National Chiao Tung University

Institute of Computer Science and Engineering

THESIS

CrowdSMILE – 運用社群網路群眾外包技術之行動學習系統

CrowdSMILE – A Crowdsourcing based Social and Mobile Integrated system for Learning by Exploration

研 究 生： 彭丹尼　　Student： Dennis Mohan Punjabi

指導教授： 林寶樹　　Advisor： Bao-Shuh Paul Lin

15th July, 2013

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碩 士 論 文

A Thesis
Submitted to Institute of Computer Science and Engineering
College of Computer Science
National Chiao Tung University
in partial Fulfilment of the Requirements
for the Degree of
Master
in
Computer Science

July 2013

Hsinchu, Taiwan, Republic of China

中華民國九十七年六月

CrowdSMILE – 運用社群網路群眾外包技術之行動學習系統

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摘要

在日常生活和活動當中，學習隨時隨地不斷地在發生，不僅僅在教室裡，更多的是在教室之外，以透過自主性的終身學習達到學習不間斷的目的。而且這樣的學習是以學習者為中心，並經由身臨其境之社交與合作的學習活動，使學習者更容易地控制與參與這個學習過程。

技術的應用使終身學習成為可能。技術使初學者容易地從網際網路存取學習內容。而移動技術的普遍性，如智慧行動裝置和高速寬頻網絡，提供了一個方便的使用平台，可隨時隨地存取基於多媒體的豐富學習內容。智慧行動裝置備有強大的中央處理器、圖形處理器和感測器，可以提供豐富、創新的用戶體驗來存取學習內容。社交網絡服務亦是另一個領域的技術，可以提供支持終身學習活動的合作環境。由於社交網絡已經廣泛地被大家所使用，因此其提供了一個熟悉的操作界面來支持社交性與合作性的終生學習。

這篇論文提出了一個基於群眾訊息之社交性和移動性的整合系統，稱為CrowdSMILE，藉由探索的方式來進行學習活動。CrowdSMILE 透過一個統一且整合的定位系統來實現終生學習，該系統整合了移動和社交技術，提供一個群體貢獻和合作性之容易伸縮與擴展的學習平台。我們已提出一個多元件的系統設計和實作一個原型系統以供測試。此外，我們也描述了 CrowdSMILE 系統的基本原理、系統設計、系統框架，使用情境和一些實驗測試結果。實驗結果顯示，第四代行動網路的高頻寬與低延遲特性可以協助實現我們所設計的系統；此外，社群網站的特性也能被使用在學習內容評分上，而 CrowdSMILE 系統的確能在使用者學習上有所幫助。

關鍵詞: 線上學習、行動學習、在地學習、群眾訊息、社交網絡、行動增強實境、第四代網路

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ABSTRACT

Learning occurs every day, not just in classrooms but even outside the classroom in everyday life and in everyday activities at anytime and anywhere. Such learning is on-going, self-paced and voluntary; and is referred to as Lifelong Learning. It is characterized by a learner-centric learning process where the learner is more in control and is more engaged through immersive social and collaborative learning activities.

Technology can be a big enabler of Lifelong Learning. For starters, it can allow easy access to learning content from the Internet. The pervasiveness of mobile technologies, like smart mobile devices and high speed broadband networks, offers a convenient platform to access rich multimedia-based learning content at anytime and anywhere. Smart mobile devices are now well-equipped with powerful CPUs, GPUs and sensors that can now provide rich, innovative, and contextual user experiences for accessing learning content. Social networking services (SNS) is another area of technology that can offer the collaborative environment needed to support Lifelong Learning activities. Because SNSs are so widely used, it can offer a familiar interface to support the social and collaborative aspects of Lifelong Learning.

This work proposes a Crowdsourcing based Social and Mobile Integrated system for Learning by Exploration called CrowdSMILE that enables Lifelong Learning through a unified and integrated location-based system. The system integrates mobile and SNS technologies to provide a crowd sourced and collaborative learning platform that is easily scalable and extendable. We propose a multi-component learning system. The design rationale, system framework, and usage scenarios are also described. In addition, we also implement a prototype of the overall system for testing. Some experimental test results are

also illustrated while using CrowdSMILE. We show that 4G networks are more suitable for our application and certain social networking features can be used as metrics for content ranking methods. Finally we also show that users found our system to be useful and showed positive attitude towards it.

Keywords: E-learning, M-learning, Location-based Learning, Crowdsourcing, Social Networking, Mobile Augmented Reality, 4G Networks

Acknowledgement

I would like to show my sincere gratitude to my advisor, Dr. Bao-Shuh Paul Lin for his invaluable guidance and support over the course of my degree. He challenged me and provided effective advice and insight which greatly facilitated the completion of this work and my learning at NCTU. I would also like to thank Dr. Li-Ping Tung. This work would not be complete in this form without her useful suggestions and feedback. Furthermore, I would like to thank the staff and my fellow members of the Intelligent Information & Communications Research Centre and also the Broadband Mobile Laboratory for their support, advice and friendship especially Ms Jacqueline, Dr. H.Y. Lin, Dr. J. Hung, Anna, Anita, Chia-Yu, Lynn, Derek and Hsiao-Chin. A big thanks to all the staff and faculty at NCTU who helped me navigate around NCTU with much more ease than I could have without them. Thank you for working hard to accommodate the international students! 你們辛苦了!

I would also like express my love, appreciation and thanks to my wife, Helly, my parents and my family for their unconditional support and encouragement as always. I would not be here without them. Thanks to them for pushing me to work harder when I needed to be pushed! They have always been around to help when I needed them. A special thanks to all my friends, colleagues and past teachers who always encouraged me to strive for the best.

I would like to thank CSUCA (Consejo Superior Universitario Centroamericano) and National Chiao Tung University for providing me with the required scholarship assistance throughout my studies in Taiwan. Finally, thanks to everyone and anyone who offered advice, support, encouragement and help in any way along this journey. One Love.

"The day you stop learning is the day you stop living." - Albert Einstein

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List of Acronyms, Abbreviations and Definitions

3G: 3th generation wireless telecommunication standard

4G: 4th generation wireless telecommunication standard

Android: Mobile Platform and Ecosystem created by Google

API: Application Programming Interface

AWS: Amazon Web Services

CBCL: Computer based Collaborative Learning

CMS: Course Management System

CrowdSMILE: A Crowdsourced-Social and Mobile Integrated system for Learning by Exploration

Crowdsourcing: The practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers

EPC: Evolved Packet Core

GPS: Global Positioning System

iOS: Mobile Platform and Ecosystem created by Apple

LLL: Lifelong Learning

LMS: Learning Management Systems

MAR: Mobile Augmented Reality

Mashup: A web page or web application that uses and combines data, presentation or functionality from two or more sources to create new services. The term implies easy, fast integration, frequently using open application programming interfaces (API) and data sources to produce enriched results that were not necessarily the original reason for producing the raw source data.

PIF: Package interchange file

P-GW: Packet Data Network Gateway

SCO: A SCORM Sharable Content Object

SCORM: Sharable Content Object Reference Model, a collection of standards and specifications for web based learning.

SDK: Software Development Kit

SNS: Social networking services

Web 2.0: Refers to concepts and technologies that enable a more participatory web than static web pages. It enables two-way interaction between users and websites/web systems.

Chapter 1: Introduction

1.1. Preface

Technology based teaching and learning activities have grown by as much as 35.6% in recent times and are replacing traditional classroom teaching methods in many situations. Commonly known as E-learning, it has rapidly become a valuable teaching and learning method as part of many formal education environments [37,65,73]. Because E-learning technologies can make it easy to access content, it is also seen as an enabler of what is known pedagogically as Lifelong learning (LLL). LLL is considered to be a largely informal process of on-going, self-paced and voluntary style of learning at one's own convenience and desire [10]. It is also characterized as being social and collaborative in that it involves others around the learner to be part of the learning process, either directly or indirectly. As its name suggests, it is said to occur throughout one's life. The LLL process is characterized by putting the learner in control of the learning content. It allows the learner the flexibility to learn when they want, how they want and from where ever they want.

One common and well-known form of E-learning systems is called Learning Management Systems (LMS). While LMSs work well in formal environments, they don't necessarily work well for informal learning like LLL because informal learning requires the learner to have complete control of the learning process. As discussed in [11,50], LMSs tend to be administration centric, restrictive and were designed to provide content to the learner and not necessarily to enable the users to engage with the content, i.e. create it, share it, modify it, adjust it, contribute to it etc. LMSs tend to follow an outdated model of simply allowing one way access to content. New collaborative and social learning models and paradigms require and seek to engage the learner more than ever in the learning process [33], especially by way of interaction with others. As such, E-learning platforms that support social and collaborative features also tend to support LLL better.

To achieve social collaboration, learners need to be able to connect with each other freely and easily. In everyday life, people use their own mobility and mobility of objects to coordinate their collaboration with each other [39]. In E-learning, content has been traditionally accessed and generated using stationary desktop PCs and as such, has confined learners to their desks and hence excluded the mobile aspect of collaboration. Mobile

technologies, on the other hand, provide a mobile, on-the-go type of E-learning as opposed to stationary E-learning and allow for more interactive collaboration, thus allowing the learners to connect better. Such mobile-anytime-anywhere type of E-learning is referred to as mobile learning or M-learning [51,54,55,62] and is basically a subset of E-learning as depicted in figure 1-1 below.

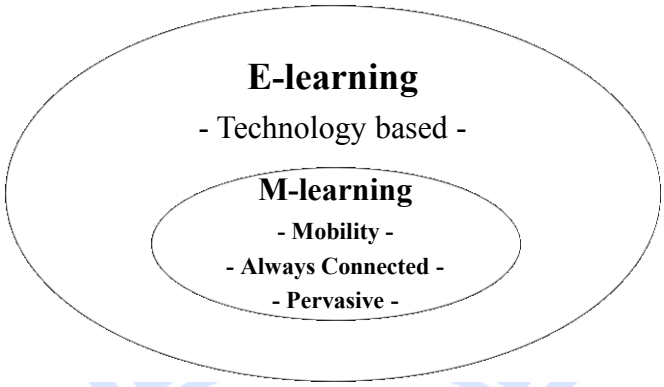

Figure 1-1: M-learning - a subset of E-learning

Over the last two decades, we have seen an increase in ubiquity and expanding functionality of mobile technologies. Rapid improvements in the area of information and communication technologies have resulted in mobile devices with advanced capabilities such as powerful processing, high-resolution touchscreen-displays and multiple sensors. Add the use of high speed broadband mobile networks into the list of capabilities and what we have is a platform that enables anytime-anywhere access to rich multimedia content stored in the cloud. The mobile platform is thus very suitable for learning activities and accessing rich learning content on the go and outdoors. Furthermore, mobile technologies like smart mobile devices, are now well-equipped with powerful CPUs, GPUs and sensors that can now provide innovative, interactive and rich user experiences for accessing learning content [38]. Studies conducted over the last decade prove the viability and efficacy of using mobile devices for LLL. For example, in 2000, Sharples et al. discussed that learning can take place at anywhere and anytime and not just in the classroom [62]. It is to be noted that since then, they realized the need for a highly portable mobile computing platform that supports LLL.

Social software may be broadly defined as “software that supports user interaction” [63]. An area that has also seen tremendous growth in the last decade is a type of social software called social networking services (SNS). There are now over 1.5 billion SNS users [21,23]. An SNS site may allow users to build and maintain social connections or relations

among people based on real-life connections, jobs, interests, hobbies, activities or all of the above. Since SNS sites inherently support user interaction, they implicitly enable collaboration based activities such as knowledge exchange, networking and community building. Such activities can also be part of what is called social and collaborative learning platforms[33] and are considered to enable LLL. LMSs tend to have limited SNS features as they support administrative functions more effectively than teaching and learning activities [47]. However, as a result of the rapid impact and growth of SNS, more and more SNS features are finding their way into LMSs as the focus is moved from administrative functions to enabling features that support LLL.

This work combines mobile technologies with SNS to create an open-location-based scalable and collaborative learning application that promotes LLL. It is designed using open and/or easily available platforms so it is easily extendable and can be adapted to any other learning system. We create a system with an explore-and-discovery-based learning application that allows the user to locate content based on preferences and location to learn accordingly. Another part of the system also empowers the learner to upload learning content to share with other learners. Our system allows the learner to be not just a content consumer but also a content producer. We enable social learning and collaboration using SNS features so the learner may engage more in the learning process.

Figure 1-2 on the following page is a model of learning that depicts LLL through use of technology. Adapted from [64,68], the model depicts learner centric learning. Technology supports the LLL process by providing engaging environments and tools for learning. The figure then also includes and shows CrowdSMILE's corresponding features that match the model. As may be inferred from the model and the figure, CrowdSMILE was designed to be about allowing the users to engage in social and location-based activities to support their LLL.

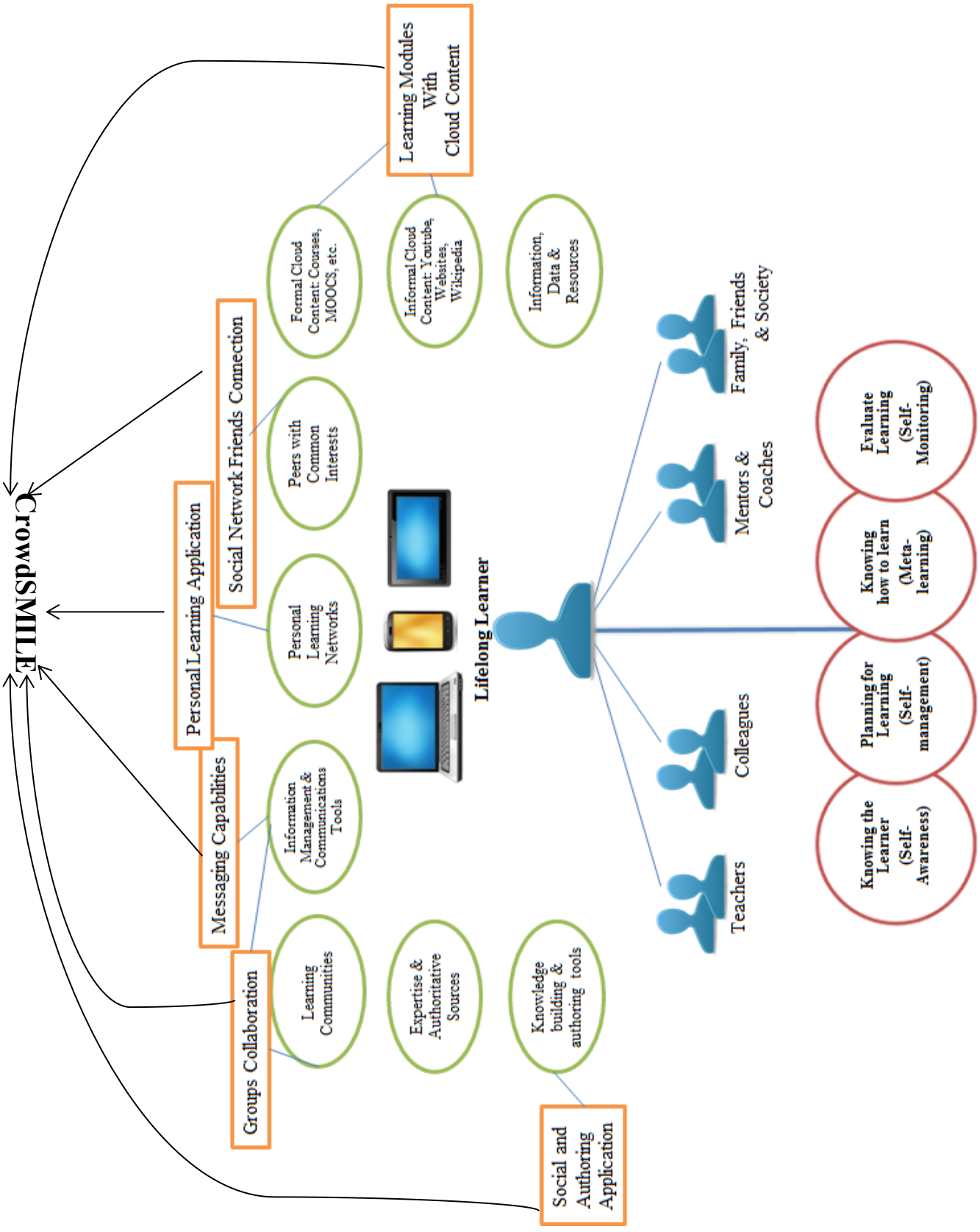

Figure 1-2: Features of E-learning and how CrowdSMILE enables those features

In figure 1-2 above, you can see some features of the CrowdSMILE highlighted in

orange that directly address aspects of the model. Based on that model, we have inferred the ideal requirements of a system that enables true LLL and shown it in figure 1-3 below.

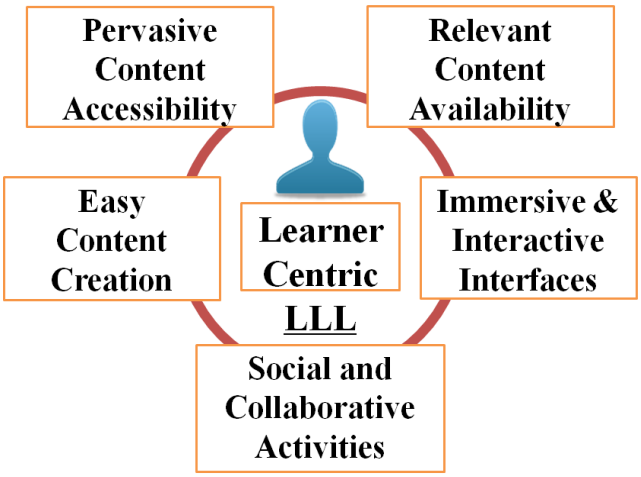

Figure 1-3: Ideal requirements of system that supports LLL

1.2. Motivation

While location-based learning, crowdsourcing, social collaboration, M-learning and E-learning are not new concepts or technologies; and systems which incorporate some of the features of those concepts and technologies exist; we deem that there are not many systems that incorporate all of them together in a combined fashion while providing an open, scalable and easily extendable system. Though they may have systems similar to what we are proposing, we show that our system can solve some of the problems identified with the other systems and also offers more features.

This project has provided us with an opportunity to create an open, scalable, flexible learning system. It incorporates crowdsourcing, SNS, mobile technologies, location-based services and combines them with a mobile augmented reality (MAR) and web based user interface to provide a unique end user learning system. The system does not just cater to content consumption, but also caters to content creation. By using an existing SNS platform, we can leverage the user base for creating new learning content and allow complete social collaboration for content creation and consumption. As such, CrowdSMILE can be a useful tool used in the process of LLL.

1.3. Problem overview and purpose

As discussed earlier, some key requirements of true LLL can be inferred to be mobility, content availability and access, collaboration capability, information and idea

exchange capability, and content authoring capability, etc. The purpose of our work is to provide an innovative, highly scalable and open collaborative platform for learning based on location and social contexts. The system is designed for use especially when on the go, anytime and anywhere, to encourage and enable LLL. We propose to do that by combining mobile technologies with SNS to provide a uniquely integrated system for collaborative learning where users can truly work with each other to create and share content for learning. The learning content is generated for the users of the system by other users of the system, in a truly Crowdsourced fashion.

Various E-learning systems that included features of SNS, mobile technologies and crowdsourcing were studied. While many offered features that were useful, they did not utilize the various technologies to the extent they could have to provide a truly integrated system that met all the identified requirements of LLL.

Some systems

- used mobile platforms but they did not necessarily utilize access to content in the cloud.
- did not allow means for generation of user content using crowdsourcing. Some did not allow any content authoring at all.
- were restrictive in how they allowed content to be presented and only allowed limited formats.
- were limited by their ability to be used in different scenarios and had limited use cases.
- limited to only mobile use while others only desktop use.

1.3.1. Problem scope

The notion of LLL suggests that more learning takes place outside formal environments than within. People may want to learn on the go, at anytime and anywhere. LLL is about being engaged in the learning process. To the best of our knowledge, there exists limited unified tools or systems that can fully engage a learner in support of LLL activities such as choosing and accessing content at will and anywhere, sharing the content, collaborating based on content, building learning communities based on content and of course contributing to content and even authoring new content.

While learners can use various systems to help with their learning, they may not find it convenient to access many different and fragmented systems to fully immerse themselves in the learning process. To further define the problem, we can say:

1) Users may get discouraged for not being able to access relevant learning content at anytime and anywhere. They may thus abandon the learning altogether or not start it in the first place. There is can be a lack of access to content or a lack of access to tools that enable content access.
2) Users may get discouraged and not achieve LLL because of not being able to share, exchange or collaborate based on the learning content.
3) Users may get discouraged from having to access multiple non-integrated systems to take part in LLL activities.

As a result of the above, a user may have less inclination or ability to learn constantly.

1.4. Contribution

To solve the problems defined, our proposal is to create CrowdSMILE, an open, reusable and integrated system that integrates existing technologies and systems to form a Mashup type learning application. Mashup type integration allows reuse of existing systems that are already familiar to the user; thus making it easier for the user to use and learn. Integration also allows leveraging existing technologies and services such as SNS. Using an existing SNS platform allows us to benefit from its existing user base for crowdsourcing based activities such as content generation by the masses, thus solving the problem of content generation. Our contribution entails building an integrated system that supports the various LLL activities by engaging the user in an immersive and integrated learning environment.

To summarize, this work proposes a Crowdsourcing based Social and Mobile Integrated system for Learning by Exploration called CrowdSMILE that enables various activities of LLL.

1.4.1. Key features of contribution:

1) Develop an open, scalable and extendable system by integrating familiar technologies and systems to form CrowdSMILE.
2) Provide LLL functionality and maintain learning context within system making it easier for user to learn.
3) Provide innovative mobile and non-mobile interfaces to support LLL activities.
4) Allow reuse of learning content by allowing content to be exported.

As a result of using CrowdSMILE and enabling Crowdsourcing based content generation, another problem is introduced. The problem is that of showing the most relevant and best content from a possibly large set of content submitted by many learners.

To solve the problem of showing only useful content, we also propose a method for content ranking based on SNS features. The ranking is then used as a metric for evaluating relevancy and quality for content which is then used to decide what to display to the learner.

1.5. Research Methodology

We address the issue of not having a unified system that enables LLL by designing and implementing CrowdSMILE. This work takes a systems approach in approaching the problem. First we review the notion of LLL to understand its requirements. We then identify the requirements of a system that would allow a learner to accomplish LLL. We then assess the requirements of the system that will be needed in order to meet the requirements of LLL. After defining system requirements, we proceed with designing and developing the system. The proposed system is developed based on integration of different technologies, APIs and SDKs to form the end result. Finally, we test the system to see if it has met the requirements identified and report the results of the following evaluations and experiments:

1) Network and Application performance testing on 3G Vs. 4G networks
2) Content Ranking Mechanism evaluation
3) System Usability Test

1.6. Thesis Organization

This thesis is divided into five chapters. Following is a brief description of the remaining chapters:

Chapter 2: In this chapter, we provide background information that led to our integrated system design.

Chapter 3: Related works are introduced, discussed and compared.

Chapter 4: In this chapter, we provide a complete overview and details of the proposed system solution to.

Chapter 5: In this chapter, we provide the results of experiments we conducted to show that our system meets requirements as defined in previous chapter.

Chapter 6: In this chapter, we provide our conclusions and future work discussion.

Chapter 2: Background

This chapter provides a background to various concepts and technologies as related to this research. It provides a good basis for understanding the overall system design and functional role and capability.

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2.1. Background Concepts – Learning, Crowdsourcing and SNS

In this section, we introduce key concepts and theories that serve as the basis and rationale for this work.

2.1.1. Lifelong Learning (LLL)

LLL is the "on-going, self-motivated and voluntary" pursuit of knowledge for either personal or professional reasons [10]. The concept of LLL recognizes that learning does not take place only in formal educational environments but throughout life and in everyday situations. It basically means that learning cannot be characterized as to only take place at a particular time or location. Research and everyone's personal experience can show that as individuals, we learn over time in different situations and activities; and especially outside the formal classroom environment. Because learning can occur at anytime and anywhere, there is always a chance for a social and collaborative element to be present. Individuals may learn from others, they may want to help others solve a problem, they may want to consult and discuss with others and so on. Such social and collaborative work naturally engages the learner more deeply in the learning process and is a key element of LLL.

While LLL can take place at any time, how it happens is largely environment and situation dependent. The environment and situation will be a factor in how and what an individual can learn. Internet enabled technology can provide an environment with tools to access rich learning content. While technology and systems can provide a learning-conducive environment, some of the relevant requirements they must meet to support LLL are [20]:

1) Users must set most of the learning goals, not the system.
2) Systems should support not just individual work and learning, but enable collaborative learning with others. The systems should support the improvement of collective knowledge as well as individual knowledge.
3) Although the learning system itself may have some built-in expertise about a particular topic, users will find most expert knowledge by locating other people who have the

knowledge through social and collaborative channels.

4) The system should be open and allow modification depending on context. The needs of lifelong learners will not be met by closed systems. While this refers to the system itself, for this work, we refer to the requirement of having open and modifiable content within the system. Users must be able to access learning content but also add and modify it.

LLL and systems that enable it, highlight the distributed nature of knowledge, i.e., learners can learn from a computational environment, but, if they desire, they can also contribute to the environment.

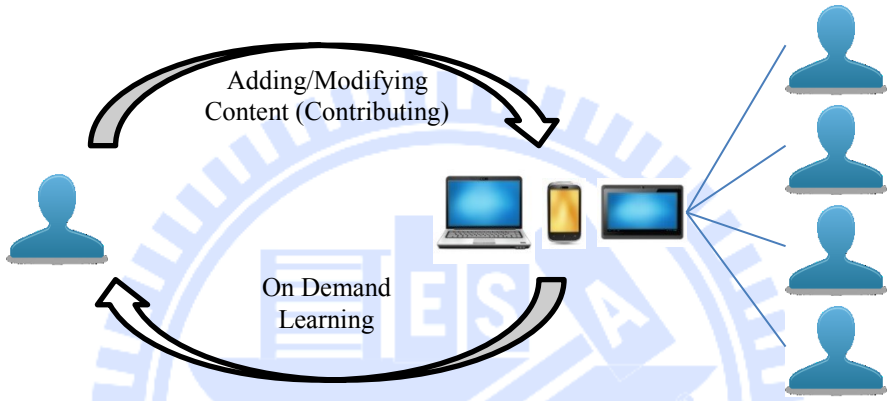


Figure 2-1: Duality of Learning – Content Consumption and Content Creation

Figure 2-1 above (adapted from [20]) illustrates the duality between learning and contributing through use of the system .

To summarize and re-iterate, we can define the ideal requirements of a system that supports LLL as:

1) Supports many users/learners
2) Allows users to set learning goals, thus be personal
3) Has high volume content availability with ability to provides context-relevant content
4) Is highly portable and pervasive (anytime and anywhere content accessibility)
5) Has content authoring and modifying capability
6) Has social and collaborative features to enable users to interact.

2.1.2. E-learning and collaborative learning

E-learning can have a very broad definition and can be defined based on a completely pedagogical point of view. For purposes of this research, we look at E-learning as the use of information and communications technology in education and learning activities and how it is applied to meet some of the pedagogical goals of LLL. Although E-learning was coined

around the year 1998, the concept is much older. In as early as 1960, the University of Illinois conducted a class where students accessed informational resources on computers while listening to lectures [71]. Around the same time as well, Stanford University experimented with using computers to teach math and reading to young children. Between then and now, E-learning has become quite popular and has evolved very much. In present day, most institutes of higher learning use some form of E-learning in respective learning environments.

Many E-learning systems were based on traditional autocratic teaching methods where there is a one way flow of transferring knowledge from teacher/system to student. Over the last decade and recently, E-learning systems have moved towards becoming collaborative learning systems, where they support a shared-development-of-knowledge approach [31] through various collaborative activities. The difference between the two types is illustrated in the figure 2-2 below.

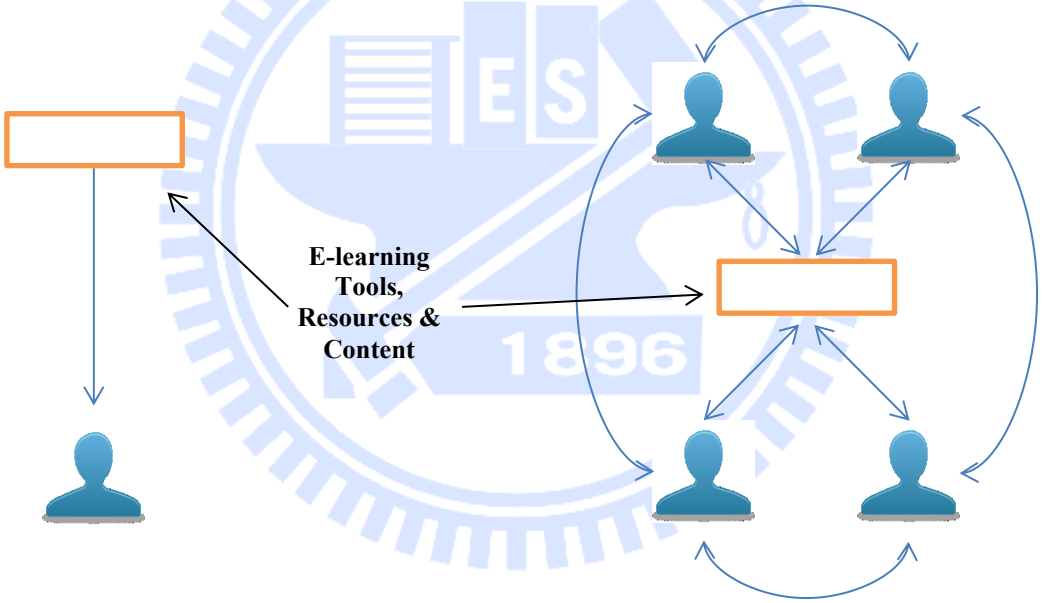


Figure 2-2: Traditional (One-way) E-learning vs. Collaborative (Multi-way) E-learning

One of the goals of E-learning is to enhance learning and teaching by using technology to either provide better access to learning content, to author and publish the learning content or simply to collaborate based on the content. E-learning employs Information and Communications technology (ICT) such as software, servers, desktops, laptops, mobile devices, communication networks, etc. for use as tools of the E-learning environment. Using these tools, the learning environment can provide better content accessibility and easier content authoring mechanisms especially when used with the Internet. Furthermore, ICT tools can also be used to promote a learning environment where everybody

can work with others to build on the knowledge and add value to the content. While such tools and E-learning are used in formal learning environments like classrooms and learning institutions, they can also be used outside in informal or non-formal environments, thereby supporting the notion of LLL.

One of the reasons for the increase of the collaborative nature of E-learning systems is Web 2.0. Web 2.0 refers to Internet based concepts and technology that enables websites that are dynamic, vibrant and interactive and allow users to do more than just retrieve information. Web 2.0 allows for a more interaction-based and participatory access to content on the web where there is a strong emphasis on community and social aspects to the content access and even content creation. Web 2.0 allows users to interact with a website, its content and through it, also with other users, in more ways than before [52]. Web 2.0 has subsequently also had its effect on E-learning systems by making them more participatory and engaging. E-learning systems are now moving towards becoming collaborative learning systems that incorporate many different social based activities to engage the leaner more. Some examples of Web 2.0 applications used in learning are: Wikis, Blogs, Social Networking Sites, Collaborative tagging systems and other mashups that try to combine different social activities into one system [61]. As E-learning becomes more collaborative and engaging, it is also being referred to as Computer based collaborative learning (CBCL), where the focus is clearly on the learning though collaboration.

2.1.3. M-learning

The immobile nature of Desktop PCs has restricted the anytime-anyplace potential of E-learning [6] to when a learner is positioned in front of the PC. While on the move, a learner is not able to access E-learning content and tools. With the ability of wireless internet communications, a mobile device overcomes such a restriction and allows anyplace access to learning content via the mobile device [54]. Mobile Learning or M-learning falls under E-learning but with an emphasis on mobility afforded through mobile technologies, i.e., anytime and anywhere access to learning through use of mobile technologies. In addition to mobility, the fact that a mobile is personal, it affords the user control of the device and as such, over how they learn using the device.

In [6], the authors discuss and identify benefits of mobile connectivity and technologies. Mobile connectivity and technologies empowers the learner to access content

when and wherever they want, i.e., the learner can control the flow of information. It can also provide collaboration through real-time or instant interactivity irrespective of location or time. These benefits can also be applied to learning as they support interactive and real-time environments while providing the user with control of what is accessed for learning. Considering the benefits of mobile connectivity, we can also list some of the benefits of M-learning:

1) Mobility – Anytime –Anywhere access to content
2) Personal nature – Allows personal control and contexts to learning
3) Control of learning – Allows users to control information flow
4) Interactivity – Allows real-time interactive social exchanges with other users

With more than 6 billion mobile subscriptions in the world at the moment and more of those subscriptions gaining access to high speed mobile broadband connections every day [27], the mobile platform is fast becoming the choice platform for accessing cloud content such as rich and high fidelity multimedia. With the proliferation of mobile technologies like smart mobile devices and high speed communication networks like 4G, learners now have access to portable technology that also allows them to access multimedia rich E-learning content from the Cloud at any time and everywhere. Furthermore, mobile devices have become smarter and allow rich software applications to be run on the devices themselves. A quick search on the internet reveals more than a total of 140,000 education categorized applications available on the two most common mobile platforms, IOS and Android [1,3]. Applications can thus be developed that allow various interactive mobile learning activities and when combined with the internet, gain access to learning content from the cloud. Together, mobility and connectivity present an excellent anytime-anywhere platform for supporting LLL.

In [34] the author discusses a FRAME model – Framework for the Rational Analysis of Mobile Education which is depicted in figure 2-3. The model describes M-learning as a process resulting from the convergence of mobile technologies, human learning capabilities and social interaction. This model serves as a useful guide for developing mobile learning systems and environments.

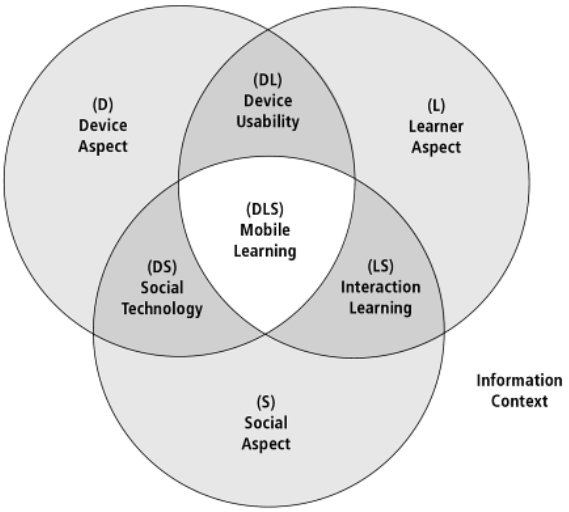


Figure 2-3: Kloone's FRAME model for M-learning

The author discusses that M-learning experiences take place within information contexts. Within the information context, the interaction between learner and information content is mediated through the mobile technology. The Device (D), Learner (L) and Social (S) aspects of learning and M-learning are depicted using the three circles. The intersections show an overlap between areas and show how they converge to form M-learning. The area in the middle, where there is a complete overlap of mobile devices, social interaction and learner aspects, depicts an idea situation for M-learning.

The (D) device aspect refers to the functional and physical characteristics of mobile devices such as portability, user interface, connectivity, input/output capabilities, sensors capabilities, software capabilities etc. Since the mobile device is the bridge between humans and content/technology access, it must be built with sufficient physical and psychological comfort. The (L) learner aspect refers to the learner's motivation, environment, emotions, cognitive abilities, prior knowledge and memories. When designing an M-learning interface, the learner aspects must be taken into account so the interface can be designed appropriately to match the learner capabilities and situation. The (S) social aspect takes into account the social interactions and cooperation. Individuals, within their social contexts, must follow their context's social norms for social exchange of information to be able to successfully collaborate. The M-learning system must be designed according to the expected social settings and environment.

The (DL) Device Usability Interaction refers to elements from both the device and the learner. This section relates to how the devices accommodates for learner to use the device

itself. Examples of such accommodations are: Does it provide an intuitive interface? Does it cater to people with learning disabilities? This in turns affects how easy it is for the learner to use the device to perform the desired functions and tasks and thus to their physical and psychological comfort and in turn their satisfaction with the device. The (DS) Social Technology intersection describes how the device enables communication and collaboration amongst multiple learners and systems. This section focuses on the means, such as network connectivity, SNS collaboration capabilities, etc., that are available for information exchange and collaboration between people with various goals and purposes. The (LS) Learning intersection describes how social interactions promote, enable and enhance learning processes. It focuses on how collaboration through social interactions allows one to extract meaning from multiple social sources. It basically represents a combining of learning and social instructional and learning theories.

DLS – The Mobile Learning process is the final outcome of combining the different aspects described above. It is the result of integrations of the Device, Learner and Social aspects. M-learning provides enhanced collaboration among learners as a result of its mobile and social characteristics.

As can be deduced, the FRAME model has characteristics related to the requirements of LLL such as mobility and social collaboration. We can conclude that by using the FRAME model as a basis for system design, we can create a system that also supports LLL.

2.1.4. Location-based contexts and learning

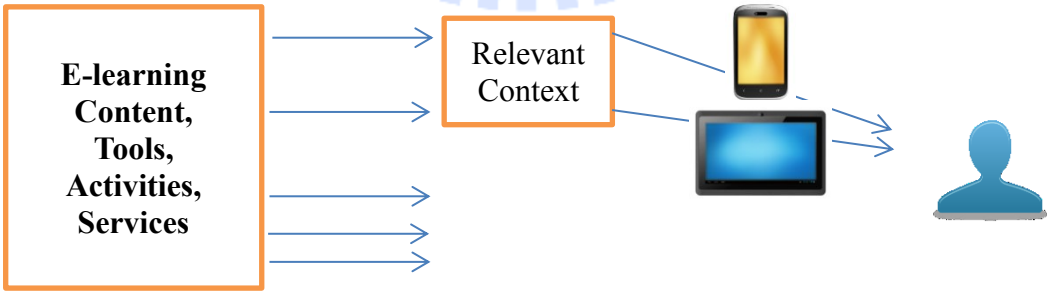


Figure 2-4: Delivering only context relevant Content to the Learner

Informal and LLL takes place in different environments. This places constraints on the learning system to deliver content that is relevant to the learner's current environment and situation. The figure above depicts the nature of having access to content but only delivering content that is relevant to the context. The learning system has to anticipate typical tasks and

scenarios through modelling of different contexts. This holds true especially in mobile environment [66] where environments and learning contexts can change as quickly as the learner moves.

Figure 2-5: Application using Location context to provide relevant content to the user.

Since learning has now become mobile with M-learning, the location has become an important context, both in terms of the learner's physical location and also the opportunities for learning to become location sensitive [8]. In learning, the location of a learner can be used as one of the contexts to provide relevant content and is referred to as Location-based learning. Mobile devices are starting to come equipped with sensors such GPS, RFID, etc. which can capture contexts including location, and this can be used to deliver an experience and content that changes according to the location [5]. Previous research work shows the use of Location-based learning in tour based applications, simulation gaming, field trip applications, etc. where the location is used to identify context and deliver content accordingly.

2.1.5. Exploratory Learning

Exploratory learning is a learning approach where learners are encouraged to explore, experiment, discover and learn on their own [9,58]. Exploratory learning allows the user to engage in explore and discover activities to achieve learning. With reference to this work, we refer to explore and discover type activities using mobile devices, applications and location-based contexts to explore and discover physical locations to learn about them.

2.1.6. Crowdsourcing

According to the Merriam-Webster Dictionary, Crowdsourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community, rather than from traditional employees or

suppliers. [44] The reason for getting a large group to contribute is so that each may, relatively easily, perform a small portion of the task in order to achieve the overall task, goal or objective. In [24], the authors discuss a number of areas and examples of crowdsourcing, showing that crowdsourcing is common and that it can be useful when leveraged to complete tasks.

Crowdsourcing can be considered a type of social collaboration as it allows many people on the internet to come together to work, either directly or indirectly to achieve a bigger common goal. With relation to this work, we look at crowdsourcing to complete content creation and publishing tasks for learning systems. One prime example of an existing and successful execution of crowdsourcing for content generation is Wikipedia. Wikipedia is a free-content encyclopaedia available for everyone to use on the internet. It leverages crowdsourcing to create and edit all its articles and has proven to be very successful. In [67], the authors use similar Crowdsourcing to generate content for a more defined E-learning system.

2.1.7. Social networking services

Figure 2-6: Social networking services, platforms and sites

Social software is software built around the goal of allowing users to communicate and interact with each other in some form or another [63]. SNSs are the fastest growing type of social software [56]. As can be seen from the figure above [41], many SNS sites exist today. An SNS site may allow users to build and maintain social connections or relations among people based on real-life connections, jobs, interests, hobbies, activities or all of the above.

From the SNS user's point of view, the basic idea of an SNS site is to establish an online identity and presence, and to then build an online social network around that identity.

One of the first tasks of users on SNS sites is usually to set up their "Main Page", a web page that will showcase their identity and their activity on the SNS site. Setting up their identity, may also refer to as setting up their SNS site "Profile". After setting up their "Profile", users proceed to start building connections and social networks. Building social networks entails finding connections which is commonly known as finding "friends". The connections may or may not be real-life ones. They can be strictly online-only connections. After finding connections, the SNS sites offer some form of "contact management" to keep a track of all the connections. The social-network building and maintaining task also involves communications and exchanges of messages with connections. SNS sites offer such messaging capabilities either by way of private messages or also by posting not-so-private messages to their connections "Main Pages". "Group pages" such as wikis or blogs also offer a method for a larger number of non-connected SNS users to exchange messages and carry out a discussion.

With the basic building blocks and functions identified earlier, users then proceed to build and maintain their connections, communities, groups and networks. The basic idea of SNSs is to allow online social contact with others in a user friendly and easy to do manner. By allowing multiple users to communicate and exchange message, SNS sites inherently support user interaction and implicitly enable collaboration based activities such as knowledge exchange, networking and community building. Such activities can also be part of what is called social and collaborative learning platforms [33] and also thus support LLL. Research has also suggested that SNSs can be used for learning purposes [42,48,59,60]. Authors in a research study [40] discuss some of the education potential of SNS sites and show that students did claim to use SNS sites for informal learning purposes, albeit that was not their main reason for use of SNS sites.

In [7,16,53] authors also suggest making use of some features within SNS for different content ranking methods. SNS features offer a wealth of data that can be mined and used in various machine learning tasks such as automated ranking of content, sentiment analysis, etc.

2.1.7.1. ***Facebook Social Networking Services (FBSNS)***

Figure 2-7: Facebook, an SNS site

Facebook is a social networking services site and platform that has become one of the most popular means of communication. Launched in 2004, it is presently one of the most popular SNS sites with more than 1 billion active users. Some of the key features and features of FBSNS relevant to this work are:

1) Facebook Profile - This is the online identity of the user on FBSNS. It can contain information about the user such as name, date of birth, home city, school information, list of friends, gender, etc. Once a user signs up for FBSNS, their profile gets populated and created automatically with the information supplied by the user.

2) Friends – Friending is the act of sending another user a friend request on Facebook. Upon the other user's approval, the two users are connected to other and are referred to as Friends. Friends can also be "Unfriended".

3) Wall – FBSNS user's main page, home page or profile space; where user's content is shown. It allows posting of messages by the user for sharing with others as any Friends of the user, can also see the wall of the user. Messages posted on the Wall are known as Wall posts and also "Status Updates". Users may also post messages to Walls of their friends. A user and their friend's may also make comments on the wall post and start a threaded discussion based on the post.

4) News Feed – A feature of the home page that is constantly updated to show activity of a user's friend. Users can see all public activity of their friends in near real time.

5) Like – Described by Facebook as "a way to give positive feedback and connect with things one cares about". Users can like posts, messages, and comments among other things

6) Share – Users often post links or other web content on their walls. Those posts may be "Shared" by their friends. Sharing is basically a form of reposting.

7) Messages and Inbox – Email like messaging facility

8) Groups – A Group can be created by any user and joined by anyone if set to open. It basically offers a separate space/page for the group where they can post content.

The FBSNS can be accessed across both desktop and mobile platforms. While it is a web based app and can be accessed via mobile browsers as well, mobile devices have native client apps to access the FBSNS.

2.2. Background Technologies

As mentioned previously, this work is a Mashup based integration of various systems and component to achieve the desired end result. In this section, we discuss some of the main technologies that we use and implement in this work.

2.2.1. Facebook SNS Platform for Developers

The Facebook Platform is a software environment provided by the social networking service Facebook for third-party developers to create their own applications and services that access data in Facebook [32]. "Facebook offers tools, services and SDKs to developers who want to integrate social experiences into their applications. Whether or not the application is on iOS, Android, mobile web or desktop web, Facebook offers tools to make integration easy." [17]. Table 2-1 shows the API/SDKs available for different environments. The Facebook platform offers various tools, services and SDKs to leverage their social platform within 3rd party applications on different platforms such as Web, iOS and Android. By using the various tools, services and SDKs, one can access much of the social content and functionality available within the platform and use it to make their 3rd party application social-enabled.

Table 2-1: Official Facebook API/SDKs Available

Platform	API/SDK
Web	JavaScript, PHP
Mobile	iOS, Android

As can be seen in table 2-2 below, additional unofficial SDKs exist and have been contributed by the developer community.

Table 2-2: Unofficial Facebook API/SDKs Available

Platform	API/SDK

Web	Flash ActionScript, Ruby NODE.js, c#

High Level Facebook Platform Components [15,17,19] include: (certain parts retrieved verbatim from documentation available on the FB developer site)

1) Graph API: The Graph API is the core of Facebook Platform. It is a simple HTTP-based API that gives access to the Facebook social graph, uniformly representing objects in the graph and the connections between them. Most other APIs at Facebook are based on the Graph API. The Graph API is the primary way to get data in and out of Facebook's social graph. It's a low-level HTTP-based API that you can use to query data, post new stories, upload photos and a variety of other tasks that an app might need to do.
   The API works using HTTP Get, Post, Delete methods. After making the request to the server using one of the methods above, the server responds with appropriate data, usually in JSON format.

```
GET /774635482?fields=id%2Cname HTTP/1.1
Host: graph.facebook.com
Connection: close

HTTP/1.1 200 OK
Content-Type: text/javascript; charset=UTF-8
Expires: Sat, 01 Jan 2000 00:00:00 GMT
Date: Thu, 11 Oct 2012 17:28:02 GMT
Connection: close
Content-Length: 48

{"id":"774635482","name":"Christopher Blizzard"}
```

Figure 2-8: Example of Graph API request and data returned

In the figure 2-8 above, we can see that after making the request using HTTP GET, the server returns JSON data along with the HTTP headers. In the figure proceeding shows some of the returned JSON data after requesting for user information using the Graph API.

2) Social plugins: Features such as the Like Button, Recommendations, and Activity Feed – enable developers to provide social experiences to their users with just a few lines of HTML.

Figure 2-9: Login/Authentication on iOS, Android and Web

3) Authentication: Facebook authentication enables developers' applications to interact with the Graph API on behalf of Facebook users, and it provides a single-sign on mechanism across web, mobile, and desktop apps. Figure 2-9 shows the different login screens.

4) Open Graph protocol: The Open Graph protocol enables developers to integrate their pages into the social graph. These pages gain the functionality of other graph objects including profile links and stream updates for connected users.

5) Iframes: Facebook uses HTML iframes to allow third-party developers to create applications that are hosted separately from Facebook, but operate within a Facebook session and accessed through a user's profile. Applications that work within the iframe are also known as Canvas applications. Canvas applications can be built using any language that supports web programming. Because canvas applications run inside an iframe, they have the appearance of running directly of the Facebook site.

2.2.2. Android Mobile Platform

Android is the world's most popular mobile platform [2]. Released by Google in 2007, it is a Linux based platform that offers a complete software stack and can be run on a wide variety of mobile devices from different vendors. Because Android is open source, it is quite popular as it can be easily extended to incorporate new and cutting edge features as they emerge.

Android delivers a complete set of software for mobile devices: an operating system, middleware and key mobile applications [68]. It provides a wide range of useful libraries (written in C/C++) and tools that can be used to rapidly develop rich featured applications. The libraries expose APIs which are used by applications. Applications on Android are built using a customized version of the Java programming language.

The following figure shows the architecture stack of Android. The Application framework, as can be seen, is very modularized and its components are designed for easy reuse by developers. Android applications run in Dalvik, a customized Java virtual machine that is optimized for low-resource environment. The actual code for applications are written in Java but are translated to Dalvik code and run in Dalvik.

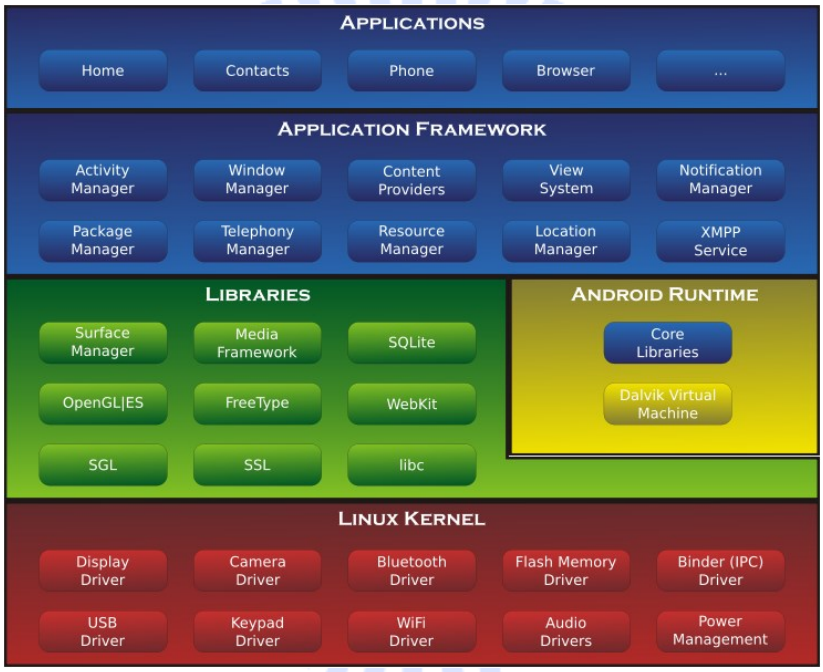


Figure 2-10: Android Platform Architecture

One of the key features of Android is the development ecosystem. A rich development environment is available: SDK, emulators, debugging tools, memory and performance profiling tools are all part of it. The SDK supports Linux, Windows and Mac platforms for development of applications. Android is considered to be secure, lightweight and effective OS.

2.2.3. Mobile Augmented Reality (MAR)

Augmented Reality (AR) is not a new concept and has been discussed in detail since 1997, but has just recently started to gain acceptance and use due to advanced processing and graphics capabilities of computing devices. AR is where the view of the real world is

augmented to enhance the user's sensory perception and information about the real world. An AR environment is accessed through a computing device whereby the real world view is augmented by sound, text, video, other data/information and additional interface interactions as a result of using AR with the device [4]. An example of using AR would be using a mobile device to record a video of a well-known landmark and while recording, information about the landmark would be super imposed automatically on the recording to provide the user with the information about the landmark, thus providing the user with additional information that would have not been available as easily/naturally without AR. While AR has many applications on fixed computing devices, with high speed mobile networks, cloud availability and high processing power in mobile devices, Mobile Augmented Reality (MAR) is now gaining popularity and has many applications such as gaming, navigation, training, etc. [57]. Figure 2-11 is an example of a MAR application which shows a live camera view of the environment with overlaid content retrieved from the internet.

Figure 2-11: MAR Application with augmented content from Internet

Figure 2-12 shows a MAR based tourism application [14].

Figure 2-12: A MAR Application with augmented information overlay

MAR also provides a tremendous opportunity to enhance M-learning by providing a very natural and intuitive method for accessing high quality information using a mobile device. MAR based exploratory learning activities such as field trips, tours and simulated games can use location-based contexts to enhance the learning environment and provide relevant content accordingly. In [36] authors propose a design for a MAR based system for engineering education. In [72], authors discuss a guide based application and make use of MAR in a museum environment. Many other published works also showcase the use of MAR in E-learning systems [12,13,70].

2.2.4. Cloud Computing

Cloud computing is the notion of providing computing services and hardware as a utility, in a request-and-use-as-you-need model. It is a model for providing ubiquitous, on-demand access via networks to a shared pool of computing resources such as other networks, servers, storage, applications and services [43]. Some essential characteristics of Cloud computing are:

1) On-demand self-service: A user can unilaterally request for and provision additional computing capabilities when needed without requiring human interaction from the service provider.
2) Broad network access: Cloud computing resources are available over the network and can be accessed by using standardized mechanisms used by platforms such as mobile phones, laptops, desktops, etc.
3) Resource pooling: The provider's computing resources are pooled to serve multiple users using a multi-tenant model. The recourses are allocated dynamically according to consumer demand. This allows leveraging of a finite set of computing resources to seem to be infinite, as users only request for additional resources when needed and release those resources when not needed.
4) Rapid elasticity: Capabilities and resources can be rapidly and elastically provisioned and in some cases, to automatically scale out when no longer required. Lik**e resource pooling, this gives the customer the impression of infinite resources available for use.
5) Measured service: Cloud systems automatically control and optimize resources usage by ensuring metering capabilities at some level of abstraction appropriate to the type of service. E.g.: Storage space used, bandwidth used, # of user accounts, # of IP addresses, etc.

Cloud computing can be offered as one of three types of services:

1) Cloud SaaS – Software as a Service – This type offers applications running in the provider's cloud infrastructure as service to the customer. The applications are accessible from various client devices through thin client interfaces like a web browser or remote desktop clients. The consumer does not manage or control any underlying infrastructure to run the applications. They simple have end user access to the application for use. E.g. Web based Email services
2) Cloud PaaS – Platform as a Service – This type offers a platform to the customer so that they may deploy their own or acquired applications on the provider's cloud infrastructure. The consumer does not manage or control any underlying infrastructure to run the applications but they do have the ability to control their application and possibly some environment settings.

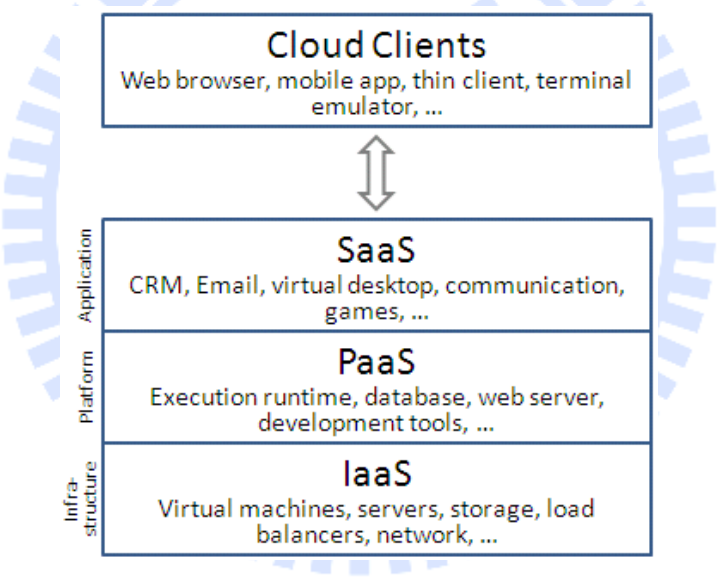


Figure 2-13: Cloud Computing Service models as layers

3) Cloud IaaS – Infrastructure as a Service – This type allows the customer to control and provision the underlying infrastructure such as networks, storage, processing capabilities, memory, etc. on their own to be able to deploy and run arbitrary software which can include operating systems and applications.

2.2.5. Web 2.0

Web 2.0 refers to web concepts and technology that enables websites to be more interaction-based and provide more participatory access to content on the web. The term was coined in

1999 by Darcy DiNucci and was popularized Tim O'Reilly. It emphasises on community and social aspects to the content access and even content creation. Web 2.0 allows users to interact with a website, its content and through it, also with other users, in more ways than before [52]. It has forced the creation of new tools that allows websites to have more interactive and rich user interfaces that promote social collaboration.

Web 2.0 allows building of virtual applications on top of existing applications for rapid deployment. It allows reuse of modular components and frameworks to create Mashups and integrated systems. Web 2.0 is about sharing, communicating and facilitating community, be it to share code, content or ideas [45].

Figure 2-14: A Tag cloud presenting Web 2.0 themes

Table 2-3: Some relevant tools that enable characteristics of Web 2.0

jQuery write less, do more. jQuery mobile framework. jQuery user interface	jQuery, jQuery Mobile and jQuery UI are a set of open source, multi-browser, lightweight JavaScript frameworks designed to make client-side scripting of HTML much simpler and easier. They are the most popular JavaScript libraries in use today. The modular approach to the jQuery library allows the creation of powerful dynamic web pages and web applications. It allows for creation of rich-user-interface based websites as per Web 2.0s concepts [29].
Google maps	Google Maps has a wide array of APIs that let you embed the robust functionality and everyday usefulness of Google Maps into your own website and applications, and overlay your own data on top of them [22].

From a learning point of view, Web 2.0 will allow the same characteristics of itself to be embedded in learning systems that are designed with the Web 2.0 concept. If Web 2.0 systems are more social, collaborative, the same will be for learning systems based on Web 2.0.

2.2.6. SCORM

Sharable Content Object Reference Model is a collection of standards for web-based E-learning. SCORM is a specification of the Advanced Distributed Learning (ADL) Initiative, which comes out of the Office of the United States Secretary of Defence. It is composed of three sub specifications:

1) Content Packaging – specifies how learning content is packaged and described. It is XML based.
2) Run Time Section – The section that specifies how the package content should be launched. It communicates with LMSs.
3) Sequencing – This section specifies how the learner can navigate between different SCOs and parts of SCOs. It is a set of rules and is also XML based.

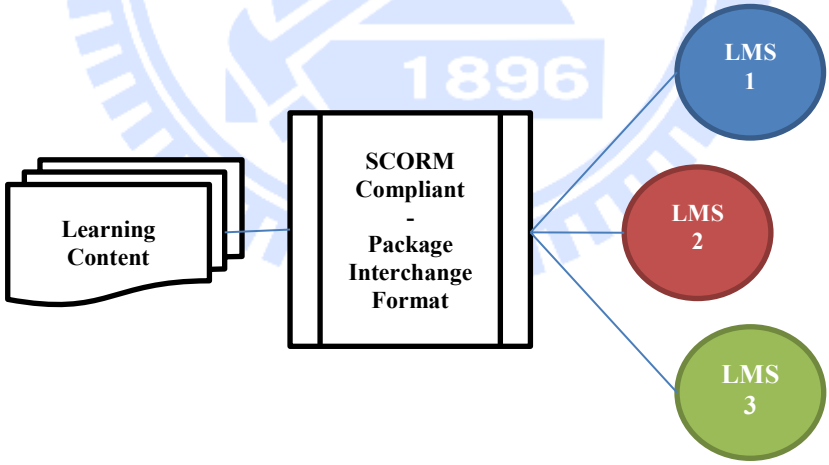


Figure 2-15: PIF files being created and reused in different SCORM compliant LMSs

In order to allow reuse of learning content, SCORM defines how content may be packaged into a transferable ZIP file called "Package Interchange Format (PIF)" so that the content may be used on other compliant learning management systems as shown in figure 2-15. The PIF must contain an XML file, referred to as the "manifest file" at its root. The manifest file contains all information about the learning content. The manifest divides the course into one or more parts called SCOs. It also contains information about how to launch

each SCO. It may also contain metadata that describes the course and its parts. LMSs refer to this file to access and deliver the learning content. This is referred to as content packaging. This content packaging allows reuse of learning materials, thus saving time and reducing content generation costs.

2.2.7. 4G

4G is the fourth generation of mobile phone communication standards as defined by the International Telecommunications Union. 4G systems provide high speed mobile broadband and low latency mobile phone networks. The peak speed requirements as set by the standards are 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility. Candidates of 4G networks are 3Gpp-LTE/LTE-Advanced and IEEE 802.16w/ (WiMAX1/ WiMAX2).

Due to their large bandwidth, high speed and low latency, there are many applications for use of such networks, like E-learning, MAR and other cloud based services. [38].

Chapter 3: Related Work

This chapter reviews related work and discusses key features of the related work as relevant to CrowdSMILE. It provides a comparison of all the systems and key functionality being reviewed.

CrowdLearn: Crowdsourcing the creation of Highly-structured E-learning Content [67]

CrowdLearn is a concept that attempts to tackle the problem of creating structured E-learning modules by leveraging Crowdsourcing content creation. They make use of their own application called SlideWiki in an attempt to showcase the CrowdLearn concept. Through their application, SlideWiki, they provide a social interface for structured content creation. The results of content authoring by users in the system are SCORM compliant learning objects that can be reused in other systems.

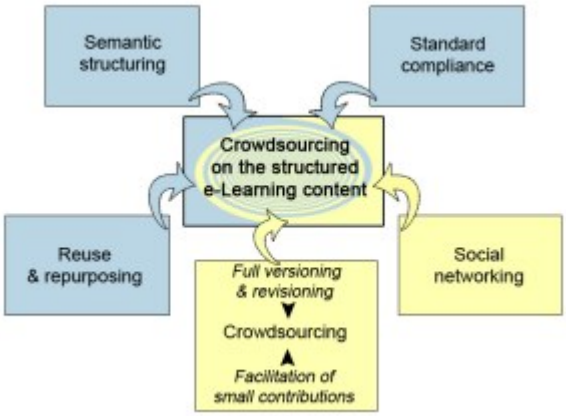


Figure 3-1: CrowdLearn Crowdsourcing Concept

The author's main focus is more on the structured content creation. They do offer limited social activities in the form of discussion about learning material. Their application SlideWiki allows creation of original E-learning content such as presentations, slides, diagrams and self-assessment tests, however, it seems to be limited to those formats [67].

While their system does offer social and collaborative functionality, it is limited or lacking in the following:

1) Content creation formats are rigid and limited. Only allows certain types of content to be created.
2) Content presentation formats are limited.

3) No deep integration of existing SNS platforms for leveraging existing platforms and user base.
4) Do not address LLL requirement of mobility and anytime-anywhere learning.
5) It does not seem to be scalable to thousands of users such as those on SNS sites.

Game-Based Mobile Learning System for Campus on Android Platform [69]

The above referenced work creates a client-server type system featuring a mobile client that implements location-based activities and a server that provides the learning content based on different contexts. Students use a mobile application with a Virtual Reality based 2D map for navigating around campus to perform various learning activities and retrieve learning content from the server. The 2D map is pre-populated and assumed to be based on GIS surveys conducted during system development or prior to use by end users.

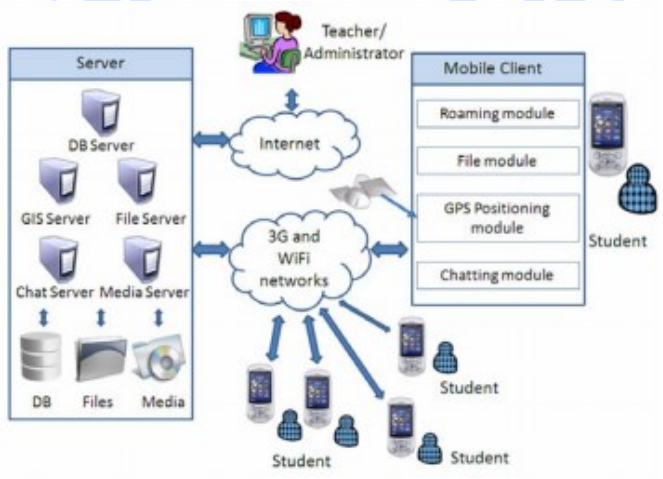


Figure 3-2: Client/Server architecture of Game based mobile learning system

Learning content is added to the system by teacher and senior users in the form of tasks that needed to be completed. The location of user is used in determining when a task is appropriate or not. Their system allows multiple users to perform tasks together and does engage the user socially.

While their system does offer some social and collaborative functionality and does support LLL, it is limited or lacking in the following:

1) Very defined environment for use with no scope for expansion and addition of contexts.
2) Use cases and scenarios limited to within context of school due to mapping requirements.
3) Limited content sources as confined to content created by teachers and senior students.
4) Do not leverage any Crowdsourcing for content creation.

5) Focuses more on content consumption than content creation.
6) No deep integration of existing SNS platforms for leveraging existing platforms and user base.
7) It does not seem to be scalable to thousands of users such as those on SNS sites.
8) Does not allow content reuse.

An Integrated GPS-supported Outdoor Exploratory Educational System—EagleEye [28]

"EagleEye is an integrated GPS-supported educational system for supporting students and teachers respectively in pursuing and facilitating exploratory learning in outdoor fieldtrip activities." The system provides a discover-and-learn type of location-based application via mobile devices for use in field trip type learning activities. The learning activity is focussed on this exploratory based learning environment where students are free to tour around a location and learn as they explore the location. This system addresses the need of creating a more interactive learning activity via use of mobile technologies and encourages LLL.

The system provides:

1) Authoring tool to create content and publish to server.
2) Repository server to store learning content.
3) Exploratory platform for use during the field trip type activity.
4) Teacher console to track student progress.

The system allows for a teacher to create content and publish to the repository server. The students then connect to the repository server and download the content prior to the field trip. What may not be apparent is that this process is a wired process, as in it requires physical connection between the authoring tool and the repository server and likewise between the exploratory platform and the repository server during the upload and download process. This is an offline system.

The exploratory tool however, does offer a user friendly interface in the form of a rudimentary augmented reality interface. Users see a map with hotspots highlighted as they approach the hotspots physically. The system uses GPS sensors to detect user location.

Their system offers limited social and collaborative functionality, although, it does

support LLL. It is however limited or lacking in the following:

1) Does not leverage mobile platform for online access to content.
2) Does not enable social and collaboration to the extent that LLL requires. Is very limited.
3) System not scalable and not practical as it requires physical wired connection to be made to download/upload content.
4) Does not leverage Crowdsourcing or any SNS features.

Location-based Guided Tour M-learning [25]

In this work, a location-based (LBS) M-learning system was setup and tested. The aim was to demonstrate the usability of LBS M-learning application.

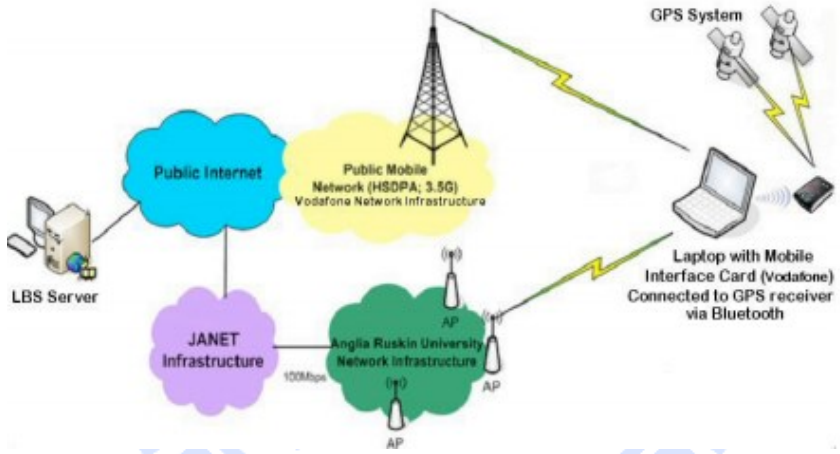


Figure 3-3: System Architecture of Location-based Guided Tour M-learning

This system was not designed to leverage SNS or Crowdsourcing. It was merely designed to provide one way access to content via mobile devices. As such we can say that it is limited or lacking in the following:

1) Very limited enablement of LLL activities. The work only discusses consumption and not creation of content.
2) No SNS integration.
3) Does not address reuse of learning content.
4) Not usable as a system in present state of design

Even though this system is lacking, it is included in this section as it uses a similar concept to that of what we propose in our system design for one component of our system.

Other Systems

Some other systems were also reviewed and were found to not meet the requirements of LLL within one unified system. Below is a comparison matrix of the different related work and systems reviewed and the features they offer as compared to CrowdSMILE.

3.1. Feature Comparison Matrix

Table 3-1: Matrix comparing related work with CrowdSMILE

Systems Comparison Matrix **Legend** **✓: Supported** **X: Not Supported** **P: Partially Supported**	**SNS Integration with Social and Collaborative Activities**	**Crowdsourced Content Publishing and Access**	**Multiple Content and Presentation Formats**	**Content Reusability**	**Mobile and Desktop Applications**	**Access to Cloud Based Content**
CrowdSMILE	✓	✓	✓	✓	✓	✓
CrowdLearn [67]	✓	✓	P	✓	P	P
Android based Campus Learning Game [69]	X	X	X	X	P	X
EagleEye Exploratory Platform [28]	X	X	X	X	P	X
Location-based Tour M-Learning [25]	X	X	X	X	P	X
Learning Management Systems [26,46]	P	X	✓	✓	P	✓
Facebook Groups [18]	✓	✓	✓	X	X	✓

Chapter 4: System Design and Implementation

This chapter discusses the requirements, use cases and overall architecture of the system according to the problems, solutions and rationale discussed in previous chapters.

Given that providing and accessing relevant content can be a problem, our system uses a Location-based context as a basis to organize and provide access to learning content. We use Social, Mobile and Web 2.0 tools and technologies to create a modular system that is built to be scalable and easily extendable.

4.1. System Definition

CrowdSMILE is a Crowdsourcing based Social and Mobile Integrated system for Learning by Exploration. It is a unified, location-based collaborative learning system that promotes LLL. It allows learners to:

- Access location-based learning content at anytime and anywhere
- Publish/author/share relevant learning content by means of immersive interfaces and social and collaborative activities.

4.2. System Usage Scenarios

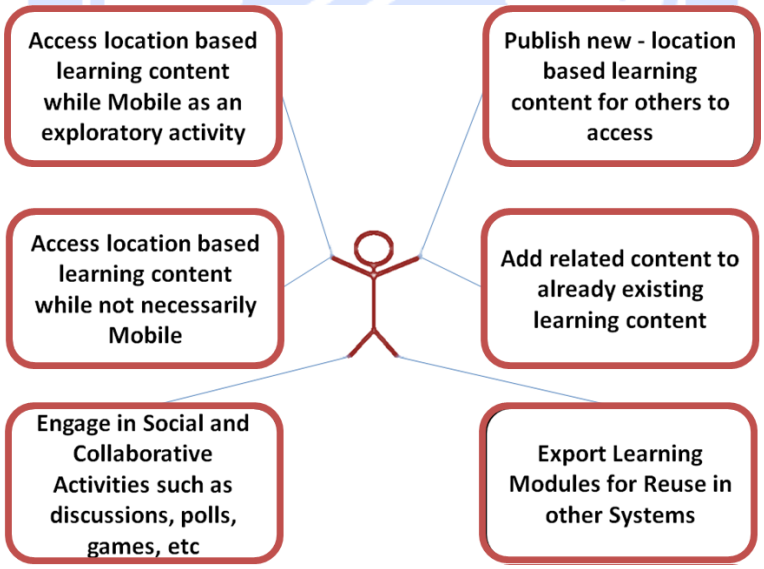


Table 4-1: System Usage Scenarios

Based on the system definition, we can expect the usage scenarios to be as depicted above. (1) Learners will want to access relevant location-based content that has already been published while being mobile and also when not so mobile. Furthermore, (2) learners will want to add to the learning experience of others in a collaborative fashion. They may want to publish new location-based learning content that can be accessed by others or they may

simply want to add related content to already existing content. (3) They may also want to engage in social and collaborative activities such as group discussions, polls, games, etc. with the content topic as the basis of such activity. (4) Learners will want to export content form this system for use in other learning systems.

4.3. System Requirements

Based on the scenarios defined above, the system must

1) Provide a mobile and pervasive interface with means to access relevant location-based learning content through outdoor exploration based activities.
2) Provide a non-mobile interface with means to access relevant location-based learning content.
3) Provide a social and collaborative environment that encourages interaction, exchange and learning as per the requirements of LLL.
4) Provide a means for content publishing, authoring and export.

In addition, to the above, we specify the following requirements to make the system more functional

1) Provide real-time and interactive access to content where possible.
2) Provide a system that is scalable to 1000s of users.
3) Provide a system that allows for reuse of learning content.

4.4. System Overview

Given that the system caters to location-based learning, we must first model what location-based learning is within the context of this system.

4.4.1. Learning Content Data Model

Learning content can refer to

1) A General broad topic of learning,
2) A more specific and narrower topic of learning that has a location-based context and falls under the first broader topic of learning or
3) The actual learning content itself that is directly related to the more specific topic, such as video, audio, text, etc. about the specific topic and that which available in different formats and presentations.

Given that this system is a location-based system; all specific learning content will have some location-based context attached to it. Given that, we model the learning content as follows:

1) We firstly associate learning content with a broad topic of our choosing. The topic can be anything the publisher wishes to author learning content about. We define this as the Mission of learning. The topic for learning is thus also the Mission of learning. For example, if we wanted to publish learning content about "National Chiao Tung University", then we define that to become the "Mission" of learning. If we wanted to publish learning content about "Science Parks in Taiwan", then that would be another Mission of learning. Within the system, we can have many such Missions of learning that can be accessed by the learners. The Missions pertain to real-life topics and interests that a learner would possibly want to learn about.

2) Secondly, within the Mission of learning, we have more specific location-based learning objectives which must obviously be related to the learning Mission. For example in relation to our Mission "National Chiao Tung University", one can publish content about the "Computer Science Department". This then becomes the location-based objective for learning. We refer to this as the learning Quest within the Learning Mission. Considering our second mission, "Science Parks in Taiwan", we can specify the learning Quest to be "The Hsinchu Science Park", which is a more specific, location-based learning objective.

3) Finally, each learning Quest will have Learning Objects, which are the actual learning content and learning tasks that will be accessed. Learning objects are directly related to the learning Quest. Learning Objects can be a task to watch a video, audio, etc. about the specific learning Quest and is the actual learning activity.

A learning Mission may have one or more learning Quests. A learning Quest may have one or more Learning Objects. The idea of a Mission is that it is a broader topic of learning and may have a wide location-based context or none at all. The idea of a Quest is that it is a more specific subject of learning and does have a specific location-based context. The Quest then contains the actual learning content such as videos, audios, text, etc. in the form of Learning Objects.

Together, they form a learning content hierarchy model for use in this system which

can be modelled as follows:

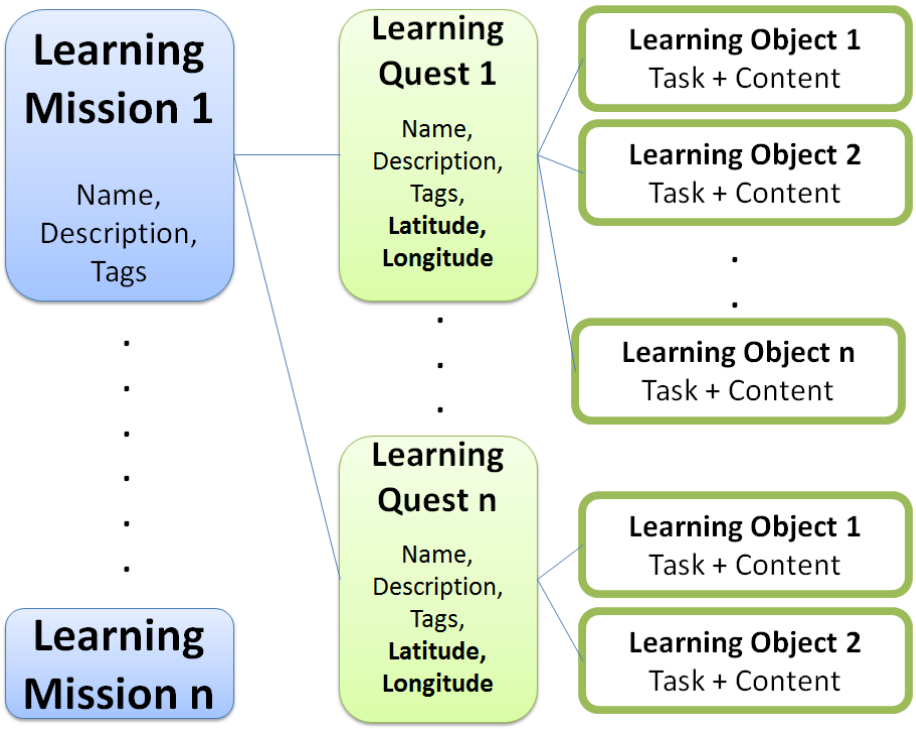


Figure 4-1: Learning Content Data Model

To summarize, a broad learning topic is defined as a Learning Mission. It can be compared to a Course. The broad learning topics will have more specific learning objectives which will location-based. The specific topics are referred to as Learning Quests. These can be compared to specific chapters within a course. The Learning Quest is what will have the actual learning materials related to it and those are referred to as Learning Objects. This can be compared to each page of a chapter. (**Page ~ Chapter ~ Course = Learning Object ~ Quest ~ Mission).** Another representation of the model is shown below in figure 4-2.

> **Learning Mission 1** ..... > **Learning Mission n**

- *Learning Quest 1*
  - Learning Object 1
  - Learning Object 2
  - -
  - Learning Object n
- *Learning Quest 2*
  - Learning Object 1
- *Learning Quest n*
  - Learning Object 1

- *Learning Quest 1*
  - Learning Object 1
  - Learning Object 2
- *Learning Quest 2*
  - Learning Object 1
  - Learning Object 2
- *Learning Quest n*
  - Learning Object 1
  - Learning Object 2

Figure 4-2: Representation of Learning Content Data Model showing n Missions

4.5. System Architecture and Design

4.5.1. Main Components and Functionality

We design our system according to Kloone's FRAME model and considering the usage scenarios identified in the previous section. The system consists of 3 main components that integrate with 2 external components. We define and develop the following the components (1) CrowdSMILE Server, (2) Social Publisher Client Application and (3) POI Explorer Client Application.

Those three components then integrate with the (1) Facebook SNS platform to use the existing social functionalities available. We leverage and make use of Facebook's messaging, groups, discussions, contact management and other social features along with its SDK for 3rd party applications. Finally, the client applications also connect with the (2) external Content hosting servers for the actual learning content. Our system does not store any content. It simply stores meta-data and links about the content allowing it to be scalable and linking to virtually unlimited content without having to worry about storage.

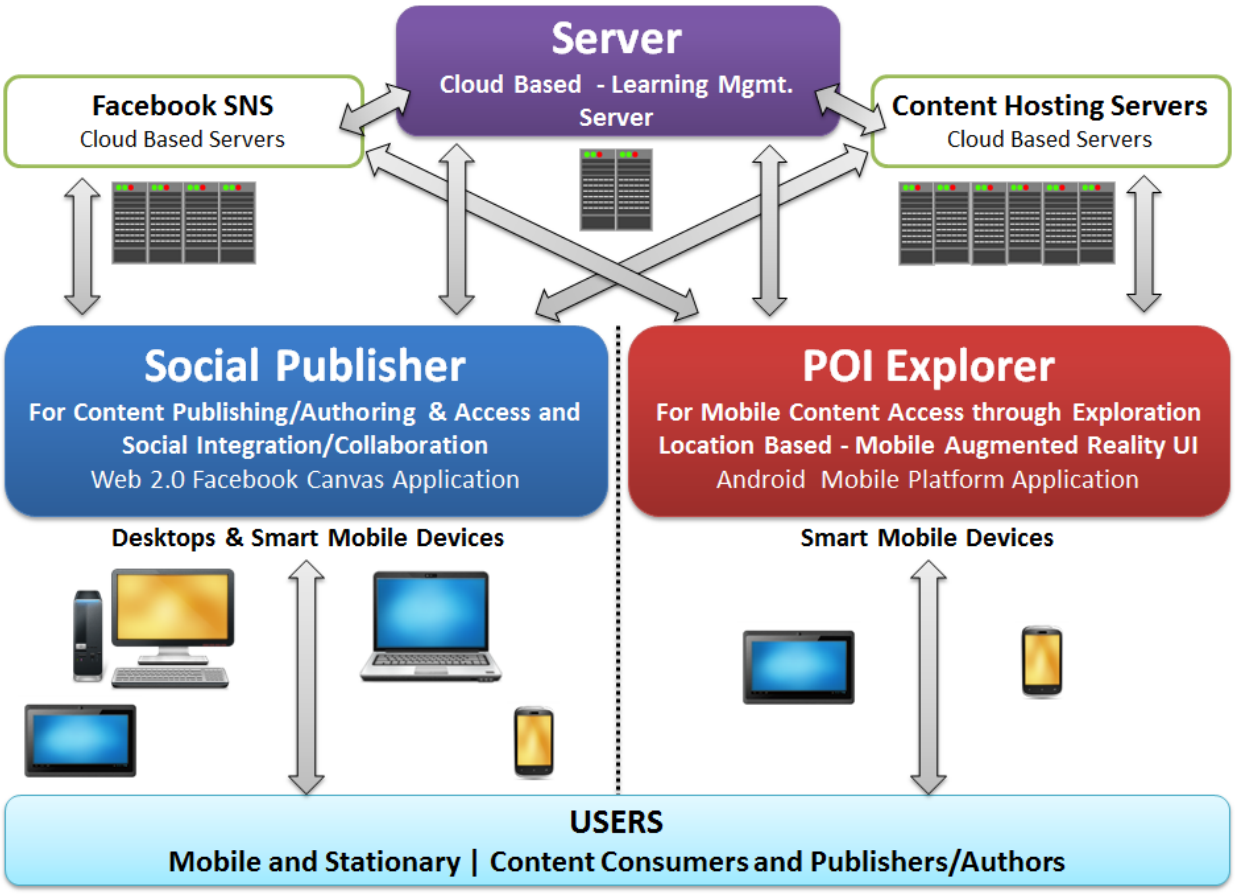


Figure 4-3: Overall CrowdSMILE System Architecture and Data/Control Flows

4.5.1.1. ***The CrowdSMILE Server***

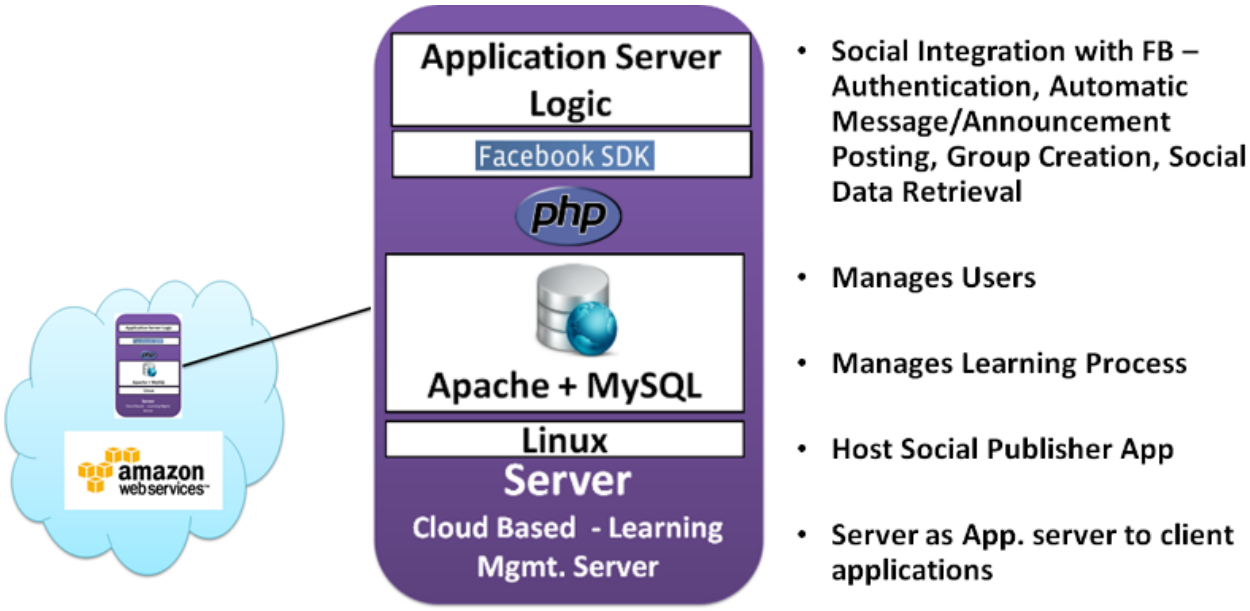


Figure 4-4: Server Architecture Details and Functions

The CrowdSMILE server is hosted in the Amazon Web Services cloud to leverage Cloud Computing. Given that it is a Cloud based application server, it can easily scale to support a large number of users. The server itself is a LAMP based server that uses Facebook's SDK to integrate with the Facebook platform and perform the necessary SNS integrations. It hosts various web services that are accessed by the Social Publisher and Explorer. Some of the main functions of the server are:

1) Provide core functionality as application server for the CrowdSMILE system.
2) Integrate with FBSNS to provide social and collaborative functionality such as wall posts, group posts, group creation, friend's information retrieval etc.
3) Manage users of the system in coordination with the Facebook platform by leveraging Facebook platform's login, authentication and single sign on functionality.
4) Manage learning process and learning content – keep track of user's progress in learning, add, delete and publish Learning content as submitted by users of the system.
5) Host social publishing web application and serve application to web clients as needed.
6) Provide the means for creation of SCORM PIFs and exporting them to allow content reusability.

4.5.1.2. ***The CrowdSMILE Social Publisher***

Figure 4-5: Social Publisher Architecture Details and Functions

The CrowdSMILE Social Publisher is a Web 2.0 based Facebook Canvas Application. It is a dynamic web based application that uses Web 2.0 technologies like HTML, JavaScript, jQuery, Google Maps and the Facebook SDK to provide an intuitive user interface for creating and publishing learning content and also accessing learning content. Because it is a Facebook Canvas application, it opens within an iFrame within the user's current Facebook session and appears to the user to be running within the Facebook site even though the website is actually hosted on the CrowdSMILE server. It provides a Social context to learning because of its integration with Facebook. Its main functions are:

1) Provide its core function which is to provide a non-mobile web UI to the learner to perform learning activities. It communicates with the Server and makes requests via web services to perform relevant actions and transactions with the server.
2) Perform Authentication and Registration of users by leveraging Facebook platform's Login, Authentication and single sign on functionality and communicating the CrowdSMILE Server.

Provide a client application and UI where learners can

3) browse through existing and available Missions.
4) author and publish their learning content.
5) add new learning content to existing Missions.
6) Provide a Social interface to the non-mobile learning aspect of the system to engage

users in the learning environment.

7) Provide an interface to access the means for creation of SCORM PIFs and exporting them to allow content reusability.

4.5.1.3. *The CrowdSMILE Explorer*

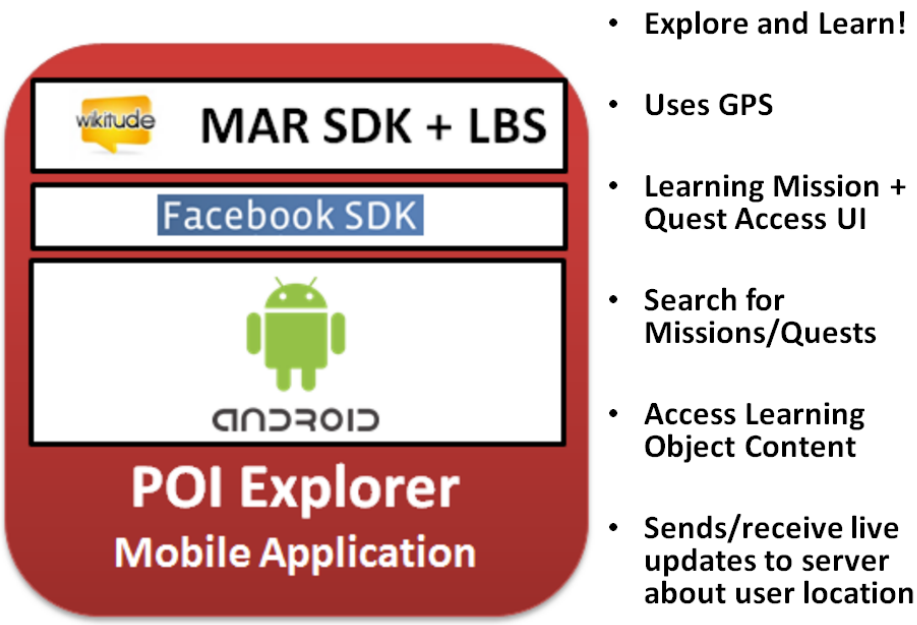


Figure 4-6: Explorer Architecture

The CrowdSMILE Explorer is an Android platform based outdoor mobile application. The application is an explore-and-discover type application and its main function is to allow the user to explore a physical environment, find Missions and access their learning content. It requires and encourages physical activity by having the user physically visit the different Points of Interests (POIs). It leverages Location-based services via GPS to provide a location-based context to the learning process. The application uses Wikitude SDK to provide a real time and interactive Mobile Augmented Reality UI that engages the user in the learning process. Its main functions are:

1) Provide its core function which is to provide a MAR UI to allow users to find and access Mission learning content.
2) Perform Authentication and Registration of users by leveraging Facebook platform's Login, Authentication and single sign on functionality and communicating the CrowdSMILE Server.
3) Provide a UI to learners to browse through existing and available Missions
4) Provide a Client app and UI for learners to add new learning content to existing Missions.

4.5.2. Component Integration

The 3 main components of the CrowdSMILE system integrate with each other via standard web based services, namely using the HTTP Secure protocol. Likewise, the main components also use HTTPS based APIs and SDKs to communicate with the external components.

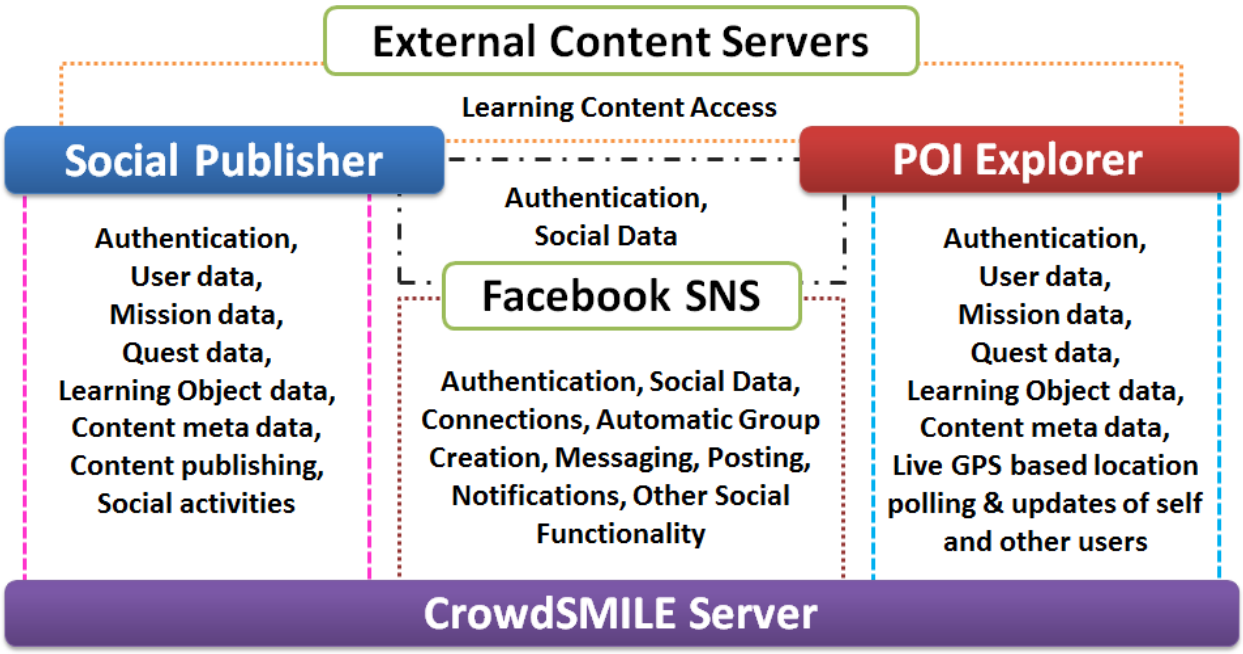


Figure 4-7: Activity and Data Flow between components of CrowdSMILE

In the figure 4-7 above you can see the interaction, dataflow and activity of each component and the other components it needs to integrate with. The Server, Explorer and Social Publisher are the main components. FBSNS and Cloud Content Servers also form an important part of the system as they allow the system to be flexible and scalable. The modular design of CrowdSMILE allows easy extension and addition of functionality to any of the parts as required.

4.5.2.1. *Social Integration*

To enable social and collaborative functionality, CrowdSMILE integrates with the Facebook SNS platform. Facebook Integration for Social and Collaborative functionality allows CrowdSMILE to use an already familiar interface in that of Facebook and leverage it to provide the user with a familiar environment. By integration with FBSNS, CrowdSMILE offers all the social functionality of FBSNS as part of CrowdSMILE environment. FB Groups can be used for discussions. FB wall posts and messaging can be used to share content between users. Learning achievements can be posted on user's own wall for social recognition

and encouragement.

As can be seen, the integration allows CrowdSMILE to provide SNS feature within its learning environment and make learning more social and collaborative, thus achieving some of LLL's goals.

4.5.3. Cloud based Content Leveraging

Because CrowdSMILE does not actually store learning content, storage overhead is very low. Audio/Video processing requirements are also non-existent. This is because CrowdSMILE simply stores metadata about actual learning content It then provides the meta data to the client apps which in turn use it to find the real location of content. Once the client applications know about the content and its location, they access it accordingly from the cloud based servers without any overhead on the CrowdSMILE server.

4.6. System Network and Communications Architecture

4.6.1. System Network Architecture

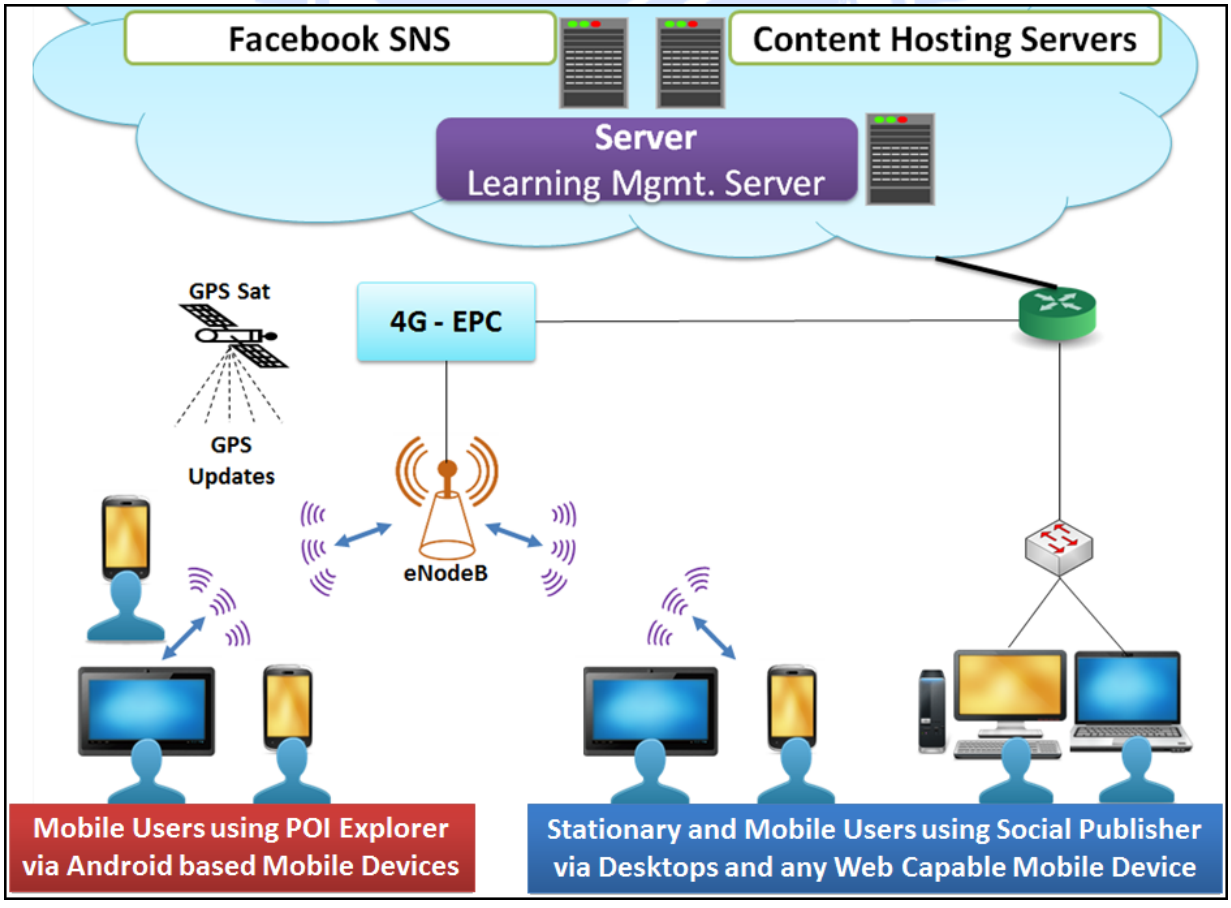


Figure 4-8: CrowdSMILE Network Architecture

One of the requirements identified was to provide a real time and interactive interface. Furthermore, learners are expected to access rich HD audio and video during learning. As such, we propose the use of 4G networks for use with our mobile learning environment. For the non-mobile environment, any high speed fixed connection should suffice. With the low latency and high bandwidth of 4G, the CrowdSMILE system is ready for interactive and group based activities that may be time sensitive. It enables future work to consider game based learning or other activities where timing is an important context. 4G is an ideal network for E-learning applications due to its low latency and high bandwidth.

4.6.2. System Communications Architecture

The components of CrowdSMILE use HTTPS based web services such as GET and POST requests for communications between each other. Data is mostly returned in JSON format for optimal data transfer and formatting. The use of standard web services enables the system to build on exposed interfaces without having to change the underlying communications method, thus making the system easily expandable.

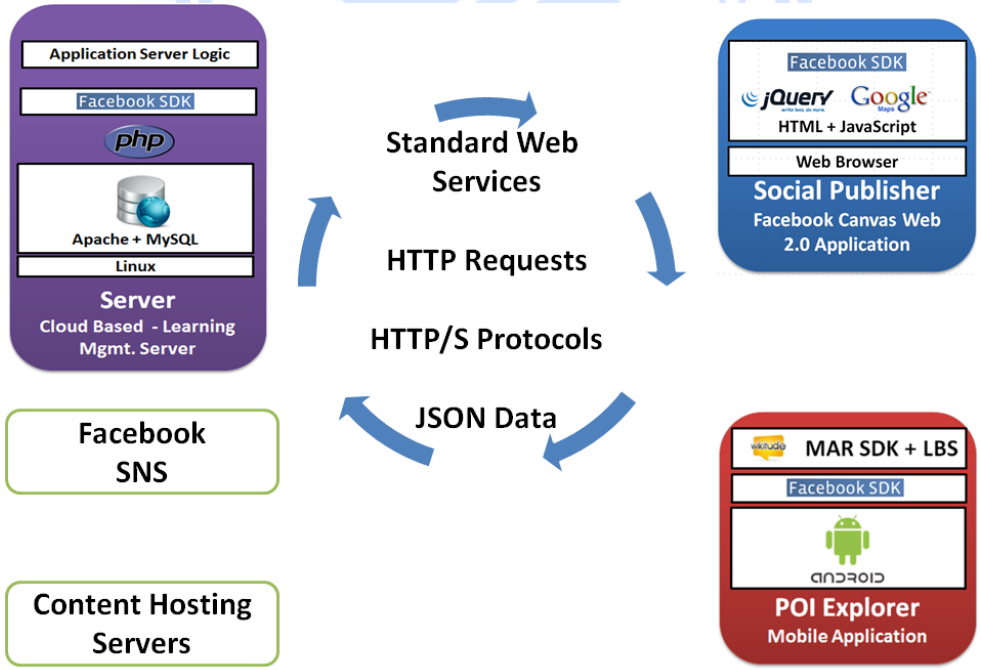


Figure 4-9: Components use Standard Web Serivces for communications

4.7. System Implementation and User Interfaces

4.7.1. The Server

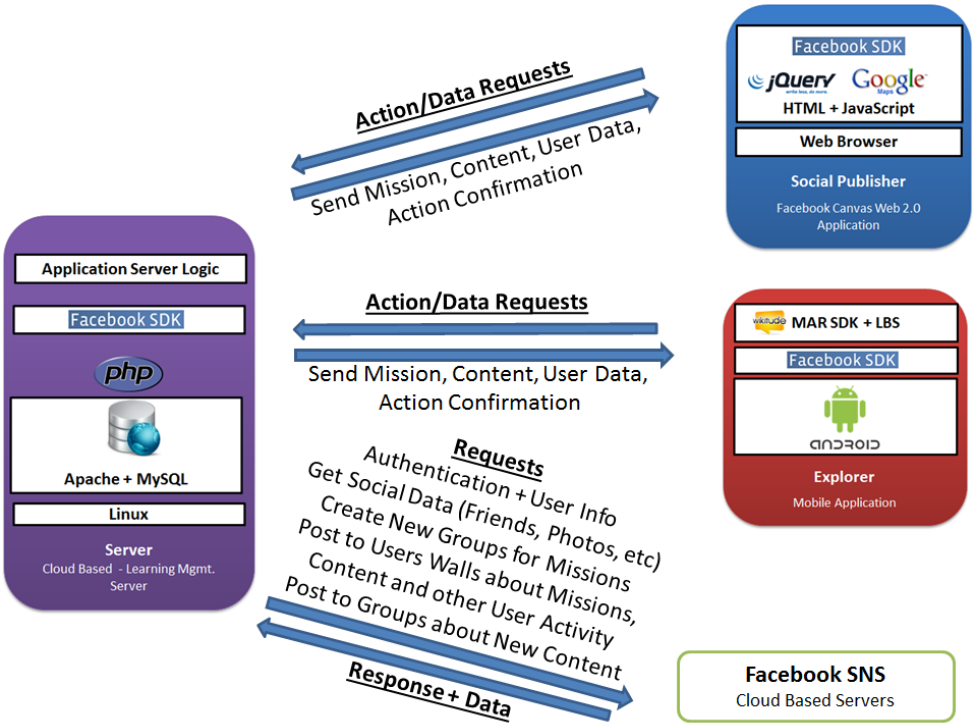


Figure 4-10: Data and Control Flow between Server and other components

The server offers the core functionality of the system. It manages the necessary data of the system and provides interfaces to the other components to access and update the data. It is also largely responsible for enabling the Facebook integration as it performs most of the automatic Social actions required by the system as can be seen in figures 4-11, 4-12 & 4-13.

Figure 4-11: Server integration with FBSNS

Automatic Creation of User Groups for discussion of Mission Content

Figure 4-12: Server integration with FBSNS

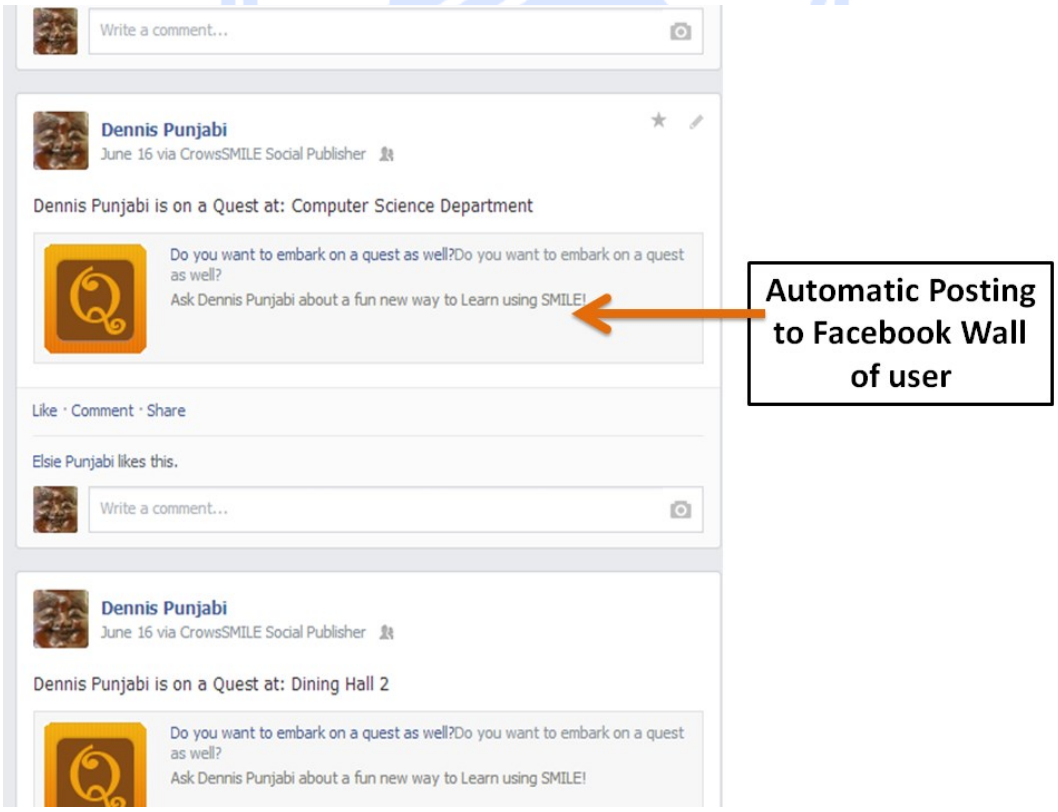


Figure 4-13: Server integration with FBSNS

4.7.2. The Social Publisher

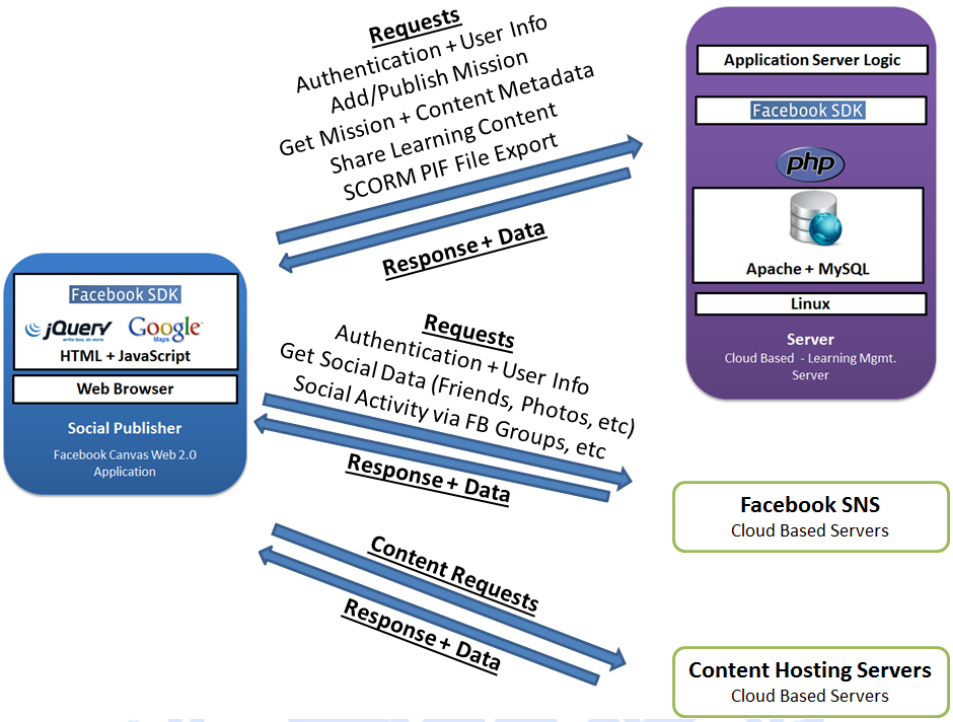


Figure 4-14: Data and Control Flow between Social Publisher and other components

The Social Publisher serves as the user's Social dashboard in the Desktop environment. It allows users to access Missions created by their friends and allows the users to add content to those Missions provided they have explore the mission using the Explorer application. This application is deeply integrated within the Facebook website environment and hence also provides the Facebook SNS features within the context of its usage. Users may easily switch between Facebook and the application seamlessly. As such, the Collaborative features of the FBSNS are just a click away and can be used within the context of learning using this application.

This is the interface also used for creating and publishing Missions and learning content. This interface also allows for exporting of SCORM content packages.

Figures 4-15, 4-16, 4-17, 4-18, 4-19, 4-20, 4-21 and 4-22 showcase the different screens and interfaces of the functions of the Social Publisher application.

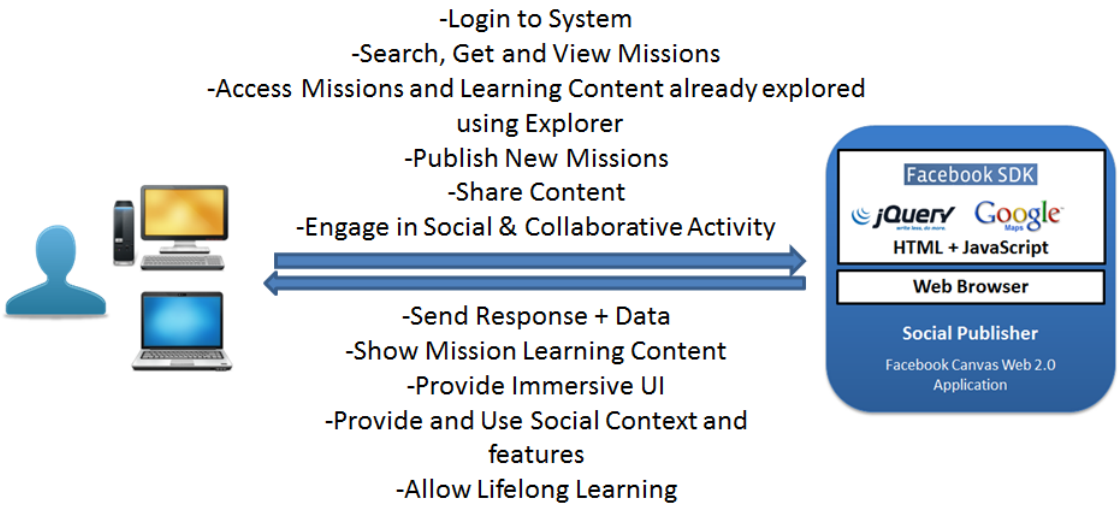


Figure 4-15: Social Explorer Functionality

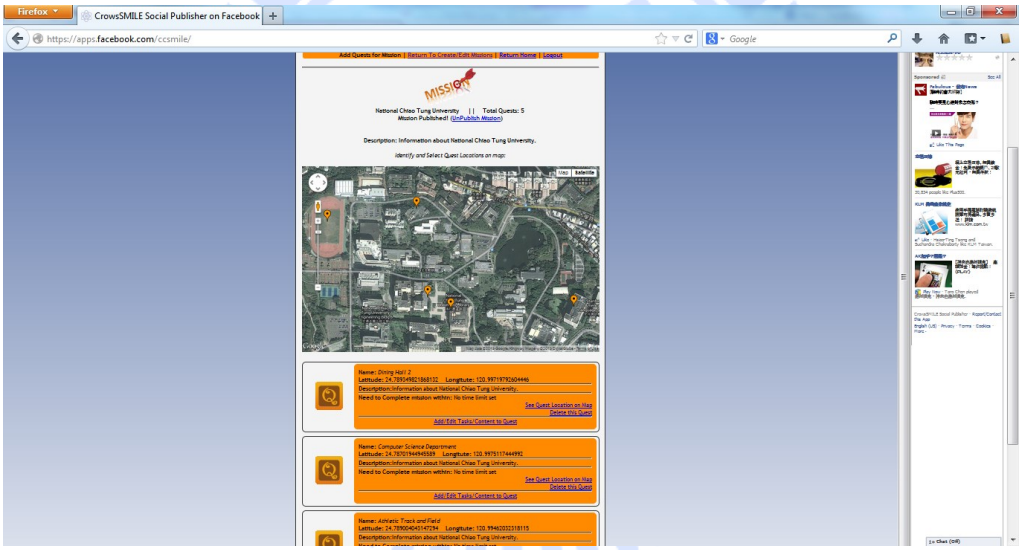


Figure 4-16: Social Publisher integrating Web 2.0 based Google Maps interface for adding Quests

Figure 4-17: Social Publisher and FBSNS integration for authentication

Figure 4-18: Social Publisher and FBSNS integration for social data

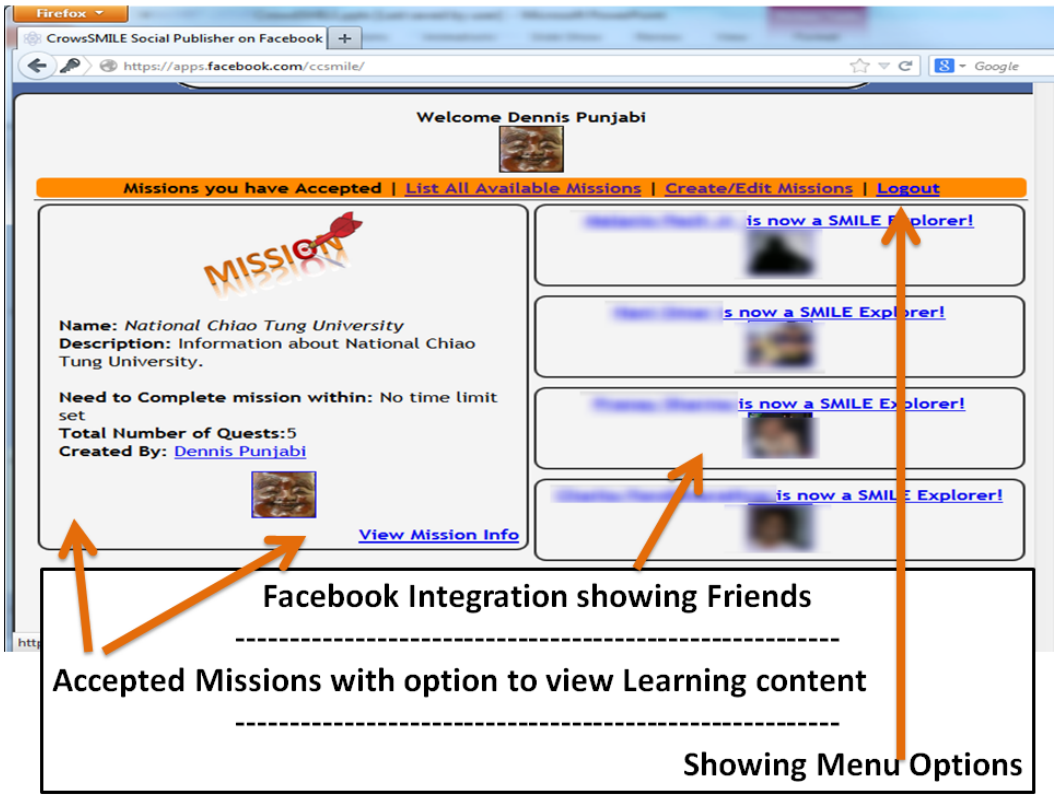


Figure 4-19: Social Publisher and FBSNS integration for social data

Figure 4-20: Social Publisher and FBSNS integration for social data. UI showing Missions listing

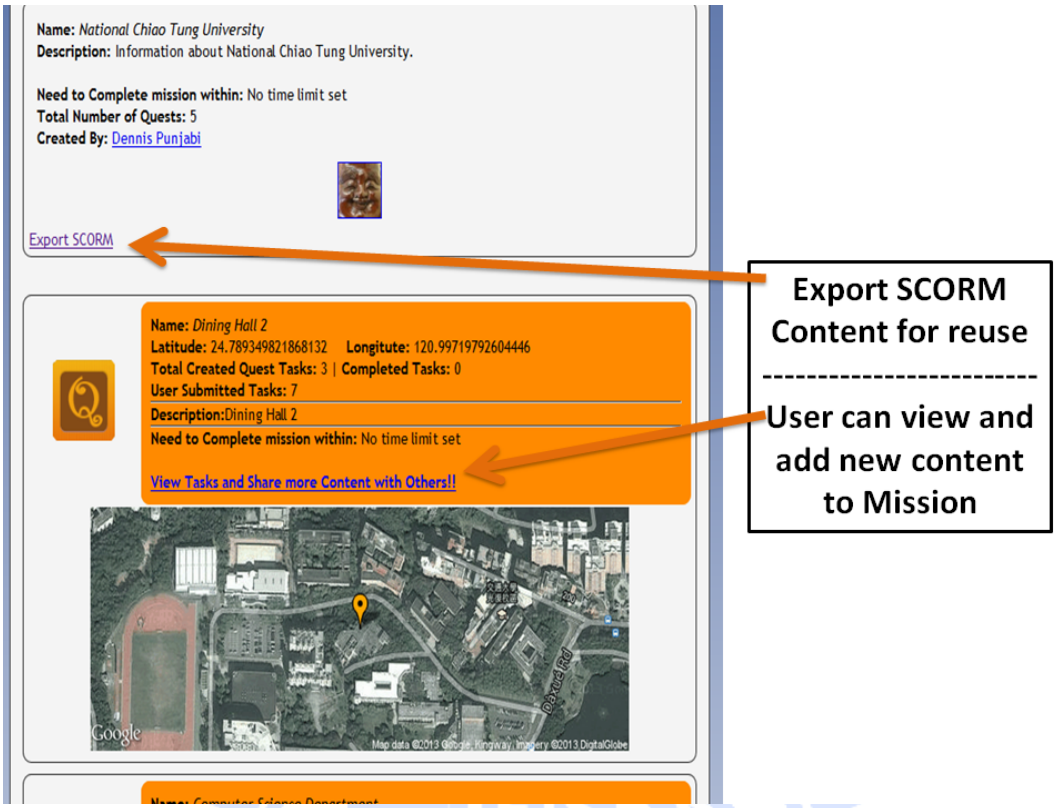


Figure 4-21: Social Publisher allowing export of SCORM PIF for reuse

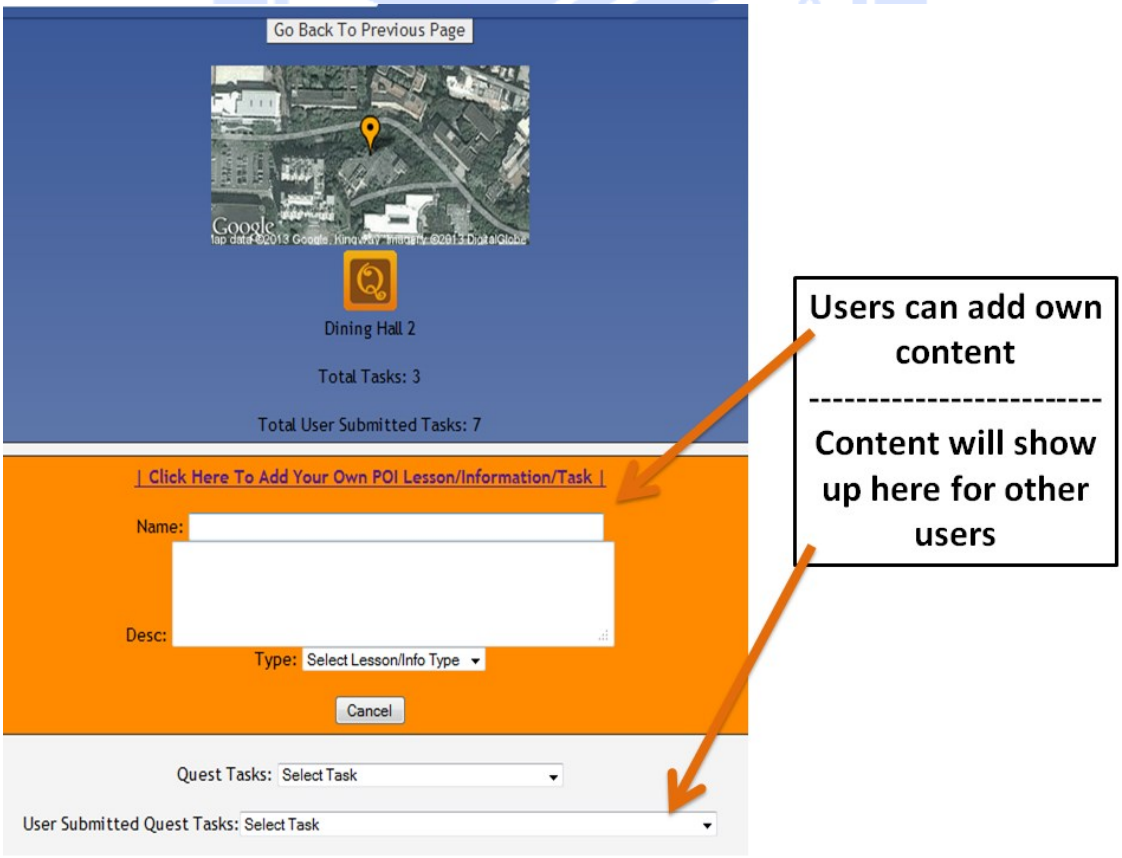


Figure 4-22: Social Publisher allowing crowdsourced content creation and sharing

4.7.3. The POI Explorer

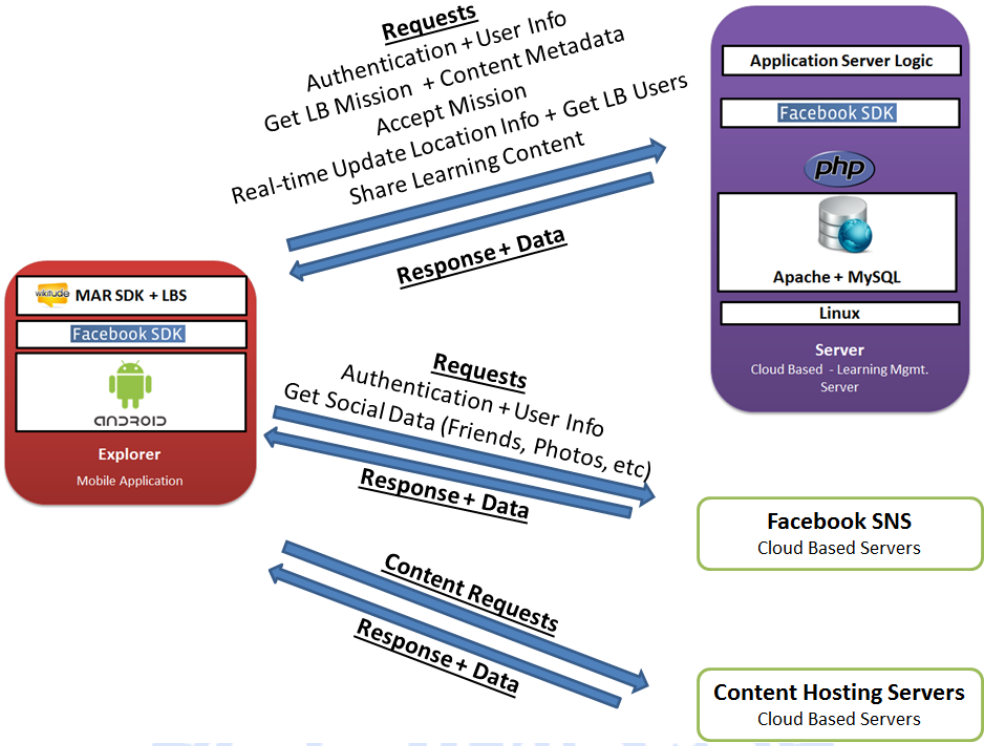


Figure 4-23: Data and control flow between POI Explorer and other components

The main purpose of the explorer is to serve as a mobile application that allows the user to explore a physical location and learn. It is mainly a content consumption tool. It makes use of high speed and low latency 4G network to access data in real-time. It provides an engaging feedback to the user in the form of a radar, which shows other users using the system at the same moment within the close by vicinity. One of the conditions of accessing the learning content is that the user needs to be present close to the POI to access the content.

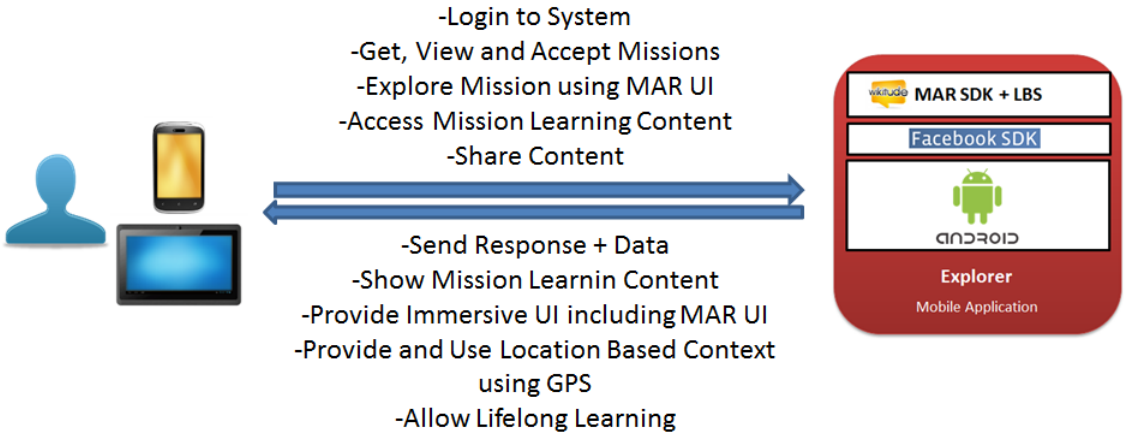


Figure 4-24: POI Explorer functionality

Figures 4-25, 4-26, 4-27, 4-28 and 4-29 show the different UI screens and functionality of the POI Explorer.

Figure 4-25: POI Explorer UI showing FBSNS integration

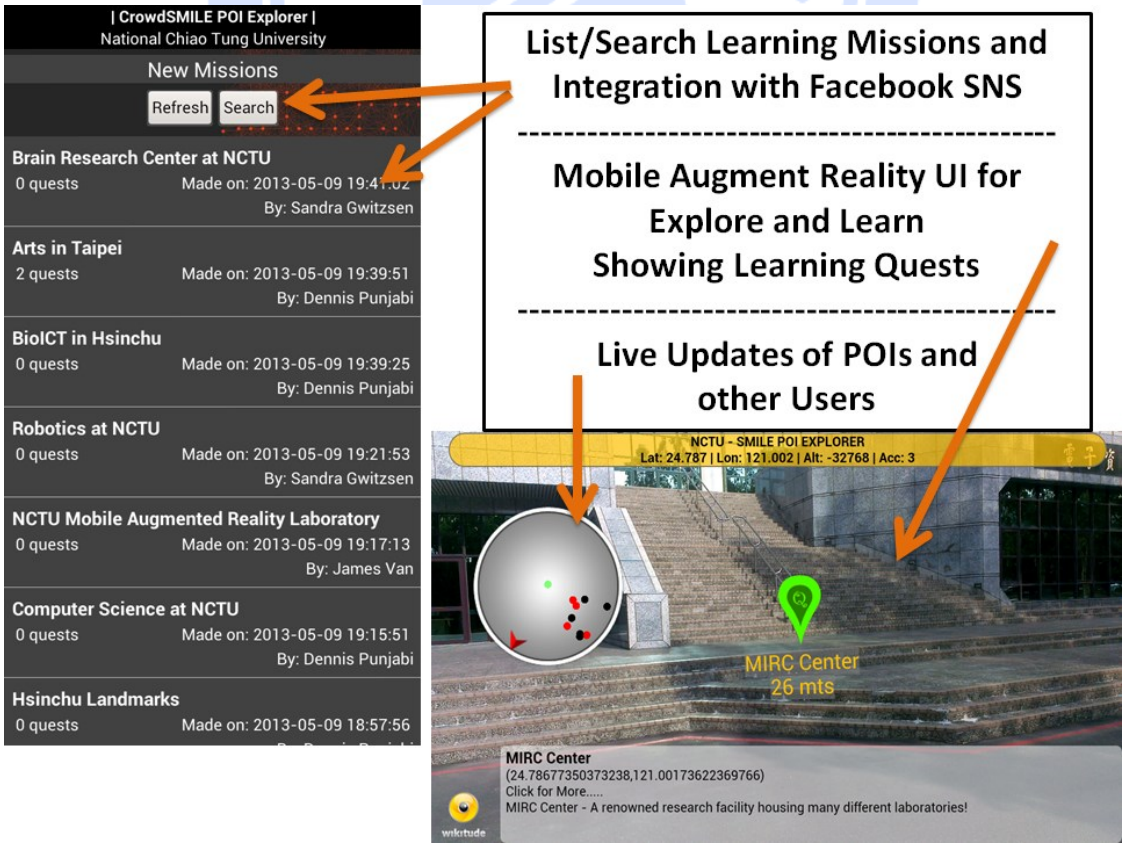


Figure 4-26: POI Explorer UI screens

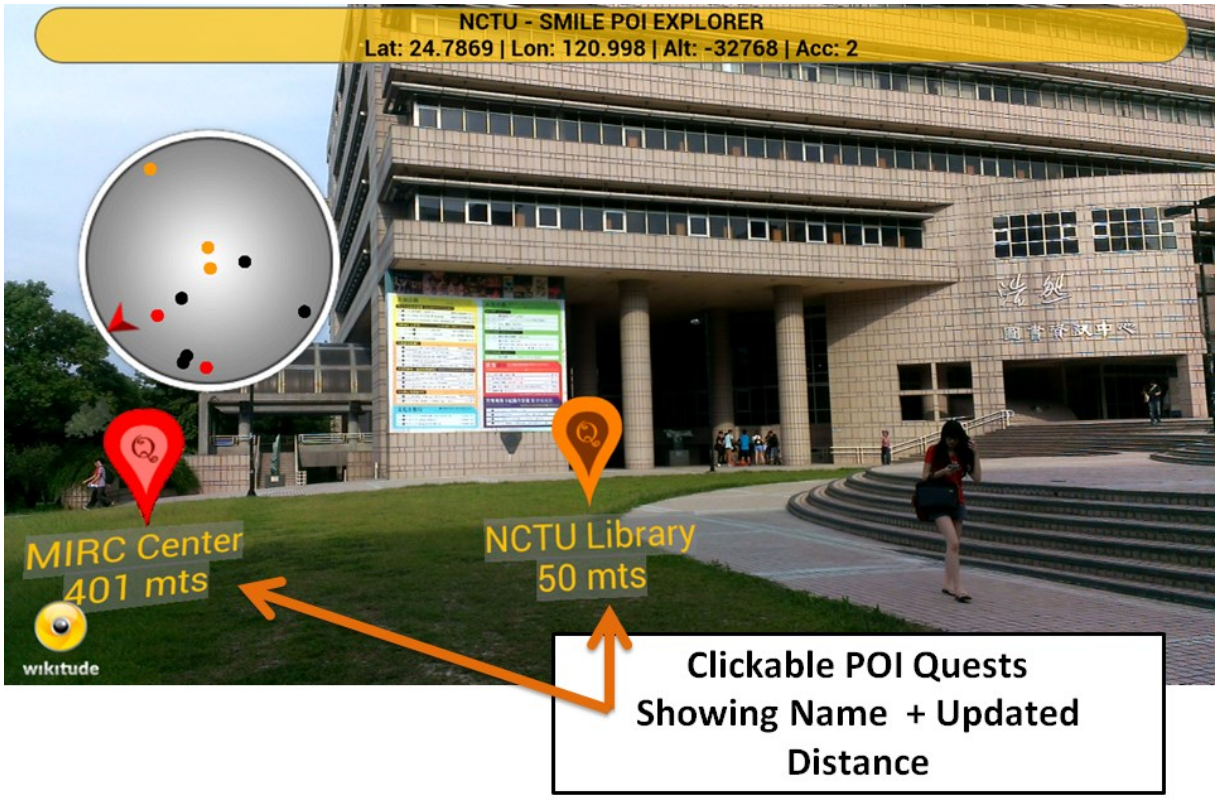


Figure 4-27: POI Explorer showing MAR view

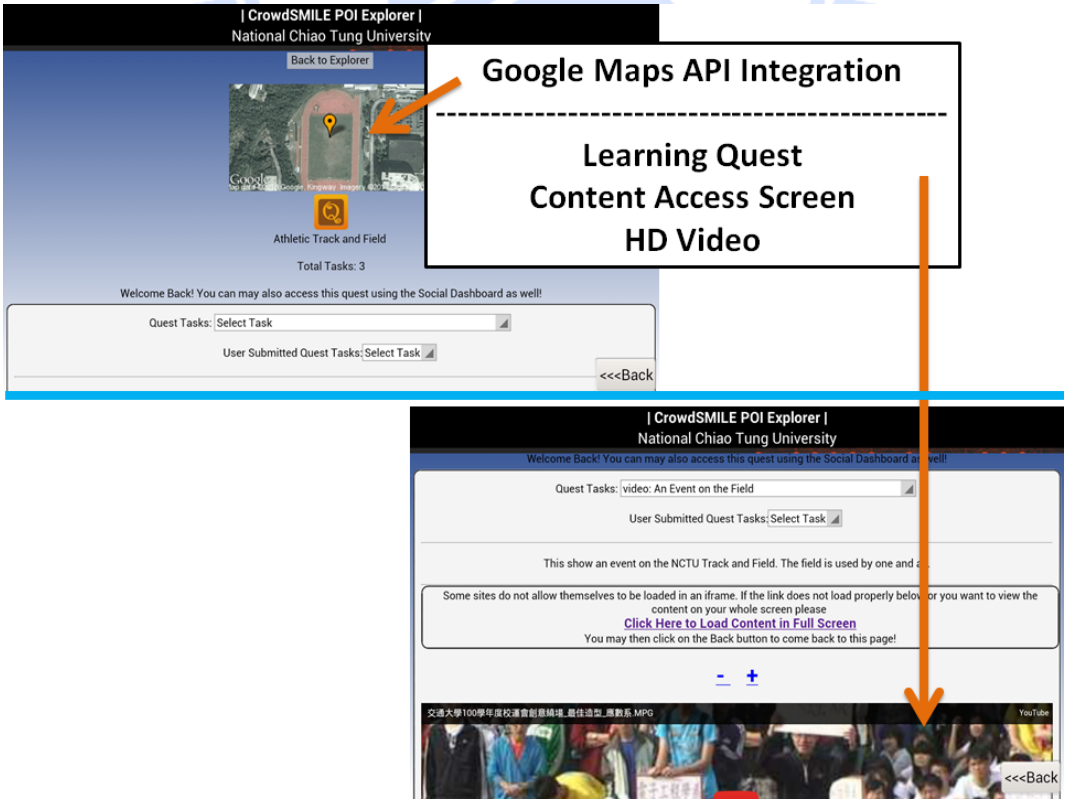


Figure 4-28: POI Explorer - Accessing learning content

Figure 4-29: Top: Users using CrowdSMILE and below, real-time MAR UI of POI Explorer

4.7.5. Top to Bottom - System Usage Scenario

1. •User 1 Logs in to Social Publisher
2. •User 1 Creates a new Mission "National Chiao Tung University" (NCTU)
3. •User 1 creates 5 Location-based Quests in Mission - NCTU Library, MIRC Building, Computer Science Dept, Dining Hall 2, Athletic Track adn Field
4. •User 1 adds Learning content for each Quest (Tasks to watch videos, read , listen to Audio and other activities)
5. •User 1 Publishes the Mission. By Publishing the mission, User 1's Facebook Wall also advertises the mission.
6. •User 2 sees User 1's wall post about the mission and Logs in to Explorer Applciation.
7. •User 2 searchs for Missions withn the area. Find one the NCTU Mission and Accepts the Mission. By accepting the mission, User 2 automatically gets added to a Facebook Group for the mission.
8. •User 2 starts to explore the area and visit each Quest and compeltes the tasks assocaited with each Quest.
9. •As User 2 is completeing her tasks, her Facebook wall is being updated with her activity.
10. •User 2's friend, User 3 see the Facebook post and also starts to use the Explorer Application and start learning outdoors.
11. •User 2 and User 3 go back to their houses and log in to the Social Publisher and add more content to the existing mission for other users to access.
12. •User 2 and User 3, join User 1 in the Facebook Group and continue discussing about the topic of the Mission, ie, NCTU.
13. •Repeat Cycle

Chapter 5: Experiment Details, Results and Discussion

5.1. Comparing system performance on 3G and 4G networks

Given that CrowdSMILE is a learning application, learners may need to access HD audio and video content as part of the learning process. Furthermore, the Explorer application's MAR UI requires low latency to be able to update the screen and send user location context back to the server quickly. To study the performance of CrowdSMILE on 3G and 4G networks in terms of transmission latency, we conducted some network experiments.

5.1.1. Test Environment

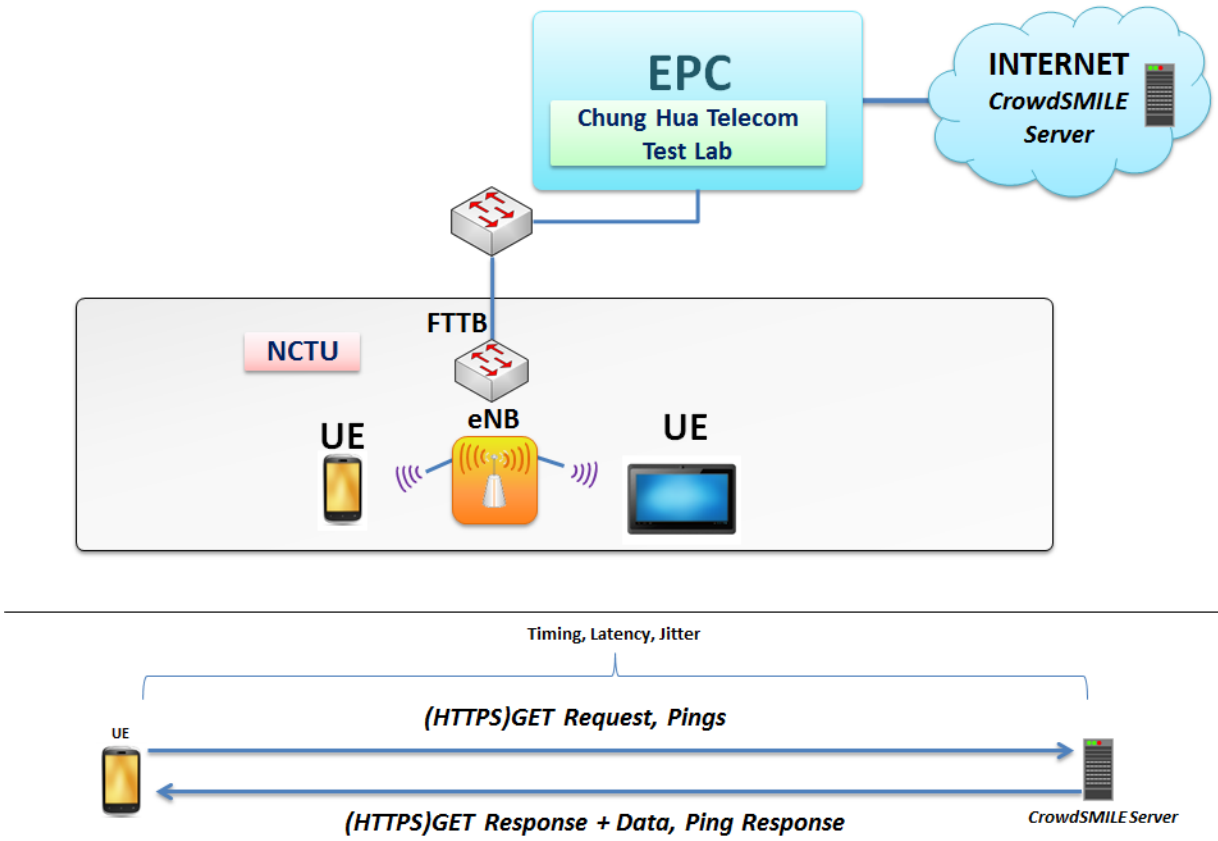


Figure 5-1: 4G Test Environment at NCTU

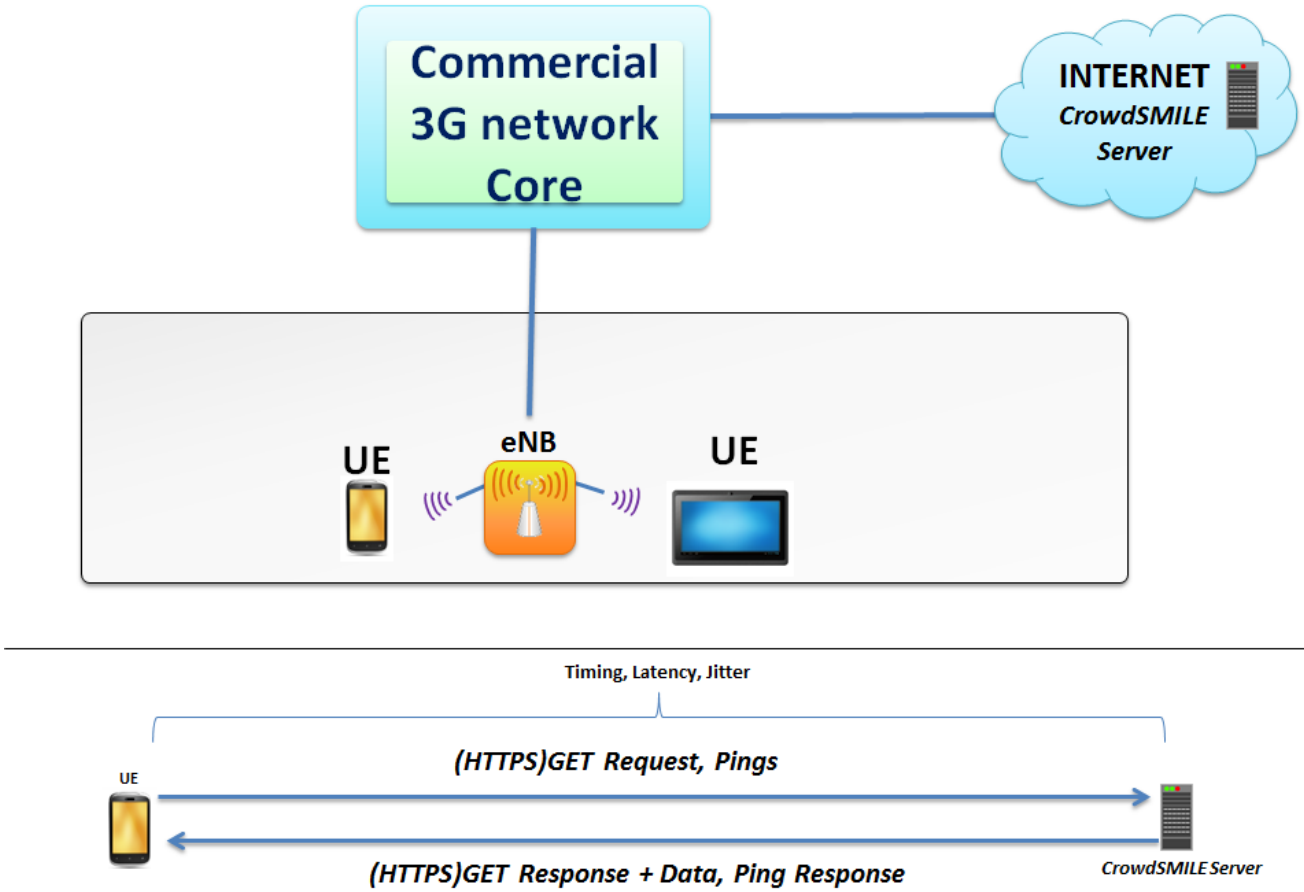
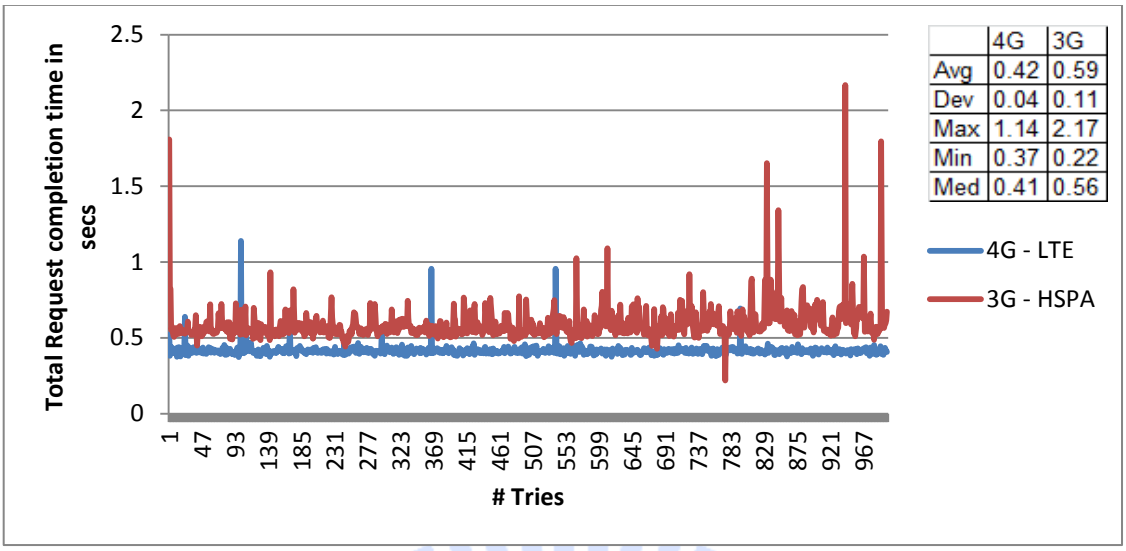


Figure 5-2: 3G Commercial Network

5.1.2. Test Method

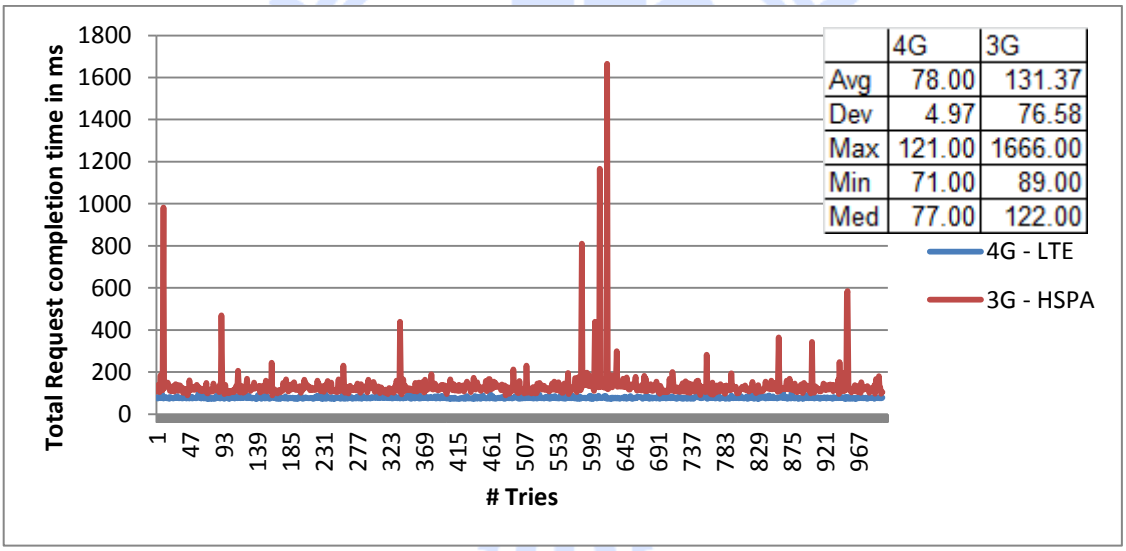
At National Chiao Tung University, a network test-bed of 4G LTE-TDD is available. Its setup is depicted in the figure 5-1.. We also had access to a commercial 3G network, whose simplified setup is shown in figure 5-1. Our application uses web services for communication. We simulated our application on both 3G and 4G network by making HTTP get requests to our server for 1000 times every day, at different times, over a 7 day period. We also conducted ping latency tests. We then analysed the results and compared them with each other. Test results of the HTTP get transfer time is summarized in figure 5-2. Test results of the latency times are summarized in figure 5-3.

5.1.3. *Test Results*



	4G	3G
Avg	0.42	0.59
Dev	0.04	0.11
Max	1.14	2.17
Min	0.37	0.22
Med	0.41	0.56

Figure 5-3: Summary - Test results of HTTPS get request to CrowdSMILE server



	4G	3G
Avg	78.00	131.37
Dev	4.97	76.58
Max	121.00	1666.00
Min	71.00	89.00
Med	77.00	122.00

Figure 5-4: Summary - Test Results of ping requests to CrowdSMILE server

As can be seen from the figure 5-3 and 5-4, 3G is slower, more unpredictable and has a higher jitter (shown in dev column). 4G is more stable and has a faster turnaround time. For rich, interactive, real-time applications, jitter is not good. Jitter causes unpredictable behaviour. Based on the above results, we can safely say that our application works better in a 4G environment. Even at this time we do not fully utilize the real-time properties, the system was designed to enable it and as such, it must be available. In this case, only the 4G environment has provided the low latency and limited jitter environment.

5.2. Content Ranking using Social Metrics

Given that CrowdSMILE leverages crowdsourcing to generate learning content, there arises a challenge of providing relevant content to the learner and not useless content. To solve the problem, we propose content ranking by using SNS features.

When a user submits new Learning content to a Mission, the link to the content with other information gets publicly posted in the Facebook group of the Mission. As the post is public, other learners may Like the link, they may Share it and of course, click on it. We propose using a combination of Likes, Shares and View counts to rank the learning content. The rank is then used as a determining factor in the listing order of content to the learner.

The number of Likes and Shares of content posted on FB can be acquired using Facebook graph API. For View counts, we use a redirector link hosted on the CrowdSMILE server that keeps a track of visits to the link while forwarding the user to the actual content. The links posted actually point to the CrowdSMILE Server with a hash key in the URL that refers to the actual URL in a database on the server. Once the link is clicked, the user is taken to the Server that logs the view as a +1 to total number of views and then redirects user to actual URL of the content.

5.2.1. Definition of Social Index

"Social Index" is the rank value of learning content posted in the CrowdSMILE system. We have come up 6 ways for calculating the Social index. We arrived at these combinations strictly by trial and error. The 6 combinations are:

$$SI_1(i) = Likes + (Shares*2) + (Views * 1.5) \quad (5.1)$$

$$SI_2(i) = (Likes * 10) + Shares + Views \quad (5.2)$$

$$SI_3(i) = (Likes + Shares) + (View * 3) \quad (5.3)$$

$$SI_4(i) = (Likes + Shares) + (View * .3) \quad (5.4)$$

$$SI_5(i) = Likes + Shares \quad (5.5)$$

$$SI_6(i) = Views \quad (5.6)$$

Where i = ID of learning content

Once we decide which SI we are going to use, we further define the SI of a Quest and Mission respectively. Let Q be Learning Quest. The SI of Q is defined as follows in equation 5.7:

$$\mathbf{SI(Q)} = \sum_{i=1}^{n} \mathbf{SI(i)} \tag{5.7}$$

where i ∈ { Learning Objects of Quest Q }

Social Index for Quests

Let M be a Learning Mission. The SI of M is defined in equation 5.8 as follows:

$$\mathbf{SI(M)} = \overline{\sum_{i=1}^{n} SI(Q^i)} \tag{5.8}$$

where Q^i ∈ { Quests of Mission M }

Social Index for Missions

We propose that once the Social Index of a Mission and its Quests have been calculated, we may use that for ranking content.

5.2.2. Experiment Setup

To evaluate our content ranking method, we conduct the following experiment. We consider user's opinions as a manual rank. We then compare the manual rank with the SI ranks. The experiment details as follows:

1) Facebook group with 50 users was setup.
2) Posted 15 Links related to a single topic in the group page. Posted around 2 links per day and monitored the activity.
3) After one week, we analysed the Likes, Shares and Views of each link posted and calculated the Social Index (SI) for each link using the 6 different methods proposed. We then randomly chose 20 out of 50 users in the group. Each user is asked to visit each link one by one and rank the content on a scale of 1 to 10, where 1 is a low rank and 10 is a high rank. We call this the manual rank.

   The hypothesis is that if the Social Index ranks are similar to this manual manual rank, we may be able to use the SI ranking method as an effective content ranking method.

4) We then compared the manual rank with the 6 Social Index based ranks. We then perform statistical analysis and compare them to find their correlation strength.

5.2.3. Kendall's Tau for Statistical Correlation

Kendall's tau [30] correlation coefficient is designed to capture the association between two variables. Its estimate (denoted τ) can be defined and expressed as follows [49]:

Let (x1, y1), (x2, y2), …, (xn, yn) be a set of observations of the joint random variables X and Y respectively, such that all the values of (xi) and (yi) are unique. Any pair of observations (xi, yi) and (xj, yj) are said to be concordant if the ranks for both elements agree: that is, if both xi > xj and yi > yj or if both xi < xj and yi < yj. They are said to be discordant, if xi > xj and yi < yj or if xi < xj and yi > yj. If xi = xj or yi = yj, the pair is neither concordant nor discordant.

$$\tau = \frac{(\text{number of concordant pairs}) - (\text{number of discordant pairs})}{\frac{1}{2}n(n-1)}. \qquad (5.9)$$

5.2.4. Test Results

RANKB6	RANKB5	RANKB4	RANKB3	RANKB2	RANKB1	RANKA
.270	.270	.319	.232	.485	.453	.

Rank A is the manual ranking method

Rank B1 = $SI_1(i)$

Rank B2 = $SI_2(i)$

As can be seen,

the correlation between Rank A and Rank B1 is **τ = .453**

the correlation between Rank A and Rank B2 is **τ = .485**

Table 5-1: Kendall's Tau Correlation Strengths

τ = 0 - .4	Weak Correlation
τ = .4 - .7	Moderate Correlation
τ = .7 - 1	Strong Correlation

Referring to table 5-1 as a guide we can see that we have a moderate correlation between Rank A and Rank B1 ($SI_1(i)$). Similarly, we have a moderate correlation between Rank A and Rank B2 ($SI_2(i)$).

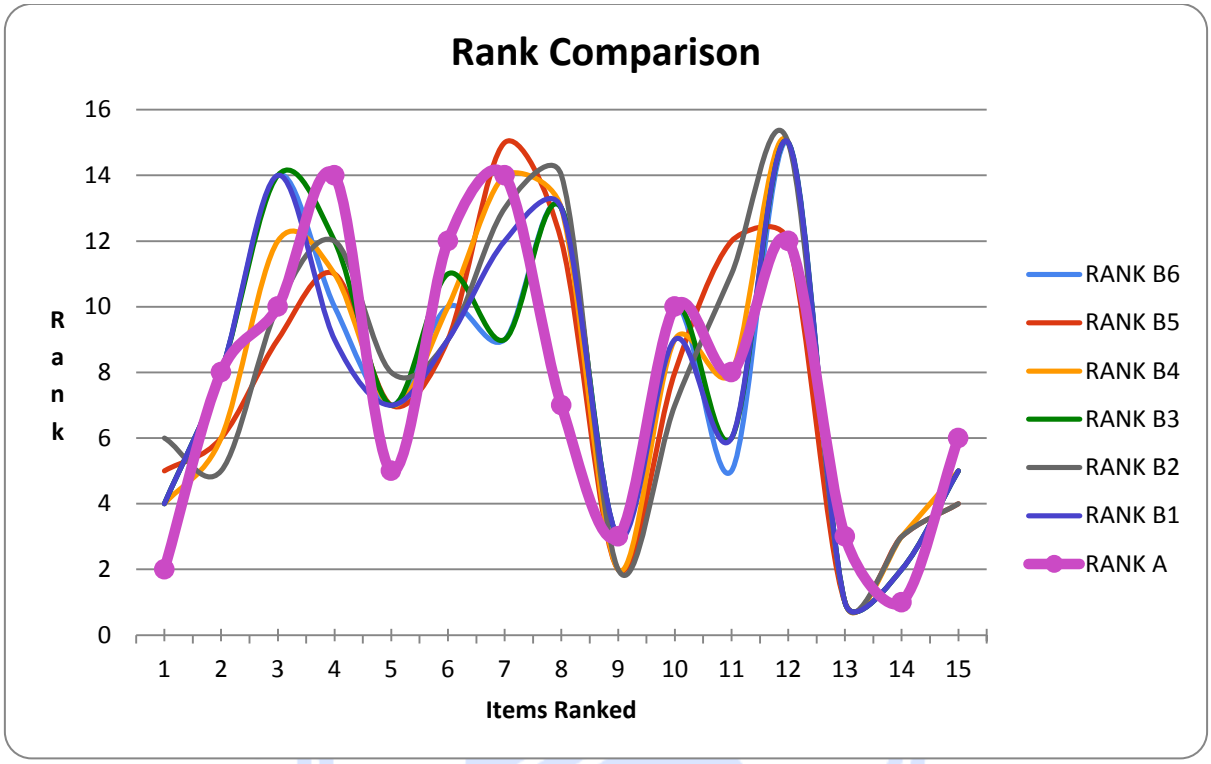


Figure 5-5: Visual comparision of ranking of items using the different methods.

Figure 5-5 above shows that there exists some correlation between $SI_1(i)$ and Rank A, and between $SI_2(i)$ and Rank A. If the graph is studied carefully, we can see than Rank A's curve follows all the other Rank's curves. It indicates that there is some relation between all of them. However, given the small sample size and the lack of a strong correlation, we would have to conclude that while there is correlation, it is not enough to be used solely as a basis for ranking.

Exploring alternative means from Facebook features may give other effective ranking methods. For example, data mining of Facebook comments is a potential solution that can be combined with our proposed method above.

5.3. System Usability and Effectiveness

As part of this work, we wanted to test the usability of the CrowdSMILE. Questionnaires and Statistical analyses are instruments for gauging user's response and feedback about the system.

CSUQ [35] is a well-known and standardized questionnaire that is used to evaluate user satisfaction and get feedback from users about a computer system, especially with small sample sizes. The CSUQ survey contains 19 questions which can be assigned into 4 categories.

Table 5-2: The questions of CSUQ

1	Overall, I am satisfied with how easy it is to use this system.
2	It was simple to use this system.
3	I can effectively learn using this system.
4	I am able to learn quickly using this system.
5	I am able to efficiently learn using this system.
6	I feel comfortable using this system.
7	It was easy to learn to use this system.
8	I believe I became productive quickly using this system.
9	The system gives error messages that clearly tell me how to fix problems.
10	Whenever I make a mistake using the system, I recover easily and quickly.
11	The information provided with this system is clear
12	It is easy to find the information I needed.
13	The information provided for the system is easy to understand.
14	The information is effective in helping me complete the tasks and scenarios.
15	The organization of information on the system screens is clear.
16	The interface of this system is pleasant.
17	I like using the interface of this system.
18	This system has all the functions and capabilities I expect it to have.
19	Overall, I am satisfied with this system.

Table 5-3: CSUQ Categories and corresponding items in Questionnaire

Category	Items
Overall Satisfaction	Items 1 through 19
System Usefulness	Items 1 through 8
Information Quality	Items 9 through 15
Interface Quality	Items 16 through 18

5.3.1. *Experiment Procedures*

A group of 18 users used and tested the system over the period of 2 weeks. Before the start of the test, each user was given an introduction to the system along with an explanation about its purpose. At the end of the test period, they were asked to complete a Computer System Usability Questionnaire (CSUQ) as defined in [35]. The survey contained 19 questions which each being a statement that the user could rate on a Likert scale of 1 – 7, where 1 is strongly disagree and 7 is strongly agree. In addition to CSUQ questions, we asked two more free text questions that required the users to add a note about their negative experience with the system (if any) and a note about their positive experience with the system (if any). A copy of the actual questionnaire is provided in the appendix.

5.3.2. *System State at start of Test*

The system was populated with 1 Mission and 5 Quests. Each Quest had at 3 Learning Objects. The users were asked to use the system to explore and learn about the Mission available. They were further asked to contribute to the system by providing learning content for each of the Quests. They were also encouraged to create their own Missions.

Table 5-4: State at Start of User Test

Missions	1
Quests	5
Learning Objects	15

5.3.3. *System State at end of Test*

Table 5-5: State at End of User Test

Missions	4
Quests	12
Learning Objects	54

As can be seen, the users were actively using the system over the test period.

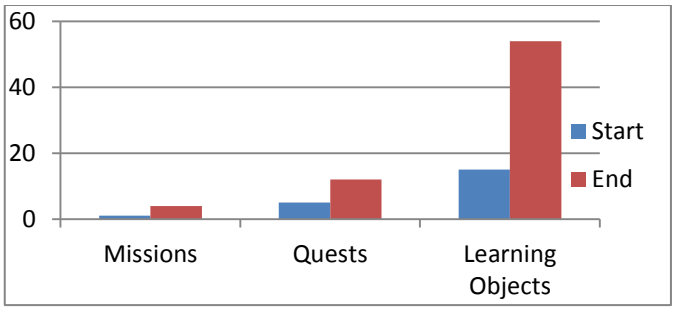


Figure 5-6: Difference in content in system (at the start of user test and at the end)

5.3.4. Survey Results

The results of the CSUQ are shown below, where N is the number of responses; AVG is the average value, DEV is the standard deviation value, MED is the median, MAX is the maximum, and MIN is the minimum.

Table 5-6: CSUQ Survey Results by Category and User Average

Category	AVG	DEV	MED	MAX	MIN
Overall Satisfaction	5.56	0.26	6	7	2
System Usefulness	5.63	0.07	6	7	4
Information Quality	5.50	0.24	5.5	7	2
Interface Quality	5.39	0.25	6	7	2

Table 5-7: CSUQ Survey Results by Category and User Average as % Score out of 7

Category	Avg as %
Overall Satisfaction	79%
System Usefulness	80%
Information Quality	79%
Interface Quality	77%

Table 5-8: CSUQ Survey Results by Question

	N	AVG	DEV	MED	MAX	MIN
Overall, I am satisfied with how easy it is to use this system	18	5.67	0.82	6	7	4
It was simple to use this system	18	5.78	0.97	6	7	4
I can effectively learn using this system	18	5.72	0.80	6	7	4
I am able to learn quickly using this system	18	5.61	0.83	6	7	4
I am able to efficiently learn using this system	18	5.67	0.88	6	7	4
I feel comfortable using this system	18	5.78	0.97	6	7	4
It was easy to learn to use this system	18	5.67	0.94	6	7	4
I believe I became productive quickly using this system	18	5.11	0.81	5	7	4
The system gives error messages that clearly tell me how to fix problems	18	4.94	1.43	5	7	2
Whenever I make a mistake using the system, I recover easily and quickly	18	5.06	1.35	5	7	2
The information provided with this system is clear (documentation, online help, on screen messages, etc.)	18	5.39	1.21	5.5	7	3
It is easy to find the information I needed	18	5.44	1.07	5.5	7	3
The information provided for the system is easy to understand	18	5.78	1.08	6	7	3

The information is effective in helping me complete the tasks and scenarios	18	6.06	0.70	6	7	5
The organization of information on the system screens is clear	18	5.83	0.83	6	7	4
The interface of this system is pleasant	18	5.22	1.51	5	7	2
I like using the interface of this system	18	5.50	1.57	6	7	2
This system has all the functions and capabilities I expect it to have	18	5.44	1.01	6	7	3
Overall, I am satisfied with this system	18	5.89	0.66	6	7	5

Table 5-9: CSUQ Survey Results by User

	Overall Satisfaction	System Usefulness	Information Quality	Interface Quality
User 1	5.84	5.88	5.71	6.00
User 2	5.26	5.00	5.71	5.00
User 3	6.68	6.88	6.57	6.33
User 4	5.05	6.13	4.29	3.67
User 5	5.63	6.13	5.43	4.67
User 6	5.58	5.50	5.71	5.33
User 7	4.89	5.13	5.29	3.00
User 8	6.00	5.63	6.29	6.33
User 9	5.95	6.13	5.43	6.67
User 10	4.47	4.50	4.86	3.33
User 11	4.95	5.50	4.71	4.00
User 12	6.74	6.38	7.00	7.00
User 13	5.16	5.00	5.00	6.00
User 14	5.63	5.50	5.29	6.67
User 15	4.95	4.88	5.00	5.00
User 16	6.37	6.63	5.86	6.67
User 17	5.53	5.38	5.71	5.33
User 18	5.32	5.13	5.14	6.00

Table 5-10: Survey – Some Negative aspects of the system

Not Enough Missions
Some phones aren't compatible with the app
Finding contents and uploading it
The interface can be more friendly and informative on how to use the system, maybe pop up messages and better fonts.
I really don't like the way that the system post information on my Facebook timeline. I want to use the system without link it to my social network or limit its access to my timeline.
Once inside the tasks, the UI is a little cluttered. You have to scroll down to find info
The system was good...but uses a lot of data bandwidth at times
Too few missions available

Table 5-11: Survey – Some Positive aspects of the system

Easy to use. Very interesting and useful idea.

Easy to use and user friendly.
Easy to use. If good and enough content uploaded it saves a lot of time searching for info about the POIs. It can be used as a tourist app with Missions (or Categories) about sightseeing, food, fun, nightlife and other stuff, so people can just take their phones out and see what POIs are around them. Over all it's pretty cool and useful.
The interface is clean, clear and very easy to use. It just needs some polishing in terms of graphical aspects
The fact it's already integrated with Facebook because, you see which missions your friends have joined making the user curious to try those missions too.
The speed of information display for the located sites, given the device's GPS works correctly

The overall assessment of the users was positive. All 4 areas scored over 77%. There were no overall negative scores. The results also show that the users could easily use the system and that they found the system to be useful. There were a few users who were not happy with the interface given that it did not work on their phone. This was due to their phone not meeting the minimum requirements for the MAR environment and was expected. The lowest question score received was 4.94 regarding error messages. This was due to the fact that when the mobile device was not able to communicate with the server, it would fail with a non-descriptive error and not provide the user with any clue about the error. This can easily be fixed to support a better user experience.

Chapter 6: Conclusion and Future Works

6.1. Conclusion

The theory of LLL is being discussed extensively. Advancements in platforms like Mobile technologies allow innovative, immersive and deeply integrated platforms for learning on the go. To enable LLL, technologies must constantly adapt to user's different requirements and adjust to provide a contextual and rich interface for learning. CrowdSMILE adapts to the learner's physical locations, learning speed and needs. It also provides an immersive interface. Thus, CrowdSMILE is a system that supports LLL.

Our work shows that CrowdSMILE can leverage Crowdsourcing to solve the problem of content creation and availability. It offers a Mobile Augmented Reality based Explore and Learn outdoor application for learning. To augment the outdoor learning, it offers a Social Publisher that allows access of learning content when not mobile and also the ability to use SNS features. We showed that the system was usable and that test users showed a positive attitude towards it as a learning platform. Due to latency and bandwidth requirements, our system works best in a 4G environment and test experiments proved the same.

Our work meets the requirements of a system that enables LLL. It empowers the user to learn on the go, at anytime and anywhere. The system is as good as its users in that content must be provided by users and built over time. The more the number of users, the more learning content will be uploaded. The more content uploaded, the more usable the system will become.

6.2. Future Work

The experiments conducted showed that users accepted the system and actually liked using it as they found it an easy way to learn. This shows great promise and will be used as motivation to further expand the system. We see to further establish this platform as a Game based Learning platform. By coupling the high speed and low latency 4G networks with rich MAR interfaces, imaging technology and innovative story based activities, this system can be adapted to enrich the learning experience through game-based learning.

While we used some rudimentary mining of Social data (Likes, Shares), we found it to

be insufficient to be used for content ranking. With the option of data mining and extracting more contexts from Social Networks, we also wish to provide a more appropriate Social context to learning. We wish to explore the Social connections, Topics preferences and use it as a basis to add to this system, a Social Learning recommendation and ranking system where topics are recommended based on Social contexts such as connections, interests, likes, shares, and other social features,- etc.

Finally, we wish for this system to become a pluggable system whereby it can expose APIs, call-backs and other middleware features that will enable other learning systems to easily integrate this system within their frameworks.

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Appendices

CrowdSMILE System Usability Questionnaire

Hi! You were chosen to test the CrowdSMILE system.

This questionnaire provides you with the opportunity to provide us with your feedback as a test user. Your responses will help us understand what aspects of the system you were satisfied with and what aspects particularly were of concern.

To as great a degree as possible, please think about all the tasks you did when you tested the system while you answer these questions. Please read each question carefully and indicate how strongly you agree or disagree with the statements.

Please answer all questions by placing a check mark ✓ or cross X under the number on the scale indicating how much you agree or disagree with the statement.

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1) Overall, I am satisfied with how easy it is to use this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

2) It was simple to use this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

3) I can effectively learn using this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

4) I am able to learn quickly using this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

5) I am able to efficiently learn using this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

6) I feel comfortable using this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

7) It was easy to learn to use this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

8) I believe I became productive quickly using this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

9) **The system gives error messages that clearly tell me how to fix problems**.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

10) Whenever I make a mistake using the system, I recover easily and quickly.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

11) The information provided with this system is clear (documentation, online help, on screen messages, etc.).

	1	2	3	4	5	6	7	
strongly disagree								strong agree

12) It is easy to find the information I needed.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

13) The information provided for the system is easy to understand.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

14) The information is effective in helping me complete the tasks and scenarios.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

15) The organization of information on the system screens is clear.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

16) The interface of this system is pleasant.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

17) I like using the interface of this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

18) This system has all the functions and capabilities I expect it to have.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

19) Overall, I am satisfied with this system.

	1	2	3	4	5	6	7	
strongly disagree								strong agree

20) Please list the most negative aspect(s) of the system:

21) Please list the most positive aspect(s) of the system:

22) Any other feedback/comments?

Thank you for giving us your time. Your assistance in this user test is appreciated.