An Expressive Conversation Language for Artificial Agent of Mixed Community

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Abstract

Those languages currently used in Agent Communication were made to be used by artificial agents only, essentially with the aim of exchanging knowledge. This paper considers mixed multi-agent systems (or communities) composed of human and artificial agents. We put forward an Expressive Conversation-Language that enables agents to form expressive dialogues; mainly deliberative dialogue such as negotiation, advice seeking, bargaining and setting up appointments. Thirty two expressive conversation acts have been formally defined. These are basic acts of conversation, such as giving and requesting information, but also promising, suggesting or asserting etc. which confer artificial agents with advanced language skills.

1. Introduction

Those Agent Communication Languages (ACLs) traditionally used in agent communication, such as KQML[1] and FIPA ACL[2], typically assume that agents of the system are artificial and that the main objective is knowledge exchange. However, if we consider those Multi-Agent Systems involving humans, *i.e., mixed communities*, then artificial agents require a new conversation language which enriches their communicational abilities so that they may participate in exchanges of ideas, bargaining sessions or planning. This article proposes an *Expressive Conversation-Language* aimed at artificial agents within a mixed community. This idea roots in Speech Acts theory[10, 11, 14], a validated theory of human interaction. ACLs are equally based upon this theory. Our intention is to enable artificial agents within a mixed community to function in a more advanced way that corresponds to the philosophical, psychological and lingis-

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[1]Knowledge Query Manipulation Language

[2]Foundation for Intelligent Physical Agent

tic realities of communication.

This paper first discusses the issues of the interaction of artificial and human agents in accordance with Speech Acts theory. We then put forward our definition of an *Expressive Conversation-Language* with thirty two expressive conversation acts, of which three are described in this article.

2   Agent and Communication models

The BDI agent model roots in Bratman[4]'s philosophical research into the inclusion of intention in action theory which is currently fundamental for modelling actions. However, although this action theory is applicable to traditional actions, conversational actions, *i.e., speech acts*, require a more specialised approach, like that laid out in Speech Acts Theory, the theory of human language use which stems from ordinary language philosophy [1, 10].

Speech Acts theory constitutes the philosophical basis of those languages used in ACLs, but they only define a limited number of task-oriented language primitives. As Traum[13] remarks, these languages were deliberately limited out of a desire for simplicity in the management of interactions, like information exchange. Thus, clearly, these languages were not intended to be suitable and are indeed unsuitable for those exchanges requiring constant interaction following a dialogue pattern. In Singh[12], alongside Chaib-Draa and Dignum in [5] advances this opinion. Those agents that use ACLs can essentially *inform* or *request*. Indeed they cannot produce declarative, commissive or expressive speech acts such as *guaranteeing, accepting, or apologising*. Interactions are likewise strictly controlled and occasionally counter-intuitive. According to Singh, it is necessary to take social aspects into account and to progress from *mental agency* to *social agency* in order to consider the agent's social surroundings.

Therefore, we propose to take up Speech Acts Theory but to dig deeper than it has been done, with the intention

of involving rational artificial agents in conversations with other agents including humans, and allowing them greater interpretative and expressive autonomy.

The dynamics of agent interaction is traditionally determined by protocol. For some years now, certain dynamic protocols have been developed to allow more flexibility within the interactive flow [3]. Among these dynamic protocols, those based upon social commitments have facilitated the treatment of actions in terms of commitments and not only as mental states.

However, all of these models for the dynamics of interaction are restricted by their merely global treatment of dialogue. Yet, as we will see, dialogue also works on a local level, whereby each processed utterance creates expectations on the subsequent speech turns, thereby endowing the exchange with a natural rhythmn. Baker[2] clearly insists upon the existence of these two fundamental levels which constitute dialogue. This local level is intrinsic to Speech Acts Theory. We do treat dialogue according to both levels. When concerned with its globality, we fall back upon Vanderveken's dialogue typologies[15].

In the following section, we briefly review Speech Acts Theory and its advantages when it comes to defining an Expressive Conversation-Language, as well as in considering the local level in the rules of interaction.

3   Speech Acts Theory

According to Speech Acts theory, the primary units of meaning of a natural language are illocutionary acts. Elementary illocutionary acts are of the form *F(P)* whereby F is the illocutionary force and P is the propositional content.

The illocutionary force *F* can be broken down into six components, which define those conditions that must be fulfilled so that the speech act should be performed with success and satisfaction: the illocutionary point, the mode of achievement, the degree of strength, the conditions that relate to the propositional content, the preparatory conditions and the conditions of sincerity. From the definition of these six components, all of the performative verbs of any natural language can be obtained. These performative verbs are organised into five different categories : assertives (description of the world), directives (direction of someone), commissives (commitment), declaratives (declaration), and expressives (expression of feelings).

Illocutionary acts are not only concerned with truth conditions, as is in classical philosophy, but also with succcess and satisfaction ones. Indeed, like all human actions, illocutionary acts have success conditions because they can be successful or not. Illocutionary acts also have satisfaction conditions because they are affected by situations over which the speaker has no control . Thus, an act which has been performed with success may not be satisfied. The con-

ditions of success must be fulfilled in the context of utterance for the speaker to perform the speech act successfully. The conditions of satisfaction must be fulfilled in the context of utterance for the speaker to perform the speech act with satisfaction. Satisfaction conditions can also generate expectations about future speech turns.

These success and satisfaction conditions, related to the performance of speech acts, are fundamental in our research. They allow a treatment of utterances that works as much at a local level as at a global level in situations of interaction whereby the exchange of agent intervention is not predefined, nor determined according to a specific protocol. We therefore propose to integrate the success and satisfaction conditions where traditional ACLs do not. The recent research performed by Elio and Petrinjak[8] likewise integrates the conditions of success (although not the conditions of satisfaction) in ACLs communication acts.

The wealth of Speech Acts theory also lies in its rigorous formalisation that stemmed from illocutionary logics [11] and the general semantics of Vanderveken[14]. However, because this formalisation is not computational, Chaib-draa and Vanderken worked on a recursive semantics based upon success and satisfaction conditions in order to improve KQML. The idea presented in this paper stems from their work.

4   An Expressive Conversation Language for agents

In Chaib-draa and Vanderveken[6], the authors propose a recursive semantics based upon the success and satisfaction conditions as defined by Speech Acts theory. They use the situations calculus which enables the formulation of utterances strongly dependent on their context. The authors introduced a set of logical relations in order to construct this semantic system: belief, desire, goal (a non-primitive operator, contrary to that of Cohen and Levesque [7]), capability, commitment, planning, intention defined on the basis of commitment and planning, and obligation in accordance with a given norm. These operators permits the expression of acts and their success and satisfaction conditions for each type. It is therefore possible to express the wide range of nuances offers by Speech Acts theory, and thereby to express all of the elementary *performable* illocutionary acts.

The recursive semantics of Chaib-draa and Vanderveken establishes then a compromise between philosophical theory and computational agents from which we put forward the definition of an *Expressive Conversation Language*.

4.1   Presentation of the language

Our *Expressive Conversation Language* presents itself as a set of conversation acts (32 acts) which we have isolated.

Our choice was made according to the definitions of performative verbs given by Vanderveken in [14]. We first selected those performative verbs which are intuitively relevant to the conversation conditions which interest us. This selection may be modified or developed; its validity is currently being tested through the analysis of conversation corpus in targeted situations. The selected conversation acts are the following:

- assertive: confirm, deny, think,say, remember, inform amd contradict,

- commissives: commit oneself, promise, guarantee, accept, refuse, renounce and give,

- directives: request, ask a question, suggest, advise, require, command and forbid,

- declaratives: declare, approve, withdraw, cancel,

- expressives: thank, apologise, congratulate, compliment, complain, protest, greet.

As we will see, we define the conversation acts with their success and satisfaction conditions and we explicitly introduce elements from the conversational background. Amongst those elements that an agent must consider during the analysis and the interpretation of Speech Acts, the degree of strengh expressed in the act and the role of the agent are certainly the most important. Indeed they are necessary in order to contextualise the interpretation of an act: the degree of strengh for quantifying the amount of insistence with which an act is expressed and the role for those interactions whereby a hierarchy is taken into account in the performance of an act. The examples will show how these two variables are taken into account. The degree of strengh and the role of the agent will be expressed merely by relative whole numbers, representing a gradient in the force of the act and equally in the role (hierarchy, authority, etc). Particularly in terms of the role, more detailed information relating to certain elements can thereby be provided in order to meet specific requirements. For instance, by this means, it could be beneficial to introduce emotional aspects which convey agent-specific information such as profile and temperament (authoritative, conciliatory, patient etc) which are necessary in the case of a rational, contextualised reasoning.

Being able to check the success and satisfaction conditions of illocutionary acts is essential to a conversational agent because the successful performance of an act depends upon them. It is these conditions which will create the dynamics of the dialogue on a local level, by creating expectations on the subsequent situations of utterance. These expectations will affect the agent's behaviour and his future actions. For instance, in the case of a command (which is only satisfied if it is obeyed), an expectation is established: the expectation that the action will be completed (expressed by the propositional content). Likewise, in the case of a promise (which will only be successful if the speaker sincerely commits him/herself to completing a given action), the expectation will constitute a list of commitments (comparable to Maudet and Chaib-draa's *commitment stores*[9]) which can be checked up on in subsequent situations.

As far as the global level is concerned, it is not internal to language but inherited from the typology of dialogues [15] and dialogue strategies. This aspect is not presented in this article.

Note: The expressions $\frac{wd}{wl}$, $\frac{wl}{wd}$, ϕ for the satisfaction conditions indicate the direction of fit of the illocutionary point, respectively from world to words, and from words to world and zero direction of fit [3]. This *parameter* gives the direction in which the act applies.

4.1.1 Promise

In order to illustrate the wide range of possibilities accorded by our model, the following is an example of the illocutionary act *Promise* which does not exist in traditional ACLs. The definition of *Promise* will be the following:

$$
\begin{aligned}
s &= do(says.to(i, j, \langle promise, p \rangle), s_u, 0, 0) \\
\text{with} &\quad (\forall p')(\forall a)(p \Rightarrow a)(\forall s')(s' \succ s) \\
s_u &= bel(i, can(i, a, p')[s] \wedge bel(i, Poss(i, a)) \\
&\quad \wedge wish(j, p)[s] \wedge int(i, do(i, a))[s'] \\
\text{and } s' &= a[s'] \wedge p[s']
\end{aligned}
$$

We can add to this definition the act's performance conditions (of success and satisfaction):

$$
\begin{aligned}
success(says.to(i, j, \langle promise, p \rangle), s) &\equiv \\
cond.success(\langle promise, p \rangle) &\quad [s] \\
satis_{wl}^{wd}(says.to(i, j, \langle promise, p \rangle), s) &\equiv \\
(\exists s', s'')(s'' \succ s' \succ s)Poss(a, s'), ..., Poss(a, s'') &\wedge \\
success(says.to(i, j, \langle promise, p \rangle), s'') &\supset \\
p[do(a, do(a, do(a, s'')))]
\end{aligned}
$$

This conversation act *Promise* is dependent upon those preconditions defined in the situation of utterance s_u and has an effect upon the subsequent situations s'. This effect can be verified by the agent during the rest of the dialogue. The conditions of success should be verified by the *cognitive* state of the agent. *Promise* as an act of conversation will therefore be accomplished if and only if: The speaker *i* has achieved the commissive illocutionary point of promising indicated in the propositional content *p*; with the specific mode of achievement which consists in committing oneself to performing *p*; with the condition upon the propositional

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[3]In the case of declarative acts, the direction of fit is dual. We will not pursue this further in this article

content that p, which represents a future action to be performed by i, is realised in a subsequent situation by means of i's performance of the action a, implied by the propositional content; i works on the assumed preparatory condition that he/she is capable of performing [4] the action implied by p and that j has a need for it; i expresses this act with the number 2 (strong) degree of strength; and with the specific condition of sincerity that i sincerely desires that p is realised through an action.

There must be identity between the situation of utterance s and the act's conditions of success in order for it to be completed successfully.

Lastly, the conditions of satisfaction for this illocutionary act must be verified not only with the *cognitive* state of the agent, in other words according to the conditions of success, but equally in accordance with the following situations (considering first of all that which immediately follows) resulting from the act.

Promise will be satisfied if and only if: the action a implied by p is actually possible in the subsequent situation(s); the illocutionary act is first completed with success in s; and i realises p because of his performance of the action a in subsequent situation(s).

The definition of the conversation act *Promise* gives a glimpse of those acts which are of a commissive nature and which can be expressed in our conversation model. Commitments are thus treated as conversation acts and are therefore situated in a wider system than that provided by dialogue models based upon social commitments.

4.1.2 Complain

In this Expressive Conversation-Language, agents may also express their feelings and their attitudes. Thus, they may equally *understand* when an agent produces any expressive conversation act and consequently react. Expressive conversation acts have zero direction of fit which enables the expression of *internal* attitudes.

Complain will be formally defined as an Expressive conversation act as follows:

$$
\begin{aligned}
\text{with} \quad & (\forall p)(\forall i,j) \\
s \;=\; & do(says.to(i,j,\langle complain, p\rangle), s_u, 0, 0) \\
\text{with} \quad & (\forall p')(\forall a)(p \Rightarrow a)(\forall s')(s' \succ s) \\
s_u \;=\; & \neg wish(i,p)[s] \\
\text{and } s' \;=\; & \phi
\end{aligned}
$$

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[4]The verb *perform* is used in accordance with Speech Acts theory.

The performance conditions will be:

$$
\begin{aligned}
success(says.to(i,j,\langle complain, p\rangle), s) \;\equiv\; & \\
cond.success(\langle complain, p\rangle) \quad [s] & \\
satis_\phi(says.to(i,j,\langle complain, p\rangle), s) \;\equiv\; & \\
success(says.to(i,j,\langle complain, p\rangle), s) \;\supset\; & \\
m(i,p)[do(says.to(i,j,\langle complain, p\rangle) \quad , \quad s_u)] &
\end{aligned}
$$

The expressive conversation act *Complain* indicates a state of affairs whereby the (true) proposition p is undesirable for i in an *affective* sense, expressed by zero direction of fit. The conditions of success and satisfaction for expressive conversation acts have the same role as other types of acts. However, to satisfy an expressive act, the agent must, in the situation of utterance, express the attitudes signified by m. An artificial agent is unable to lie, here as elsewhere, but a human agent can lie and his artifical agent partner will have no way of knowing this unless it has prior information. We therefore assume that human agents will be sincere when dealing with artificial agents. Expressive acts are particularly useful when applied to animated or embodied conversational agents.

4.1.3 Inform

We have chosen to present *Inform* as an essential example.

In Speech Acts theory, unlike the communication act *Inform* in FIPA ACL, the performative verb *Inform* is not a primitive but an assertive verb, expressing a number 2 (+2) degree of strength. It is comparable to the primitive verb *Assert* because it is not only a case of asserting a proposition p but it also means believing the proposition (and having reasons to believe) and believing that the hearer does not already know it and therefore having the intention of making him believe it. We consider here that the agent's role is neutral (value 0) and therefore not relevant to this example.

We therefore obtain a speech act in its own right, in a given situation s which is defined in the following way:

$$
\begin{aligned}
s \;=\; & do(says.to(i,j,\langle inform, p\rangle), s_u, 2, 0) \\
\text{with} \quad & (\forall s')(s' \succ s) \\
s_u \;=\; & bel(i,p)[s] \wedge bel(i,(\neg bel(j,p)))[s] \\
& \wedge int(i, bel(j,p))[s'] \\
\text{and } s' \;=\; & bel(j,p)[s']
\end{aligned}
$$

The conditions of performance will then be:

$$
\begin{aligned}
success(says.to(i,j,\langle inform, p\rangle), s) \;\equiv\; & \\
cond.success(\langle inform, p\rangle) \quad [s] & \\
satis_{wd}^{wl}(says.to(i,j,\langle inform, p\rangle), s) \;\equiv\; & \\
p[s] \wedge p[s_u] \quad \wedge \quad bel(j,p)[s'] &
\end{aligned}
$$

The conditions of success for this speech act should be verified with the cognitive state of the agent. The conversation act *Inform* will be performed successfully if and only if: The speaker i has achieved the assertive illocutionary point of informing what is expressed in the propositional content p; with the specific mode of achievement of wishing to inform the hearer j about p; with the propositional content condition that p should be true in the given context; i assumes the preparatory condition that the hearer j does not know p; i expresses this speech act with the number two (strong) degree of strengh; the speaker i is sincere.

Finally, the conditions of satisfaction for this illocutionary act should be verified in the following situations, starting from the next complete state of the world resulting from the speech act. The conversation act *Inform* will then be satisfied if and only if: p is in fact true in situation s, and j believes p because of i's performance speech act.

As a comparison, it is significant that in the definititon of *Inform* given in FIPA ACL, this communicative act is always performed flawlessly because it has no conditions of success nor satisfaction, but only preconditions and effects. This way of functioning is deemed insufficient for conversation between humans and agents when one is familiar with the mechanisms presented above. It equally gives rise to errors and misunderstandings even within communication protocols. It is this that inspired Elio and Petrinjak [8] to add conditions of success to ACLs.

5   Conclusion and future work

This paper focusses on the definition of a new language, an *Expressive Conversation-Language* for rational agents within a mixed community. This language bases itself upon Speech Acts theory and Discourse typologies in order to propose the introduction of success and satisfaction conditions in the definition of language so as to employ the two fundamental levels of dialogue which come into play in the expression and comprehension of language in a conversation.

From a technological point of view, we are currently developing a mock-up of a conversational agent to be applied to e-business. The role of this agent is to help a human agent, by means of dialogue, to make purchases on the internet. During the dialogue the agent identifies the human's wishes in order to orient him towards the best choice. This type of dialogue is strongly task-oriented because it depends on the agent's role. Consequently, in accordance with discourse typology, we will only deal with deliberative dialogues of all kinds: deliberations, bargaining sessions, negotiations etc. Thus, the object of the dialogue will always be to choose or decide, and in the dialogue most of the conversation acts will be directive or commissive yet without excluding other types, in particular expressive acts, which can be found in all types of dialogues.

Besides *simple* conversational agents, we will also be looking into animated or embodied conversational agents (ECA) which are depicted graphically and whose profile or attitudes (facial expressions or gestures) can affect their way of *speaking*. They may possess the *desire* to pursue a conversation or to end it abruptly. Thus a co-operative agent will always try to reply and to make his answers as complete as possible (eg. by giving additional information on the product).

Our mock-up is currently making itself known. It has already enabled a representation of both fundamental levels of dialogue and has validated the choices that were made when defining the Expressive Conversation-Language.

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