Building Coalitions of Competitors in the Negotiation of Multiparty e-Contracts through Consultations

Anderson P. Avila-Santos, Jhonatan Hulse, Daniel S. Kaster and Evandro Baccarin
Department of Computing, University of Londrina, Londrina, PR, Brazil

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Abstract: This paper argues that software agents may build two kinds of coalitions in e-negotiation processes. The first is the typical one in which the parties define roles, rights, guarantees before the negotiation starts. They act as a team. Either the whole coalition succeeds in the negotiation or fails. In the second one, addressed by this paper, the coalition members are competitors. They collaborate exchanging information before the negotiation trying to align their strategies to some degree. Such collaboration only occurs because there is some particularity (e.g., nearness) that can optimise their business processes if most of the coalition members succeed in the negotiation. They aim at maximising their chances of success in the negotiation, but act solo. It is important to note that the main challenge in this scenario lays on the fact that the coalition members are not bind to the coalition. They may act within the negotiation differently from what they had agreed previously. This gives rise to the concept of *fairness*, which is discussed in this paper. The paper also argues that the materialisation of coalitions within a negotiation protocol fits better in a multiparty negotiation protocol. Thus, it extends the *SPIℂA* Negotiation Protocol with the so-called *consultations*. The paper presents a study case that shows that consultations can be benefic to the suppliers, the industry and the consumers.

1 INTRODUCTION

A coalition is an arrangement of two or more parties who cooperate to attain a mutually desired outcome (Guo and Lim, 2012). It may leverage a given particularity common to a few negotiators in a way that is advantageous to other parties besides those negotiators themselves.

In previous papers, we presented *SPIℂA*'s multiparty contracts and negotiation protocol. If all clauses were successfully negotiated, a multiparty contract is signed by the involved parties. This paper extends the negotiation protocol allowing that a few negotiators, although competitors, organised in a coalition, exchange information that may help their own decision making during the negotiation. Such an extension is made by means of the so-called *consultations*. We argue that with minimal change in our negotiation protocol, we have open a wide window of possibilities of new patterns of negotiation.

The problem assessed in this paper is how to allow members of a coalition exchange information and intentions to achieve some kind of benefit within a multiparty negotiation, restricted that each of them plays solo within the very negotiation. As a consequence, only a subset of the coalition members may be successful in the negotiation. One alternative would be the members sign a subsidiary contract among them, however, this alternative would oblige every member to honor the subsidiary contract even if one or more of them do not win the subsequent negotiation. The approach we introduce in the paper is to allow members of a coalition perform a "draft" negotiation, in a way they may align their strategies, without obliging them. This gives rise to the discussion about the *fairness* of the coalition members.

To illustrate the problem, consider the negotiation scenario depicted in Figure 1. There is a food company (FC) that produces granola. Among other ingredients, it needs to buy grapes. There are six grape producers ($G_1 \dots G_6$), however, none can individually fulfil the whole amount of grapes needed by the industry. Thus, it will buy grapes from half of them. Due to the geographic specificities, there are 2 groups of grape producers: farms G_1, G_2 and G_3 can share the transportation means (they are on the fringes of the road R_1) and the others cannot. Thus, the farms G_1 to G_3 intend to take advantage of their nearness

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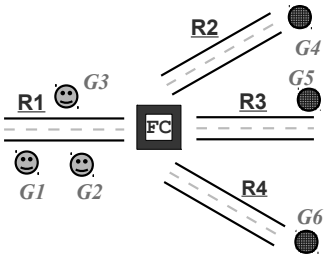

Figure 1: The Granola Company negotiation scenario.

and build an alliance among them to leverage their competitiveness against the other producers. Nevertheless, as none of them is sure that will win the negotiation with FC, signing a subsidiary contract to guarantee the transportation sharing is too risky.

The main contributions of this paper are: (1) it proposes an extension of our multiparty negotiation protocol that allows coalition member to exchange not binding information about their intentions to improve the negotiation process without exposing sensible information; (2) it shows that such information exchanging among the coalition member benefits other parties besides the members themselves; (3) it shows that the coalition members do better when they are committed to the coalition.

This paper is organised as follows. Section 3 overviews a multiparty contract and a multiparty negotiation protocol we proposed previously. Section 4 extends *SPICA* with consultations. Section 5 presents the implementation scenario described above. Section 6 runs several experiments using this negotiation scenario with and without consultation and assesses the outputs. Section 7 presents related work. Finally, Section 8 concludes the paper.

2 COALITIONS OF COMPETITORS: A NEW APPROACH

Coalitions among players of a given industry is a common practice. They may associate to make the local market less inhospitable for all of them, to cut costs, to increase profits, etc. However, such an association is previously built in a way to protect their individual interests. Different types of legal instruments, such as contracts, covenants and treaties, are used to establish clear boundaries among the members. They can carefully choose which information will be shared and provide penalties in case of a misbehaviour.

There is another type of coalition, perhaps less organised, less structured in which the association do not only depend on the members' will, but also on the events to come. We name this type as *coalition of competitors*. For instance, in the scenario presented in Sec. 1, a few farms are competitors, however none of them is able to provide alone the amount of grapes demanded by the food company. They can be more competitive working together, expecting that all of them will provide grapes for the food company. However, such expectancy will be confirmed (or not) by a subsequent (future) negotiation in which other players also take part. In this case, only prudential trust can be employed.

This paper focuses a few interesting questions that arises in the second type of coalition, such as: in what extent can a party trust in another coalition member? Will it behaviour within the actual negotiation as the coalition has sketched in advance? Is it worth to take the risk of taking part of such coalition?

These questions give rise to another concept that we refer as *fairness*. It expresses the level of conformance of the actions a negotiator takes comparing to what it promised to the coalition.

3 *SPICA* MULTIPARTY CONTRACT AND NEGOTIATION PROTOCOL

In this section, we present a glimpse of our multiparty contracts and negotiation protocol. This brief explication provides to the reader a few concepts she needs to understand our proposal.

The negotiation process is guided by a contract template. Negotiators exchange messages that comply with the *SPICA* negotiation protocol. One of the negotiators is the so-called Leader, who coordinates the negotiation process. If there is an agreement, a contract instance is produced and signed. The negotiation process may be helped by the so-called Notary. It is a trustworthy third-party that, e.g., receives and counts votes.

A contract template consists of a set of clauses with blanks to be filled in. Such blanks are referred to by the so-called *properties* and the negotiation process aims at assigning values to them. Thus, a contract instance is a contract template with its properties successfully negotiated. The obligations (or rights) stated in a clause may bind (or benefit) several partners. Roughly, a clause is composed of a text that describes the rights and obligations and two lists of partners. The description is a plain text, but its words may be prefixed by an ontology name that elucidates the intended meaning of such word. Property names may also be embedded in the text. In addition there

are two lists with identifications: the so-called *obliged partners*, i.e., the ones that should cooperate to accomplished the clauses provisions; the so-called *authorized partners* those that will share its benefits.

An illustrative example of a clause for the scenario proposed in Section 1 after it was negotiated is presented in Fig. 2. In a nutshell, this clause rules that farms G1, G2 and G4 (obliged parties) must deliver a given amount (property QTY) of grapes to FC (authorized party) at a given price per ton (property PTON). The values agreed within the negotiation are assigned elsewhere in the contract.

```
text: The @OBLIGED will deliver to
@AUTHORIZED the amount of #QTY tons of grapes
at the price of #PTON euros each ton.
obliged: G1,G2,G4
authorized: FC
```

Figure 2: A simplified clause.

Basically, a negotiation process runs as follows. In general, the negotiation of a contract is a part of a larger process that is controlled by another entity of our framework, the so-called *Coordination Manager* (CM) (Bacarin et al., 2004). Such a manager demands that a given contract model be negotiated. A new negotiation instance is created and a leader negotiator is chosen. This leader decides how the properties will be negotiated. The leader chooses the most appropriate style to negotiate the properties of a clause. In our scenario, six farms competed (within an auction) to deliver the grapes, but only the winners are nominated in the obliged list and will cooperate to provided that total amount of grapes expected by FC, e.g., each one will provide a third of QTY. Note also, that a few of them are coalition members (G1 and G2), but G4 is not. A detailed discussion about our proposal for multiparty contracts is outside the scope of this paper.

The protocol defines the messages and the data exchanged among the players of a negotiation. They convey several parameters that tune up a specific negotiation, identify the sender and the receivers, and help establishing correlation among messages. Only the relevant parameters for the purpose of this paper are presented.

3.1 Exchanging Data Types

Most of the negotiation messages build on two basic data types: *Request For Proposals* (RFPs) and *Offers*. An RFP invites another party to negotiate a set of properties. A negotiator A sends an RFP to a negotiator B asking for a value for one or more properties. More specifically, an RFP conveys three pieces of data: a set of *asked properties*, a set of *assigned properties* and a *restriction*. The example below shows an RFP written in a simplified notation. The RFP proposes a value for QTY (3), asks a value for property PTON, but imposes that it would be lesser than 700.

$$\ll\{\texttt{QTY:3}\},\{\texttt{PTON}\},\texttt{'PTON}<\texttt{700'}\gg$$

A negotiator A proposes a value to one or more properties sending an Offer to a negotiator B. If negotiator B accepts it, both negotiators are committed to the proposed values. A negotiator answers an RFP sending back an Offer that assigns values to the asked properties.

The example below shows an Offer that answers the previous RFP. Note that this Offer does not change the proposed value for property QTY (it should not) and assigns the value 690 to property PTON.

```
[QTY=3, PTON=690]
```

RFPs and Offers are used to build several styles of negotiation that boil down to three basic ones: bargain, ballots, and auctions. Bargains are used within bilateral negotiation, auctions are used when there is competition among a few negotiator, and ballots, when consensus among negotiators are needed. Other styles (e.g., different flavours of auctions) are obtained from different setups of these basic ones.

3.2 Negotiation Interfaces

The negotiation messages are defined by means of a set of interfaces (Java, in the current implementation) with methods to be implemented by the different negotiation players.

Figure 3 exemplifies the use of some of those interfaces. It depicts the auction messages and the players. The players are: the Notary, the Leader negotiator (FC) and other negotiators (farms). The exchanged messages are represented by arrows (e.g., the first arrow depicts the sending of a message from Leader to Notary). Each arrow has a caption that displays the message sent (*firstAnswerToProposal*, in the example). This caption presents the name and the main parameters of the invoked method with a prefix that identifies its interface (LeaderIF, in the example).

An auction is a sequence of the so-called *auction steps*: (1) The Leader sends a *firstAnswerToProposal* message asking the Notary to advertise and conduct an auction. This message inform the Notary how many bids (*nbids*) to collect (e.g., 3) within a given interval *t* (e.g., 10s). The auction's subject is described either by an RFP or by an Offer. In the former, the bidders propose values for asked properties (as usual

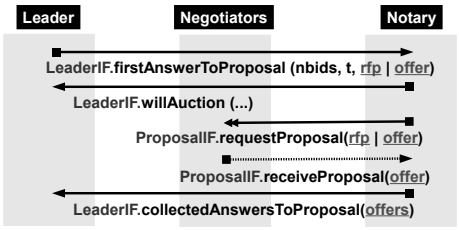

Figure 3: The steps of an auction in *SPICA*.

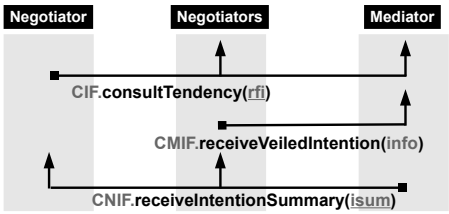

Figure 4: Pattern Summary of Intentions in *SPICA*.

in English auctions); in the latter, the interested bidders may agree to the proposal (as usual in Dutch auctions). From now on, we will use RFP auctions. (2) The Notary accepts the task (message *willAuction*) and broadcasts the RFP (message *requestProposal*) and waits as demanded. The negotiators receive the RFP and (3) send Offers to the Notary in response (message *receiveProposal*). The Notary collects them and (4) sends them to the Leader (message *collectedAnswersToProposal*). If the Leader guesses it can have better bids, it may run another auction step enhancing the restrictions stated in the RFP: in the example it would try to decrease the grape price. For instance, if the cheapest bid received within the auction step proposed PTON=690, FC would ask the Notary to conduct another step imposing that PTON$<$690.

Ballots have a similar pattern. Briefly, votes are sent instead of bids. Bargains happen between only two negotiators.

4 INCLUDING CONSULTATIONS IN e-NEGOTIATION PATTERNS

The negotiators in a coalition use the so-called *consultations* to exchange information about their intentions or trying to establishing mutual consensus during the negotiation process. It is important to note that the consultation process happens "out the boundaries" of the negotiation process and its results are not binding. It means that a negotiator's actions within the negotiation process need not comply to its response within a previous consultation.

We augmented the protocol with the so-called *consultation messages*, specified by means of a few new interfaces, which uses two exchanging data types: *Requests For Information* (RFIs) and *Information* (Info). We also provided a trusted third party to help the consultation interactions, the so-called *Mediator*.

An RFI is very similar to an RFP: it asks values for properties, but also lower and upper bounds for them. An Info is similar to an Offer: it proposes values for asked properties and also informs upper and lower bounds for them, however, the negotiator which issued an Info is not committed to it.

The consultations may happen in two different ways: (a) aiming at convergence of intentions; or (b) agreeing on proposal. These patterns are described in the following.

In *convergence of intentions*, the negotiators share information and each of them makes its better effort trying to align their strategies. For instance, in our negotiation scenario, the negotiators inform their individual transportation cost and based the aggregated mean value, they estimate how much they would save if they shared the transportation means. Thus, each negotiator make a more attractive individual offer to the food company. This pattern as two flavours: (a) Summary of Intentions; and (b) Burst of Intentions.

- **Summary of Intentions:** Figure 4 depicts this kind of consultation. It is started by means of the message *consultTendency*. Such message is answered by a subsequent *receiveVeiledIntention* message. This message does not disclose the negotiator's intentions to the group, but sends them to the Mediator who summarises all received intentions (e.g., calculate the mean value) and broadcasts the summary to the group (message *receiveIntentionSummary*).
- **Burst of Intentions:** A negotiator asks other negotiators about their intentions regarding a specific issue. All negotiators broadcast their intentions. It is not helped by a Mediator.

In the *Agreeing on Proposal* pattern, the negotiators aim at a consensual answer for a specific issue. It is similar to the *Summary of Intentions* pattern, but a ballot is run to find such consensus.

5 TEST CASE: GRANOLA COMPANY

This section presents the implementation of the negotiation scenario in Sec. 1. For brevity's sake, the focus of the paper lays on the negotiation of one item (grapes) and the consultation pattern is the *Summary of Intentions*.

The negotiation Leader is the food company (FC) which provides the contract model. FC wants to pay the least price. Thus, it runs several auction steps asking decreasing prices for the grapes. At the end, FC will agree with the three best bids to provide the grapes. Note that, there can be zero to three CC members among the providers.

By their turn, the grape producers use decision tables to assess the proposals they receive: for each property each negotiator has a value (or a range of values) it considers a "good deal" (i.e., the expected value – EV) and for which it will always agree upon. There are also values the negotiator will never agree upon. Values in-between will be accepted with specific probabilities: the nearer to the expected value, the higher the acceptance probability. Decision tables keep such values and probabilities. Such strategy, although simple, is quite effective to simulate the negotiation.

A few of the grape producers can share the transportation to enhance competitiveness (G_1, G_2 and G_3). Thus, they compose a consultation community (CC). The community's negotiators may change (temporarily) their expected values (EV) according to the consultation result. It was implemented as follows.

Each CC member, besides its decision table, keeps two pieces of information: the total production cost (ToPC) and the percentage the transportation contributes to the total cost (TRCp). Thus, the negotiator's expected profit (EP) is easily calculated as a function of TPC, TRCp and EV.

Before negotiating the grapes, the CC runs a consultation of the kind *summary of intentions*, as follows. (i) Each negotiator sends to the Mediator its transportation cost. (ii) The Mediator returns to the CC members the mean value (TRCm). (iii) The negotiators assume that TRCm will be the total transportation cost for them. Such assumption considers that a single truck load is able to transport the grapes of all those producers, therefore it would be underused by a single producer. Since they will share the transportation, each negotiator will chip in a third of this value (they are 3 members). (iv) Next, they recalculate their expected value to have the same profit margin they would have previously (EV'). (v) Finally, the CC members partake the negotiation using the adjusted decision table.

It is noteworthy that the presented consultation did not considered a property of the contract. Instead of consulting about the value of the grapes (contract property), the consultation was about another parameter that the negotiators could minimise if they could take advantage of their geographical nearness (i.e, the transportation cost).

The reasons for using a Summary of Intentions were twofold: it aimed at maximising the win-win approach among the CC members and also hiding sensible values.

Once consultation is not binding, the commitment a negotiator has regarding to CC may vary. We refer to the level of commitment of a negotiator as its *fairness*: the more committed, the fairer. The measure of fairness is a real number in the range $[0,1]$: 0 means that the negotiator is not committed at all to the consultation results; 1 means that the negotiator is fully committed to such results. To evaluate how the fairness behaviour affects the performance of a CC, each CC member keeps another piece of information: its fairness (F). Every member will change its expected value to $((F * EV') + (1 - F) * EV)$. Thus, in one extreme a fully fair CC member ($F = 1$) will use the recalculated expected value (EV') as described previously. Conversely, a fully unfair member ($F = 0$) will not change its decision table.

6 ASSESSMENT

We ran several experiments to assess the outcomes of using consultations in the test case.

The experiments presented in this section address the following questions.

1. Have the coalition members provided grapes to the industry as a group more often than individually?
2. Has the profit of the each coalition member increased when compared to the profit the farm had before becoming a coalition member?
3. Has the procurement price decreased (for the industry)?
4. In what degree the level of commitment (fairness) of the coalition members influence the results for a given individual member and for the whole coalition?

The first and second questions assess whether the coalition was advantageous for its members. The third question tries to determine if the coalition conferred benefits to the consumers. It supposes that, once the industry obtains cheaper grapes, its products can also cost less to the consumers. The last question assesses the level of risk of using consultations, since they do not imply strict commitments.

We built a basic setup that aimed at assessing the first three questions by means of a batch of executions. In this setup, all CC members had their fairness set to 1 (fully committed). To evaluate fairness, the

basic setup was run a second time now varying the degree of fairness of the coalition members. All experiments were executed 20 times (half with consultations, half without them). In the following, we plot and comment the achieved results.

With regard to Question 1, Figure 5 shows how many auctions a negotiator won (in percentage) comparing experiments with and without consultations. That figure shows that the CC members, when stuck to the consultation ($F = 1$), did no worse than not using consultation. In fact, all did better, but G3 that had the same outcome. This result to G_3 is because it already was quite competitive. This figure also shows that G_6 is the most competitive negotiator among the non CC members.

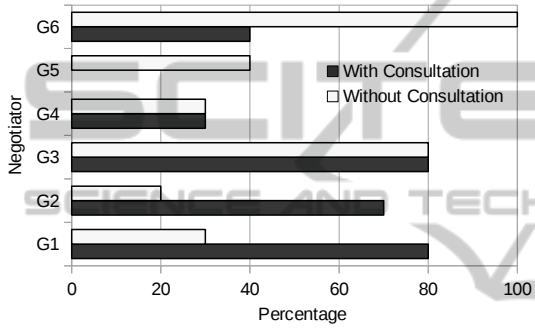

Figure 5: Winning negotiators with and without consultations.

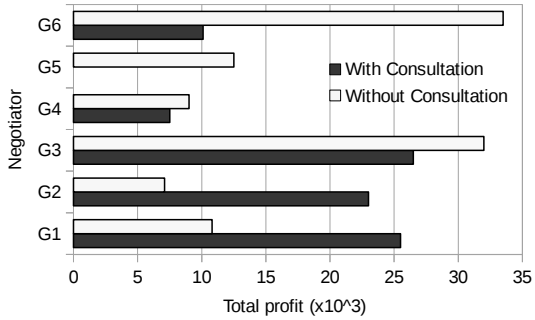

Figure 6: Total profit achieved with and without consultations.

Question 2 is addressed in Figure 6, which shows the sum of the profits attained by each negotiator within 10 experiments. It is easy to notice that the non CC members did much worse when the other negotiators were running consultations. It is noteworthy that G_3 did a slight bit worse when partaking the consultation (again, because it was already competitive). However, it would not know this fact beforehand. Moreover, if G_3 is compared to G_6 (both the most competitive in their groups), we can see that G_6 did much worse. Thus, if G_3 would have refused to participate in the CC, G_6 could do it somehow and their outcomes would be inverted.

Regarding Question 3, Figure 7 sums up the total value paid by FC within 10 experiments. FC has clearly paid less when consultation was active. We also wonder if the total value paid by FC was correlated to the number of CC members that won a given auction. Figure 8 was used to investigate such hypothesis. This figure comprises bars and lines. A bar represents to total value paid by FC in a given auction, and the lines shows how many CC members won such an auction. For instance, in the first auction with consultation FC paid a bit more than 60,000 to the winners and all three CC members won that auction. Conversely, in the first auction without consultations, FC paid at most 60,000 to the winners and only one of them was a CC member. There is no clear correlation between the cost and the number of winning CC members. However, this figure confirms that the only existence of consultations brings the cost down due to the competitiveness rising.

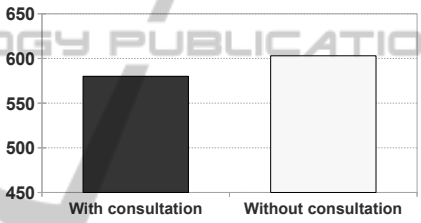

Figure 7: Total cost for the FC ($*10^3$).

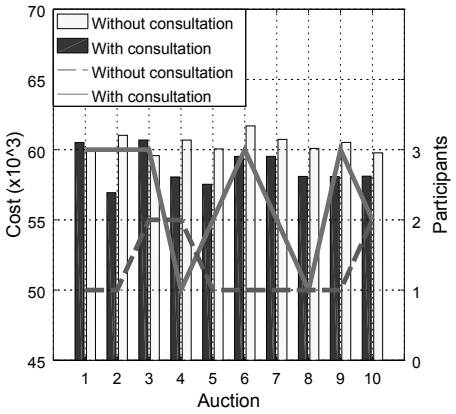

Figure 8: Cost by auction instance and number of winning coalition members with and without consultations.

In order to assess how fairness influenced the negotiation process (Question 4), we ran two experiments. In the first (Figure 9), all CC members were set with the same fairness and the total profit of the CC member (after 10 negotiations) was summed (solid blue line). Similarly, the profit of the non-members was summed (dashed green line). This was repeated for different fairness (0, 0.1, 0.2, . . . , 1). For

instance, when the CC members were set with $F = 0.6$, the total profit of the CC members was higher than 80,000 and for non-member, less than 20,000. This figure shows that the CC members do better altogether when they are fair. In the second experiment (Figure 10), two CC members had the same fairness ($F = 0.5$) and the remainder (G_1) had its fairness varied. For each level of fairness, we ran 10 negotiations and calculated the total profit G_1 gained. Its clear the ascending pattern as G_1 become more fair, reaching the maximum profit of more than 30,000 at $F = 0.8$.

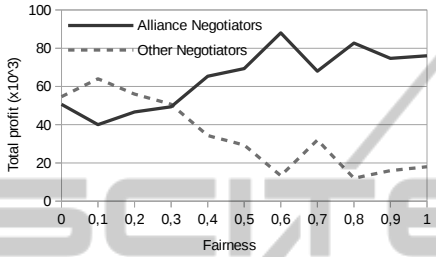

Figure 9: Total profit varying the fairness of all members.

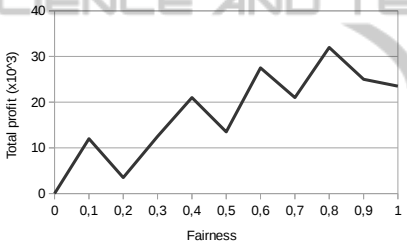

Figure 10: Profit varying the fairness of only one member.

7 RELATED WORK

The notion of coalitions has been studied by the game theory community for a long time and it has proved to be a useful strategy (Horling and Lesser, 2004). It has gaining increasing interest by the Information Technology community as an interaction pattern to develop complex multi-agent systems. There are a few software methodologies tailored to agent-oriented systems that allow implementing this organisational paradigm (Isern et al., 2011). However, several proposals regarding automatic negotiation employs case-specific implementations, such as (Yu et al., 2013). Works that present more structured implementations usually rely on negotiation protocols and frameworks.

Most of the negotiation protocols are based on bilateral interactions, e.g., (Shakun, 2005) and (Brzostowski and Wachowicz, 2014). However, collaborative organisations need negotiation protocols that are multiparty and interactive (Darko-Ampem et al., 2006). There are a few multiparty negotiation protocols in literature, e.g., (Fujita et al., 2012), (Klenk et al., 2012) and (Szapiro and Szufel, 2014). These works differ from ours, since they do not integrate several styles of negotiation, namely,bargain, ballots and auctions for the negotiation of a given multiparty contract. In addition, our negotiation protocol also provides a non binding coalition mechanism.

According to (Peleteiro, 2014), *coalition formation* is a process in which agents associate to achieve a goal or to increase their performance, and is guided by *rules of formation*. She also mentions the problem of *stability* of a coalition, i.e., the level of incentive a member has to withdraw (*internal stability*) the coalition and a non-member has to join it (*external stability*). Another aspect she considers is if the coalition is *statically* or *dynamically formed*. In contrast with the former, in the latter the agents are constantly willing to change the coalition they belong to. A coalition may be ruled by a *leader* that imposes its strategy. According to (Yu et al., 2013), another issue regarding coalition formation is how to allocate the profit among its members.

Our protocol does not tackle the coalition formation problem, but supposes that it was somehow built prior the negotiation and, most important, it does not bind the members of the coalition.

Stability of coalitions is an issue worth of discussion. In general, a coalition of agents behaves as a block. Thus, internal and external stability is a clear concept. Our proposal is quite different. A coalition of competitors has three distinct moments. In the first moment, the coalition members exchange information in order to be somehow aligned during the actual negotiation. The second is the very negotiation. In this phase, the coalition members may be fair to that alignment or not. If they are fully unfair, we can consider that they left the coalition (no internal stability). Conversely, if they are fully fair, they stayed in the coalition. However, as we mentioned previously, a coalition member can be partially fair. In this case, the concept of stability becomes blurred. Finally, the third moment is the coalition realisation, i.e., the members that succeed the negotiation become the signatories of the produced contract. Note that, this realisation may also be partial, once a few of the coalition members may fail in the negotiation.

Another difference of our approach for coalitions is that there is no leader ruling or coordinating the acts of the coalition members and there is no direct allocation of profits among the members. In our case, profits may be earned indirectly, e.g., by increasing competitiveness. In addition, (Guo and Lim, 2012) argues that coalitions are just formed to reduce the

intrinsic complexity of multiparty negotiations. In our proposal, it is not an issue.

8 CONCLUSION

A coalition is referred as in the literature as an organised, framed, protected, as a solid and monolithic block. It is materialised before the negotiation takes place. It is as if the coalition was a big negotiator acting in behalf of its individual parties.

This paper focused on a second kind of coalition, that we called coalitions of competitors, which is a more challenging, risky and fluid association of negotiators. It differs from the previous one in four basic features. First, the coalition is not formalised and materialised beforehand. In fact, a few negotiators intend to build a coalition. They exchange information either before or during the negotiation process to maximise their chances of success. However, had they tuned up their decision processes, each one negotiates by itself. Thus, the coalition is actually realised after the negotiation. This leads to a second difference: it can produce partial coalitions, as just a few of the coalition members end up succeeding in the negotiation. The third is that, since the coalition may succeed only partially, a negotiator does not wish to commit to an agreement that will bind it independently of the result of the negotiation. Finally, as consequence, any coalition member may act within the actual negotiation differently from the previous coalition agreement.

We reified coalitions through the *SPICA* Negotiation Protocol. This protocol was suitable for this purpose once it implements multiparty negotiation of multiparty contracts. The protocol was extended to allow coalition members to exchange information within a negotiation process by means of consultations. The effectiveness of such extension was assessed by means of an experimental negotiation scenario. The results were twofold: (a) the execution of a bunch of experiments showed that exchanging information different from those present in the multiparty contract being negotiated improved the outcome to the negotiators (CC members and FC) as well as the consumers of the product delivered by FC; (b) in general, do better the members that are fair to the coalition.

Future work includes assessing the other two consultation patterns that were just mentioned in this paper and improving the intelligence of the negotiators.

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