Using Speech Acts and Agent Architecture to Support Successful Stakeholder Requirements Negotiation

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Abstract

Speech act theory has been used on numerous occasions to create an underlying framework on which communication technologies can be built. Electronic mail filtering methods, communication support tools and modelling techniques using several variants of speech act theory have all been proposed in the last few years. Distributed organisations employ various communication methods in order to share knowledge around the globe; however many of the techniques are asynchronous, time consuming and culturally dependant. This is further exacerbated when conducting projects in such an organisation, that stakeholders are globally distributed and different business and social norms are employed. By applying various speech act theories and using BDI architecture as a framework, it should be possible to create an agent negotiation architecture especially for distributed organisations. This will allow stakeholders enter their project requirements quickly to reach agreements through negotiation, which allow projects to run smoother, faster, with less ambiguity in stakeholder requirements.

Keywords: Speech acts, Requirements negotiation, Agents, Distributed organisations, Stakeholders

1 INTRODUCTION

Most software projects can not meet all their cost, schedule, quality, or requirements objectives. Although the reasons for project failure are often known, project success rates are still very low. According to the Standish Group [1], only about one-sixth of all projects in the United States were completed on time and within budget, nearly one third of all projects were cancelled outright, and well over half were considered "challenged." This is similar to the findings that Taylor reports, revealing that from 1027 IT projects only 12.7% were considered successful [2].

There are many reasons for project failure ranging from poor stakeholder input and stakeholder conflicts, to ambiguous requirements and poor project management. However all these problems are exacerbated when conducting a project in a distributed organisation. Other issues such as the distance between stakeholders, different working culture and business norms and the time zones occupied by the stakeholders all have to be taken into account as well as the common complaints already mentioned. One of the main reasons for project failure cited in the Chaos report for project failure was ‘user requirements’. By creating an agent framework which will target resolving requirement ambiguities, we hope to provide a quick, yet affective way of negotiating stakeholder requirements in distributed organisations. This should lessen the probability of project failure and increase the chance of project success.

Speech act theory has been found to be increasingly applicable to software design [3]. It has been suggested that the repertoire of speech acts used in electronic communication is close to that of human speech. By using various speech act theories to create an agent negotiation framework, it should be possible to provide an effective and efficient method of requirements negotiation for distributed organisations. This paper aims to illustrate the positive impact speech acts can have on project success by applying agent technology.

2 SPEECH ACT THEORY

Although there is no de facto definition of what classifies as a 'speech act', it is widely accepted that a speech act is an act of communication. The original speech act theory was developed by Austin [11] in 1962 which aimed at developing a sound theory of language. His work was extended by Searle [12] [13] who stated that a speech act (illocutionary act) 'forms the minimum meaningful unit of language and consists of three individual components: a context, an illocutionary force and propositional content. The theory of speech acts distinguishes between illocutionary acts, such as telling someone something, and perlocutionary acts, such as convincing someone of something. The illocutionary force consists of an illocutionary point e.g. the 'purpose' of the speech act as well as strength of point, sincerity conditions and the strength of these conditions. Searle then goes on to classify the illocutionary acts into five distinct categories [13].

1. Assertives – e.g. The speaker commits to something being the case
2. Directives – e.g. The speaker attempts to get the hearer to do something
3. Commisives – e.g. The speaker commits themselves to a future course of action
4. Expressives - e.g. The speaker expresses a psychological state such as feelings or attitudes
5. Declaritives – e.g. The speaker brings some new state into the world

Although Searlean speech act theory is still widely reviewed and built upon, criticisms have been levelled by various academics that Searle's theory fails to describe reasons for carrying out the requested actions, i.e. the distinction between empirical and rational coordination of action. Habermas suggests that in strategic action, participants are motivated by their own private goals [15]. They may compete or cooperate, but even when they cooperate they do it only to strive towards their own goals. In general, speech acts are acts of communication. To communicate is to express a certain attitude, and the type of speech act being performed corresponds to the type of attitude being expressed. By using speech act theory to create a high level agent architecture for requirements negotiation, the process should be both flexible and easy to catch any errors that occur.

3. AGENT TECHNOLOGIES

Although there is no industry accepted definition of the term 'agent', there are industry standards of what qualities one should possess in order to be called an agent in the first place. The agent must be capable of autonomous action in order to meet its goals and objectives e.g. the system should be able to act without the direct human intervention (or other agents), and should have control over its own actions and internal state [4]. An agent should also be flexible, a quality which is highly valued in distributed organisations. Being flexible, the agent should be able to perceive their environment and respond in a timely fashion to changes that occur in it as well as being proactive in that environment. This means agents should be able to exhibit goal-directed behaviour and take the initiative where appropriate. Agents should be able to exhibit social behaviour when trying to reach their own goals and also when trying to help other agents in their problem solving activities. Agent facilitated negotiation has greatly researched in the past 10 years [5] [6] [7]. However, in recent years, many researchers and practitioners have focused on the design of market architectures for electronic commerce, and on protocols governing the interaction of self-interested agents engaged in such transactions. Other areas which have been focussed on include agent based supply chain management systems, third party mediation methods and online auctions.

The use of agents for online negotiations in various markets has been a well researched area in recent years. However, despite numerous advances in agent technology, there is still no industry wide agreement on what 'negotiation' actually means.
'Negotiation is a process of joint decision making between two or more parties in an effort to resolve their conflicting demands' [8].

'Negotiation is the process during which participants communicate with one another to come to a mutually acceptable agreement on any matter' [9].

'Negotiation is a basic mechanism for interaction that allows the members in a multi-agent system to coordinate their actions and reach a favourable agreement' [10].

By reviewing the recent literature that has been published in the agent domain, it is clear to see that there are certain keywords in all negotiation definitions that are vital for negotiation to take place. Therefore, rather than produce yet another definition for 'negotiation', we will attempt to identify the vital elements for negotiation to take place using various speech act concepts and theories, then suggest a suitable framework for agent based negotiation for project requirements.

3.1 Elements needed for negotiation to take place

1. There must be 2 or more entities wishing to enter into a negotiation.

For any negotiation to happen, there must be 2 or more entities willing to negotiate over some information (i.e. a price, a time, a requirement) Should only one entity wish to negotiate, nothing will happen as no other entity is willing at that time. Using Searle's' classification of a speech act, we can identify the three components needed, the context, the illocutionary force and the propositional content. The context of the speech act is concerned with the following attributes; the speaker, the hearer , the time and place and the possible world/ environment in which the speaker resides. As our research focuses on agent technology, both the speaker and the hearer are agents taking part in the negotiation process. The negotiation takes place as soon as the stakeholder has finished entering their requirements into the agent which resides on the stakeholders computer.

Context
Speaker : Agent #1
Hearer : Agent #2
Time : When stakeholder has finished entering requirements into the agent
Place : On the stakeholders computer

The illocutionary force consists of many attributes. The illocutionary point shows the purpose of the speech act e.g. to assert or direct oneself. The mode of achievement of the illocutionary point, demonstrates how the speaker will perform the speech act, e.g. humbly ,arrogantly or as a peer on an equal basis. The strength of the illocutionary point differs, depending on whether the speakers asks, or commands the hearer to do something whereas the preparatory conditions state whether or not the speaker has the power to command. The propositional content conditions refer to whether or not the speaker has asked the hearer to do something impossible e.g. draw a circle with 3 sides. Sincerity conditions, on the other hand, refer to whether or not the speaker intends to do what he/she promises. For example, saying ' I will give you a million pounds' may be taken as very insincere due to the amount of money being offered, however ' I will lend you five pounds' , may be viewed as a more sincere promise. The strength of the sincerity conditions illustrate to what extent one believes in what one says, as the speaker may not necessarily believe what they are saying.

The following example illustrates one of the first actions that an agent performs in the negotiation process; when the agent searches proactively for another agent to enter into negotiation.

Illocutionary force

Illocutionary point: Directive - to ascertain whether another agent is willing to enter into negotiation
Mode of achievement: As a peer
Strength of Illocutionary point: Asking (as opposed to a command)

Preparatory conditions: Any agent can ask to enter into negotiation with any other agent
Propositional content conditions: The agent must ask a valid question
Sincerity conditions: The agent cannot ask to enter into negotiation with another agent unless it has requirements to negotiate with.
Strength of sincerity conditions: The agent believes that it wants to negotiate with another agent.

The act of one agent asking another agent to enter into negotiation with it, can be classified as a 'directive' as the speaker (Agent #1) is attempting to get the hearer (Agent #2) to do something (enter into negotiations). When Agent #2 does respond to Agent #1, it will be a commissive illocutionary act with the possibility of also being declarative. Should Agent #2 not be busy e.g. negotiating with another agent, and has requirements to negotiate with, Agent #2 will commit to entering into negotiations with Agent #1 as it helps both agents reach their goals i.e. negotiate with all available agents and prioritise the stakeholders requirements accordingly.

2. Decisions must be an acceptable outcome for both / all parties

If no entities are willing to make decisions, the negotiation will never get started and therefore no parties will achieve their goals or even a suitable compromise. When certain parties make decisions based on the information around them, this should have a 'knock on' affect for all the other entities and other decisions will be based on the decision just made by one particular party. In order for one agent to enquire as to another agents availability, it must display both social and proactive behaviour, else all agents would remain in a static state and no negotiations would happen. The focus of Searlean speech act theory is on the speaker, or in this case, the 'agent'. The success of a speech act depends on the speakers ability to perform a speech act that should be understandable and successful [15].

KQML or the Knowledge Query and Manipulation Language is a language and protocol for exchanging information and knowledge. It is one of the more popular languages used between agents [16] [17] [18], it is both a message format and a message-handling protocol to support run-time knowledge sharing among agents. KQML can be used as a language for an application program to interact with an intelligent system or for two or more intelligent systems to share knowledge in support of cooperative problem solving. In the definition of the success of the speech act [15] both the speaker's and the hearer's view have to be considered. The success of the speech act requires that both have a shared understanding of the context, that the speaker succeeds in performing an understandable and valid speech act and that the hearer understands the content and accepts its validity claims.

To have a shared understanding of the context, all requirements must be documented in the same way and in the same language, thus reducing the possible problems of the agents not being able to communicate with each other. Speech act theory can also be applied to the human 'agents' of the project e.g. both the stakeholders and the project team. The hearer must have the same understanding as the speaker when the speaker is communicating information, else the meaning is lost. Requirements ambiguity is a problem because different readers of the requirements specification may understand different things. If the project team's understanding of the document differs from that of the stakeholders, then the stakeholders are likely not to be satisfied with the implementation by the project team. Ambiguity can increase when conducting a project in a distributed organisation. Due to different organisational norms , the same term can be interpreted in different ways by different stakeholders. This can cause problems in the later stages of the project life cycle as misunderstandings over what is meant and what is interpreted can cause requirements to not be fulfilled. Therefore each requirement entered will be spell checked and keywords identified. Should an agent believe that a word is a 'keyword' the agent will ask the stakeholder to classify what they mean and the explanation will be stored in an online glossary. This allows both the project team and the stakeholders to see how other people understand certain terms and any inconsistencies can be identified quickly and discussed early in the project life cycle.

3. Basic goals must be agreed upon before negotiation takes place

Boehm argues that there is no complete, objective set of requirements in an environment which are waiting to be written down [14]. Instead, as a project proceeds, both the project team and the stakeholders learn what is desirable and thus the requirements evolve. If all parties willing to negotiate have not agreed upon their goals before entering into the negotiation process, they will have no idea whether or not what they are agreeing to is for their good. Therefore all stakeholders should have a basic idea of what they want to achieve before they agree to enter into negotiation with the various parties in the system. All agents will have the same goal; to negotiate with as many other agents as possible and negotiate the priority of their requirements against the requirements priority of the other agents. When two agents have entered into negotiation and have both reached a mutually satisfactory agreement both agents will keep a record of their negotiation and assert that no more negotiations need to be conducted between them with that particular requirement

4. AGENT NEGOTIATION FRAMEWORK

We shall include the intricate low level negotiation protocols, rather than focus on the high level requirements framework. Once this has been validated we can then progress, using the framework to implement the protocols needed for agent requirement negotiation to take place. Figure 1. shows the sequence of actions that take place once the stakeholder has entered their requirements. Agent #1 accepts all the stakeholders requirements and locates another agent who may be willing to enter into negotiation. Agent #1 enquires as to whether that agent is 'free' i.e whether it has requirements and is not in negotiation with any other entity. The speech acts that will be incorporated into the framework are listed below:

1. Commitments - A simple promise can be classed as the commitment to perform an action. When an agent agrees to enter into negotiation with another agent, that commitment must be honoured.
2. Assertions- When an agent asserts a statement, it assumes that statement to be true. For example, an agent would not enter into negotiation with another agent unless it was free and had requirements to negotiate with. When an agent asserts 'I am free' it allows other agents to negotiate with it.
3.Questions - Agents can question each other as well as users questioning the agents. Agents can ask other agents if they are free to enter into a negotiation state, then the agent who is asked can assert a 'yes' or a 'no'.
4. Answers to Questions - When agents answer a question they assert a statement they believe to be true. There should always be an answer to a question. Should the agent ask a question and not receive an answer, the agent may wait for a period of time before trying again.
5. When the agent has finished negotiating with the other agent, they both 'flag' each other e.g. note who they have negotiated with, so that they do not enter into negotiation with the same entity again.

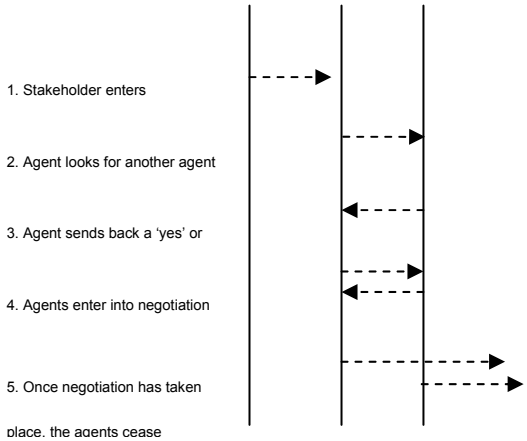

Figure 1. Sequence diagram showing first stages of requirements negotiation

Not all speech acts that occur will be discussed or used in the framework. No expressive illocutionary acts will be modelled as such agents cannot express a psychological state e.g. feelings or attitudes. Strength of sincerity conditions will not be used in the framework either, since agents can either assert or not assert a statement

Figure 2. illustrates the information that is required as an input to the agent and who supplies that information. On the left of the diagram, it is clear to see that the stakeholder enters the following information into the agent; the title of the requirement, the short text (e.g. the requirement detailed very briefly) , the full requirement specification , the priority of that requirement and any dependencies that requirement has on other requirements. The project team will enter the stakeholders rank into the agent (e.g. how important the stakeholders requirements are to the project compared with the rest of the stakeholders) and the stakeholders ID, so that after the negotiation process , the project team can see where each requirement originated from. After all negotiations are over, the agents will present the project team with a list of all the stakeholders prioritised requirements , which the project team can then discuss with each individual stakeholder.

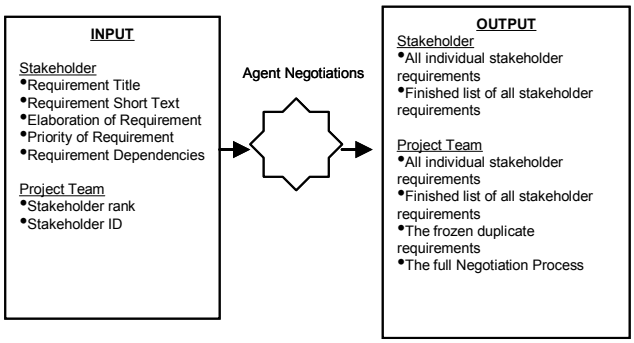

Figure 2. The information inputs and outputs of the negotiation process

5. POST-NEGOTIATION PROCESS

It must be made clear that although this method should produce unambiguous, prioritised requirements from stakeholders globally distributed, this method is not meant to be used on its own, rather a compliment to other requirements prioritisation methods already used in industry. For example, once all the stakeholders have entered and prioritised their requirements, the agents will then take over and hopefully be able to negotiate with other agents to produce a requirements list satisfactory to all stakeholders concerned. However, several modern software engineering processes [19] [20] advocate an iterative life-cycle approach. This involves that the set of requirements are refined throughout the system life-cycle. Therefore the requirements entered into the agents at the beginning of the life cycle will almost certainly end up being changed and altered as the project progresses. Discussions can happen in a variety of ways facilitated by different medium. Emails can be sent out to each stakeholder , asking them to review the requirements list and see if they agree with the decisions. This has the advantage of not being dependant on the different time zones the stakeholders reside in, yet is static , with little room for feedback and has no face to face communication. In addition to automatic negotiations by agents, video conferencing can be used to voice concerns and assess each requirement to make sure every stakeholder is happy with their requirements priorities. Feedback can be obtained quickly and everyone has the same information so that future decisions can be made. However, some stakeholders will have to be awake at various early / late times due to the time difference and video conferencing can be expensive, especially if in a relatively small company.

6. IMPLEMENTATION

Although we have yet to produce any empirical data, demonstrating the positive impact of agent negotiations can have on project success in distributed organisation, we can, however propose a speech act based framework for agent negotiations and the process of how negotiations will be carried out. Figure 3. shows the high level agent architecture that we will be implementing. Every agent will have a unique identification number associated with it, i.e. an 'ID' so that the project team are clear on where each requirement originated and should any errors occur in the system, the agent responsible will be known. 'Knowledge' refers to the information that each agent will have. Each agent will have a set of requirements, entered by a stakeholder, it will also know the priority of these requirements, which is vital for negotiation to take place. Agents must also be aware of time, else they could be waiting indefinitely for an agent to respond to a request, causing the process to basically 'hang' e.g. an eternal loop will have been created. If an agent knows they have been waiting too long for a certain request , they can cancel the request and carry on being proactive and search for other free agents. 'Actions' refer to the actions the agent can choose to perform when the stakeholder has finished entering their requirements into the agent. It can identify certain words which it thinks are 'keywords' in the requirement, and ask the stakeholder to identify them. These words will then be sent to the online glossary for the project team to peruse.

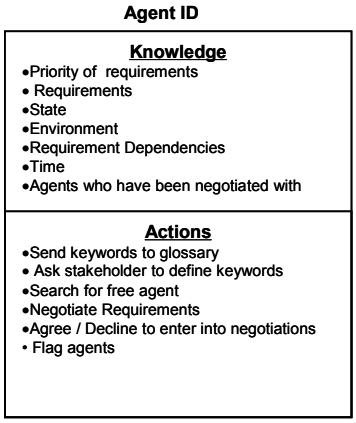

Figure 3. Proposed high level agent architecture

7. CONCLUSION & FUTURE WORK

Project failure is still affecting many companies and costs millions of pounds every year. By focussing on one of the key reasons for failure and proposing a viable solution, it should be possible to decrease the probability of project failure, especially in a distributed organisation. Speech acts are not merely a means of describing entities, but also a means for analysing why certain actions happen. Some speech acts are not primarily acts of communication and have the function of affecting institutional states of affairs. These types of speech acts provide a valuable framework for creating an agent architecture suitable for requirements negotiation. By utilising agent technology, the time and effort required by both stakeholders and the project team should decrease, as should the ambiguity in the individual requirements. By reducing ambiguity, yet still allowing stakeholders to remain stationary i.e. not travel to negotiate the requirements, project success should be easier to obtain, with any problems being highlighted at an early stage of the project lifecycle. Future work should allow us to implement the negotiation framework and the agent architecture, allowing us to assess the model in a physically working environment.

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