AGENT COMMUNICATION FOR ROLE PLAYING IN THE IDEA ASSOCIATION PROCESS

IH-CHENG LAI
Department of Architecture, Chaoyang University of Technology, Taichung, Taiwan
Graduate Institute of Architecture, National Chiao Tung University, Hsinchu, Taiwan
ihcheng@arch.nctu.edu.tw

Abstract. This paper proposes a framework for the specification of communication mechanisms that regulates interactions among agents participating in role playing in the idea association process. Since agents process a sort of human-like behavior, our approach is made taking as reference human communication characteristics through using role playing as metaphor. Therefore, we first analyze the characteristics of human communication, deriving role playing for linking ideas in the human world. By integrating with ACL mechanisms, we propose a framework to express communication mechanisms for exchanging message in a multi-agent framework called DIM-2. Finally, the framework is evaluated through an experiment. Also its computational feasibility of a support system for the distributed interactions is discussed in this paper.

1. Introduction

Design is a creative activity that depends on the evolution of many ideas, especially in the conceptual design stage. *Idea association*, originally identified by Ancient Greek, is an important behavior for generating diverse ideas. Linking ideas as the action provides an incremental interaction metaphor in the idea association process (Lai, 2005). Furthermore, such interactions involve different participants' idea interchanging (Osborn, 1963), which is called *interplay*. Through dynamic interactions among distributed knowledge, the interplay involves *distributed interactions* (Lai and Chang, 2005). According to different design situations, a designer while participating in the idea association process plays different *roles* to link his/her internal design knowledge and experience, as well as external participants' ideas. By

studying such distributed interactions via the view of roles, the theory of Role Play (Yardlet-Matwiejczuk, 1997) uses role playing in modeling psychological situations and provides a useful metaphor for understanding of the distributed interactions of idea association.

In the computational domain, software agents (simply called agents) can be thought of as a distributed computational system. With autonomous, reactive, and communicative behaviors, agents can autonomously participate in role playing to interact with internal and external design situations. For interplaying with different agents, agent communication is the key factor in the role playing. Basically, agent communication can be performed by exchanging information by means of well-formed speech acts (Searle, 1969). Agent Communication Languages (simply called ACL) have been proposed to express a full meaning of a message uttered, in term of sender intentions, information exchanged, symbols used, etc (Wooldridge, 2002). These components within ACL provide some computational mechanisms for agent communication for role-playing in the idea association process.

2. Linking Ideas in Two Interplays

As described above, the key for idea association is a method of linking human long-term memory to the ideas (Rapaport, 1974). Also, Osborn (1963) argued that the linking process also involves linking different participants' knowledge in a stimulated discussion among team members. Therefore, idea association involves dynamic interactions that participants *act* and *re-act* internal and external knowledge through a dynamic linking process. In the cognitive domain, the theory of Role Play mentioned before provides some important mechanisms for our realization of such interactions.

2.1. ROLE PLAYING

Role-play can be considered a way of deliberately constructing an approximation of aspects of a 'real life' episode or experience under acting/re-acting process (Chang, 2004). Chang and Lai (2004) summarize that there are three important mechanisms of role-play: *situation*, *engagement* and *scenario-based interaction*. The three mechanisms provide our understanding of the idea association process.

With situation, the linking ideas can be divided into a set of plays and interplay between internal knowledge and external knowledge. This leads to the scenario-based interaction that will be used as the model for describing the linking process of ideas. Engagement will be the concept for realizing the principles of linking different knowledge and the idea it is associated.

Following the concept of interplay, this can be further elaborated for the mechanism of linking.

2.2. TWO INTERPLAYS

Linking ideas, similar to role playing, is always engaging in the 'as-if' condition, and then act/re-act according to the internal design knowledge and external design situation (such as design task, design problem, time duration, participant number etc). Therefore, each role can interplay with itself, other roles and design environment (Chang, 2004). With the theory outlined by role-play, Lai and Chang (2005) identify the three important characteristics of role playing with respect to two interplays: *internal interplay* and *external interplay* (Figure 1). Through a linking process, participants can engage in linking ideas within the two interplays. The two interplays are described as follows:

1. External interplay: For generating ideas in conjunction with other participants' ideas, each designer (such as DRole_1) interplays with other participants (including DRole_2, DRole_3, DRole_4, DRole_5 and Director), as well as the external design situation. The interplay directly influences his/her role playing in the internal interplay.
2. Internal interplay: In the internal interplay, each participant (such as DRole_1) can play different roles (including Role_5, Role_1 and Role_3), and use different roles' design knowledge to link ideas to his/her long-term memory. According to design consonance (Lai and Chang, 2005), these participants always select the most connected ideas as the outcome in the two interplays described above.

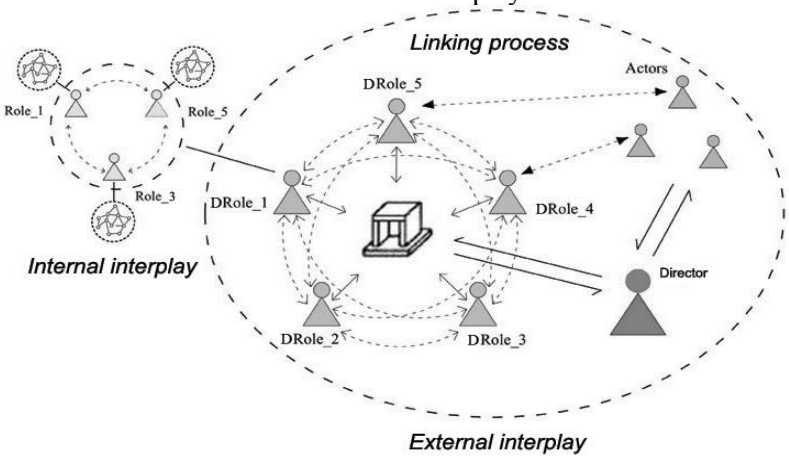

Figure 1. Two interplays in a linking process: internal and external.

The two interplays follow a sequentially ordered process for exchanging message. To avoid message confliction, only one participant can send the message to other participants (one or many) at the same time. Petrovic and Svetel (1994) argue that the relations of act/re-act of message exchange among participants include one-way and two-way. In one-way, while a participant sends the message to others, they just receive the message and have actions. In two-way, while a participant send message to others, they receive the message and have actions. Simultaneously, they send back another message for responding to the sender.

3. Agent Communication

While viewing agents as automatic knowledge entities, human designers as well as agents can play different roles, and then apply different design knowledge to link design ideas in the two interplays. For communicating with each other, the two interplays involve different communication mechanisms between these agents and human designers. The communication mechanisms can be reified through speech acts and agent communication language.

3.1. SPEECH ACTS

Speech act theory treats communication as action (Wooldridge, 2002). It is predicated on the assumption that speech actions are performed by agents just like other actions, in the furtherance of their intentions. Searle (1969) identified several properties that must hold for a speech act performed between a receiver and sender to succeed. Searle also attempted a systematic classification of possible types of speech acts, identifying the following five key classes.

1. Representatives: A representative act commits the sender to the truth of an expressed proposition, such as informing.
2. Directives: A directive is an attempt on the part of the sender to get the receiver to do something, such as requesting.
3. Commissives: Commit the sender to a course of action, such as promising.
4. Expressives: Express some psychology state, such as thanking.
5. Declarations: Effect some changes in an institutional state of affairs, such as declaring play.

The five types of speech acts provide some communication actions that correspond with the relations of act/re-act within the two interplays.

3.2. AGENT COMMUNICATION LANGUAGE

In the computational domain, multi-agent theory focuses on the communication among agents (Wooldridge, 2002). Speech act has directly influenced a number of languages that have been developed especially for agent communication, such as FIPA, KQML etc. Basically, ACL mainly composes of the *message content* (MC), the *sender* (S), the *receivers* (R) and the *communication intentions* (CI). The message content expresses the information exchanged. The sender is the creator of the message. For this reason, the receivers should know his/her identity for stimulating different behaviors. Several communication intentions (called performatives) for defining the intended interpretation of message according to five types of speech acts described above.

These ACL components provide our understanding the communication mechanism in the two interplays. Compared with KQML, FIPA provides more standard languages than KQML (O'Brien and Nicol, 1998). For standardizing the language for linking ideas among agents, FIPA is selected as our ACL for implementing agent communication for role playing in the idea association process.

4. Implementing Agent Communication in Two Interplays

In order to implement the communication mechanisms in a computational way, we use a multi agent framework called DIM-2 (propose by Lai and Chang, 2005) as the agent communication environment of the two interplays.

4.1. DIM-2: A MULTI AGENT FRAMEWORK FOR COMMUNICATION

DIM (proposed by Lai, 2005) originally is a case-based reasoning framework for supporting idea association in the early conceptual design stage. By integrating DIM with DARIS (proposed by Chang and Lai, 2004), DIM-2 is proposed for implementing distributed interactions of linking ideas. In DIM-2, there are five types of agent entities including the user agent (UA), the director agent (DA), the role agent (RA and RAS), the stage agent (StA) and the scene agent (ScA).

Through three interplay elements, the five types of agent entities involve dynamic interactions for linking ideas. The three interplay elements are *knowledge representation, linking principles* and *linking process*. Knowledge representation represents design ideas and memory organization within agents'. Linking principles provide the capability to allow agents to associate diverse ideas differently. Through linking process in the internal and

external interplays, these agent entities can dynamically interact various design situations.

4.2. MAPPING ACL COMPONENTS TO TWO INTERPLAYS

By mapping the ACL components to the communication mechanisms of the two interplays within DIM-2, a communication framework for role playing in the idea association process is proposed. The mapping methods are described in the following sections.

4.2.1. Sender and Receiver

Based on the communication mechanisms described above, sender and receiver are UA, DA, RA, RAS in the internal interplay. The relation of act/re-act between RAS, UA or DA is one-way. And the relation of act/re-act between RAS and RA is two-way. In the external interplay, sender and receiver are UA, DA, ScA and StA. The relation of act/re-act among them is mostly one-way.

4.2.2. Message Content

For linking ideas, there are different message contents in the two interplays. The internal interplay is to generate personal ideas of each user (including UA and DA). The message content includes role skill (rs), idea entity (ie), linking principle (lp) and role identity (ri). The external interplay is to generate public ideas of all users. The message content includes different design problem (dp), time duration (td) and role number (rn).

4.2.3. Communication Intention

Without criticizing any generated ideas in the idea association process (Osborn, 1963), the communication intentions between agents and human designers mainly compose of two classes of speech acts. They are representatives (such as *inform, failure, propose* performatives) and directives (such as *request*, *CFP* performatives). Besides, declarations class (such as *request-when*) provides an action to control time duration for linking ideas.

In final, the two interplay processes and their communication mechanisms described above can been seen in Table 1 and Table 2. For examples, step 1 in the external interplay, the sender and the receiver are DA and StA respectively. The message content includes roll skill, design problem, time duration and role number. For controlling the time duration of the play, the communication intention is request_when.

TABLE 1. External interplay process

	S	R	MC	CI
Step 1	DA	StA	rs, dp, td, rn	request_when
Step 2	StA	DA	I will start the external interplay	inform
Step 3	StA	ScA	rs, dp, td, rn	request_when
Step 4	ScA	UAs	rs, dp, td, rn	inform
Internal interplay in UA and DA				
Step 5	DA	ScA	Generating ideas	CFP
Step 6	ScA	DA	ie	propose
Step 7	DA	StA	ie	request
Step 8	StA	UAs	ie	inform

TABLE 2. Internal interplay process

	S	R	MC	CI
Step 1	UA	RAS	td, ri, lp, ie	request_when
Step 2	RAS	UA	I will start the internal interplay	inform
Step 3	RAS	RA	lp, ie	CFP
Step 4	RA	RAS	lp, ie	propose or failure
Step 5	RA	RAS	lp, ie	request
Step 6	RAS	RAs	lp, ie	inform
Step 7	UA	RAS	Generating ideas	CFP
Step 8	RAS	UA	ie	propose
Step 9	UA	ScA	lp, ie	request
Step 10	ScA	UAs	ie	inform

These communication mechanisms within the two interplays are implemented by using the Java Agent DEvelopment framework (JADE) with FIPA agent communication language. The reasoning engine we used for resolving and searching the suitable constraints over representation is JESS (Java Expert System Shell).

5. Experiment

For evaluating the agent communication mechanisms, we conduct an experiment involving three third year undergraduate students that use DIM-2 for linking ideas in different geographic location. The experiment concentrates on developing design ideas in the conceptual design stage. The design task is related to the spatial organization of a single-family row house design. Addressing a design problem of circulation, these participants (including

human and machines) participate in role playing for linking ideas in 20 minutes.

The three students are UA_1, UA_2 and UA_3. Each student should select three different RAs for role playing in his/her internal interplay. UA_1 also is the DA guiding the whole process of the play. Basically, in DIM-2 environment, students use several interfaces supported by JADE to input related message contents through the following three steps.

1. Initializing the play: each student should insert his/her selected RAs' identities, and connect their agent platforms through HTTP Message Transport Protocol. Also UA_1 needs to insert StA and ScA.
2. Editing the script: Only UA_1 can edit the script through inputting message contents of StA and ScA in the external play (seen in Table 1).
3. Generating ideas and links: each student inputs related message contents for role playing (seen in Table 2) to generate ideas and links in the two interplays.

During the linking process, the agent communication and their message exchange in the two interplays can be visualized through an interface in DIM-2 environment seen in Figure 2. Also, the design outcome (called idea map) composed of several idea nodes and links between them that can be automatically demonstrated through a graph visualization interface.

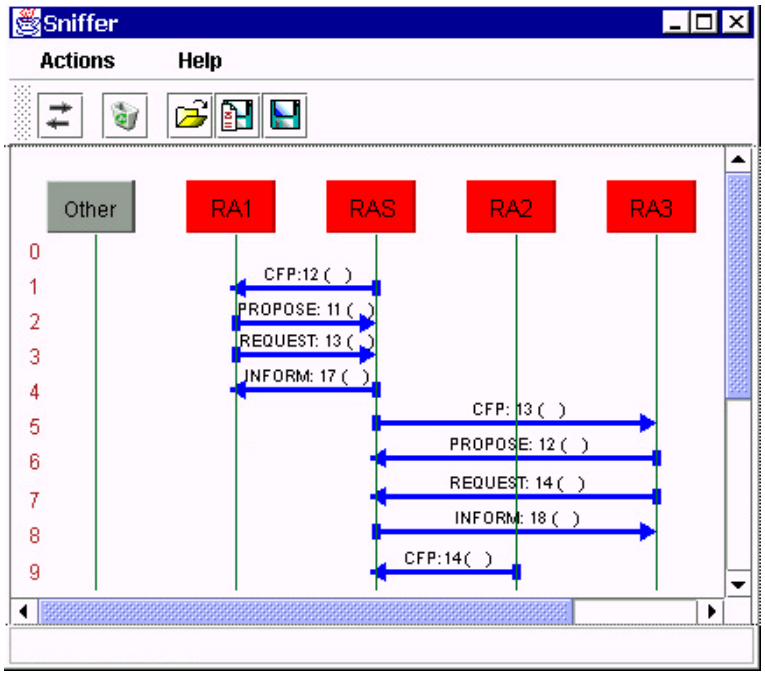

Figure 2. The interface for visualizing agent communication of UA_1 internal interplay

6. Discussion and Conclusion

Through the design experiment, using the ACL components can effectively computerize the communication mechanisms within the two interplays. Besides, different types of speech acts play an important role for acting and re-acting between agents and human designers. Some advantages of the communication framework can support distributed idea association under real situation as described below:

1. Distributing multiple participants' interactions: The two interplays involve three types of participants' communication: human-to-human, human-to-machine and machine-to-machine. It will therefore be helpful for distributed interactions of idea association.
2. Connecting the blocked linking process: Through dynamically changing the relations of ACL components, the blocked linking process can be connected automatically in different ways. They are idea combination and idea passing in the external and internal interplays respectively.
3. Recording the communication process: In DIM-2 environment, the communication process in the two interplays can be recorded dynamically. It either provides agents' learning or allows human designers to re-use the process for linking and generating ideas.

In addition, Chang (2004) argues that interplay can be visualized in four network topologies: ring, star, peer-to-peer and cluster. By creating different containers and platforms, JADE provides some partition mechanisms for organizing multi agents' communication dynamically. Thus, our future study will explore different network topologies for agent communication in the two interplays through integrating the partition mechanisms with role playing. Following the development of the communication framework, an essential prerequisite of preparation for supporting distributed interactions in creative problem solving meetings can be established.

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