profile (see

Figure 4). This data can then be analysed and used in other applications that are built on top of the learning platform. Conversely, data about the student can be used to inform the CLE, for example in the way students are grouped together. This way, various learning theories can be tested and validated using hard data, rather than or in addition to more qualitative data that are, for instance, collected through questionnaires.

Our current efforts focus on a subset of the challenges that we have described earlier. In particular, we focus on assessment and learning. The CLE provides lecturers with means to not only assess the final product of a collaborative assignment, but also the process which created it. By allowing lecturers to easily create collaborative assignments and mix and match group members, learning is supported on a number of levels. For example, by pairing students of different abilities, good students are forced to explain their reasoning, thereby gaining a better understanding, while not so good students benefit from having a peer explain the concepts [26].

Ownership is partially addressed by the CLE as well in that it shows which students created which text. Having said that, it should also be noted here that the picture provided is by no means complete. Communications between students happening in the real world or outside the tools (and even the video and audio connections are not saved). There is a clear conflict between privacy and the ability of lecturers to monitor their students. We are planning to address this at least partially by e.g. providing statistics and aggregated values rather than the raw access to the data – for example, we can present percentages of work being done by different students, time they spent on the system, number of keystrokes etc.

4.2. Student Care Management

The Student Care Management (SCM) project focuses on the need of faculty and management to have timely information about students, courses, and the university as a whole. It uses data analytics techniques to identify critical students, provide trend-analysis on courses, offer anomaly/outliner detection on student progress or behaviour, etc.

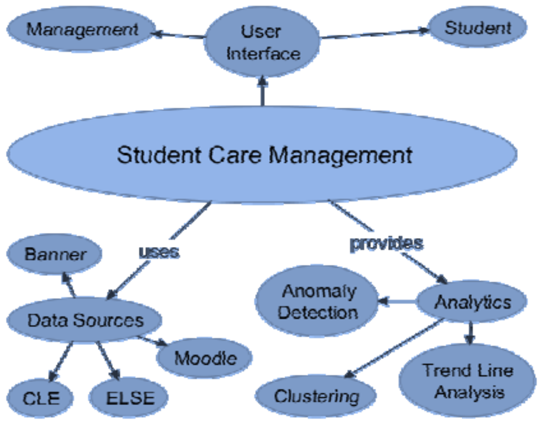

Figure 6. Modules of SCM

It makes use of data that is available at various data sources at university, such as the student information system, learning management system, and the learning platform (See Figure 6). Similarly to the CLE, the SCM's goals are twofold. On the surface, it provides management and faculty with intelligence about various relevant entities at university. In addition, it provides functionality to the platform. This includes the provision of relevant data to the profile, but also algorithms to analyse data that can be used by other systems. As mentioned earlier, the CLE will use a grouping algorithm; and this algorithm is actually borrowed from SCM.

The SCM project is an example where the power of cloud based system becomes clear. By leveraging data that is available on a number of different systems, and using computationally demanding algorithms, management and faculty can benefit from timely information about students, courses, and the whole cohorts. For example, SCM can identify sudden changes in student behaviour and bring this to the attention of the student's mentor, so as to be able to provide proactive student care intervention. At the same time, the system needs to ensure that the data is only shown to people who are authorised to do so; in other words, the privacy preservation and security issues of the system.

4.3. EBTIC Learning & Social Environment

EBTIC's Learning & Social Environment (ELSE) is a system that leverages advancements in social networking and intelligent systems to create a proactive and adaptive platform that promotes informal collaborative learning. Although ELSE provides the usual social networking tools such as a activity wall, groups, and file sharing, it does not solely or primarily rely on the user to find content, search for groups and identify friends or collaborators. It aims to use various techniques that are being researched and investigated to identify content, collaborators and groups that are relevant to a particular user at that point in time and make appropriate recommendations, therefore supporting the user in achieving his/her learning and social objectives more effectively.

ELSE automatically populates and maintains part of the student profile with available data from the university systems. This ensures that changes in the studied subjects are taken into account as the student progresses through the academic year and avoids spamming him/her with no longer needed material. The user will naturally retain the ability to modify and change the profile (learned by ELSE) as needed.

In summary, the recommendations will not only be based on a static list of interests, name or number of common friends, but rather on current interests derived from user activity, educational needs, expertise level and even social activities and club memberships where appropriate. For example, a student who is studying astronomy and in need of help might be put in touch with another student who is a member of the astronomy club and is known to have contributed in that subject, even though he might be an engineering student.

The environment also considers various motivation theories to incentivize users to collaborate and share information in a fair and objective manner to ensure its sustainability.

It can be said that ELSE is meant as a place for informal learning, hence, there are no restrictions as to the actual use, and it is hoped that students not only discuss academic but also non-academic topics.

5. Conclusion

In this paper, we discussed the relevance of cloud computing for the global education sector in the context of the campus of the future. We identified a number of challenges that need to be addressed, and showed how cloud computing can provide parts of the holistic solutions. A new perspective in the application of mobile cloud education within the next generation intelligent campus environment has also been introduced.

With regards to the international iCampus initiative that EBTIC is leading, different aspects of the six-pillar campus framework, in particular the use of mobile cloud education, are presently being investigated. A number of promising projects have been put in place and we discussed aspects of how they integrate within the larger vision of the campus of the future, and how they tackle some of the issues we have identified in this article.

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