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Development of FIPA English Auction Interaction Protocol for Multi-Agent Systems

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Abstract

Foundation for Intelligent Physical Agents (FIPA) English Auction interaction protocol allows the customer to handle the auction by both propose and inform messages only, while it can increase the interaction domain for the customer in order to make FIPA English Auction interaction protocol more flexible to use. In this paper, we will propose a model for enhancing FIPA English Auction Interaction Protocol. This model will enable different communicative acts to be available to the customer for different reasons, these communicative acts are "refuse"," failure" and "cancel" messages. Finally, we will show when to use each of the additional communicative acts and for what reasons. These acts are explained using UML diagram and JADE platform as scenarios.

Keywords: auctioneer, customer, FIPA English auction interaction protocol, multi-agent systems

1 Introduction

An agent is a computer system that existing in some environment and that is able of autonomous action in this environment in order to achieve its design objectives [1, 6]. Multi-Agent Systems (MAS) is an agent based system that consists of more than one agent. MAS interact together to satisfy some set of goals. Each agent is considered as a locus of problem solving activity which operates asynchronously with respect to other agents [12, 15]. Interaction protocols are models of behavior that agents have to follow up to engage a communicative interaction with other agents within MAS [10]. Java Agent Development Framework JADE is a software framework fully implemented in Java language. It is a middleware that facilitates the development of multi-agent systems. It is a robust and efficient environment for distributed agent systems [3, 5, and 13]. JADE is used to develop multi-agent systems in compliance with the Foundation for Intelligent Physical Agents (FIPA) specification [7]. FIPA interaction protocols specifications deal with pre-agreed message exchange protocols for Agent Communicative Acts (ACL) messages.
This paper proposes a model for enhancing FIPA English Auction Interaction Protocol using UML diagram and JADE platform to describe each step of the new model. This enhancement is able to improve the characteristics of the MAS, including system efficiency, flexibility, reliability and responsiveness, as we will show in the rest of our paper.

2 Fipa English Auction Interaction Protocol

FIPA English Auction Interaction Protocol has at least two agents, Initiator and Participant. The initiator (also called auctioneer) attempt to find the market price of a good by proposing a price less than the actual market price and then gradually raising the price. For each announcement of the new price, the auctioneer waits a propose message from the participants (also called customers), and if there are at least one customer indicates that it will accept the price, then the auctioneer proposes a new call with incremented price. The auction continues until no customers are prepared to pay the proposed price, and in this case the auction ends. The good is sold to a customer if the last price that was accepted by him exceeds the auctioneer's reservation price. Otherwise, the good is not sold [4, 9].

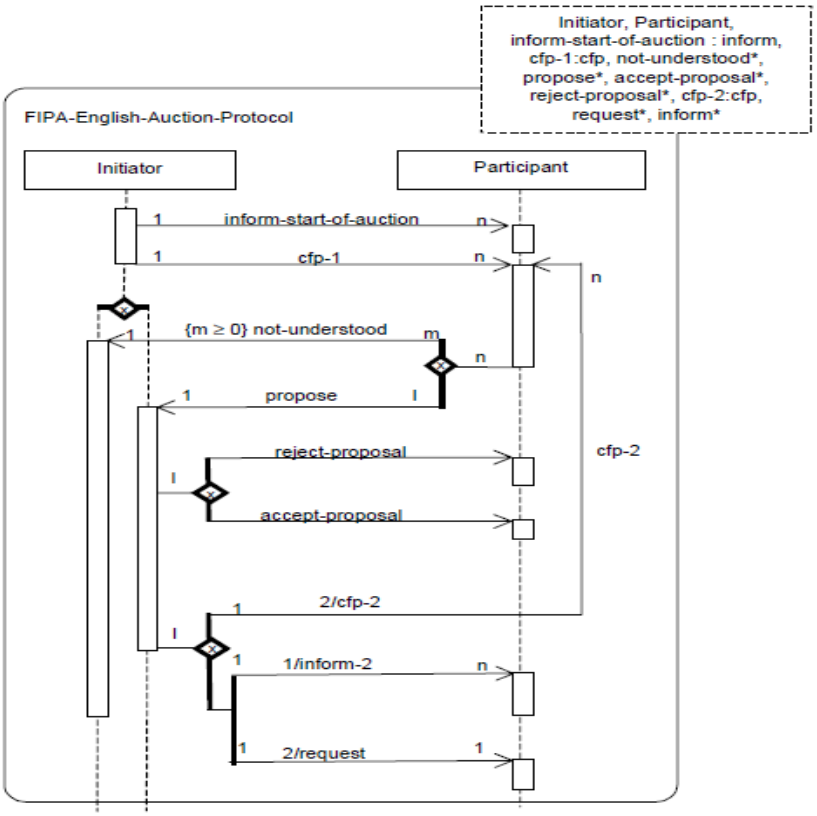

Fig. 1. UML diagram for FIPA English Auction Interaction Protocol [4].

Fig. 1 shows the FIPA English auction interaction protocol diagram explanation [9]:

1. The auctioneer sends "inform" message to all participants to indicate the beginning of new auction.
2. Using call for proposal "cfp" message to indicate the initial value of the good. This message is sent to all participants.
3. After specific period of time declared by the auctioneer, the participants can either send "not-understood" message or "propose" message to the auctioneer. The "not-understood" message is used when the participant does not recognize the received message, while the "propose" message is used when the participant interested in the announced price and wants to show his willingness to pay the proposed price.
4. If the participants send "propose" message, the auctioneer will send "accept-proposal" message, which it is a general purpose acceptance of a proposal that was previously submitted, to at least one participant and send "reject-proposal" message, which it is a general-purpose rejection to a previously submitted proposal to the rest participants.
5. Repeat steps 2 to 4 with new price.
6. If there are no participants interested in the new price, the auctioneer will send

"inform" message to indicate the winner agent and "request" message for the winner agent to pay the price.
7. If the participant sends "not-understood" message, the auction will end automatically.

3 Related Works

There are many related works about Interaction protocols between multi-agent systems. Bai, et al., [11] presented a Colored Petri Nets based approach to form flexible interaction protocols between agents. This approach allows agents to analyze a protocol and check whether the protocol is understandable and advantageous to the objectives of agents. While L. Braubach, and A. Pokahr [8] produced a goal oriented approach for interaction protocol, which allow developers to concentrate on the details of message passing instead of thinking in terms of the application domain by hiding message passing details. The oriented approach goal reduced the efforts for realizing agent communications, while interaction objectives remain conserved in the implementation and in the integration with the internal agent architecture. In the work of B. Marzougui, et al. [2] a new formalism for modeling MAS based on Petri net (PN) was implemented to describe the internal state of each agent modeled and its behavior. By having these features, it is easy to modeling the dynamic behavior of complex systems and the communication between these entities. To this end, mathematical definitions were proposed for the transitions. The reasons behind chosen the PN are the power of expression, the modeling of the interactions size of network and finally the gain at the level of modeling time.

S. Pujari and S. Mukhopadhyay [14] developed a learning system for physically impaired students based on MAS. The learning system is modeled on the basis of both centralized as well as distributed multi-agent planning. The current system selects the appropriate environment for interaction based on the classification of the impairments of the students. In addition, this system consists of agents which are developed using JADE agent technology that helps the students with disabilities to continue studies from their own places. The benefits from using this system is to allow the students with disability to continue their studies from the home without going to any institution, and therefore, the number of literate disabled students will increase. In contrast with the above mentioned works, the authors of this work will use the multi-agent systems in order to enhance FIPA English auction interaction protocol by adding additional ACL messages.

4 Motivations

FIPA English Auction Interaction Protocol has very few communicative acts from the customer to the auctioneer, which are "propose" and "inform" messages only [4,5]. In this work we will develop additional acts that will enhance the communication between auctioneer and the customers. These acts will be named as

"refuse", "failure" and "cancel" messages that are available to the customers for the following cases as shown in the following table1:

Table1. Additional Communicative acts for the English auction interaction protocol

Name of the Communicative Act	Reason for using the act
"refuse"	If the winner agent refuses to pay the agreed price.
"failure"	If the payment process from the winner agent failed.
"cancel"	If the winner agent wants to cancel his action, either that the *"propose"* message or the involvement in the whole auction is canceled.

5 Proposed Solutions

In the previous section, we mentioned the communicative acts that will be added to the FIPA English Auction Interaction Protocol. In this section, we will show the FIPA English Auction interaction protocol after the modification.
Fig. 2 shows the modified FIPA English Auction Interaction Protocol. This protocol allows users to access the auction with additional options, and we will show these options as scenarios:

A. If the final bid for the auction was offered by customer3, and auctioneer sent "inform" message to all customers in the auction telling them that winner agent is customer3, then the auctioneer also sent "request" message to customer3 asking him to pay the agreed price. After customer3 had received the "request" message, customer3 refused to pay the price for the following reasons:

1. Winner agent discovered that the balance in his credit card is less than the price that he must pay.

2. Winner agent is not going to pay because another person, such as his son, was the one who placed the bid and had not discussed the bid with him.

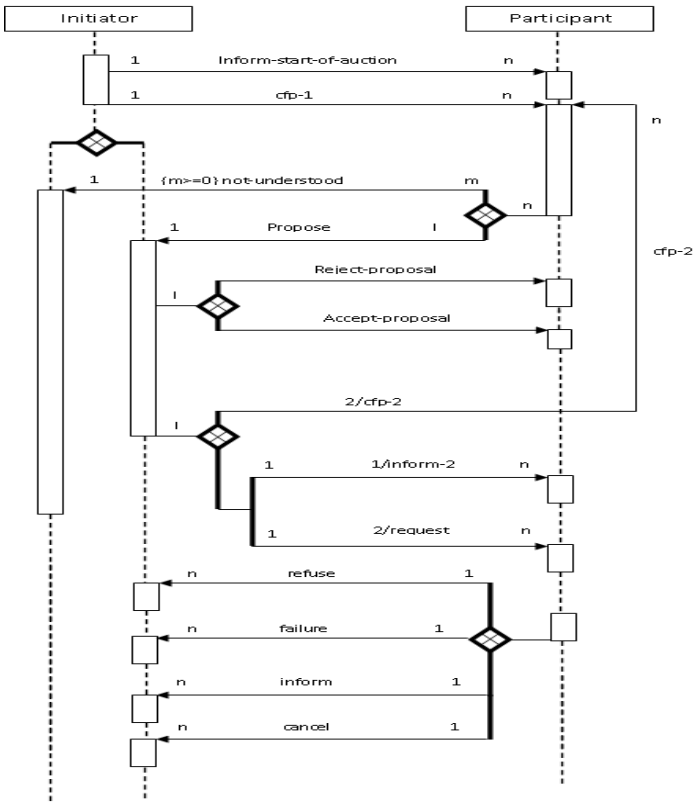

Fig. 2: Modified FIPA English Auction Interaction Protocol

We have proposed a solution for such cases in the modified FIPA English auction interaction protocol. It can be done by adding new feature that allows the winner agent to send "refuse" message to the auctioneer, as shown in figure 2.
Fig. 3 shows that the winner agent can send “refuse” message with content “cannot pay the price” to handle “request” message that was sent by the auctioneer.

```
INFO: [Request-IP-Responder] [Customer3] Request
handled by the creation of refuse msg:
(REFUSE
:receiver (set (agent-identifier: name
Auctioneer@192.168.1.8:1099/JADE
:addresses (sequence http://192.168.1.8:7778 /acc))))
:content “Cannot pay the price.”
:reply-with Auctioneer@192.168.1.8: 1099/JADE
1303227135597: in-reply-to R1393227135597_0
:protocol fipa-request
:conversation-id C20304786_1393227135597)
```

Fig. 3: Sample of code for "refuse" message.

In Fig. 4, the auctioneer sends "inform" message to all customers in the auction with "English auction starts" content. After that, the auctioneer sends "cfp" message to all customers with initial price equals to 10. The interested customers send "propose" message to the auctioneer. Three customers send "propose" message for

the same price but in different time, starting with customer3 then customer2 and finally customer1. In this case, the auctioneer sends "accept-proposal" message to customer3 and "reject-proposal" message to customer2 and customer1. This behavior is based on the customer who sends "propose" message first.
After that, the auctioneer sends another "cfp" message with incremental price equals to 11. No one of the customers interested in the new price and the auctioneer can now send "inform" message to all customers.
The auctioneer sends "inform" message to customer3 to tell him that he must pay the price, but winner customer discovered that he can't pay the price, since the balance in his credit card is less than the agreed price, or another person, such as his son, was the one who placed the bid and had not discussed the bid with him.
According to this failure, customer3 must send "refuse" message to the auctioneer with "Can't pay the price" content. As a result, the auction ended unsuccessfully.

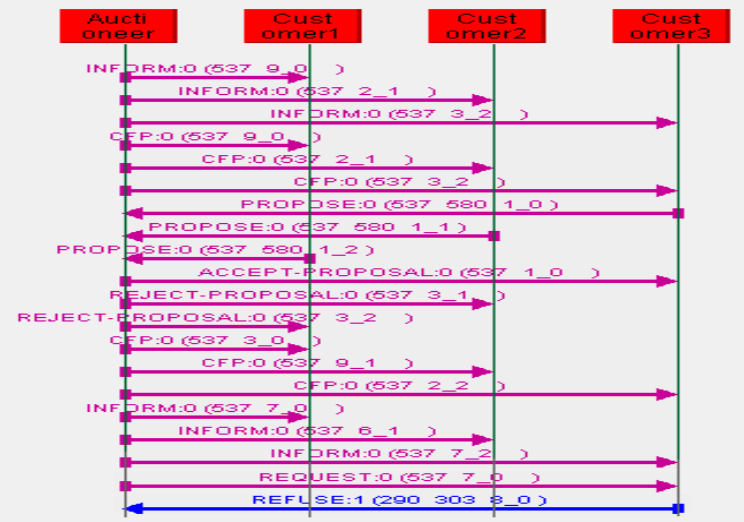

Fig.4: UML diagram for "refuse" message

B. If the final bid for the auction was offered by customer3, and auctioneer sent "inform" message to all customers in the auction telling them that winner agent is customer3, then the auctioneer also sent "request" message to customer3 asking him to pay the agreed price. Customer3 is going to pay the price, but during the payment process, some failure occurs, such as:

1. CVC/CVV security code on the front or back of the credit card is being entered incorrectly, and the transaction cannot be completed.
2. Credit card has been expired.
3. Incorrect password.

We have proposed a solution for such cases in the modified FIPA English auction interaction protocol. It can be done by adding new feature that allows the winner agent to send "failure" message to the auctioneer, as shown in figure 2.

Fig. 5 shows that the winner agent can send “failure” message with content “payment procedure fails” to handle “request” message that was sent by the auctioneer.

```
INFO: [Request-IP-Responder] [Customer3] Request
handled by the creation of failure msg:
(FAILURE
:receiver (set (agent-identifier: name
Auctioneer@192.168.1.8:1099/JADE
:addresses (sequence http://192.168.1.8:7778 /acc)))
:content “Payment procedure fails.”
:reply-with Auctioneer@192.168.1.8: 1099/JADE
1303227135597: in-reply-to R1393227135597_0
:protocol fipa-request
:conversation-id C20304786_1393227135597)
```

Fig.5: Sample of code for "failure" message.

In Fig. 6, the auctioneer sends "inform" message to all customers in the auction with "English auction starts" content. After that, the auctioneer sends "cfp" message to all customers with initial price equals to 10. The interested customers send "propose" message to the auctioneer. Three customers send "propose" message for the same price but in different time, starting with customer3 then customer2 and finally customer1. In this case, the auctioneer sends "accept-proposal" message to customer3 and "reject-proposal" message to customer2 and customer1. This behavior is based on the customer who sends "propose" message first.
After that, the auctioneer sends another "cfp" message with incremental price equals 11. No one.

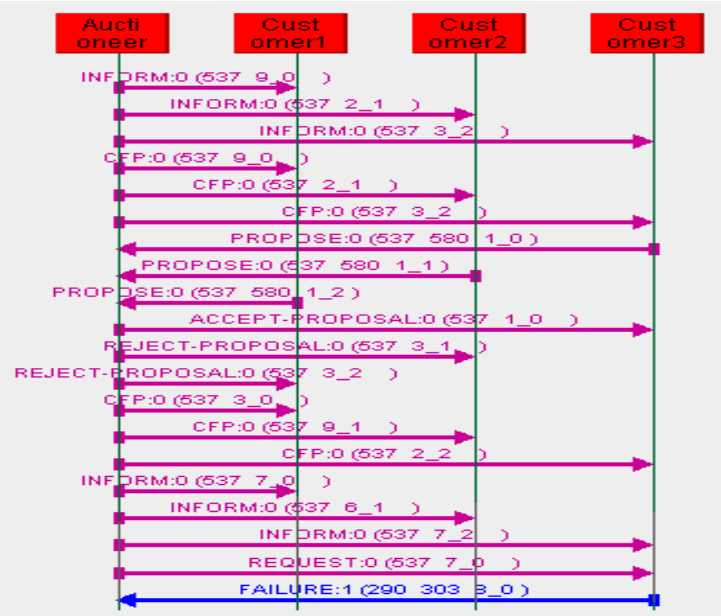

Fig.6: UML diagram for "failure" message.

of the customers interested in the new price and the auctioneer can now send "inform" message to all customers.
The auctioneer sends "inform" message to customer3 to tell him that he must pay the price, but during the payment process, some kind of failure occurs, let we say that the security code on the front or back of the credit card is being entered incorrectly.
According to this failure, customer3 must send "failure" message to the auctioneer with "Payment procedure failed" content. As a result, the auction ended unsuccessfully.

C. If there is a customer that wants to retract a bid in the FIPA English auction interaction protocol for any of the following reasons:
1. The customer made a typographical error and sent "propose" message for the announced price.
2. If the description of the item has significantly changed since the customer placed his bid.
3. The customer changing his mind about the good or auction.
4. If there are two auctions for different goods and the customer wants to be the winner agent of one of these auctions, not both.

We have proposed a solution for such cases in the modified FIPA English auction interaction protocol. It can be done by adding new feature that allows the winner agent to send "cancel" message to the auctioneer, as shown in figure 2.
Fig. 7 shows that the winner agent can send “cancel” message with content “cancellation of the proposal” to handle “request” message that was sent by the auctioneer.

```
INFO: [Request-IP-Responder] [Customer3] Request
handled by the creation of cancel msg:
(CANCEL
:receiver (set (agent-identifier: name
Auctioneer@192.168.1.8:1099/JADE
:addresses (sequence http://192.168.1.8:7778 /acc)))
:content “Cancellation of the proposal.”
:reply-with Auctioneer@192.168.1.8: 1099/JADE
1303227135597: in-reply-to R1393227135597_0
:protocol fipa-request
:conversation-id C20304786_1393227135597)
```

Fig.7: Sample of code for "cancel" message.

In Fig. 8, the auctioneer sends "inform" message to all customers in the auction with "English auction starts" content. After that, the auctioneer sends "cfp" message to all customers with initial price equals to 10. The interested customers send "propose" message to the auctioneer. Two customers send "propose" message for the same price but in different time, starting with customer1 then customer2.
Customer1 had decided to cancel his proposal because he made a typographical

error and sent "propose" message for the announced price. According to this mistake, customer1 must send "cancel" message to the auctioneer with "Cancellation of the proposal" content and the auction in this case acts like that there are no customer1.
As a result, the auctioneer sends "accept-proposal" message to customer2 since customer2 is the only remaining customer who had sent "propose" message for the announced price. After that the auctioneer sends another "cfp" message with new price, equals to 11, but customer2 is not interested in the new price. The auctioneer sends both "inform" and "request" message to customer2, then customer2 sends "inform" message to the auctioneer.

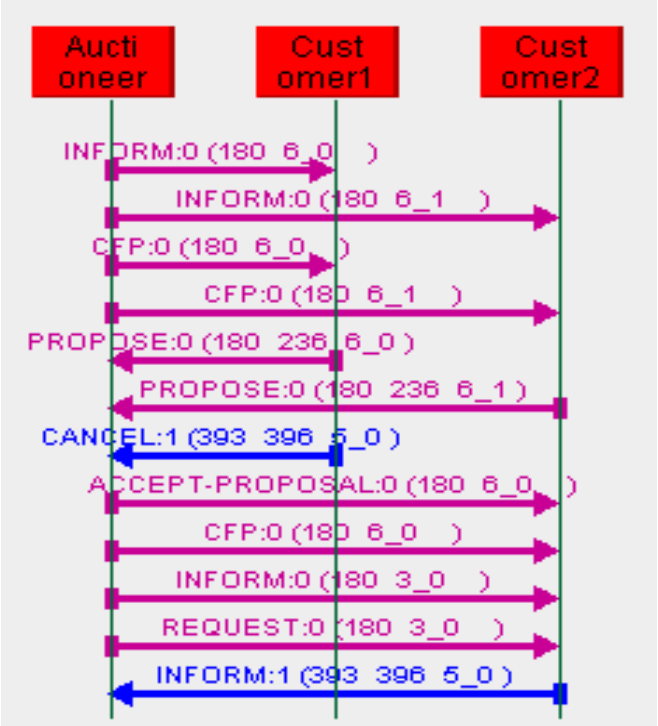

Fig.8: UML diagram for "cancel" message, reason1 and reason2.

In Fig.9, the auctioneer sends "inform" message to all customers in the auction with "English auction starts" content. After that, he sends "cfp" message to all customers with initial price equals to 10. The interested customers send "propose" message to the auctioneer. Three customers send "propose" message for the same price but in different time, starting with customer3 then customer2 and finally customer1.
In this case, the auctioneer sends "accept-proposal" message to customer3 and "reject-proposal" message to customer2 and customer1. This behavior is based on the customer who sends "propose" message first.
After that, the auctioneer sends another "cfp" message with incremental price equals

to 11. No one of the customers interested in the new price and the auctioneer can now send "inform" message to all customers.
When the auctioneer wants form customer3 to pay the price, he must send "inform" message to the winner agent to pay the price, but customer3 changed his mind about the auction and wants to cancel his bid. Customer3 must send "cancel" message to the auctioneer with "Cancellation of the proposal" content.

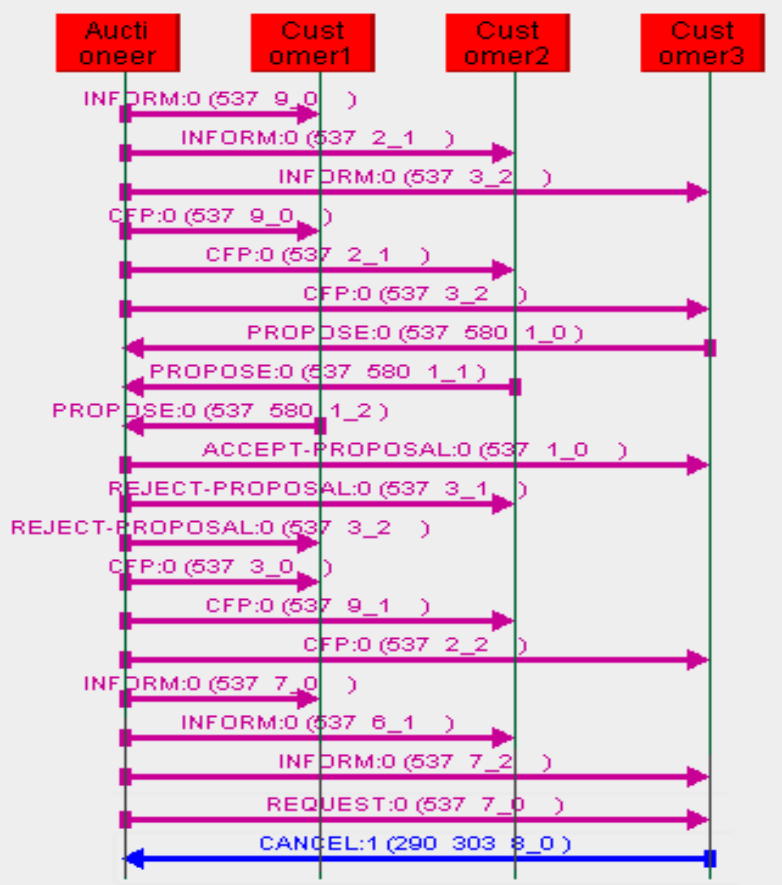

Fig.9: UML diagram for "cancel" message, reason3 and reason4.

6 Conclusions

We have developed a model for FIPA English Auction Interaction Protocol to be used in multi-agent systems. This model has allowed different communicative acts to be available for the customers, such as failure, refuse and cancel messages. For each of these communicative acts, we have mentioned several reasons for using them. After running the modified interaction protocol, we noticed that both of the efficiency and the number of interactions that can be done between agents are increased. This leads to make the modified FIPA English Auction interaction protocol more flexible to the customers. The additional acts used in the English auction improved the interaction procedure between different agents in MAS in

addition to the most known advantages, such as increasing system efficiency, flexibility, reliability and responsiveness. In this work it was noticed that, the available ACL messages for customers were increased leading to increasing the efficiency of the whole auction. Furthermore, the flexibility of our protocol was improved by assigning different ACL message for different reasons, and as a result both of the reliability and responsiveness of our protocol was increased.

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