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The Benefits and Potential of Innovative Ubiquitous Learning Environments to Enhance Higher Education Infrastructure and Student Experiences in Saudi Arabia

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Abstract: The concept of ubiquitous learning has become an important topic and a breakthrough in the field of education. This study conducts an investigation of esteemed literature regarding the optimization of effectiveness and efficiency in ubiquitous learning environments, through the integration of RFID and wireless technologies (including near field communication), in a sole service network. Also, the study demonstrates and analyzes the usefulness of current applications implemented to create ubiquitous learning environments, while considering the potential of new relationships with technologies and with the environment to facilitate the evolution of the technology with superior performance. Innovative relationships are considered by the author in analyzing the literature while relating the developments to possibilities (assuming money is no object). The emphasis is a university environment. The study mostly emphasizes the benefits of the development and integration of such a sophisticated technological learning environment. Meanwhile, the target audience is both the undergraduate and graduate-level members in the fields of education, such as computer sciences, Information Technology (IT), engineering technologies, or other hybrid fields. This study is to include considerations in the development and application for security protocols to be deployed in the network towards a ubiquitous computing network within a university campus, while the security protocols are to define a set of innovative services to the network users. This study highlights both the theory and technology behind the Ubiquitous Learning Environment (ULE). The ULE allows for great potential in a university environment to conduct activities which meet their academic or other informational mission statements and organizational objectives.

Key words: Electronic learning, near field communication, wireless networks, intellectual property, information technology, mobile learning, radio frequency identification, ubiquitous, ubiquitous learning environment

INTRODUCTION

Recent Information Technology and Networking researches and developments are in quick progress toward ubiquitous network in the century of wireless information technology. The ubiquitous network concept is to provide any information for everyone at anytime and anywhere immediately (Fig. 1). This study demonstrates the usefulness of current applications implemented to create ubiquitous learning environments, while considering the potential of new relationships with technologies and with the environment to facilitate the evolution of the technology with superior performance. The integration of RFID and wireless technological devices allows for such a system to make use of the high performance potential, from both devices functioning in unison, for innovative service which surpasses previous developments. With this, the ubiquitous learning environment allows for great potential in the university (or other potential) environments to conduct activities which meet their academic or other informational mission statements and organizational objectives. RFID technology is known to facilitate the efficient identification of objects and localization across a learning environment (which may be up to tens of meters in width). Naturally, the area is large enough to create a ubiquitous learning environment for typical groups of students or research faculty members (as well as clinicians or other groups with such data and learning needs) such as lab groups, classrooms, research teams, or groups of various students within designated sections of a library. Experts in the field are quick to point out ubiquitous technology is continuing to develop and spread and its applications have begun to influence learning in various fields (Liu and Hwang, 2009; Lyytinen and Yoo, 2002). Meanwhile, the integration of wireless technology with such a setup allows for the technology to be assisted with restricting the localization range to a few centimeters (Fig. 2).

As wireless technology is commonly embedded in mobile phones and the spectrum of other mobile devices

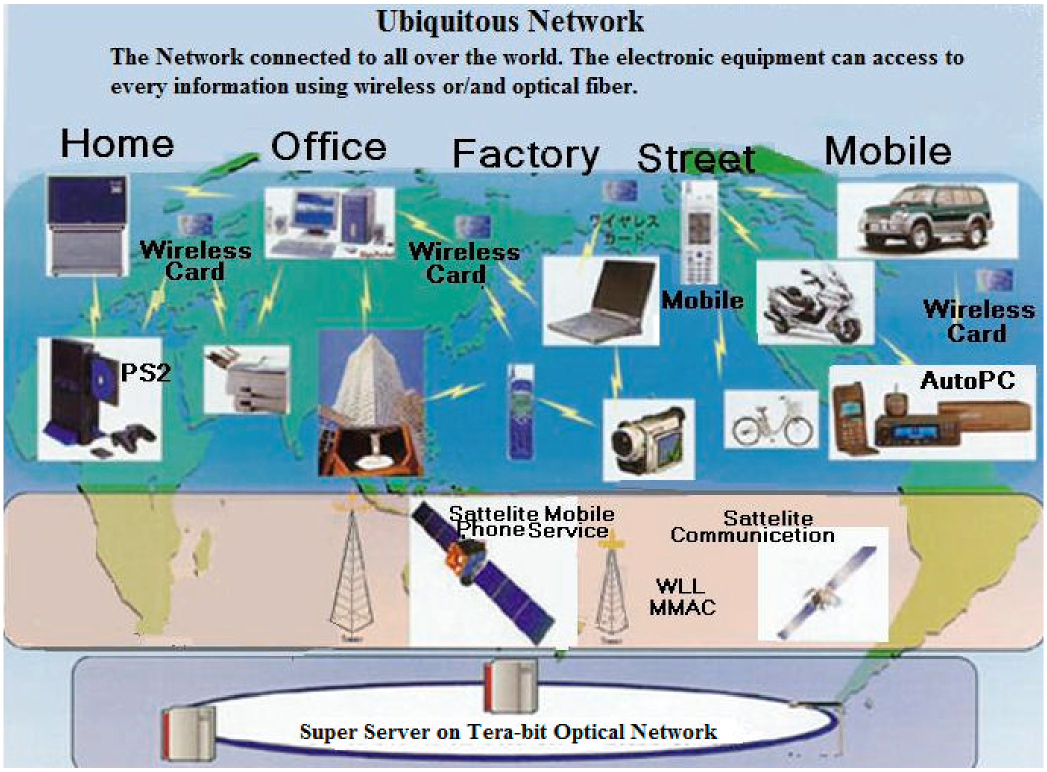

Fig. 1: Society/World-Wide Ubiquity (Suematsu *et al*., 2009)

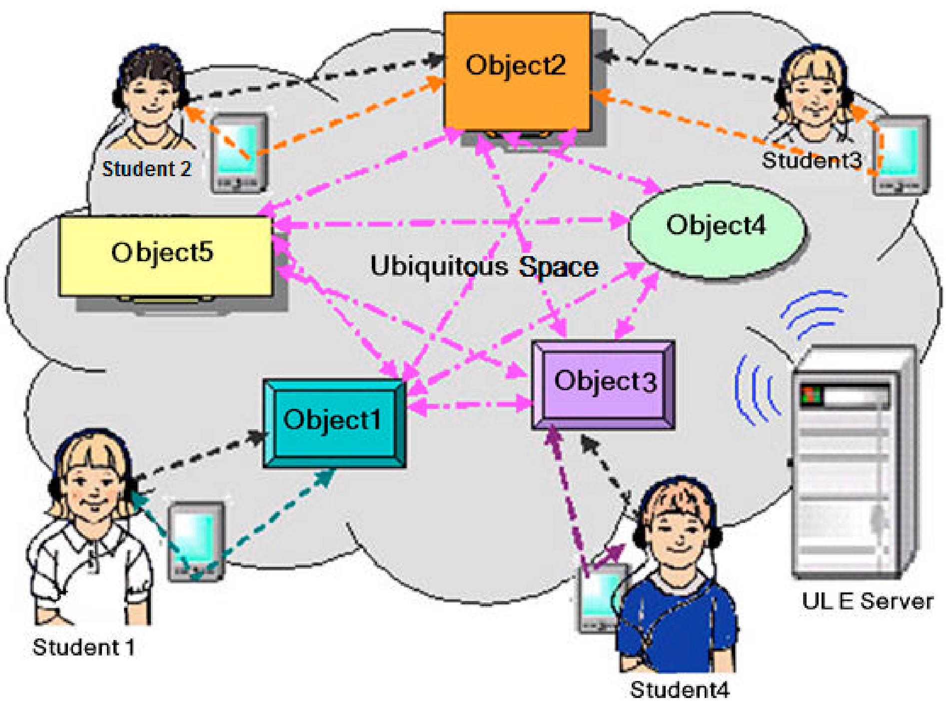

Fig. 2: Fundamental Organization of ULE (Jones and Jo, 2004)

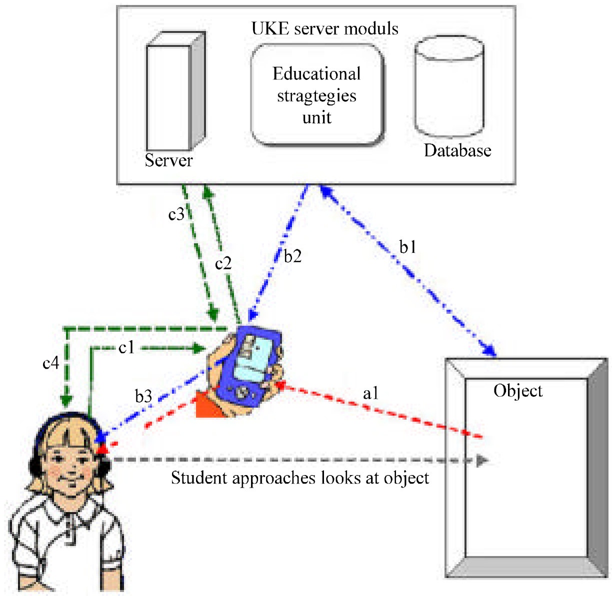

Fig. 3: Standard interaction of student and ULE components (Jones and Jo, 2004)

which have been developed and placed on the market (and likewise used increasingly to enhance learning networks, allow for distance learning and the integration of Web 2.0 technology with curricula) users have benefitted from the advantage of additional processing power and memory capacity; this can greatly enhance learning networks while catering to many academic programs and learning needs. Also, RFID does not demand that its users participate in a personal identification process, as this is conducted in another implicit manner. However, the inclusion of Near Field Communication (NFC) wireless technology demands that users initiate communications across the system.

The crucial concepts in literature followed by a discussion of potential services for a university environment are outlined in the following pages. The potential and variety of possibilities for ULEs and ULE are highly recommended for university inclusion. Clearly, the ULE is the next step in learning potential, following the trend of computerized learning application to online learning and the further evolution of mobile learning (Fig. 3).

OBJECTIVES AND METHODOLOGY

The main objective of this study is to outline specific manners by which learning and teaching processes can be enhanced (as well as administrative processes) in university campuses for the sake of superior learning capabilities and experiences. The freedom of the ubiquitous learning environment is great, while its conceptual potential is even greater. The abilities of technology continue to improve while they allow for further evolution of ubiquitous learning environments and this in turn allows for increasing optimization of academic and informational processes. The emphasis of this study remains on the university and learning efforts which take place within a university environment, however it can be assumed that the potential applications of the technology and systems to improve other environments are also present. While the potential for the enhancement of ubiquitous learning environments within the university campus remains the primary emphasis, the RFID and wireless technologies will be the emphasis of technological developments, applications and recommendations for future improvements.

More specifically and namely, this study aims to introduce a standard framework for an optimized learning environment within a ubiquitous computing university campus, to demonstrate the potential for improvement of the abilities for student groups to collaborate among themselves or with supervisors and instructors, to engage students more deeply within the active learning process (particular those students whom may have otherwise felt more excluded from normal classroom activity), to permit users to provide timely responses to answers related to the daily activities of students on campus and to demonstrate the potential for a system which is easy to upgrade and reprogram (or to be reused similarly in other applications). Secondary objectives include describing and proposing the abilities for the system to secure transmitted information from unauthorized users (and other breaches in standard authorized access), increasing the reliability of the system through the utilization of specific fault tolerance techniques and lastly to demonstrate the results and recommendations of the potential for ubiquitous learning environments through simulating the appropriate processes and procedures.

The methodology employed to achieve these objectives include the research of esteemed technological and theoretical developments and research; while this study will make use of existing studies (rather than include a unique survey questionnaire analysis, interviews, or testing a technological prototype in a campus, due to funding and authoritative limitations), full consideration is given to recent developments so that the proposed recommendations are beyond merely coherent and informed. The proposed recommendations stress innovative applications of existing technology, using existing theory and technological components as a template, to facilitate technological mediums in the development a custom solution which maximizes the student experience at any university.

Theoretical developments and current studies

Introduction to RFID: Mickle *et al.* (2008) described that the radio frequency identification (RFID) is one of the most commonly discussed technological components used in ubiquitous technology systems (Geddes, 2004; Kumar and Chatterjee, 2005; Mickle *et al*., 2008). This specific component contains a wide variety of possible users across various learning environments. Because of this variety, there is great potential for RFID in developing specific services and providing to a variety of learning needs in academic institutions (or other organizations which may desire the creation of a similar learning system). Within the category of RFID, the EPCGlobal Class 1 Generation 2 (aka Gen 2) specification for RFID has been the topic of deeper analysis in recent years, as its applicability holds great potential for furthering the development and potential uses of the ubiquitous learning environment (Mickle *et al*., 2008; Savill-Smith and Kent, 2003). Meanwhile, however, although, the technology has been considered in such detail while being the subject of deeper applications by many computer scientists and other technological and educational specialists, sub-categories of technology within the RFID relationship with ubiquitous technology has simultaneously been the subject of great concern in the area of privacy and security. This level of concern in an academic environment or large university rivals that of wireless security, as the open-natured network inherent in RFID networks creates a level of vulnerability within the network and with the sensitive information exchanges between users. Intellectual Property (IP) patents have long considered the developments of RFID, however few developers have been able to fully harness its power throughout the evolution of technology. Perhaps the three most crucial elements in the development of RFID in relation to IP begin with the Electronic Article Surveillance (EAS) (and its evolution into the foundation of RFID), the integration of RFID with newer technologies such as the aforementioned Gen 2 technology (among others) and the specific patents relevant to RFID communicative protocols and their providence of a new emphasis the uses of RFID (Mickle *et al*., 2008).

The RFID technology by itself is a ubiquitous technology which educators and program developers may consider to be exciting, highly practical and holding great potential for the continuous improvement through blending with ever improving technology. An example of potential client-server relationships between users is show in Fig. 4.

The RFID has long been the foundational element of the concept of ubiquitous learning environments (ULEs) and will likely continue to be the foundation. Developments in wireless technology and computer applications, such as the improvements seen in software through Web 2.0 software, have the potential to greatly enhance ULEs when integrated with RFID.

Integrating technology with RFID to facilitate university services: The RFID plays a fundamental role to allow data to be transmitted to all included locations, networked devices and varieties of users with the accessibility of having the potential for communicative or informational access at any given time. RFID is supported by the aforementioned spectrum (and potentially other) technologies, while the capabilities of wireless, sensor networks, Web 2.0 and other areas that have already revolutionized areas of computer technology; the superior enhancement of academic experiences (and the potential to improve the learning experiences) and extension of the university as a beacon for education (Mickle *et al*., 2008; Kumar and Chatterjee, 2005).

Sensory technology can be connected to wireless communication equipments and has the potential to capture, disseminate, or process useful data for a maximized educational experience. Meanwhile the extensions of Web 2.0 can be combined with this and RFID for a new level of potential to increase learning, as seen with the rise of distance education and the integration with mobile devices with classrooms (Geddes, 2004; Mickle *et al*., 2008). Meanwhile, the sensory device has yet to see the scope of online and distance learning (or even the integration of mobile devices) initiatives.

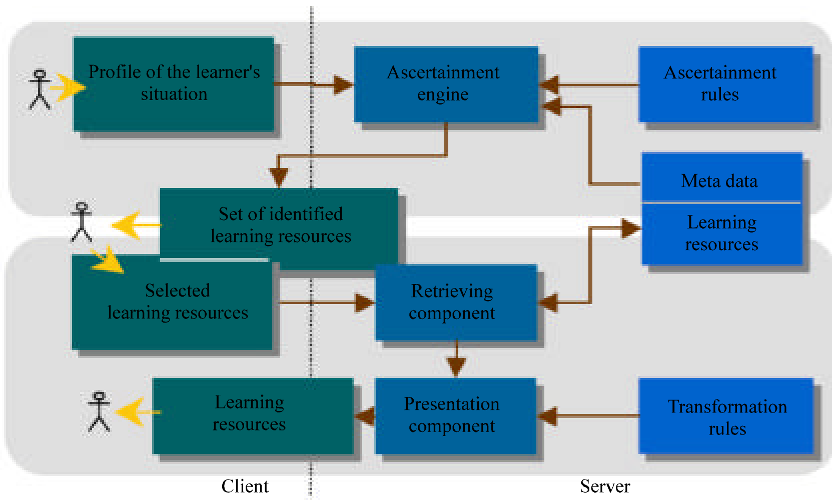

Fig. 4: Potential client-server relationships in computerized ULE (Bomsdorf, 2005)

Some researchers expect that future smart devices integral or coupled with developments in RFID will extend the ULE far beyond campus boundaries (Kumar and Chatterjee, 2005). The present mobile applications which are not specifically designed to enhance the learning experience have already been developed to an extent that the environment has become virtually naturalized as people are often completely unaware of the computer chips or smart technology being handled. Meanwhile, some analysts assume that future extensions of ULEs and RFID technology will maintain current data including personal information and user location while privacy advocates claim that privacy features will be a nearly endless problem as the vulnerability for intrusion lies in the very nature of the concept (Kumar and Chatterjee, 2005).

The educational environment has a varying consideration of the impact of privacy intrusion cases in current system vulnerabilities and these same concepts would seemingly apply to future developments. The potential for severe consequences such as identity theft, financial theft, network sabotage, other sensitive information exchange and destructive elements is less likely in comparison to the potential for vulnerable businesses or homes to be breached. However, some sensitive information may be exchanged unwillingly and the potential for academic dishonesty across the network also seemingly increases. These processes neither undermine the potential for instructor or student services within the university nor the benefits to accessibility to decrease in proportion. Whereas, security protocols may also be developed with a more strategic objective of handling these cases, many researchers do not warn that the disadvantages of vulnerabilities should be a discouragement to the development and implementation of any ULE. Theoretically, this is similar to the initial discouragement of computer use, software use and emails during their inception because of the increased possibility for negative consequences and the unique type of potential intrusions (Kumar and Chatterjee, 2005).

Functionality and privacy issues: The RFID tags may be attached to ULEs without the prior knowledge of the consumer and this is thus a great concern for privacy advocacy groups. According to analysts and experts within privacy advocacy groups, user privacy is greatly enhanced in the event that consumers are aware of informational best practices. Users are commonly provided with an opportunity to select between informational provision and informational usage, while the user privacy is lessened in the case that there is undesired marketing contact or data acquisition without the user giving prior consent to any party (Kumar and Chatterjee, 2005). Meanwhile, privacy advocates consider the case of the university and learning environment, claiming that even when educational databases contain a purely transactional data including names, addresses, products, or services, these services provide the fundamental source for development of the most detailed profiles through the facilitation of such great interconnectivity between each element while easily assisting with ubiquitous RFID (Kumar and Chatterjee, 2005). This is in further support that the vulnerabilities of the ULE should not be an overall deterrent to the freedom and spectrum of services available with the application of a ULE integrating wireless NFC with RFID.

Impact of technological enhancements on student learning: Electronic learning (or e-learning) and mobile learning or (m-learning) have been at the heart of the ubiquitous environment concepts and theory. Because of this, educators across the world have begun to consider ways by which this technology can be applied to improve collaborative learning, accessibility and other fundamental concepts in education (Looi *et al*., 2010; Savill-Smith and Kent, 2003). Dew (2010) described the potential learning software in a ULE for the university students (Fig. 5).

With such an effort, consideration of the potential services such as attendance and connectivity (via wireless and sensor technology) which could be offered by schools have been commonly proposed. Naturally, such an implementation involves both the investment and risk. Moreover, the absence of these issues would have resulted in even further experimental knowledge and observations of results in students and faculty in these areas (Savill-Smith and Kent, 2003). Programs such as Second Life allow for students to use mobile technology to conduct medical simulations, simulating real-life situations as well as inherent medical risks for an optimized learning experience (Varvello *et al*., 2008). Computer based education has become increasingly prevalent across the spectrum of its areas in education system as the results have been clearly proven up to the rise in Web 2.0 technology, however these technologies do not always have a place at all institutions where resources and acquisition are commonly a problem (Jones and Jo, 2004).

The influx of online learning programs during the mid to late 1990s has given rise to continuing extensions of technological feats with academic applications (Fig. 6). This initial development was a revolutionary breakthrough for all of the participating educational institutions and the ULE has a similar potential to offer

Fig. 5: Example of potential learning software in a ULE (Adopted from Dew, 2010)

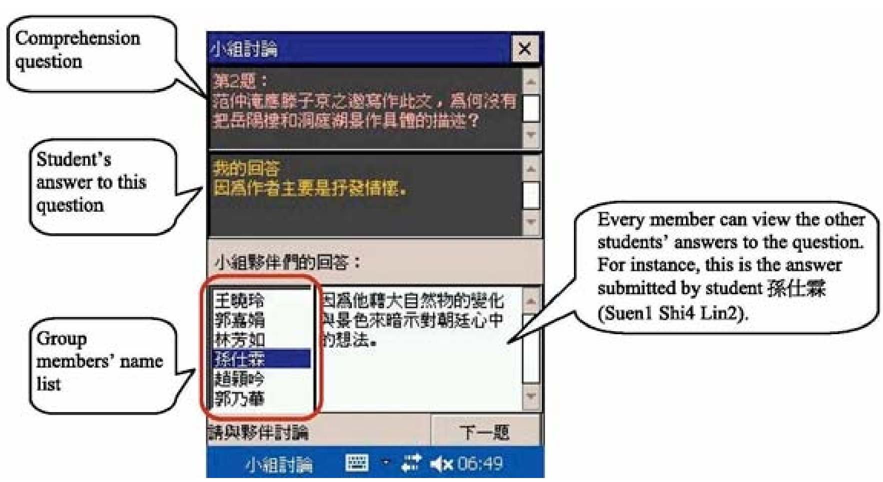

Fig. 6: Mobile learning program in China (Chang *et al*., 2010)

new levels of accessibility and academic participation. The learning process has also been revolutionized while the convenient technology continues to improve the management capabilities for both in-house tertiary education systems, distance education, mobile applications through Web 2.0 software and the streamlining of such developments (Jones and Jo, 2004).

ANALYSIS, DISCUSSION AND CONTRIBUTION

Considering the concepts described in the relevant academic literature and applying it to a deeper consideration of technology and potential applications, the desirability for a ULE in any academic institution with free monetary resources is evident. The improved ubiquitous learning environment allows for many things to be possible in academic efforts and general learning needs, while many specific services can be further expected. The specific services, which could be expected from the proposed developments for an integrated ubiquitous learning environment, include students acquiring receipt of assignments, handouts and grades through the use of strategically located tagging devices with personal mobile technology, the potential for students to acquire schedules and scheduling updates (or announcements), services allowing students to participate in a classroom group discussion through collaboration with Web 2.0 software and NFC technology, the ability for instructors to distribute assignments and quizzes across the classroom with wireless applications, the ability to record attendance in lectures (or labs, exams, or other activities,) through the use of RFID technology, applications for the instructors to carry out surveys or course assessments in class while making use of the integrated equipment and increased accessibility for real-time chats between any student and faculty member. Other potential expectations are the ability for the campus community to use their wireless devices within the university through the strategic location and combinations of phones against tagged posts, the distribution of RFID tags across various facilities across a university campus (including roadways) which can be used in locating either equipment, people, parking areas and other service areas or objects.

Generally, the combination of RFID with wireless technologies such as the NFC technologies in an optimized ubiquitous learning environment can provide the aforementioned services in an efficient and effective way. In this discussion (including applications and recommendations), the RFID system is assumed to be used primarily to locate people or objects within a designated service area, including classrooms and a broader interconnected university campus. Further applications of the aforementioned services include the ability to take student attendance using entry and leaving times of student devices passing through checkpoints (rather than manually via instructor software,) and the application of the NFC technology to be traded with larger pieces of data across various users including files exchanges, acquiring schedules, receipt of payments and more.

The pervasiveness of RFID has been explosive in the computer markets and high-budget program developments from technology advanced or other highly successful academic institutions. The interest in the technology in these areas has been explosive in recent years, while research and development in RFID is commonly made possible through the development of outside technology including the above stated devices as well as advances within the areas of location sensing equipment and other advanced sensors, access control technology such as those recently evolving for buildings, the technology responsible for automatic toll collection, animal tracking and other GPS tracking technology (navigation, disable or criminal citizens, etc.,) supply chain management, airport technology, healthcare organization, library organization and more (Mickle *et al*., 2008). Currently, although many patents have been developed for the purpose of applying RFID towards EAS or developments for student needs in an academic environment, influxes in desired patents for RFID applications into many systems which could facilitate a ubiquitous learning environment have actually stagnated some development as a result of the required reviewing (Mickle *et al*., 2008). Increased licensing and patents for new technologies for themselves or in unique combinations or applications have commonly crossed into one another, thus in some cases even when the potential to benefit some academic area was realized and developed with technology, the need could not always be met as a result of the licensing issues. The consideration of future ULE systems may thus be subject to similar setbacks within the university environment. Even though the developments in technology and the progression of IPs and licensing allow for innovation to be applied to most institutions; a great deal of universities have been reluctant to shift their learning systems and data bases to facilitate the technological accessibility and services as described. Many assume that ULEs will be present in upcoming years just as naturally as personal computers and local area networks.

Aside from the ability to provide the students and faculty with a vast variety of superior services through the integration of an effective ULE environment, another role of the educational system itself lies within providing such flexibility and accessibility to additional programs such as distance learning and unique classroom applications that include more real-world functions (such as clinical activities, public library or public sector functions and inventory, multi-university programs, relationships with other external organizations and more. Potential information and educational developments within such a system potentially include university conferences regarding RFID technology and its potential influences, open discussion forums and online dialogue platforms, information (including research studies which provide an introduction to RFID and benefits to all members of the university, barriers to considering potential improvements, applications to additional non-educational services such as attendance and parking and more), publicizing all regulations, the development of demonstration projects and a variety of data including educational efforts and initiatives worldwide (see Appendix A for a detailed table including a breakdown across nations around the world) (Weber and Vickery, 2008). Naturally, the objective of the university is to maximize learning in some increasingly specialized area and the development and strive to carry out these procedures is easily complimented by such initiatives in the ULE development. University activities, once the system has been implemented and services are activated, would be increased in some areas while decreased in others. The desirability of custom development and implementation is not undermined by this, however, for the reasons described as well as others.

ULE is clearly an evolutionary step in technology blending with the world of academia. Mobile learning is commonly considered to be a form of computer learning. However, the accessibility and processes involved provide nearly an entire new dimension as location is no longer an issue. Distance learning requires that students be at home or at least online, while mobile technologies allow for students to better blend their employment and personal obligations (or leisurely activities) with their academic progress (Geddes, 2004). Mobile learning, similar to the development and potential for the ULE, provides a new extension of internet functionality and online learning and the additional benefits (aside from the aforementioned flexibility) encompass increased flexibility, reduced expenses, decreased size of required equipment and improved user friendliness across some services (Jones and Jo, 2004). The vulnerabilities to online learning and mobile learning are similar to the ULE, although the ULE creates a physical concentrated space for intrusion, creating a greater need for encryption and physical security that may extend beyond the needs of basic wireless encryption (due to the RFID element and potential applications). Mobile learning is a combination of technology as is the development of ULE and the analogies related the potential with the technology are similar in that permanent connections are reduced and accessibility is maximized both on and off campus. If the wireless service used in conjunction with the RFID is to include the maximized and optimized developments of wireless networks and mobile learning, the spectrum of devices which may be used to fully access and utilize the ULE is thus conducive to optimal efficiency and effectiveness with the currently available technology. Theoretically speaking, a ULE should allow this if it is to be maximally effective as a concept. Table 1 shows the comparison of four learning environments, Desktop-computer assisted learning, mobile learning, pervasive learning and ubiquitous learning.

The nature of the learning process is naturally pervasive as the learning process is naturally present while students can potentially learn without even being conscious of the process (Jones and Jo, 2004). In this, Geddes (2004) among others support the potential for the student to learn statistically improves with the increased opportunity to receive various services from any location, especially when considering the increasing burden on student scheduling and the expensive and time-consuming nature of the university experience (Geddes, 2004). Source information in a ULE is present in embedded objects while it can also make use of sensing technology and this simply requires the presence or activation of the student as they go through their daily lives. The advantage of accessibility and variety of services helps to ensure that students will succeed and in the event that students are unable to attend a lecture or acquire materials

Table 1: Comparison of four learning environments

Learning environments	Embedded in the learner's surrounding environment	Where	Mobility
Desktop-computer assisted learning	NO	Office desktop computer	Low, Difficult to move
Mobile learning	Limited flexibly to obtain information about the context	Everywhere lightweight devices such as PDA	High
Pervasive learning	Yes but highly localized in specific environment	Dedicated computers, small devices such as sensors, pads	Low, localized
Ubiquitous learning	Highly embedded	Mobile devices, communicating with embedded computers anytime and anywhere	High

in a conventional setting, the circumstances commonly serving as barriers (work, sickness, personal crises, or even distracting leisurely activity) pose less of a threat to student success with the improved accessibility in a ULE. A ULE can further provide props and stimulus require to greatly improve student encouragement and motivation to participate and some students may even find this more desirable in the case they are withdrawn, shy, or simply do not have the energy to collaborate in person. An example of selections and an effectively combined set of technologies is described For example, if the learner is outside of a building, then a GPS location tracking function will be invoked to return his/her location in terms of building name/number; while the learner is inside a building, then indoor tracking system (RFID or sensor network) will be invoked to return the location in terms of room number. Once the location is positioned, we will decide whether to disclose the location based on the learner's privacy preference (Yang, 2006). Meanwhile, additional concerns relevant to the technology and processes in this situation are given deep consideration with Please note, the privacy preference is dynamic and can be adjusted based on location and temporal constraints. For example, if the learner is inside an office building, then he/she is willing to disclose the room number where he/she is currently is to the public, while if the learner is out of office, then the position is only disclosed to his colleagues and family members (Yang, 2006).

The potential for universities to enhance their influence as an educational institution is clearly great with the development of the ULE and the services currently possible with the available technology (both in a spectrum of hardware and software compatible with such hardware) are optimized extensions of university services which may be provident of the most detailed university objectives. In definition, the ULE concepts include pervasiveness, pedagogical applicability and the flexibility in the environment. This may even be developed to the extent that chains of institutions may be able to be more efficient in the construction of facilities, requiring less physical space as less students require university-specific resources at one time. Students on the campus, meanwhile, can take advantage of the university specific services through the sensory technology for a maximized organizational and educational experience.

Figure 7 shows a ubiquitous network society, where people can access variety of services using various terminals. Devices such as mobile phones, laptop computers, PDA's, sensors, automobiles and digital appliances are connected to each other to create a network and provide secure and seamless service. The ubiquitous service middleware, is a the latest platform which is currently being developed to support different services, including various types of technology such as: web-telephony cooperation to support easy communication between users anytime anywhere, single sign-on to reduce user burden and context management to offer the user environment optimized service.

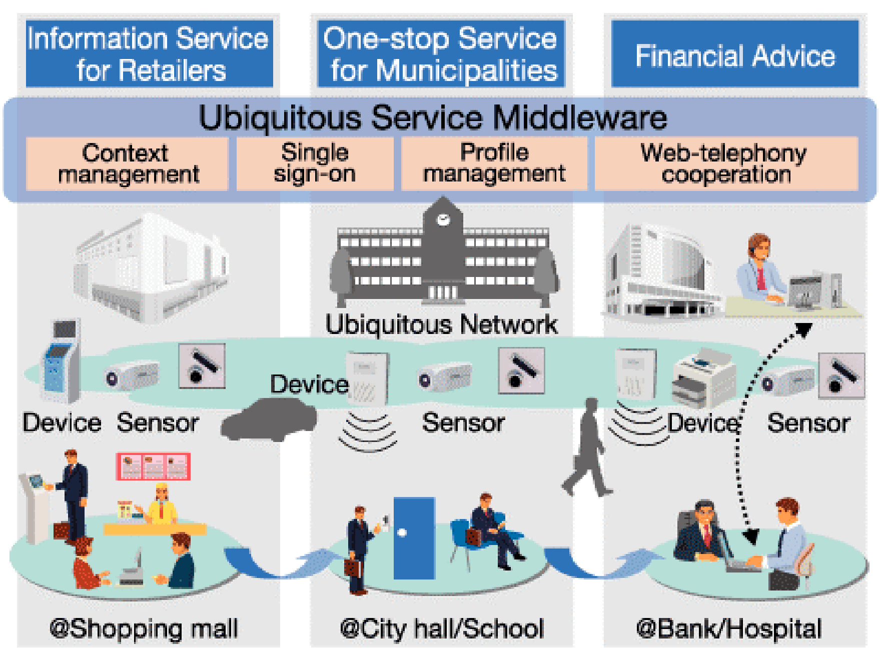

Fig. 7: Sensor Imaging Technological Applications (http:// www.hitachi.com/rd/research/sdl/07/soc_01.html)

CONCLUSIONS AND RECOMMENDATIONS

Although, the RFID technology in itself has only recently been considered in great detail with regards to the improvement of the ULE (and the potential for learning environments in universities in general,) yet the technology has an extensive history which mirrors the streamlining of computer technology with academia. Wireless technology is an example of an element seen in current academic applications including distance learning, the integration of mobile technologies with Web 2.0 software and integrations with academic curricula. The work in these areas and others including passive RFID standards, EAS, sensing technology, article location technology and the other various technologies outlined in the above literature review and discussion reveal the potential for the development to continue alongside the evolution of technology. With the recent rise of elements such as Bluetooth technology, wireless internet, the spectrum of mobile devices and the variety of Web 2.0 convenience services and software (and the applicability of all of these technologies in facilitation of the learning process), the potential for the once purely theoretical concept of a ubiquitous learning environment has become a reality with internet technology and can continually improve and be extended. This can be done in greater detail and accessibility to locations such as libraries, the classroom and areas beyond the campus for continually accessible distance learning and collaboration. Some analysts have pointed out that the automation of IPs can play a major role in the accessibility of the fundamental developments of RFID technology and it may also potentially play a role in the evolution of other technology described above (or also ad hoc RFID specifications) in the literature (Mickle *et al*., 2008).

In a superiorly optimized ULE containing the most developed modern technology, the integration of RFID and wireless technologies is within the boundaries of a current reality to create a successful ULE. Fundamental components of a ULE, which is virtually recommended to any university with the means to invest and improve the education of students would thereby include microprocessors, a ULE server module, wireless technology and sensors. With these, microprocessors are assumed by experts to serve to embed memory in all objects and devices, ULE server modules are to serve to manage network resources, wireless technology serves to facilitate communication and sensors are to detect presence via light or motion (Jones and Jo, 2004). There are clearly a variety of options for all technologies, while wireless technology selections should consider signal strength, power consumption and compatibility with devices.

Overall, the benefits of ULE are numerous and crucial to the university mission. ULE is the next best step forward following personal computing, laptops and internet and mobile applications. The relationships in education discovered within the ULE learning experience include the opportunity for a ULE to service the student body and faculty body simultaneously and the student can participate and grow despite lifestyle challenges or personal issues. A custom solution for a university combining the best technologies proven to be effective is ideal for any learning environment which can afford to consider such an effort.

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