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Building a Dynamic Social Community with Non Playable Characters

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SUMMARY A challenge faced by the video game industry is to develop believable and more intelligent Non-Playable Characters (NPCs). To tackle this problem a low-cost and simple approach has been proposed in this research, which is the development of a gossip virtual social network for NPCs. The network allows simple individual NPCs to communicate their knowledge amongst themselves. The communication within this social network is governed by social-psychological rules. These rules are categorized into four types: Contact, whether the NPC are within a contactable range of each other; Observation, whether the NPCs actually want to talk to each other based on their personal traits; Status, the current representation of the NPCs; and Relationships which determines the long term ties of the NPCs. Evaluations of the proposed gossip virtual social network was conducted, both through statistical analysis and a survey of real users. Highly satisfactory results have been achieved.

key words: *Intelligent NPCs, Gossip Virtual Social Networks, social-psychological rules*

1. Intoduction

The development of Role Playing Games (RPGs) has evolved over the last 30 years [17]. A RPG can be defined as a game where a player assumes the persona of character(s) within a fictional environment and the player has the ability to drive the story. The story progression can either be accomplished in a linear fashion, where the events of the predetermined story come one after another; or in non-linear method, where the story is not predetermined, and the player has the choice to make decisions to influence the outcome of the story. Computerized RPGs have evolved from basic single player text-based digital media to complex Mass Multi-player Online Role Playing Games (MMORPG). Much focus has been given to the development of graphics, sound effects, story lines, main character's structures and game play mechanics. One aspect that has been given comparatively less attention is the intelligence of the Non Playable Character (NPC). NPCs are still mostly underdeveloped within Role Playing Games (RPGs) and highly sophisticated NPCs required a large amount of time and effort to build [4], [5]. A NPC is a background character, typically providing information about themselves or the game world. In certain ways, NPCs can be considered as a special type of intelligent agents. An agent is a computer program that is autonomous, aware of its environment, exists over a long period of time, has the ability to adapt and change, creates and achieves goals [18]. Intelligent agents have been used in many areas, including simulations, human-computer interface designs and computer-assisted educations. They are also widely used in intelligent learnings. A rather early approach is NetLogo [21], a multi-agent programming language which provides a way to simulate the micro-level behaviours and macro-level patterns of agents based on certain rules. The purpose of Netlogo is to provide a generic simulation environment for the development of agents, which can be a molecule, an ant, or a buyer. Starzyk et al. [20] proposed a new machine learning approach called motivated learning. The evolvement of agents in their system focused on individual goal achieving, rather than establishing relationships among them. In [6], the agents are provided with intrinsic motivations which drive their intelligent learning and the ultimate emergent cognition. They also simulate the dynamics of the online social network [14] although the focus there is more on behaviours and relationship development of the human players in the social network.

Although they can be considered as agents, NPCs in the context of games are often not as intelligent as a commonly understood agent, especially those used to simulated humans. They are usually pre-scripted for some simple functions such as giving information/instruction to the player. It is not a requirement that a NPC has the ability to change, adapt or set goals and in most games they are not programmed with such abilities. The intelligence of NPCs can no doubt be greatly improved if they can be implemented as intelligent agents. However the amount of time and effort required for implementing the large amount of NPCs required for a game as intelligent agents make it almost impossible for game developers to take such an approach.

The evolution of gaming throughout the decades has seen some improvement of NPCs. However they are still fundamentally pre-scripted and isolated. NPCs started to appear in RPGs in the late 1980s, such as in the famous Final Fantasy series. Those NPCs can provide simple information, typically describing themselves or the world that they live in, provide or remind players of the current task etc., usually with a single sentence. NPCs can be in the other roles such as a shop keeper, etc. Throughout the game, either no or very little change would occur to the NPCs. In the 1990s the role of the NPCs expanded. They were able to provide more information about the game's current events, and give their own personal view of the situation. In addi-

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tion, some NPCs would support the players by giving tips, e.g., on how to locate secret items, etc. Some NPCs could choose from a few versions of speeches to match the current situation of the game. Generally the behaviours of the NPCs would still remain the same throughout the game. Towards the late 1990s, NPCs in some games have been steadily improved. Deus Ex [13] and Hitman [3] not only advanced the interactions between the player and NPCs, but also implemented some pre-scripted movement and activities for NPCs. Despite the improvement, most aspects of the NPC still remain one dimensional. NPCs still repeat their previous messages to the player. The paths of the NPCs are predictable, which can be taken advantage by players, particular in the Hitman series. In today's RPGs, the levels of intelligence of NPCs vary greatly. For example, the multi award winning Mass Effect Series [7] has very deep NPC conversation structures. The player can decide what conversation path to take, sometimes with little or no knowledge of the chosen path, resulting in more realist and unpredictable outcome. In some other RPGs, a NPC can have a large impact on a game, changing the environment and story on a large scale. One game in which the realism of NPCs has been significantly improved is Oblivion [8], where NPCs can interact with other characters, although this interaction lacks the social aspect on message passing between NPCs.

There has been some research for intelligent NPCs, [15] presented an approach to represent the characteristics and status of NPCs, and different tendencies of NPC behaviours based on the value of their characteristic and status, known as their properties. The NPCs are made to be responsible for determining their own behaviours. For example, a NPC with a violent tendency is expected to perform violent actions, such as hitting or yelling rather than helping out other NPCs. Their contribution is an AI system on their current needs. However it is unclear how the NPC decides what the correct item is. [8] investigated what patterns are responsible for developing more believable NPCs. Several patterns of NPCs were studied and some of the limitations were also identified. The work provided good analysis on how to improve the intelligence of NPCs. However the NPCs are fundamentally autonomous. Large amount of effort and complicated algorithms are required to improve the intelligence of each NPC. A simulation tool has been developed in [11] to create believable NPCs. Their aim is to develop NPCs that can evolve their emotions and social relations, based on their personality and roles. In this model, each NPC is characterized by its personality, which is defined by a set of traits, and its social roles, which determines its social relations with other NPCs and the player. Such relations are only defined in pairs and are static, such as employee/manager, child/father, patient/doctor, etc. NPCs in this system are only characterized by the defined personality such as extroversion and neuroticism, while simple but useful factors such as gender and age etc. are not considered.

In this paper, a system is proposed so that the intelligence of the NPCs can be self-evolved. Our aim is to build a social community of individual and diverse NPCs. These NPCs would be able to form opinions and make decisions based on up-to-date information as they exchange information within the community. The information and advice they can provide to the players are hence not entirely pre-script, neither are their opinions about the players and the environment. As a result, the perception of the NPC's intelligence will be greatly improved, and their interaction with the players will no longer be dull and pre-planned. The automated system of knowledge discovery and retrieval for the NPCs greatly reduces the time needed to develop intelligent NPCs, since they are now able to self-evolve. Such a system will benefit both gamers by providing them a new and different gaming experience and game developers by giving them the support mechanism to create low cost intelligent NPCs.

The rest of the paper is organized as follows. Section 2 describes the design and implementation of the proposed gossip virtual social network (GVSN) and how it facilitates communications between NPCs and with the player. Section 3 demostratues the mobility and conversation abilities of the NPCs. Section 4 presents the evaluation of the proposed system through experiments. Section 5 concludes the paper and provides some recommendations for future work.

2. The Gossip Virtual Social Network (GVSN)

This section describes the development of a virtual social network that has the ability to simulate social communication between NPCs within a RPG. This gossip virtual social network has been designed to be governed by a set of rules based on social psychology, so that NPCs are able to communicate, based on their traits, their knowledge and their relationships. The type of information that is exchanged would be based on the characteristics of NPCs, the relationship between the NPCs (and the player), and the current game events. NPCs would be capable of exchanging simple information including their name, age, gender, and occupation, as well as complex information, such as their activities, interests, beliefs, opinions and their current inventory.

[1] proposed a design and initial implementation of a decentralized Social Networking System (SNS). This project extends their networking idea for building a virtual social network (VSN) for the NPC community. Much more complicated relationships have been explored and implemented so that the virtual communication could better imitate the real human society. Peer communications with the popular gossip algorithm [9] in computer networks has been adapted as the communication mechanism in this GVSN due to its robustness and low cost [10]; while the P2P topology is employed as it scales well to a large number of nodes, and is adaptive enough to connect to many different NPC groups.

2.1 Gossip Algorithm

The communications among nodes in the virtual social network are based on the gossip algorithm, which is a discriminative process. The idea of the discriminative filter is to en-

sure that well known NPCs would have a higher contact rate. The information transmitted between nodes is also selective, depending on their relationships. For example, the player tries to pass certain information to a NPC who happens to have an "unlike" relationship towards the player. The NPC would reject to establish communication with the player, so the information fails to be passed to that particular NPC. The player then attempts to contact another NPC who has a "friend" relationship towards the player. This time the information is successful passed. If the information received is considered sensitive by the NPC. That NPC can only pass it on to its friend or trusted NPCs.

2.2 Rules Governing the Communication

Four types of rules are developed to govern the ways communications take place. 1) Contact: NPCs must be within close proximity to start communicating. 2) Observation: a NPC must first identify whether another NPC is worth contacting before it is able to start the communication. 3) Status: every NPC has a current state at any given time, which is made up of both a social and inventory status. It provides the mechanism of determining what information can be communicated between the NPCs. 4) Relationships: There are different relations between any two NPCs and between a NPC and the player, which governs the long term choice of who and what to be communicated by NPCs. The virtual social network of NPCs has the ability to establish concurrent conversations, which provides the freedom to exchange information among multiple NPCs.

- Contact

For communication to take place, a NPC must be able to identify other NPCs in the contact range. For the time being the contactable range is defined only by proximity. Two NPCs within the contactable range are not necessarily able to have a conversation. Further rules will apply to determine whether such communication could take place.

- Observation

When two NPCs are within the contactable range, one of the NPCs will begin the process of observing the other. The type of relationship existed between the two NPCs will affect the observation results. For example, a more positive relationship will improve the chances that the two NPCs will be able to communicate, while a more negative relationship will result in the opposite effect. Initially relationships can be defined by the game developer for greater control; otherwise all NPCs can be set to be neutral to each other.

Observation of the NPCs is partly defined by the personalities of the NPCs. Other factors include gender, age, race and class. The generally accepted position of psychologist is that personality is the unique pattern of enduring thoughts, feelings and actions that determines a person [2]. Among the four commonly used approaches for the definition of personality, the traits approach is considered to be the most suitable in this project, as it is easier to quantify and seems to be the most accurate for research purposes. The Five-Factor Model describes personality as five different traits: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness [22]. The Five-Factor Model is a variation of the trait approach, where a series of statements describes a person's personality traits, the inclinations or tendencies that dictate how a person usually thinks and behaves [19]. All these traits can be implemented to play a role in the development of intelligent NPCs. Currently in this research only the trait of extraversion is implemented, as this trait is mostly responsible for how social an individual is. Extraverts are typically more social and outgoing, enjoying parties and other social group activities. They are more willing to take risks, and love excitement and changes, therefore are expected to have more friends and are more likely to disclose information to others [12]. Introverts behave the opposite, tend to be quiet, thoughtful and reserved, avoiding social situation where possible. Introverted people are most likely to make fewer friends, therefore are expected to know less about the world, if depending on social communication.

Table 1 Observation data for genders.

Gender	Male	Female
Male	95	85
Female	80	95

Five characteristics of a NPC are currently implemented in the Observation rules. 1) Whether the NPC is *introverted or extraverted*; 2) the *gender*, simply defined as male or female; 3) The *age*, organized into six different groups: child, teenager, young adult, adult, middle age and elderly; 4) The *social class*, currently ranked as lower, middle, upper, and royal class; and 5) the *race*, which is defined by the game developer as it is impossible to define generic types races. For example, in the game Starcraft the races are defined as Terran (Human), Zerg (Parasitic Insectoid) and Protoss (Humanoid); and in Warcraft 3 the playable races are defined as Human, Orc, Night Elf and Undead.

In the sample game developed for this project, a simple set of observation data is used. Each characteristic is represented by a dataset, a 2D Integer array. Every element contains an already predefined probability for each characteristic combination. The NPC that first initializes the observation determines what row is to be accessed, then NPC that is been observed determines what column to access. For example, as shown in Table 1, a male NPC has a 95% chance to talk to another male; however he has only an 85% chance to talk to a female. A female NPC has also 95% chance to talk to another female, but has only 80% chance she will talk to a male. All traits work on the same principle. Once the value from the database has been extracted, it is compared to the random value of each trait. If the random value is greater than the database value, that trait is considered to be true. Currently all five traits must be true for two NPCs to communicate.

Each NPC will be given a set of values for these five

characteristics. They are generally fixed throughout the progress of the game. When two NPCs are in agreement in all of the five characteristics, the two NPCs will proceed to a conversation.

- Status

Status refers to the current states of a NPC at a given time. It consists of both the social and inventory status. During the initialisation of the GVSN, each NPC is assigned with certain knowledge, entailing information such as their occupation, what activities they like to do, what interest they have, and what beliefs they hold. In addition each NPC is also allocated information about their current inventory. Such as what items they own, what clothes they wear, and weapons they use. Included with every piece of information is the NPC's opinion of that knowledge. This opinion is simply defined as whether the NPC agrees or disagrees with such knowledge. For example a NPC might like to play basketball; therefore this piece of information is assigned as a liked activity. However the same NPC might also know about football, but instead dislike that piece of information, meaning that he or she dislikes football. Opinions are assigned for each piece of information in either the social or inventory status of every NPC.

Social status is the structure that contains the personal information about a NPC. When two arbitrary NPCs are communicating, they have the option to either talk about themselves, or any other NPCs whom they have meet in the past. Other topics include some current game events or any information about the player(s), including their own attitude towards the player.

The NPC who initializes the communication (the contactee) makes the decision on the topics to be discussed. This decision is depended on his or her analysis of the shared information between the NPCs. The discussed topic could be the occupation, activities, interests and beliefs of the contactee or contacted NPC. The analyses are performed in two steps. Firstly it is checked whether the contacted NPC knows about the information that the contactee is putting forward. For example, if two NPCs both know how to play chess that is more likely to be talked about than in the case when only one NPC knows about that particular topic. Topics that are known to both NPCs are assigned a random value ranging from 0 to 20, while topics that are only known to one NPC are assigned a random value ranging from 0 to 8. Next it checks whether the contacted NPC shares the same opinion on that particular piece of information. If the two NPCs both agree to like or dislike a certain topic, there will be additional chance that the topic will be selected for communication. Likewise if they disagree on a topic, the chance is reduced that the topic will be selected for communication. For example, again if two NPCs both know how to play chess, but one likes to play and the other dislikes, this topic is rarely raised for discussion. For a topic that is unknown to a NPC, the topic has an even chance to be either liked or disliked by that NPC. In many cases, the number of topics within the types is not equal, so each type results are averaged out, which prevents types with more knowledge from gaining an advantage over types that has less knowledge.

Table 2 Social static calculation datax.

Type A (Postive)	Type B (Negative)
t1, Like = (0 : 20) + 5	t1, Dislike = (0 : 20) - 5
t2, Like = (0 : 20) + 5	t2, Dislike = (0 : 20) - 5
t3, Unknown = (0 : 8)	

Table 2, shows that the NPC knows about five unique topics within a particular type. Each topic is assign with a random value within the status rule set. For example, both liked and disliked topics are allocated with random value between 0 and 20, the difference liked topics are given a bonus of positive 5 and disliked topics are given a bonus of negative 5. Unknown topics are simply signed with a random value between 0 and 8. This particular NPC knows about two types, A and B respectfully, where each is made up of a series of topics. The sum of all topics is calculated then divided to form the outcome for a particular type. For example, type A could have the values of (12, 16, 5) with an outcome of 11. Type B could have the values of (8, 9) with an out of 8.5. The total is calculated from the all type outcomes. With these results, the selection calculation can be done; each outcome is divided into the total, resulting in a probability of selection. In this case, Type A has a probability of approximately 56%, where Type B has a probability of approximately 44%. Once a type has been selected, a topic within that type is randomly chosen.

- Relationships

For the GVSN to work in the long term, relationships between entities, which can be NPCs and/or players, need to be formed, evolved and maintained. This is important because the information exchange is more likely to be among entities that have positive relationships, and less likely to happen for entities with negative relationships.

When the GVSN is initialized, every entity is provided with a list of all other entities with an initial relationship and a numerical value "level" indicating the current numeric state of the relationship. A game developer can define any type of initial relationships among the entities. Many different kinds of relationships can be defined. In this paper, three different types of relationships are presented, each of which has its own sub types. The first type is *Neutral* or starting type, which means that there is little, or no prior communication experience or opinion between two entities. The sub types here are "stranger" and "acquaintance", where "stranger" means totally no prior communication and "acquaintance" means little prior communications. The next relationship type is *Positive*, which includes sub types "friend", "close friend" and "best friend". The final relationship type is *Negative*, which includes the sub types "unliked", "enemy" and "arch enemy". Even though it might not be very common for people to have enemies or arch enemies in real life, within RPGs both the positive and negative relations exist commonly.

During the communication the outcomes of all conversation are recorded. Such outcomes are used to determine whether and how the relationship between two entities will be changed. If the outcome is positive the relationship level is increased. If the value of the relationship level has reached a certain threshold, there is a possibility that a more positive relationship is formed. A similar process occurs for the negative relationships. Note that there should be limited number of "best friend" and "arch enemy" for any NPC. Otherwise all relationships over enough time will become either "best friend" or "arch enemy", which is obviously unrealistic. All sub types of both positive and negative relationships could also have a quota to limit easy evolutions. If the relationship level increases to the threshold but a new relation cannot be formed since there is no vacancy, it remains in its current state and the level is set to the previous point of the current relationship. Both the positive and negative relationships are dynamically changing all the time depending on the encounters between entities. For example, a NPC can become a "friend" then "unlike" and then again a friend with the same NPC.

With the combination of the relationships model, the GVSN reinforces itself. NPCs that are friendly have greater chance of being contacted, while NPCs that are unfriendly are very often avoided.

2.3 Memory

The proposed GVSN is designed so that NPCs can exchange information among themselves and with the player based on their characteristics and social relationships. Every NPC within the GVSN is allocated a memory system to store information based on the memory system proposed on the theories in psychology [2]. All NPCs have the ability to gain information and store it in its memory. Once communication has started between NPCs and/or the player, the memory of the NPCs will be modified constantly. All memories are retained during the lifetime of the game, until the game is terminated. For important information that is specifically designed to remain in the network, a new data structure was created, called "SignificantSelectiveInformation". Both the players and NPCs can pass information that is significant to them and loosely decided which NPC would obtain this important information. For example, a player can pass important information to a NPC. The NPC considers the information to be significant, but only pass this information to a selective number of NPCs. The selection process is determined by the relationship value between NPCs.

Once a NPC learns a new piece of information, the information is stored in the short term memory. With topics been repeated in conversation, the memory starts to strengthen, until it reaches a maximum threshold and the memory is permanently stored. The same memory is removed from short term memory. The process of strengthening memories is based on an exponential growth function. Without a stimulus the short term memories decay over time, until a minimum threshold is reached, which will result in the information being removed from memory.

3. Implemementation of the GVSN

The proposed Gossip Virtual Social Network is implemented into a simple game, called "The Search for the Stolen Ring" to showcase its functionalities. The design of the game is a 2D top-down perspective RPG, where the player can control a single character. The game is made up two types of locations, a larger town map called Seashore town consisting of shops, a hotel and a church, and a smaller bar map. The game is capable of having dynamic number of mobile and non-mobile NPCs. The player assumes the role of the main character, Phil, a detective who is trying to locate the ring. The objective of the game is to locate the ring from a disliked NPC, accomplished by the player questioning other NPCs about the ring, and discovering relevant information which can lead the player to the ring. The NPCs consistently communicate among themselves about different issues, including information that is helpful to the progression of the game. The player needs to gain trust of different NPCs so he can get useful information from them.

The gossip virtual social network is implemented as a multithreaded system that each NPC is represented by his or her own thread, allowing for concurrent conversations within the game.

3.1 NPC Movement

In this game the movement of the NPCs is restricted to only four directions, up, down, left and right. This restriction is also applied to the player. All NPCs immediately start to move with a pre-defined starting position and direction. Both definitions are determined by the game designer, prior to game play. Each NPC will continue to move in one direction, until a point on the map, called a junction is reached. Simply put, a junction is a pre-defined point on the game map where the NPC direction can be manipulated. This is accomplished by having two points, one attached to the NPC, the other attached to the junction. When both points intersect, i.e., they occupy the same pixel, a new direction can be assigned to the NPC according to the property of the junction. Each junction point is assign with pre-defined directions. Currently at the time of intersection the selection of NPC direction is done randomly among the directions of the junction.

3.2 NPC Conversation

A conversation system was design and implemented for both the NPC-to-NPC and player-to-NPC communications in the game. Depending on situations, the conversation system loads in a specific modifiable script file. These script files are made up of two types of texts. The first type is text that is unchangeable, mostly common words that make up the sentence structure. The other type is the reserved words, similar to the *reserved words* that are found in programming

languages. Some of the reserved words are the following, random_greeting, contactee_name and ss_type.

These reserved words are located within the text and can be replaced with either the appropriate word or randomly selected word. For example, the reserved word, "contactee_name" is replaced by the NPC's name that first invoked the conversation.

The conversation system has also been designed to handle the questioning and answering between the NPCs and for the player to witness communications between friendly NPCs, though the player must be in the close proximity of the conversation.

This type of conversation is also possible between the player and the NPC. However the unique aspect of this conversation model is that the player can decide the type of conversation to have with the NPC, either passively or aggresively.

4. Experimental Results and Discussion

This section reports the experiments and evaluation results of the proposed gossip virtual social network for NPCs through its implementation in the game "The Search for the Stolen Ring". Two different experments have been conducted in order to evaluate the performance of the GVSN both quantitatively and qualitatively. The first experiment is designed to evalulate all three aspects of the GVSN, by setting a number of different initial states for the NPCs and observing/measuring their interactions. The purpose is to measure quantitively how information is propagated within a social network of NPCs and their relationship evolves over time. The second experiment is conducted with a number of volunteer human players. A survey is conducted on their experience of playing the game especially on their feelings towards the NPCs within the proposed GVSN. It is aimed to understand whether people are interested in the proposed self-evolution of NPCs within RPGs, and whether the proposed GVSN provides a good solution for that purpose.

The first evaluation in Experiment 1 is to show how different observation traits can affect how NPCs make contact with each other. Two different sets of observation traits values are assigned to the NPCs. In both sets there are six male and six female NPCs and half of them are extraverted while the other half are introverted. In the left set, there are three NPCs in each age, race, and social class group; but in the right set, all NPCs are considered to be teenagers, belonging to the middle class and are in the same race. It is expected that the contact rate of the left set should be much lower than the right set, and the experimental results show in Fig. 1 confirm it.

The next evaluation is on how different social status could affect topics raised by the NPCs. In the first set of social status assigned to the twelve NPCs (referred to as "social_set_1"), their occupations are set to be all different and many of them do not like their own occupations. Their activities and interests are partly overlapped with mixed "likes" and "dislikes", but all of them "like" a belief "Gravity". As

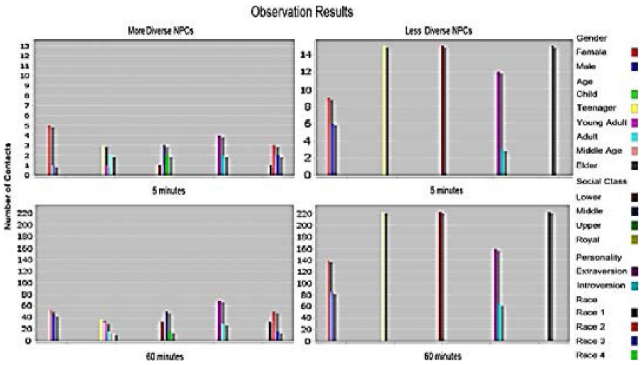

Fig. 1 Contact numbers of the more diverse vs. less diverse NPC groups over 60 minutes.

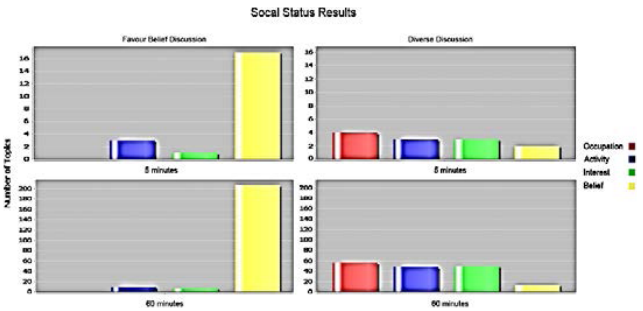

Fig. 2 Statistics on different topics being discussed among NPCs over a time period of 60 minutes.

a result all the NPCs should favour "Gravity" as a discussion topic. There would be some discussion about some activities or interests, but occupation should almost never be discussed, as none of the NPC can relate to another's occupations, and many do not like to talk about their own occupations either. In the next set (social_set_2), the NPCs have each been assigned a different belief for which they really like. Their occupations, activities and interests are all set to be the same. It is expected that the NPCs will discuss mostly occupations, activities and interest. However there should still be some discussions on their beliefs, since every NPC likes what they believe in, even though their beliefs differ. Unlike in social_set_1, no "dislike" is assigned to any of the social status of the NPCs, so the only factor for selecting discussion topics is whether the topic is known by both NPCs.

The statistical results on the topics being discussed among the NPCs over a period of 60 minutes in the game are shown in Fig. 2. The graphs on the left shows that the favorite discussion topic in social_set_1 is "belief" even from the early stage, due to the fact that every NPC liked the belief of "gravity" and they have mixed opinions on other topics. The graphs on the right, however, show a diverse range of discussion where almost all topics are raised often. Despite "belief" being ranked the lowest within the diverse discussions, it is still talked about fairly often.

The last evaluation in Experiment 1 is on how relationships are formed and evolved. The social status in so-

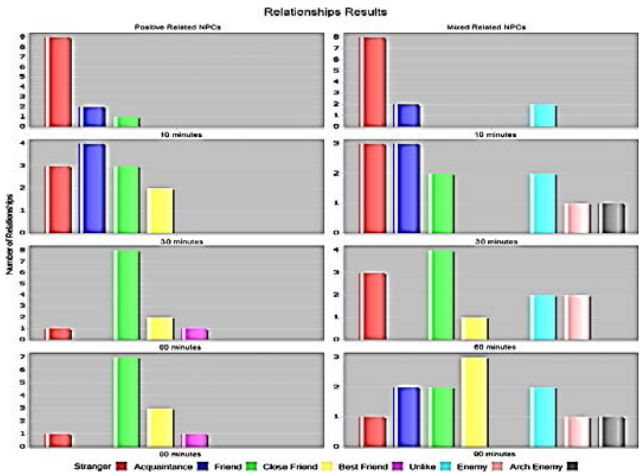

Fig. 3 Relationship results over a time period of 90 minutes.

cial_set_1 above is used first, where all NPCs like the belief "gravity". The NPCs are most likely to talk about "gravity", due to their familiarity and favouritism towards their conversation that they share a common interest and opinion, the relationships among them are expected to become more positive. A new set of social status data (social_set_3) is then used where the NPCs have a wide range of topic and mixed opinion in all social traits. It is possible that the NPCs would have mixed experiences through their conversations. Sometimes the NPCs will agree, but very often they will disagree. The evolution of relationships will also be mixed.

The statistical result on relationship evolution is shown in Fig. 3. The eight graphs show the relationships of a NPC, named Jessica. The graphs on the left show the relationship evolutions of Jessica towards other NPCs with the social status described in social_set_1, while the graphs on the right show those of Jessica towards NPCs with the social status in social_set_3. For the full demonstration of the relationship results, an additional 30 minutes is needed. 10 minutes after the game started, both sets show very similar results, where most of the NPCs are "strangers" to Jessica, as indicated by the red bar. However some of the NPCs are starting to form either a positive or negative relationship with her by this time. By the 30 minute mark, the majority of the NPCs have formed some kind of relationship with her. In the first group where the NPCs are agreeable with each other, such relationships are mostly "Acquaintance" or "Friend" denoted by the blue and green bars. As for the second group where the NPCs have mixed opinions, both positive and negative relationships have been formed. Towards the end of the 90 minute mark, Jessica has evolved her relationships with the agreeable group in the positive direction, including a "best friend" relationship formed. With the mixed group, she has continued to maintain and evolve both positive and negative relationships with them.

To evaluate whether the gossip virtual social network has the potential to improve the experience of game players, a second experiment was conducted with a number of openly-recruited volunteers playing the game "The Search

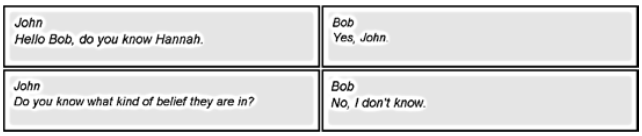

Fig. 4 NPC John questioning NPC Bob about NPC Hannah.

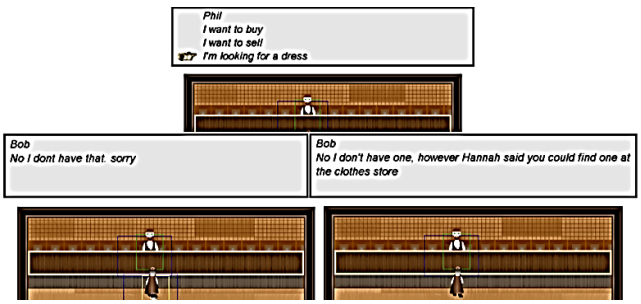

Fig. 5 Two different responses from the shopkeeper.

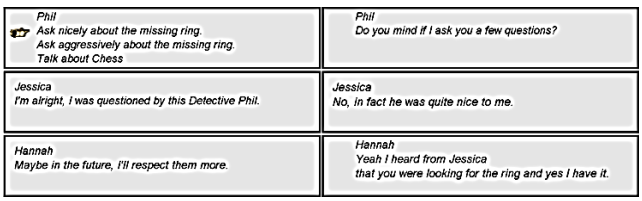

Fig. 6 NPC gaining impression on the player through another NPC.

for the Stolen Ring". Each of them was given the role of Detective Phil, and they were free to play the game any way they preferred and interacted with any of the NPCs in any manner they chose. The users are informed the objective of the study before they started playing the game. During the game playing, they would observe whether/how the NPCs evolve and provide help to them. Depending on the choices they made, some of the players successfully fulfilled the goal of the game (retrieving the stolen ring) while some actually failed. A survey is conducted when they finished playing, on their gaming experience, especially on their interaction with the NPCs and whether the NPCs have become more intelligent and helped them to achieve their goals. Some sample scenario and conversations happening in the Seashore bar during the game are extracted and shown in Fig. 4 ~ Fig. 6.

In the game with GVSN, there is consistent information exchange within the social network of the NPCs. Figure 4 illustrates one possible type of conversations where the NPCs are talking about another NPC. NPCs can also use the same method to enquire about the player within the game and vice versa. Figure 4 shows the conversation between NPC John and NPC Bob where John is making enquires about another NPC Hannah to Bob. Since Bob is having a "Friend" relationship with John, he is happy to share information with John. When John asks whether Bob knows Hannah, Bob checks his memory, and locates the name Hannah, which he then responds positively to John. John contin-

ues to ask Bob about Hannah's beliefs. After checking his memory, Bob realises that he does not have such knowledge. He then informs John that he does not have the information.

In most RPGs, there is an element of business activities, where player are required to buy and sell items to survive and progress through a game. Such business activities are often conducted through shopkeeper NPCs. The shopkeeper NPC's activities are commonly limited to two types, *check whether he has what the player is looking for*, and *sell to the player if he has that item*. In "The search for the Stolen Ring", an additional component has been added to the shopkeeper NPCs. The shopkeeper can also learn information about a particular item, from a regular NPC, such as *who has spoken about such an item*, and *where to locate it*. The interactions between a player and a shopkeeper NPC now include an additional option, to inquire about a particular item. The shopkeeper can respond to the query as "Yes I have what you are looking for" if he has what the player wants; "No I don't have that" if he doesn't have it and have no knowledge about it at all; or "No, I don't have that, but ⟨NPC's name⟩ said you could find one at ⟨this different location⟩", if he does not have the item but learned from another NPC that the item is available at a different location. Figure 5 illustrates these two different responses.

A very important aspect of the game is the changing of relationships between NPCs and the player. Such relationships play an important role in the progress of the game. A scenario is illustrated in Fig. 6 where the player has already established certain relationships with all the NPCs. A NPC, Hannah, has a relationship of "unlike" towards the player initially. If the player tries to communicate with Hannah she would return a negative response and the conversation would not proceed. The evolving relationship shown in Fig. 6, NPC Hannah's impression towards the player has improved indirectly through his communication with Jessica, a close friend of Hannah. NPC Hannah's impression and her relationship towards the player have been improved so much, that when she learns from Jessica that the player is looking for a ring that she happens to possess at the time, she is now willing to hand it over to the player. This demonstrated how communications between NPCs helps the player in progressing the game.

A survey was conducted in Experiment 2 to record the experience and feedback from the players on the GVSN proposed. For this research it is important to establish if the participants is a gamer or not, because their opinions could differ greatly. The first part of the survey is on the background of participants on video games and RPGs, such as whether they actually play games, and if so how much and what they have played, whether they normally interact with NPCs voluntarily and if not, why not. The second part of the survey asks the participants to evaluate the performance of this research, 31 people participated in the survey. Out of the 31 particupants, seven were female, and 29 were under the age of 30. Out of the 31 participants, 25 have previous experience in gaming, 6 have not. Their response on the survey questions are presented separately below. It is interesting to note that 1 female non-gamer provided negative evaluation to all questions asked.

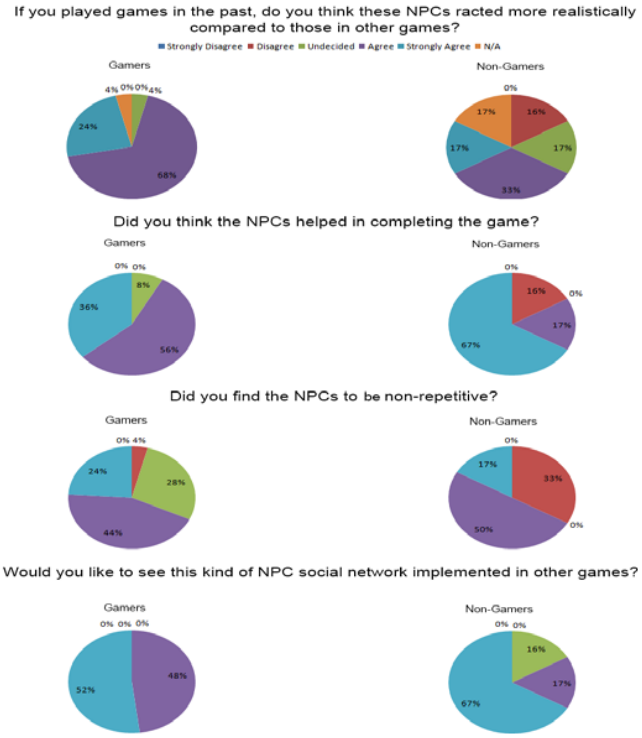

Fig. 7 Survey results.

Figure 7 shows the evaluation results from the survey. It can be clearly seen that there is a generally overwhelming approval on the proposed GVSN.

5. Conlusion and Future Work

The objective of this research is to develop a low-cost method to improve the intelligent level of NPCs in RPGs. It is believed that such an objective can be achieved by developing a mechanism for NPCs to share information among them. This was accomplished by researching in fields such as believable characters within games, social intelligence psychology and different network algorithms. A gossip virtual social network (GVSN) is proposed and developed, which is a network capable of exchanging information among NPCs and hence allow them to selfevolve. Communications in this network are not random, and not pre-scripted. Rather they are based on a set of rules derived from social-psychological principles. The GVSN can be easily used by game developers to improve the intel ligence level of their NPCs, simply by making them more knowledgeable through information exchange. A sample game is developed to demonstrate and evaluate the performance of the GVSN. Two experiments have been conducted based on the sample game, first a detailed quantitative analysis on the performance of the NPCs to evaluate the behaviour and evolution of the gossip virtual social network; and second, a qualitative survey of real human players, including both

gamers and non-gamers, on their opinion towards the proposed self evolving NPCs through the gossip virtual social network. The evaluation results show that the proposed gossip virtual social network enables the NPCs to evolve their knowledge and skills through communications. They are less repetitive, more responsive, and hence act more like intelligent beings, without the expensive cost normally associated with developing intelligent agents.

Future work includes studies on more complex status and social psychology where the NPCs could become aware of social schemas, stereotypes and attitudes. The GVSN will be used as the mechanism for research on more complicated social behaviour of NPCs and hence more sophisticated game environment. The communication in the GVSN is currently one-to-one, which could be expanded to include one-to-many or many-to-many communications.

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