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Virtual Brokerage and Closure: Network Structure and Social Capital in a Massively Multiplayer Online Game

Cuihua Shen[1], Peter Monge[2], and Dmitri Williams[2]

Abstract

This study proposes a structural approach to examining online bridging and bonding social capital in a large virtual world. It tests the effects of individual players' network brokerage and closure on their task performance and trust of other players. Bridging social capital is operationalized as brokerage, the extent to which one is tied to disconnected others, and bonding social capital as closure, the extent to which one is embedded in a densely connected group. Social networks were constructed from behavioral server logs of *EverQuest II*, a Massively Multiplayer Online Game. Results provided strong support for the structural model, demonstrating that players' network brokerage positively predicted their task performance in the game and players embedded in closed networks were more likely to trust each other.

Keywords

social capital, bridging, bonding, brokerage, closure, virtual world, MMO, social networks

In recent years there is increased interest in investigating the social implications of the Internet from communication scholars. Internet and various social media applications such as emails, online forums, Social Network Sites, and Massively Multiplayer Online games (MMOs) have changed our social and work lives in profound ways (Baym, 2010; Wellman & Haythornthwaite, 2002). The immense diffusion of communication technologies is often

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juxtaposed with another important trend, one that is characterized by a marked decline of collective activities and civic engagement in contemporary societies (Fischer, 1982; McPherson, Smith-Lovin, & Brashears, 2006; Norris, 2002; Putnam, 2001; Tönnies, 1974). A critical question thus lies in evaluating the potential of new media technologies in weakening or augmenting social capital, which generally refers to social networks and the resources accumulated within them (Coleman, 1988; Putnam, 2001).

In examining the relationship between Internet and social capital, the qualitative distinction between two types of social capital is especially important. Bridging social capital results from weak ties that bind disparate groups, while bonding social capital results from strong ties that provide emotional and substantive support (Putnam, 2001; Williams, 2006a). This distinction allows for the creation of different types of social capital from various activities in online and offline communities (Norris, 2002; Shen & Williams, 2011; Williams, 2006a). Much of the Internet-focused social capital research tends to operationalize and measure bridging and bonding social capital as the *benefits of individual social relationships* (e.g., Ellison, Steinfield, & Lampe, 2007; Williams, 2006a). In essence, the extent to which a relationship creates bridging or bonding social capital depends on the value produced from the relationship itself. Few studies, however, have focused on the network structure within which the individual relationship is situated.

Drawing from the work of Granovetter (1973), Coleman (1988), and Burt (2005), this study proposes and tests a structural approach of online social capital as a valuable alternative to the popular outcome-based approach. Two distinct types of social capital, bridging and bonding (Putnam, 2001; Williams, 2006a), correspond to two distinct network structures, brokerage and closure (Burt, 2005). Therefore, studying the structural properties of bridging and bonding social capital provides valuable insights about the social consequences generated within networks. This alternative structural approach was tested in player social networks in a large-scale MMO, *EverQuest II*. Results provided strong support for the structural model, demonstrating that players' network brokerage positively predicted their task performance in the game and players embedded in closed networks were more likely to trust each other.

Theory and Hypotheses

What is Social Capital?

Social capital is an inclusive yet ambiguous concept that invokes different meanings in different groups (for overviews, see Adler & Kwon, 2002; Portes, 1998). Burt (2005) defines social capital as "the advantage created by a person's location in a structure of relationships" (p. 5). Coleman (1988) defines social capital as a function of social structure producing advantage: "It is not a single entity but a variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors—whether persons or corporate actors—within the structure" (p. S98). Putnam (2001) defines social capital as "social networks and the norms of reciprocity and trustworthiness that arise from them" (p. 19). Assuming individuals

are self-interested and rational, Burt's definition emphasizes *individual* benefits created by structural locations. By contrast, Coleman and Putnam recognize that social capital is both individual and collective; it not only creates benefits for individuals in the social structure, but also brings positive externalities for the community in the form of trust, norms, generalized reciprocities, and collective actions (Coleman, 1988; Putnam, 2001). Despite their different emphases, these definitions all recognize that social capital constitute both the structure and some value produced by the structure (Putnam, 2001; Resnick, 2001; Williams, 2006a). Empirical research has linked social capital with various positive outcomes for individuals and communities, including career success, civic engagement, lower crime rates, and better public health (Burt, 1992; Coleman, 1988; Kim, Subramanian, & Kawachi, 2006; Putnam, 2001).

Social capital has provided an important and productive theoretical frame for research on the societal impact of digital media (Kobayashi, 2010; Quan-Haase & Wellman, 2004; Williams, 2006a). Internet use has been associated with the decrease as well as increase of social capital. Early research on Internet effects found that the vast diffusion of the Internet is leading to social isolation and a continuing disintegration of communities and societies (e.g., Kraut et al., 1998). Because of the "inelasticity of time," time spent online unavoidably encroaches on face-to-face time with family and friends, thus weakening one's social capital (Nie & Erbring, 2002). Others argue that Internet and various social media applications provide additional avenues for social interaction, with unprecedented functionalities to help maintain existing social relations and build new ones (e.g., Ellison et al., 2007; Wellman & Haythornthwaite, 2002). Recently, researchers have started to recognize the significant nuances of the characteristics of digital media as well as the purposes, behaviors, and existing psychosocial conditions of individual users (Hargittai & Hinnant, 2008; Shen & Williams, 2011). In particular, it is important to consider not only the changing *amount* of social capital, but also the different *types* of social capital as a result of Internet use (Norris, 2002; Williams, 2006a). Two types of social capital have been identified: bridging and bonding (Coleman, 1988; Putnam, 2001).

Bridging and Bonding, Brokerage and Closure

According to Putnam (2001), bridging social capital is inclusive. It is often linked to loose and ephemeral connections, which Granovetter (1973) called "weak ties." Bridging social capital may provide heterogeneity in opinions and resources, information diffusion and a broad worldview. By contrast, bonding social capital is exclusive. It is often linked to emotionally close and long-lasting relationships, which Granovetter (1973) called "strong ties." Bonding social capital undergirds reciprocity and solidarity, builds trust within homogeneous groups and provides substantive and emotional support. These two types of social capital may have distinct influences on a variety of outcome variables. For example, bridging ties are found to be a more substantive predictor of democratic engagement than bonding ties (Hampton, 2011), while both community bridging and bonding social capital contributed protective effects on public health (Kim et al., 2006).

The conceptual complexity that social capital constitutes both the social structure and the outcome produced within the structure has contributed to the difficulty in searching for an operationalization. Bridging (or bonding) is sometimes operationally defined as social ties linking individuals with the same (or dissimilar) socioeconomic attributes, such as ethnicity, gender, education, and occupation (Beaudoin, 2011; Kim et al., 2006). In online contexts where socioeconomic information may not be necessarily available, many studies have opted for an outcome-based approach, including the development of the Internet Social Capital Scales (ISCS; Williams, 2006a). Such an approach attempts to operationalize bridging and bonding social capital according to their expected outcomes, such as broad worldviews and information diffusion (bridging) as well as emotional support and access to limited resources (bonding; Ellison et al., 2007; Williams, 2006a). ISCS and similar scales have since been widely adopted by researchers of Internet effects and greatly facilitated empirical studies in this area (e.g., Burke, Kraut, & Marlow, 2011; Choi, Kim, Sung, & Sohn, 2011; Ellison et al., 2007; Steinfield, Ellison, & Lampe, 2008).

As Williams (2006a) noted, the ISCS and most existing research have made a deliberate choice to operationalize social capital as the effects of the social structure, instead of the structure producing these effects. Such an outcome-based approach, however, "simply suggests that the networks are the causal agents or moderators of the social capital measured by the [ISCS] scales" (Williams, 2006a, para.6). Taking a structural approach, the current study attempts to logically separate the formation of social capital from its expected effects (Portes, 1998) and examine networks as "causal agents or moderators" (Williams, 2006a, para.6) of social capital in online settings. This structural approach is a valuable complement to the outcome-based approach, because it allows for a better understanding of the mechanisms associated with observed social consequences brought by Internet use (Williams, 2006a), and because the emphasis on social capital formation processes may generate insights for the design of social worlds online.

The structural approach to operationalizing bridging and bonding social capital can be traced back to Granovetter's (1973) study of job seekers, in which he found that weak ties with acquaintances provide a broader set of information and opportunities than strong ties with family and friends. In his study, tie strength represents a proxy measure of the proportion of shared contacts. For any two arbitrarily selected individuals A and B, S is the set of any persons with ties to either or both of them. As Granovetter argued, ". . . the stronger the tie between A and B, the larger the proportion of individuals in S to whom they will both be tied, that is, connected by a weak or strong tie" (p. 1362). In other words, weak ties are the people with whom one has few common contacts, but strong ties are the people with whom one shares many friends. Different degrees of network overlap would lead to differing social outcomes. Burt (1992, 2005) further explicated the theoretical model of brokerage and closure with the concept of structural holes, which represent the lack of connection between any pair of individuals in the network.

Brokerage refers to social structures where people build connections across structural holes (Burt, 2005). That is, brokerage occurs when the broker links otherwise unconnected others. For example, as shown in Figure 1, a network broker C independently connects to individuals A and B, but there is no direct link between A and B. Therefore, as a broker, C

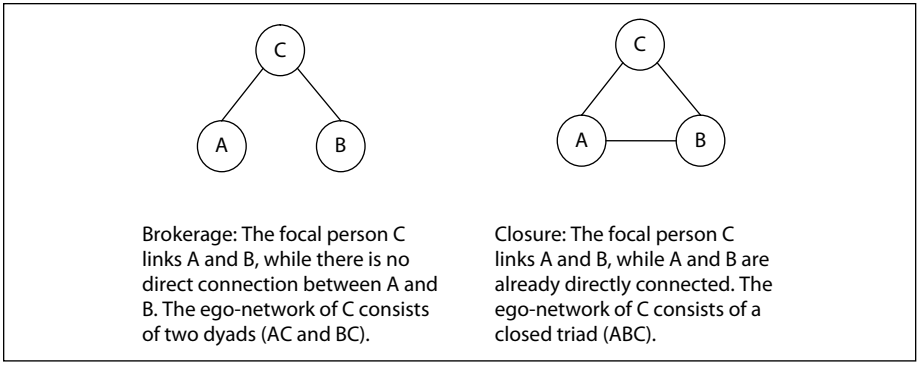

Figure 1. A simple structural illustration of brokerage and closure.

becomes an *indirect* connection between A and B. Compared with already connected people, unconnected people are more likely to have different ideas and resources. The more disconnected the contacts in a focal person's network, the more the focal person is exposed to diverse opinions and practices. This structural position contributes to C's superior performance (in Granovetter's study, more job opportunities), as A and B are likely to supply heterogeneous rather than redundant information and resources.

Closure, on the other hand, refers to the social structure where the focal person stays on their side of the structural hole. In other words, closure occurs when the focal person links to already connected individuals. As connected people tend to share similar views and resources, closure shields the focal person from variations in opinion and behavior. Using the same example, the focal person C links to A and B, while A and B are already directly connected (Figure 1). C is likely to get redundant information from A and B, which would not provide C with much advantage in a job search. But with everyone connected to everyone else, such a closed network could reinforce existing knowledge and opinions. Also, since bad behaviors would be easily caught by the group, people are unlikely to perform them, thus breeding trust and group cohesion within.

In sum, brokerage and closure represent two distinct network structures that are linked with bridging and bonding social capital, respectively. As Putnam (2001) puts it, brokerage is good for "getting ahead" while closure is useful for "getting by" (p. 23). Numerous studies have confirmed the connection between brokerage and achievement. Within organizations, individuals' mobility is enhanced by having an informational network rich in structural holes (Podolny & Baron, 1997). In less hierarchical organizations such as TV project teams, spanning more structural holes was found to induce better performance in teams producing more popular TV programs (Zaheer & Soda, 2009). On a population level, a recent study using national mobile communication data in United Kingdom revealed that diversity in individual relationships contributes strongly to the socioeconomic well-being of communities (Eagle, Macy, & Claxton, 2010). Studies also confirm the impact of closure in creating trust and community solidarity. Coleman (1988) found

that high-school adolescents are less likely to drop out of school if they live within closed networks of adults because people in these neighborhoods tend to watch out for each other and share the responsibility of supervising children. Burt (2005) tested closure effects in two populations: Senior managers in a computer manufacturing company and staff officers in financial services. In both populations, people who shared common third party ties were more likely to trust each other.

The structural view of social capital has rarely been examined in online worlds. Among the few network-based studies, Ganley and Lampe (2009) studied brokerage and closure as generative mechanisms for online social capital in a large online community, *Slashdot*. They found that users' reputation in the community, as measured by a system ranking called "Karma," was positively associated with network closure. Burt (2011) studied brokerage and closure in a large virtual world, *Second Life*. Results confirmed the predicted effects of both structures, as brokers who spanned more structural holes in their networks tended to found more groups and found more groups that remained active, while people who were embedded in closed networks tended to trust each other more.

Brokerage and Closure in EverQuest II

Based on the above review, it is reasonable to expect that brokerage and closure would also produce similar effects in MMO communities such as *EverQuest II* (*EQII*). *EQII* launched in November of 2004 as a sequel to *EverQuest*, an early online game that many considered to have defined the genre of MMOs as we know it (Bartle, 2003; Lastowka, 2009). The *EverQuest* franchise presents game rules and goals that are nearly identical to *World of Warcraft*, one of the most popular MMOs. An industry report showed that there were 46 million American MMO players who spent a total of 3.8 billion dollars on MMOs in 2009 (Caoili, 2010).

EQII has several features that encourage social interaction. A division of labor among the character choices (called "classes") provides the basic mechanism to incentivize collaborative play. During a play session, individuals are able to join groups to combat monsters and accomplish quests together. As character classes have distinct abilities that complement each other, it is much more efficient to play in a group consisting of diverse character classes than to do it alone or in less well-balanced groups. A unique mechanism of group collaboration is mentoring, which allows experienced characters to play with less-experienced characters to help them gain points and quickly progress to higher character levels. In mentoring events, mentors lower their original character level temporarily to match the levels of their apprentices. Mentors pay for this by earning a discounted number of experience points from play and apprentices gain a 10% experience bonus. Mentoring is thus a form of help that is especially useful when two players with disparate levels want to play together.

A more permanent form of collaborative play is organized in "guilds," which use a hierarchical leadership structure to coordinate in-game actions and accomplish joint tasks (Ducheneaut, Yee, Nickell, & Moore, 2007; Taylor, 2006; Williams et al., 2006b). Guilds can range in size from several players to several hundred. Like other MMOs on the market,

EQII provides built-in functionalities to assist guild formation and management, such as guild rosters and guild banks. As such, guilds provide a stable social backdrop within which players may have repeated interactions and develop meaningful social relationships (Williams et al., 2006b).

In addition to collaborative play, social interactions in *EQII* also take the forms of player-to-player trade, house-visiting, and in-game chat. Players can gather and produce in-game items and trade for other desirable in-game items or in-game currency. They can choose to buy or sell items through computer-controlled brokers, and such transactions do not involve direct contact with another player. Alternatively, they can also trade directly with another player if the two avatars meet "face-to-face" at a specific location in the game world to finish the transaction, which represents a genuine type of player-to-player interaction. *EQII* also allows players to purchase virtual houses using in-game currency, decorate their houses with furniture, and store and display items and amenities (e.g., a crafting station) in the house. As the number of items a player can carry on-the-go is very limited, an in-game house provides much needed space to store weapons, potions and other valuable objects. House owners can grant access privileges to others players (called "trustees"), so that the trustees can enter the house, interact with, and even remove house owner's belongings. Thus, granting another player housing rights in *EQII* is analogous to entrusting a friend with the key to one's house in the offline world. Lastly, players can also send messages to each other through the in-game chat system, which is similar to the instant messaging function available in many non-game virtual environments.

In *EQII*, network brokers who span structural holes, that is, those who connect otherwise unconnected characters, are likely to be exposed to diverse information and resources. To put this idea in context, brokering happens in *EQII* when people engage in social interaction with other players, especially when they reach out to meet new people outside of their own cliques. Structurally, in a three-person network, the focal person C plays with A as well as B. But A and B are not directly connected in the game (see Figure 1). In other words, a broker's ego-network consists of dyads but few closed triads. As mentioned earlier, by design, the game mechanics of *EQII* encourage collaborative play among characters with different specialties. As players "level up," they are increasingly confronted with challenging monsters and quests that can only be tackled successfully if they amass a variety of resources (e.g., epic weapons and armors), build a repertoire of knowledge and skills (e.g., the ability to resurrect team members immediately after death), and devise sophisticated strategies for collaborative combat, all through communication via active networks with players of different classes and specialties. The details and arcana of an MMO are immense—so much so that almost no one player can master them all. This incentivizes players yet further to connect and engage in information exchange. Unsurprisingly then, Steinkuehler (2004) argues that MMOs are essentially "communities of practice" (Wenger, 1998) where learning occurs socially. Gaming is not mastered through explicit instruction of codified knowledge (although reading manuals can be helpful, especially for novices) but rather through various social interactions with more experienced or knowledgeable others. As such, through their diffuse connections, brokers

are exposed to nonredundant knowledge, skills, resources, and strategies, all contributing to more successes in combat, group challenges and questing than their peers who are less connected and who only interact with a couple of regular playmates. Brokers are able to get things done and get them done faster. Observing the behavioral patterns of some of the best players on *EverQuest*, known as "the power gamers," Taylor (2006) noted: "The reliance on, and involvement with, social networks and resources—Web information and bulletin boards, guilds, and off- and online friendship networks—indeed reveals power gamers to be some of the most socialized players in MMOs" (p. 81). Therefore, the following hypothesis is proposed:

Hypothesis$_1$ (H_1): The degree of brokerage in players' social networks will be positively associated with their task performance.

While brokering structural holes helps provide diverse information and resources, network closure creates homogenous groups and enhances solidarity and mutual trust. Closure happens when *EQII* players interact only with a small but dense network of playmates. In their ego-networks, individuals are surrounded by tightly connected and redundant ties. As shown in Figure 1, the focal person C plays with A as well as B, while A and B are already directly connected in the game. In other words, a person's ego-network is closed if it consists of triads (i.e., the contacts are themselves directly connected). In a closed network, people tend to do things together and do so repeatedly. They develop shared knowledge, routines, and strategies for game play, and in so doing create a common identity and sense of belonging. As everyone knows everyone else, a reputation system is naturally in place, promoting in-group trust and preventing deviant behaviors from occurring. Small "family" groups or guilds are typical examples of closed networks. Some of those in-world interactions are extensions of substantive relationships in the offline world (Nardi & Harris, 2006; Skoric, Tang, Liao, & Poor, 2010). People are content and comfortable staying within their own cliques. Boundary-spanning behaviors are infrequent—people do not normally venture outside of the group to interact with strangers. Therefore, the groups or networks they belong to demarcate the boundary of their play experiences. The ties that bind a closed group can be qualitatively different from the ties that broker structural holes in *EQII*. As Taylor (2006) observed in the world of *EverQuest*, in small family guilds, "collective actions arise not from an instrumental orientation. . .but from mutual values of one another" (p. 48).

Therefore, it is reasonable to expect that the degree of closure in players' ego-networks would positively predict their trust of other players, an important element of bonding social capital. Compared to the people with whom one plays on an ad hoc basis, a closed network represents a stable social group within which one could have repeated interactions and develop meaningful social relationships. For any pair of players, they are more likely to trust each other if their connection is embedded in a closed network (i.e., they are also connected indirectly through mutual friends). The degree of redundant ties engulfing one's connection with another player should be positively associated with the level of trust. Therefore, the following hypothesis is proposed:

Hypothesis$_2$ (H_2): The degree of closure in the network embedding two players will be positively associated with the level of trust between them.

Past research in offline contexts has indicated that brokerage and closure effects can be contingent upon demographic variables such as age and gender (Burt, 2005). In addition, as MMO research suggests, character classes define different play experiences, so it is possible that individuals' class choice may influence their performance in the game (Ducheneaut, Yee, Nickell, & Moore, 2006; Huang, Shen, Williams, & Contractor, 2009). By design, *EQII* and similar MMOs explicitly reward collaboration among individuals of different character classes, therefore the diversity of character classes among one's playmates is likely to contribute to superior task performance. Players are also likely to perform better as they spend more time in the game. As guilds are recognized as the virtual "third places" that play a pivotal role in the creation and maintenance of social capital (Williams et al., 2006b), guild membership may also influence the effects of brokerage and closure. Therefore, the above variables were included in the analysis to control for extraneous variance.

Method

Data

Sony Online Entertainment, the company that owns *EQII,* provided the research team with unobtrusively collected server logs of game play from January to September 2006. These behavioral data contain information on player demographics and in-game attributes, and were also used to construct player social networks. *EQII* uses an elaborate log system that collects time-stamped data on almost all individual and collective activities occurring within the game, such as economic transactions, questing, messaging, combating, and crafting, as well as static attributes of players such as their character class. Just like other MMOs, *EQII* operates on numerous servers, which are parallel versions of a persistent virtual world. *EQII* Servers can be categorized into four types based on their game rules and features: Player-versus-Environment, Player-versus-Player, Role-Playing and Exchange. The data selected for this study focused on the server Guk because it represents the most common server type of *EQII* and similar MMOs—Player-versus-Environment, where players compete against computer-controlled nonplayer characters (Ducheneaut et al., 2006).

Three player networks were constructed for analysis: trade, mentoring, and housing. A trade network was constructed based on player-to-player transactions, where both avatars have to travel to a specific location in the game world to meet "face-to-face" to finish the transaction. Trade relations were considered to exist as undirected ties between two players if they completed one or more transactions. The strength of trade relations were calculated by the number of transactions between two players. For the mentoring network, if one character A mentored another character B, a directed tie was constructed from A to B. The strength of the mentoring relationship was calculated by

aggregating the number of mentoring events between two players. A housing network was constructed as a directed network, so that a tie from A to B indicates that character A gave character B the rights to use A's house. Some players used houses exclusively to transfer items among their own multiple characters in *EQII*. Because such practices involve no interpersonal interaction, these ties were removed from the housing network.

Network Measures

Network size (Degree). Network size was measured by counting the number of unique alters in an ego-network. This measure is essentially the same as degree centrality, or the degree of an ego-network (Freeman, 1979; Wasserman & Faust, 1994).

Brokerage. Following the procedure in Burt (1992, pp. 51-54), brokerage was measured as the effective size, or the count of bridge relations, of a focal person's network. Ego i's relationship with person j is considered a bridge if j has no connection with any of ego's other contacts. Therefore, in an ego-network, the minimum effective size is zero (all of ego's contacts are connected among themselves) and the maximum effective size is the total number of contacts (none of the contacts are connected to each other, thus every tie is a bridge). Effective size was calculated by summing the nonredundant portion (the extent to which a tie is a bridge) across all the j contacts in the ego's network, using the following formula:

$$\sum_j (1 - \sum_q p_{iq} m_{jq}),\ \mathrm{q} \neq \mathrm{i, j}$$

where p_{iq} is the proportion of ego *i*'s resources invested in alter *q*, m_{jq} is the marginal strength (explained below) of *j*'s relationship with *q* within ego's network. Because the raw count of tie strength (how many times a relation occurs between two characters) can vary widely from character to character, the raw count was further normalized into a measure of marginal strength, which is a proportion equal to the raw count of tie strength between ego and alter divided by the maximum number of relations ego made with anyone, also following procedures presented in Burt (1992, 2011).

Closure. Closure indicates the extent to which members of groups are closely connected. A widely used composite measure of closure, network constraint, was employed. This measure was computed following the same procedure presented in Burt (1992, pp. 54-65), using the following formula:

$$C_{ij} = (p_{ij} + \sum_q p_{iq} p_{qj})^2,\ \mathrm{q} \neq \mathrm{i, j}$$

where p_{ij} is the proportion of ego i's resources invested in the connection with person j, p_{qj} is the strength of q's tie to j. This constraint score measures ego i's dependence on a specific other j, and it was used in the analysis to predict the trust between ego i and j. To align the scale of this measure with other variables, the constraint score was multiplied by 100 and rounded to the nearest integer. A large score of constraint signals a high degree of closure. The trade and mentoring networks from January 1 to September 10, 2006 were used to compute brokerage and closure measures.[i]

Other Measures

Demographics. Two demographic variables were included in the analyses: players' age and gender (as opposed to the gender of their avatar). Information on gender and birth date was self-reported when players registered their profiles with *EQII*. Gender was coded as a dichotomous variable and age was calculated by subtracting the year of birth from 2006.

Total play time. The server log recorded the total number of seconds a character had been played since its creation, which was then transformed into the total number of hours.

Character Level. Every player's highest character level earned by September 2006 was extracted from the server log. The minimum level was 1 and the maximum level possible was 70.

Character class. Each character could choose a player character class which had a distinct set of skills and strength for combat. The game has 24 classes, which were condensed into four archetypes, Fighter, Priest, Scout, and Mage.[ii] Character class was measured as three dummy variables (Priest, Mage and Scout; Fighter was the comparison group). This information was also used to generate a dyadic variable describing whether two players were of the same class.

Character class diversity. The diversity of character classes among a player's social network was measured by Blau's index of diversity (Blau, 1977), using the following formula:

$$1 - \sum p_k^2$$

where members of one's social network are spread across k qualitatively different categories (four character class archetypes), and p_k indicates the proportion of members in the kth category. Blau's index is most commonly employed to measure categorical diversity among members of a group or social network (Harrison & Klein, 2007), and its value can range from zero (all members are in the same category) to (k-1)/k.

Guild membership. The server logs contained information on the name of the guild players belonged to at the time of the study. This information was used to generate a dyadic variable describing whether two players belonged to the same guild.

Task performance. Task performance was measured by players' character level. Because character level may be partially attributable to players' total play time, total play time was also included in the models as a statistical control. Therefore, when total play time was held

constant, characters who reached higher levels were viewed as having better task performance.

Trust. Trust was measured on the basis of the housing network. Player A was viewed as trusting player B if A granted B the rights to use A's house in *EQII*. This operationalization was chosen because it was consistent with the classic definition of trust—"the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer, Davis, & Schoorman, 1995, p. 712). In the current research context, the trustee could do real harm to the house owner by removing objects that the owner may have spent hundreds of hours to accumulate. Therefore, trust was measured between pairs of players (from A to B) as a binary variable (1 if A gave B housing rights, 0 otherwise).[iii]

Analysis

Stata 11 was used for the statistical analysis. H_1 was tested through a series of hierarchical regression models by examining the effects of brokerage (measured by effective network size) on task performance (measured by character level, with total play time included as a control). The hypothesis would be supported if brokerage was positively associated with task performance. H_2 was tested through a series of logistic regression models examining the effects of closure (measured by constraint) on the binary dependent variable of trust (measured by ego's decision to grant housing rights to alter). As the unit of analysis in the test of H_2 was a tie between two players, and one player could connect with multiple others, observations within clusters (individuals) may not be independent, resulting in test statistics with inflated Type I error. Therefore, we calculated robust standard errors using Stata's cluster function to adjust for within-cluster correlations between ego's multiple relations (Williams, 2000).

Results

Among the 27770 active players on the *EQII* server Guk during the study time period, 17% were female and 83% were male. The mean age was 33.10 years old (SD = 9.60). The mean character level was 32.94 (SD = 18.84). The basic demographics of players are consistent with previous reports in similar MMOs (Griffiths, Davies, & Chappell, 2003; Yee, 2006).

H_1 predicts that players' brokerage would be positively associated with their task performance. Correlations are presented in Table 1 and the results of parallel regression tests in the mentoring network as well as the trade network are shown in Table 2. Model 1 consists of the control variables, while Model 2 includes brokerage, as measured by one's effective network size. Controlling for total play time, age, gender, character class, and character class diversity in the corresponding network, brokerage scores in players' mentoring networks ($b = 0.38$, $p < .01$; R^2 change = .04, $p < .01$) and trade networks ($b = 0.06$, $p < .01$, R^2 change = .06, $p < .01$) were found to have a significant and positive impact on

Table 1. Correlations Among Variables in Regression Models Predicting Character Level (N = 27,770).

	M	*SD*	1	2	3	4	5	6	7	8	9	10
Total play time (hrs)	466.29	849.94										
Female (D)	0.17	0.38	0.01									
Age	33.10	9.60	0.06**	0.09**								
Mage (D)	0.28	0.45	−0.04**	0.00	−0.004							
Priest (D)	0.22	0.41	0.06**	0.08**	0.05**	−0.33**						
Scout (D)	0.20	0.40	−0.03**	−0.03**	−0.03**	−0.31**	−0.26**					
Mentoring class diversity	0.40	0.30	0.15**	0.002	−0.03**	−0.01	0.05**	−0.01				
Trade class diversity	0.37	0.31	0.17**	−0.003	−0.03**	−0.01	0.04**	−0.01	0.94**			
Brokerage (Mentoring)	5.83	10.94	0.19**	0.01	−0.01	−0.02**	0.03**	−0.03**	0.49**	0.51**		
Brokerage (Trade)	74.94	91.44	0.51**	0.02**	0.04**	−0.01	0.01	−0.003	0.38**	0.41**	0.44**	
Character level	32.94	18.84	0.64**	−0.05**	0.01*	0.01	0.05**	−0.04**	0.47**	0.49**	0.46**	0.64**

Note: D indicates dummy variable (male characters and the Fighter class are the comparison group)
*p <.05.**p <.01.

Table 2. Regression Models Predicting Character Level (N = 27,770).

	Mentoring Network		Trade Network	
	Model 1	Model 2	Model 1	Model 2
Total play time (hrs)	0.01**	0.01**	0.01**	0.01**
Female (D)	−2.62**	−2.72**	−2.53**	−2.81**
Age	−0.01	−0.01	−0.01	−0.02**
Mage (D)	1.50**	1.81**	1.51**	1.51**
Priest (D)	0.48*	0.66**	0.53*	1.00**
Scout (D)	−0.56*	−0.11	−0.51*	−0.57**
Mentoring class diversity	23.48**	17.11**		
Brokerage (Mentoring)		0.38**		
Trade class diversity			23.83**	17.54**
Brokerage (Trade)				0.06**
R^2	0.55**	0.59**	0.56**	0.62**
Standard Error	12.63	12.12	12.52	11.67
R^2 change		0.04**		0.06**

Note: D indicates dummy variable (male characters and the Fighter class are the comparison group); Numbers represent unstandardized regression coefficients.
*p <.05. **p <.01.

character level. In other words, for players who spent the same amount of play time in *EQII*, those with a larger brokerage score (effective network size) reached higher character levels. Also, one unit increase of brokerage in the mentoring network contributed more to task performance than the same increase in the trade network. Therefore, the results provide strong support for H_1.

H_2 predicts that network closure around ego's tie to another player would be positively associated with ego's trust in that player. The logistic regression models predicting ego's trust towards others are reported in Table 3. Model 1 consists of the control variables, while Model 2 includes the closure score (as measured by constraint) for the ego-alter connection. Closure in both mentoring (b = 0.01, p < .01) and trade networks (b = 0.03, p < .01) exerted a positive and significant influence on the likelihood of trust. The total effect was stronger in the mentoring network (Psuedo R^2 change = .0054, p < .01) than in the trade network (Psuedo R^2 change = .0001, p < .01). Thus, H_2 is also supported.

Discussion and Conclusion

This study proposes a structural approach to understanding bridging and bonding social capital in a large MMO, *EverQuest II*, and tests the effects of network brokerage and closure on players' task performance and trust. Based on players' trade network and mentoring network over the course of nine months, brokerage (as measured by effective network

Table 3. Logistic Regression Models Predicting Trust in Player Dyads (N = 163,814).

	Mentoring Network				Trade Network			
	Model 1		Model 2		Model 1		Model 2	
Ego is female	0.418	0.052**	0.418	0.052**	0.412	0.052**	0.411	0.052**
Alter is female	0.343	0.039**	0.332	0.039**	0.339	0.039**	0.339	0.039**
Age difference	−0.022	0.003**	−0.021	0.003**	−0.022	0.003**	−0.022	0.003**
Play time difference (100 hrs)	0.006	0.002**	0.007	0.002**	0.005	0.002**	0.005	0.002**
Same character class	0.296	0.064**	0.290	0.064**	0.292	0.064**	0.290	0.064**
Same guild	1.531	0.039**	1.466	0.040**	1.548	0.039**	1.548	0.039**
Network size								
Mentoring	−0.003	0.001**	−0.001	0.001				
Trade					0.003	0.000**	0.003	0.000**
Network closure								
Mentoring			0.011	0.001**				
Trade							0.031	0.012**
Pseudolikelihood	−20,189.277		−20,070.917		−20,167.728		−20,165.545	
Pseudo R^2	0.0755	**	0.0809	**	0.0765	**	0.0766	**

Note: The dependent variable is trust (a binary variable equal to one if ego gives housing rights to alter); for each model, the first column represents the coefficient and the second column represents the robust standard error (adjusted for within-cluster correlation between ego's multiple relations using Stata's cluster option); all same-account housing (trust) ties are excluded from analysis.
*p < .05. **p < .01.

size) and closure (as measured by network constraint) scores were calculated for every character. Brokerage describes the extent to which a focal player brokers otherwise unconnected individuals in the network. A high brokerage score in one's ego-network indicates abundant variations in information, ideas and resources from connections to different groups, thus leading to better task performance. Closure describes the extent to which a player connects to other players who are already connected among themselves. A high closure score indicates redundant and consistent information and opinions within densely knit clusters, thus it may lead to trust and group solidarity. As such, the distinction between network brokerage and closure maps well to the distinction between bridging and bonding social capital.

Consistent with our hypothesis, brokerage had a significant and positive impact on task performance. Controlling for demographics, character class, character class diversity in one's network, and total play time, players who spanned more structural holes in their trade and mentoring networks tended to reach higher character levels than those who were constrained by redundant (interconnected) contacts. Similarly, the closure effects also received empirical support. Pairs of players who were socially embedded in closed networks showed a heightened trust towards each other, controlling for gender, age difference, play time difference, whether two characters were of the same class, and whether two characters belonged to the same guild. Our results demonstrate that both individual attributes (e.g., gender) and dyadic attributes (e.g, whether two players were guildmates) contributed to

task performance and trust, but they only explained a limited amount of variance. The social network engulfing an individual (or two connected individuals) also plays a key role in determining task performance and trust. A structural approach thus allows us to "zoom out" and take into account the higher order network configurations when examining social capital outcomes.

One important consideration is the generalizability of the findings reported here. Are the effects of brokerage and closure merely a result of specific game mechanics of *EQII* itself? This question is particularly relevant for brokerage, since *EQII* explicitly incentivizes collaboration among players with diverse skillsets, represented by their different character classes. Replications of the current test with other kinds of online relationships and in other virtual worlds are clearly warranted, but several factors suggest that the findings have implications beyond the *EQII* context. First, it should be noted that the game-specific effects of *character class* diversity in a player's network (measured by Blau's index) were distinct from the benefits of *network* diversity resulting from brokerage, and both were included simultaneously in our analysis (see Table 2). In other words, when the class diversity of one's network was kept constant, players who brokered otherwise unconnected playmates tended to perform better than those who were embedded in a closed network of partners. Therefore, brokerage contributed to task performance over and above what would be expected from *EQII*'s reward mechanism alone. Second, our analysis of *EQII* is consistent with findings from several other online worlds that have distinct rules and social architecture. In *Second Life*, brokers were more likely to found popular, long-lasting groups, and participants embedded in closed networks were more likely to trust each other (Burt, 2011). Another study of a Web 2.0 site *Slashdot* found that network closure positively contributed to a participant's status in the community, as indicated by Karma ratings, while brokerage was associated with a broad network that traversed different circles (Ganley & Lampe, 2009). Both *Second Life* and *Slashdot* are very different from *EQII*—one represents an unstructured sandbox-type virtual world with neither fixed story line nor character development trajectories, and the other is an online discussion community mainly focusing on technology issues. In addition, brokerage and closure effects are well-established in various offline networks, from business organizations (Burt, 1992) to broad national communities (Eagle et al., 2010). Taken together, they provide evidence that the achievement-enhancing effect of brokerage and trust-generating effect of closure are clearly present in a variety of online and offline contexts. Finally, a growing body of literature has recognized that, despite their varying themes and goals, virtual worlds often operate on the same social, behavioral and economic principles of the offline world (Bainbridge, 2007; Castronova et al., 2009), and attitudes and skills acquired in virtual worlds may spill over to other contexts (Kobayashi, 2010). For example, "leadership in online games offers a sneak preview of tomorrow's business world. In broad terms, that environment can be expected to feature the fluid workforces, the self-organized and collaborative work activities, and the decentralized, nonhierarchical leadership that typify games" (Reeves, Malone, & Driscoll, 2008, p. 3). Hence, MMOs such as *EQII* could potentially become training grounds for participants to develop various leadership and teamwork skills that may require years of experiences in the offline context, including, as discussed here, the skills to identify structural holes and

effectively broker different groups and explore heterogeneous information and opportunities (Burt, 2010, 2011).

This study contributes to Internet-focused social capital research in a number of ways. Although the network characteristics of social capital have been well-researched for offline communities, this study represents one of the first such attempts in online contexts. This structural approach is an important complement to existing research which tends to focus on the observed outcomes of social capital. This structural approach allows for a better understanding of the mechanisms associated with observed social consequences brought by Internet use by logically separating the formation of social capital with its expected effects (Portes, 1998). Such a logical separation opens up potential opportunities for communication scholars to investigate other interesting social capital outcome variables, such as civic engagement and social support, even though this study was only able to examine task performance and trust between playmates. Further, unlike existing studies that rely primarily on self-reports collected from a relatively limited pool of often isolated individuals, this structural approach capitalizes on behavioral network data unobtrusively collected from entire populations of connected individuals. Such an approach could significantly reduce data subjectivity and sampling bias—typical problems associated with self-reported data (Williams, 2010). The scale, comprehensiveness, and precision of the dataset are rare in communication research. This study joins recent efforts (Burt, 2011; Lazer et al., 2009) in illustrating how "computational social science" can be fruitful for discovering emerging patterns and effects of our increasingly mediated social interactions. Lastly, because this study focuses on network structure as an explanatory variable of social capital outcomes, it could provide insights for designers and practitioners who seek to purposefully "rewire" networks to achieve different relational goals. For example, online communities could incorporate recommendation systems that suggest potential connections to individuals, in order to expose them to diverse opinions in a political discussion forum, or to build densely knit networks in a social support group online.

This study has several limitations that should be addressed in future research. First, this study was not able to measure or control participants' prior interactions offline or via other communication media. Studies showed that a significant portion of social interactions in MMOs occur between existing friends and family members (Nardi & Harris, 2006; Shen & Williams, 2011). Future research is encouraged to examine how existing relationships could influence network formation and social capital. Second, this study did not examine additional contingency factors which may affect the formation of social capital. One such contingency variable is the content of the network (Burt & Schott, 1985). As shown in Table 2, all else being equal, one unit increase in brokerage of one's mentoring network contributed 0.38 unit increase in character level, while one unit increase in brokerage of one's trade network only contributed 0.06 unit increase in character level. Both brokerage scores were found to influence task performance, but one was much more substantial than the other. A plausible explanation is that, compared to trade relationships, mentoring relationships entail greater commitment—mentoring happens during a group or raid event, with a more advanced character temporarily lowering in level to match a lesser character. Mentoring is also more exclusive (one apprentice at a time) and

substantive, as it may last through a several-hour long play session filled with multiple successful battles as well as failed ones. Because of the difference in network content, it is not surprising that players typically have fewer mentoring ties ($M = 5.83$) than trade ties ($M = 74.94$). The discrepancy in network content could have contributed to their differing effects—bridging relations in the mentoring network are more valuable than those in the trade network in providing knowledge, resources, and combat tactics, and thus are more effective in enhancing task performance. A promising future research direction, therefore, is to systematically test and compare the effects of social structure in different types of online relationships. Third, as the study relied on cross-sectional networks, the results are purely associational and cannot assert causality. It may be true that network closure facilities trust, but it is also possible that trusting relationships lead to mutual friends. Future research should take the opportunity to explore the longitudinal transformation of social capital using network panel data. Lastly, this study uses behavioral network data only. Other types of data, including surveys and in-depth interviews, are likely to add value to a purely structural approach. For example, self-reports of participants' pre-existing relationships as well as their communication channels outside the online world can provide important insights about their trust and network patterns.

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Notes

i The trade and mentoring networks from January to September 2006 were used to compute effective size and network constraint, even though our data also allowed us to generate a "grouping" network based on players' collaborative play. The grouping network is an affiliation network by definition. Within a combat group, everyone is connected to everyone else, thus leading to extremely high constraint scores. Therefore, it is not productive to compute effective size and network constraint scores for the grouping network. Trade and mentoring networks, by contrast, were selected because they consist of dyadic relations. A trade or an instance of mentoring happens between two characters and only between two

characters. Any trade or mentoring relation between two characters is independent of other trade or mentoring relations in the network.

Since there were two networks, one option was to combine both the trade and mentoring networks into a comprehensive network of players and compute effective size and constraint measures. The Quadratic Assignment Procedure (QAP) was used to test the association between the trade and mentoring networks on a dyadic basis. Results showed a low correlation ($r = 0.19$, $p<.001$), indicating that one relation was able to predict another, but the extent of tie co-occurrence was very limited. Therefore, these two networks were treated separately and two sets of brokerage and closure scores were computed and used in the analyses.

ii For each class archetype, players are able to select from six character classes. The Fighter archetype includes Berserker, Guardian, Monk, Paladin, Bruiser and Shadowknight. The Priest archetype includes Fury, Warden, Mystic, Templar, Defiler, and Inquisitor. The Mage archetype includes Warlock, Wizard, Conjurer, Illusionist, Coercer, and Necromancer. The Scout archetype includes Dirge, Troubador, Ranger, Swashbuckler, Assassin, and Brigand.

iii Among all the characters active during January to September 2006, about 23% (6312 characters) owned a house in *EQII*.

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