THE DESIGN OF A LOCATION-BASED NEIGHBORHOOD GAME THAT
STIMULATES THE GENERATION OF SOCIAL CAPITAL

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Table of Contents

1. Introduction

     Highly-connected social network is essential for the well-being of a neighborhood. Social capital is a measurement to evaluate social network through analyzing relationships within a given group (Carpiano & Fitterer, 2014). The change of neighborhood social capital can be assessed by questionnaires with 4 dimensions, including trust, norms of reciprocity, supportive network and personal network (Takagi, Ikeda & Kawachi, 2012). Social media like Facebook provides platform for people to communicate and build relationship online, but they cannot stimulate the generation of new relationship. Moreover, according to Feld (1981), offline communication has better performance in generating social capital than online communication because offline communication boosts joint and organized activities. Location-based mobile games like Pokémon Go allows players to play face-to-face, and they increase self-disclosure of the players (Sung et al., 2017). Therefore, a location-based social media has the potential to outclass traditional social media in generating new relationship and generating offline relationship. According to Deterding (2011), "Gamification is the use of game design elements in non-game contexts". It aims to motivate the activity of users and to increase user retention (Chen, 2017). Gamification is an innovative way to improve user participation and motivation, and it can be implemented in the design of a location-based social media. To involve users to participate in the application and to generate social capital, the report will design a location-based neighborhood game. The goal of the neighborhood game is to provide a platform for communication within and between neighborhoods and to motivate people with different anticipations and expectations to play the game and to generate social capitals through playing the game.

2. Literature Review

2.1 Previous work on designing location-based game

     The essentials of designing a location-based game can be learned from the existing location-based games. In the study of Neustaedter et al. (2013), the successful spread and popularity of location-based game Geocaching is analyzed, and 6 lessons for developing scalable location-based game are provided. A scalable location-based game means that the game is played and spread in a wide range and is played by many people. The authors conducted their study by playing the game directly and by questionnaires. The result is summarized as 6 lessons. One of the lessons is that the propriety and rules can be developed by players themselves. The analysis of Geocaching provides some practical advices for developing a scalable and popular location-based game.

     The design of a location-based game project called ZWERM also provides some insights for developing the location-based neighborhood game. The design and the outcomes of the game is summarized in the study of Coenen et al. (2013). The purpose of the game design is to boost local self-organization, which can be achieved by the activation and consolidation of neighborhood social capital. The game design implements a game system design framework call MDA, which is composed of mechanics, dynamics and aesthetics. Mechanics refers to the rules and components of the game. Dynamics refers to the anticipated players'

interactions and activities based on the mechanics of the game. Aesthetics refers to the anticipated emotional feedback of players based on the game activities and game experience. As the purpose of game is to generate social capital, another element call Goal is involved in the game design. The evaluation of the game is analyzed based on three aspects from MDAG framework, which includes Fellowship, Challenge, Pastime and Expression. The results show that the generation of social capital is achieved by the generation of new relationships and the consolidation of existing relationships.

2.2 Motivations of players

    The design of a game needs to satisfy the motivations of a variety of players. To conduct effective game design, different player types with different motivations should be considered in the game development. In the study of Chen (2017), motivational affordances is defined as the attribute that describes the extent of satisfying the motivation of a person. High motivational affordances indicate that more people can be attracted or be satisfied by the game, and user's activity and retention are increased. Moreover, the value of motivational affordances of a game element may change according to the situations (Deterding, 2011). Some game elements will not motivate people in a certain context. For example, leaderboard may not have high motivational affordances in a tabletop role playing game as the experience when playing the campaign is more important. Therefore, situated motivational affordances, which refers to the motivational affordances of a game element in a certain situation (Deterding, 2011), is used. To increase the motivational affordances of a game, taxonomy approaches and empirical researches are conducted to analyze the anticipated demand of users (Chen, 2017). In the study of Chen (2017), to integrate gamification in the context of Open Street Map, the motivations of users are classified into two categories, which include extrinsic motivation and intrinsic motivation. Intrinsic motivation is defined as inherent satisfaction of doing an activity, such as altruism and self-actualization, and extrinsic motivation is defined as exterior outcomes such as fame and skills. Therefore, the analysis of motivation in the context is important for the design of a location-based neighborhood game.

    The motivation of the players in Geocaching provides some insights for designing a location-based neighborhood game that can generate social capital. The study of Cord et al. (2015) conducted a survey among the Geocaching players in city Leipzig. The survey reveals that the motivation to play Geocaching varies. The main motivation of Geocaching players is to go outside and experience nature. Adventure and exploration are the two game elements that have high motivational affordances. Moreover, social interaction is not as an important motivation as experiencing nature in Geocaching. Therefore, the mechanics of a location-based neighborhood game that focus on generating social capital will be different from Geocaching.

    The intrinsic motivation of players is more significant than extrinsic motivation (Chen, 2017; Ryan et al., 2016). Self- Determination Theory (SDT) is used to analyze people's intrinsic motivations (Ryan et al., 2016). SDT can be divided into three parts in a game design context, which are autonomy, competence and relatedness. Autonomy refers to the willingness of doing a task. High autonomy is achieved when activities are related to personal interest and goal. In the context of a game, voluntary and initiative activities indicate high autonomy. Competence refers to the sense of influence and the desire of challenge.

Competence is gained when players receive positive feedback and accomplish achievements. Relatedness is defined as social connection and the feeling of presence in the community. It is related to the gain of social capital in the game. The study indicates that the attraction of the current popular video games matches Self-Determination Theory. Therefore, SDT is useful for evaluating the efficacy of a location-based neighborhood game and the motivation of its players.

2.3 Frameworks of a game's design

MDA (Mechanics-Dynamics-Aesthetics) framework is a well-developed framework for the design of a game as discussed in the ZWERM project (Coenen et al., 2013). In the study of Duarte et al. (2017), MDA framework is combined with DF framework for a game design. MDA framework, and the agency of traditional MDA framework is examined. Results indicates that the game designer works on the Mechanics layer, but the Dynamics layer and Aesthetics layer are not directly controlled by the designer. The Mechanics of game influences the dynamics and aesthetics of a game. On the contrary, the players generally first experience the aesthetics and dynamics of the game and then start to understand the mechanics of the game. Another framework called Distinct Features (DF) uses a series of distinct features such as "animate" and "digital" to categorize a game. A game can be separated from other games using DFs, and the relevant design elements can be revealed. To combine DF framework with MDA framework, the distinct features can be extended as a layer in MDA.

A conceptual model for game design is provided in the study of Sarangi et al. (2015). Five key components in two phases of game design is summarized. The first phase is the gamification phase, when game mechanics and game elements are determined. The second phase is the analysis of user experience, when the perception of the game, situational motivational affordances and interactional context are analyzed.

Both active contribution and passive contribution can be involved in the design of a location-based neighborhood game. Active contribution means making contributions intentionally, and passive contribution means making contributions unintentionally (Chen, 2017). The result indicates that a game stimulating active contribution in VGI can better satisfy players' motivation.

2.4 Generation of social capital

Bourdieu et al. (1992) provides a definition of social capital as "the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition". However, the definition of social capital has developed through time, and there are conflict definitions among literatures (Zhong, 2011; Robison et al., 2012).

The generation of social capital can be divided into activation and consolidation of social capital (Coenen et al., 2013). The activation of social capital refers to the generation of new relationship, and the consolidation of social capital refers to the maintenance of existing relationship. According to Ellison et al. (2007), relationships creates or abandons as a person's social network changes. The failure for maintaining old relationship means the loss of social capital. To investigate the change of social network, the author used a scale called

Maintained Social Capital to quantify the maintenance of old relationship. The study analyzes the gained social capital in Facebook. According to the result, maintaining existing relationship by Facebook is more significant than acknowledging new people. Therefore, traditional social media like Facebook may not generate new relationship effectively. On the contrary, the location-based game project ZWERM is effective in forming new relationship. According to Coenen et al. (2013), the game mechanism of combo check-in effectively creates new relationship within the community. Therefore, designs like combo check-in can stimulate the activation of social capital.

Social capital can be categorized as bonding social capital and bridging social capital. Bonding social capital connects to the strong relationship between people, such as the relationship between family members and close friends (Aharony, 2015). Bridging social capital connects to the weak relationship, which usually forms a social network with the purpose of information-sharing and reciprocity (Ellison et al., 2007). The measurement of social capital needs to cover both bonding social capital and bridging social capital.

Questionnaires and surveys are used for measuring social capital (Aharony, 2015). In the study of Ellison et al. (2007), the measurement of bridging social capital is achieved by 8 items in the questionnaire, and the measurement of bonding social capital is achieved by 5 items.

Location-based games stimulates offline interaction, which can benefit the generation of social capital. The study of Matzat (2010) compares virtual interaction with mixture of offline and online interaction in the context of online community development. According to the result, among the knowledge-sharing online communities, the mixed communities has higher trust between members and fewer free rider behaviors compared to the completely online communities, which indicates that high social capital is achieved with online-offline social network. In the study of De Zúñiga et al. (2017), social capital is categorized into offline social capital and social media capital. Social media provide platforms for people with low self-esteem to communicate with others, and they offer new ways for people to participate in political activities. Moreover, empirical evidence shows that social media change the structure of communication and social connection as online communities can provide broader support and sense of belonging. According to the survey's result, social media social capital and empirical social capital are distinct, but social media social capital shows identity with offline social capital on norms and community values. According to Zhong (2011), the online communities of MMORPG (Massively Multiplayer Online Role-Playing Games) have high civic engagement and collective play, which indicates high online social capital. However, the online social capital is not significantly related to offline social capital. The online social network in MMORPG is less likely to be extended offline.

3. Methods

3.1 Top-down Game Design Framework

3.1.1 Introduction

The design of the location-based mobile game is inspired by graffiti. Although graffiti is usually regarded as vandalism, they display a demand of communication in a certain location, and the contents of graffiti are related to the specific location. For example, the graffiti on a

desk in a library are likely related to student's activities, such as assignments and exams (University of Waterloo, n.d.). To simulate the effects of graffiti, the location-based game will allow players to create posts on a map based on their current location, and the posts can only be viewable within a certain range on the map. The posts can be linked together to simulate the conversations in graffiti. To emphasize the connection with graffiti, the game is named as Graffiti.

MDA framework is used for the game design structure. The design of the game started from Mechanics, and the expected Dynamics and expected Aesthetics of the game will be analyzed

3.1.2 Mechanics

The mechanics of a game includes game components, actions and rules. The components, actions and rules of Graffiti are summarized below.

The components of the game are Energy, Experience, Posts and Pinpoints. Each player has an attribute called energy, the value of energy reflects the resource that the player has. The more the energy a player have, the more actions the player can do. The energy that a player has will be represented by an energy bar in the game interface.

Experience is another attribute of a player, which reflects the efforts that a player spends on the game. Once a player gains enough experience, the player will level up. Players with higher levels will have more tools to use, have larger maximum energy, get assess to more marker icons, and create posts and pinpoints with greater radius. Experience is expected to motivate the competence of players by giving them the sense of achievement.

Players can create posts based on their location, which will display as a marker on a map. A post can contain texts and an image. A post has an attribute called radius, which is the visible range of the post, so players outside the range will not have the post displayed on the map. An upvote button will bind to each post. A post can point to another post or a pinpoint on the map, the links are represented by lines and line networks on the map. The links are used for commenting or setting up a dialog between players.

Players can also create posts on any location on a map. The posts created this way are called Pinpoints. Pinpoints has similar mechanics as posts, but the radius of a pinpoint is set by the creators, and they cannot be upvoted. The maximum radius of a pinpoint is determined by the level of the player. A pinpoint cannot point to a post or a pinpoint.

Upvoting is one of the actions a player can do. When a player clicks on a upvote button of a post, the range of the post will increase. Players gain energy from upvoting other people's post, but they will lose energy when creating posts and upvoting posts created by themselves. Players gain experience from creating posts and upvoting. The amount of radius increment will reduce as radius becomes larger, so upvoting a high-radius post will be less effective than upvoting a low-radius post.

Posts can point to another post or a pinpoint on the map, which will create a link between the markers. Pinpoints can only be referenced by other posts. Pinpoints and posts are represented by markers on the map. Once a marker is linked by or linked to another marker, the connections or links between the two markers are set up. If player clicks on any one of the linked pair of markers, the other marker will also pop up. This will trigger a chained effect to display all the related posts. Moreover, although some markers are out of sight, if they are

related to any in sight markers, they will also be revealed in the map.

3.1.3 Expected Dynamics

The radius of a post will steadily increase. A post's radius increases when being upvoted, so the range of the post increases, and more players can view the post. Therefore, the post can potentially be upvoted by more people. However, the increment value of radius will reduce as radius becomes larger, so the upvotes are less effective. The combined effect of more upvotes and less efficiency will lead to a steady radius increase.

Players are expected to upvote other's posts often. As both creating markers and upvoting their own posts will consume energy, players may find high demand on energy. However, the only way to gain energy is to upvote other's posts. Therefore, the action of upvote will be common in the game.

There will be patterns of linked markers. The links between markers will create a symbiosis effect between posts. Any one of the markers is clicked, the other post will also pop up. A post's visible range depends on all its related posts.

There will be patterns of the spread of markers. The posts are likely to cluster in high population-density area such as universities, gyms and dormitories. However, the pinpoints are expected to distribute in low density area, where individual markers are more noticeable. Pinpoints is also used for setting up a gathering point on the map.

3.1.4 Expected Aesthetics

Players will interact actively with the game elements. The motivation of players will be fulfilled when a player levels up, gets a high-radius post or spreading his or her favorite post to further area. To maximize efficiency of leveling up, players are expected to upvote other's posts frequently to gain energy and create posts or pinpoints for experience. To maximize efficiency to get a high-radius post, a player will create high-quality contents in their posts so that other players are more likely upvote their posts. To spread out their favorite posts, players may not upvote a single post consistently as the increment of radius is not significant. They will create posts that point to their favorite posts instead so that the combined visible area is increased, which is more effective than upvoting their favorite posts.

Cooperation between players is expected in the game. For example, players may ally with each other to upvote each other's posts, which will build up trust between players and increase social capital. Moreover, the good atmosphere of commenting and referring posts can build up relationship between players and further improve the structure of social network.

3.2 Assessment Design

The evaluation of the game design consists of two measures, which are user motivation and the efficacy of game elements. The purpose of evaluating user motivation is to analyze the emotional well being of players when playing the game and provide reference for new game element design, so the future updates will be designed to satisfy the motivation of target players and to supplement the missing motivation components. To evaluate the player's motivation, the survey will be based on Self-determination Theory. The measurement scale of user motivation is nominal. The players will rate the three aspects of self-determination including autonomy, competence and relatedness, which corresponds to the three types of

player motivations including personal interest, sense of achievement and social interaction. The feedback of motivation evaluation will be used to analyze the types of user's motivation and their statistics including weights and counts. On the other hand, the purpose of evaluating the game element efficacy is to analyze and improve the existing game elements. The measurement scale of game element efficacy is ordinal, which ranges from 1 to 5. 1 means that the game element has no efficacy, and 5 means it has full efficacy. The game elements to be evaluate are Posts, Pinpoints, Upvote and Linking.

To evaluate the generation of social capital, three measures using ordinal scale from 1 to 5, including consolidation of existing relationship, generation of new relationship, and the transformation from online social capital to offline capital, will be analyzed. 1 means the generation of social capital is none, and 5 means the generation of social capital is significant. The purpose of evaluating creation of relationships, consolidation of relationships and transformation from online social capital to offline capital is to compare the different ways of generating social capital and their relationships.

The sample game design assessment is shown in Appendix 2.

4. Results

The location based mobile game is a web app, which can be visited both in mobile mode and desktop mode. The web server is initialized with WAMP, which provides basic web service including Apache, PHP and MySQL. It also provides management tools like phpMyAdmin. The library Data Structures (DS) for PHP is used to provide convenient data structures to realize some algorithms in the back-end.

The URL of the game is https://graffiti.uwaterloo.ca/. The detailed design is provided in Appendix 1.

4.1 Back-end

Laravel is used to set up the back-end environment for the web server. Laravel is a Model-View-Controller framework using PHP. The framework consists of constructions elements including routes, models, views, controllers, middlewares, migrations, etc. Controllers are the core elements of Laravel. They receive HTTP requests from routes, handle the requests, and then return views or results to the user's web client. Routes direct a URI such as "/index" and "/info" to a corresponding controller. Routes need to be specified with a specific HTTP request type such as get and post. The views in Laravel corresponds to the web page, which is also the returning object of controller. Laravel views use Blade template. The Laravel Blade template is used for inserting PHP codes inside a web page for managing layouts and public html elements. PHP code is rendered before the rendering of page. Models are used to interact with the server database. Laravel Eloquent models represent a table in the connected database, which is convenient for queries inside Laravel.   Middleware filters the requests that come into the application. Some middlewares related to Laravel Authentication are pre-registered during the setup of Auth. Except the middleware used for Laravel authentication, a middleware called root is used for verifying admin users. An extra Laravel dependency called "grimzy" is used to process location-based data, store geometry in database and do spatial analysis.

Laravel offers a quick way to set up the authentication controllers. After running "php artisan make:auth" command, the controllers for authentication including ForgetPasswordController, LoginController, RegisterController, ResetPasswordController and VerificationController are set. Moreover, the corresponding views are also set up in the views/auth folder. The User Eloquent model is for the connection with the "user" table in the database.

To enable registering by email and resetting passwords by email, a mailing server using SSL and SMTP is used for the game. The SMTP mail driver is provided by Gmail.

Two models called Post and Pinpoint are used for connecting the tables "posts" and "pinpoints" in the database. The controllers PostController and PinpointController are initialized with "resource" command, so basic functions like store and destroy are initialized inside the controllers. Store will handle a HTTP post request and store the input posts and pinpoints in the database. Destroy will remove a post or a pinpoint based on the input post id or pinpoint id.

To display a management page for a player's posts and pinpoints, an index function is used within the PostController, which will redirect the website to the view "posts/index.blade.php". Inside the view, posts, pinpoints and their information are displayed. The button Delete inside the view will redirect to the corresponding Delete function. The button Go To will direct to the game interface, and the center of the screen will be the corresponding post or pinpoint.

To load the posts and pinpoints based on user's location, the functions loadposts and loadpinpoints in PagesController are used for retrieving posts based on the user's location. The related posts will also be loaded. To retrieve all the related posts, the function first searches for the root of each post tree, and then the function conducts a tree traversal. The insight posts and their related posts will all be returned.

To process the upvote action, a function called upvote in PagesController will handle upvote HTTP request. The initial radius for a post is 100m. The quantity of radius increment is determined by the equation below:

$$\text{R}_{new} = \text{R} + \frac{316}{\text{R}^{\frac{1}{4}}}$$

Therefore, when R reaches 1600 m, the quantity of radius increment will be around 50 m. What's more, when R reaches 25526 m, the quantity of radius increment will only be around 25m.

4.2 Front-end

Laravel uses Blade template for the website design, which is a PHP templating engine that allows plain PHP code to be used in views. The front-end environment is initialized with React using "php artisan preset react" command. Leaflet, Bootstrap, jQuery are the three main libraries used for the front-end development.

The game interface is defined in "pages/index.blade.php", which consists of a map and a navbar. Within the map, the buttons for creating posts and pinpoints, energy bars and experience bars are hovered over the map. The map will display markers representing posts and pinpoints. Object "node" is used to represent posts and pinpoints, which has properties

including "id", "fromid", "toid", "marker", "line" and "circle", which are either the properties of posts or pinpoints, or the rendered layers in Leaflet. Nodes are added to a global array called "nodelist" when they are retrieved from the server. Object node also has a method called addfromid, which is called when a child of a marker is loaded. The function getNode will retrieve a node from nodelist by the node's id or initialize a new node when the id is not found. Once a user clicks on a marker, all the related markers, the moving ant paths representing direction of links and the green aura indicating the radius of the markers will also pop up (Figure 1). Function chainOpen and chainClose handle the open and close of linked posts. Extra Leaflet plugins including leaflet-ant-path, leaflet-polylinedecorator, leaflet.beautifymarker, leaflet.marker.highlight, L.Icon.Pulse are used for better appearance. Two modals are used for creating posts and pinpoints. The modal for creating post has 3 options, which are the button for canceling marker selection, content and an optional image link. The modal for creating pinpoints also has 3 options, and the options are content, optional image link and the radius of the pinpoint. The navbar contains redirection buttons to direct users to introduction page, their posts and the update page. The account options like reset password and log out can also be find in the navbar.
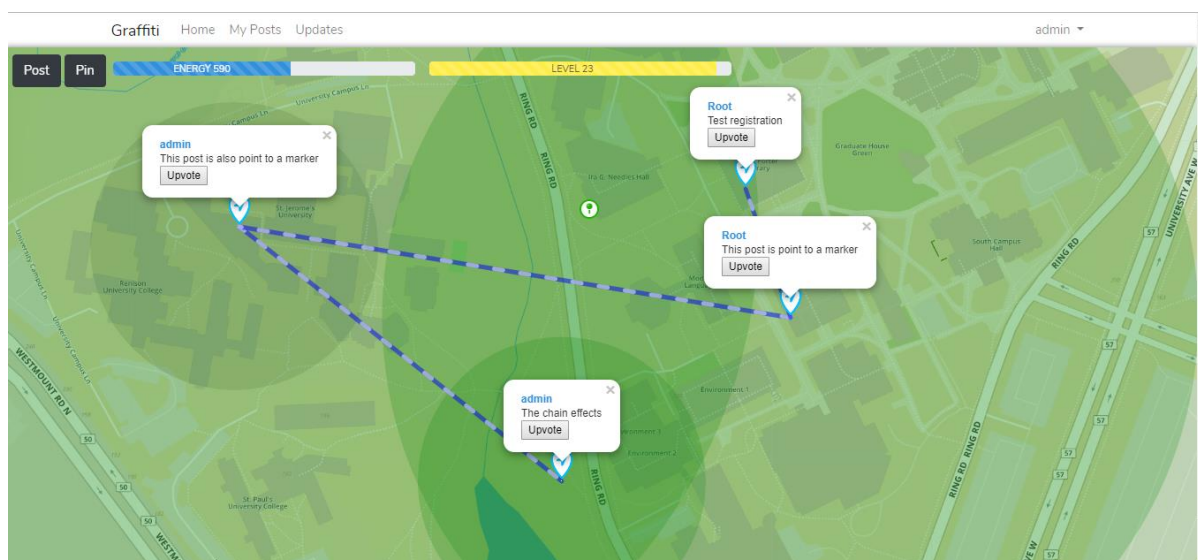
Figure 1: A screenshot of Graffiti showing the simultaneously opened markers, polylines and the green aura indicating the radius of the posts
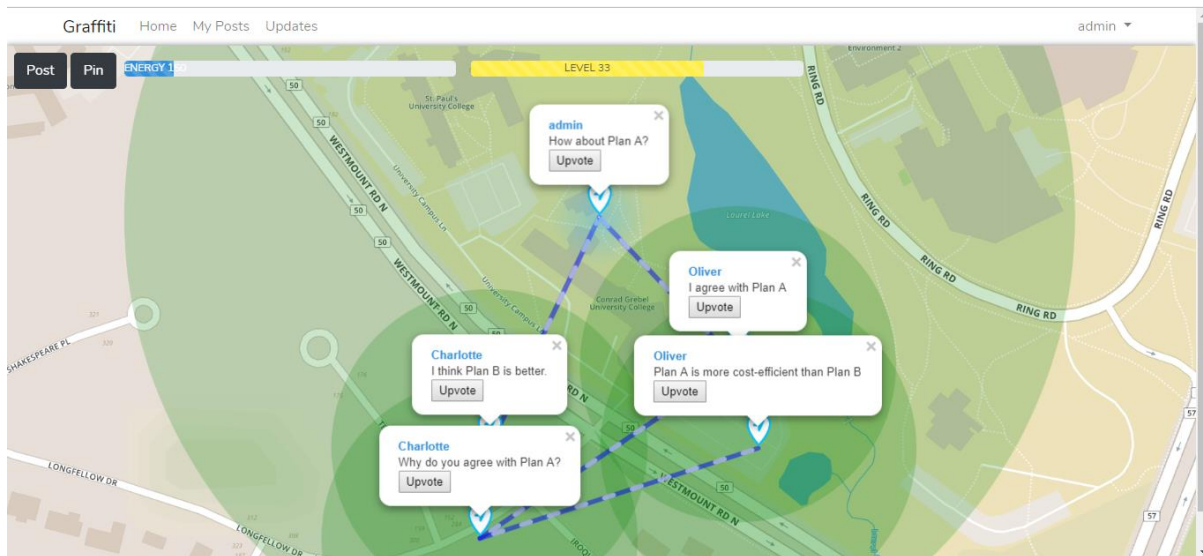
5. Discussion

5.1 Broader implications

The game is an innovative design of social media. Traditional online social media like Facebook lists message in temporal order, and the newest message will be displayed first. Although some messages are geo-tagged, the messages are not directly displayed on a map, so it may not be an effective way to display the spatial attributes. Compared to traditional social media, Graffiti displays the messages on a map directly. Replies and comments are represented by the links between markers. Upvoting a post will increase the message's visible range to let more people see it. The mechanics of linked markers will bind messages together so that a conversation or a discussion can be represented on a map. Moreover, displaying message on map may increase the reading speed of a conversation as the conversation is

linked as a two-dimension network instead of a one-dimension thread.

The game provides a platform for effective communication within and between neighborhoods. As the range of each post and pinpoint is limited, a message is usually only visible in the scale of a neighborhood, which will encourage players to create community-related posts and pinpoints. By this way, regional topics will be the majority. Moreover, the nearby neighborhoods are geographically connected, so the communication of a neighborhood can be easily spread to nearby neighborhoods, which will boost the communication between neighborhoods. What's more, the popularity of the game may motivate people to communicate regionally using the app. If the base number of players increases to a certain scale, constant conversations and customs may form. Some regional events may use this platform for broadcasting, and attenders may respond to the events by linking to the event markers. Players may discuss regional issues geographically by linking markers to form a marker group (Figure 2). Regional public involvement campaign can also apply participation methods such as Nominal Group Technique using this game.

Figure 2: The screenshot of Graffiti displaying an example of regional discussion

The game is an innovative way to generate social capital. Unlike traditional social media, the game enables location-based communication by displaying the threads of messages on the map. Therefore, the relationships of players are bound to their geographic locations. Moreover, the display of messages is only related to the relative distance between the player's location and the marker's location, and the messages are all open to the public. Therefore, the game has the potential to generate new relationship between players in the same region.

The game can support geographic social network analysis. The links between messages can reflect the relationship between players. Frequent communications indicate strong social bonds. Therefore, the game can be used for analyzing the relations between geographic vicinity and the structure of a social network.

5.2 Limitations

Experimental approach is used for the game design, and the outcomes cannot be

foreseen. First, the game mechanics are designed for the purpose of generating social capital. Although the game may increase social capital through the gameplay, it is unpredictable that whether the game will have high user retention. Moreover, more game elements are needed to add to the game. The game currently only has four main operations, which are post, pinpoint, upvote and linking. The limited operations may reduce players interest. What's more, the reward mechanics for long-term playing is not significant. Although higher levels will unlock new markers or higher attributes, it may not increase players' retention. Finally, the design of game is subjective. MDA framework only provides a structure for the game design, and it is not a routine for game design. The game components, actions and rules are subjectively created by me, so it is difficult to evaluate the game design before testing them online. To improve the gameplay, the design of the gameplay to be updated frequently, and adaptive game design and monitoring of the user activities is required for future game development.

It is difficult to compare the generation of social capital with other social media. Although the assessment may help to evaluate the types of social capital and the efficacy of social capital gain, it is impossible to compare the game with other social media. The generation of social capital is also related to the scale of the application, the base of user numbers and the time that players spend on the game. A detailed assessment is required to compare the efficiency of different social media. Future studies may focus on discussing the comparison and quantification of social capital efficiency.

6. Conclusion

Location-based mobile game has the potential to thrive and generate social capital in a community. An experimental approach is used to evaluate the outcome of a location-based mobile game, and the game Graffiti is designed for the purpose of generating social capital. MDA framework is used as a structure for game design. The Mechanics, expected Dynamics and expected Aesthetics of the game are summarized. To evaluate the outcomes of the game, the game design and the generation of social capital will be assessed. The assessment of game design consists of the evaluation of player's motivation based on Self-determination theory and the efficacy of game elements like Posts, Pinpoints, Upvote and Linking. The assessment of generation of social capital examines the consolidation of existing relationship, the generation of new relationship and the transformation from online social capital to offline social capital. To implement the game design, a website (https://graffiti.uwaterloo.ca/) is developed as the interface of the game. The web server uses WAMP to provide the web services including Apache, MySQL and PHP. The back-end of web development uses Laravel PHP framework, and the front-end uses Leaflet, Bootstrap, jQuery to provide the dynamic map services and game interactions.

The game is an innovative design of location-based social media as it allows users to post messages directly on a map, upvote messages to increase their visible radius and link messages together to form a conversation. Moreover, the game will boost the communication within and between neighborhoods because the messages are geographically displayed with limited radius, which may stimulate regional discussions and provide a platform for broadcasting regional events and public involvement campaigns. What's more, the game will stimulate the generation of new relationship to increase social capital, and the game enables

social network analysis in the context of geography. However, one of the limitations of the game is that the outcomes of the game is still unknown before public testing. The experimental approach for game design limits the prediction of the results. Moreover, although the assessment of the game can evaluate the game design and the generation of social capital, it does not compare the game with other social media, so the advantage of the game over other social media will be unknown without a detailed comparative assessment.

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Appendices

Appendix 1: The Detailed Web Development Design

Front End

1. Laravel Blade Template

   The Laravel Blade template is used for inserting PHP codes inside a web page for managing layouts and public html elements. PHP code is rendered before the render of page.

   Screenshot: Blade template enables the use of conditionals and loops of PHP

```
@section('content')
    @if (count($logs) > 0)
        @foreach ($logs as $log)
        <div class="well">
            <div class="btn btn-dark col-sm-12" data-toggle="collapse" href="#update{{$log->id}}"
            role="button" aria-expanded="false" aria-controls="update{{$log->id}}">
                <h3>{{$log->title}}</h3>
            <small>Created by {{$log->user_name}} at {{$log->created_at}}</small>
            </div>
            <div class="collapse" id="update{{$log->id}}">
                <div class="card card-body">
                    {{$log->content}}
                </div>
            </div>
        </div>
        @endforeach
    @else
```

2. Bootstrap

   Bootstrap is a front-end component library, which can be used for managing HTML layouts, grid systems and styles. Bootstrap is usually used by specifying types in the class of HTML components.

   Screenshot: The use of Bootstrap to configure a modal

```
<div class="modal fade" id="sendPost" tabindex="-1" role="dialog"
aria-labelledby="postTitle" aria-hidden="true">
    <div class="modal-dialog modal-dialog-centered" role="document">
    <div class="modal-content">
        <div class="modal-header">
        <h5 class="modal-title" id="postTitle">Post</h5>
        <button type="button" class="close" data-dismiss="modal" aria-label="Close">
            <span aria-hidden="true">&times;</span>
        </button>
```

3. jQuery

   jQuery is an easy-to-use JavaScript library that can make event handling, Ajax requests and DOM/HTML manipulation. The basic syntax of jQuery is "$(selector).action()".

   Screenshot: Loading posts to the map using Leaflet and jQuery

```javascript
$.post("/pages/loadposts",{lat:lat, lng:lng},function(markers){
    //console.log(markers);
    $.each(markers,function(i,val){
        var m_location = L.latLng(val.location.coordinates[1], val.loca
        var m_username ="<p class='my-0 text-primary font-weight-bold'>
        //var m_radius = "<p class='my-0 text-success font-weight-bold'
        //var m_user_id = val.user_id;
        //var m_radius = val.radius;
        var html = document.createElement("div");
        $(html).append(m_username);
        if(val.content) {
            var m_content = "<p class='my-0'>" + val.content + "</p>";
            $(html).append(m_content);
        }
        if(val.link) {
            var link = "<img class='rounded mx-auto d-block img-respons
            $(html).append(link);
            //icon
        } else {
            //icon
        }
        //$(html).append(m_radius);
```

4. Leaflet

Leaflet is a library for creating interactive maps. The Leaflet object "map" is used for the rendering of map canvas. Object "layer" is used for adding elements to the map. For example, object "marker" and "polyline" are extension of layer, which displays markers or polylines on the map. Leaflet objects have methods, properties and events, which are used for handling the attributes and interactions of the objects.

Screenshot: Adding a circle to the map

```javascript
//circle
var circle = L.circle(mylatlng, {
    color: 'opaque',
    fillColor: 'black',
    fillOpacity: 0.1,
    radius: 100
});
circle.addTo(mymap);
```

5. Views

The views in Laravel corresponds to the web page, which is also the returning object of controller.

Auth Views

Auth Views include pages like login, register, verify and reset passwords. Auth Views are initialized when setting up Laravel using command "php artisan make:auth".

Screenshot: The login view from Auth

Include (Inc)

Inc is a folder containing "messages.blade.php" and "navbar.blade.php".
Message.blade.php displays success or error notices when certain action is taken by
the users. Navbar displays the navbar in every web page in the server. Messages and
navbar are included in the layout.
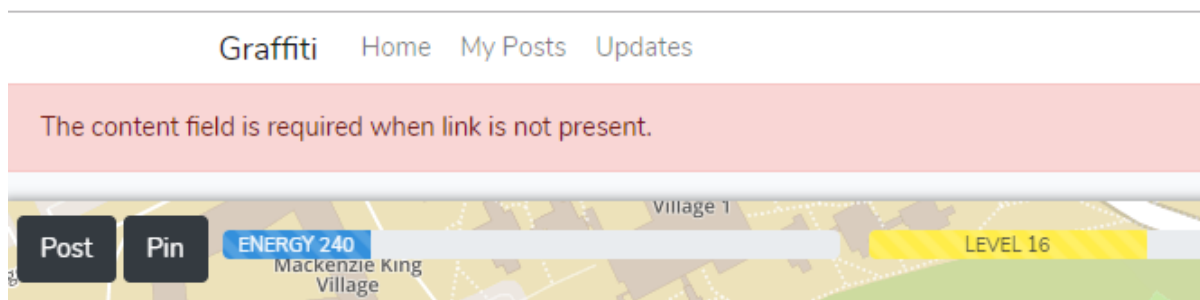
Layout

Layout includes the head part of HTML, which includes dependencies like header
scripts, fonts, libraries and Leaflet references. Messages and navbar are also loaded
here.

```
<!-- Scripts -->
<script src="{{ asset('js/app.js') }}" defer></script>

<!-- Fonts -->
<link rel="dns-prefetch" href="https://fonts.gstatic.com">
<link href="https://fonts.googleapis.com/css?family=Nunito" rel="stylesheet" type="text/css">

<!-- Styles -->
<link href="{{ asset('css/app.css') }}" rel="stylesheet">

<!-- JQuery -->
<script src="https://ajax.aspnetcdn.com/ajax/jQuery/jquery-3.3.1.min.js"></script>
```

Pages

The following blade.php file handle each web page individually.
Index: Display the main game interface.
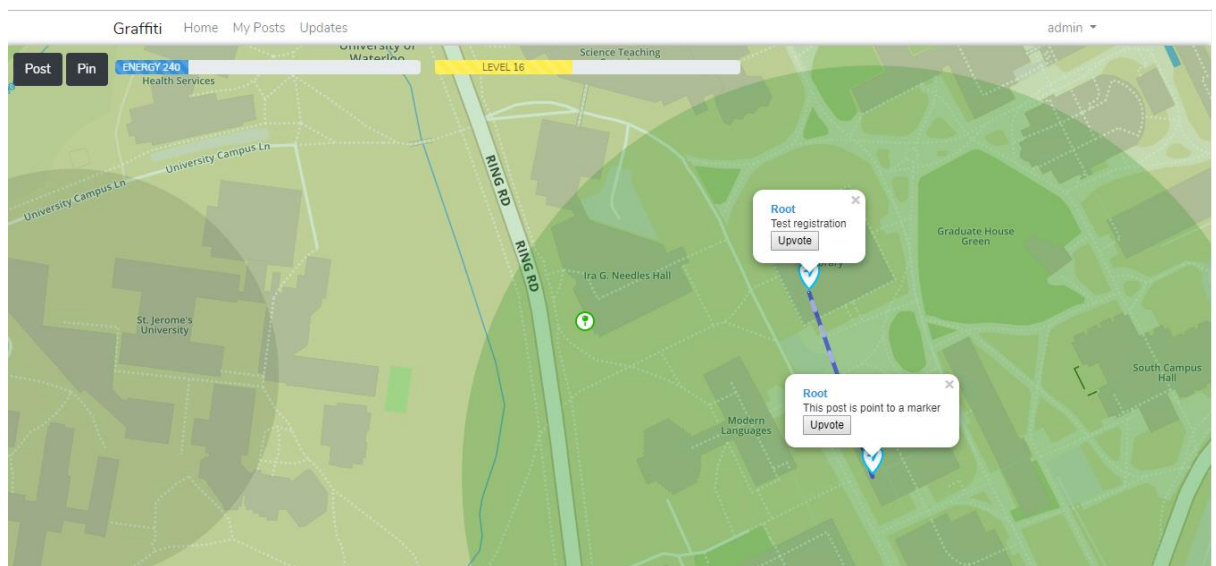
Info: The entry of the website, which displays the introduction of the website.
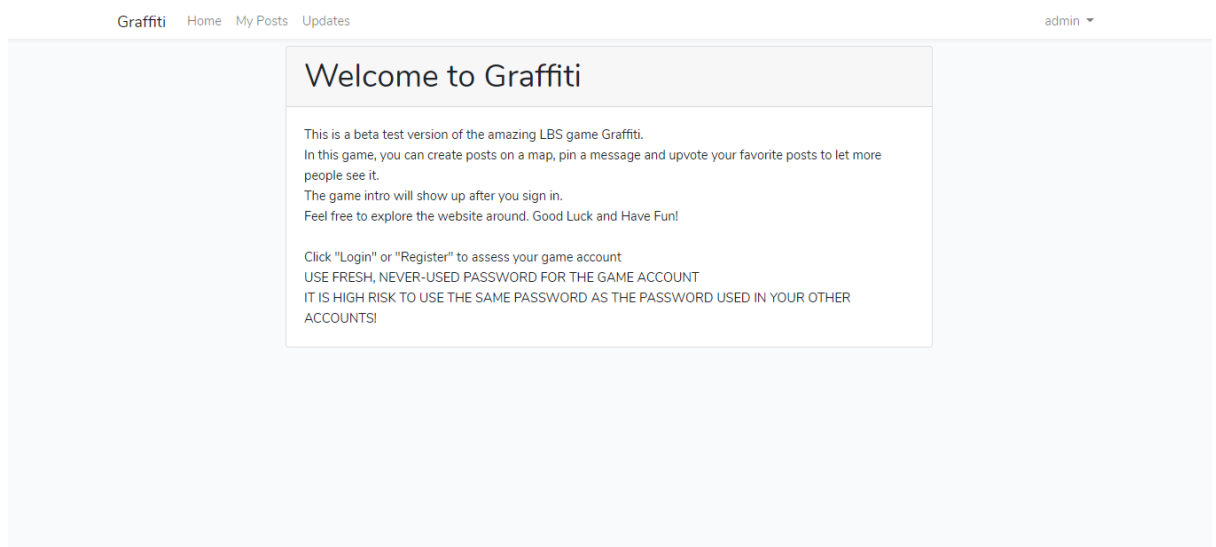
Posts.index: Display the posts and pinpoints created by the user.
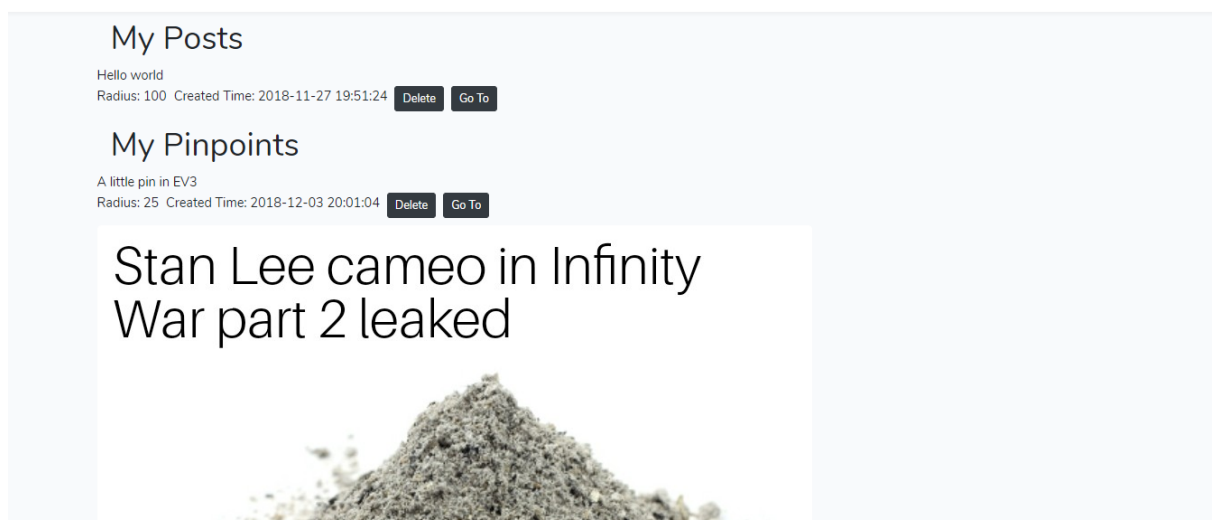
Updates.index: Display the updates created by admin users.

Updates.create: The form for submitting updates.

Dashboard: The direction page after a user is logged in

Back End

Laravel Framework is a Model-View-Controller (MVC) Framework for back-end web development. The coding language used by Laravel is PHP.

1. Routes

   The routes are registered in the file "web.php". Routes direct a URI (such as /index, /info) to a corresponding controller. Routes need to be specified with a specific HTTP type.

   Resources

   Two resources are used in the route directory. A resource usually has route entries like create, store, show, edit, update and destroy. Posts and Updates are the two resources.

   Auth

   Auth route entries are automatically set up when initialing Laravel with Auth service, which includes routes like login, register, password.request, password.reset and logout.

   Others

   The five entries Index, Info, Loadmarkers, Upvote, Dashboard will direct the request to the corresponding controller

```php
*/
Route::get('/index', 'PagesController@index')->name('pages.index')->middleware('verified');
Route::put('/index/{jsonlocation}', 'PagesController@goto')->name('pages.goto')->middleware('verif
Route::get('/info', 'PagesController@info')->name('pages.info');
Route::redirect('/', '/info', 301);
//load marker |
Route::post('/pages/loadmarkers', 'PagesController@loadmarkers')->name('pages.loadmarkers');
//upvote manipulation
Route::post('/pages/upvote', 'PagesController@upvote')->name('pages.upvote');

Route::resource('updates', 'UpdateController');

Route::resource('posts', 'PostController')->except([
    'create', 'show', 'edit', 'update',
]);
//verify is true
Auth::routes(['verify' => true]);

Route::get('/dashboard', 'DashboardController@index')->name('dashboard');
```

2. Controllers

   Controllers are the core elements of Laravel. They receive HTTP requests, handle the requests, and then return views to the user's web client.

   Auth

   Auth is a directory of controllers that handle authentication related request, such as login, registration and verification, which is initialized by the Authentication service in Laravel.

   DashboardController

   DashboardController receive redirection of login request and return view Dashboard to user.

PagesController

PagesController manages the request of displaying the main page, displaying info page,and handling load markers request and upvote request.

PostController

PostController handles requests related to posts, including index, store and destroy.

UpdateController

PostController handles requests related to updates, including index, create and store.

3. Middlewares

Middleware is a mechanism that filters the requests that come into the application. Some middlewares related to Laravel Authentication are pre-registered during authentication setup. Except the middleware used for Laravel authentication, a middleware called route is used for verifying admin users.

```php
class CheckRootUser
{
    /**
     * Handle an incoming request.
     *
     * @param  \Illuminate\Http\Request  $request
     * @param  \Closure  $next
     * @return mixed
     */
    public function handle($request, Closure $next)
    {
        if (in_array(Auth::id(), [12])) {
            return $next($request);
        }
        return redirect(route('PagesController@index')-with('error','Assess Denied'));
    }
}
```

4. Models

Laravel Eloquent models are the server representation of a table in the connected database. Three models, which are Post, Update, and User, are connected to the posts, updates and users table in the database.   Eloquent models are effective for retrieving and querying the data in the database.

```php
<?php

namespace App;

use Illuminate\Database\Eloquent\Model;
// It must use the SpatialTrait and define an array called spatialFields
use Grimzy\LaravelMysqlSpatial\Eloquent\SpatialTrait;

class Post extends Model
{
    use SpatialTrait;
    //Table Name
    protected $table = 'posts';
    //Primary Key
    public $primaryKey = 'id';
    //Timestamps
    public $timestamps = true;

    //specify spatial fields
    protected $spatialFields = [
        'location',
    ];
}
```

5. Database Migrations
   Database migrations are useful for reimplementing the database structure in another
   server environment. It is effective to transfer the database structure in another server.
   Users, password reset tokens, posts and updates are the four migrations.

```php
class CreatePostsTable extends Migration
{
    /**
     * Run the migrations.
     *
     * @return void
     */
    public function up()
    {
        Schema::create('posts', function (Blueprint $table) {
            $table->increments('id');
            $table->unsignedBigInteger('user_id');
            $table->string('user_name');
            // Add a Point spatial data field named location
            $table->point('location');
            $table->text('content')->nullable();
            $table->text('link')->nullable();
            $table->unsignedBigInteger('radius')->default('100');
            $table->timestamps();
        });
    }
```

Appendix 2: The Sample Assessment Design
Game Design Assessment
Evaluation of the Game Design
Question 1 evaluates the player's motivation based on Self-determination Theory using nominal scales.
1. What is your main motivation to play the game?
    A. For social interaction
    B. For personal interest
    C. For sense of achievement

Question 2 evaluates the efficacy of game element Posts and Pinpoints using ordinal scales.
2. How often do you use these posting options?
Post
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.
Pinpoint
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.

Question 3 evaluates the efficacy of game element Upvote using ordinal scales.
3. How often do you upvote when reading a post or a pinpoint?
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.

Question 4 evaluates the efficacy of game element Point To (linking posts) using ordinal scales.
4. How often do you link to a post when creating your post?
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.

Question 5 offers a reference for future game design.
5. What features or improvement do you want the game to have in the future? Provide your advices here.

Evaluation of social capital
Question 6 and 7 evaluates the consolidation of existing relationship using ordinal scales, each of the question has 0.5 on weight.
6. How likely would you recommend this game to your friends?
1: Never, 2: Not likely, 3: Likely, 4: Very likely 5: Always.

7. How often do you interact with players you know (like close friends) in the game?
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.

Question 8 and 9 evaluates the generation of new relationship using ordinal scales, each of the question has 0.5 on weight.

8. How likely would you try to make friends with the players you meet in the game?
1: Never, 2: Not likely, 3: Likely, 4: Very likely 5: Always.

9. How often do you interact with players that you don't know in the game?
1: Never, 2: Not often, 3: Sometimes, 4: Very Often 5: Always.

Question 10 evaluates the transformation from online social capital to offline capital using ordinal scales
10. How likely would you try to meet some players offline?
1: Never, 2: Not likely, 3: Likely, 4: Very likely 5: Always.