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An Evaluation of Using a Social Network Group within a 3D Collaborative Learning Environment

A Case Study: Open-Wonderland and Facebook

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Abstract

Although extensive research has been carried out on 3D collaborative learning environments and the role of groups and communities in social networks, few studies exist which adequately cover the relationship between these two. In this dissertation, the author articulates the effectiveness of the integrated environment of these two factors by suggesting a novel prototype and conducting an evaluation session. For the proposed model, a *Facebook Group* was utilised as a repository for learning content and its members were applied as system actors. On the other hand, the *Open Wonderland* platform was selected as an environment for 3D virtual collaborative activities. Since tacit knowledge can be gained via collaborative group-based activities and discussions, a new Wonderland module was developed to integrate this platform with the Facebook group. Similarly, explicit knowledge can be learnt directly via the prepared contents and files which are provided within the group repository. Furthermore, this integration may result in enhancement of the accessibility issue for learning content since the content can be available both in the 3D world and the 2D Facebook Group. In other word, this system can be applied both for synchronous interaction as well as asynchronous data retrieval. Finally, the proposed model was evaluated by means of a two-hour task-based assessment and a user-satisfaction questionnaire by ten postgraduate Iranian students at the University of Essex and the University of Manchester, the outcome of which was enormously promising.

Keywords:

Web 2.0, Social Network Groups, Learning System, 3D Virtual Collaborative learning Environment, Human-Computer Interaction, Usability Evaluation

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Chapter 1 :
Introduction

Nowadays, Web 2.0 applications are part of many people's lives. Online Social Networks for communication purposes such as Facebook, Twitter, Google+ or knowledge-sharing Wikis such as Wikipedia are well-known examples of Web 2.0 technology. At the heart of understanding Web 2.0 technology is the concept of Interactions. In other word the gap which had been found between the users and Sir Tim Berners-Lee's invention, Web 1.0, was filled with this technology. Web 2.0 applications have come to emphasise the users as new content of the system. Furthermore, Web 2.0 applications caused a rapid transmission of the messages among its users. For instance, news the East Azerbaijan earthquakes of Iran in 2012, before being announced by other media such as news agencies, was spread by Twitter users via hashtags[1]. Therefore, it can be seen how Web 2.0 applications can be widely used tools for the distribution of information and knowledge. The transfer of knowledge is organised into two major categories: the explicit knowledge and tacit knowledge. The former is based on a straight process of learning from available content; however, the latter is gained from the conclusion of a discussion. These two types of knowledge transfer can be supported by different applications in Web 2.0.

Additionally, Web 2.0 has affected online learning systems. E-learning 2.0 is derived from the combination of Web 2.0, legacy learning system and human factors. One of the most significant current discussions in learning systems involves the design of a web-based collaborative learning environment to meet learners' needs. Many kinds of these systems have been implemented and assessed by users in terms of usability and effectiveness. In this project, the author aims to propose a model of collaborative learning system to support both aspects of knowledge transfer.

The proposed model is composed of a 3D collaborative learning environment and a Social Network. On the one hand is a 3D collaborative learning environment which has been widely investigated by the researchers. It is worth mentioning that these papers will be reviewed in the next chapter. A 3D collaborative learning environment is generally known as a game-based environment with academic goals. This environment provides some facilities for students and teachers to collaborate with each other such as voice interaction and text-based interaction.

On the other hand is Social Networking, which is known as one of the most important applications of Web 2.0. In recent years, there has been an increasing interest in this field and a number of articles have been published. Social Networking is identified as a social structure of nodes which have some direct or implicit relationship. A Social Networking community is defined as certain nodes sharing a common interest. Therefore, this community can be an academic-based community, and its members may be the learners and tutors.

So far, however there has been little discussion about the effect of Social Networking on students' lives, and no individual investigation has been found into the integration of a content-based community in a Social Network with a 3D collaborative learning environment, which is

[1] Hashtag (#) is used to emphasis on a unique term as meta-data. It is common in Web 2.0 applications such as Social Networks or microblogging.

recognised as the most interactive environment for learners. This dissertation seeks to address the gap between explicit and tacit knowledge in the 3D collaborative learning environment by introducing the abovementioned integrated system.

The primary goal of this study is to evaluate the features and effectiveness of a Social Networking community within a 3D collaborative learning environment to discover the role of community-based activities in the learning process. For this purpose, I have chosen a Facebook group with academic members as an example of Social Networking communities, and the Open Wonderland platform as an instance of 3D collaborative environment. Learners can discuss the Facebook posts, add their comments via the 3D environment and also talk with each other through this environment. A Facebook group is used as a repository of the content, since all of the comments should be automatically added to the corresponding post in a group. Furthermore, the more advanced proposed system has the ability to record voices and text conversations and save them to the Facebook as a file. The significant advantage of this system is the availability of content in a well-known Social Network as well as the use of a 3D collaborative learning system. Therefore, it can increase the pace of accessibility and reduce learner anxiety. Moreover, it allows users to gain tacit knowledge, since it provides real-time communication in different ways, as well as explicit knowledge since it records the interactions and enables non-real-time interaction.

The reminder of this dissertation is organised as follows. Chapter 2 will explain the background and a brief history of Social Networks as well as the 3D collaborative learning environment. In addition, the critical literature review will be provided in this chapter. The founded gap within the literatures led the author to create a prototype of the proposed system. Chapter 3 will suggest a hypothesis and a methodology. Chapters 4, 5 and 6 will be designed from a software engineering point of view. These chapters will begin by laying out the requirements of the proposed model. Also, the legal issues concerning tools and platforms will be clarified in Chapter 4. Chapter 5 will look at how the proposed system is analysed and designed. Many diagrams and architectural models will be illustrated in this Chapter. Afterwards, the implementation process and deployment of the proposed system will be fully elucidated. The procedures, tasks, and results of the evaluation will be presented in the Chapter 7. The final chapter will offer the conclusion and suggestions for future work. Moreover, the user documentation and a questionnaire will be provided in a supplementary section.

Chapter 2 :
Background and Literature Review

This section is a literature review of collaborative social media, particularly for educational purposes. The goal of this review is to highlight the effect of Social Networks on the students' lives and also to evaluate some collaborative aspects in the 3D learning environment. This section is divided into two major subcategories: Social Networks and Collaborative 3D Learning.

2.1 Social Networks

The term *communication* has the Latin root *communis*, meaning to share, and is used to represent the exchange of information between the information sender and its receivers. This information can be in oral or written form. One of the most powerful tools for establishing the communication is the Internet

2.1.1 Web 2.0 Background

The past two decades have seen the rapid development of the Internet in many aspects. The first systematic study of the World Wide Web was reported by Sir Tim Berners-Lee in 1989. In his investigation, WWW[2] was found to cause globalisation. This proposed model was based on static Webpages which provided the information for browsing without user interaction. Web developers used the HTML[3] language to create a website since it matched with an HTTP network protocol. This massive effort is documented in CERN, an international high energy physics research centre near Geneva, by Berners-Lee [2].

The problem with Berners-Lee's approach was that it failed to take interaction between users and webpages into account. The gap between the users and website is filled with the idea of Tim O'Reilly [3]. One of the well-known slogans in computer science supporting his opinion is "The user is the content". The other supporting evidence for the abovementioned recommendation was shown by The New York Times when they selected *'YOU'* as the person of the year in 2006 [4]. The result of this study opened a new area in Internet technology called Web 2.0.

Herbert Marshall McLuhan, the Canadian philosopher, coined the phrase '*Global Village*' to represent the world. He assumed a perfect world as a small village in which its citizens are linked together through electronic media [5]. In consideration of this statement, it seemed Web 2.0 could increase the pace of globalisation since it supported the 'Users' more than previous systems and they could communicate and interact easily.

2.1.2 Web 2.0 Applications and Communities

Interaction is at the heart of Web 2.0. Ractham and Firpo stated that peoples can converse, collaborate, and share their knowledge [6]. All of the abovementioned actions required an

[2] World Wide Web
[3] HyperText Markup Language

interaction between two or more users. Therefore, it was possible to implement certain software products over the Internet called Web 2.0 applications. Mavromoustakos and Papanikolaou grouped the Web 2.0 applications into three principal categories with regard to user interaction. The first category consists of content-management platforms such as Wikis; the second one consists of experience sharing such as tweets and final category is online logs such as blogs. They suggested that all of these types could be compounded as one combined program called a Social Network [7]. In the following section, these three categories will be explained briefly.

Bo Leuf and Ward Cunningham in 1995 introduced wiki for the first time [8]. The term is taken from of the Hawaiian word *'wikiwiki'*, which means 'quick and speedy'[4]. A wiki is an application of Web 2.0 for helping users create, edit, revise or link articles. One well-known example of wiki systems is Wikipedia. An investigation by Voss in 2005 showed that Wikipedia had more than 4 million articles in 100 languages [9]. Hence, Wikipedia was known as the most popular encyclopaedia in the world.

Weblog was a bare plan originally coined by Jorn Barger in 1997 [10]. It recorded the information from each member and presented them in reverse chronological order [11]. The mechanism used for Weblog was LIFO[5] or a stack-based algorithm. The abbreviated term *blog* can be applied both as a noun and a verb. The user who makes the message is known as a *blogger* and the action of writing a new post is called *blogging*, which is derived from the expression 'Web-Logging' [7, 12].

Personalisation and usability were identified as the two critical success factors for weblogs by Paquet [11]. The former is related to the content creator or blogger and his correspondence with audiences, and the latter investigates how the system is easy to use with regard to the HCI[6] viewpoint. Since regular users do not have a strong technical background in computer science to create new content, usability is one of the most significant issues in the Web 2.0 applications. In other words, the process of creating a new message or editing the existing one should be sufficiently easy for the users.

However creating a weblog can be a simple action, collecting the valuable information might not be easy as a production process when the load of information is presented [7]. The RSS[7] technique was introduced to solve this problem. RSS is used for reading the new published posts from the target source. It is a web format and uses an XML-based structure in order to be a platform independent technology. Time saving is the main feature of using RSS because the user does not need to open the target website. Moreover, the search function can help the reader to retrieve the desired information without wasting his time. Nevertheless, the privacy of the

[4] http://goo.gl/jfqjX
[5] Last In First Out
[6] Human-Computer Interaction
[7] Really Simple Syndication (Originally: Rich Site Summary)

content can be a problem in the weblogs. Mavromoustakos and Papanikolaou raised their concerns regarding this issue since they believed that bloggers and readers had some legal liabilities for the content such as the issue of confidentiality [7]. In support of their idea, Ebner considered the blog as a personal application with more liability issues while Wikis were suitable for collaborative tasks such as group documentation for a specific title [12]. Therefore, Barger's proposal might have been more interesting if he had considered group-centred services as well as the individual-centred one.

There is an unambiguous relationship between Web 2.0 applications and groups of people with common interests. Sørensen and Skouby in 2008 showed that there is no obligation for the type of material in the mentioned applications. It can be varied from professional knowledge to an individual diary. Nevertheless, more valuable content type is the user who generates it [13]. Moreover, a group of people who informally discuss and share their experiences is called a community of practice by Wenger et al. [14]. Hence, Web 2.0 applications could be a potential tool for supporting this feature. In summary, none of the previously mentioned tools were comprehensive since some of them were individual-centred and they did not pay enough attention to the group-centred activities such as a blog and also vice versa, wiki for instance. Consequently, Social Network Services were introduced to integrate these two types of activity.

A considerable amount of literature has been published on the Social Network. Liccardi et al defined this term as a social construction of nodes which have isolated and organizational characteristics and there are some relationships among them inside the specified domain [15]. Alani and Goecks classified these relationships into two broad types including strong or formal relationships and weak or informal one [16, 17]. The former one is used for the direct connection between two nodes, however, in the latter connection there is at least an intermediate node between those two. The algorithm to expand the network with the use of intermediate node is called *Friend of a Friend* or *Neighbouring Matchmaker* by Hamasaki [18]. Although this mechanism is not strong enough to guarantee the privacy and security, it is a reasonable approach for communities to extend their network.

In the last decade, there were some online communities such as Theglobe.com and Tripod.com [19]. Most of them were based on the user interaction in a limited way such as chat. In 1994 Geocities, which was hosted by Yahoo!, provided a free web space for each Yahoo! members. A Social Network Service is an online community which specifically represents the structure of nodes and their connections [20]. Throughout this dissertation, the term Social Network will be used to refer to the Social Network Service. Romm-Livermore and Setzekorn claimed that user profile is one of the most impressive features in the Social Network [21]. Besides the profile, how to handle friends is another significant functionality of Social Networks. The investigation of Steve Rosenbush in 2005 highlighted the popularities of Social Networks among other websites since MySpace had more page visits than Google [22].

In February 2004, Mark Zuckerberg with his colleagues Eduardo Saverin, Andrew McCollum, Dustin Moskovitz and Chris Hughes implemented a new Social Network for Harvard students [23]. After a while, they extended their approach to include more Universities and colleges. Facebook was known as the most popular Social Network around the world, due to Kazeniac's study in early 2009 [24]. Furthermore, Facebook has been ranked the second most popular website, according to the Alexa Web Information site at the end of July 2012 [25]. An article, written by Nicholas Carlson in Business Insider stated that Facebook had more than 901 million monthly active users [26] while this figure had reached 1,087,452,160 by the end of July 2012, reported by CheckFacebook.com [27]. Therefore, if we consider that the world population is 7,030,033,879 (reported by World POPClock Projection[8] on 1st August 2012), then more than 15% of world's population have their own Facebook account.

This evidence shows the acceptability of the Social Network and in particular Facebook among other websites. It seems Social Network with its remarkable features such as communities or groups can be an attractive tool for integration with other systems to implement the strong collaboration among its users.

2.1.3 Social Networks and Learning

As discussed before, communication caused an enormous improvement in IT[9], especially in the World Wide Web. Similarly, it has an undeniable role in the learning environment since Biström suggested more communications between students and their instructors may increase their academic performance on both sides [28]. Therefore, communication and more precisely interaction is the intersection point between Information Technology and the learning environment.

Nowadays, Social Networks have become a part of students' lives, and it is extremely difficult to ignore their impact on the majority of students. They interact with their classmates as well as their teachers in this environment, however, most of the time they consider non-academic issues such as friendship or events. Furthermore, they form a community for their classmates with the name of the institute or the title of their subjects and maybe the year of entrance. For instance, at the University of Essex, there are several groups on Facebook, Twitter and LinkedIn for different students. University of Essex[10], University of Essex Computer Science and Electronic Engineering[11], University of Essex Fresher 2011[12] are three examples of this kind of group within the Facebook environment; nevertheless, there are no academic posts in those groups. Therefore, one question that needs to be asked in those environments is how students can find

[8] http://www.census.gov/population/popclockworld.html
[9] Information Technology
[10] https://www.facebook.com/uniofessex
[11] https://www.facebook.com/uni.essex.csee
[12] https://www.facebook.com/UniEssexFreshers

the right group to join others and collaborate with other members for solving their problem effectively. This important question was argued by Licardi et al. at the Innovation and Technology in Computer Science Education conference in Dundee [15].

Furthermore, Breslin described other functionalities of Social Networks including network of friends, profile, sending a private/public message, forums, managing events, writing a blog and sharing media [29]. All of the mentioned functionalities are required to have a comprehensive learning system. Rodrigues et al. proposed a model for illustrating the interaction between a learning system and Social Network [1], which has been shown in Figure 2-1.

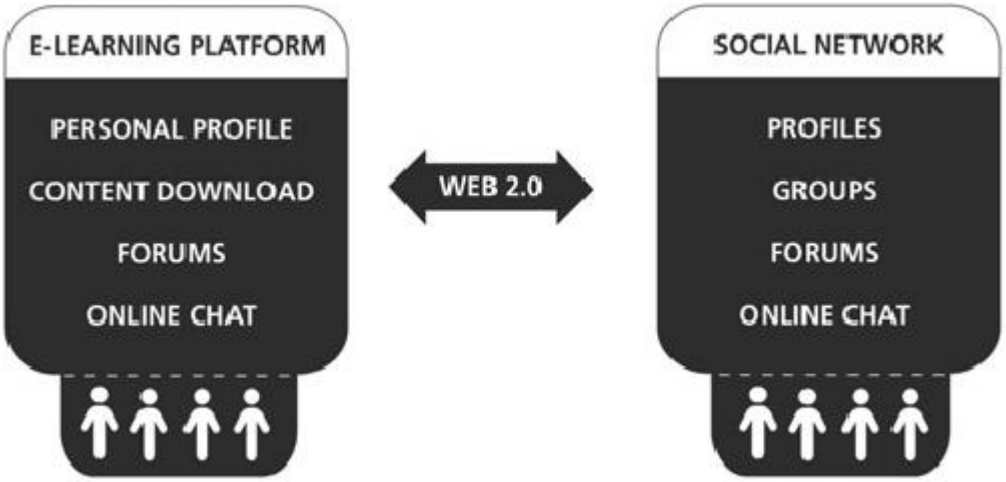


Figure 2-1 Interaction between the Learning Environment with Social Networks [1]

To summarise the discussion, it is concluded that Social Networks are applications for communication that can be used in the education system. A strong relationship between Social Networks and the Collaborative Learning Environment has been reported in the literature.

2.2 Collaborative 3D Learning Environment

Karl Marx in 1867 was apparently the first to use the term *collaborative works*. He defined this expression as a procedure to produce a plan in which some individuals worked together [30, 31]. Moreover, Lipponen has provided further explanation of collaboration since he defined this word as a co-construction of knowledge with communal commitment among the partakers; therefore, collaboration can be a reasonable solution for group activities, peer interaction and sharing and dissemination of knowledge which are used in the learning environment [32, 33].

Accordingly, this part of the dissertation provides a brief overview of the history of learning systems. Then, it reviews the needs for collaborative learning environments and 3D collaborative learning environments respectively.

2.2.1 E-Learning Background

The procedure of acquiring the knowledge or the skill is generally known as a learning process. This process can be carried out regardless of time and place [34]. Many educational tools such as PowerPoint presentations or listen again facilities were provided by Information Technology to make the learning process independent of these two limitation factors. However, this approach supported the reusability issue which was one of the most fundamental aspects of the design discipline. It offered no solution for availability and distribution of these contents.

The web-based e-learning[13] system (also known as web-based teaching system) was presented as an alternative approach to the traditional method which was based on physical classrooms and contents. Although it has the some similar paradigms to the former method, all of the contents were available on the particular website. Therefore, this method could solve the abovementioned problem since the contents were accessible for all students and teachers over the Internet.

This approach had some further advantages. For instance, since the Internet had become widespread enough in developed countries, there was no need for additional infrastructure for the implementation of this kind of learning system. In addition, most of the new technologies are based on the Web. Consequently, using web-based e-learning could enhance some other aspects of e-learning such as portability. A well-known example of this kind of system is the mobile-based learning environment. Malik et al. proposed a portable learning system with a Bluetooth-based e-learning facility [35]. Moreover, the web-based e-learning system could meet some of the requirements for disabled students since they need more attention and more time to deal with their problems. Bruno et al. investigated an adaptive learning system for deaf students published in [36]. In summary, using a web-based learning system makes the learning process closer to its definition provided in 2.2.

Sumathi classified e-learning systems into four categories. The first two groups were defined for the self-learners. The first group used offline educational content such as CDs which were provided by others, while the latter was based on students who found the mentioned content on their own. Most of the time, they used online content which was retrieved from the Web. Similarly, the remaining groups were Internet-based. However the significant difference between these two categories was real-time interaction. Therefore, non-real-time e-learning systems were grouped together as the third category while the fourth category consisted of real-time e-learning systems such as audio/video conferencing [37].

In conclusion, the latter two groups alter the teaching methods since students collaborate with each other and their tutors over the Internet, and there is no restriction on the physical classroom. In this procedure, the knowledge is generally gained by sharing experiences in some

[13] Electronic Learning

collaborative tasks. Biström in [28] argued that this kind of learning system constructs a new area of the learning environment called the Collaborative Learning Environment.

2.2.2 Collaborative Learning Background

The term *collaborative learning* is used by Apostolos to refer to an educational exercise which is based on the real-time cognitive and mental effort of diverse students who have common objectives and are equally liable for their achievements [38]. However, Johnson & Johnson's definition focused on the level of learning. The CL[14] for them has been applied to situations where students work within small groups and collaborate with other group members to maximise their academic performance [39]. The other discussion was raised by Holzinger in [40] and Weiss in [41] and is related to Lack of Interaction, which is known as a failure point for collaborative tasks such as learning. They believed that more interactions caused more motivation among the learners.

Furthermore, John-Steiner defined CL with regard to social interaction [42], since the basic principles of CL argued by Vygotsky and Piaget [43-45] are based on this factor. Additionally, CL and Identity are considered as two research variables in Mead's Social Act Theory [46]. Wang and Burton reviewed this theory and stated that Mead's theory is a part of social learning theory in which the learning process is introduced as a consequence of social interaction [47-50]. Lytras in [51] and Pouladi in [52] demonstrated that e-learning would have been more persuasive if it had considered social interaction. Wang and Burton concluded three failure parameters for the CL from the social interaction viewpoint [50]. The first was '*group tension*' which had been studied by Smith in 2005 [53]. The second constraint was pointed out by Barron in [54] and Nuthall in [55] which was called '*perceived group statuses'*. Finally, the last limitation was '*social loafing*', considered by Salomon in [56]. The last limitation has been argued by Karau and Williams as a situation in which an individual's effort is not enough to achieve the ultimate group's purpose and may potentially cause some negative effect on other members [57]. All the studies reviewed so far, however, suffer from the fact that group members need to achieve their goal even if one of the members does not make a sufficient contribution. In this case, the mentioned member would receive the credits because other members would have to compensate for his laziness. This drawback is known as the '*free-rider effect*' and was investigated in [39] and [58]. It seems that the existing accounts fail to resolve the contradiction among a group of people, social interaction and task allocation. One of the possible reasons for this fact can be a lack of attention to group activities in the current educational system.

Therefore, interaction is the main component in Collaborative Learning, and consequently it plays a key role in e-learning systems. As well as interaction, social and human factors are significant in the mentioned systems. In the next section, these two elements will be assessed,

[14] Collaborative Learning

and some of the existing e-learning systems will be examined. This review shows the importance of integrating social media in the learning environment.

2.2.3 Collaborative Learning Systems

In the section on the Web 2.0, this technology was introduced to fill the gap between the users and systems. In other words, it enhanced the interaction between these two components. It is possible to consider Web 2.0 applications such as weblogs as communication media. Therefore, integrating traditional e-learning with Web 2.0 technology resulted in a vast improvement in web-based learning systems. Ebner named these kinds of system as the first version of web-based e-learning. He classified these systems into two broad types in terms of synchronicity. The famous examples of asynchronous systems are emails and forum-based learning while for synchronous systems, there are chat and online conferences.

One of the most respected models in the first version of e-learning was the Learning Management System abbreviated LMS. In this system, the high quality contents were usually provided by tutors and were accessible via the Internet for the learners. However, these systems were not strong enough to satisfy their users. Students had to download the contents and read them via the screen or printout. Therefore, the motivation factor, which is related to the interaction, had been lost among the learners. The more interactive system was highly appreciated, as users were able to discuss the materials and contribute their own comments.

The more advanced LMS had some features for communication in both synchronous and asynchronous ways. One well-known example of real-time communication is chatting and for non-real-time communication there is the commenting facility. Furthermore, interactive exercises and online quizzes were added to support all of the events that may occur in the physical classrooms. This has been done with the help of Web 2.0. Moreover, integration of the LMS with Web 2.0 application such as Wikis and Social Networks resulted in more interaction between learners and teachers.

One of the famous Learning Management Systems is Moodle. A large and growing body of literature has investigated Moodle's features. Moodle has certain features to add information to the courses. This information can be in the form of text or files. Furthermore, the assessment processes and techniques are usually mentioned in Moodle with a repository for past exam papers. Course materials, such as presentations and examples, and homework distribution are two regular features for most LMSs. In addition, a discussion forum, private messaging, blog and the user's profile are provided for Moodle users.

In 2011, Mchichi et al. proposed a new Moodle-based learning system with a built-in forum, blog and Wiki [59]. Also, they used YouTube, Flickr and Twitter for multimedia and knowledge-sharing purposes. The aforementioned applications are examples of Social Media.

Therefore, the authors believed that using these types of application could enhance the academic performance of students and teachers alike. The high-level architecture of their recommended model is shown in Figure 2-2.

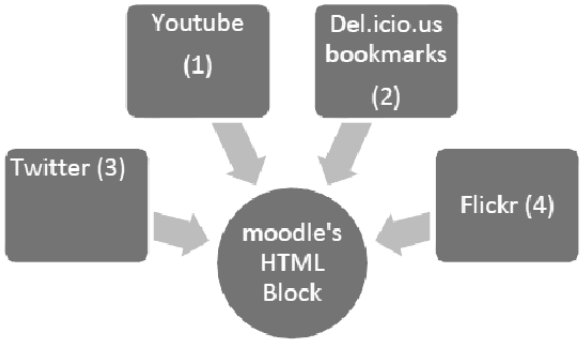


Figure 2-2 Mchichi et al.'s Moodle-based model [59]

In summary, the additional functionalities of their system may be divided into four categories. Using Google AJAX[15] search API[16] enabled online video streaming for their system via YouTube. This feature has been shown as (1) in the above figure. The deli.ico.us bookmark facility[17] which is indicated by (2) could be possible in various techniques including tagroll or links group. The third category is based on Twitter (3) users and their status. Finally, Flickr (4) users can use a Flash Flickr widget and Flickr RSS feed to share and upload their pictures. These kinds of interaction led the researchers into a new discipline of the educational system, which has been called e-learning 2.0 or the second version of e-learning systems.

Stephen Downes was apparently the first to use the term e-learning 2.0 in 2005 [60]. In his article, he stated that Web 2.0 technology is more than a technology since it is a social revolution. Jafari et al.'s investigation in 2006 showed that e-learning 2.0 is much smarter than the previous system since it works similarly to the MashUp technology [61]. They argued that the ultimate goal of e-learning 2.0 is to combine the social factors and a learning environment in order to have a unified learning framework. Similarly, '*learning curve for the idea itself*' and '*time to realize*' were introduced by Ebner as two reasons for the success of e-learning 2.0. He used Dave Pollar's ideas for his conclusion.

Dave Pollar stated the e-learning systems from a stakeholders' viewpoint. He suggested e-learning systems must be accomplished by all of its users including teachers as well as learners. He argued his idea with some questions in his blog such as '*Let other people edit my document?*' [12]. Furthermore, he studied the power of new tools and their impact on people's lives. This is the key point to show the importance of 'time' in the technology.

[15] Asynchronous Javascript And XML
[16] https://developers.google.com/web-search/docs/
[17] http://googlemodules.com/author/Carlos+Andres+Osorio/

Ebner considered Pollar's idea since he pointed to time as the second success factor for e-learning systems. He believed that any cultural change needs sufficient time to become stable; thus there is no exception for the culture of education. Therefore, we do not expect all students and teachers to use e-learning systems.

However, Ebners's model seems to be more desirable since he focused on social aspects as well as interactions. Finally, he concluded that the next version of e-learning is a function which is derived from three parameters including the first version of e-learning, Web 2.0 and Human Factors. His formula is shown in Figure 2-3.

$$e - Learning\ 2.0 = f(\ (e - learning\ 1.0)\ , (Web\ 2.0)\ , (Human - Factors)\ )$$

Figure 2-3 Ebner's Formula for e-learning 2.0 [12]

2.2.4 3D Collaborative Learning Environment

Nowadays, video games are extremely popular among students. Because of this attractiveness, most students are familiar with the 3D environment. They can quickly find out how to walk or how to hold an object in this kind of space. Dafoulas stated that students who play video games can navigate in most virtual environments [62]. The Federation of American Scientists has heightened the influence of video games in learning aspects [63]. They argued that some skills can be gained through the gaming environment. For instance, there are many games that require strategic thinking as well as problem solving abilities, or maybe they need convincing interpretative analysis.

Liarokapis et al. suggested a game-based learning model for e-learning systems. However, they proposed a classroom-based learning system which was dependent upon the video games [64]. Bronack et al. criticised the model that Liarokapis et al. had suggested from their findings [65]. They believed that the 3D virtual learning environment is not comparable to the traditional class-based learning system because it can make more opportunities for learners to explore the virtual world and likewise allows them to choose their own path through the 3-Dimensional space. Therefore, integration of the Virtual Environment and Collaborative Learning Environment is one the most significant current discussions in the subject of e-learning. Furthermore, the architecture, design and implementation of this kind of system has been investigated by many researchers, such as Bouras and Tsiatsos in [66], who focused on the multimedia virtual system; Tegos et al. in [67], who focused on the multi-user functionality and X3D technology for the representation of the virtual learning systems; or Kao in [68], which is mainly based on access grid technology for the mentioned systems.

The relationship between social interactions and collaborative virtual environment has been widely investigated by de Freitas [69]. Correspondingly, Constable has defined the 3D virtual world as a game-like online environment which has social media functionality as well as a

learning goal. However, the actions, activities and rules required to achieve this goal may be different with the game-based software [70]. From these two literatures, it seems that this kind of system can support social interactions. Because of this argument, Shipin et al. have considered virtual learning as a sub-category of social media under Web 2.0 applications [71]. They explained social media as a network media which follows Web 2.0 rules with the social inter-personal interactions tools.

Since collaborative virtual learning systems strongly support user interaction, the idea of using this method as an experiential learning environment was offered by Jarmon et al. in [72]. In his study, Second Life was considered as an instance of a virtual learning environment. Second Life is a popular example of collaborative virtual environments. Many organisations are using this platform for their virtual offices. AOL, Dell and Reuters are well-known examples of these companies. Second Life has an easy scripting language (Linden Script Language, abbreviated to LSL), for making a new interactive object or modifying existing ones [38]. Bedford et al. suggested Second Life as a virtual learning platform in which real-time interaction is possible. He identified three groups based on real-time interaction: experiential activities which were reviewed at the beginning of the paragraph, project-based activities and community-based activities [73], which were discussed in the previous section.

Several attempts have been made to clarify the advantages of collaborative virtual learning systems. Dong et al. listed two factors in this issue with respect to culture of communication among the learners including, making opportunities and simplifying social interaction as well as communication and reducing social nervousness [74], since the pressure of face-to-face conversation may be reduced when it forms as online communication.

Apostopolos et al. added the incentive aspect of creating *a cognitive model* from complicated or *abstract material* [38]. They believed that creating and using graphical content can be more enjoyable for teachers as well as learners. Furthermore, using these kinds of tools can help teachers to use tangible examples for their intricate problems. Likewise, Chen et al. have identified the visualisation of teaching materials and the relationship among the learners as a major strength of these types of system [75]. However, Prasolova-Førland has argued that the methods used to determine the appropriate topics in the 3D environment for visualising and simulating the contents can be a challenging task [76].

The benefits of collaborative virtual learning systems for the disabled student was investigated by Müller and Koubek [77]. In addition, the safety of the environment and reducing the expenses and time of learning were pointed out by Settapong et al. in [78]. Furthermore, Jaligama and Liarokapis have found that using the learners as an active participant in the learning process can help them to improve their sense of responsibility particularly, in higher education [79]. Moreover, the recent study of the relationship between collaborative behaviours and team performances heightened the importance of using a collaborative virtual environment in group-

based tasks to enhance performance [80]. It is worth noting that this project is aimed at understanding the effectiveness of conducting the collaborative group-based tasks in a virtual environment. However, these tasks are based on functionalities that are carried out in the community of a Social Network.

Lastly, one of the most fascinating features of the virtual worlds is an avatar. Kim introduced the avatar as an online appearance of each user in a virtual world [81]. It can raise the level of interaction among the online users. Usually, an avatar can be made by consumers of the virtual world in their own style. Although fashioning an avatar is one of the most exciting parts of 3D spaces, the default avatar is ready for the impatient users. Also, with the help of an avatar, a user can walk through the 3-dimensional spaces via input devices such as a keyboard. They can figure out the objects in the virtual world and use them in an interactive manner. It seems that an effective avatar can illustrate the mood of the user. Peterson defined an avatar as a user-controlled tool for representing emotional reactions such as sadness [82]. Additionally, he argued that avatars should execute some personal gestures such as shaking hands in order to be more interactive with other avatars. Since learning is a kind of interactive activity, an avatar can be used to enhance this factor.

In summary, the 3D collaborative learning environment with its special features such as text-based chat, voice chat and avatar can be a good choice for the learning system since it provides some opportunities for interaction among its users. However, it can increase anxiety among users who are not familiar with the new technologies. Furthermore, connecting to the 3D world requires more resources such as time and bandwidth than 2D applications. On the other hand, since Social Networks is identified as the most widely-used application on the Web, and Facebook is known as the most popular Social Network, it seems that using this platform can spark more enthusiasm among the students for the learning process. To have a more comprehensive learning environment it can be argued that integrating a 3D collaborative learning environment with a well-known 2D application might be accepted by a broader range of users.

Chapter 3 :
Research Approach

The literature and current state of knowledge in two subjects including the Social Networks and 3D Collaborative Learning Environment have been reviewed in the previous chapter. This chapter begins by laying out the theoretical dimensions of the research, and addresses the gap between these two cases. The section begins with a hypothesis. It will then go on to describe the methodology used for this research.

3.1 Research Hypothesis

In reviewing the literature, a little investigation was found into the association between a social network and a 3D collaborative learning environment. However, a strong relationship between these two has been reported.

Social Networks are defined as online platforms illustrating the relationship between their members and enabling some kind of interaction for them such as the facility to comment. Social Networks are one the most important applications of the Web 2.0 technology.

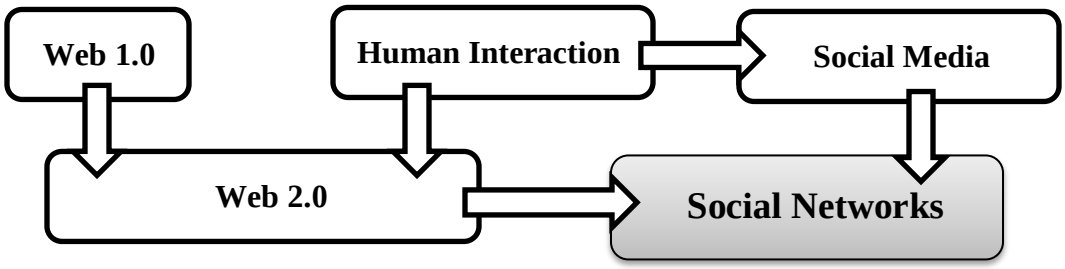


Figure 3-1The Social Network's Factors

Moreover, Web 2.0 technology causes a huge improvement in learning systems. The lack of interaction issue was solved with the first version of web-based learning. However, this system suffered from some serious limitations resulting from ignorance of human factors. Therefore, the second version of e-learning was introduced to consider the human factors as one of the most significant aspects of such systems.

In addition, video games were defined as one of the most widely used tools for the students. Surprisingly, these kinds of tools were found to increase the rate of thinking among their users since they force the users to discover a certain solution to achieve their goals. This factor was known as a type of assessment. On the other hand, the past decade has seen the rapid development of virtual environments which are very similar to computer games.

Therefore, using the virtual environment as a learning system could have a number of attractive advantages including increased interaction among the users, which raises enthusiasm and motivation, and the provision of a more attractive environment for students and teachers alike, since they like to play the video games and they can quickly understand how to deal with the virtual environment and how to discover its features.

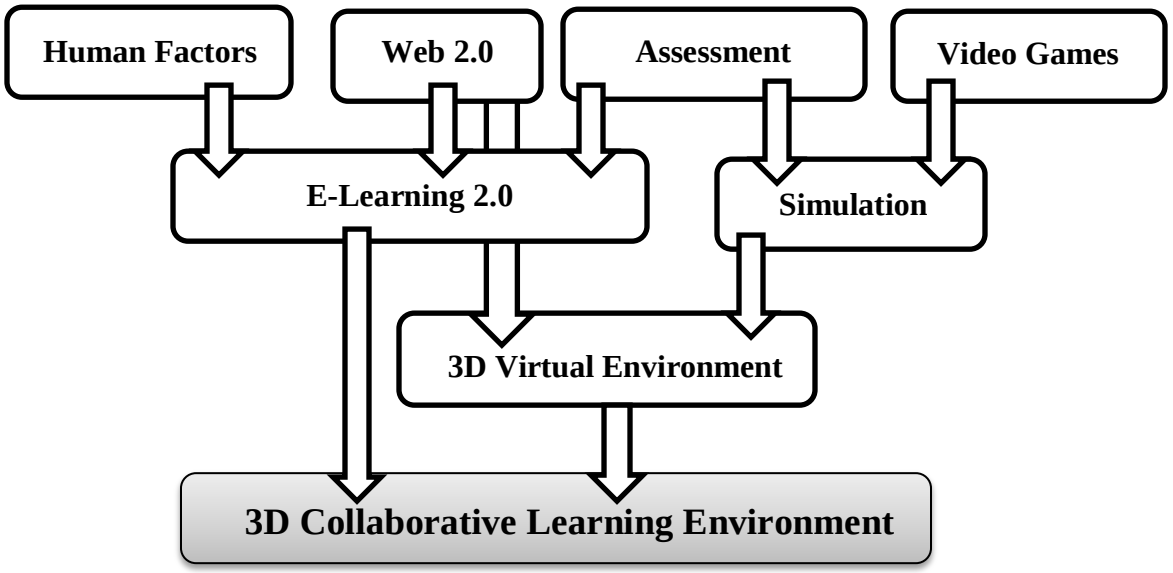


Figure 3-2 The 3D Collaborative Learning Environment's Factors

There are many common factors in the two figures above, such as Web 2.0 and human effects including human factors and human interaction. If the intermediate levels in Figure 3-1 and Figure 3-2 are ignored and these two diagrams are merged, the following diagram can be arrived at.

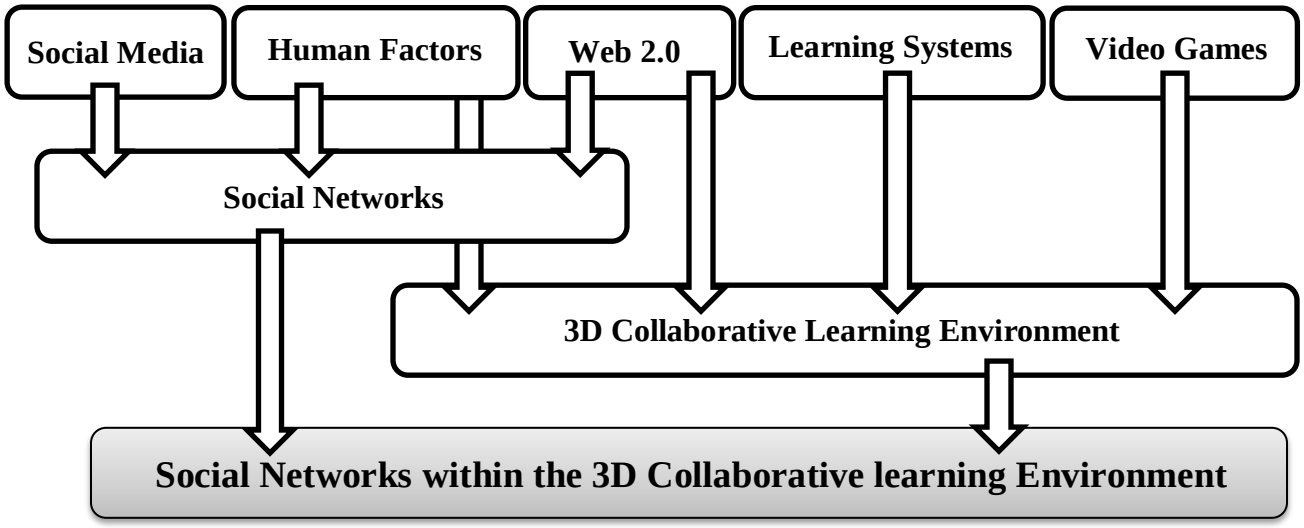


Figure 3-3 The Gap between Social Networks and 3D Collaborative Learning Environment

Hence, it could conceivably be hypothesised that:

> The integration of a Social Network Group or Community into 3D Collaborative Learning Environment can better meet the learners' need for collaborative tasks such as discussions.

3.2 Research Methodology

From the previous section, it has been concluded that the integration of Social Networks with a 3D collaborative learning environment can be more effective for the learners. However, it is better to narrow down the hypothesis to discuss the usefulness of a community or a group in a Social Network within the virtual collaborative learning environment.

A community consists of many members who have common interests and a specific goal. All of the members have some particular tasks and activities which must be carried out in order to achieve an ultimate goal. If the members of a community are distributed around the world, they will use a network for communication. With the evolution of Web 2.0, communication among the users can be established on the Internet. This type of community is known as virtual community and can be found within Web 2.0 applications such as Social Networks. Since the final aim of the students is identical, it can thus be suggested that it is possible to use a community or a group of students within Social Networks with an academic purpose. For example, it is possible to find a group of students who attend a specific subject/year in a specific University.

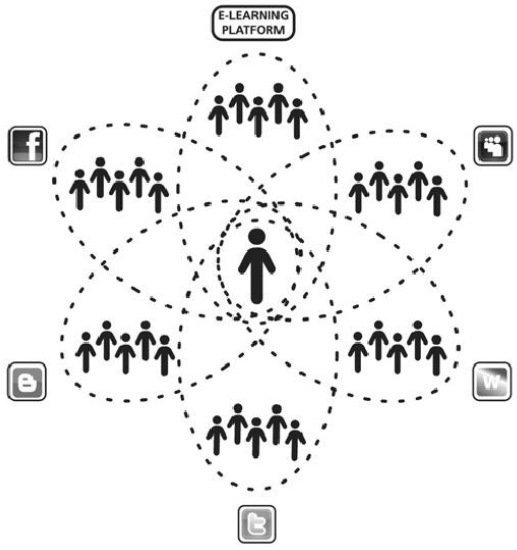


Figure 3-4 Sketch of Web 2.0 community [1]

So far, the integration of a social network and learning platform has only been applied to 2-dimensional and non-real-time learning environments. However, this study set out with the aim of assessing the importance of Social Networks in 3D Collaborative Environment.

It should be noted that knowledge can be classified in terms of learning process into e*xplicit knowledge* and *tacit knowledge*. The former is a kind of knowledge which can be transferred from one person to another explicitly via audio-visual tools. However, the latter is used when knowledge is gained within a discussion or through other indirect means. Although using tacit knowledge is more challenging than using explicit knowledge, it can be more effective since it requires more thought before being accepted. The methodology which is used to integrate a group in a Social Network within the virtual collaborative learning environment seems to cover both of these two types of knowledge since it supports document-based learning as well as real-time discussions.

In this proposed model, students can interact in different ways to gain knowledge. All users have a dual identity including a Social Network profile and 3D collaborative learning username. They

can use the chat facility to send direct messages to others in a 3D learning environment. However, when they participate in a particular discussion they can add their comments on the specific title. Commenting is one of the most important features in Social Networks. The difference between these two facilities (chat and comment) is that chat can be non-goal-oriented, while comments are used to expand a particular domain and must have a specific goal. Furthermore, our proposed model allows the users to talk to each other via the collaborative learning facility. These conversations should be goal-oriented since all of the users are members of a specific academic group. Therefore, this model increases the rate of interaction among the users and this factor may cause the growth of motivation and original thinking and consequently might be an important reason for enhancing the learning of tacit knowledge.

Regarding explicit knowledge, users can access all kinds of documents via the system. The source of the documents is in the Social Network, so they can load them in the 3D spaces. In other words, the Social Network is assumed as a repository for the learning content. This content can be in forms of textual documents, presentations, videos, or even a question or a poll. Moreover, the voice conversation between the users can be recorded via the virtual environment and can be saved into a group within the Social Network.

From the students' view, they can check their classmates' profiles very quickly and gather some information about them since all of the usernames in the collaborative learning environment are linked to their corresponding profiles in the Social Networks. This action can be carried out in real-time by simply clicking on one of the user's posts in the virtual environment. This situation is highly likely in the distance learning environment, where many new students are talking about a new discussion and they have never previously met each other. Therefore, they can quickly browse their Social Network's profile and it may possibly ease and accelerate the introduction process. Furthermore, this model can determine cheating among the students. This feature can be implemented via monitoring the graph of the relationships (also known as network) among the students. For instance, it can facilitate the identification of plagiarism since tutors can see the students' network. Therefore, the tutors' ability to seek the learners' network and identify any suspicious user will help them to find the source of plagiarism. It is worth noting that two people can be in the same network despite not being friends or even friends of a friend.

In this research, one of the variables is a group of Iranian students studying at the University of Essex. This group has been created on Facebook, which has been defined as the most popular Social Network in the world in 2.1.2. The instance of 3D collaborative environment which is used is Open Wonderland. Open Wonderland is an open source pure Java platform which has many ready-to-use modules. However, developers can extend its modules or create new ones. In this research, the second approach is applied since there is no available module for sharing content between Open Wonderland and Facebook. Therefore, the provided prototype has a new module which is called *Facebook Group Integration*.

In order to understand how the proposed system may enhance the learning process, a series of tasks were performed and discussed in the Evaluation chapter. Two evaluation methodologies will be employed to assess the effectiveness of proposed system. The usability evaluation will be applied via a *user-satisfaction* questionnaire as well as *Think-Aloud protocol* and *Focus Group*. Besides, *affordances* of Facebook Group for learning will be discussed in the mentioned chapter.

Furthermore, the methodology which is used to design a prototype is a personalised version of an Agile Unified Process. Despite the fact that AUP[18] is basically a good approach for business process systems, it is selected for the learning system since it is quick enough to produce a basic prototype after three months. RUP is based on the Rational Unified Process which aimes to deal with users' requirements with respect to time and funding. Besides, AUP is an iterative approach; therefore, user feedback and changing the requirements are extremely important in this methodology. Similarly, user comments are greatly appreciated in the learning systems since learners and teachers are the most important consumers of the learning services.

As stated before, AUP is an iterative approach. It has four major phases including inception, elaboration, construction and transition. After these four phases, a draft product will be created; however this artefact cannot be the final product since AUP is an incremental approach and it may need more development cycles before being finalise. The prototype which is delivered at the end of this project is the result of the first increment of the AUP.

The feasibility study and the estimation of time are studied in the inception phase. Although it has a quick look at the software requirements, the aim of this phase is not to outline all the requirements. In business projects, the artefacts of this phase are the primary use case model and the vision document. However, in this project, the artefact of this step changed to the proposal document which was submitted on 23rd March, 2012.

The second phase of the AUP is elaboration in which the draft architecture of the first version of the prototype is produced. The requirement specification and use cases are completely defined in this phase. In the construction phase, a working version of the software will be delivered. However, the functionalities of this model are limited to the highest-priority. Moreover, the deployment of the system and user evaluation will be carried out in the transition step. All of these three remaining phases have been documented in this dissertation.

[18] Agile Unified Process

Chapter 4 :
Requirements Specification

In the research approach, it has been stated that a new prototype will be developed to evaluate the effectiveness and acceptance of our proposed system among the learners. The first step to design a new prototype is to identify the requirements. This chapter is structured in four sections. The first two sections present the functional and non-functional requirements needed for the development process. Section 4.3 provides a brief description of the platform and the tools used to create a new module. The final section explains the constraints and dependencies that may be faced during the implementation. This chapter is considered as an artefact of the elaboration phase within the AUP methodology.

4.1 Functional Requirements

In software engineering, functional requirements are described as the tangible functionalities of a software system, such as carrying out a particular action. Most of the functional requirements are used to define the use cases. This section will outline the functional requirements of the proposed system. However these requirements are divided into two categories. The requirements in the first category are implemented in the prototype and known as the high-priority requirements, while the second category states the requirements that have yet to be implemented in the prototype but should nevertheless be applied to the final system.

The most important functional requirement of this system is authentication and authorisation. Since the Facebook authentication service is highly rigid, the authentication and authorisation of Facebook group users and permission issues are highly problematic. It is important to note that the Facebook group which is used is not an open group and only its members can see and post items.

After authentication and authorisation, group members can see the posts and comments of the Facebook group within the 3D collaborative environment. Therefore, the second functional requirement can be retrieving the data from a Facebook group in an Open Wonderland environment.

The other functionality of this system is communication features among the learners as well as tutors. Since the proposed system is highly interactive, users can communicate in different ways such as speaking through their microphones and headsets and using the written chat feature which is provided by the Open Wonderland platform.

The ability to add a new post in the 3D world is defined as the last requirement for the prototype. The authenticated user should have permission to add a new post. This can be added to the Facebook group as well as the 3D world. This feature helps the users create a new discussion in the 3D space and use the Facebook group as a repository for their conversation.

Furthermore, the ability to make a new comment on an existing post has been added to this system. This is a significant issue for increasing the rate of interaction in the proposed system. It is possible to state that this functionality is more important than creating a new post, since it increases the interaction between the system's users.

Some other functional requirements are still available for future implementation. For instance, one of the most attractive features for the learners can be recording the voice conversation among the students and saving it to the Facebook group as file content. This can be done via a module within the Open Wonderland platform. With this functionality, learners can listen to their previous conversations. Moreover, this functionality can help the learners through gaining tacit knowledge.

The other important functional requirement can be checking the popularity of content. This functionality may be more important for teachers than learners. They can understand which content is more attractive for the learners and which content does not motivate them enough to initiate discussion. The most active discussion can be called the *hottest*. Although Facebook group policy for ordering posts is newest first (including post and comment), our proposed system must have a feature for users to select which ordering method they prefer – reverse chronology or popularity.

4.2 Non-Functional Requirements

In software engineering, non-functional requirements are described as the qualitative aspects of a software system. Unlike the functional requirements, these requirements are not tangible and usually there is no metric to measure them. However, non-functional requirements are as important as functional requirements. In the following, the non-functional requirements met by the proposed system will be explained.

The most important non-functional requirement in the proposed system is usability. This concept is defined in Human-Computer Interaction as an easy to use system from the user's point of view. Need analysis is a well-known method in usability testing. This method again focuses on the software requirements; however it is based on the end-users' needs more than technical requirements. This non-functional requirement will be evaluated by a group of students who are members of the Facebook group and the result will be illustrated in the Evaluation chapter.

Our proposed system is platform-independent since it runs over an Open Wonderland platform. This platform is a pure Java-based 3D environment; therefore, it is accessible via multiple operating systems. Regarding the legal issue of Open Wonderland, it is worth mentioning that it has an open source license under the GNU[19] General Public License version 2.0. Moreover, it

[19] http://openwonderland.org/about/faq#Licensing

has client-server network architecture. Besides, Facebook policy[20] allows the developers to use a Facebook platform for their applications. However to create an application using the Facebook platform it is vital to have a well-known application engine with SSL[21] certification particularly because of privacy issues. Therefore, our system uses the Google App Engine since this service gives the developer an HTTPS web-based space in which to develop their applications.

The other non-functional requirement is a backup system. Since we are using the Facebook group as a repository, this platform has a very strong backup policy and reliable restore system for its contents. Furthermore, the availability of our proposed system, which is one of the critical non-functional requirements, is based on the downtime of the Open Wonderland server, since Facebook guarantees that the minimum availability of its server is 99.999%. In other words, the maximum downtime of the Facebook server is five minutes per year.

The final non-functional requirement in our proposed system is the documentation issue. The delivery of documents is performed in two steps. In the first step, a proposal document was delivered in which the efforts of the inception phase were explained. The second phase is this document, which is the final document for the prototype.

4.3 Description of Platform and Tools

In the previous section, a brief description regarding the platforms used in this project was expressed. This section is designed to fully discuss the Open Wonderland platform and the Facebook platform as two major environments used in the proposed model. However, some other platforms and engines such as the Google App Engine are used in the backbone of the system.

The main programming language used in this project is Java. Open Wonderland is the pure Java platform; therefore, there is no need to use another programming language or scripting language to create a new module. Besides, Apache Ant is required to run the Open Wonderland server. The Ant is an open source Java-based library, under the under the Apache License 2.0[22], for compiling Java-based programs with regard to its build files. The Apache Ant 1.8.4 was chosen for this project. Furthermore, since Open Wonderland is a collaborative project, it needs a versioning and revision control system. Apache Subversion or SVN is selected for this purpose since it is an open source system with the same license as Ant. Moreover, it is fully compatible with Google Code which is the source code repository[23] for the Open Wonderland platform.

[20] https://developers.facebook.com/policy/
[21] Secure Sockets Layer: an encryption protocol to increase the security in web-based systems
[22] http://www.apache.org/licenses/LICENSE-2.0.html
[23] http://code.google.com/p/openwonderland/source/checkout

The other part of the proposed system is the Facebook platform. However, this platform is based on PHP, a Java-based API[24] chosen for integration. This API is developed by the RestFB team and is an open source library under the MIT License[25]. The source code of this API is available in Google Codes. This API allows the developer to use the Graph API[26] of Facebook in Java. Although RestFB does not provide a solution for the authentication process through the Facebook platform, it supports other objects within the platform such as group, posts and comments.

For authentication and authorisation of users in the Facebook platform, two other APIs are used including JSON and visural-common. The former is used as an exchange between text and data. In other words, it can take text and produce an object in a different programming language. Since Facebook Graph API is text-based, this API is used to create the corresponding object from a particular text. The latter API is used to divide the text into useful sections. The main application of visural-common is when a part of a URL[27] is going to be selected.

Additionally, the proposed system has a particular application to generate the access token which is required for the authentication and authorisation process. Google App Engine is chosen as an application engine since it allows the programmer to use the JSP[28] for their applications. GAE[29] delivered a cloud-based service for developers to host their web-based applications. JSP is a web based technology for Java development. The scenario of this process will be explained in the 5.4.2.

The IDE[30] used for the programming is NetBeans. This IDE is open source software under a dual license consisting of the Common Development and Distribution License version 1.0 and the GNU General Public License version 2.0[31]. Since this IDE supports all the requirements of the proposed system, it has been selected for this project. NetBeans is compatible with the subversion system for team projects. Furthermore, it has a built-in Ant tool; however, it is possible to change the Ant home directory to customise its version. In addition, it can accept the plugin in order to add a new feature to this IDE. The Google App Engine plugin is available for NetBeans users. Therefore, NetBeans provides an integrated environment for our proposed model since it supports all the prerequisites of our project including application-based and web-based technologies. To develop a new module in Open Wonderland, an application-based Java free-form project has been used while for authentication purposes, the type of project must be changed to Google App Engine web-based projects.

[24] Application programming interface
[25] http://restfb.com/#licensing
[26] https://developers.facebook.com/docs/reference/api/
[27] Uniform Resource Locator
[28] Java Server Pages
[29] Google App Engine
[30] Integrated Development Environment
[31] http://netbeans.org/cddl-gplv2.html

4.4 Constraints and Dependencies

Since this system is composed of two heterogeneous platforms, the probability of risks and constraints is higher than in usual systems. One dependency and one constraint of the proposed model will be discussed in this section.

Implementing a Facebook authentication and authorisation is an onerous process. There was a previous unsuccessful effort to integrate the Facebook platform into an Open Wonderland platform. The failure point of this system was the authentication process. After authentication, the most important action is authorisation. Giving the correct permission is known as a dependency for our proposed system. For example, group members with 'enough' permission to write contents should be able to create a new post. This dependency has been fully implemented in our proposed system.

A Facebook Graph API is a new way of calling Facebook objects. All the previous methods including the legacy REST API[32] are discontinued and Facebook highly recommends the developer to use Graph API for their new applications since the other APIs will be abolished. However, there are some limitations in this new API and it needs more investigation by the Facebook developer. One of the constraints that affect our project is a limitation in calling the files (except photo formats) within a group. Although there is a files connection in the group object, it has not yet been implemented. When this function is called, it returns an error which is shown in Figure 4-1.

```
{
  "error": {
    "message": "Call to a member function on a non-object",
    "type": "BadMethodCallException"
  }
}
```

Figure 4-1 Error Message for Calling a Files Method

This issue was reported to the Facebook developer team on 17th July, 2012, and its status is still reopened. Therefore, when this bug is fixed, a new functionality for showing the documents and spreadsheets can be added to our system within a new patch.

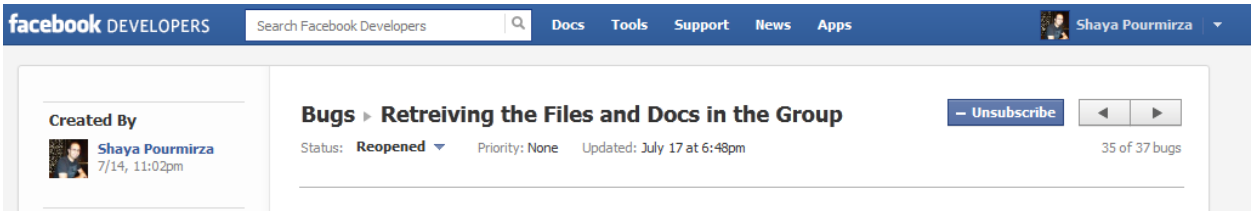


Figure 4-2 The Reported Facebook Bug

[32] https://developers.facebook.com/docs/reference/rest/

Chapter 5 :
Analyses and Design

In the previous chapter, the functional and non-functional requirements for designing a prototype were discussed. In addition, the platforms and tools, constraints and dependencies which may be encountered during the implementation were described. In this chapter, the next two process of the software engineering, analysis and design, will be explained. From the Agile UP viewpoint, this chapter is part of elaboration and construction phases and its artefacts can be some models and diagrams for implementation procedure.

This section is divided into three main subjects. In the first sections, Facebook Graph API, authentication and authorisation procedure and a brief ER[33] diagram will be provided. 5.2 will analysis the Client-Server architecture of Open Wonderland platform. The reminder of this chapter will demonstrate the graph and diagrams for proposed prototype.

5.1 Facebook Graph API Architecture

The first leg of the integration process is Facebook platform which has a graph-based architecture. With regard to this architecture, this platform introduces a new graph-based API for developer, called *Graph API*, for data transferring. Graph API identifies the type of data into two main group including the *objects* and *connections*. Objects are applied to the entities such as users, pictures, groups, pages while connection refers to the relationship between the objects.

All of the objects have their own exclusive identifier and can be called via this identifier. However it is possible to call the objects through the URL (https://graph.facebook.com/id), the returned response is in form of a JSON object. In the other side, a connection is used for retrieve the object-relationship information. Figure 5-1 exemplifies the difference between the objects and connections since connections are illustrated by the arrows, whereas objects are displayed by the filled geometric shapes.

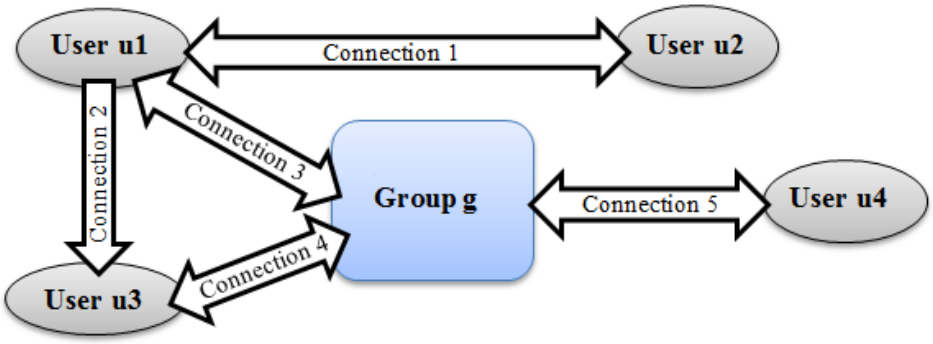


Figure 5-1 An example of Social Graph in the Facebook Platform

In this figure, Group is applied both as an object in g and three connections including 1, 2 and 3. Likewise, u1 can be used as an object and connection. Clearly, it is a User object, although it

[33] Entity Relationship

might be a mutual friend connection between u2 and u3. Furthermore, connection 1 shows a friendship relationship and connection 2 demonstrate a friend request which is one-way relationship in Facebook terminology. In the following sections the architecture of our proposed model will be discussed.

5.1.1 Facebook Group Entities

For modelling a new system, it is important to identify the entities which will be used for design discipline. In the proposed model, four Facebook entities are declared including User, Group, Post and Comment. These entities are grouped as Facebook's objects and shown by rectangles in Figure 5-2 Entity Relationship Diagram. Moreover, the relationships between these entities (Facebook's connections) are shown by diamonds and each of them has its own cardinality. In addition, the ellipse shapes are applied for the properties and the key property of each object is its unique id which is distinguished by underlining. This property is used for method invocation via the HTTP request.

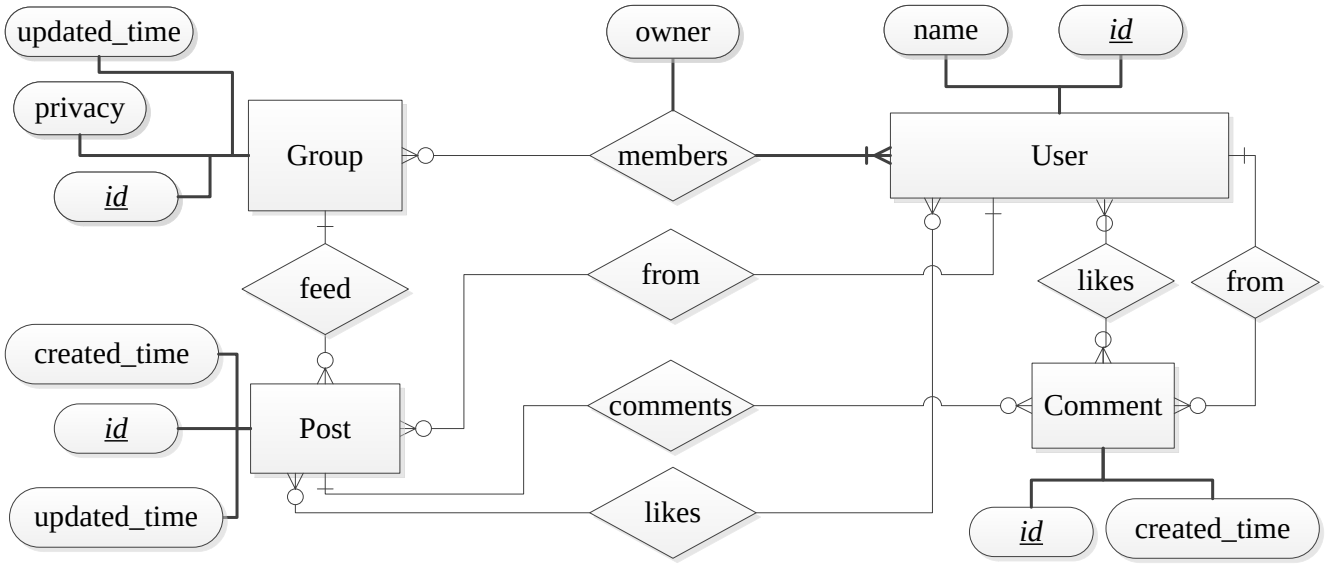


Figure 5-2 Entity Relationship Diagram

5.1.2 Facebook Authentication Architecture

Facebook platform authentication and authorisation is based on *OAuth 2.0*[34]. This method is a token-based authorisation technique to allow the users use the content of source platform in other secure platforms. Although Twitter is still based on OAuth 1.0, many well-known organizations such as Google and Microsoft move on to its second version. The main difference between these

[34] http://oauth.net/2/

two versions is, the latter can only be implemented on the platform with SSL certificate and signature is no longer required for each request while the former is based on the signature.

The following workflow will review the authentication and authorization procedure of Facebook platform. A full details explanation of this procedure will be provided in the authentication and authorisation use case scenario.

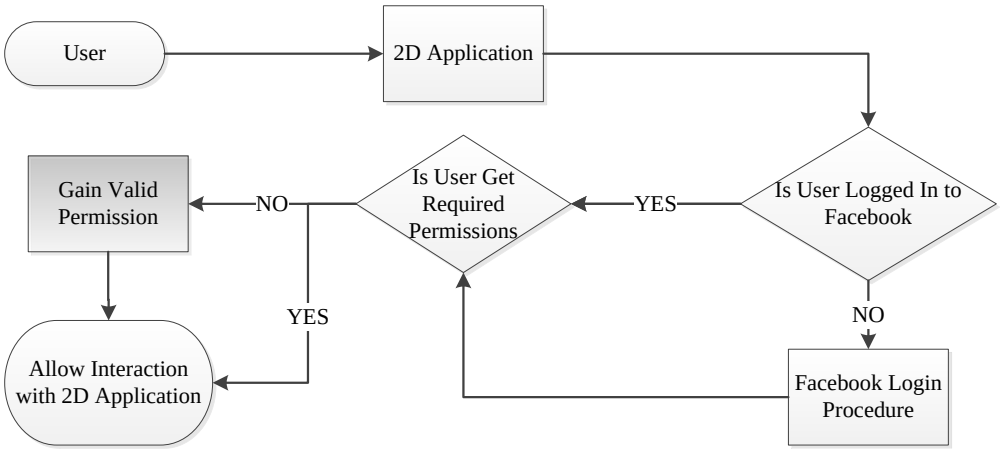


Figure 5-3 Authentication and Authorisation Workflow

The most important step within this workflow is *Gain Valid Permission* which is displayed by a grey rectangle. In other words, this process describes the authorisation and release the access token which is required for the interaction.

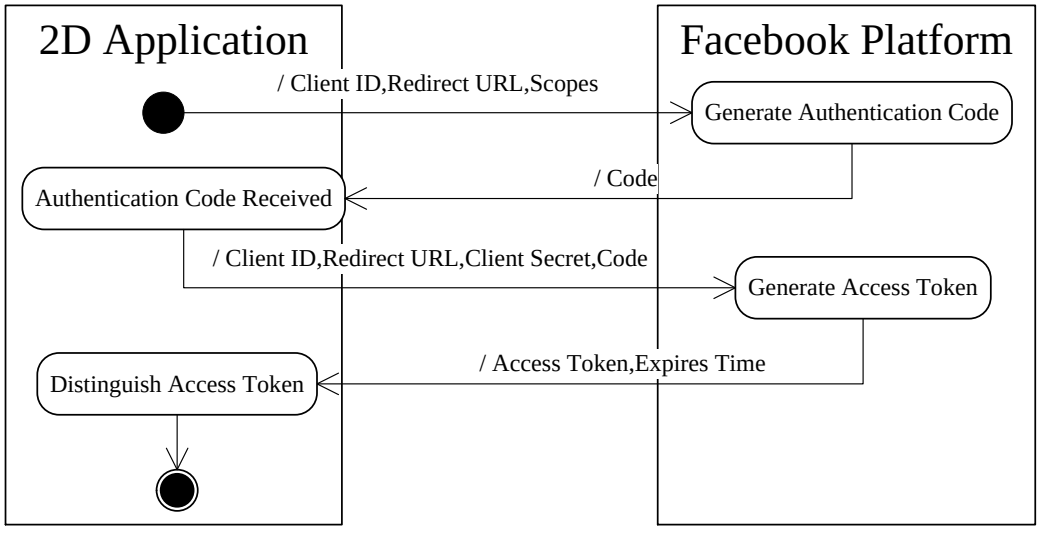


Figure 5-4 Authentication Activity Diagram

Figure 5-4 Authentication Activity Diagram displays an activity diagram for the authentication process which was marked in the authentication workflow. Each arrow in this diagram indicates

a secure HTTP request and the labels on the arrows are the parameters which send via each request. This scenario is also included in the authentication and authorisation use case scenario in 5.4.2.1.

5.2 Open Wonderland Architecture

Open Wonderland platform is formed on the client-server architecture. From the high level view, it is possible to divide the wonderland platform into three layers. The virtual world browser concept brings up in the highest level. This browser can connect to different Wonderland servers and download the contents and behaviour of them, since they have their own individual functionality. The rendering engine which is applied to this browser is *MT Game*. This engine is built to add the multi-processing capability to the old *jMonkeyEngine*[35] [83].

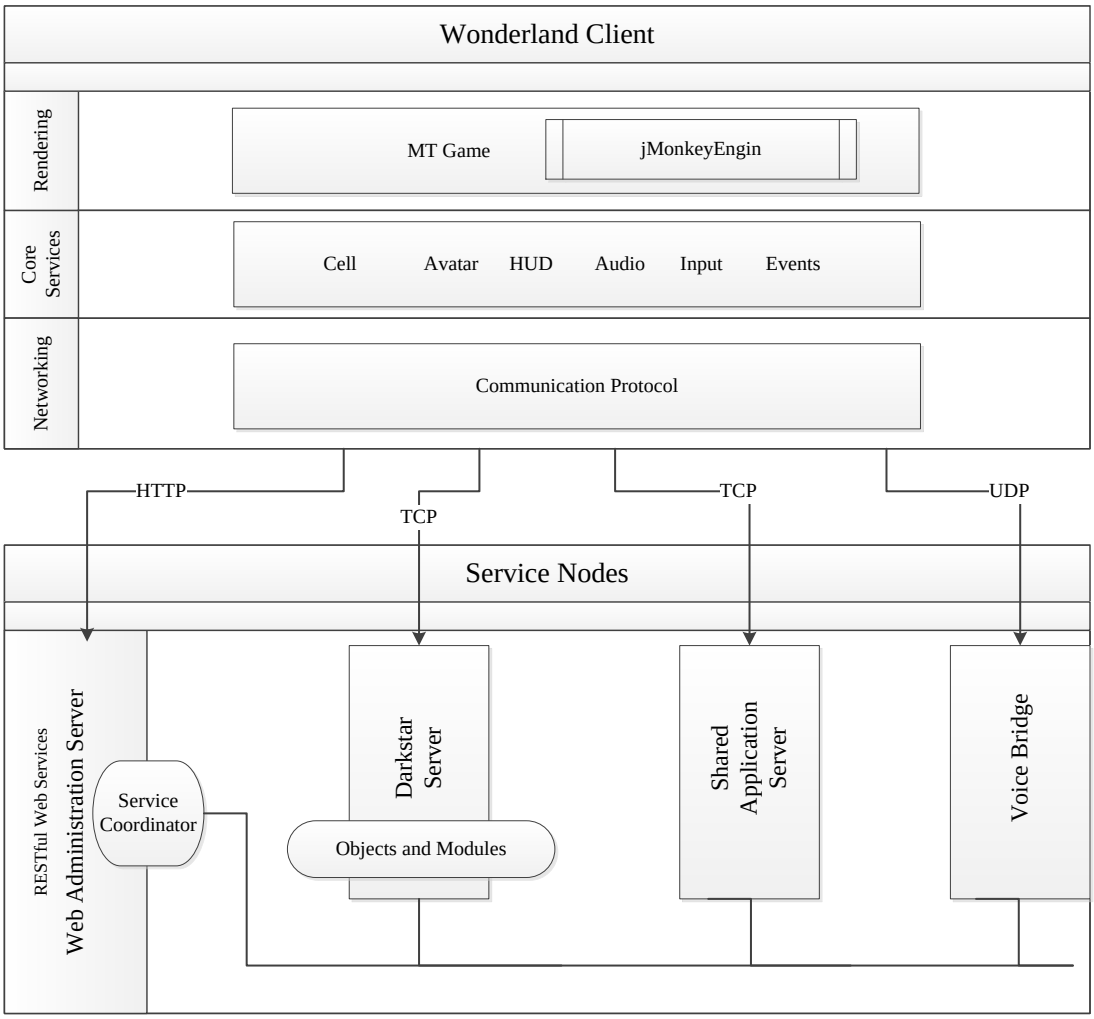


Figure 5-5 Open Wonderland Architecture

[35] http://jmonkeyengine.com/

Below the first level, server consists of many different services and these services can collaborate to make a specific world. There are four major servers in this layer. The *web administration server*, which is run over the open source Glass Fish[36] Java Enterprise Edition Application server, is applied as a service coordinator. The second server is *Darkstar*, which is usually used in the game platforms, to keep track of the position of the users and objects. Moreover, darkstar participates in communication between the client and server via its simple messaging techniques. *Standard Server Component* is the third server, which is runs over *Linux* or *Solaris* systems, to share the server-hosted applications. Finally, the last server is *jVoiceBridge*[37] is used for server-side voice mixing enabling the VoIP[38] technology [83].

Moreover, in the lowest level, the contents of a specific virtual world can be found. This level is mainly the connection between the client and darkstar server. It is made of the objects with the specific position in the virtual world and some set of share-properties which can be seen by all the users. This synchronisation is carried out by the darkstar messaging mechanism which was introduced in the previous paragraph. For instance, avatars, buildings, mountains, chairs and all of the other objects are grouped in this level. Figure 5-5 Open Wonderland Architecture, which is produced with regard to a network diagram model which Jonathan Kaplan and Nicole Yankelovich provided in [83] and the Kaplan's interview titled High Level Architecture Explanation in Open Wonderland portal, illustrates the client-server architecture of this 3D platform.

5.3 Data Flow Diagram

Data flow diagram, abbreviated DFD, is illustration of the flow of data in the whole system. Frequently it is applied for the context determination of the processes within the system. This diagram is the second step in the three most essential methods in SSADM[39] methodology. The basic DFD or level 0 (also known as context diagram) determine the relationship between the external actors and current system.

Figure 5-6 System Data Flow Diagram (Level 0)

[36] http://glassfish.java.net/
[37] http://java.net/projects/jvoicebridge/
[38] Voice Over Internet Protocol
[39] Structured Systems Analysis and Design Method

A more detailed Data Flow Diagram (level 1) for authentication and authorisation is provided in Figure 5-7.

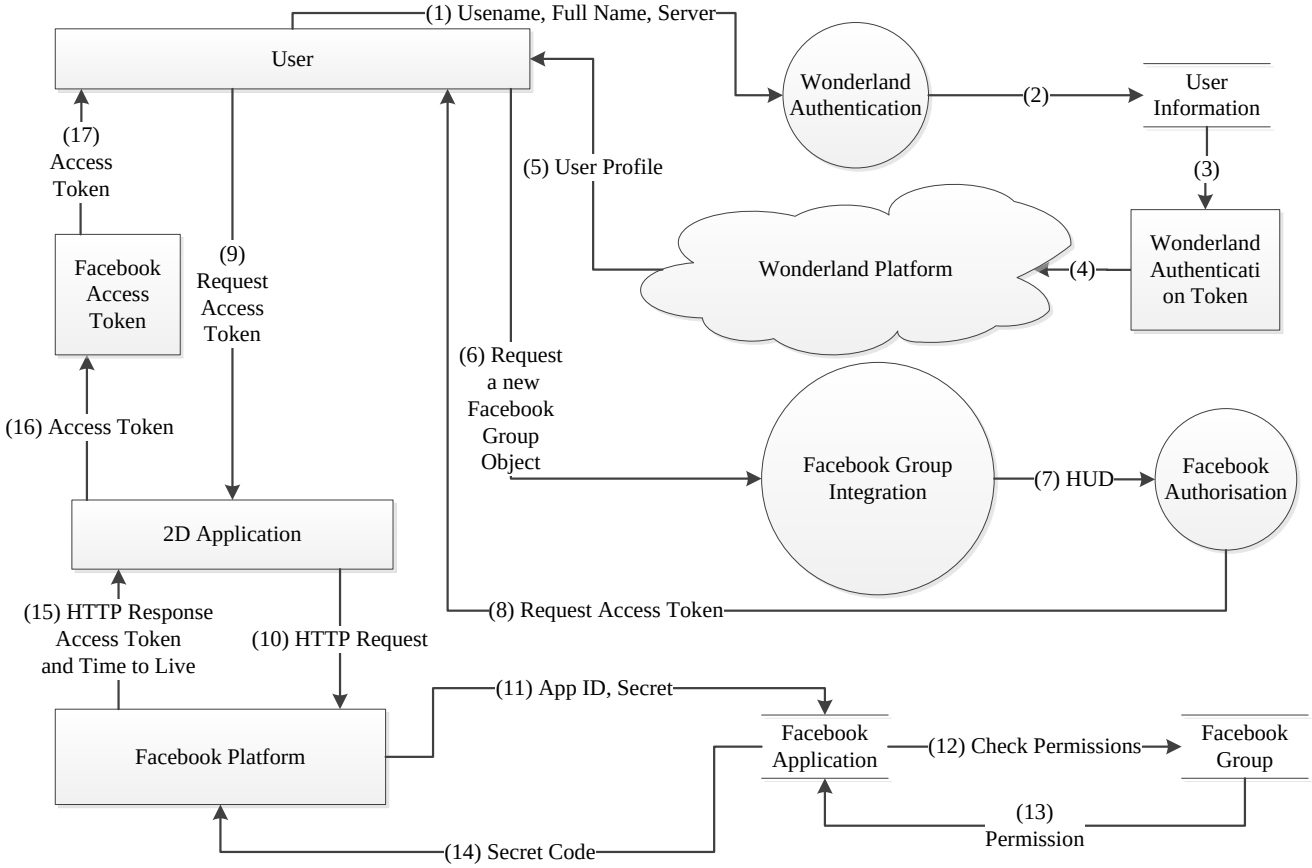


Figure 5-7 Authentication and Authorisation Data Flow Diagram (Level 1)

The above diagram displays the authentication procedure with regard to both Open Wonderland platform and Facebook Platform. After the 17th step, user gains the access token. Now, he should insert his access token to retrieve the information from the Facebook.

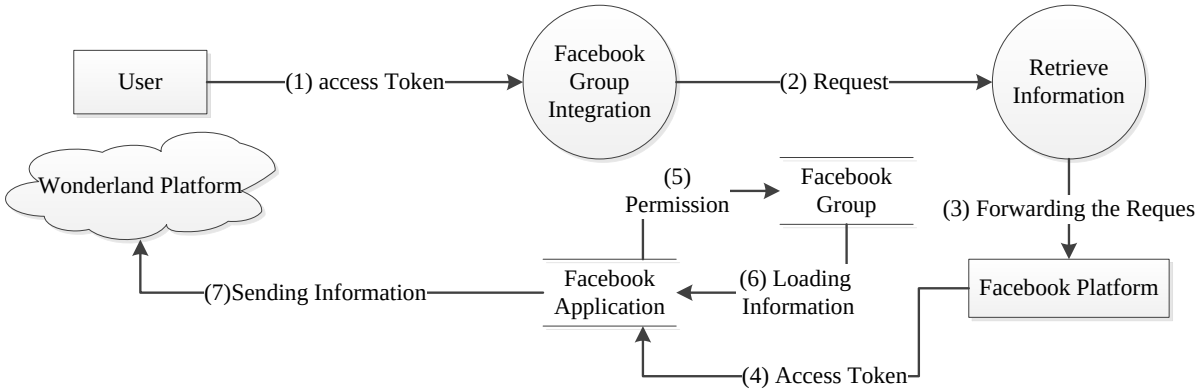


Figure 5-8 Retrieving Facebook Group's Data Flow Diagram (Level 1)

After the Figure 5-8's seven steps each Facebook group post will be loaded in the 3D Environment. Since these posts should be presented by a 2D wonderland application, the *poster*[40] *(version 0.2)* is selected for this purpose. The data which are shown in the poster can be both a post message and the belonging information such as its comments.

The other functionality of the proposed system can be create a new discussion or add a new comment on the existing post. For this purpose, using the external link to the 2D application has been suggested. However, it seems possible to achieve this feature within a 3D world by other modules such as *Sticky note*[41] *(version 1.0)* which can be used for writing a simple plain text. Figure 5-9 is aimed to display the Data Flow diagram at the first level for this functionality.

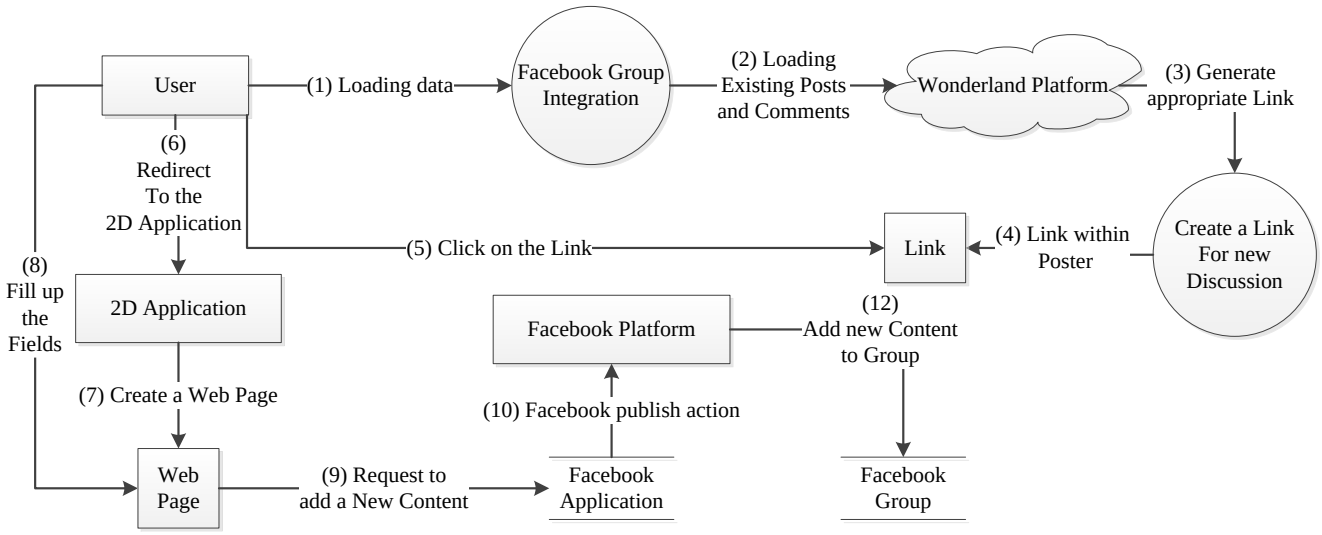


Figure 5-9 Post a New Content to a Facebook Group's Data Flow Diagram (Level 1)

The above figure is produced to show the 12-steps procedure for adding a new content to a Facebook group. For this purpose, wonderland creates an appropriate link and redirects the user to the specific webpages with some blank field for comments and new Discussion.

In summary, the proposed model should have four functionalities. First and most important is authentication and authorization. Both of these procedures are based on token-based models. Retrieving the data is introduced as the second most important functionality of this system. This process does not require communicating with 2D application; however, to meet the other functionalities, this communication is necessary. The remaining two functionalities is the ability to add a new comment and a new discussion into the Facebook group. In the next section, these functionalities will be applied as certain use cases.

[40] http://goo.gl/kBOQo
[41] http://goo.gl/23wGN

5.4 Use Cases

In this section, the use case diagram of whole system will be illustrated. The title of each use case is chosen due to its goal as an action verb. In addition, the fully dressed scenario of all use cases will be presented in this section. Please note that, these scenarios are a kind of high level scenario without any technical words.

5.4.1 Use Case Diagram

The proposed system has four major functionalities which were introduced in the previous chapter. These functionalities lead the author to identify four use cases for this system including: Authenticate Users, Retrieve Data, Create a New Discussion and Add a New Comment. In addition, Authorised User which is inherited from Unauthorised User with an additional *Access Token* is the main actor of the system. However, Facebook Application and Facebook Group are two external actors for the system. In this diagram, the system is applied to both Wonderland Facebook Group Integration module and 2D application. The system use case diagram is shown in Figure 5-10.

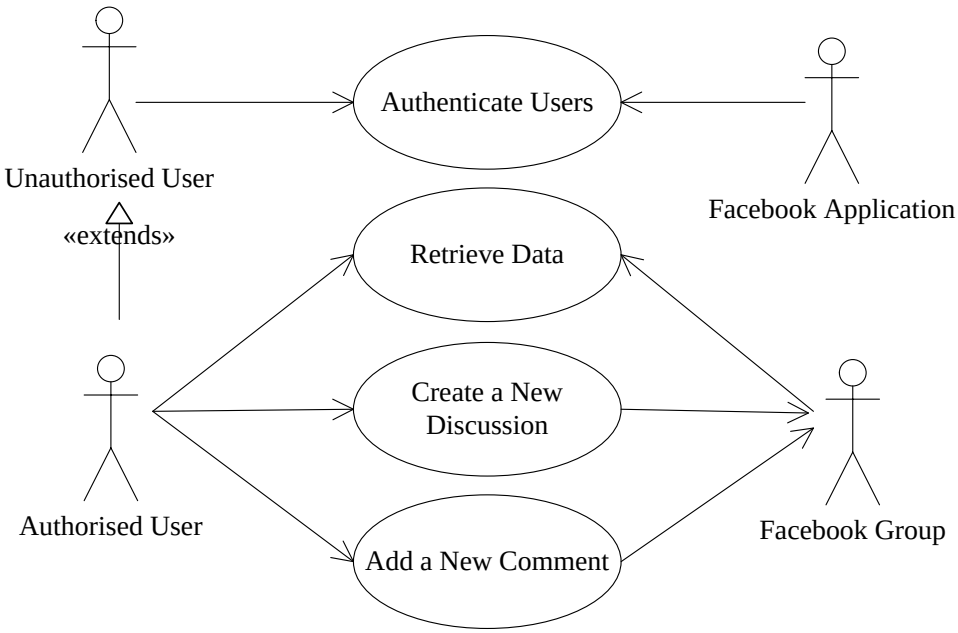


Figure 5-10Use Case Diagram

This diagram shows the straightforward features of the application. Here is the summary-level scenario of the whole system: (1) An unauthorised user selects the Facebook Group Integration module from the Wonderland *Cell Pallete*. (2) A HUD[42] appears on the client browser requests an access token. (3) User clicks on the link provided by HUD. (4) System generates an access

[42] Heads-Up Display

token via the Facebook application. (5) User copy the access token to his clipboard and paste it into the blank field of HUD. (6) Wonderland connects to the Facebook group and retrieves data and changes the status of user to authorised user. (7) User clicks on the link to create a new discussion. (8) A new webpage is opened which contains a field for the title of discussion. (9) User clicks on the link to add a new comment. (10) A new webpage is opened which contains a field for adding a new comment.

5.4.2 Use Case Scenario

In the previous subsection, the use case diagram was illustrated and a scenario of whole system was provided. The fully-dressed scenario for the all four use cases will be discussed in this subsection. In the main scenario, all the sentences must be started with the actor's name such as user, Facebook application and Facebook group or by the name of systems. The additional information for each use case will be stated in this subsection.

5.4.2.1 U.C. 1: Authenticate User

Scope:

Each user must have his/her own *Access Token* to communicate with the system.

Level:

User-Goal Level

Primary Actor:

User

Stakeholder:

User, Open Wonderland Platform, OAuth 2.0 Mechanism, Facebook Authorization

Pre-Condition:

The Open Wonderland server has been run.

Post-Condition (Success Guarantee):

Access Token will be generated.

Main Scenario:

1- User requests to connect to the wonderland server.
2- System requests login information.
3- User inserts username, full name and server address and presses the '*login*' button.
4- Wonderland Client tries to load a 3D world with an avatar for the user.
5- User selects the '*Insert*' option from the menu bar.
6- System shows the options for Insert including: '*Object*' and '*Model*'

7- User selects '*Object*' option.
8- System shows Insert Object window (aka. *Cell Pallete*).
9- User selects '*Facebook Group Integration*' and press '*Insert*' button.
10- System renders a cube surfaced by Facebook logo.
(`uk.ac.essex.wonderland.modules.facebook.client.FacebookCellRenderer`)
11- System shows a HUD and requests a Facebook Access Token.
(`uk.ac.essex.wonderland.modules.facebook.client.FacebookAccessToken`)
12- User clicks on the '*click here*' text on the HUD.
13- System opens a webpage via the default web browser for Facebook authorisation.
14- User clicks on the link to generate an Access Token.
15- System redirects to an authentication URL.
(`AuthenticationProperties.getLoginRedirectURL(appId, url, scopes);`)
16- Facebook Authorisation generates an authentication code within a current URL.
17- System retrieves the code from the URL.
(`AuthenticationProperties.getAuthURL(String authCode);`)
18- Facebook Authorisation generates an `access_token` and `expires` time.
19- System fetches these two values from the current session.
20- System shows an Access Token.
21- User copies his/her Access Token on the HUD and presses the '*OK*' button.

Extensions:

*A- At any time, the connection between client and server maybe lost.
a. User must try to connect to server, again.
*B- At any time, Facebook Authorisation system refuses to generate an Access Token.
a. User jumps to level 13 in the main scenario.
14- User has not been approved by Facebook.
a. User has not logged in to the Facebook.
i. System redirects user to the Facebook login webpage.
ii. User inserts his/her Facebook login information.
b. User has not been authorised by 3D E-Learning Facebook application.
i. System requests user to allow user for using the application.
ii. User clicks on 'Go to App' button.
iii. System requests user for required permissions.
1. `read_stream` permission
2. `publish_stream` permission
iv. User clicks on 'Allow' button.
20- User inserts an invalid Access Token.
a. System does not show any posts.
i. User jumps to level 5 in the main scenario.

5.4.2.2 U.C. 2: Retrieve Data

Scope:

System retrieves data from the Facebook group and loads them into the virtual world. Furthermore, system seeks the changes every 15 minutes.

Level:

User-Goal Level, Subfunctions

Primary Actor:

User, Open Wonderland Platform

Stakeholder:

User, Wonderland Platform, Facebook Application, Facebook Group, RestFB API

Pre-Condition:

An Access Token has been generated by the system.

Post-Condition (Success Guarantee):

All of the posts, comments and pictures will be loaded into the virtual world.

Main Scenario:

1- User submits an Access Token to his client browser.
2- Client receives an Access Token via an Observer Pattern in the renderer class.
3- Client sends an Access Token within a message from to server.
4- Server receives an Access Token.
(`FacebookCellMO.FacebookAccessTokenMessageReceiver`)
5- Server creates an object of FacebookClient.
6- Server sends an HTTP request via FacebookClient to retrieve the data.
7- Facebook Application receives a request and passed to the Facebook Group.
8- Facebook Group sends a JSON object for each post.
9- Server receives JSON objects.
10- RestFB API converts each JSON object to POST object.
11- Server uses a Darkstar transaction to convert each request to a task and write the results immediately.
12- Server creates a vector of POST and an inner vector of COMMENT for each post.
13- Server creates a POSTER module for each cell of posts vector and set an appropriate text and position.
14- Each poster is shown on the client browser by synchronising the ClientState and ServerState.
15- Server schedules a periodic task for keeping update the world.
(`executor.scheduleAtFixedRate(runnable, 1, 10, TimeUnit.MINUTES);`

Extensions:

*A- At any time, the connection between client and server maybe los
    a. User must try to connect to server, again.
*B- At any time, Facebook Authorisation system refuses to generate an Access Token.
    a. User jumps to level 13 in the main scenario of U.C. 1.

5.4.2.3 U.C. 3: Create a New Discussion

Scope:

User requests to create a new discussion into the Facebook Group.

Level:

User-Goal Level

Primary Actor:

User, 2D Application

Stakeholder:

User, Facebook Application, Facebook Group, 2D Application

Pre-Condition:

Facebook Group Integration module has been selected.

Post-Condition (Success Guarantee):

A new discussion will be posted into a Facebook group.

Main Scenario:

1- System creates an appropriate link with an Access Token and Group ID.
2- System generates a POSTER module with the mentioned link.
3- User clicks on the link.
4- System opens a webpage via the default web browser for a New Discussion.
5- User inserts a title of discussion into the blank field and presses the '*Submit Your Discussion*' button.
6- System creates a new instance of FacebookClient.
7- System sends a message with publish object of Graph API with FacebookClient.
8- System shows a successful message within a webpage with other discussion's title.

Extensions:

*A- At any time, Facebook Authorisation system refuses to generate an Access Token.
    a. System redirects user to the '*Error: Server Error*' webpage.
    b. User jumps to level 13 in the main scenario of U.C. 1.

7- App Engine refuses to write a new post into the Facebook group.
   a. User generates a new Access Token.
   b. User tries again from the level 1 main scenario.

5.4.2.4 U.C. 4: Add a New Comment

Scope:

User requests to add a new comment to an existing discussion into the Facebook Group.

Level:

User-Goal Level

Primary Actor:

User, 2D Application

Stakeholder:

User, Facebook Application, Facebook Group, 2D Application

Pre-Condition:

All the existing discussions and comments have been loaded in the virtual world.

Post-Condition (Success Guarantee):

A new comment will be added to the selected discussion.

Main Scenario:

1- System creates an appropriate link with an Access Token, Group ID and Post ID.
2- System generates a link at the bottom of each POSTER module.
3- User clicks on the link.
4- System opens a webpage via the default web browser with the title and existing comments of the selected discussion.
5- User inserts a comment into a blank field and presses the '*New Comment*' button.
6- System creates a new instance of FacebookClient.
7- System sends a message with publish object of Graph API with FacebookClient.
8- System shows a successful message within a webpage with the discussion's title and all of its comments.

Extensions:

*A- At any time, Facebook Authorisation system refuses to generate an Access Token.
   a. System redirects user to the '*Error: Server Error*' webpage.
   b. User jumps to level 13 in the main scenario of U.C. 1.

7- App Engine refuses to write a new post into the Facebook group.
   a. User generates a new Access Token.
   b. User tries again from the level 1 main scenario.

5.5 Activity Diagram

In the previous section, all the required use cases were explained. In this section an activity diagram for the system will be presented.

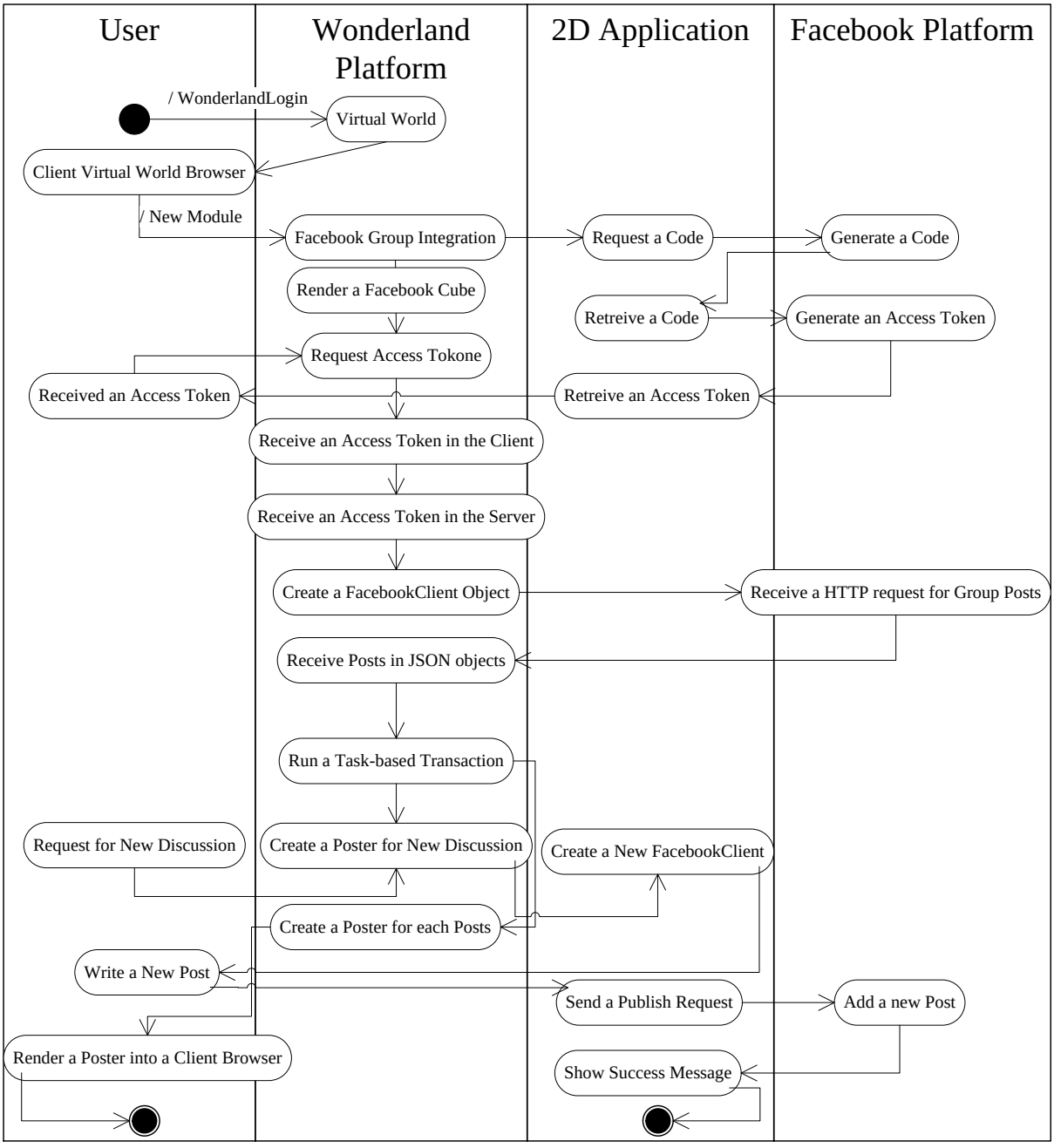


Figure 5-11 System Activity Diagram

Activity diagram illustrates the workflow from an initial point to the final state of system. Figure 5-11 System Activity Diagramis designed with regards to the scenarios and steps which were discussed in 5.4. However, in this diagram, U.C. 3: Create a New Discussion and U.C. 4: Add a New Comment have been merged since they have similar workflow.

5.6 Class Diagram

This section will be divided into two major categories. First a full-details class diagram for the 2D application will be illustrated and then an abstract Facebook Group Integration module's class diagram will be displayed. However, first, it is important to identify the packages.

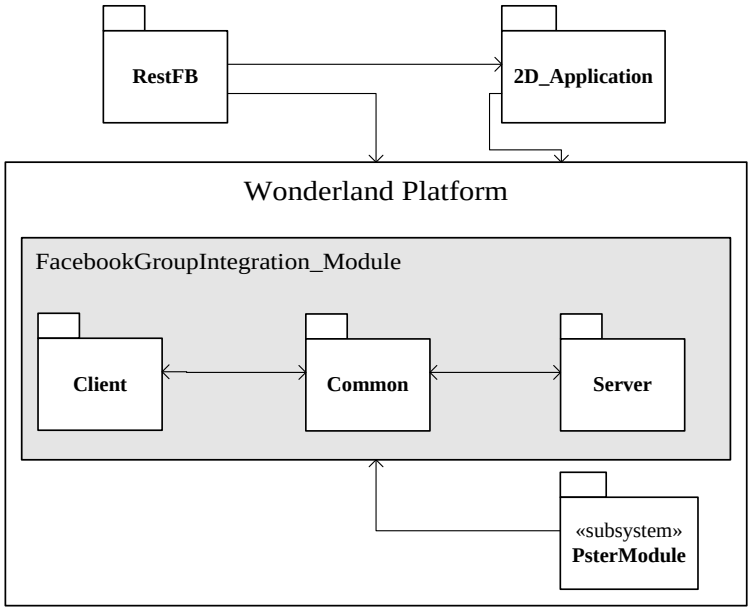


Figure 5-12 Package Diagram

Figure 5-12 illustrates the connection between packages. RestFB package is used as an API for converting the Facebook JSON objects to an appropriate objects such as Post, Comment, User and Group. 2D application is applied for the generating an access token as well as creating a new discussion and adding a new comment. Undertheneath of Wonderland Platform there are some packages. The new proposed module has three main packages including Client, Server, and Common package. Common package will be required for the common classes between client and server. Moreover, the state of client and server will be held in this package. A poster package is a Wonderlan module to displaye a basic HTML content. Since this module is based on *jLabel*, it cannot support any web scripts and CSS[43]. The details of each packages will be presented in the following two class diagram.

[43] Cascading StyleSheet

5.6.1 2D Application Class Diagram

Figure 5-13 2D Application Class Diagramshows the relatioship between the main classes in the 2D application. This classes are placed within 2D_Application package which is shown on Figure 5-12. This package has three java classes including a servlet. The first class is `AuthenticationProperties` which is used for crating an appropriate HTTP Request to the servlet, named `TempServlet`. After this process, an `accessToken` will be generated and passed as a string parameter to the `FacebookTestApp` class which includes all the required methods for dealing with the RestFB API. Furthermore, six JSP pages are designed to show the results via web browser. The navigatiob map of this webpages also will be displayed 2D application class diagram. The first JSP page is used for runnig the servelet and generating an Access Token which will be shown on the second `temp.jsp`. `Index.jsp` is the main user interface of the 2D applciation which includes all the posts, comments and extra information of the content of Facebook Group. The remainin pages will be required for adding a new content to the Group from virtual world via 2D App.

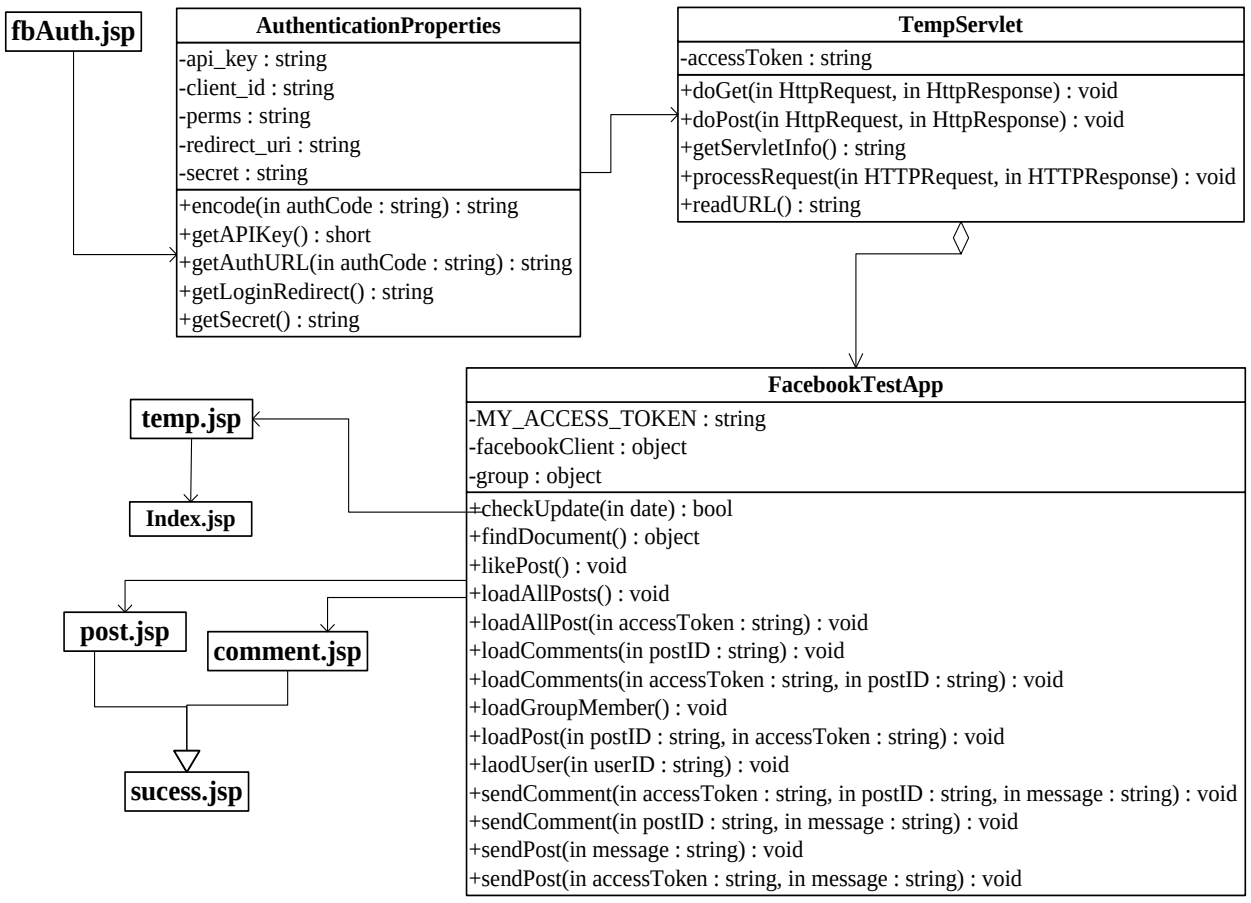


Figure 5-13 2D Application Class Diagram

5.6.2 Wonderland Module Class Diagram

A connection of the Facebook Group Integration's classes will be discussed in this section. A package diagram indicates Wonderland module has three main packages including Client, Server and Common. Figure 5-14 Wonderland Client-Server connectionexplains the connection between the client and server packages; however, the more precise model should consist of an intermediate package which holds `FacebookCellServerState` and `FacebookCellClientState`.

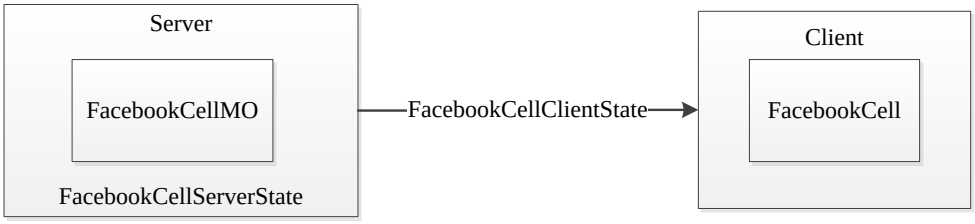


Figure 5-14 Wonderland Client-Server connection

An abstract class diagram of the proposed Wonderland module will be presented in Figure 5-15 Wonderland Class Diagram More than Common package, a new inner package, called `jme.rendered`, is added to the model. All the essential wonderland classes are filled with light grey. Moreover, the dashed line shows an indirect relationship between two classes via their parents. More details class diagram will be provided in the Implementation Chapter.

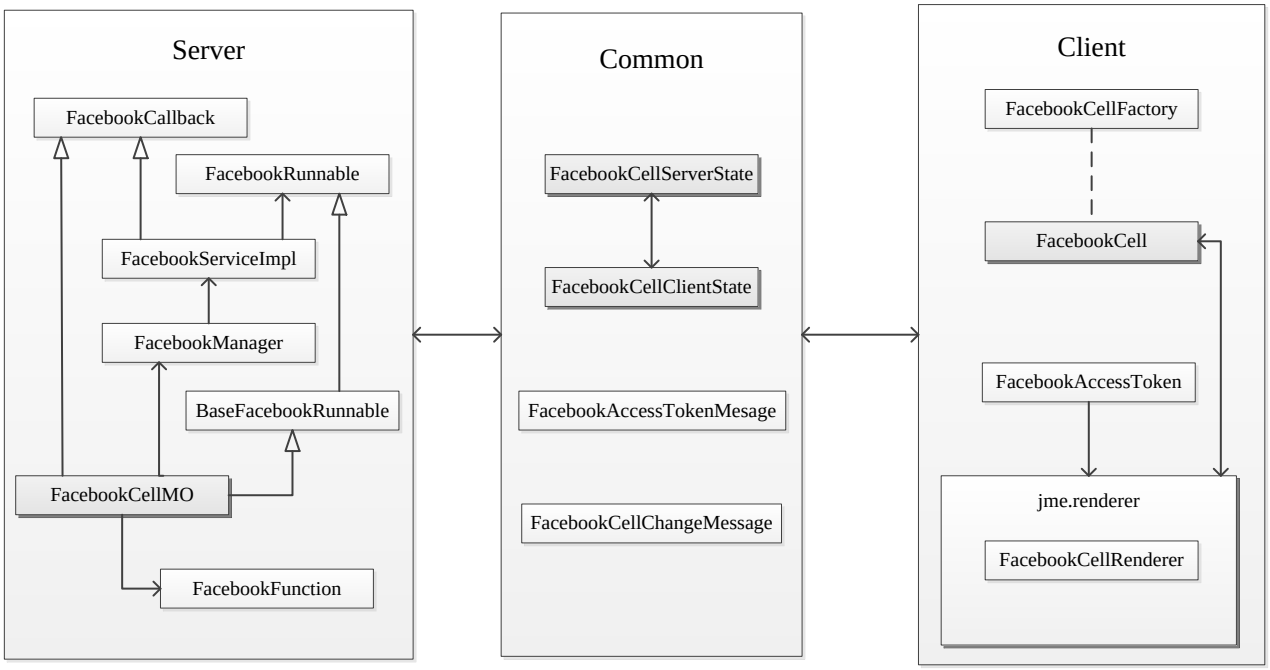


Figure 5-15 Wonderland Class Diagram

Chapter 6 :
Implementation and Deployment

In the previous chapter, the essential design diagrams such as ER diagram, use case diagram, activity diagram and class diagram were presented and discussed. This chapter will focus on the details of implementation and deployment of the identified use cases, activities and classes. The delivered artefacts of this discipline will be two required application including a 2D application, which is applied for posting data to the Facebook and generating an Access Token, and a new Wonderland module, called Facebook Group Integration. Furthermore, an emphatic effort in the implementation and deployment process will be done in construction and transition phases of Agile UP.

This chapter has been organised into two sections. The first section will express the details of implementation of 2D application and deployment to the Google App Engine and the latter will discuss about a Facebook Group Integration module and deployment on the Wonderland server.

6.1 2D Application

This section begins by laying out the implementation details of the 2D Application, and then looks at how this application will be deployed on the Google App Engine.

6.1.1 2D Application Implementation

Figure 5-13 2D Application Class Diagram specified the classes which are required for the implementation with full details of method signatures including input and return parameters.

One of the most important functionalities of this application can be authorisation system with the Facebook application and get the permission from the Facebook group. The order of steps which is required for generating an access token was outlined in its use case scenario. The `fbAuth.jsp` page contains an anchor element which is linked to a `getLoginRedirectURL()` within a `AuthenticationProperties` class.

```
<a href="<%= AuthenticationProperties.getLoginRedirectURL() %>">Click me!</a>
```

Code 1 – Redirect to Facebook Graph API login URL

This class returns a string which is populated by `client_id`, `redirect_uri` and a list of `perms`. All of these parameters have been defined as `private static final String` properties. After this step, a new URL will be generated by the Facebook Application with an authentication code. Once the mentioned code is received by the application a new servlet will be run. The procedure in this servlet is organised as the follows:

First, it gives a current URL, retreives the authentication code (via Facebook Graph API object) and passed this parameter to `getAuthURL(String authCode)` method which is held by `FacebookProperties` class. In this method a new Authentication URL with the authentication code will be generated. Then, this URL will be sent to the Facebook platform via the servlet and

the Access Token can be split from the received URL from the HTTP response via the visural-common API. This value will be displayed on the client web browser.

```
public static String accessToken = null;
public static int expires = 0;
protected void processRequest(HttpServletRequest request, HttpServletResponse
response) throws ServletException, IOException {
      PrintWriter out = response.getWriter();
      ...
      try {
            String code = request.getParameter("code");
            if(StringUtil.isNotBlankStr(code)) {
                  String authURL = AuthenticationProperties.getAuthURL(code);
                  URL url = new URL(authURL);
                  try {
                        String result = readURL(url);
                        String[] pairs = result.split("&");
                        for (String pair : pairs) {
                              String[] temp = pair.split("=");
                              if (temp.length != 2)
                                    throw new RuntimeException("Error!");
                              else {
                                    if (temp[0].equals("access_token"))
                                          accessToken = temp[1];
                                    if (temp[0].equals("expires"))
                                          expires = Integer.valueOf(temp[1]);
                              }
                              if (accessToken != null && expires != null)
                                    response.sendRedirect("temp.jsp");
                              else {..}
                        } catch (IOException e) {
                              throw new RuntimeException(e);
                        }
                        ...
                  }
            }
      } finally {
            out.close();
      }
}
```

Code 2 - `processRequest` method

In this step, user can continue with the 2D application or just copy the authentication code for using in the Facebook Group Integration module. If the first option is chosen, the page will redirect to the `index.jsp`. This page will be populated by `FacebookTestApp.java` which uses RestFB API to communicate with Facebook platform. FacebookClient is the most important object in this API since the request can be send and receive by this object.

```
public class FacebookTestApp {
    String MY_ACCESS_KEY = TempServlet.accessToken;
    FacebookClient facebookClient = new DefaultFacebookClient(MY_ACCESS_KEY);
      ...
}
```

Code 3 - `FacebookClient`

This API receives the requests from the Facebook platform in the JSON object and converts them to a correspondent object. For example, it is possible to retrieve a post from Facebook or send a new comment to this platform by their IDs which has been introduced in 5.1.

```
Post post = facebookClient.fetchObject(postID, Post.class);
facebookClient.publish(postID + "/comments", FacebookType.class,
Parameter.with("message" , message));
```

Code 4 – Retrieve/Send Information

Furthermore, there are two additional webpages for posting a new discussion and adding a new comment to the group. These two pages are specially used for Facebook Group Integration, since the instance of FacebookClient is created by the user's Access Token in the virtual world. For instance, for creating a new comment the following `<form>` element has been applied.

```
<form
action="successfull.jsp?trans=cmnt&postID=<%=postID%>&accessToken=<%=accessTo
ken%>" method="POST" name="form<%=postID%>">
      <input type="text" name="inputComment<%=postID %>"/>
      <%String newComment = request.getParameter("inputComment" + postID); %>
      <input type="submit" name="cmntSubmitBtn<%=postID %>"
            value="New Comment" formaction="<%
            if (newComment != null && newComment.trim().length() > 0) {
                  fb.sendNewComment(postID, newComment, accessToken);
                  response.sendRedirect("successfull.jsp?trans=cmnt&postID="
            + postID + "&accessToken=" + accessToken);} %>" class="fbtab">
</form>
```

Code 5 – Add new Comment `<form>` element

Code 5 – Add new Comment `<form>` element indicates that the redirect link needs a unique identifier of the post, the Access Token. The value of new post received from the text within a text field and the name attribute of this input is generated regarding the post's unique identifier.

In summary, 2D application has two major responsibilities in the proposed system. First, it should generates a validate Access Token for the Facebook authorisation. Second, it creates an appropriate webpage for adding a new comment and a new post to the Facebook. However, the other functionality of this system can be found on the `index.jsp` page. Most the Facebook group content such as posts, comments, pictures and group members with most of their properties such as created date, sender, the number of likes and comments can be accessible via the main webpage of 2D application. Moreover, for adding a new comment or creating a new discussion there is no need to use another webpage since the main webpage has quick access facility for these two actions. Therefore, this application can be used both in conjunction with Facebook Group Integration module as a content generator or solely.

In this section, the overview of the 2D application was presented. The details of deployment of this application on Google App Engine will be discussed in the coming section.

6.1.2 2D Application Deployment

Since Facebook application should be deployed on the secure App Engine, Google Web Engine has been selected for this purpose. There is a Netbeans plugin[44] to integrate the Google App Engine with this IDE, developed by Project Kenai[45]. After importing a plugin, it is necessary to add a new server to the NetBeans services. Moreover, GAE has a Java-based SDK[46] for the developer which can be added its server[47].

A 2D application is a kind of Java EE project; however, it is implemented on the GAE server. The required libraries in this application are: `restfb-1.6.9.jar`, `json-20080701.jar`, `visural-common-0.5.0.jar` and the libraries which are needed for the GAE. In addition, `web-appengin.xml` file contains the certain information regarding the application such as the app name and version.

```
<?xml version="1.0" encoding="UTF-8"?>
<appengine-web-app xmlns="http://appengine.google.com/ns/1.0">
    <application>shoopi</application>
    <version>1</version>
    <system-properties>
        <property name="java.util.logging.config.file"
                                    value="WEB-INF/logging.properties"/>
    </system-properties>
    <sessions-enabled>false</sessions-enabled>
    <threadsafe>true</threadsafe>
</appengine-web-app>
```

Code 6 – `web-appengine.xml` file

Furthermore, `web.xml` consists of servlet mapping and configuration instruction. Code 6 describes the session timeout and a servlet mapping for the `tempServlet` as an example.

```
<session-config>
      <session-timeout> 30 </session-timeout>
</session-config>
<servlet>
      <servlet-name>TempServlet</servlet-name>
      servlet-class>Facebook_Java.TempServlet</servlet-class>
</servlet>
<servlet-mapping>
      <servlet-name>TempServlet</servlet-name>
      <url-pattern>/temp</url-pattern>
</servlet-mapping>
<welcome-file-list>
      <welcome-file>fbAuth.jsp</welcome-file>
</welcome-file-list>
```

Code 7 – Part of `web.xml` file

[44] http://kenai.com/downloads/nbappengine/NetBeans69/updates.xml
[45] http://kenai.com/
[46] Software Development Kit
[47] https://developers.google.com/appengine/docs/java/gettingstarted/installing

6.2 Facebook Group Integration Module

This section provides a class diagram and a code review for the three Wonderland packages including client, common and server. The deployment of a new module into a Wonderland server environment will be discussed in the last sub-section.

6.2.1 Wonderland Client

The class diagram of the client package is shown on the Figure 6-1. There are three classes within the client package. Furthermore, this package has an inner package for rendering the shapes and object on the Client 3D browser.

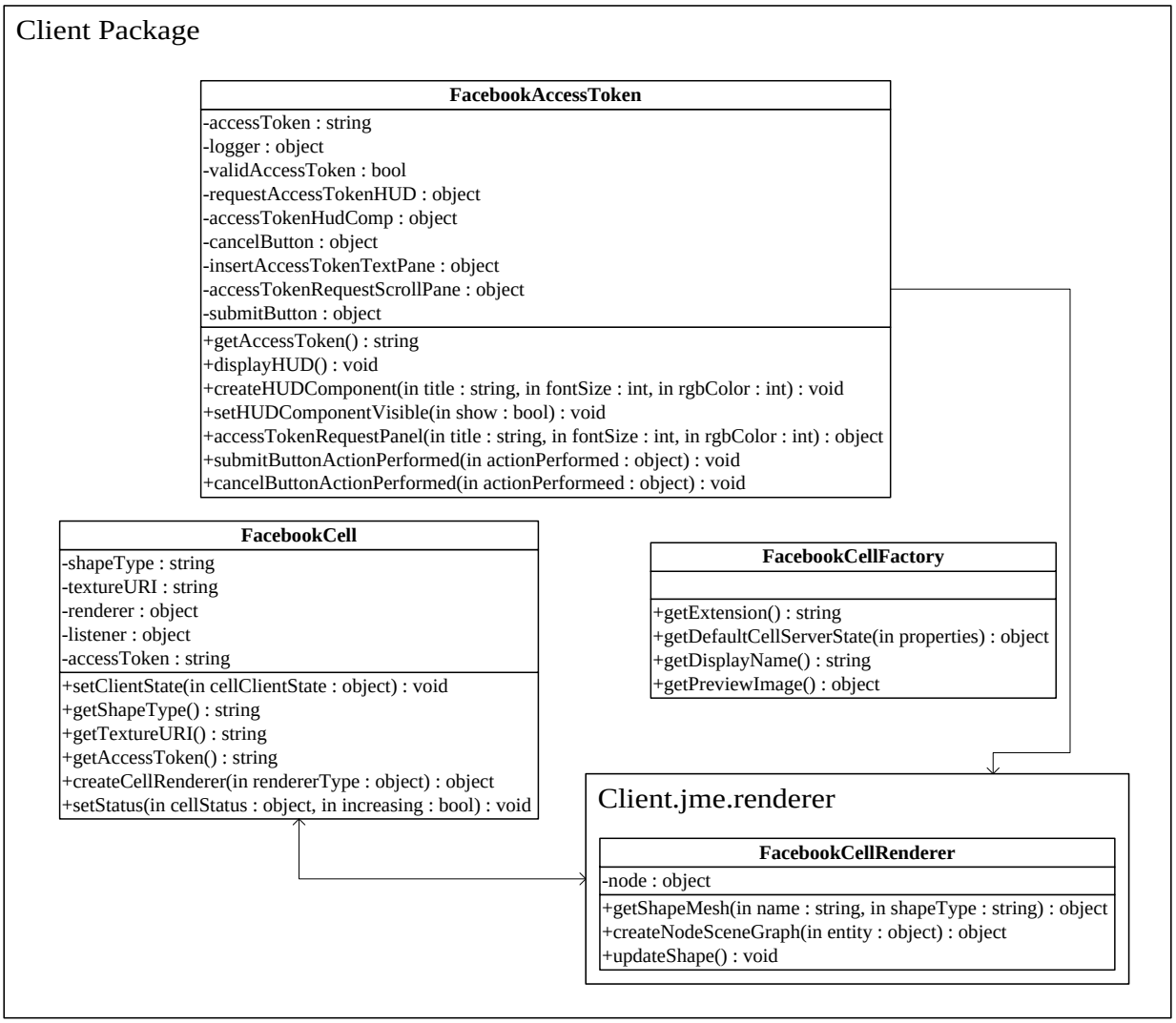


Figure 6-1 Client Package Class Diagram

The Wonderland client package should have a class which is extends `Cell` class. This class is used to for a copy of object on the client system. If two users using a same object, then each of them has an instance of cell object in their own system. The constructor of this class has two input parameter including the id of the new module and a cache version of the module.

```
public class FacebookCell extends Cell {
…
	public FacebookCell(CellID cellID, CellCache cellCache) {
		super(cellID, cellCache);
	}
…
}
```

Code 8 – `FacebookCell` constructor

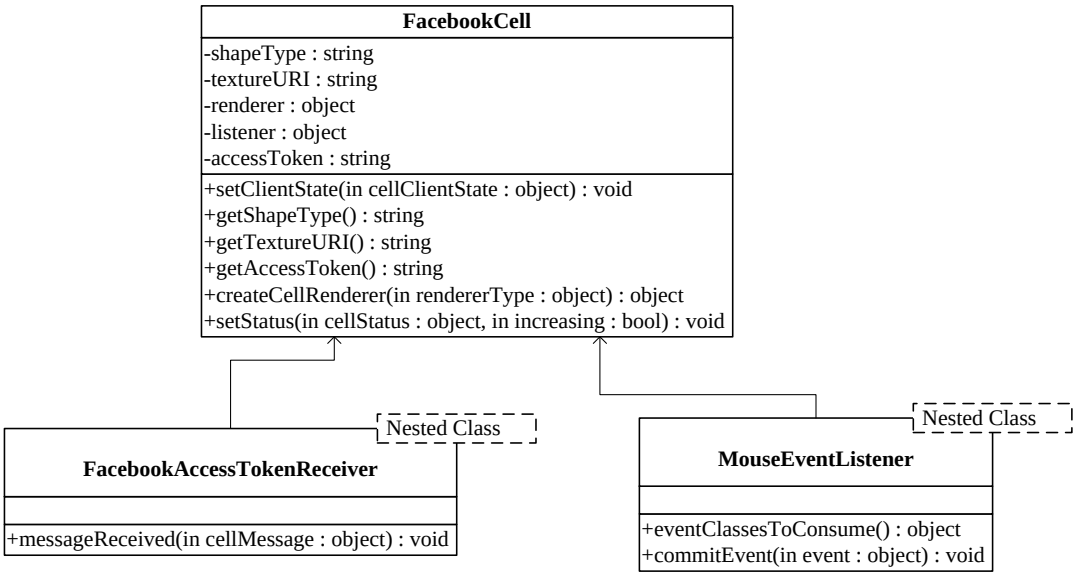


Figure 6-2 - `FacebookCell` Nested Class Diagram

Furthermore, Figure 6-2 illustrates that there are two inner classes in the `FacebookCell`. The first class is a listener for a mouse event to change the Facebook cube to a sphere and the other is a message receiver for the AccessToken. However after implementing the server module, it seems that there is no need for a message from the server to the client regarding an Access Token.

```
class MouseEventListener extends EventClassListener{…}

class FacebookAccessTokenMessageReceiver implements ComponentMessageReceiver{
	public void messageReceived(CellMessage message) {
	…
		if
		(!accessTokenMsg.getSenderID().equals(getCellCache().getSession()
		.getID())) {
			…
			accessToken = accessTokenMsg.getAccessToken();
```

```
                        …
                }
        …
        }
}
```

Code 9 – `FacebookCell` inner classes

The other class which is essential in the client package is `FacebookCellFactory` which extends a `CellFactorySPI`. This factory is applied to show a new module into the cell pallete.

```
@CellFactory
public class FacebookCellFactory implements CellFactorySPI {
…
        public <T extends CellServerState> T
        getDefaultCellServerState(Properties props){
                FacebookCellServerState state = new FacebookCellServerState();
        …
        }
        …
}
```

Code 10 – `FacebookCellFactory` structure

When a module is loaded in the Wonderland client browser, it shows a HUD on the screen. This screen has been created in the client's system by the `FacebookAccessToken` class. An observer pattern is used for notifying the changes from this class to other classes. This change will be happened when users insert their Access Tokens.

```
public class FacebookAccessToken extends Observable {
…
        public FacebookAccessToken() {
        requestAccessTokenHUD =
        HUDManagerFactory.getHUDManager().getHUD("main")
        displayHud();
      }
        private JPanel accessTokenRequestPanel(String title, int fontSize, int
        rgbColor){…}
…
}
```

Code 11 – `FacebookAccessToken` structure

When an Observable class notifies a change this change can be received on the other classes which implements the Observer classes. In the `FacebookCellRendere` class this mechanism has been applied. `FacebookCellRenderer` is a kind of `BasicRenderer` class. This class is created in the `jme.rendere` package within a client package.

```
public class FacebookCellRenderer extends BasicRenderer {
…
        private Node node = null;
        public FacebookCellRenderer(Cell cell) {
                super(cell);
        }
        protected Node createSceneGraph (Entity entity) {
```

```
        …
                String name = cell.getCellID().toString();
                String accessToken = ((FacebookCell)cell).getAccessToken();
                if(accessToken == null) {
                      final FacebookAccessToken accessTokenObj = new
                      FacebookAccessToken();
                      accessTokenObj.addObserver(new Observer() {
                            final String name = cell.getCellID().toString();
                            public void update(Observable o, Object arg) {
                                  FacebookAccessTokenMessage msg = new
                                  FacebookAccessTokenMessage(cell.getCellID(),
                                  accessTokenObj.getAccessToken());
                                  cell.sendCellMessage(msg);
                            }
                      });
                }
        …
        }
        …
}
```

Code 12 – `FacebookCellRenderer` structure

6.2.2 Wonderland Common

In the previous section, an instance of Access Token and a cube shape were created. Now, these objects should transfer to the server package via an intermediate package called common. The classes within common package can be accessible both on the server and client side.

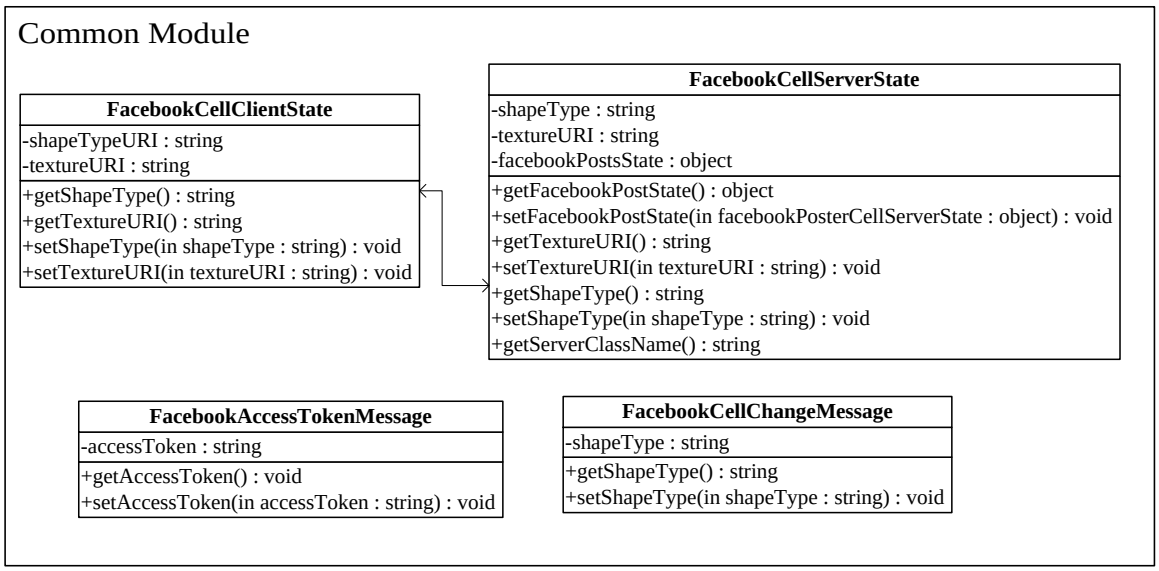


Figure 6-3 Common Package Class Diagram

In Figure 6-3 the two vital classes from the Wonderland platform are `FacebookCellServerState` and `FacebookCellClientState`. The former is applied to

determine the position and properties of the object which is load on the client browser. In other words, it contains some information regarding the state of a cell. This information is kept in a file with wfs[48] extension. Therefore, this class is a part of Wonderland server and its responsibility is keeping the clients up to date with the server states. The latter class is used for looking for the updates which are come from the client to inform the server by communicate through the former class. In summary, these two classes are applied for keeping the world up-to-date by getting changes from the client with `FacebookCellClientState` and set them into the server and applied to other clients with `FacebookCellServerState`.

```
public class FacebookCellClientState extends CellClientState { … }
@XmlRootElement(name="shape-cell")
@ServerState
public class FacebookCellServerState extends CellServerState{
…
      @XmlElement(name="shape-type")
      private String shapeType = "BOX";

      @XmlTransient
      public String getShapeType() {
            return this.shapeType;
      }
      // Normal setter method

      @Override
      public String getServerClassName(){
        return
        "uk.ac.essex.wonderland.modules.facebook.server.FacebookCellMO";
      }
…
}
```

Code 13 – `CellServerState` and `CellClientState` inheritances

The other remaining classes are used for synchronising messages for an Access Token and the state of Facebook shape. Since these two classes have a same structure, one of them will be selected for further discussion. The structure of FacebookAccessTokenMessage is shown on Code 14. It has a very simple structure with a property and a setter and a getter method for applying encapsulation. Its constructor gives an additional parameter to specify a cell ID.

```
public class FacebookAccessTokenMessage extends CellMessage{
      private String accessToken = null;
      public FacebookAccessTokenMessage(CellID cellID, String accessToken) {
            super(cellID);
            this.accessToken = accessToken;
      }
      //Normal setter and getter methods…
}
```

Code 14 – `FacebookAccessTokenMessage` structure

[48] Wonderland File Service

6.2.3 Wonderland Server

This section, first illustrates a class diagram of whole server package and then gives a few details regarding some classes which are required more discuss

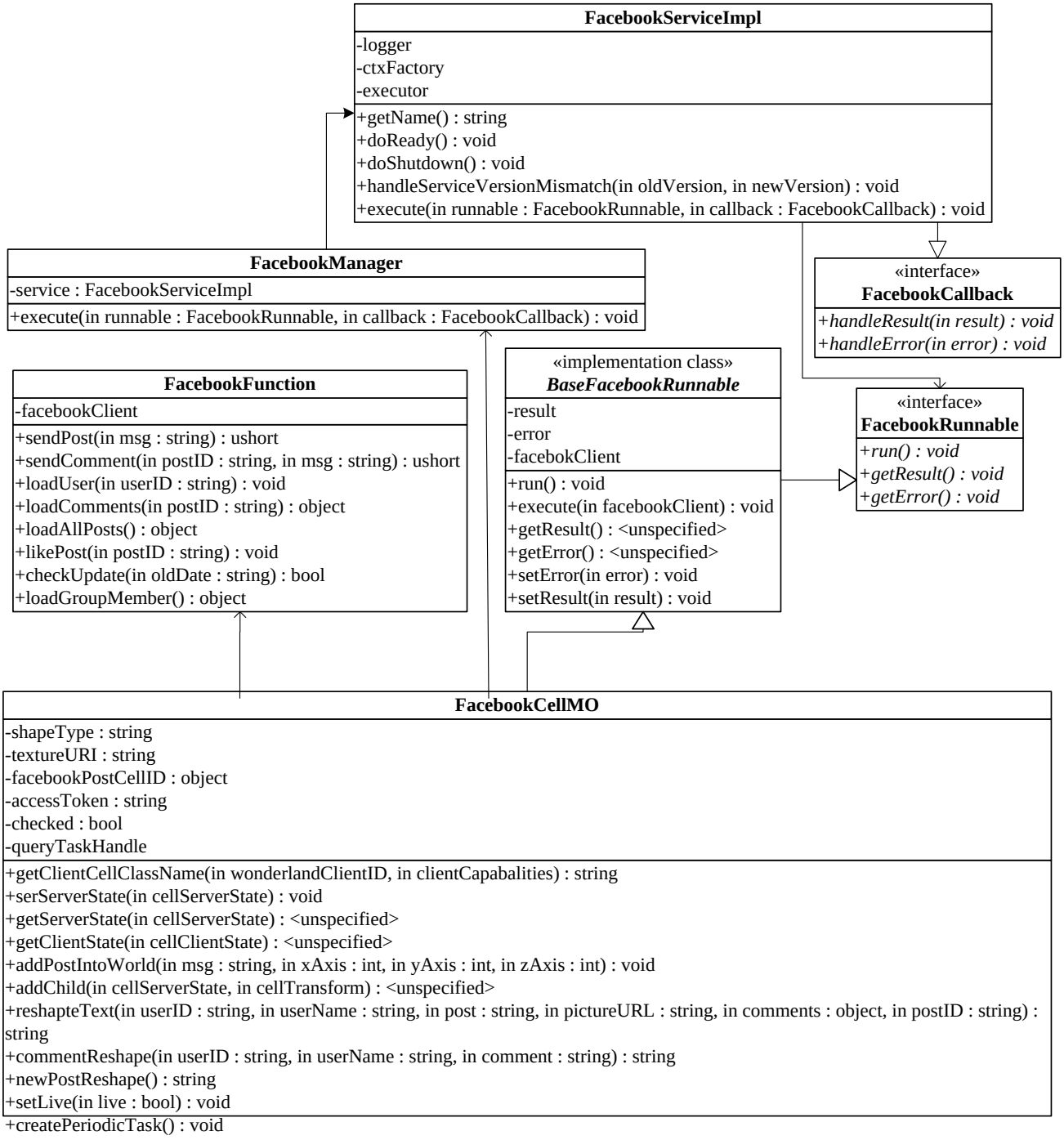


Figure 6-4 Server Package Class Diagram

The figure in the previous page displays a class diagram with all the methods' signatures. The essential method from Wonderland platform viewpoint is `FacebookCellMO`. Wonderland platform's definition for *managed object* is applied for the objects in the client and their status in the server. From this definition, it can be therefore that, server should consist of managed object for each cell for synchronicity purpose. CellMO (MO is a darkstar term) class implements `ManagedObject` and can be used in the server for keeping clients up-to-date in real-time.

```
public class FacebookCellMO extends CellMO{
      @Override
      public void setServerState(CellServerState state){
            super.setServerState(state);
            …
      }
      @Override
      public CellServerState getServerState(CellServerState state){ … }
      @Override
      public CellClientState getClientState(CellClientState cellClientState,
      WonderlandClientID clientID, ClientCapabilities capabilities){…}
      private CellMO addChild(CellServerState setup, CellTransform transform)
      { … }
      …
}
```

Code 15 – `FacebookCellMO` structure

In addition, this class has four nested class which will be shown on Figure 6-5. The firs inner class is `FacebookAccessTokenMessageReceiver` which receives a message from the client via the `FacebookAccessTokenMessage` class in the common package.

```
private static class FacebookAccessTokenMessageReceiver extends
AbstractComponentMessageReceiver {
      public FacebookAccessTokenMessageReceiver(FacebookCellMO cellMO) {
            super(cellMO);
      }
      public void messageReceived(WonderlandClientSender sender,
      WonderlandClientID clientID, CellMessage message) { … }
}
```

Code 16 – `FacebookCellMO` structure

When an Access Token message received by CellMO, it run a task-based transaction to retrieve data from a Facebook platform.

```
FacebookManager manager = AppContext.getManager(FacebookManager.class);
manager.execute(new GroupPosts(facebookClient), new GroupCallback(cellMO));
```

Code 17 – `messageReceived` method inside `CellMO`

The other remaining inner classes are part of task-based transaction mechanism. For instance, `GroupPost` is used for populate a vector of `Post` objects from a Facebook group and `GroupCallback` is necessary to handle the results and write them immediately which is one of the most important features of darkstar service.

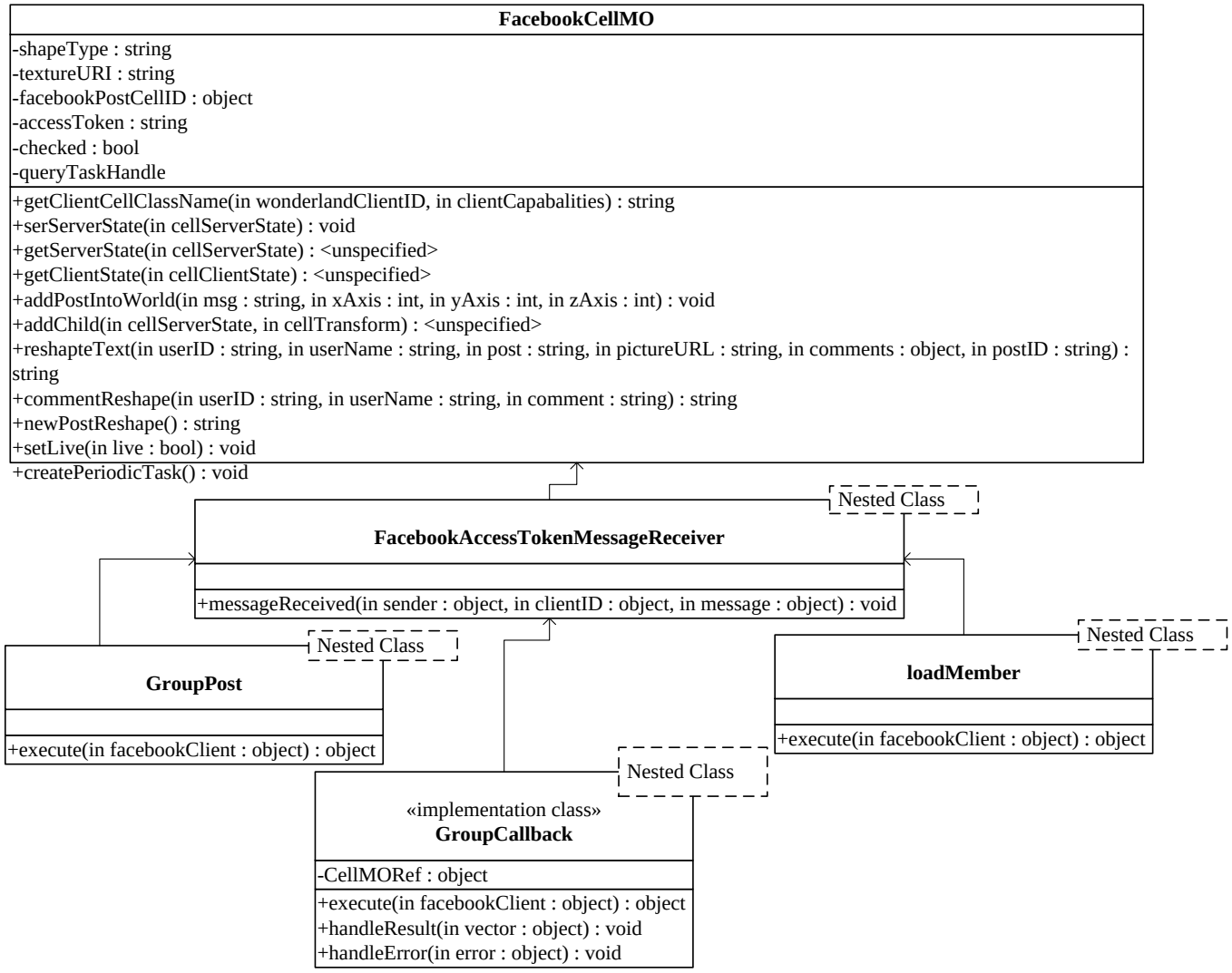


Figure 6-5 `FacebookCellMO` Nested Class Diagram

Moreover, the other class which is used to manage task-based transaction is `FacebookManager` which contains an instance of `FacebookServiceImpl`. `FacebookServiceImpl` uses a `FacebookCallback` to handle the result of service and a `FacebookRunnable` to run a request. For keeping the environment up-to-date, this service sends a request every 10 minutes via `executor` property which is an instance of `ScheduledExecutorService`.

```
executor.scheduleAtFixedRate(runnable , 1, 10, TimeUnit.MINUTES);
```

Code 18 – Periodic Task

Within this class there are five inner classes including: `FacebookTransactionContext`, `TransactionContextFactoryImp`, `FacebookRunner`, `FacebookKernelRunnable` and

`FacebookCallbackWrapper`. The methods' signature and the relationship of these classes are shown on Figure 6-6.

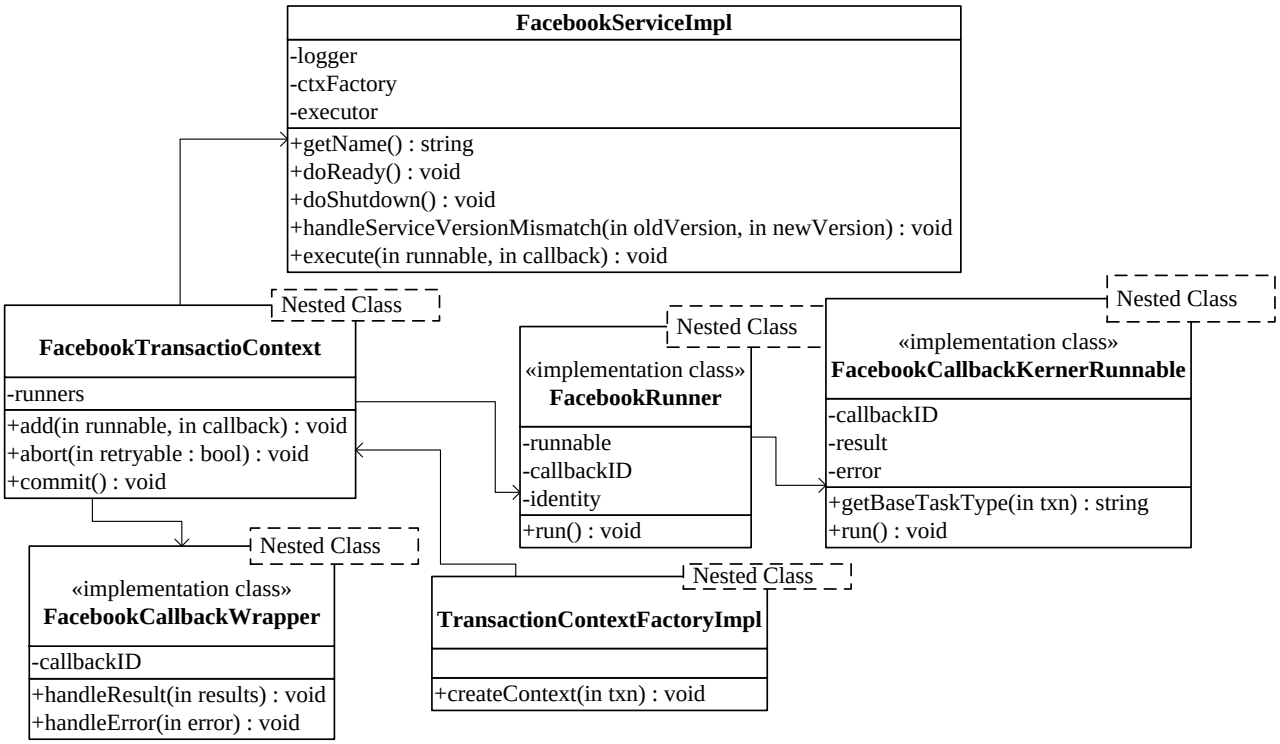


Figure 6-6 `FacebookServiceImpl` Nested Class Diagram

6.2.4 Module Deployment

Section 4.3 indicated that Wonderland server is based on the Apache Ant. Therefore, each module should contain `build.xml` file which consists of required paths and instructions for deploying a module into server. Moreover, each module should contain a `my.module.properties` to specify the path of server and also module's versions. This file can be accessible from the `build.xml` since there is a `<property>` element with a file attribute underneath of `build.xml`'s root, `<project>` element. All the external libraries which are used in the module should be addressed in `build.xml` according to their packages.

```
<?xml version="1.0" encoding="UTF-8"?>
<project name="wonderland-${module.name}-module" default="dist" basedir=".">
      <property file="my.module.properties"/>
      …
      <pathconvert property="module-client.classpath">
            <path location="${appbase.dir}/build/client/appbase-client.jar"/>
            …
      </pathconvert>
```

```
      <pathconvert property="module-common.classpath">
            <path location="${appbase.dir}/build/client/appbase-client.jar"/>
            <path location="${current.dir}/../../../wonderland-
            modules/stable/poster/build/server/poster-server.jar"/>
            …
      </pathconvert>
      <pathconvert property="module-server.classpath">
            <path location="${current.dir}/lib/restfb-1.6.9.jar"/>
                  <path location="${current.dir}/../../../wonderland-
                  modules/stable/poster/build/server/poster-server.jar"/>
                  …
      </pathconvert>
      …
</project>
```

Code 19 -Facebook Group Integration's `build.xml` structure

In addition, some information regarding the building, distribution and deployment of a new module such as the path of the appropriate folder can be found in this file by a `<target>` element. Also, this element contains the services and libraries which are required for generating final `.jar` file. Code 20 will illustrate required elements, libraries and services as well as generated folders such as art, build and dist for a Facebook Group Integration. If all the required factors are provided, Wonderland new module can be completely deployed on its server.

```
<target name="build" depends="-module-init, -module-compile-common,
                                                -module-compile-server,
                                                -module-compile-client"/>

<target name="dist" depends="build">
      <mkdir dir="${module.dist.dir}"/>
      …
      <client>
            <!-- <clientjar> required services and libraries -->
                  <!-- <include> required folder (Client and Common) -->
                  <fileset dir="${current.dir}/src/classes">
                        <!-- <include> Client Properties -->
                        <include name="${module.src}/client/**/*.png"/>
                  </fileset>
            </clientjar>
      </client>
      <server dir="${current.dir}/lib">
            <include name="restfb-1.6.9.jar"/>
            <!-- <serverjar> required services and libraries -->
                  <service type="Service" provider=" FacebookServiceImpl"/>
                  <service type="Manager" provider=" FacebookManager"/>
                  <!-- <include> required folder (Server and Common) -->
            </serverjar>
      </server>
      <art dir="${current.dir}/art"/>

        </module>
    </target>
    <target name="deploy" depends="dist, -module-deploy"/>
    <target name="clean" depends="-module-clean"/>
```

Code 20 - `<target>`s elements within `build.xml` file.

Chapter 7 :
Evaluation

This section will review the steps and results of an experiment conducted to evaluate our proposed prototype. The first section will express the three methodologies applied for the evaluation procedure. A user trial session will be explained in the second section and the final section will classify and analyse the results collected from the experiment. This section is extremely important from a research viewpoint, and the results of this section can be considered as an artefact of the software testing process which is part of all the phases in the AUP methodology.

7.1 Evaluation Methodology

This section is divided into two subsections on the basis of evaluation methodologies. The next three paragraphs will explain the *Usability Testing* including its two well-known approaches: *Think-Aloud Protocol* and *Focus Group*. Thereafter, it assesses the affordances of 3D virtual learning environments with an integrated Social Network Group module.

Most of the interactive environment will be designed according to users' needs. Therefore, it is essential to evaluate this type of product by their users. The past twenty years have seen increasing interest in the field of user-centric evaluation methods. Jakob Nielson classified this evaluation process into four major group including: *Empirically*, *Informally*, *Formally* and *Automatically*. Moreover, he argued that the last two techniques are not useful enough for usability evaluations [84]. The first method is based on the availability of the real user to assess the system, while the second relies on the evaluator's abilities and experiences.

Usability evaluations for a proposed prototype will be conducted in a role-play session based on the *think-aloud* protocol. In this method, however, users are not the real consumers of the system; they pretend to be real and think about their requirements. It is worth noting that all the volunteer users are MSc and PhD students at the Universities of Essex and Manchester who had previous experienced of a traditional learning environment. Therefore, they are acquainted with the weaknesses and strengths of the aforementioned education system.

Moreover, a *focus group* methodology will be applied to assess the effectiveness of discussion in the collaborative learning environment within a group of people. This method can help the evaluator to gain better feedback from the users' perception of the proposed system. Finally, users will fill in a five-point Likert scale questionnaire which is designed with regard to Jakob Nielsen's *Framework of System Acceptability* and Ben Shneiderman's *criteria* for usability of a digital system [85]. The first framework considers *learnability*, *efficiency of use*, *memorability*, *few and non-catastrophic errors* and *subjective satisfaction*, while the other relies on the quality and appeal of *pictures* in the environment, *readability* of contents, applying different and harmonised *colours*, facility of *navigation* to the correct spot, increasing *interactivity* among the users as well as the objects, application *features* and *functions* and *accessibility* of the content. This Questionnaire will be shown in section B of the Appendices.

As well as usability testing, the concept of *affordance* will be reviewed briefly in this section. This term is understood as a quality of environment that allows users to carry out particular tasks. Therefore, in the 3D environments, affordance can be applied to the practices which are carried out by the user to interact with the virtual world. However, there is a slight difference between activities in collaborative learning and affordances. The former accentuates the social sides of group work while the latter focuses on the effort of each individual member of a group to exert their influence with the help of a collaborative environment [20]. Furthermore, Dalgarno and Lee's investigation on learning affordances of a 3D virtual environment concludes that this type of environment may have some privileges compared to non-3D learning environments when taking certain cognitive assumptions and potential features of the 3D learning environment, which are displayed in Figure 7-1 Dalgarno Model for 3D Virtual Learning Environments (Unique Characteristics + Learning Affordances) [86], into account [86].

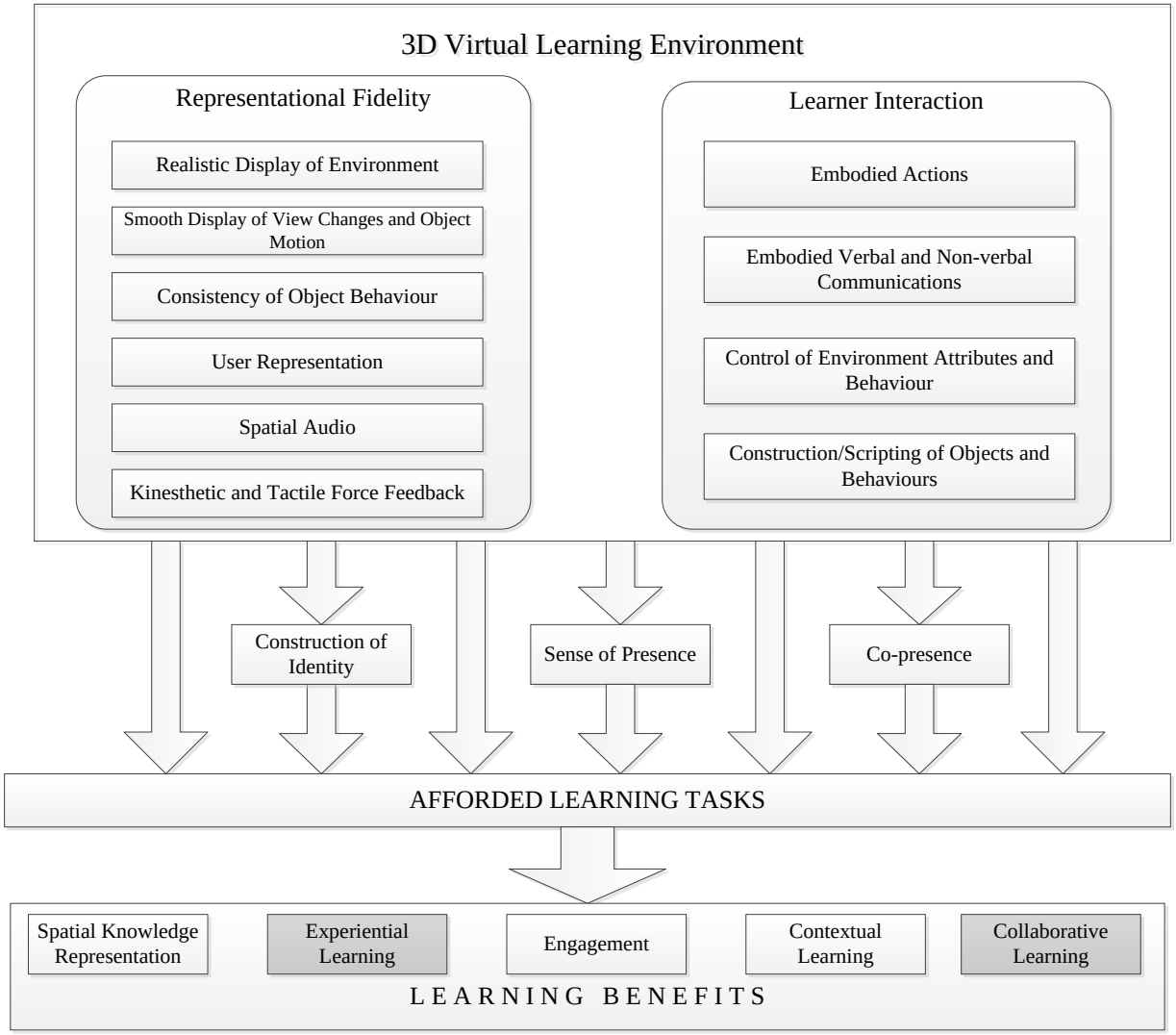


Figure 7-1 Dalgarno Model for 3D Virtual Learning Environments (Unique Characteristics + Learning Affordances) [86]

Our experiment confirms that learning outcomes are associated with rate of high-fidelity interaction among the participants in the 3D spaces. Each component in a learning environment helps to increase this type of interactions can be suggested as a positive factor for such environments. For instance, since *avatar* is employed to express the users' emotions as well their reactions, it may be a beneficial element for the virtual worlds. In the context of this project, adding some representative fidelities aspects such as user representation and spatial audio besides interaction features such as the ability of verbal communication to the members of Facebook Group, who have a common goal, can cause certain learning benefits among them. Since Facebook Group can encourage the students to contribute in the discussions, because of its popularity, it can be applied as a communication media to raise the rate of interaction. This factor can be considered as learning affordances for the proposed system. It can be thus that, there are similarities between the attitudes articulated by the learning benefits in this study such as collaborative and contextual learning and those described by Dalgarno.

The degree of transferring knowledge in an integrated 3D with Social Network Group learning environment will be assessed and the results of this evaluation will be analysed in 7.3.

7.2 User Trial

This section will explain the evaluation session which was held on 25th August 2012. The participants were ten Iranian postgraduate students from MSc to 4th year PhD studying either at the University of Essex or the University of Manchester and whose majors were different, including students from the fields of linguistics, biomedicine, law, management and business administration, civil engineering and computer science. There were four male and six female volunteers and their ages ranged from 22 to 37, with the mean age being 28. All the participants were enrolled in a Facebook group, named '*3D Virtual learning*'[49], before the session had started.

The evaluation process was conducted in a two-hour practical session and a twenty-minute questionnaire. Since Persian was the first language of the participants, this was chosen for communication between them. Each user was in a separate location and they were connected to the Wonderland server via the admin's IP address and port number. Users downloaded the required files to run the Wonderland client. Since most of the users were unfamiliar with computer science and the Java environment, running the Wonderland client took longer than expected.

At the beginning of the session, the admin provided a twenty-minute description regarding virtual worlds and collaborative tasks and allowed five minutes for the user to customise their arbitrary avatar. These activities were part of the ice-breaker in an evaluation process.

[49] https://www.facebook.com/groups/246428652139549/

Afterwards, the admin highlighted the importance of collaborative group-based tasks which can be supported by a 3D virtual environment. However, to prevent any bias in the result of evaluation, he did not discuss the advantages of using a Social Network group. A new one-hour discussion, titled *explicit vs. tacit knowledge* was held among the participants in a specific location with seven chairs and some tables.

Figure 7-2 - Evaluation Process - Discussion

Finally, the admin asked users to gain their Access Token via the 2D application. Continuously, it was requested that certain tasks be carried out in a specific time, such as adding a new comment on an existing discussion or creating a new discussion from the virtual world in a Facebook group. For instance, the admin requested one of the participants to create a new discussion which is shown in Figure 7-3 and he added two comments under this discussion, which are displayed in Figure 7-4. After half an hour, this section of the evaluation process was completed.

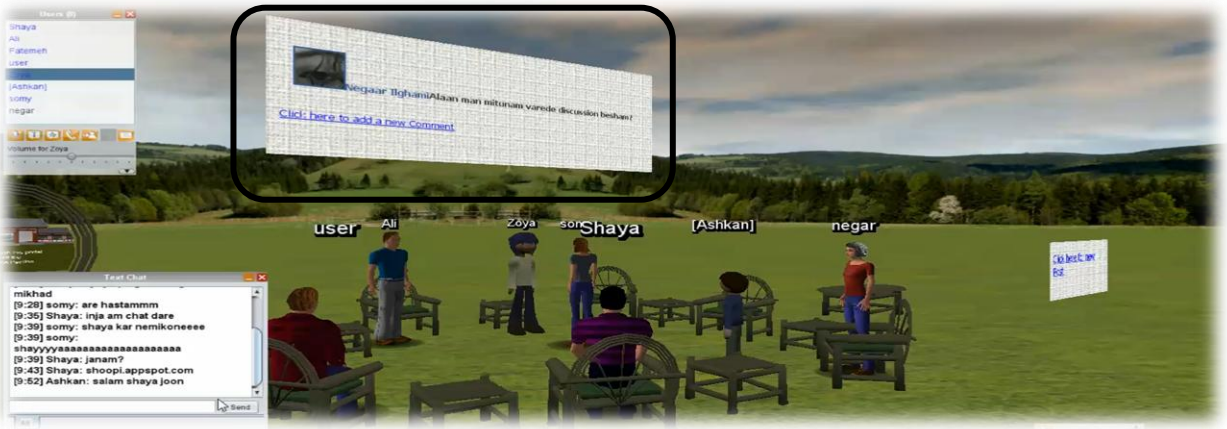


Figure 7-3 Task-Based Evaluation (1)

Figure 7-4 Task-Based Evaluation (2)

Immediately, a new poster was added to the virtual world which contained a link to the questionnaire. Participants linked to questionnaire[50] which had been designed on the SurveyMonkey[51] free questionnaire engine. The admin allowed a fifteen-minute period in which the participants had to fill in the questionnaire and a five-minute closing discussion after the submission of the questionnaire. The results from this questionnaire will be discussed in the next section.

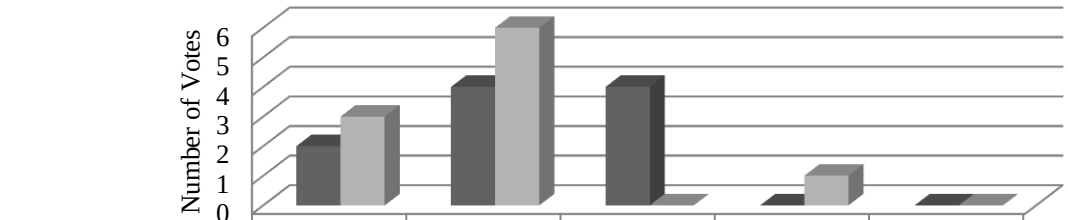
7.3 Results

Upon completion of the evaluation process, the statistical information from the questionnaire will be reviewed and analysed in this section. These results will be divided into two separate categories including the outcome of the task-based usability test, which was calculated by the evaluator, and the scores of the questionnaire queries which were filled in by the participant.

In the task-based procedure, the average time for creating a new discussion or adding a new post was one minute and five seconds from the first click to the final appearance in the virtual world, which was calculated by the evaluator. This figure shows that the proposed system is neither too fast nor too slow. Furthermore, task completeness was the other measure to evaluate, and this scored an 80% success rate since only two subjects were unable to carry out their assigned tasks because of low memory and poor graphics capabilities on their machine. Therefore, no one encountered any functional requirement and usability problem in carrying out their tasks. Other measures such as gained knowledge, efficiency, visual appeal, user's preferences and their satisfactions were also asked in the questionnaire.

[50] http://www.surveymonkey.com/s/WVWQMGH
[51] https://www.surveymonkey.com/

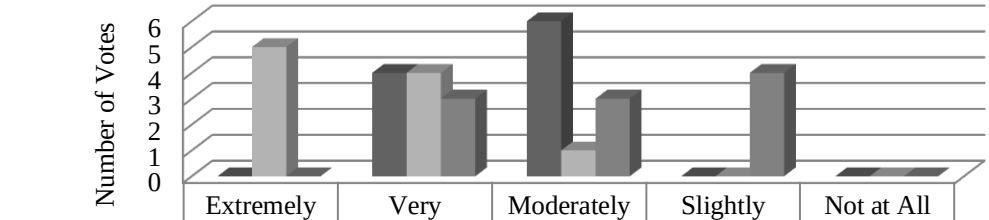
The first question was with regard to the verbal discussion in the evaluation session. As expected before, tacit knowledge was more acceptable for 3D virtual learning. However, the explicit knowledge result was over the satisfactory level. This result is shown in Figure 7-5 - Question 1 – Result.



	Extremely Well	Very Well	Moderately Well	Slightly Well	Not at All Well
Explicit Knowledge	2	4	4	0	0
Tacit Knowledge	3	6	0	1	0

Figure 7-5 - Question 1 – Result

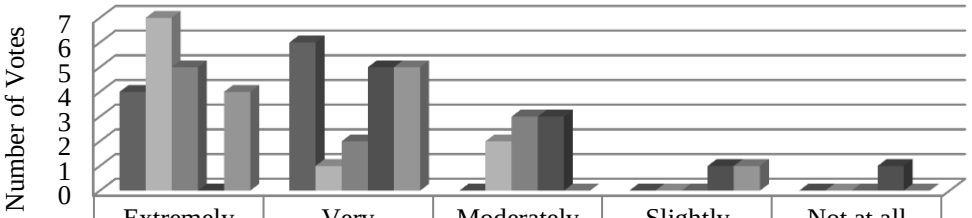
The second question concerned the efficiency of the proposed system. This question was divided into three layers: time efficiency, accessibility and technological infrastructure. Since this system is based on a 2D application, the evaluator expected better results for time efficiency, however, accessibility earned a good result. The low rating in technological infrastructure was predictable.



	Extremely Effective	Very Effective	Moderately Effective	Slightly Effective	Not at All Effective
Time	0	4	6	0	0
Accessibility	5	4	1	0	0
Infrastructure	0	3	3	4	0

Figure 7-6 - Question 2 - Result

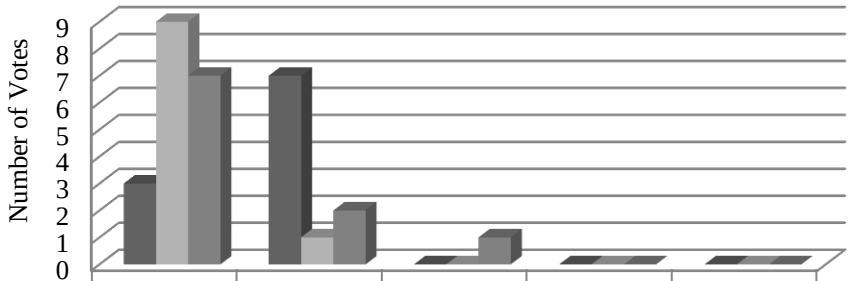
The third question raised certain visual appeal issues with regard to Ben Shneiderman's criteria of acceptance. The result showed that readability of content and the harmonisation of colours such as poster backgrounds and font colours were pleasant. The other issue concerned navigation through the virtual world, where no one was completely satisfied; however, they were not disgruntled either. Finally, the 90% gratification rate for interactivity among the participants can be supporting evidence for why this type of integration was proposed.



	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing
Image	4	6	0	0	0
Readability	7	1	2	0	0
Colour	5	2	3	0	0
Navigation	0	5	3	1	1
Interactivity	4	5	0	1	0

Figure 7-7 Question 3 - Results

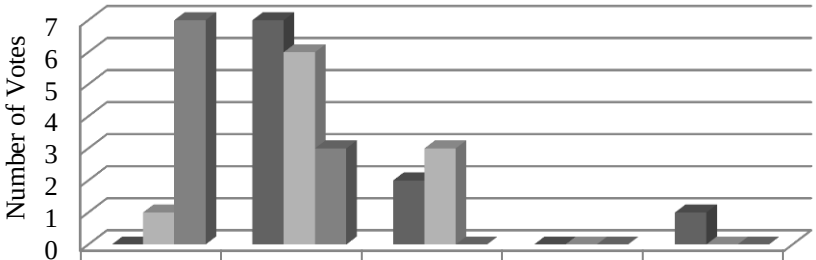
Question 4 assessed the proposed system in terms of social science. It asked how integration of a Social Networking group into a collaborative learning environment could be useful in terms of collaborative learning tasks, social media and psychological factor. The third concept was selected since students were interested in working with Social Networks and it seems it is possible to employ this platform within a learning environment. Results indicated that participants shared the same opinion as the evaluator.



	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Collaborative Learning Tasks	3	7	0	0	0
Social Media	9	1	0	0	0
Psychological Factor	7	2	1	0	0

Figure 7-8 Question 4 - Results

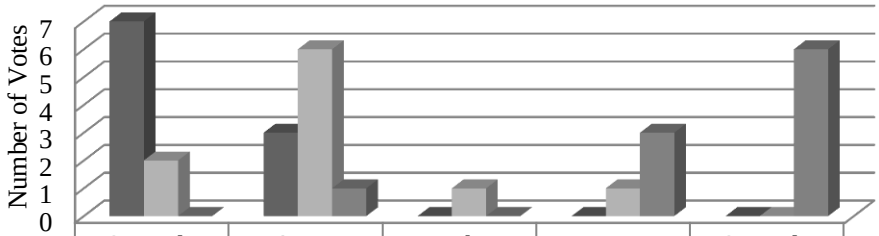
In question 5, most of the users (70%) strongly agreed and the reminder agreed with the use of a collaborative learning environment with a Facebook group module to get to know the other participants via their Facebook profiles. Figure 7-9 Question 5 – Results displayed the result of this question, which is another positive indication for proposing this integration.



	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Pure VCL	0	7	2	0	1
VCL only with 2D Application	1	6	3	0	0
VCL with a Social Network Group	7	3	0	0	0

Figure 7-9 Question 5 – Results

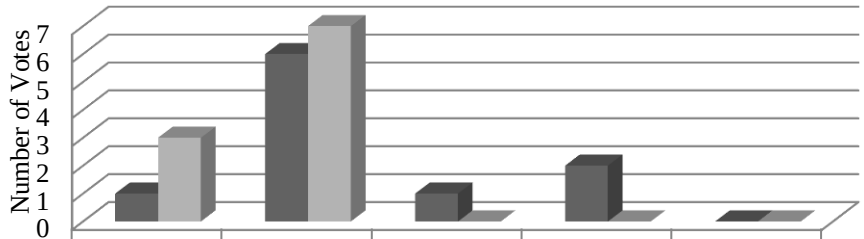
Generally, it is believed that Social Networks can distract students from concentrating on learning purposes. Question 6 requested participants to express their thoughts before and after this experiment. Before this session, all of the participants had the same opinion; however, after the evaluation, surprisingly, 90% changed their mind and agreed with using a group of Social Networks for learning purposes.



	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Before the Experiment	7	3	0	0	0
After Experiment with External Notification	2	6	1	1	0
After Experiment without External Notification	0	1	0	3	6

Figure 7-10 Question 6 – Results

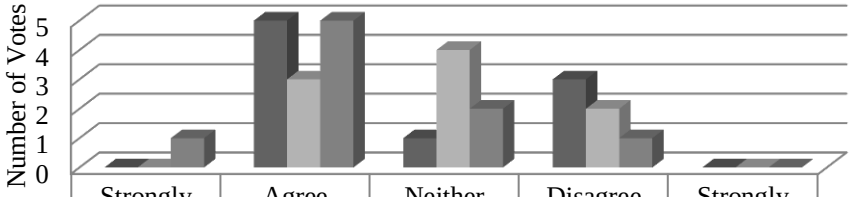
The seventh question addressed the required computer science background requirements for the users. Three of the participants said that a little over general computer knowledge can be required for the users, however all of them agreed there is no need for users to have video game experience.



	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Computer Science Knowledge	1	6	1	2	0
Video Game Experience	3	7	0	0	0

Figure 7-11 Question 7 – Results

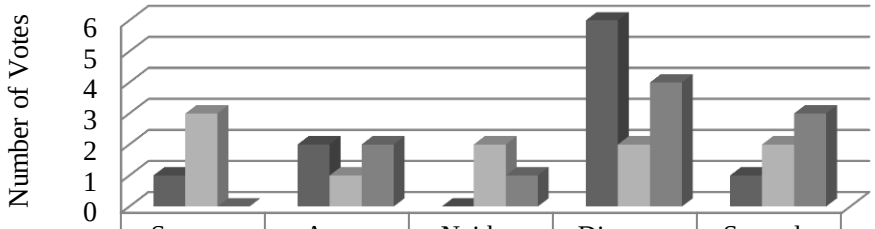
Question 8 pertained to the speed of actions and activities in the system which was discussed in the second paragraph of this section. All participants were not fully satisfied with the performance issues. One of the participants skipped this question. The result of this question will be displayed in Figure 7-12.



	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Reading Group Contents	0	5	1	3	0
Creating new Discussion	0	3	4	2	0
Posting New Comment	1	5	2	1	0

Figure 7-12 Question 8 – Result

Question 9 had the most variable answers in this questionnaire. A challenging issue of using different environments for a learning system was discussed in three levels. Just 10% of the participants strongly disagreed with using a virtual 3D environment for learning, however 60% did not agree with using a pure Social Networking for this purpose. Astonishingly, an unexpected result occurred on the integrated environment, where 70% believed that this system could be beneficial for learning systems. Figure 7-13 will illustrate this unexpected and promising result.



	Strongy Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Using Virtual Environment for Education	1	2	0	6	1
Using Social Networking for Education	3	1	2	2	2
Using Integrated Environment for Education	0	2	1	4	3

Figure 7-13 Question 9 - Result

To conclude, there was a closing question for the final satisfaction of each participant. Despite the proposed system's prototype having raw implementation, it was accepted by the participants, since no one expressed dissatisfaction with this system. The result was 5 strongly agrees and 5 agrees. From this outcome, it can be therefore concluded that the idea of this integration seems to be valuable for the learners with regard to both social and educational viewpoints.

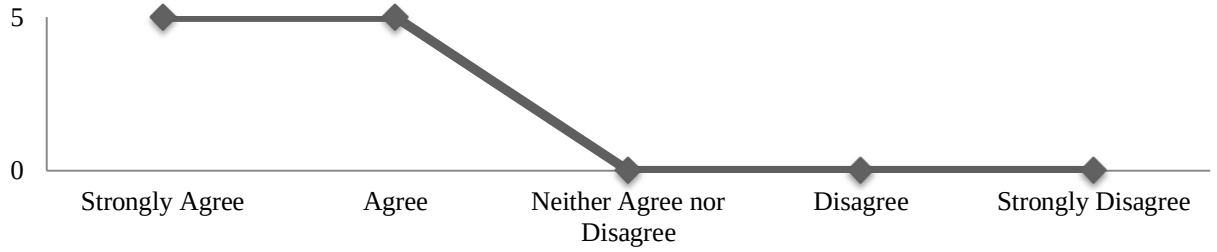


Figure 7-14 Question 10 - Result

Chapter 8 :
Conclusion

This dissertation has investigated the potential of using a Social Network group or community in developing a 3D collaborative learning environment. The challenge was to find a novel innovative approach to support learners' requirements, such as accessibility for learning collaboratively. A '*group*' within a Social Network was assigned as a research variable since its members have a common goal, which is compulsory for collaborative activities.

Based on the breadth and depth literature review, delivered in Chapter 2, there were few studies to connect these two mentioned fields. A new hypothesis was posed which claimed that '*The integration of a Social Network Group or Community into 3D Collaborative Learning Environment can better meet the learners*'. Therefore, the requirements for designing and implementing an integrated system were identified and a prototype was proposed. This prototype has three certain functionalities which are required for an integrated system: authentication and authorisation, retrieving data and sending it back.

Since Facebook is known as the most popular Social Network in the world, a Facebook Group was selected as an instance of an online social community. The idea of using Facebook in group form instead of its typical manner offers excessive motivation for its members to shape their interaction into goal-based communication. This kind of collaboration is highly appreciated in the learning environment, where users seek for knowledge during their interactions. Therefore, the Social Network Group or Community has enough potential for it to be applied to learning systems such as 3D virtual collaborative learning environments. An example of this environment applied in this project was the Open Wonderland platform. The contents of these types of group were implemented as an object into a 3D virtual world.

One main objective of this project was to develop a new Wonderland module to integrate these two platforms. The implemented module communicates with the Facebook Group via an Access Token. To generating an Access Token, a new Facebook Application was developed which employs the OAuth 2.0 technique to link the user to their Facebook account. Moreover, this application was applied for the purpose of creating a new post or adding a new comment from the 3D world to the Facebook Group. Therefore, the developed Wonderland module supports three main functional requirements of the proposed model.

The initial results of the questionnaire showed that the prototype was accepted among users and it encouraged them to participate in the discussion and interact with other group members more effectively. Furthermore, they were able to access to contents very quickly via the Facebook Group as well as connecting to the 3D virtual world. The other issue appreciated by participants was the ability to navigate to the Facebook profile of each user.

Overall, returning to the hypothesis posed at 3.1, it is now possible to state that using a Social Network Group or Community within a 3D virtual collaborative learning can improve the ability to meet learners' requirements for collaborative learning tasks.

One implication of these findings is that both social group interaction and the concept of accessibility should be taken into account for a 3D collaborative learning environment. Considerably more investigation is required in order to develop a comprehensive integrated module. For instance, adding a listen again facility to record the voice conversations and upload them to a Facebook Group would be a good target for possible improvement.

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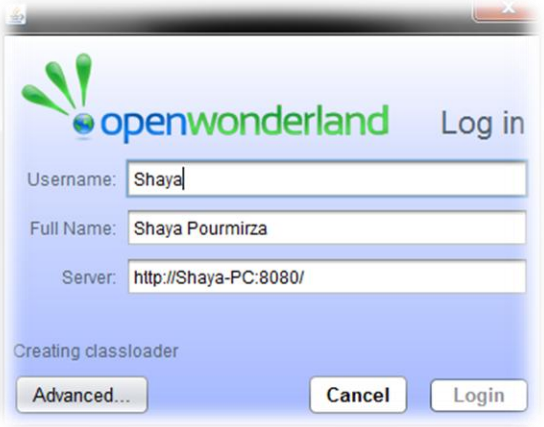
Appendices

A. User Documentation

1- User requests to connect to the wonderland server.
2- System requests login information.
3- User inserts username, full name and server address and presses the login button.

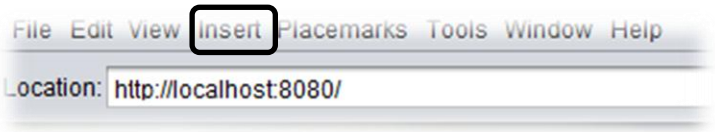


Appendices I - Wonderland Login Screen

4- Wonderland Client tries to load a 3D world with an avatar for the user.

Appendices II - Wonderland Environment

5- User selects the Insert option from the menu bar.



Appendices III - Wonderland Client Browser - Menu Bar

6- System shows the options for Insert including: Object and Model
7- User selects Object option.
8- System shows Insert Object window (aka. *Cell Pallete*).
9- User selects Facebook Group Integration and press Insert button.
10- System shows a HUD and a cube surfaced by the Facebook logo.
11- User clicks on the '*click here*' text on the HUD.

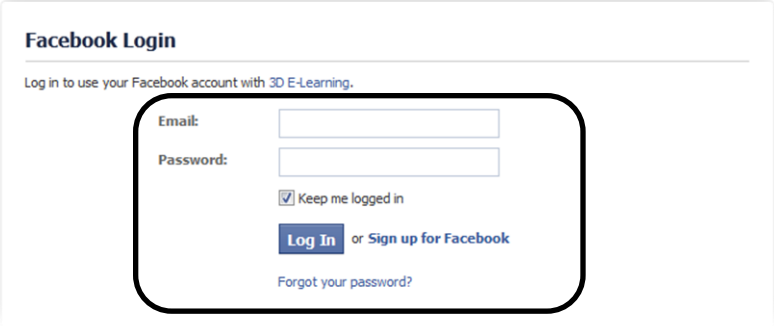
Appendices IV - Wonderland Cell

Appendices V - Facebook Group Integration HUD

12- System opens a webpage via the default web browser for Facebook authorisation.
13- User clicks on the link to generate an Access Token.

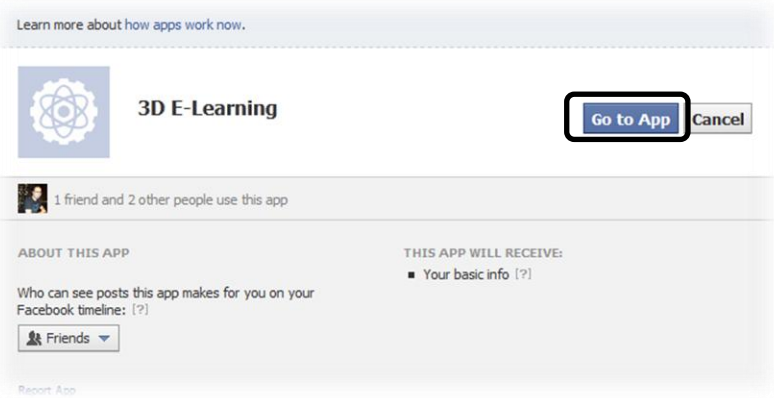
Appendices VI - Authentication Servlet (Home Page)

a. If user has not been approved by Facebook.
   i. User has not logged in to the Facebook.
   ii. System redirects user to the Facebook login webpage.
   iii. User inserts his/her login information.



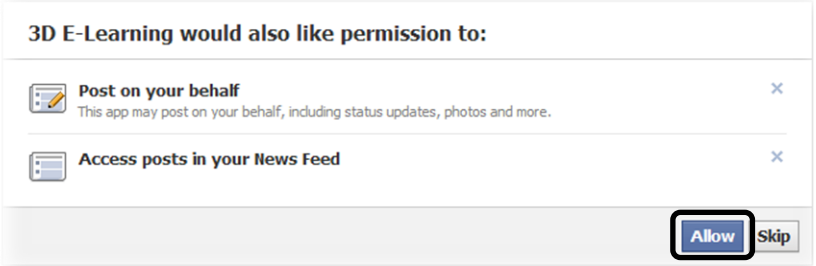
Appendices VII – Facebook Login

c. User has not been authorised by 3D E-Learning Facebook application.
   i. System requests user to allow user for using the application.
   ii. User clicks on 'Go to App' button.



Appendices VIII – Facebook Application

   iii. System requests user for required permissions.
   iv. User clicks on 'Allow' button.



Appendices IX – Facebook Application Permissions

14- System shows an Access Token.

Appendices X - Authentication Servlet (Access Token)

15- User copies his/her Access Token on the HUD and presses the 'OK' button.

B. Questionnaire

1. How well does this system meet your learning needs according to:

Explicit Knowledge	Extremely Well	Very Well	Moderately Well	Slightly Well	Not at all Well
Tacit Knowledge	Extremely Well	Very Well	Moderately Well	Slightly Well	Not at all Well

2. How effective is this system regarding the resource saving:

Time	Extremely Effective	Very Effective	Moderately Effective	Slightly Effective	Not at all Effective
Accessibility (2D & 3D Application)	Extremely Effective	Very Effective	Moderately Effective	Slightly Effective	Not at all Effective
Technological Infrastructure	Extremely Effective	Very Effective	Moderately Effective	Slightly Effective	Not at all Effective

3. How visually appealing is this system regarding the:

Images	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing
Readability	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing
Use of Colour	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing
Navigation	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing
Interactivity	Extremely Appealing	Very Appealing	Moderately Appealing	Slightly Appealing	Not at all Appealing

4. I found a number of functions in this system were well integrated in terms of:

Collaborative	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

Learning Tasks					
Social Media	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Psychological Factors	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

5. I would prefer to use

Pure Virtual Collaborative Learning (VCL)	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Integrated VCL With a 2D Application	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Integrated VCL With a 2D Social Group to know the other participants	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

6. Social Media Communities distracted me during study time

Before Experiment	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
After Experiment with Notification	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
After Experiment without Notification	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

7. I would imagine that most people would learn to use this system very quickly

Without Computer Knowledge	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Without Video Game Knowledge	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

8. This system is not fast enough for:

Reading Group Contents	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Creating a Discussion	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Creating a new Post	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

9. I thought there was too much inconsistency in:

Using Virtual Environment for Education	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Using Social Networking for Education	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Using Integrated Environment for Education	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

10. Overall, I am quite satisfied with this system

Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree