國立交通大學

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博 士 論 文

使用資訊科技方法研究虛擬世界 –

探勘多人線上遊戲中的玩家活動資訊

Using an Information Technology Approach to Investigate Virtual Worlds:

Mining Demographic Data in MMOGS

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摘要

本論文的主旨在於提出一套資訊科技的方法，以觀察並分析虛擬世界（線上遊戲）中玩家所產生出來的社會、群體與個人行為。虛擬世界是相對於實體世界而言，通常是指電腦中介或網路中介的環境，也因其環境的關係，使得想觀察在虛擬世界中使用者活動的研究者難以在其中進行研究。隨著個人電腦的普及、網路的發展與便利、以及線上遊戲的盛行，線上遊戲世界幾乎成了虛擬世界的代名詞。在一開始，線上遊戲沈迷甚至被認為是青少年在教育上與行為偏差上的重要因素；然而，隨著線上遊戲內容的發展，國內外學者或遊戲開發者均意識到線上遊戲內容包含了人際交往、交易、合作、組織、學習等可能性，因此線上遊戲成為除了家庭與工作場所外最重要的第三場所（The Third Space）[1]。然而，由於線上遊戲世界為網路與電腦中介的環境，並且使用者是透過自己所創立角色，在一個遊戲公司所設計的遊戲主題下與其他使用者進行互動。因此，過去的「線下」（或者說「遊戲外」）的研究方法，例如質化的訪談或量化的問卷法，難以觀察並分析這些玩家在遊戲中的行為動態。而本論文的主要目的，則是利用現在線上服

務的 Web 2.0 趨勢，以資訊科學資訊擷取的取徑，直接取得玩家在線上遊戲世界的活動，以克服在虛擬世界的環境下進行研究的困難。

Web 2.0 其中一個主要的現象為服務提供者除了在提供服務本身之外，尚提供一套程式語言，讓電腦終端的使用者能自行開發片段程式以取得服務的內容，或依照使用者自己本身的喜好來寫作、修改、下載、掛載其所需的插件。這些特色可以從以下目前在網路上十分流行的 Web 2.0 服務中發現，例如 *igoogle*, *Firefox Extention*, 與 *Yahoo! Widget* 等。這些現象符合了 Web 2.0 創建與分享的特徵。而在數位遊戲的開發上也有如此的特徵，例如世記帝國（*Age of Empires*）與魔獸爭霸三（*Warcraft III*）等區域網路連線性質的即時戰略遊戲均提供地圖編輯器給使用者自行設計地圖並與其他使用者分享；而線上遊戲第二人生（*Second Life*）則自行開發一套腳本語言（Script Language）提供使用者設計虛擬環境中的場景、建築、物品、和角色的衣著與動作；線上遊戲魔獸世界（*World of Warcraft*）也允許使用者修改、寫作與載入遊戲的使用者操控介面。

以魔獸世界的使用者自製介面來說，其功能不僅能夠改變玩家操控介面的外觀，尚能夠和 Web 2.0 服務的特徵一樣，透過服務提供者所開放的應用程式介面（Application Programming Interface: API）來擷取在服務背後使用者在線上所產生的活動紀錄。而本論文則利用這樣的特色來長期不間斷地紀錄玩家在線上遊戲中的活動以觀察玩家在遊戲中的互動、成長與動態。和過去遊戲外或線下的方法比較上，以資訊方法進行玩家的行為探勘不但能夠提供全面性的量化結果，更能夠提供長時性的觀察，對於以往受限於

線上環境而難以研究的議題，例如玩家的分工、合作與溝通、玩家在遊戲內經驗的成長、線上遊戲中組織的成長與消退、玩家參與遊戲內玩家自組組織的趨勢與行為、乃至於大範圍跨文化的比較（例如在本論文中會提到的台灣與美國的玩家動機行為推論比較）等。以線上遊戲資料擷取為方法，本論文內容包含了博士生涯的數項成果，主要為 1) 和過去在社會學的組織區位學的研究成果相較下，以資訊蒐集進行量化研究更能夠掌握到在遊戲中的組織變化與動態；2) 遊戲中的玩家會因為遊戲內容的影響與來自其他玩家的壓力而決定加入或離開遊戲內的組織；3) 和台灣的玩家相較之下，美國的玩家更重視在線上遊戲中與人互動的娛樂性。

關鍵字：人工智慧、資料探勘、線上遊戲、虛擬世界、數位遊戲、虛擬社群、虛擬組織

USING AN INFORMATION TECHNOLOGY APPROACH TO INVESTIGATE VIRTUAL WORLDS: MINING DEMOGRAPHIC DATA IN MMOGS

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Abstract

A growing number of researchers are looking into ways that online virtual and game environments are affecting human activities, including communication, interpersonal relationships, and community interactions. Whereas the first game researchers focused on the potential for virtual world "addictions," they are currently accepting the premise that virtual space and online games are evolving into a collective "third space" in competition with family, work, and school [1]. However, those researchers must deal with significant barriers based on the nature of network environments, online games, and cyberspace. For example, the large majority of users interact via their avatars and from divergent computer terminals, therefore dynamic online and in-game behaviors are difficult to observe and analyze by conventional off-game approaches (e.g., surveys or interviews) [2]. This dissertation will describe a method for overcoming those barriers.

As network services have evolved over the past two decades, a growing number of service providers have started using easy-to-understand programming languages such as markup language XML and script language Lua, and are now providing application programming interfaces (APIs) to give users the power to refine and develop their own user interfaces (UIs). These user-designed UIs are often executed as add-ons or plug-ins attached to main applications. Examples include the *Mac OS Dashboard, Yahoo! Widget,* and *Google Desktop Sidebar*. This flexible feature has also been adopted by the designers of *World of Warcraft* (*WoW*), currently the world's most popular Massive Multi-player Online Game (MMOG). *WoW* players can design or modify their own UI add-ons to supplement in-game controls, create guides and maps for solving missions, and collect in-game information on other players or game environments. The third use will be the focus of this dissertation—specifically, taking advantage of the UI feature to collect analyzable data on human behaviors in virtual space. The resulting data can be used to perform quantitative longitudinal analyses, as opposed to restricted qualitative analyses of data gathered via interviews and surveys aimed at specific groups. In this dissertation I will highlight the advantages of the personalized UI feature for investigating virtual worlds and give three examples of potential investigative uses: how in-game communities grow and decline, how players join and leave guilds, and how Taiwanese and American gaming cultures differ. As background I will discuss the characteristics of Web 2.0, user-created data, and client-designed user interfaces—all of which blur boundaries between content providers and users as well as between game designers and players. My results indicate that (a) compared with conventional research on organization ecology, the proposed method is capable of capturing in-game guild evolution dynamics; (b) players usually leave guilds or quit group play due to group mission pressure; and (c) compared with Taiwanese players, American players put more emphasis on recreation.

Keywords: Artificial Intelligence, Data Mining, Massively Multiplayer Online Games, Digital Games, Cyberspace, Virtual Communities, Virtual Worlds

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1. INTRODUCTION

1.1. *Massive Multiplayer Online Games—Virtual Worlds*

Virtual worlds are computer-based simulation environments that allow users to interact via avatars. They are often described as persistent, shared, and computer-moderated environments in which multiple users interact with each other and make changes via individual representations and movements in real time [3]. Due to increased time spent online and greater complexity in online behaviors affecting physical world communication, interpersonal relationships, and communities, virtual worlds are now recognized as real but not concrete [4]. Virtual worlds visually mimic complex physical spaces in which people can interact using self-created avatars as alter egos [5]. Although they have other non-entertainment applications (e.g., education, public policy making, business trades, advertising simulations) [6, 7], most virtual worlds that are the targets of research are game-based [3], mostly text-based Multi-User Dungeons (MUDs) and graph-based Massive Multiplayer Online Games (MMOGs). The immense popularity of MMOGs is reflected in the number of subscribers in 2006: 14,000,000 and growing [8].

Launched in 2003, *Second Life* is a typical web-based virtual world (Figure 1). Since 2003 it has attracted 13 million "residents," with up to 50,000 playing at the same time (http://secondlife.com/whatis/economystats.php). Compared to other MMOGs, *Second Life* has no clear goals, missions, experience levels, or victories. The main activities are social communication, participation in group activities, and producing/selling virtual objects and services (e.g., virtual building construction, giving music lessons). This and similar games (e.g., *ActiveWorlds, Kaneva,* and *Entropia Universe*) blur the boundaries between virtual and physical worlds—for example, the virtual "Linden Dollar" currency in *Second Life* can be exchanged for real world currencies (265 Linden Dollars = $1US when this report was being written), virtual *Second Life* objects have been sold on *ebay*, and at least one country (Sweden) has created a virtual *Second Life* embassy to introduce its culture and to canvass visitors.

Another remarkable example of a virtual world is *World of Warcraft (WoW)* created by *Blizzard Entertainment* (Figure 2). *WoW* is currently the world's most successful MMOG, with over 10 million players as of January 2008. *WoW* crosses regional and cultural boundaries, providing services in North America, Europe, and East Asia. Main *WoW* activities include visiting virtual "zones," accepting and executing missions, upgrading avatar levels, buying, selling and trading treasure and equipment, and joining guilds. *Blizzard* continues to develop and distribute expansion packs and game content updates (especially high-end group missions) as part of its major effort to retain players. It is also attracting considerable research attention in terms of its in-game communities, organizations, and player characteristics.

Figure 1. *Second Life* screenshots. All objects are user-created. Two buildings at the top of the screenshot are embassies, one for the Maldives and one for Sweden. Avatars in central section are involved in an online meeting. *Second Life* players have the power to design game actions, including sexual behavior.

Figure 2. *World of Warcraft* Screenshot. Similar to most other MMOGs, *WoW* avatars use weapons to win experience points and to earn gold.

The dramatic increase in the number and quality of MMOGs since 1997 has impacted not only the game market, but also multiple aspects of gaming society and culture [9]. The popularity of gaming and the formation of MMOG online/offline communities have resulted in the breaking down of boundaries formed by age, sex, race, and national origin. The rapid increase in the number of online games has resulted in a steady stream of new products developed by a growing number of commercial companies. Designers have increasingly focused on detailed aspects of game societies consisting of player avatars, and the growing number of increasingly sophisticated games is attracting exceptionally high numbers of new players. The average age at which children begin to play video games has fallen at the same time that the number of adults subscribing to online games has sharply increased [10, 11].

As MMOG popularity has grown, players have become more immersed in virtual worlds consisting of game situations and player communities. Individual players spend considerable time, money, ideas, and emotional energy creating avatars and maintaining relationships with each other. Avatars often evolve into identities that players adopt when trading game-based equipment, knowledge, and virtual capital and property. In some cases game capital and property take on value in the physical world, and game achievements, friendships, and appearances take on emotional or personal value. Game-related transactions create second lives for many players [12], leading to a description of online games as a collective "third place" whose status competes with family, work, and school [1]. Compared to other types of virtual worlds, MMOGs attract greater research attention because they cross boundaries between countries and cultures, yet the location of servers in different countries allows for the expression of unique cultural characteristics during play. Accordingly, they allow for studies of hierarchies, societies, organizations, and individuals in both virtual and physical worlds.

MMOGs and online/offline social interactions are drawing considerable attention from players, game developers, and researchers in the computer and social sciences [13]. Topics attracting the greatest research interest include the effects of a player's social context on choosing games to play, common online and offline resources used to solve problems during initial stages of game play, how experienced players establish new goals and how their decisions are affected by online and offline social interactions, how players participate in processes that form social norms in virtual societies, how players gain experience and expand their social networks inside and outside the games they play [14], how players form informal communities and highly structured organizations [15], and how players create or design new game content [16]. Today's players not only come together in the same virtual space to play, but also form offline player communities. Today's players frequent game websites and discussion boards to share their experiences and to discuss game-related issues.

1.2. *Approaches to Investigating Virtual Worlds*

The large majority of users enter virtual worlds from divergent computer terminals, thereby posing several considerable challenges to online game research. Most efforts to date have entailed qualitative approaches (e.g., individual and group interviews, secondary data study [17], participation in games by researchers who then reflect and report on their experiences) and a handful of quantitative efforts (e.g., surveys[2]) to investigating player motivations and activities. However, statistical analyses and experiments with small numbers of research subjects generally fail to detect trends or the strong effects of variables [5]. Combined, these challenges and factors have resulted in deficiencies in understanding individual player behaviors and the nature of interactions within online communities. Furthermore, long-term MMOG trends in such areas as in-game organizational change and avatar level upgrading are difficult to trace and record. It is particularly difficult to monitor increases in one avatar's level, even when using longitudinal surveys and interviews. Choosing survey samples that represent certain population segments is also difficult due to the potential for respondents to misrepresent their age, gender, and other demographic characteristics.

In summary, the online virtual world properties of persistence, closed communities, being based on the Internet, and multiple user properties pose five important challenges to conventional quantitative or qualitative approaches to investigating player behaviors: (a) interview and survey samples can be biased in terms of representability and generality; (b) players find it difficult to describe what they are doing when they are immersed in games, with different players offering different descriptions of the same avatar behaviors; (c) conventional approaches are ineffective in providing cross-sectional and longitudinal observations at the same time; (d) researchers currently cannot obtain in-game data without the permission of and support from game companies; and (e) cross-cultural studies are particularly difficult to design and execute for virtual worlds.

With the help of computer science and information technology, some researchers are using digital video recorders [13] and computer monitor recording software to collect data on in-game activities. In some cases, they are using computer monitor recording software to record the online behaviors of avatars and digital video recorders to collect data on how players control user interfaces, their emotions, and their responses to game events. Others are using monitor recording software to assess human-computer interface efficiency. These methods demands long hours of replay viewing and analysis, and results are highly dependent on the ability of researchers to observe consistent behaviors and to analyze motivations behind them.

Some researchers are beginning to design their own programs to collect online information from such sources as Bulletin Board Systems (BBS) and transaction logs for online auction websites such as *Yahoo! Auction* and *ebay*. Recent developments in markup languages are allowing researchers to retrieve and integrate information from web pages, although such efforts are limited to text-based online resources. For closed, non-text based MMOG environments, users and researchers are limited to filtering network packets to retrieve in-game information—for example, designing a "bot"[1] that automatically kills monsters, upgrades avatar level, and earns money. This method is somewhat inconvenient because it is best done when the target network address can be obtained; it is less effective when a user's long-term behaviors are monitored by an onlooker. Another challenge to using bots is that game designers are increasingly concerned about transactions involving virtual goods on *ebay* and other auction websites, with most (as well as many players) arguing that the use of bots is unfair to the spirit of online game playing. Accordingly, some game companies are starting to encrypt network packets in an effort to block bot applications. While this may satisfy the

[1] A "bot" is a third-party intelligent agent capable of automatically controlling avatars to slaughter monsters or non-player characters. Bots are capable of upgrading avatar experience levels when players are away from their computers. Most designers and players complain that bots ruin the fairness of game, and some game designers encrypt network packets to block bot activity.

desires of players, it serves as another challenge to researchers.

Due to recent developments in computer science, especially in the concept of open source programming, more and more online service providers are releasing application programming interfaces (APIs) that allow users to create applications or plug-ins to access and record online information and activities; examples include *Google desktop*, *MSN Messenger*, and *Yahoo!Widget* API development kits. Furthermore, some service providers are giving their virtual world users access to online information. For example, several real time strategy (RTS) games are now providing access to text-based user activity logs, which allow users to analyze and understand their own playing strategies. Two games that offer this feature are *Starcraft*[2] and *World of Warcraft*; *WoW* allows users to access and record information and activity logs for their own and others' avatars.

2. BACKGROUND

2.1. *Player*

2.1.1. Player modeling

Bartle [3] notes that player demographic data are important to game companies wanting to investigate what kinds of players like specific MMOGs (in order to know where to look to

[2] *Starcraft* is a real-time strategy game developed by *Blizzard Entertainment* and released for Microsoft Window in 1998. http://www.starcraft2.com/

increase membership) and how MMOGs might be altered to attract new players and to retain existing players. Academic researchers can take advantage of the same data to learn how players control avatar behaviors, as well as to organize their analyses in terms of player type (e.g., newbies, casual, hardcore) [18, 19] and motivation (e.g., seeking personal achievement or social interaction) [20]. Data on avatar behavior can also be used to identify gold farmers (players interested in earning real-world currency) and white-eyes (players who purposefully try to disrupt games or otherwise break gameplay rules) [21]. Bartle [22] used motivation to categorize MMOG players as achievers, socializers, explorers, and killers; these categories have been the bases for a large number of discussions by other researchers. Note that Bartle used online surveys aimed at gaming communities to gather the data for his categories. For my research I used avatar demographic data for similar analytical purposes.

2.1.2. Power Leveling

Potential level upgrade speed is recognized by players as an important factor influencing the popularity of online games, especially MMOGs. Game design complexity affects level upgrade speed, which in turn influences how long a player continues visiting the same game. *WoW* designers clearly focused on this important aspect of their product when creating a game that allows players to learn the game environment and gain a sense of control very quickly. Some game designers have applied dynamic difficulty adjustment (DDA) features that use a player's experience growth or flow status to adjust mission difficulty. For example, *WoW* contains missions that allow newbies to reach level 10 in less than 5 hours. Players at subsequent levels can take part in more complex actions such as small-group raids (for up to 20 avatars), joining guilds, or riding horses. A major difference between *WoW* and its predecessors is the speed at which players can reach the highest avatar level (70)—an average of two months, but possibly as fast as one week. At one time, players had to spend at least one year to reach the top level, and many never succeeded. Upgrade speed is strongly influenced by player behaviors: since players in groups are required to share experience points with other avatars, guild membership and cooperation can slow down player advancement [1]. Players gain experience points much more quickly by repeatedly killing the same monster at a fixed location without guild support; those interested in rapidly advancing their avatar levels can take advantage of this tactic.

2.2. *MMOG Communities*

The characteristics of communities formed by online game players is a sociological issue receiving considerable attention from virtual world researchers [3]. Designers of the most popular MMOGs recognize that a sense of community is an important factor for player retention, and therefore often create several community levels, from casual teams and friendships to complex hierarchical guilds. However, community development relies on how its members organize themselves to obtain achievement or to simply have fun. Recognizing the range of possibilities, developers have designed (a) multi-avatar missions promoting group play, (b) friend lists for players to maintain private in-game connections, and (c) structured guilds and group (raid) missions to promote formal communities. For their part, players are usually creating independent web sites for discussing online game community issues and sharing information.

In-game communities are recognized as centrally important to retaining players. The ways in which players organize themselves and make decisions to join or leave game world organizations are drawing attention from real-world sociologists and enterprise managers. Good guild leaders in an MMOG are recognized as having potential for becoming good team managers in the physical world [23]. For this reason, game communities are also receiving attention from researchers of organization ecology [24, 25]. Whereas real world organizations have clear goals that resist change due to members joining and leaving, virtual world organizations have no clear initial goals and therefore suffer from frequent member movement. McPherson [24] has proposed an ecological model of competition among social organizations for members, defining ecological niches in a manner that brings together organizational geography, time, member characteristics, and social composition. Successful organizations grow and unsuccessful organizations either disappear or are absorbed into other organizations. Virtual-world guilds are involved in active competition with other guilds for members, and their growth and disappearance may be viewed as compact examples of change in real-world organizations.

In organizational ecology terms, a competitive relationship exists between organizations that overlap temporally or geographically. The criterion used to measure or evaluate an organization is called a niche, with every organization having its own niche dimensions (e.g., employee education level, age, occupational prestige, type of service). Since MMOGs cross geographic, age, gender, education, and occupation boundaries, synchronicity defined as in-game time overlap between different players is considered an important niche dimension. In most MMOGs, an avatar can only join one guild, which adds to the competition among guilds to recruit new members. From the player perspective, avatars join guilds to achieve social, personal, and/or game goals. However, MMOG player motivations are more likely to change over a short period of time compared to real-world member motivations, making guild dynamics much more complex. Since surveys and interviews only capture single moments, they are less likely to identify why players join and leave guilds and less efficient in obtaining detailed data on guild categories frequently mentioned by players (e.g., elite, leisure, and family guilds). In contrast, avatar demographic data can be used to investigate niche dimensions such as organizational structure, synchronicity, and social network properties.

2.2.1. Informal and Formal Groups

Due to the high-end content design found in recent MMOGs, players are showing a growing tendency to form social structures and to play together to gain experience points by completing complex missions [17, 26]. According to some researchers, it is not uncommon for players to spend eight or more hours in one session playing with other members of their communities [26]. Using *WoW* missions as an example, many are designed for small group activities involving avatars at level 30. To complete these missions, players form temporary groups, visit a few dungeons together, and coordinate their activities to defeat monsters. These informal groups and casual missions often lead to larger groups consisting of both online and offline friends, then to guilds marked by explicit rules and management structure, then to temporary hybrid groups formed to solve the largest and most difficult missions [17]. To support these groups, game developers are providing private communication channels for guild members and a steady stream of new raid missions.

Table 1 presents *WoW* community and/or group categories in terms of Bartle's (2003) and Taylor's (2006) definitions and categories: formal or informal, temporary or permanent, flat or hierarchical structure, and hard-wired or soft-wired relationships.

Table 1. Categories of *WoW* communities according to definitions from Bartle (2003) and Taylor (2006).

Community	Community in *WoW*	Number of Players	formality	Time-persistence	Structure	Relationship
Pairs	Players in *WoW* may pick up to play together and share their experience points	2~5	Informal but recorded by *WoW*	Often temporary	Flat	Hard-wired or soft-wired
Pickup groups	There are many missions designed for small group after avatars achieving level 30.	3~5	Informal	temporary	Flat	Soft-wired
Friends	Players can store other avatars to their friend list for contact.		Formal	Permanent	Flat	Hard-wired
Groups for raiding	Players often follow the guild schedule to solve a sequential raiding mission. *WoW* raiding missions need high degree of coordination of players. Each raiding mission has its requirement on the number of participants and their levels.	5, 10, 20, 40.	Formal	Temporary	Flat	Hard-wired
Guild and ally groups	Guild is a well-structured group in *WoW* with exclusive sign and name. Players manage their guilds, recruit new member, and plan to solve raiding mission by themselves.	10~480	Formal	Permanent	Hierarchical	Hard-wired
Hybrid groups	Different guild's members often cooperate to attend the battleground playing in *WoW*.	40	Formal	Temporary	Hierarchical	Hard-wired

2.2.2. Game Element for Forming Groups—Guild

Since the creation of Multi-User Domain games (MUDs, precursors of MMOGs), guilds have attracted considerable attention from players, game developers, and researchers. Originally viewed as self-emerging organizations formed among avatars belonging to different players, guilds have evolved to become an important factor in game design following the successful implementation of guild mechanisms in *Ultima Online*, *EverQuest*, and *Lineage*. These mechanisms (which continue to be refined and improved) are now viewed as important selling points for games in the same manner as mechanisms for upgrading avatar levels and equipment. The high percentage of players joining guilds also attests to their essential position in game worlds, as well as their suitability as a focus for research on MMOG development, the behaviors of players who join guilds, and social tendencies in game playing. For long-term users and power gamers, the importance of guilds can approach that of the game itself [14, 27].

Guild member avatars have exclusive guild names and flags, and game systems often set aside conversation channels for intra-guild communications. Taking into account system and design variation, guild functionality and capability tend to be MMOG-specific. For example, guilds in *Final Fantasy XI* have special conversation channels, *Lineage* guilds have access to treasuries for storing guild-owned equipment and gold, and *WOW* and *EverQuest* guilds are given special roles that encourage long-term cooperation and coordination among members. Different levels of purposefully designed tasks explicitly and implicitly guide players to various self-organizing activities [28].

Initially, the decision to join a guild and the process of doing so were considered the most important criteria for player categorization. As guilds and data collection techniques evolved, researchers broadened their investigations to include player experiences, the sharing of those experiences, searches for friendship, cooperation for performing missions, and the formation of virtual social norms [14, 21]. Guild structure and activity are now viewed as representative of player interactions and social networks. Guild growth and decline are viewed as reflections of player needs, especially since guilds now tend to satisfy the social needs of players in virtual worlds and serve as centers for interaction in the physical world.

Due to the growing complexity of MMOGs, newbies are increasingly choosing to play the same games and to join the same guilds as their friends in the physical world; this allows them to rely on each other for help in elevating skill levels. Veteran players report asking friends and acquaintances in the physical world to join their guilds as a means of reducing the risks involved in dealing with strangers. Such actions are the result of different perceptions regarding risk and trust for different guild functions [29]—for instance, socializing, seeking help to solve problems or to build skills and experience, and organizing unified attacks and defenses. A simple example is the exchange of tips, gifts, or favors between players with distinctly different skill levels or experience. Those who act as the givers in these scenarios are often generous, placing less value than the receivers on their gifts or favors [30]. Givers often have enough time to evaluate the capabilities of the receivers, thus reducing the sense of risk. However, perceived risks involved in exchanging equipment and other resources increase rapidly when players form large groups to attack cities or camps; in these situations, exchanges among players are more likely to be controlled by a trust mechanism. Game guilds consisting of real-world friends help reduce the sense of risk [28].

Since game companies acknowledge the importance of player communities to game life spans (and profits), they have strong motivation to incorporate guild-based activities into their products. However, companies also know that different players have different motivations for playing, and therefore they must address those motivations while providing various incentives associated with guilds. For example, guild members must belong to the same faction, and certain virtual classes and occupations (e.g., priests) are considered more valuable to guilds than others.

Bartle's [22] proposed player categories include achievers, explorers, socializers, and killers, each with characteristics and powers considered essential to establishing successful guilds. The expanding variety in guild functions has significantly increased the complexity of game social interaction mechanisms—for instance, guild management tasks attract players with specific interests in organizing. Bartle [3] has identified two player types—politicians and planners—who are more likely to participate in establishing and building guilds as a means of achieving their personal game goals. Game mechanisms such as information sharing, learning, cooperation, and dragon killing points (DKPs) also encourage communication and cooperation within guilds in order to set goals, establish trust and reputation, and show responsibility [14, 31, 32]. Still, variety in individual player motivation and purpose translates into multiple reasons for creating or participating in guilds as well as distinct differences in guild style and position. Power gamers are more likely to create what are known as *Uber guilds*, inexperienced players are more likely to form newbie guilds, socializers tend to establish social guilds, and game-focused guilds generally consist of players with little interest in spending time chatting with other players.

2.2.3. Game Content for Promoting Group Play—Raiding Missions

"Raids" (also referred to as "raid missions" and "guild missions") are high-end activities suitable for groups of 20 to 40 avatars. Raids often consist of a series of missions requiring up to one week to complete. The serial structure of these missions means that players must collaborate more than once for planning and execution purposes. *WoW* designers have also incorporated raiding missions suitable for groups consisting of 40 avatars whose levels go as high as 60 or 25 avatars whose levels go as high as 70. One game feature that encourages guild membership is the fact that players can obtain rare equipment and treasure only by participating in raid missions. However, a successful raid produces only one copy of a coveted piece of equipment or treasure, therefore a guild must perform the same raid mission many times in order to make sure that all members have their own copies. This design feature requires a sense of trust [31]; the perception of being a valued member of a team may explain why mission execution is a very popular aspect of *WoW*'s high-end content. Furthermore, different raids require different combinations of avatar abilities; inappropriate combinations usually result in failure.

Game researchers interested in collaborative behaviors view online game raids as "large-scale cooperative problem-solving endeavors [1]." One of their more interesting observations is the willingness of individual players to collaborate according to their avatar capabilities. Thus, *WoW* avatars that serve as "tanks" during raids must be willing to withstand attacks from powerful monsters; "healers" accept responsibility for restoring the lives of other avatars; and the sole purpose of "DDers" is to inflict harm on monsters. To manage these tasks, guild members organize themselves into hierarchies that include such positions as "raid leaders" skilled at planning and execution and "DKP" managers who reward guild members in accordance with their level of participation in a mission.

Methods for executing missions can be used to categorize guild type, since intra-guild communication and mission and member management are considered important factors in an individual's decision to join or leave a guild. Researchers of games such as *EverQuest* have described guild mission play as "work-like play."[1, 33] Whether mission execution is considered work or play, it has become a very popular aspect of *WoW*'s high-end content. Over one-third (35%) of all Taiwanese *WoW* guilds that I collected data on were raid guilds. This phenomenon shows that *WoW* game design has impacted the virtual world game community; in turn, it is inspiring researchers to place special analytical emphasis on how high-end activities influence player society.

Guild types vary according to diversity in player motives and game design; accordingly, researchers to date have used a combination of goals, motives, and size to categorize them [17, 34]. However, it is very difficult to infer guild organizing behaviors that affect player communities from data on initial player motives, since they include such complex behaviors and factors as stability, equilibrium, dismissal, breakdown, and conflict over participating in missions and sharing rewards—issues that often develop based on interactions between player and game environments. Another barrier to understanding these phenomena is the above-mentioned difficulty of gathering in-game data to record the dynamics of guild evolution, type, collective behavior, and movement between guilds.

2.3. *WoW (World of Warcraft) and Client-Designed User Interface*

2.3.1. *WoW* Success

Between its November 2004 release and January 2007 (the most recent data available), *WoW* has attracted more than 8 million subscribers in North America, Europe, Korea, China, Australia, and Taiwan. The previous record of 3.5 million subscribers was held by *Lineage*. It is currently believed that one-half of the world's MMORPG subscribers are *WoW* players [8]. In North America, 220 game servers are used by 2 million subscribers—roughly ten times the 200,000 Taiwanese players who have used that country's 46 *WoW* servers since its release date [35]. Players and analysts generally agree that *WoW* has created completely new styles of play and new types of game culture, therefore it is attracting considerable research interest in the same manner as its popular predecessors, *Lineage* and *EverQuest*.

2.3.2. *WoW* Game World

At the beginning of play, *WoW* players are allowed to choose a specific server to play on. The three options for server type are player-versus-environment (PvE), player-versus-player (PvP), and role-playing (RP). Players who choose the most popular servers (PvE) cannot kill other player-controlled avatars, but players who choose PvP servers can participate in player killing (PK) combat. The RP server type is for players who prefer fantasy storylines. Players also select one of two faction types (*alliance* or *horde*) that differ greatly in terms of appearance, capabilities, and storylines. Based on faction choice, players must choose from four "races" (e.g., human members of an alliance or *orc* members of a horde). The final player decision concerns avatar class, with examples being *warlock*, *warrior*, and *priest*. These four choices affect player decisions and processes in joining guilds. Note that since the first two decisions (server type and faction) are not commonly found in MMOGs, they serve as examples of how game design can influence player communities.

Blizzard Entertainment's response to the server choice issue has been to provide PvP and PvE game situations simultaneously on separate servers. Once an avatar is placed on one server, the player cannot move it to another. In addition, free PK on PvP servers is only allowed between avatars belonging to different factions; otherwise, both sides must agree to PK behavior in advance, or PK must be scheduled for a specific time in a specific arena. Conversation, trading, group formation, giving assistance, and all other interactions between avatars from different factions are forbidden. As a result, many view PvE servers as supporting more leisurely play compared to competitive and violent PvP environments. The two settings are strong reflections of conflicting player styles and preferences.

Another strong example of how design influences player interaction and game environment is choice of avatar race. Players have eight choices divided equally between two factions: *night elves, gnomes, humans,* and *dwarves* belong to the alliance faction, and *orcs, trolls, the undead,* and *taurens* belong to the horde faction. Older fantasy MMOGs (e.g., *The Ring* and *Dragonlance*) gave similar choices to players, but not as many. Experienced players are well aware of how their selections affect play. Most players know that alliance avatars tend to be brighter, more civilized, and attractive and that horde avatars tend to look evil, savage, and cold. Previous studies have shown that avatar appearance and ability are important factors that influence player choice [36, 37], therefore design differences among *WoW* factions and races may hold clues regarding player tendencies in social interactions.

3. ENVIRONMENTS AND APPROACHES

3.1. *New Trends for Peer Designers to Investigate Digital Worlds*

Five characteristics of online virtual worlds mentioned in section 1.2 limit research methods for investigating them. Computer monitor recording and network packet filtering are two alternative methods for data collection; the shortcomings of each are discussed in section 1.2. In this section I will look at two current web 2.0 service trends: client-designed user interfaces and open user-created data trends, both serving as examples of how providers welcome user participation in certain aspects of service design for purposes of sharing and personalization. Combined, the two trends allow services to meet the needs of different populations and to integrate online information access. For example, *Google Desktop API* allows users to read e-mail, check on the weather, and monitor sports scores and stock prices on a single browser screen.

3.1.1. Open-Data Trends

With the development of the World Wide Web, the amount of information available online is growing exponentially. Digital tools are making it easier to record activities and exchange information than their counterparts in the physical world. Without digital tools, player activities in the physical world are difficult to record for research purposes; furthermore, some kinds of online information still require cooperation from service providers—for example, non-text-based services (e.g., MMOG avatar information and online maps) and author information placed in the deepest levels of webpage hierarchies. Virtual world researchers also find it necessary to cooperate with game companies to obtain network traffic statistics and subscriber information to analyze MMOG connection quality and gamer populations (

Figure 3).

Open data provided by service providers have the following properties: (a) third-party users can only access data through an API; (b) interested users often need to apply for authentication keys to access data; (c) some private data fields are restricted to prevent improper access; and (d) open data have fixed fields and meanings that make analysis easier. Using *Google* series service APIs as an example, *Gdata* ("Google data API protocol") allows users to query syndication format data using an authentication mechanism to access user-created data. Other *Google* services support the *Gdata* protocol for developing APIs: *Google Apps, blogger, calendar, web album, YouTube, and social network API*. Other examples include e-commerce or citation service websites such as the non-commercial *flickr* service API (http://www.flickr.com/services/). Many third party applications have been developed based on this API, including *flickrball*[3] (which gives access to a six-degrees-of-separation experiment

[3] *flickrball*: *http://www.mindsack.com/flickrball/*

using *flickr* picture tags) and *retrievr*[4] (which allows users to draw sketches or upload images to find similar photos on *flickr*). MMOGs also provide accessible data for client-side developers; a good example is *Blizzard Entertainments'* decision to give *WoW* users access to basic avatar demographic and auction information. The central point of this dissertation is that this feature can be modified and used to investigate in-game player activities. *Warhammer Online* is also adopting this feature, and other games and game designers are expected to follow suit.

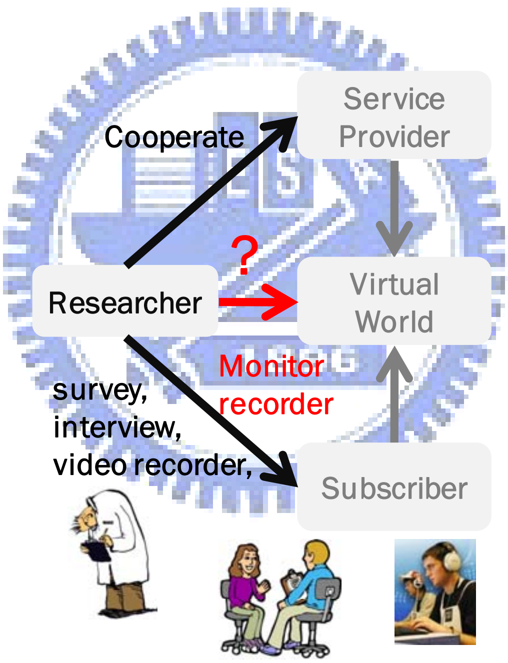

Figure 3. Relationships and interactions among service providers, web services (virtual worlds or MMOGs), and researchers.

3.1.2. Client-designed User Interface

Most UIs used with network services or PC software are fixed, single-user interfaces that

[4] retrievr: http://labs.systemone.at/retrievr/

provide functions defined by the service provider; users cannot alter them or add new components. As designers put greater emphasis on UI usability, a growing number are giving users the ability to design their own components for attachment to main service applications. A popular means of delivering this feature is providing a main engine and several default components called *add-ons* (Figure 4 and Figure 5). APIs for UI design differ from the data APIs mentioned above—for example, *Yahoo Widgets API* (http://widgets.yahoo.com/tools/) and *Google Gadget API* (http://code.google.com/apis/gadgets/). Users can also add third-party components. Common add-on functionalities include writing memos, reading E-mail and RSS news, and checking personal calendars.

Based on this trend, several add-ons are automatically downloaded and attached on the main screen the first time that players connect to *WoW*; they can later download additional add-ons written in *WoW* UI API from third-party websites. UI design is an important issue for game companies, who are acknowledging (a) player desires to quickly become familiar with game controls and content, and (b) the shortcomings of single fixed UIs to meet the various needs of complex MMOG game content (e.g., completing initial missions, joining guilds, participating in raids, and executing combat). Compared with the original *WoW* UI shown in Figure 6, the third-party product in Figure 7 is more suitable for group missions. The *WoW* UI is created using the Lua script language for functionalities and xml for appearance. Since 2004, Lua has been used to design stories, events, NPC rule bases, and UIs for many real-time strategy games, role-playing games, and MMOGs: *Supreme Commander, Ragnarok Online, World of Warcraft*, and *Warhammer Online*.

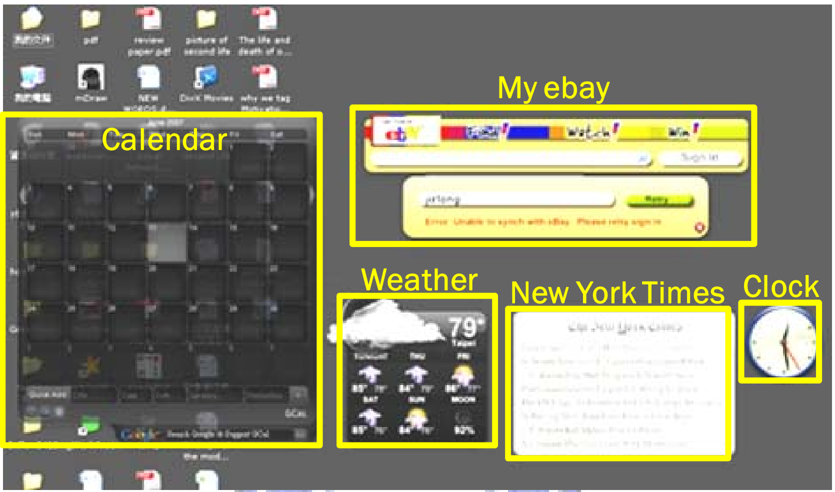

Figure 4. *Yahoo! Widgets*. Users can design their own add-ons or insert add-ons made by third-party service providers and designers.

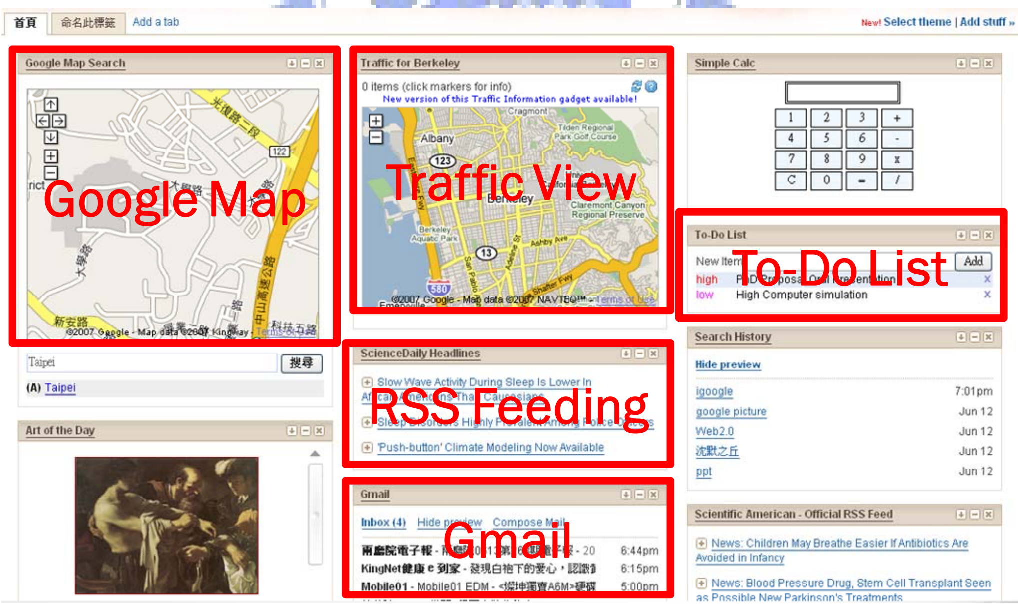

Figure 5. *iGoogle*. Users have the power to add gadgets to the *iGoogle* panel. Since it is a webpage, it requires a browser.

Figure 6. An original player-controlled UI provided by WoW.

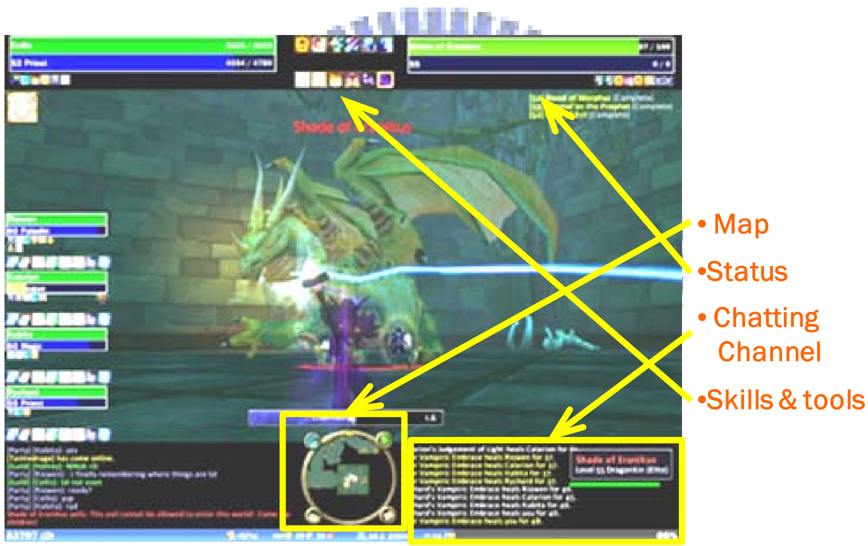

Figure 7. Modified UI created by third-party source. Client-designed UIs can be found and downloaded from player-sharing community websites.

3.2. *Web 2.0 Trends in Game Community*

Web 2.0 characteristics found in digital games include player involvement in game design, shared playing logs, and client-designed UIs. Some early examples are MUDs that allowed players to design rooms and room functions (Bartle, 2003). Today, in addition to MMOGs, Real-Time Strategy (RTS) and First-Person Shooter (FPS) games also give users tools for designing their own maps, missions, and combat scenarios. Player-designed games that utilize combinations of map editors or APIs with main game programs are called *mods*; they are generally available for downloading from game-related websites. One of the most famous mods is *Counter Strike*, which uses the FPS game *Half Life's* engine and structure. Another example is *Warcraft III World Editor*, which is similar to *StarCraft's* level editor but allows users to create and edit their own maps and scenarios. Many Asian players have designed *Warcraft III* mods using different storylines (e.g., Chinese or Japanese historical legends) and different game play features (e.g., multi-player tower defenses and two-team combat). A list of the best-known player-designed mods is presented as Figure 8.

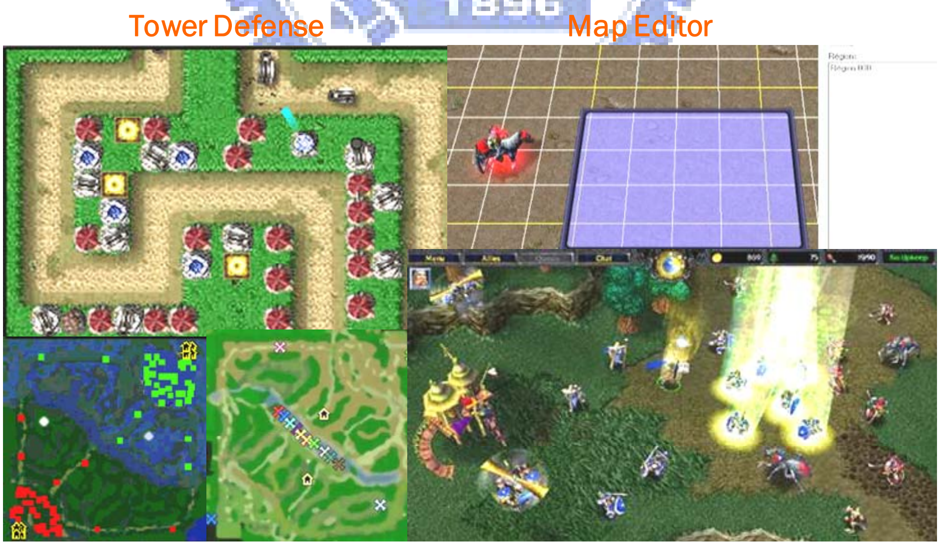

Figure 8. Screenshots of *Warcraft III* mods including two types of gameplay: tower defense and two-team combat.

Blizzard Entertainment is the most successful example of a MMOG company encouraging its players to create, share, and download player-designed user interfaces. The three main UI functions are (a) assisting with in-game control, (b) creating hints, maps, and libraries for solving missions, and (c) collecting in-game information on avatar status. Whereas the most basic function of user interfaces is to provide the outward appearances of game or website services, my objective emphasizes the third function. Using *WoW*'s "AltasLoot" function as an example, its main use is to provide data on the probability of "loot dropping"[5] when a monster is killed (Figure 9). Dropping probabilities are calculated based on information collected from peer users—a function that I believe can be used to collect data on in-game avatar status.

Figure 9. Screenshot of a *WoW* player-designed UI called *AltasLoot*, which provides probability of loot dropping.

[5] When a player kills a monster, it drops "loot" and gold as rewards. However, loot for two monsters of the same type aren't always identical, therefore *AltasLoot* has been designed to calculate the probability of loot being dropped from individual monsters. The *AltasLoot* UI only records loot dropping events for the player who attaches it as an add-on.

3.3. *Investigating WoW Using the Client-designed UI Feature*

WoW is attracting considerable research attention, similar to its popular predecessor, *EverQuest*. *EverQuest* researchers felt that they had no choice but to spend long periods playing the game they were studying, browsing discussion boards, and participating in or observing game design workgroups to build their knowledge of game situations, backgrounds, and cultures. It is now generally accepted that time-slice approaches are insufficient for investigating progressive guild development and life cycles (i.e., creation, development, splitting, and disbanding); such topics require data collected over time periods ranging from several weeks to six months. For the most part, these time-consuming methods have been passed over in favor of online/offline surveys and interviews aimed at understanding player motives and behaviors [8, 22, 34]. Another major challenge for researchers is the above-mentioned need to gain support from game companies for data collection.

In order to attract and retain players, many companies are creating mechanisms that allow players to modify avatar appearances, characteristics, skills, and abilities to organize and join guilds. As mentioned earlier, *Blizzard Entertainment* has made one of the most dramatic moves in this regard by giving *WoW* players the ability to create and modify their personal interfaces by means of an API. This feature allows users to collect progressive data on grouping, communication, and guild formation and development. I have used this same tool to monitor changes in avatar participation in specific guilds over time and to use guilds as game agents for the purpose of analyzing their distribution, differences, and life cycles. Specifically, I have designed a *WoW* add-on that I call census++ to automatically record data on time, camp (alliance or horde), avatar name, guild membership, level, race, class, and zone. A log sample is shown as Table 2. Data that are returned from individual queries reflect information for all avatars on one server. The time interval between successive queries depends on the number of avatars on the server; average data recording frequency is once per 15 minutes.

Table 2. Example of *WoW* avatar behavior data collected using the game's player-designed user interface.

Date	**Time**	**Avatar ID**	**Guild**	**Level**	**Race**	**Class**	**Zone**
2007/9/17	13:25:23	冰心冷語	Aza Aza	70	血精靈	法師	影月谷
2007/9/17	13:25:23	Debuff	Aza Aza	45	血精靈	法師	菲拉斯
2007/9/17	13:25:23	忘月	Aza Aza	61	不死族	牧師	撒塔斯城
2007/9/17	13:25:23	Miyuki	Banshee	25	牛頭人	德魯伊	提里斯法林地
2007/9/17	13:25:23	Tubaobao	Banshee	42	食人妖	獵人	荊棘谷
2007/9/17	13:25:23	死亡漣漪	Banshee	53	不死族	盜賊	阿塔哈卡神廟

WoW currently operates 32 servers in Taiwan. There are two server types, player vs. player (PvP) and player vs. environment (PvE); avatars on one server cannot interact with avatars on another. Players using a PvE server cannot fight with player-controlled avatars in opposing camps unless both players agree ahead of time. These restrictions allow servers to be viewed as unique societies. Note also that individual avatars can only join one guild, although guilds can recruit new members and try to convince players to switch guilds. These exclusive server and guild design features result in the hierarchical game world framework shown in

Figure 10. Each hierarchy level requires a separate analysis of recorded log data. For example, at server-level researchers can compare differences in guild growth and decline in PvP and PvE servers, and in-game community guild-level researchers can categorize guild types according to player level and size and observe changes in those parameters.

Since *census++* runs as a background program in *WoW* and records player status over time, interested researchers can perform both cross-sectional and longitudinal analyses. Examples of cross-section topics include (a) size and level distribution of guilds on one server, (b) member balance between two camps, (c) avatar level distribution, and (d) guild member survey. Examples of longitudinal topics include (a) changes in guild level and size, (b) avatar movement between guilds, (c) efficiency in avatar level upgrading, and (d) consistency and reliability in guild mission participation.

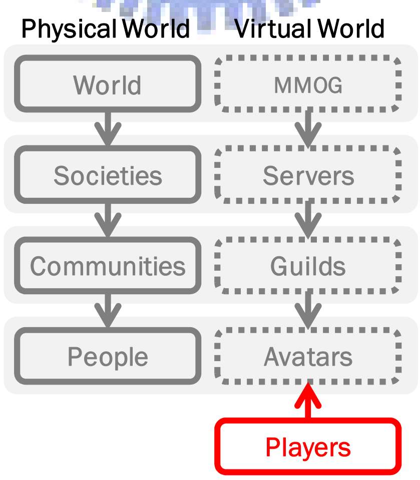

Figure 10. Structure and hierarchy comparisons between physical and virtual worlds.

4. RESULTS

4.1. *Data Coverage*

Different datasets were established for specific topics and *WoW* update events. Data on period, frequency, server type, and total numbers of avatars and guilds in each dataset are listed in

Table 3. The first set, consisting of data from 62 Taiwanese servers between January and April of 2006, were used to analyze *WoW* guild dynamics. Since in-game guilds change slowly, collecting frequency was adjusted to once every 6 hours. Since Taiwan *WoW* service began in November of 2005, the dataset is considered young enough to capture early guild dynamics. Three datasets from American and Taiwanese servers created between the end of 2006 and early 2007 were used to determine differences between the two player cultures in terms of behaviors aimed at game achievement. A shorter collection frequency allowed for monitoring all changes in avatar level upgrading and guild activities. The fifth dataset was established to address the topic of why players leave their original guilds and join other ones. This topic required a longer data collection period.

Table 3. Datasets. Different dataset recording frequencies, periods, and scales were used for different purposes.

File	Collection Time	Frequency	Server Type	Total Avatars	Total Guilds
Taiwan	1/6~4/6(2006)	6 hours	All 62 Taiwanese servers	641,805	285 per server
US	9/1~9/25(2006)	12mins	1 PvP + 1PvE servers	40,038+50,703	1437+1456
Taiwan	12/1~12/25(2006)	15mins	1 PvP server	8,394	156
US	1/3~1/18(2007)	18mins	1 PvP server	41,097	1312
Taiwan	9/15~12/15(2007)	40mins	Selected 5 servers, 2 PvE+3 PvP	98248	

4.2. *Dynamics and Evolution of MMOG Guilds and Other Organizations*

4.2.1. Introduction

Online game guilds have a hierarchical leadership structure that allows players to act as unified groups to solve joint missions. Whereas guilds used to be viewed as informal and unplanned organizations, some recently released online games have incorporated guild formation into their structure, adding mechanisms for establishing guilds and designing goals and missions that require coordinated actions by members of well-organized teams [3, 38, 39]. Since online players frequently change their personal gaming goals, they often leave active guilds to join others. Accordingly, online guilds are now experiencing cyclical lives that entail creation, development, member suspension, splitting, merging, and disbanding, thereby becoming perhaps the most representative social organization in online game societies.

A plug-in was designed for attachment to 124 avatars in order to collect data from 62

Taiwanese *WoW* game servers (21 PvE and 41 PvP) between 2/10 and 4/10/2006. Data on avatar nickname, race, class, level, and location were automatically recorded three times per day (Table 2). Whereas in older games such information could only be obtained via direct avatar interaction, the plug-in made it possible to perform a diachronic census. For the data collection period, increases were observed for such measures as total number of avatars, average level, number of avatars achieving the highest level, and average number of guild members. However, it should be noted that the total number of guilds decreased over time—a reflection of the tendency of guilds to merge as game worlds develop. The statistics in Table 4 show that 48 percent of all horde avatars were placed on PvP servers, compared to 28 percent placed on PvE servers.

Table 4. Data collected from Taiwanese WoW servers between February 10 and April 10, 2006, including total numbers of avatars, average avatar levels, percentages of level-60 avatars among all avatars on individual servers, total numbers of guilds, average guild size, and Alliance/Horde ratio for PvP and PvE servers. Data were collected four times per day from an average of 40 PvE and 20 PvP servers.

	Player vs. Environment Server			Player vs. Player Server		
Feb-06	Avatar Number	Average Level	Lv60 Member (%)	Avatar Number	Average Level	Lv60 Member (%)
	9796.37	31.27	18%	11534.74	32.95	25%
	Guild Number	Average Guild Size	Alliance/Horde	Guild Number	Average Guild Size	Alliance/Horde
	202.05	48.89	72:28	196.89	58.96	71:29
Apr-06	Avatar Number	Average Level	Lv60 Member%	Avatar Number	Average Level	Lv60 Member%
	8684.15	32.16	21%	10145.88	34.19	28%
	Guild Number	Average Guild Size	Alliance/Horde	Guild Number	Average Guild Size	Alliance/Horde
	174.51	50.53	52:48	169.78	60.72	52:48

4.2.2. Results

Avatar level distribution can serve as an indicator of current game world development. In addition to the 60 Taiwan *WoW* servers described above, 2 more were added during the study period; both were aimed at new gamers. As shown in Figure 11, of the 10,696 avatars whose average level was 30, 2,655 (26%) had achieved the highest possible level. None of the other levels from 0 to 59 accounted for more than 4 percent of all avatars.

According to the collected data on player choices for faction, race, and class, no special tendencies or patterns were noted in terms of guild membership with one exception: the percentage of avatars joining guilds increased steadily with avatar level. Between levels 16 and 20, approximately one-half of all avatars belonged to at least one guild. At level 60, 93 percent of all avatars were guild members. Combined, the average percentage of guild membership for all *WoW* avatars in the study sample was 65.7 percent. The data strongly support the ideas that in *WoW*, guild membership is a common phenomenon and guild play holds an important position.

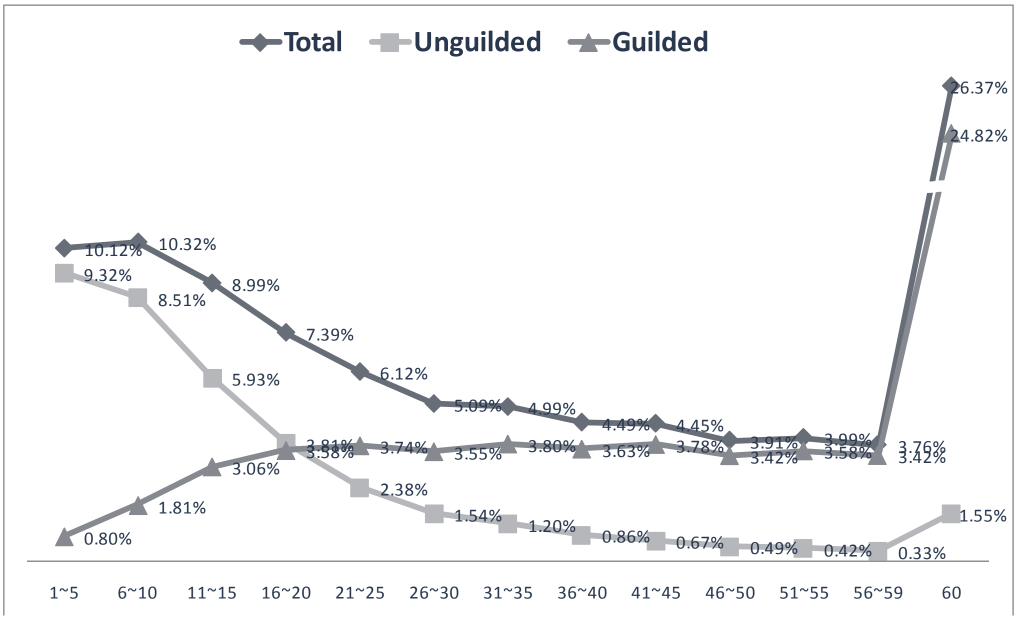

Figure 11. Avatar level distribution for *World of Warcraft* in Taiwan. Data were collected on 02/10/2006 for 641,805 avatars on 60 servers. More than half of all avatars between levels 16 and 20 were guild members.

Based on results from previous quantitative studies, guild membership numbers and average member levels are representative of a guild's human resource power, since the two criteria directly influence the ability of guilds to execute raids. Previous analyses of guild activities in *WoW* indicate that (a) guilds can be categorized into several distinct types—small, large, elite, unstable, and newbie; and (b) guild size distributions are similar across different servers: an average of 180 members, with a small number of extra-large guilds and a large number of small guilds. Furthermore, since *WoW* designers took into consideration different goals among early, middle, and late-stage players (e.g., chatting, exchanges of support, resource sharing, executing guild missions), it can be concluded that member level distribution reflects guild activities, goals, and functions.

I recorded changes in guild size on the 62 Taiwan *WoW* servers from February to April of 2006 and compared differences between the 2 newest servers (in operation for two months) and the 60 that had been operating for at least four months. New avatars were continually being created on the newest servers—in other words, guilds on those servers were more active than guilds on the older ones (Figure 12a). These results indicate a thriving initial stage and a lack of interest among older, more established guilds to recruit new avatars (Figure 12b). For the older guilds, the main focuses are apparently on membership dynamics and competition with other guilds. According to the subsequent analysis on change in average guild level and scale, activities and trends among communities exert important influences on game world ecology.

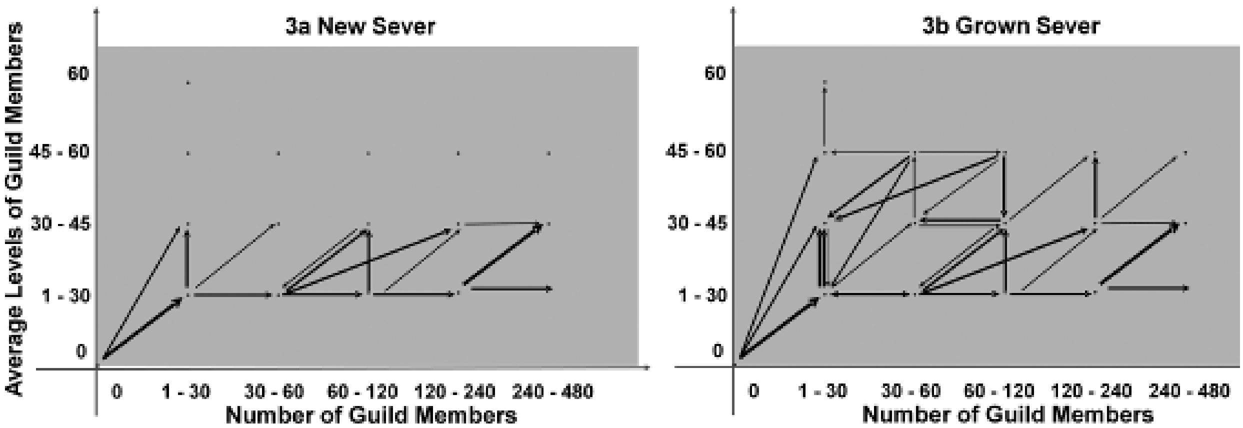

Figure 12. Differences between new and mature servers. A mix of growth and decline is noted in 2b.

In addition to differences in static guild scale, an investigation was conducted on the dynamics of guilds with the potential of being affected by gaming environment (Figure 13). According to the upper boundary of avatar level (60), a relationship was noted between increasing average level of avatars on a server and growth in the average level of guilds as their members approached level 60. The opposing forces of guild expansion and centralization can result in an ambiguous boundary of guild size—a maximum of 480 members. I noted that the greatest amount of guild instability occurred among those with approximately 60 members whose average level was 60.

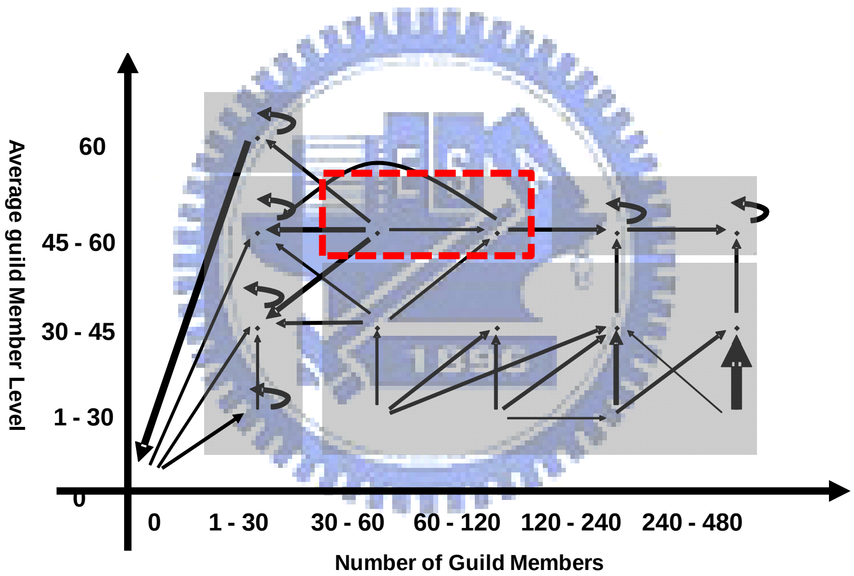

Figure 13. Guild scale transformation. Array thickness represents transformation probability potential. Data were collected four times per day on average between February and April, 2006 from an average of 40 PvE and 20 PvP servers.

It is possible to construct a prototype *WoW* guild life cycle from these results (Figure 14). Most guilds start very small and primarily consist of low-level members; large numbers of these small guilds are continuously established on individual servers. Most come up against standard guild management problems right away, and only a few successfully resolve them and develop into functional newbie guilds capable of recruitment and level upgrading. Since low-level avatars tend to leave and join other guilds, many unstable newbie guilds consist of small numbers of high-level members; this is especially true for long-term newbie guilds that maintain small membership numbers. Large guilds that successfully maintain their community relations can use their collective resources to execute multiple raids. Those that don't must struggle to overcome their lack of stability in order to become large guilds capable of executing late-stage missions. A significant number suffer from the loss of key high-level members, while others lose large numbers of low-level members and consequently evolve into elite guilds that tend to disband once their members acknowledge their inability to garner enough resources to conduct raids.

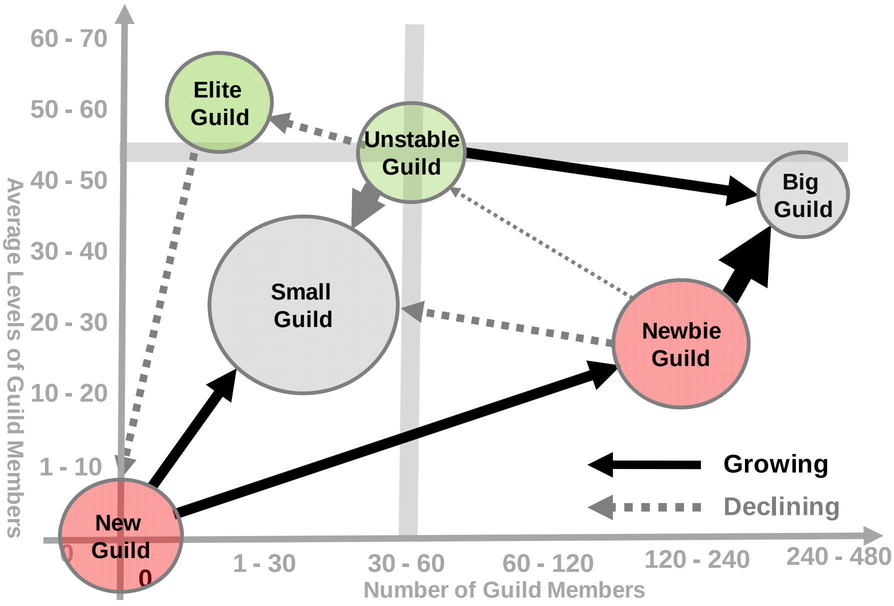

Figure 14. Life cycles for six basic guild types.

In summary, mature guilds must actively develop their memberships in terms of numbers and average member levels to ensure their survival, which explains why new avatars find it very easy to join *WoW* guilds. These conditions and management needs distinguish *WoW* and other recently released games from older MMOGs that have a small-guild focus. The *WoW* emphasis on solving missions means that its guilds are likely to differ significantly from traditional game guilds consisting of mixed offline/online friendship networks. The *WoW* game design also guarantees instability and variety in guild and community network structure.

The guild dynamics shown in Figure 14 were collected from January to April of 2006, just after the November 2005 launching of the Taiwanese *WoW* game. A main finding of this study is that newbie gamers join guilds in increasing numbers for purposes of seeking assistance. I observed several newbie guilds whose average member level was below 30 recruiting additional newbie gamers by providing hints and helping them to solve missions. These guilds put more emphasis on experience sharing, social interaction, and communicating at the expense of high-end group missions. In the three years following the introduction of *WoW* in Taiwan, *Blizzard Entertainment* merged unbalanced and/or underactive game servers and distributed a new expansion pack in which the highest level was increased from 60 to 70. The packs featured additional high-end content for advanced players, including group missions and maps. The requirement for the minimum number of avatars for high-end group missions was decreased from 40 to 25. *Blizzard* has also made it easier to upgrade avatar levels—another change aimed at retaining more players.

Differences between current and previous versions are shown in Figure 15. Three noticeable changes are (a) average member level in large guilds is rapidly approaching the highest level boundary—in other words, more players are achieving the highest level; (b) the number of newbie guilds (now also referred to as *leisure guilds*) is decreasing; and (c) the average level threshold is increasing but guild size is decreasing due to the features offered in the new expansion pack. Possible explanations for why newbie guilds are disappearing are (a) after three years of development, most players have come to recognize group missions as *the* main feature of *WoW* play; (b) the major percentage of new avatars are being created by original players; or (c) since avatar level upgrading has become easier and since more game tips are being shared on websites, players are less dependent on newbie guilds for help. This would explain the transformation from “newbie” guilds to “leisure” guilds that put greater emphasis on recreation.

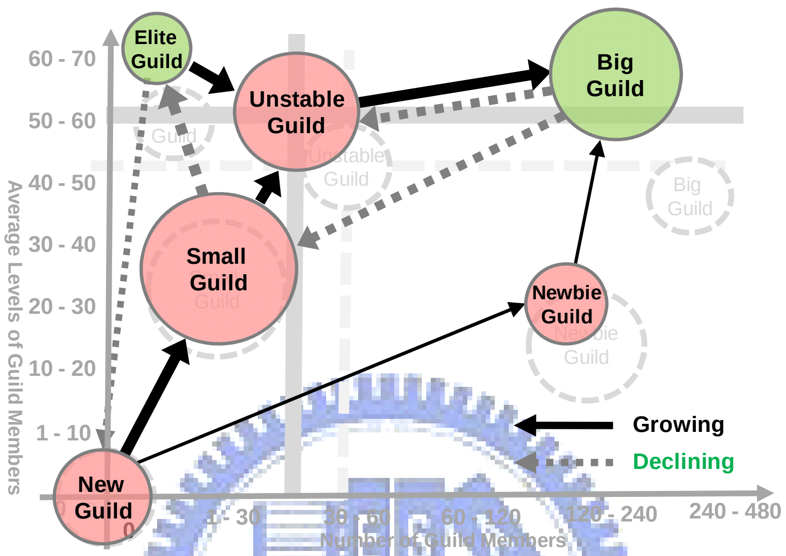

Figure 15. Guild life cycle after *Blizzard Entertainment* launched its official expansion pack in Taiwan (September-December, 2007).

4.3. *Dynamics of Player Leaving and Joining Guilds*

In an earlier section I discussed treating individual guilds as organisms and using average level and number of members to categorize them. Conventional approaches to data collection may be sufficient for showing the complex dynamics of change in those parameters, but they do little to explain why guilds undergo change. For example, the data in Figure 15 indicate that large guilds eventually lose members and change into unstable guilds, but the data are not useful for analyzing member motivations for quitting guilds—for instance, whether ex-members leave the game entirely, or if they simply stop taking part in group missions. The data also fail to identify the kinds of guilds that players move to, making it difficult to analyze motivations such as more friendly group mission schedules, family-like atmospheres, a desire for new or different friendships, or a preference for playing as a solo avatar. It is assumed that the act of leaving a guild means that the player is somehow dissatisfied, and the demographic data collected by UIs can be used to identify core problems that might trigger dissatisfaction.

4.3.1. Experiment and Results

As stated above, guilds can be categorized into large, small, unstable, elite, new, and leisure according to their average member levels and numbers. I used the *WoW* UI to record player movement between guilds (e.g., from a large guild focused on raiding missions to a leisure guild). An illustration of player movement between guilds is presented in Figure 16. I believe that such movement—especially from large to unstable guilds—reflects players' unwillingness to endure strict group mission schedules and their desire for more relaxed play. In contrast, player movement between similar guilds (especially small and/or unstable guilds) may indicate player frustration over (a) not achieving the highest level; (b) growth in their original guilds or conflicts with other members; (c) lack of acceptance by a large and well-established guild; or (d) finding a similar guild that will allow them to quickly upgrade their avatar level. The phenomenon of players leaving newbie guilds to join unstable guilds may reflect player needs for challenges and achievement.

However, the data under discussion cannot explain why large guilds persist in having enough players for solving group missions. To address this issue I looked at the records of players who remained with their original guilds for long periods of time—from newbie to unstable to large (Figure 17). Figure 18 represents a mix of the information shown in Figure 16 and Figure 17 and an attempt at shedding light on the dynamics of player movement between guilds: (a) newbies show a tendency to stay with their original guilds through initial periods of growth, although there is a significant number who quickly search for advanced guilds with greater potential for higher player achievement rewards; (b) high-end players may leave large guilds when they can no longer play according to strict group mission schedules; and (c) newbie guilds with stronger recreation motivations often welcome high-end players from large guilds for the experienced help that they can offer, but those new high-end players may leave quickly to pursue personal achievement or avatar equipment. These results suggest that group missions and level upgrading mechanism designs exert significant impacts on player decisions to join and leave guilds. Group missions affect guild joining behaviors in at least two ways. The small group mission game feature encourages players to form family-like small organizations, and achievements and loot produced by group missions motivate players to form large and uber guilds.

Finally, I recorded data on avatars who left their original guilds but did not join new guilds—in other words, players that quit organizational play. According to the data shown in Figure 19, a significant number of players in unstable guilds chose to leave group playing activities. One possible reason is the combination of strict group mission schedules plus the added factor of insufficient manpower to complete group missions. The two factors are strongly tied to each other in that the lack of manpower puts pressure on existing members of unstable guilds to participate in guild missions more frequently. In comparison, larger guilds (especially uber guilds) have enough manpower to execute multiple group missions simultaneously and still allow some members to sit out if they desire.

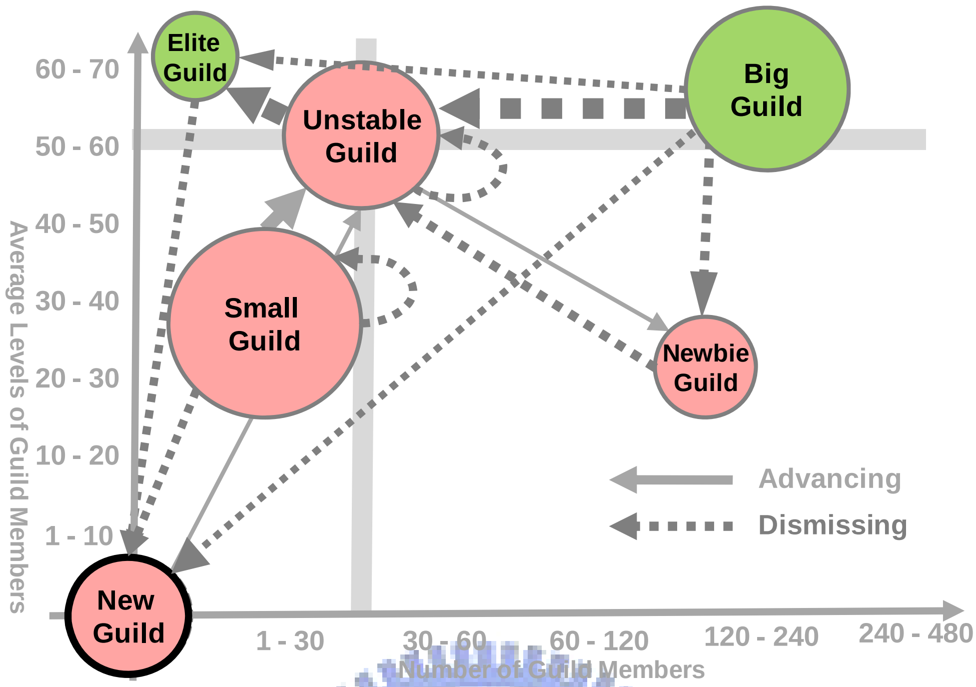

Figure 16. Player changing guild behaviors. The thickness of arrow stands for amount of players changing behaviors.

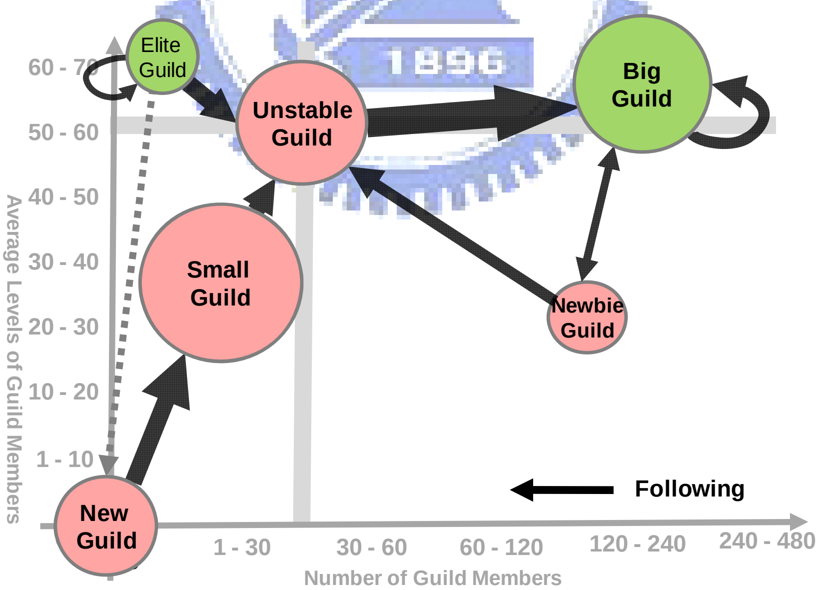

Figure 17. Dynamics of player staying at original guild and following with their guild growth.

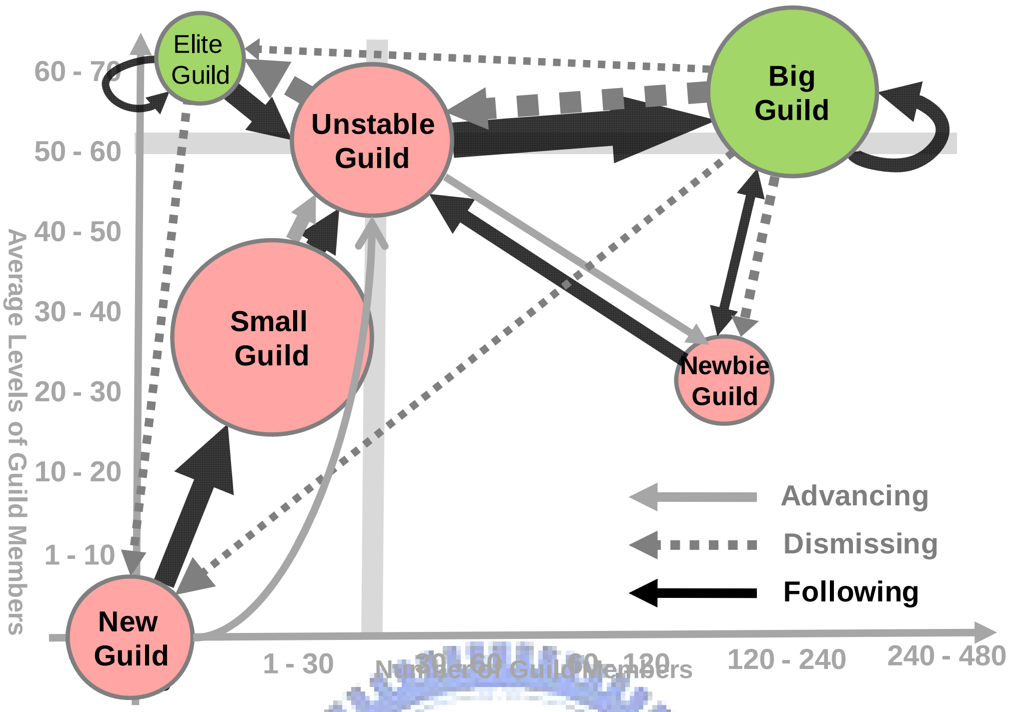

Figure 18. Dynamics of player leaving and joining guilds.

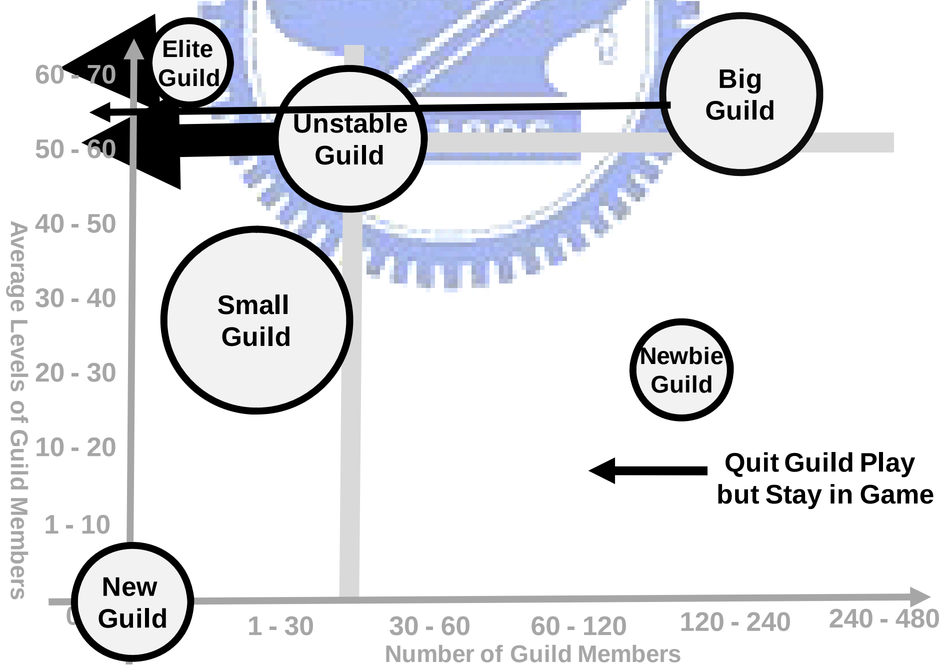

Figure 19. Data collecting on avatars who leave original guilds but don’t join other guilds.

4.4. *Comparing Player Behaviors in Different Cultures*

4.4.1. Introduction

The dramatic increase in the number and quality of MMOGs since 1997 has impacted game markets as well as multiple aspects of gaming society and culture [9]. For instance, today's players not only come together in the same virtual space to play, but also form offline player communities. Today's players frequent game websites and discussion boards to share their experiences and to discuss game-related issues. In Taiwan they often discuss and compare differences between players and games in different countries (e.g., game design, avatar appearance and power balances, special playing styles, game management, and reward mechanisms). A popular topic is comparing player motivations and behaviors between Taiwan and America, and how such differences might affect game servers and vice versa.

When monitoring public online game discussion boards in Taiwan, I have noticed Taiwanese players praising American-based server cultures and player behaviors and criticizing their fellow Taiwanese players' gaming styles and behaviors. A comment occasionally seen on http://www.gamer.com.tw (Taiwan's largest online player community discussion board) states that "Players on American servers place more importance on recreation and cooperation while players on Taiwanese servers place more importance on personal achievement." Other opinions offered without the benefit of supporting evidence include "Taiwanese players are 'level farmers'" (a term used to describe individuals who play aggressively for the sole purpose of upgrading their avatar levels). Consequently, some Taiwanese players tolerate the slower communication speeds and 8-12 hour time differences that accompany connecting to North American servers. These players tend to express strong opinions on American playing scenarios to the detriment of Taiwanese player styles. I found evidence of respect given by indigenous Taiwanese players to their peers who play on America servers, and comments that seem to express a strong desire to participate in the "ideal gaming world" that they perceive as existing in the US.

The content of Taiwanese player discussions on differences between gaming cultures can be categorized in terms of (a) the debate over achievement versus recreation, (b) the degree of "experience farming," and (c) the fairness of "valet experience farming" (i.e., hiring another player to earn experience points for your avatar). As mentioned above, I have noted a tendency among Taiwanese players to criticize each other for placing too much importance on achievement at the expense of a game's recreational aspects. I tested this opinion by observing the efficiency of avatar level upgrades and monitoring avatar movement to determine fixed locations where players know they can farm experience points.

The collection and analysis of in-game data can be used to determine player avatar upgrades and achievement tendencies between Taiwanese and American players. For example, based on the assumption that most players either work or attend school during daytime hours, I can use data on the number of players at different times of the day to estimate the amount of player efforts to automatically upgrade avatars without being present (e.g., using bots or hiring "professional gold farmers"). Results from comparative searches of ebay.com and ebay.com.tw indicate that the Taiwanese website offers more of these special services and a greater variety compared to the American version. American players who are interested in gaining experience away from the game tend to gravitate toward websites that provide virtual gold exchange services, whereas Taiwanese players are more likely to hire agencies to procure hard-to-earn equipment or to upgrade avatar levels, reputations, and ranks. I view these tendencies as evidence that Taiwanese players place much more importance than their American counterparts on level achievement. However, such an argument must take into account the greater tendency of American *WoW* game masters (GMs) to arrest professional gold farmers to limit unfair behavior—an example of how game management can influence in-game player behavior. Verification requires a large amount of in-game evidence on avatar level upgrading efficiency.

Guild activity is another aspect of this issue that needs to be taken into consideration. Some Taiwanese players who have left *WoW* argue that "all Taiwanese guilds are utilitarian—they only farm equipment and gold." To test this claim, I collected guild recruitment announcements from Taiwanese and American servers; I found evidence that American guilds do the same. One Taiwanese guild announcement stated that players were welcome to join if they could “regularly attend raid missions 5-6 days a week from 8:00 pm to 12:00 pm.” In contrast, an American guild announcement stated that willing participants “must be ready to farm potions all day. You must have a thick skin and have a high capacity for verbal abuse.” Some guilds in both countries even stipulate that raid leaders have the power fire members who cannot regularly attend raid missions. This leads some players to complain that raid missions can become boring and block individual player efforts to upgrade their levels and/or earn essential equipment. Conflicting motivations can lead to what is now called guild drama—that is, frequent player movement between guilds. On the other hand, guilds that farm gold can reward new members who show a willingness to regularly participate in raid missions. Since the evidence suggests that both Taiwanese and American guilds place great importance on raids, additional in-game data is required to verify which group gives greater emphasis to achievement and benefits.

Play researchers generally focus on three topics: player characteristics, player behaviors, and environment. Players from different national or ethnic cultures tend to express different gaming behaviors. These behaviors can be affected not only by physical environment (e.g., alone at home versus group play at an Internet café), but also by the order of virtual game status. Our focus in this paper will be differences in player behaviors that are influenced by national culture. I used the client-designed user interface feature of *WoW* to collect data on avatar level, participation in a guild, time spent online, and frequently visited locations. The avatar data were used to determine level upgrading efficiency and level farming activity, and the guild data were used to determine the degree to which Taiwanese players treat guild missions as work or play. The two data types were used to evaluate differences in Taiwanese and America *WoW* player behaviors and to support or refute claims commonly found on Taiwanese game community discussion boards.

4.4.2. Experiment and Results

I collected data from two servers (one PvP in Taiwan and one PvP in the US) between December 2006 and January 2007 (three weeks total). The US "Executus" server hosted 41,097 avatars and the Taiwanese server hosted 8,394. Avatar nicknames, guild affiliations, locations, and levels were automatically recorded once every 30 minutes throughout the collection period. Data sets and results can be found at http://writing.wwlc.nthu.edu.tw/*WoW*/. Basic descriptions of the two servers are given in Table 5. I found that the number of avatars on one American server could be five times the number on one Taiwanese server. However, the numbers of level-60 avatars were almost identical. The percentage of avatars at level 60 can be interpreted as the potential capability of all avatars on a server to execute raid missions. Level-60 avatars accounted for 42% of all avatars on the Taiwanese server but only 10.8% on *Executus* (Results of other American servers can be found at above-mentioned website). Despite this large difference in high-end player proportions, the distribution of player online time was equivalent across the two servers (Figure 20). I used this measure as the basis for comparing differences in player behaviors (e.g., level upgrading efficiency and periodic participation in raids).

Table 5. Descriptive comparison of Taiwanese and American *WoW* servers.

	US	TW
Number of players	41,097	8,394
Number of level-60 players	4,421	3,552
Level-60 player percentage	10.8%	42%

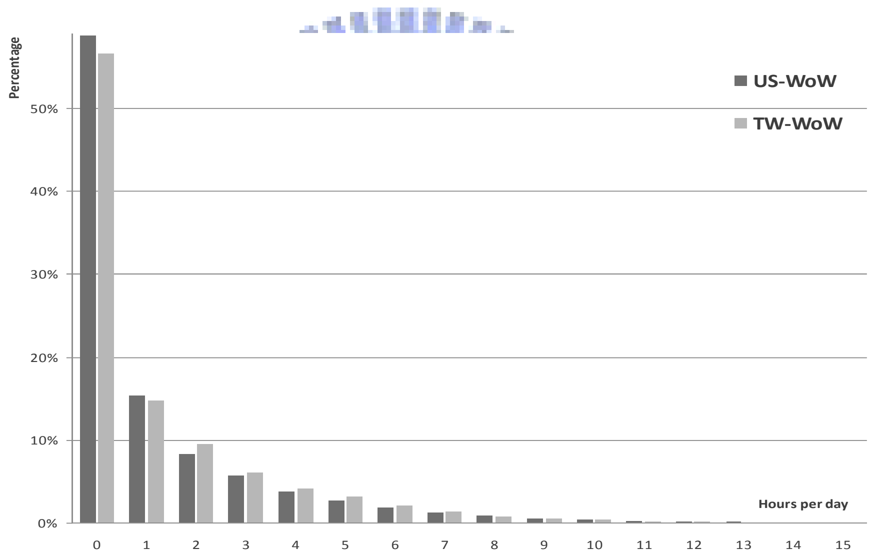

Figure 20. Average playing time for players on the Taiwanese and American *WoW* servers used in the study.

I calculated guild size distribution to gain an understanding of the potential raiding ability of American and Taiwanese game guilds. The results shown in Table 6 indicate that the number of guilds divided by the total number of avatars was higher for the American server versus the Taiwanese server, indicating that guild activity on the American server is greater than on the

Taiwanese server. However, the number of large guilds (with more than 40 level-60 avatars) was similar between the two servers, meaning that the potential raiding abilities of the two groups were also similar. Although the numbers of Taiwanese guilds and avatars was much smaller than those on the American server, the Taiwanese server had a larger percentage of large guilds, indicating greater raiding ability (Figure 21). As shown in the right-most column of Table 6, our results are in agreement with those reported by Williams et al. [40].

Table 6. Comparison of guild-related characteristics for the Taiwanese and American *WoW* servers.

	US	TW	Previous Research[17]
Number of guilds	1,302	157	909 (2,728/3)
Percentage of single-avatar guilds	16%	22%	18%
Maximum avatar number in a guild	368	472	257
Average number of avatars (single avatar guilds deleted)	20.7	46.2	16.8
Median (single avatar guilds deleted)	9	5	9
Number of large guilds (level-60 avatars>40)	27	21	-
Percentage of large guilds (level-60 avatars>40)	2%	14%	-

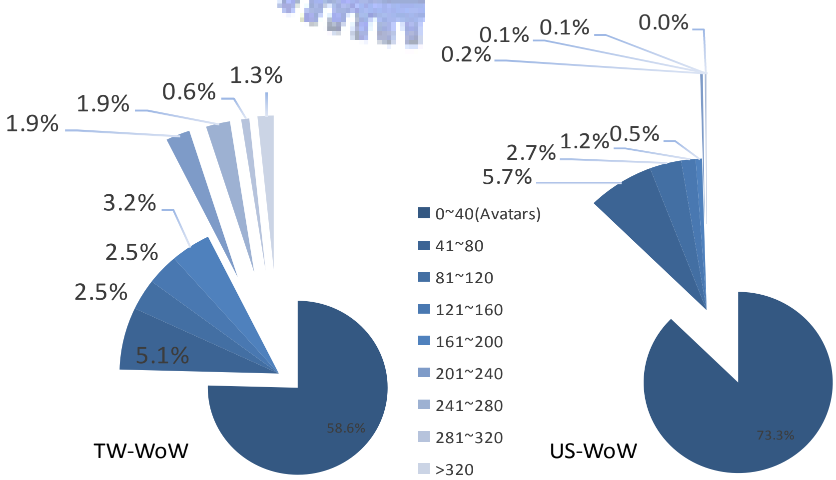

Figure 21. Size distributions of the Taiwanese and American guilds used in the study.

4.4.3. Level Upgrading Efficiency

To measure level upgrading efficiency I collected data on individual avatar levels once every 30 minutes for three weeks; the appearance of an avatar was interpreted as meaning that it participated in the game during the following 30 minutes. At lower levels it is possible to use a simple calculation of upgraded levels divided by online time. However, *WoW* makes it more difficult for players to reach each new level, therefore upgrading from level 21 to 30 is much more difficult than upgrading from level 11 to 20. Ducheneaut et al. [17] used a linear function to estimate *WoW* upgrading time. I adopted this approach to express level upgrading efficiency for each avatar as

$$\text{Level\_Upgrading\_Efficiency} = \text{Estimated (lower, upper)}_{(sec)} / \text{Actual (lower, upper)}_{(sec)}$$

Accordingly, the higher the upgrading efficiency level, the less the amount of time spent on upgrading an avatar.

Average avatar level upgrading efficiency values for players on the Taiwanese and American servers are shown in Table 7. The 1.62 value for Taiwanese players means that they upgraded their avatars 1.62 times faster than the original estimated upgrading speed [17]. In comparison, the upgrading efficiency level for American players was 0.93—a significant difference. In terms of average daily playing time, I found that the average for Taiwanese players was only 1.13 times that of the American players. In other words, both Taiwanese and American players spend approximately the same amount of time playing (and have similar time distributions), but the average Taiwanese player upgrades his or her level faster than the average American player. This suggests that Taiwanese players tend to pursue level upgrades more vigorously than American players.

Table 7. Data on level upgrading efficiency and playing time per day for players on the Taiwanese and American *WoW* servers used in the study.

Server	Average level upgrading efficiency	Average playing time per day (minutes)
American	0.93	90.46
Taiwanese	1.62	102.19

Figure 22 contains data on upgrading efficiency distribution for Taiwanese and American players; since levels 1-10 are set aside for newbies, only avatars with levels higher than 10 were taken into account. The data indicate (a) a larger divergence in Taiwanese level upgrading efficiency compared to that for American players and (b) most American players' upgrade efficiencies were at slow speeds. Among players on the Taiwanese server, 9% upgraded their avatars at speeds more than twice the average, but the same was only true for 3% of the players on the American server. Results from comparisons of average rate and distribution of level upgrade efficiency provide further evidence that the players on the Taiwanese server place more importance on level upgrades than players on the American server. The faster speed explains the Taiwanese tendency to reach level 60 in a shorter time period as well as their greater participation in high-end game content. This has several implications in terms of time spent playing, the purchase of pre-paid player cards, and the ability of high-level players to help newbie, organize raiding guilds, or show off their skills to other players. This information cannot be viewed as evidence supporting the idea that Taiwanese players are more likely to participate in level and experience farming, but it does support the contention that Taiwanese players are more motivated by achievement compared to American players.

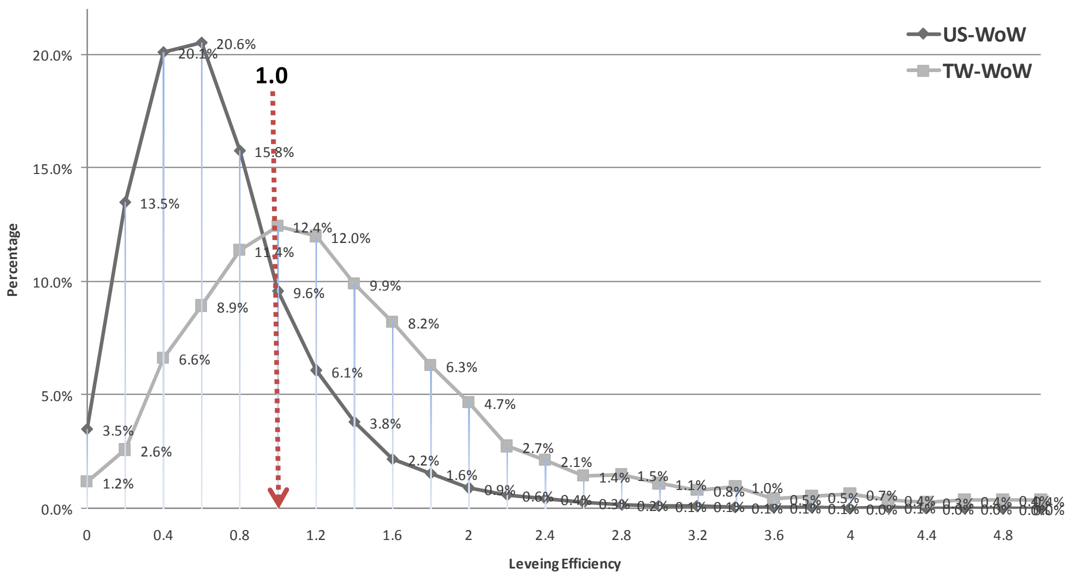

Figure 22. Distribution of level upgrading efficiency for players on both servers. Only avatars with levels 11 or higher were considered.

4.4.4. Faithful Participation in Guild Missions

To investigate the circumstances of executing periodic raid missions, I collected data on

157 guilds on the Taiwanese server and 1,302 guilds on the American server (Table 6). As stated above, although the number of guilds on the American server was larger, the proportion of large guilds was greater on the Taiwanese server (14% versus 2%). I also collected data on each guild's raiding activity during the three weeks; guild raiding time distributions are shown in Figure 23. They indicate that 12.3% of Taiwanese guilds perform raids at least one day per week compared to 1.01% of American guilds. Guilds with more than 20 members participating in a current mission were regarded as major guilds. Raid missions with no major guild participation were not taken into account in our research. I calculated the average number of days per week that guilds conducted raid missions. Twelve guilds on the Taiwanese server participated in raiding activity at least two days per week; three guilds participated in raids five days per week. Since full raids require participation by 40 avatars, I assumed that 480 avatars took part in the 12 raid missions, accounting for 5.7% of all 8,394 Taiwanese player avatars. These results indicate that the Taiwanese guilds were much more active than the American guilds in terms of executing raid missions.

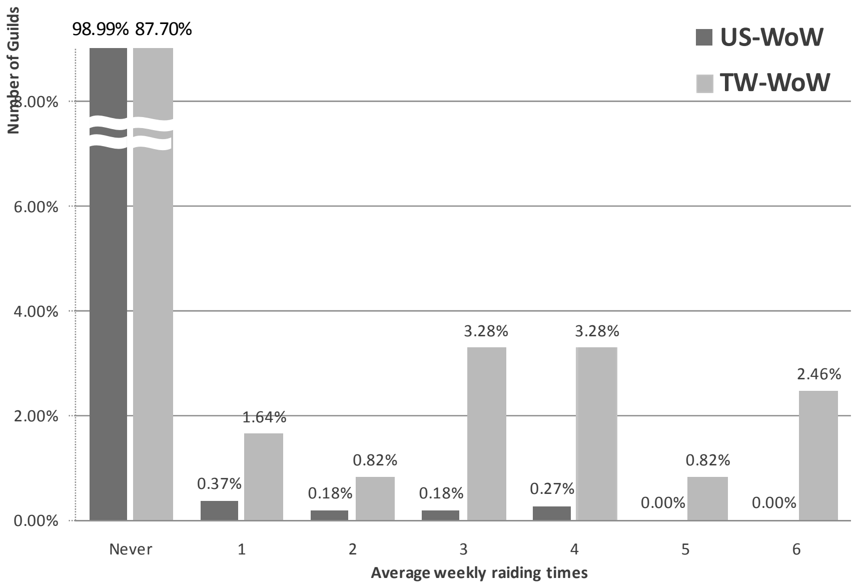

Figure 23. Average weekly raiding time distribution for guilds on both *WoW* servers (single avatar guilds deleted).

I limited our analysis to missions requiring the participation of a major guild and assumed that repeated raiding activity was a sign of achievement behavior. *WoW* features three major raid types, each consisting of several smaller missions with various levels of difficulty. Guilds that regularly succeed in executing difficult raid missions earn good reputations in gaming communities, with the official *WoW* website occasionally compiling lists of the top 10 guilds in terms of raiding status. However, some guilds find it difficult to attract 40 members to participate in raids, and therefore are forced to rely on assistance from non-member avatars. Although guilds offer gold or less valuable equipment in return for non-member participation, non-member avatars are usually not allowed to earn a full share of a successful raid's rewards. Accordingly, these non-member players can be viewed as participating in raid missions without promises of achievement. Teams with large percentages of independent or temporary members often find it difficult to assign fair rewards, even when some of those members play for reasons of exploration instead of achievement. I therefore treated raids executed by casual teams as examples of non-achievement raiding.

Results from our comparison of guild raiding behavior between avatars on the Taiwanese and American servers indicate that (a) in terms of guild size distribution, the Taiwanese server had a higher proportion of large guilds; (b) guild attitudes toward raid missions differ, as indicated by the number of missions executed by leading guilds versus the number executed without leading guilds; and (c) Taiwanese guilds put more effort into the periodic execution of raid missions. These achievement-oriented guilds cultivate and recruit players based on their willingness to pursue guild achievements, leading us to suggest that Taiwanese *WoW* players have stronger achievement tendencies than American *WoW* players.

5. PC GAME EXPERIENCE: EVALUATING PLAYER EXPERIENCE IN *STARCRAFT* BY REPLAY ANALYSIS

5.1. *Introduction*

Closed or otherwise tightly controlled online game environments pose challenges to researchers and game companies interested in observing player activities and understanding player feelings. Mining log from MMOG is not the only way to obtain in-game player activities and information. MMOG is also not the only genre or platform that allows its player or researcher obtaining in-game data. Several game companies are now providing means for storing and accessing game logs and for collecting data on individual avatars. Another example of using demographic approach to investigate in-game player activities is analyzing replay of Real-Time Strategy(RTS) games to evaluate design of both hardware and software user interface such as mouse, keyboard, and hotkey combinations, or to learn player strategies composed by hotkey control and buildings construction. Game AI entails the use of artificial intelligence technology to create computer-controlled avatars that can be trained to behave like human-controlled avatars. The biggest challenge for researchers and game providers interested in game AI is the ability to design non-player character (NPC) behaviors that give real players a feeling that they are interacting with other real players. Typical NPCs in online- or console role-playing games (RPGs or MMOGs) are monsters, country lords, hotel owners, or village residents. In RTS games the list also includes soldiers or heroes. A new and important development in game AI is the emergence of computer-controlled characters capable of engaging in combat, controlling the use of limited resources, creating army units and buildings, and mining gold and energy. The programs that allow for combat with human players require an enormous amount of design effort in terms of strategies and interaction options.

Computer game developers are constantly looking for ways to use artificial intelligence

(AI) in such areas as non-player character (NPC) navigation, NPC coordination, NPC planning and learning, player modeling, resource management, and path finding and steering [41-43]. In computer games, AI would be used to both control individual characters and single computer opponents and to provide strategic direction for a "computer-controlled" player (e.g., simulated military forces or cities controlled by computer) [42]. Computer-controlled opponent is a background program which is capable of automatically engaging in combat, controlling the use of limited resources, creating army units and buildings, and mining gold and energy. But the programs that make combat with human players possible require an enormous design effort in terms of strategies and interaction options. Considering that the main goal of game AI is not to build agents that express optimal behaviors but to provide a sense of fun [42], the biggest challenge for researchers and game producers interested in game AI is designing NPC behaviors that give real players the feeling that they are interacting with other real players. At the same time, designers would like to create highly skilled computer-controlled players that provide challenging opportunities for game practice. Instead of building a large of amount of decision rules, designing adaptive computer-controlled opponent capable of learning by imitating human player is possible to shorten development cycle and increase variety and fun of game.

Research on game AI character strategy and decision making emerged from the design of AI opponents in two-player games such as *checkers* and *Othello* [44-46]. *Othello* in particular proved that computer-controlled opponents could be designed to not only compete with but also regularly defeat human players. However, in these games players take turns making moves, while today's designers are interested in creating teams of agents to engage in combat in continuous, non-turn simulated environments [47, 48]. *RoboCup Soccer* (http://www.robocup.org/02.html), a real-time soccer game played by two teams of agents, is a popular environment for practicing an AI concept known as Case-Based Reasoning (CBR)—solving problem by learning expertise embodied in past cases, rather than encoding classical AI rules [47].

Taking into consideration the complex environments of commercial games, Ponsen and Spronck [49] developed a lattice for representing and connecting abstract states for *Wargus*, a moderately complex RTS game that mimics the popular commercial game *WarCraft II*. Other researchers have used it to manage a real-time city and to prevent repetitive failures in *SimCity* [50], and to develop a computer-controlled opponent in a shooting game named *Quake II* [51]. Buro suggests that RTS games provide a good environment for testing ideas for many of these aspects, especially real-time planning, decision making under uncertainty, opponent modeling and cooperation, resource management, and path finding [41]. Research on AI in RTS games is receiving broad support from defense agencies interested in strategy development as well as commercial game developers for creating vivid online scenarios [47].

In RTS games, players control their own units and engage in real time combat. Game play consists of rapid multiple-unit actions requiring resource collection and control, base building, technology development, and military unit control [52]. RTS user interfaces generally consist of a combination of computer keyboards and mouse pointing devices. Since familiarity with game controls and combat strategies is critical to winning, “pro-gamers” frequently practice 10 hours per day to develop and hone high-level tactics and tricks, both of which are attracting research attention. Pro-gamers are known to collect data on and directly observe other players in competition for the purpose of learning and developing effective strategies to defeat their opponents.

Two of the biggest challenges to researching AI and human player strategies and behaviors in RTS games include unique game world features and game environments that are tightly controlled by game companies [41, 47, 53]. Nevertheless, several attempts have been made to motivate AI research in this area. The *Open-Real-Time-Strategy* (ORTS) project is proposing the establishment of a programming environment for conducting real-time experiments and the construction of an AI system that outperforms human players [41]. Key elements of RTS games that ORTS researchers are defining and controlling include terrain design, real-time interaction, unit action and movement, and team command. A second project, *Testbed for Integrating and Evaluating Learning Techniques* (TIELT), is a free middleware tool that integrates AI decision systems and a simulator [53]. Aha et al. have used it to create an

AI case-based plan selection system in *Wargus* [47]. *Wargus* allows users to play *WarCraft II* using a Stratagus engine that enables them to modify numerous in-game parameters depending on a researcher's needs.

I have decided to use a different research strategy: collecting thousands of game replays from the *GosuGamers* game community (http://sc.gosugamers.net/replays.php) and using the game logs to evaluate player behaviors, analyze player strategies, and train an AI system to learn player strategies. Most of our game replays have been collected from highly skilled pro-gamers participating in open competitions. Our long-term goal is to design a computer-controlled opponent that can learn player strategies and styles and employ them in game combat with human players.

5.2. *Replay Analysis*

The method of collecting in-game demographic data has been recognized as an efficient scientific approach to investigate virtual world [54]. Some game companies allow their players being capable of collecting the in-game data. For example, the replays of *StarCraft* and *WarCraft* can be saved for further review and analysis as well as the designer of *World of Warcraft* allows its players gathering demographic data on player's avatar in whole game server [27]. Some researchers cooperate with game company to obtain logs of game server or networking data for exploring the player behavior and game ecology [55]. Other researchers locate their avatar at several hot locations to obtain the player's chatting history or demographic data [56].

I used replays of *StarCraft* games to analyze player strategies in terms of building construction order and unit creating strategies. *StarCraft*, a RTS game produced by *Blizzard Entertainment*, was released for use with the Windows operating system in 1998. In its first year, StarCraft became the most popular game in South Korea, and is credited with starting a successful pro-gaming scene in that country. Pro-gamers in South Korea are media celebrities; a professional gamer can earn up to $100,000 US per year through contests. Gaming competitions, which are broadcast live and rebroadcast over three television channels dedicated to professional gaming, attract audiences of one million viewers every night [57]. *StarCraft II* is scheduled for release in late 2008.

StarCraft replays contain sequential logs of player actions. The main advantage of using action logs instead of video to review combat history is that action logs are much smaller and therefore easier to share for analysis by players. *StarCraft* players can use the *StarCraft* main program to simulate original games by reading log-based replays. A few players have created decoding tools such as *BWchart Replay Analyzer* (http://bwchart.teamliquid.net/) to decode non-text binary files for studying replays. *BWchart* gives users the ability to review statistical information, increases or decreases in actions per minute (APM), building order, hot key usage, and military distribution (broken down into airborne forces, mechanized troops, and infantry units). APM data can be interpreted as reflecting player familiarity with game control, building order as representative of a player's strategies for creating units and engaging in combat, and hot key usage as an indicator of NPC control efficiency. At least two real time strategy (RTS) games—*StarCraft* and *WarCraft III*—allow users to read their own activity logs for the purpose of analyzing their personal playing strategies. The same information offers researchers excellent opportunities to study player actions during all phases of a game.

I used a software program called *LordMartin Replay Browser* to convert binary replay files into text-based files for advanced analysis. A summary example of a replay log is presented as Table 8. The browser shows player IDs, maps, replay dates, and instruction content. Data are made available on at least two forms of player strategies: actions and building order.

Table 8. Selected actions and corresponding descriptions. To preserve anonymity, players are named "Player1" and "Player2"

Actions	**Description**
[E:\Fly[jOin]_KT.MGW)LastMAN.rep	*Map path.*
_KT.MGW)LastMaN	*Map name.*
_2005-04-29 06:08	*Recorded time.*
_Player1,0,T,1,Human,2,200	*Player1 ID and reported species.*
_Player2,1,T,1,Human,2,233	*Player2 ID and reported species.*
15,player1, Train SCV	*Player1 instruction for training a space construction vehicle (SCV) to construct a new building.*
15,player2, Train SCV	*Player2 instruction for training a SCV to construct a new building.*
1750, Player1, Build Barracks	*Player1 instruction for building a barracks.*
2125, Player2, Train Siege Tank	*Player2 instruction for training a siege tank.*
2140,Player1,Select,9,3631,3631,3632	*Player1 mouse selection*
2150, Player2, Research Siege Tank	*Player2 instruction for researching a siege tank.*

5.3. *Learning Player Strategies by Case-based Reasoning*

I adopted Aha et al.'s case-based reasoning (CBR) approach to construct our system for learning and predicting individual player strategies by mining series of actions from replays. CBR has been widely adopted in games such as checkers and *Othello*, team sports such as *RoboCup Soccer* and *Simcity*, and the real-time strategy game *Wargus* [47]. Instead of designing a finite state machine or rules to construct a computer-controlled player, I used CBR to train a system to learn player behaviors via series of actions found in player replay logs. In RTS games, game play actions or decisions that can be analyzed in terms of strategy include base building, unit selection, strategic movements, attacks, and technology development. Constructed buildings, military units, money, and other resources can be studied as game play states. In RTS game play, creating military unit and upgrading technology require constructing specified building in advance. Consequently, building construction is considered especially important for performing the other two actions. Our proposed model treats buildings status as game state as well as the action of constructing building as strategy between two states (referred to as cases in CBR). Figure 24 illustrates a buildings state example of the *Terran* species in *StarCraft* and several possible choices for going to next state. A state possibly consists of a set of buildings including a *Command Center* and a *Supply Depot*, denoted by {1, 1, 0, 0, …, 0}. One may consider to construct next building. According to limited building order, if player has enough "minerals" or "gas", players can choose next building among

Command Center, *Supply Depot*, *Barracks*, *Engineering Bay*, or *Refinery*. Player will choose a building according previous personal experience and current military development including the number of military units and technology upgrading. To sum up, player has several choices of next buildings and must choose according to evaluation of other feature including military units and technology developments.

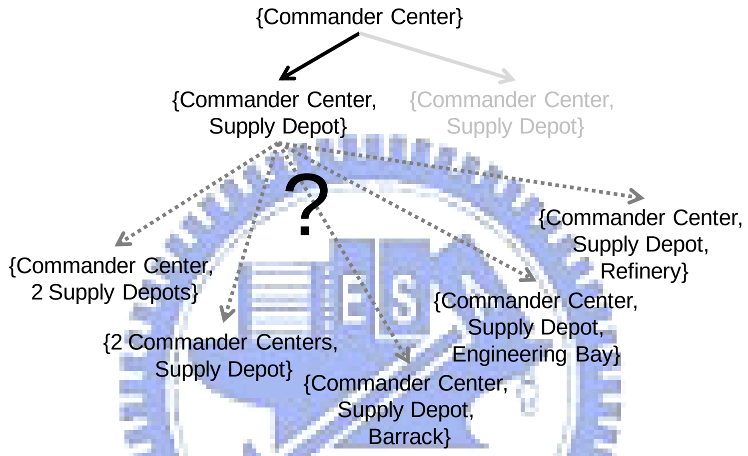

Figure 24. Example of possible building sequence in *StarCraft*.

$$Building\_set_a\{B_1, B_2, \dots, B_n\} \xrightarrow{Strategy_s} Building\_set_b\{B_1, B_2, \dots, B_n\},$$

B_n denotes the number of *n*-th building. Our proposed model adopts six hierarchical features for evaluating a game state: the numbers of buildings, units, and technology research for two players. These six features of building set *a* can be denoted by:

$$\{F_1^a, F_2^a, F_3^a, F_4^a, F_5^a, F_6^a\}$$

F_n denotes the *n*-th hierarchical feature. Each feature contains a suite of values. Using the *Terran* species in *StarCraft* as an example, the "player units" feature includes lists showing the number of space construction vehicles, seaborne vessels, etc. The "player's buildings" feature includes lists of the numbers of “supply depots”, “command centers”, and so on. An example of all six hierarchical features is default features denoted by {{1,1,0,…0}, {5, 0, …, 0}, {0, …, 0}, {1,1,0,…0}, {5, 0, …, 0}, {0, …, 0}}.

I can calculate distance between two cases of one feature using the following equation:

$$Distance(F_i^a, F_i^b) = \sqrt{\sum_{j=1}^{n}(F_{i,j}^a - F_{i,j}^b)^2}$$

with parameter *i* indicating the *i*-th feature, parameter *j* the number of different kinds of features, and parameter *a* and *b* the two cases. Because I adopted six features for evaluating states among different replays, six distances are obtained between two cases. Considering different variations in the number of units, technologies, and buildings, I used a ranking mechanism to normalize the three variables, with shorter distances indicating a higher rank. Next, I can use the ranking feature to obtain a distance equation between two cases. In the following equation, *Rank_Distance* represents the degree of similarity between two cases among different replays. In RTS game play, building construction state can be equivalent between two different replays, but the status of six features between them can be far different. Therefore, *Rank_Distance* is applied for normalizing the score of each strategy among different replays.

$$Rank_{Distance(Current,Past_k)} = \sum_{i=1}^{6} Rank_i(Current, Past_k)$$

with $Rank_i(Current, Past_k)$ denoting the sorted rank of feature i's distance between the k-th past and current case, i denoting the i-th feature, and k the k-th past case.

I collected data on 100-300 rounds (seeing the experiment in next section) of combat for the same player in order to train our decision system. The simple training process only needs to break down each round of combat into a number of cases before storing them. Once a player's action construct a new building, the changed case is recorded and the constructing action analyzed in terms of strategy. The decision system consists of a large pool containing a lot of such recorded cases and corresponding strategies. It is possible to define strategy performance by tracing the results of several rounds, with the strategy performance value increased by one point following a victorious round and decreased by one point following a losing round. Each new inputted round has the potential to change the performance results of identical strategies occurring in the original decision system. This can be expressed as:

$$Performance(Strategy_s, Past_k) = \begin{cases} Win: +1 \\ Unknown\ or\ Draw: Unchanged \\ Lose: -1 \end{cases}$$

Collected rounds for a single player are divided into two groups: a training group that forms the strategy and case pool, and a group for verifying the predictive accuracy of the trained decision making AI system. An example of proposed CBR system is listed in Table 9.

The predicting and verifying process algorithm consists of following steps:

1) Inputting a query round (replay) from the verifying group. Getting the first entry of replay. The default building set is the first inputted query case. Taking Terrain for an example, the default building set will be one *Command Center* and one *Supply Depot* which can be denoted by {1, 1, 0, 0, …, 0}. The default query features will contain five military units. Both opponent's and player's default features will be equivalent which can be denoted by{{1,1,0,…0}, {5, 0, …, 0}, {0, …, 0}, {1,1,0,…0}, {5, 0, …, 0}, {0, …, 0}}.

2) Getting next entry in query round. If the entry contains a building construction command, using this building as corresponding strategy of query case and going to next step 3); if not, the entry must contains a uniting creating or technology developing command, modifying current query features, and getting next entry until getting a building construction command.

3) Using the inputted query case and current query features to query the trained decision making system.

4) Finding equivalent cases between inputted case and cases in the decision system, then obtaining the corresponding strategies for each equivalent case to move to the next

case. If inputted case can not be found in cases pool, it and its corresponding strategy will be added into cases pool.

5) Calculating each strategy's score by summing identical strategies' performance and dividing that value by *Rank_Distance* between current query features and corresponding cases' features, then choosing the best strategy.

$$Score(Strategy_s) = \sum \frac{Performance(Strategy_s, Past_j)}{Rank\_Distance_j(Current, Past_j)}$$

6) Determining if the "best choice" strategy is equal to the corresponding strategy in the query round, then going back to step 2 and repeating the process until the end of the replay.

Table 9. Example of current case and equivalent pass cases. The best choice should be case 1.

		Equivalent case 1	Equivalent case 2	Equivalent case 3
Current query case {1, 2, 1, 1, 0, …, 0} Current query features{{1, 2, 1, 1}, {3, 1}, {1, 1, 0, 0}, {1, 3, 0, 0}, {4, 1}, {1, 1, 0, 0}}	**Features**	{{1, 2, 1, 1}, {5, 0}, {1, 0, 0, 0}, {1, 2, 1, 1}, {4, 1}, {1, 1, 0, 0}}	{{1, 2, 1, 1}, {4, 1}, {1, 1, 0, 0}, {1, 3, 0, 1}, {5, 1}, {1, 1, 0, 0}}	{{1, 2, 1, 1}, {4, 0}, {1, 1, 1, 0}, {1, 3, 1, 0}, {4, 2}, {1, 2, 0, 0}}
	Distance of features	{0, 2.24, 1, 1.73, 0, 0}	{0, 1, 0, 1, 1, 0}	{0, 1.41, 1, 1, 1, 1}
	Rank of features	{0, 3, 2, 2, 1, 1}	{0, 1, 1, 1, 2, 1}	{0, 2, 2, 1, 2, 2}
	Rank of distance	9	6	9
	Performance	3	3	2
	Score	0.33	0.5	0.22

5.3.1. Results – Calculating the percentage of strategies accurately predicted by the trained decision system

Collected data on building construction sequence can be used to analyze and categorize player strategies and playing styles. Those decisions can be visualized as decision trees, with each node representing building status and each link representing a decision to construct a new building. Figure 25 shows a weighted decision tree formed by one *Terran* species player engaging in combat 100 times with a *Zerg* species player. The game begins at the top of the figure; link thickness represents how many times the same strategy was used during the 100 clashes. The data indicate that during the early stages of combat, the player had a strong tendency to use the same strategies again and again; during the middle stages, no single strategy was dominant; during the final stages, the player returned to the habit of repeatedly using the same strategies. This result can explain why only ten to thirty percentages of possible states are observed in real game play. The decision spaces of three *StarCraft* species are shown in Table 10. Each state represents a set of buildings and each strategy represents a player's construction command. Although large differences exist between available states and strategies for each species, the statistical results show that players chose only average three to five strategies at each state. This result indicates that player had strong tendency to use similar strategies.

Table 10. Number of building states and construction strategies for three species. Statistics were obtained before and after100 rounds of training from each species

		Terran	*Zerg*	*Protoss*
Original decision space	Number of possible states (cases)	2,234	901	388
	Number of strategies between states	10,887	3,828	1,354
	Average number of available strategies at each state	4.87 (10887/2234)	4.25 (3828/901)	3.49 (1354/388)
After training 100 rounds of play	Number of observed states	148 6.6%(148/2234)	93 10.3%(93/901)	109 28.1%(109/388)
	Number of strategies between observed states	278	164	177
	Average number of strategies at each observed state	1.87 (278/148)	1.76 (164/93)	1.62 (177/109)

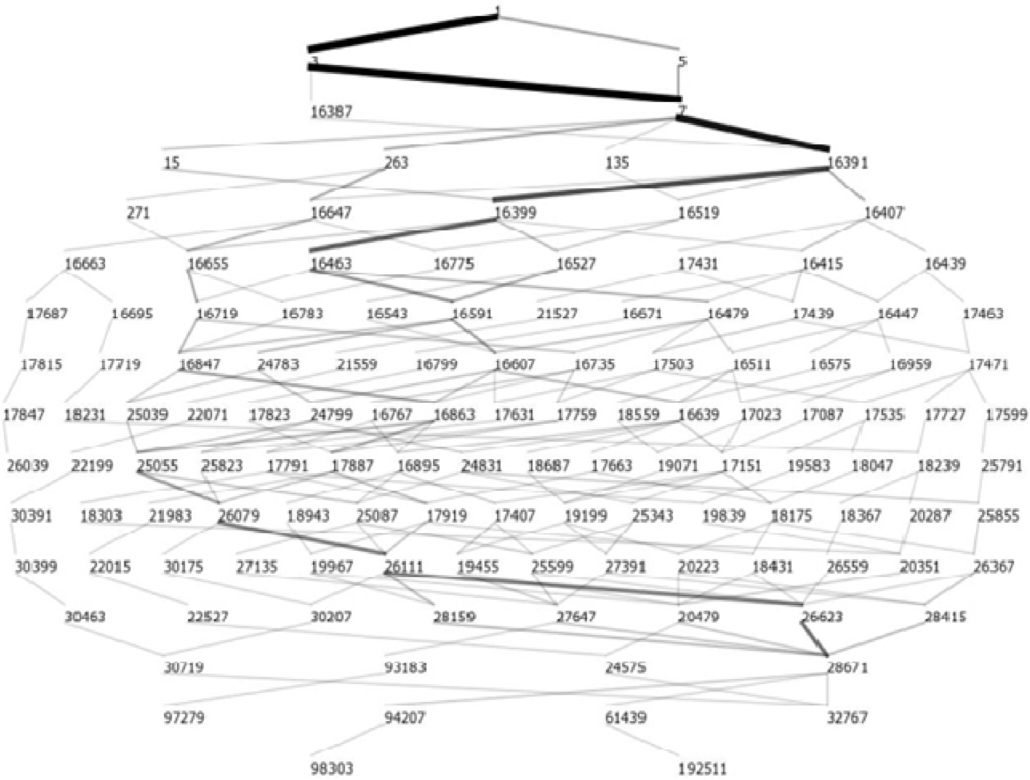

Figure 25. Building sequence representing 100 combat incidents between a "*Terran*" species player and a "*Zerg*" species player. Link thickness indicates number of times the same strategy was used. Node ID number indicates building status.

For each species, I chose one player's replays as an example for training our system and verifying prediction rate accuracy. Each player had 300 replays available for training. Other 30 replays were used to verify the predicting accuracy of the fully trained decision system. Predicting accuracy is expressed as the percentage of strategies accurately predicted by a trained decision system. Table 11 lists the system's predictive accuracy after being trained by 100, 200, and 300 replays. Changes in predicting accuracy for the three players are graphically illustrated in Figure 26. In all three cases, predictive accuracy increased when more rounds were inputted into the decision system; this was especially true for the *Protoss* species player due to its possible states are far fewer than other species'. Figure 26 also shows the large variation in prediction accuracy for the *Zerg* species player.

Table 11. System predictive accuracy. Statistics were obtained after training 100, 200, and 300 rounds of play for each species (Replays of each species belong to only one player).

Spicies		After 100 rounds	After 200 rounds	After 300 rounds
Terran	Observed (States, Strategies)	(148, 278)	(173, 349)	(195, 412)
	Predictive accuracy	56.5%	62.4	65.1
	Maximum Predictive accuracy	68.5%	80.6%	84.9%
Zerg	Observed (States, Strategies)	(93, 164)	(127, 248)	(136, 277)
	Predictive accuracy	62.0%	62.2%	63.4%
	Maximum Predictive accuracy	76.8%	83.4%	86.9%
Protoss	Observed (States, Strategies)	(109, 177)	(135, 235)	(155, 288)
	Predictive accuracy	67.9%	72.6%	72.8%
	Maximum Predictive accuracy	80.8.9%	86.9%	88.6%

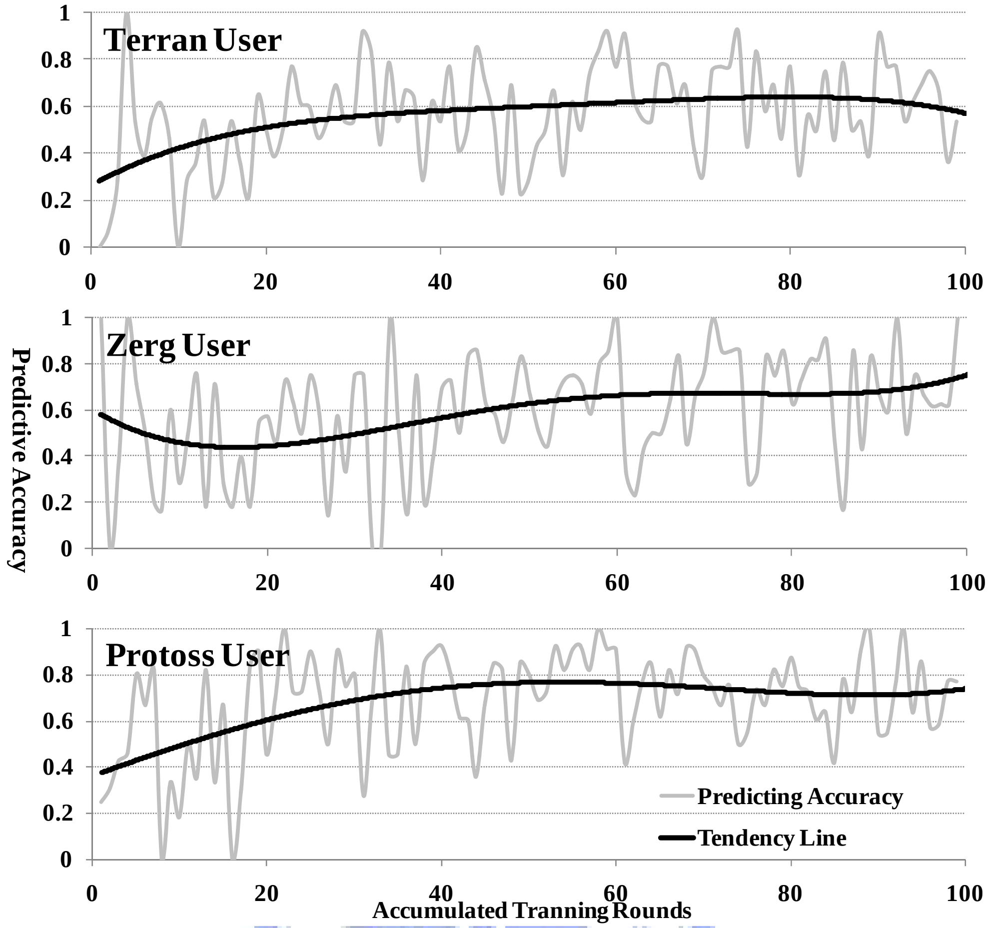

Figure 26. Predictive accuracy of the first 100 rounds for player using *Terran*, *Zerg*, and *Protoss* species. After 20 rounds of training, predictive accuracy was generally higher than 50 percent. Graph indicates large variation in predictive accuracy for player using *Zerg* species due to large variation in player strategies.

6. Conclusion and Discussion

Virtual worlds have reputations as one-way, open cyberspace environments that welcome players but not investigators. The procedure proposed in this dissertation takes advantage of open source UIs to collect data on player behaviors, player community formation and evolution, and player behaviors in different cultures. The four main topics were (a) factors that support game guilds and their dynamics and evolution, (b) testing Taiwanese players' assertions that they emphasize achievement while American players emphasize recreation, (c) analyzing *WoW* content in terms of how players organize themselves to solve complex missions, and (d) analyzing how game design affects game play, player social networks, and community dynamics. Additional discussion focused on how the emerging trend of player-created game content is blurring the boundary between producer and consumer, creator and audience, and designer and player.

New data sources and collection options are creating new research opportunities. In this study I confirmed that the client-designed UI feature of *WoW* can be used to monitor short-term avatar behaviors. In terms of game development and design, the quantitative methods introduced in this paper can help companies study game situations in order to understand how various mechanisms influence player actions. The same methods can support research efforts to better understand guild dynamics, game design, game society development, virtual world characteristics, and player organization. The advantages of the proposed method can be summarized as follows:

1) It can provide quantitative results for reviewing current virtual world player activities. Compared with conventional approaches, it can provide both cross-sectional and longitudinal observations.

2) It supports pre-analysis for surveys or interviews in a manner that helps researchers choose appropriate topics, create samples, and form questions. For example, pre-analyses of guild dynamics and player movement between guilds can help researchers identify common avatar and organizational behaviors.

3) Virtual world results may be used to study individual or organizational dynamics in the physical world. For example, data on the behaviors of players who leave raiding guilds may be used to explain why real-world employees move from one job to another.

There are at least three benefits for players, researchers, and game designers who utilize the data collection tools and analytical methods described in this dissertation:

1. They can support game community formation and maintenance. Shared replays give players opportunities for reviewing, discussing, and learning about their own or others' control skills, strategies, and behaviors. In South Korea, players are forming fan clubs for popular pro-gamers and for competition-related discussions. Replays encourage further analyses among fans and the publication of certain strategies in the same manner that chess players are known to discuss tactics and defenses. Such interactions help maintain a balance in abilities across species or classes by helping players upgrade their skills and improving playing mechanisms.

2. They can assist game company efforts to review player responses. Instead of passively monitoring commercial sales figures for their individual games, companies can analyze replays to make game design decisions, and monitor player actions to determine how users react to changes. For example, level-upgrading mechanisms often draw a great deal of player interest in terms of speed and limitations. Companies can make upgrading more challenging or easier as they see fit.

3. Assist in game AI development. Most NPC interaction rules are directly designed by game developers with little if any consideration of personal playing styles. By mining data on player actions, designers can construct a range of strategies for their NPCs to match specific human playing styles. This will help bring the day when users can practice with their own game AIs or with game AIs based on future opponents' playing styles. This goal requires a mechanism for automatically building interaction rule databases that can be embedded into NPCs.

Newly emerging virtual worlds are currently being compared to and associated with web-based social services. For example, *ActiveWorlds* allows companies and developers to build virtual worlds using the *Facebook* platform and *ActiveX*. *Facebook* provides not only social networking services, but also a framework for software developers to create applications based on its social networking features. Other virtual world designers and users are creating social networking services for player interaction; examples include *Virtual MTV*, *Theres.com*, and *EA Lands*. These tools can be used to collect demographic data on virtual world participants for a variety of purposes, including the provision of additional advanced services. Players can now use Lua to modify their UIs of *WoW* and other MMOGs such as *Warhammer Online* which is scheduled to be launched at the end of 2008 by *EA Mythic*. There are several virtual worlds that continue to operate with no obvious goal other than providing platforms for social interactions. In-game data can be used to design new social-oriented services such as the *Second Life* feature for meeting new friends.

Future researchers may want to explore several topics using the methods described in this paper—for example, correlations between player characteristics and avatar character decisions. This knowledge can be used to determine if game world differences tend to influence player choices or if player choices lead to game world partitions. Other research possibilities are studying the influences of Western and Eastern cultural differences on game worlds and searching for virtual world influences on physical world behaviors.

7. RELATED PUBLICATION LIST

C. T. Sun, J. L. Hsieh, C. H. Chen, and Holin Lin. " Comparing Taiwanese and American *WoW* Player Cultures in Terms of Achievement," In *Proceeding of International Conference of Digital Game Research Association(DiGRA2007)*, Tokyo, Japan, 2007.

C. H. Chen, J. L. Hsieh, and C. T. Sun, “Player Guild Dynamics and Evolution in Massively Multiplayer Online Games.” *Cyberpsychology & Behavior* (SSCI, to appear at Nov. 2008)

J. L. Hsieh, C. H. Wong, and C. T. Sun “Building a Player Strategy Model by Analyzing Replay of Real-Time Strategy Games.” In *Proceeding of IEEE World Congress on Computational Intelligence*, Hong Kong, 2008(IEEE).

J. L. Hsieh, C. H. Wong, and C. T. Sun, "Evaluating Real Time Strategy Game Player Experiences and Playing Styles," in *Proceeding of ACM International Conference Computer-Human Interaction 2008(ACMCHI2008) Workshop Evaluating User Experiences in Games*, Florence, Italy, 2008(ACM SIGCHI).

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