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Multi-criteria Decision Analysis for Change Negotiation in Process Collaborations

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Abstract—**In a process collaboration, changes rarely confine themselves to a single company, but can spread over the network of partners, resulting in a whole process of negotiation. This paper employs techniques from the domains of multiple criteria decision making (MCDM) and group decision to deal with change negotiation in process collaborations. In particular, it utilizes multi-criteria reasoning to model preferences of collaborators over different criteria. A particular issue in this context is scaling since in a collaboration of heterogeneous partners, identical outcomes might have different meanings for partners. A role-play experiment has been conducted with students from computer science and business administration in order to simulate change negotiation using realistic process collaboration scenarios. The experiment results have been analyzed and in turn, compared to the different normative solutions, representing various approaches to fairness and efficiency of group solutions.**

1. Introduction

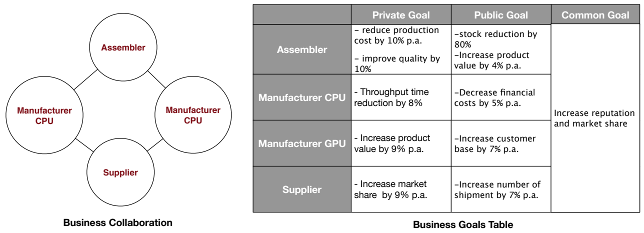
In a coopetitive environment, besides focusing on their core businesses, companies are often embedded in inter-organizational processes with networks of partners or even competitors. This allows companies to gain competitive advantage, expand their client base and tap into new markets by addressing skill or resource gaps [1]. Despite the advantages of such business process collaborations in terms of competitiveness and profits, dealing with change remains a major concern [2]. Indeed, due to market dynamics, companies are often forced to adapt their processes and align them with their objectives. Changes are not always local to one partner but can spread over the collaboration network [3], and consequently affect the involved partners as well as their corresponding goals and strategies [4]. Changes can lead to conflicting impacts on the partners and can threaten the longterm relationship between collaborators. Furthermore, changes can be implemented in different ways, and thus propagate differently, leading to a multitude of propagation alternatives with distinct costs. A negotiation process in which partners collectively make a decision about the proposed change alternatives becomes therefore necessary [5]. In the group decision making domain, several methods have been proposed to overcome the complexity of alternatives evaluation and improve the decision-making process [6], [7].

From a practical point of view, in a collaboration, each of the involved partners holds a *private process* that describes its business logic and a *public process*, visible to its collaborators, that defines its contribution to the collaboration [3], [8], [9]. Together, all collaborators agree on a *choreography model* that gives a global view on how they interact with each other. Each of these models is characterized by a set of business goals that serve as a key performance indicator to evaluate the efficiency of the collaboration or the private processes separately. In turn, goals can be expressed in terms of criteria such as reliability or expenses. Thus, a change may lead to a situation in which multiple conflicting decision factors (goals, partners, criteria) are to be considered simultaneously.

In [5], we have presented a simple model from group decision making to address change negotiation in collaborative business processes. In this paper, we extend the theoretical model to support multi criteria, multi objective and multi party negotiations. Notably, change propagation is not bound to the direct partners, but can transitively expand to partners that are not initially affected by the change. This increases the complexity of the decision making compared with bilateral negotiations. Additionally, partners use different metrics and do not interpret values in the same way. Therefore, using an appropriate scaling method to make all criteria as well as scales of different partners comparable becomes crucial. This paper also conducts a role-play experiment in which students simulate business collaborations and negotiate change scenarios. This will be followed by an analysis of their decisions and comparison with the normative solutions provided by the theoretical models.

In summary, this paper addresses the following research questions:

- RQ1 How to formulate the multi criteria, multi objective, multi party change negotiation in business collaborations?
- RQ2 What is the appropriate scaling model to adopt in order to deal with the heterogeneity of collaborators data?
- RQ3 How could these models be used to support cooperative change decision making in realistic scenarios?



Business Collaboration

	Private Goal	Public Goal	Common Goal
Assembler	– reduce production cost by 10% p.a. – improve quality by 10%	–stock reduction by 80% –Increase product value by 4% p.a.	Increase reputation and market share
Manufacturer CPU	- Throughput time reduction by 8%	–Decrease financial costs by 5% p.a.	
Manufacturer GPU	- Increase product value by 9% p.a.	–Increase customer base by 7% p.a.	
Supplier	- Increase market share by 9% p.a.	–Increase number of shipment by 7% p.a.	

Business Goals Table

Figure 1. Collaboration Example: Just-in-time Manufacturing of Laptops

The remainder of the paper is structured as follows. Section 2 presents a motivating example, Section 3 formalizes the change negotiation problem, and Section 4 discusses the scaling problem. Section 5 presents a role-play experiment, simulates a negotiation process and analyzes the outcome. Finally, Section 6 discusses the related work and Section 7 concludes the paper.

2. Motivating Example

To illustrate the change negotiation problem, we consider a business process collaboration scenario for just-in-time manufacturing of laptops involving four partners: (i) an *assembler*, (ii) a *CPU manufacturer*, (ii) a *GPU manufacturer* and (iii) a *supplier*. Central to this collaboration is the assembler, who focuses on just-in-time assembling of laptops for different client segments. In this regard, the assembler's business focus lies in optimizing this assembling process as well as all surrounding activities that are involved, such as quality assurance, software installations and maintenance.

Figure 1 depicts business objective examples of the different collaborators of the just-in-time production scenario. Each of the business objectives of one partner; e.g., private goal, is measured against the corresponding process model; e.g., private model. The collaboration combines expertise of the involved partners to increase reputation and market share; i.e., common goal. Each partner contributes to this global goal in a different way (through its public process), and aligns it with a public goal; e.g., stock reduction by 80% for *assembler*. Additionally, each partner defines a private goal aligned with its private process; e.g., reduction of production costs for *assembler* and throughput time for *CPU manufacturer*. Note that each of the business objectives can depend on a multitude of criteria such as execution time, reliability or expenses.
Now, assume that *assembler* wants to reduce the assembling costs and improve the quality of its products. In order to do so, three major change alternatives to its process are proposed. All of the proposed alternatives result in different change propositions to both *Manufacturer CPU* and *GPU*; e.g. run additional quality checks to reduce defective components, which also might be implemented in different ways. Some of the proposed change alternatives on the *manufacturer* might, in turn, involve the *supplier*, which has to provide additional material.

This results in a set of change propagation alternatives that have different costs and impacts on the process models as well as the objectives of each partner in the collaboration[1].

Figure 2 describes two change propagation alternatives, where the *assembler* is the originator. As a consequence of a business change, two implementation alternatives are possible. Each of those alternatives impacts the collaboration differently. While the first change alternative propagates to all partners, the second one does not affect the *Manufacturer GPU*. In this example, for simplicity, each public change alternative resulted in exactly one private change alternative. However, the proposed approach considers multiple private change alternatives as a result of a public one. In change alternative 1, the *Assembler* propagates first to *Manufacturer GPU* and *Manufacturer CPU*, which transitively propagates to *Supplier*.

Computing change impacts in the context of process collaborations has been addressed in several works [2], [3], [9], [10]. In particular, change impacts on public and private processes has been thouroughly tackled in [3]. In the following, we adopt the change propagation functions defined in [3] to compute change effects. Accordingly, the table of Figure 2 summarizes the change impacts on the different criteria time, reliability and expenses. For simplicity, the concrete process models as well as the actual process changes and their effects are abstracted, but the reader may refer to the appendix[1] for a complete information about the process collaboration, the changes and the cost functions. The table of Figure 1 summarizes the values of the criteria time, reliability and expenses for the public and private process of each partner before and after change alternative 1. Those values where not generated randomly but computed using the change propagation functions defined in [3] as well as realistic objective functions. All values were thereafter normalized.

While change alternative 1 has good impacts on the private process of the supplier execution time and reliability (increase of 42.8%), it has negative effects on its expenses (increase of 0.59%). Similarly, it has negative effects on the assembler execution time. This results in conflicting impacts on either the utilities of the same or different partners. Using multi-criteria decision making (MCDM) techniques can assist deciders to select an appropriate change propagation alternative that is fair and efficient for all partners. In particular, it helps selecting a fair solution while considering diverse and conflicting criteria and objectives.

3. Problem Formulation

Goals. As aforementioned, a business collaboration is an agreement between organizations to do business together in order to achieve a *common goal* G. A collaboration can be defined formally as a contract that specifies the role

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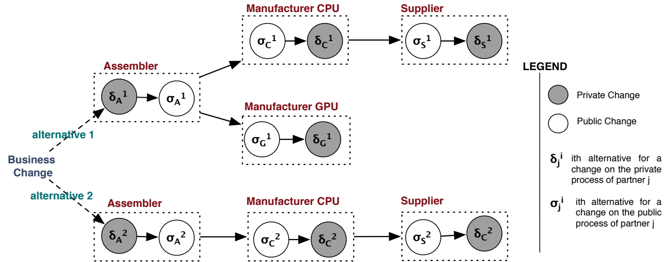
[1] Process models, goals and change impacts are provided as supplementary material: http://www.wst.univie.ac.at/communities/c3pro/index.php?t=downloads



	Private Process									Public Process								
	Before			After			difference rate (%)			Before			After			difference rate (%)		
	T	E	R	T	E	R	T	E	R	T	E	R	T	E	R	T	E	R
Alternative 1																		
S	7.3	427.6	0.265	7.17	430.1	0.378	1.78	-0.59	42.87	0.66	8.76	0.65	0.31	6.7	0.93	52.63	23.5	42.8
MGPU	9	678.4	0.11	9	687.7	0.14	0	-1.39	27	2	12.2	0.18	2.7	10.6	0.18	-35	0.13	0
MCPU	14.4	3537	0.43	13.98	3533	0.46	2.92	0.1	5.02	0.9	15.19	0.63	0.81	13.52	0.96	-10	10.99	52.3
A	65.7	2516	0.68	66.35	2534	0.89	-0.91	-0.71	30	38.4	1160	0.94	39	1178	0.94	-1.65	-1.54	3

Legend T: time (h) E: expense (K-euro) R: reliability A: assembler MGPU: manufacturer GPU MCPU: manufacturer CPU S: supplier

Figure 2. Change Propagation Alternative Costs: Before and After Change

of each partner; e.g., its public model. The latter is visible to all partners and reflects the *public goal* G_i of the respective partner in the collaboration. While a partner shares its public process and goals with its collaborators, its internal business logic as well as its *private goal* g_i remain hidden. The fulfillment of a private goal g_i depends predominantly on the private and public process of partner i, and can be influenced by the public processes of its collaborators.

Criteria. A collaboration agreement does not include solely the way partners should interact or the business objectives, but also defines a certain quality of service QoS to be met during the collaboration. This QoS can be expressed in terms of execution time, reliability or expenses; i.e., criteria. These criteria are tightly connected with the different business objectives, which in turn, can be evaluated through these criteria. Each of the aforementioned goals can be expressed in terms of a different set of criteria. For simplicity, we assume that all goal types depend on the same set of criteria C.

Change propagation. A change can spread over a collaboration and consequently might affect directly or transitively different partner public and private models as well as their corresponding goals. This implies a sequence of changes to the public and private processes of the partners affected by the change (cf. Figure 2). As described in [3], change propagation follows these three steps:

- Private-to-public propagation (Pr2Pu): Changes are propagated from the private process to the corresponding public process of the same partner. This has consequences on the public goal of the partner G_i.
- Public-to-public propagation (Pu2Pu): Changes are propagated to the affected partners; i.e. the effects on their public processes. This has consequences on the common business goal G and the public goals G_i of the affected partners.
- Public-to-private propagation (Pu2Pr): Changes are propagated to the corresponding private processes of the affected partners. This has consequences on the goals g_i

Since goals are evaluated over criteria, then a same change can impact differently each of these criteria. In the following, we define private and public changes for a partner i as δ_i and σ_i respectively.

Change impacts on Goals. The impact of changes on the different goals (common goal, public and private goals of each partner) can be seen as being dependent on the changes to the public processes of all partners. Thus, the common decision problem of the partners involved in the change consists in agreeing on a new set of public process models. Consequently, each design alternative is represented as a vector of changes to each partner public model, i.e., $\sigma^k = (\sigma_1^k, \sigma_2^k, \ldots, \sigma_m^k)$. Then, the impact on each of the goals is a function, which depends on such change vector. In the following we consider the functions G^j, G_i^j and g_i^j as the respective impacts on the global goal, public and private goals of a partner i with respect to criteria j.

$$\begin{aligned} &G^j(\sigma_1^k, \ldots, \sigma_m^k) \\ &G_i^j(\sigma_i^k, \sigma_{-i}^k) \\ &g_i^j(\delta_i^k, \sigma_i^k, \sigma_{-i}^k) \end{aligned} \tag{1}$$

where $-i$ refers to all partners except partner i, k refers to the change alternative number and j to the criteria. For simplicity, we use G^j, G_i^j and g_i^j.

Preferences and utility function. When evaluating process changes, each partner takes into account the common goal as well as its public and private goals. Since each of the goals is defined based on a set of criteria, then assessing the impacts of the changes on each of these criteria is primordial to the selection of the best alternative. Depending on its business strategy and objectives, each partner may assign preferences to each of these criteria and goals. We represent this simultaneous overall evaluation of all goals via a multi-criteria multi-objective utility function (cf. Figure 3). For a partner i, the utility function requires three matrices: (i) a matrix of the change propagation alternative impacts on the different criteria and goals, (ii) a matrix describing the weights given to each of the criteria w_i^j (j:1..n), and (iii) a matrix that defines the weights given to the private, public and common goals. Obviously, the sum of the weights for the criteria as well as of those for the goals are equal to 1; i.e., $\sum_{i=1..n} w_i^j = 1$ and $w_i^G + w_i^p + w_i^r = 1$. Considering the different preferences for both the criteria and goals, and assuming that the aggregation functions f and h are **additive** (sum of the attributes), then the utility function for partner i and change alternative δ^k is given by the following Equation 2.

$$u_i(\delta_i^k, \sigma^k) = w_i^G \sum_{j=1..n} w_i^j G^j(\sigma^k) + w_i^p \sum_{j=1..n} w_i^j G_i^i(\sigma^k) + w_i^r \sum_{j=1..n} w_i^j g_i^j(\delta_i^k, \sigma^k) \tag{2}$$

where δ_i^k is the $k-th$ private change alternative of partner i and σ^k is the change vector of all public changes caused by σ^k. Note that u_i represents the perspective of partner i for the evaluation of a change propagation alternative, and does not include the private changes of the other partners.

During the negotiation process, this could create incentives to misrepresent the effect of changes on one's private goals. For example, to avoid a certain change, one could indicate that this change would be even more damaging to one's private goals than it really is. This reflects directly the degree of trust between the collaborators and influences the efficiency of partnership. For simplicity, in Equation 2, we omitted the scaling function that transforms all values onto a common utility scale, and assumed that all values are normalized with respect to criteria and objective functions. Section 4 will discuss how to normalize the different values and bring them to the same scale.

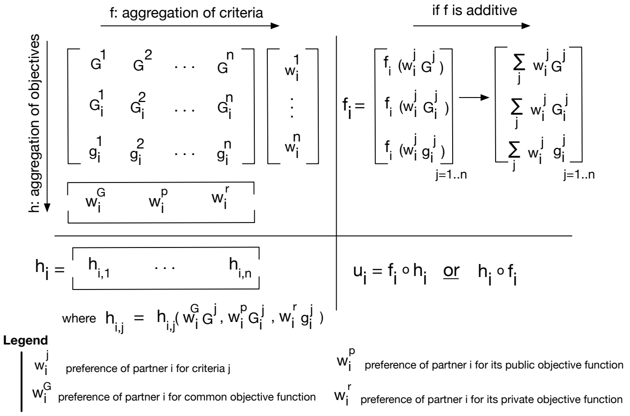


Figure 3. aggregation of criteria and objective functions

Collective decision. After evaluating the impacts of change alternatives on all collaborating partners, the latter engage a negotiation process to eventually agree on one alternative that reflects better their corresponding goals. In general, alternatives can be evaluated by measuring their efficiency and fairness [6]. Efficiency can be defined as maximizing the total output to the group, i,e. the sum of utilities. If utilities are all scaled between zero and one, then

$$Eff^k = \frac{1}{N} \sum_{i=1}^{N} u_i(\delta_i^k, \sigma^k) \tag{3}$$

Fairness refers to the balance of payoffs between the partners. In the case of multiple partners, fairness can be measured as the mean absolute difference of all pairs of partner utilities divided by the average.

$$F^k = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} |u_i(\delta_i^k, \sigma^k) - u_j(\delta_j^k, \sigma^k)|}{2N \sum_{i=1}^{N} u_i(\delta_i^k, \sigma^k)} \tag{4}$$

For a more thorough discussion about approaches from the group decision making and cooperative game theory domains that can be applied to determine the best alternative, the reader may refer to [5]. In this paper, we adopt three different functions: (i) additive, (ii) Nash bargaining and (iii) the Raiffa-Kalai-Smorodinski (RKS), as defined by Equations 5, 6 and 7 respectively.

$$\max U(\delta^k, \sigma^k) = \sum_i w_i u_i(\delta_i^k, \sigma^k) \tag{5}$$

$$\max N(\delta^k, \sigma^k) = \prod_i (u_i(\delta_i^k, \sigma^k) - d_i) \tag{6}$$

$$\max K(\delta^k, \sigma^k) = \min_i \frac{u_i(\delta_i^k, \sigma^k)}{\max\limits_k u_i(\delta_i^k, \sigma^k)} \tag{7}$$

where w_i is a weight assigned to member i's preferences in the group, d_i is partner i's utility for the *disagreement point*, i.e. the solution that would obtain if the partners did not agree on some alternative.

4. Scaling

In a business collaboration, partners typically use different scales and heterogeneous data for evaluating their processes and objectives. Even thought the objective functions and the criteria can be the same, the way they interpret the values might be different. For example, an expense value has no meaning except that assigned to it by a partner. The same expense value can be considered as very high by one partner, but fair by an another. Therefore, it is important to have a common understanding on what each value means to each partner in practical terms. This goes by considering subjectivity in the scaling model to avoid inconsistency and misinterpretation of values. An interpretation predominantly depends on several factors such as the company objectives, size and profits.

Furthermore, a change on one partner's process might have divergent effects on the different criteria used for evaluating the corresponding business objectives. For instance, a change might simultaneously result in a decrease of the partner reliability (negative effect), a decrease of its process average execution time (positive effect) as well as its process expenses (positive effect). The conflicting impacts of changes on the criteria as well as the distinct criteria scales add more complexity to the decision making process. In order to evaluate correctly and compare the change alternatives, a standardization of the different dimension values becomes necessary. There exist a multitude of approaches in group decision and operational research which deal with normalization and scaling issues, ranging from the fuzzy measures and integrals to the analytic hierarchy process (AHP) [11]. Figure 4 depicts an AHP representation of the example of Figure 1 and represents the relationships between criteria, goals and utilities as well as the corresponding weights. In this work, an alternative represents a change propagation scenario that affects multiple partners, objective functions and criteria. Therefore, the scaling method should not only consider subjectivity through transforming the absolute values into relative scales, but also weight and combine values along with multi-objective, multi-criteria and multilateral decisions.

Figure 5 considers two partners *Assembler* and *Manufacturer*, along with the multiple dimensions in terms of criteria and objective functions. In particular, we consider the criteria expense and assume that the impacts of a change alternative on *Assembler* expenses are measured in million euro, while they are in kilo euro for *Manufacturer*. In table (a), the usage of the rate as a mean to normalize values will give a ratio of 0.2 to both *Assembler* and *Manufacturer*. Reasoning about the ratio only will consider the solution as fair since both partners increase their expenses with the same rate, with respect to their actual value intervals. However, this does not consider that *Manufacturer* loses only 1 K-euro which is very small in comparison with 1 M-euro for *Assembler*. In table (b) of Figure 5 uses the normalization equation $(x - min)/(max - min)$, where each value is deducted by the minimum value and divided by the difference between the maximum and minimum values. The advantage is that all absolute values are reduced to a same scale of values between 0 and 1. This combined with the weights of the criteria (preferences) can be useful to compare change alternatives for a same partner. However, it still does not solve the problem of subjectivity between partners. In order to deal with this problem of commensurateness, it is important to elaborate a homomorphism function between the values of both *Assembler* and *Manufacturer* for the criteria *expense*. Using a direct ratio between the mean values of both *Manufacturer* and *Assembler*; e.g., (K-euro/M-euro = 1/1000) will still favorite the dominant partner with high values; i.e., *Assembler*, since it will select change alternatives that does not have strong impacts on *Assembler* and neglect the impacts on *Manufacturer* in k-euro even if they represent 80% of the latter budget.

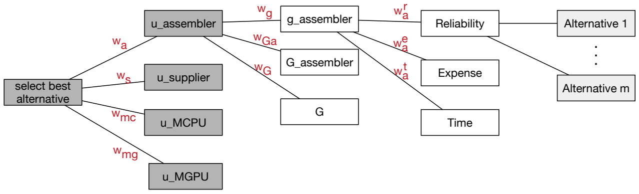
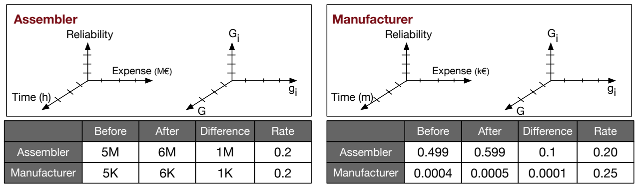


Figure 4. Hierarchy Analysis Process



	Before	After	Difference	Rate
Assembler	5M	6M	1M	0.2
Manufacturer	5K	6K	1K	0.2

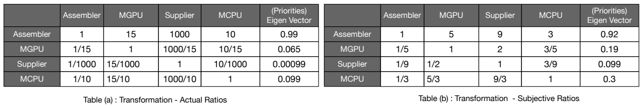
Table (a) : change impact on the Expense

	Before	After	Difference	Rate
Assembler	0.499	0.599	0.1	0.20
Manufacturer	0.0004	0.0005	0.0001	0.25

Table (b) : change impact on the Expense - Normalization

Figure 5. Scaling

Therefore, it is important that the homomorphism function takes into consideration the subjectivity instead of a simple ratio. For example an expense of 1M-euro can be relatively seen as 10 k-euro by a multi billion company, since the profits that it will generate through this change can be tremendous and measured in millions. The transformation function can be complex, but in this paper, we consider a linear transformation, where each partner, for each criteria, defines a transformation ratio to the new scale unit. Table (a) of Figure 6 uses the actual ratios between partners for the criteria *expense*, while Table (b) includes ratios that consider subjectivity of partners. A cell in the table defines what a same expense value of parter A means for partner B. The result is an eigenvector, which values are then considered as weights to scale the expenses of the corresponding partner [11]. The same approach can also be used for the criteria dimensions to be able to compare time to reliability for example. This is particularly useful for intangible criteria which are not quantified. Eigenvector values of Table (a) will always favor the *assembler* which is considered as dominant, while those of Table (2) can be more fair since it considers subjectivity. All values then will be transformed to the new scale and then again normalized using the equation $(x - min)/(max - min)$ to bring values to the interval [0..1].



	Assembler	MGPU	Supplier	MCPU	(Priorities) Eigen Vector
Assembler	1	15	1000	10	0.99
MGPU	1/15	1	1000/15	10/15	0.065
Supplier	1/1000	15/1000	1	10/1000	0.00099
MCPU	1/10	15/10	1000/10	1	0.099

Table (a) : Transformation - Actual Ratios

	Assembler	MGPU	Supplier	MCPU	(Priorities) Eigen Vector
Assembler	1	5	9	3	0.92
MGPU	1/5	1	2	3/5	0.19
Supplier	1/9	1/2	1	3/9	0.099
MCPU	1/3	5/3	9/3	1	0.3

Table (b) : Transformation - Subjective Ratios

Figure 6. Relative Measurements

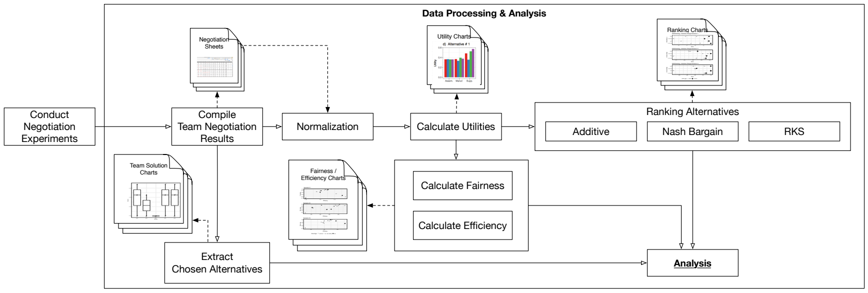


Figure 7. Experiment Methodology

5. Experimental Evaluation

The goal of this section is to put the concepts defined in this paper to test[2] and answer research question RQ3. Following the methodology outlined in Fig. 7 we set out to setup student experiments with the goal of simulating collaborative change negotiation, as well gathering and generating exploitable data for further analysis. While ultimately the goal of our approach is to serve as a tool for decision making in the context of collaborative change negotiation, through this experiment we set out to first evaluate its usability for the purpose of gaining insight into each team's reasoning process for negotiation. Thus, the following questions served as guideposts and allowed us to use our approach for evaluating the negotiation results.

- Is it possible to explain a dominantly chosen alternative by teams negotiating the same scenario?
- Are there alternative solutions with better outcome, which the teams did not consider?
- Did teams always consider fairness in picking their alternatives, or did they deviate to come to a more efficient solution? Is this efficiency reflected as benefits for one partner dominating the negotiation or distributed fairly among all team members?
- How to identify the group preference for negotiation scenarios leading to the chosen alternatives?

Analyzing the selected solutions using the guideposts helps understanding the usability of the proposed approach and how it can support change decision making (RQ3).

5.1. Experiment Setup

This section presents the experiments that we have conducted with the students in order to simulate change negotiation in collaborative processes and evaluate the importance of the proposed approach in decision making. Within the methodology, you can see it summarized under the activity *"Conduct Negotiation Experiments"* of Fig. 7. The experiment is based on a role-playing method (cf. [12]) where students experience realistic scenarios by assuming a specific role in a business collaboration and interacting with other students who also play different roles in the same collaboration. The students were asked to build teams of 3 to 4 participants, with each team designing a collaboration scenario and each student in the team adopts a role of a specific business partner.

Students Background. The experiment was conducted with students having two different backgrounds: (i) business process modeling and management and (ii) business administration. The former are master students with a good knowledge of workflow systems, while the latter are master students with a good knowledge of group decision making. BPM students were already trained on business process modeling, process collaborations and change propagation. Note that guidelines and utility function examples were given to students before the experiment. The experiment follows three milestones where intermediary results (e.g., process models or changes) are validated by BPM experts at the end of each milestone. Checking the quality of the models, utilities functions and changes by us ensured qualitative results that reflect realistic scenarios to be used for negotiation and decision making simulation.

Collaboration Setup. First, each team was asked to select a domain e.g. manufacturing, logistics, and define a real-world collaboration scenario. The number of collaborating partners depends on the number of participants per team, where each partner defines its role and the objective of its business. Then, each team builds its choreography model by considering which information or items should be exchanged between its members, and specifying who provides what, how they interact and in which order. Once the choreography model is built and the role of each member is defined, each partner derives its public process $\mathbf{Pu_p}$ and consistently defines its private process $\mathrm{Pr}_\mathbf{p}$. Students were asked to keep their private processes hidden from the other partners. To each activity in the public, private and choreography model students have to assign initial values to tasks corresponding to the criteria **time** (average execution time in time unit), **expense** (cost of required resources: number, type and price per resource), and **reliability** (a float number within the range $[0, 1]$). Similarly, XOR branches within the process have to be annotated with activation probabilities.

Each partner defines an objective function for each of its private and public models that reflects the quality of the model with respect to its business objective ($\mathbf{G_p}$ and $\mathbf{g_p}$). Similarly, each team defines an objective function for its choreography model $\mathbf{G}$. Objective functions are of the form $\mathbf{g} = (g_{time},\ g_{expense}, g_{reliability})$.

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[2] More details about the experiment and results can be found in: http://www.wst.univie.ac.at/communities/c3pro/index.php?t=downloads

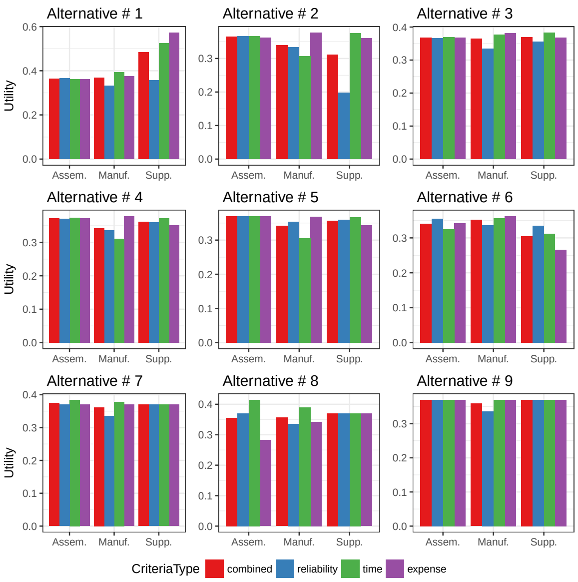

Figure 8. Utility Chart: partner utility values per criteria under a change alternative

The process and collaboration models were validated and corrected by us at the end of this milestone.

Change Simulation. Each partner in a team was asked to design one business change that results in at least three process change alternatives. A change is either inserting a new set of activities, removing or replacing existing ones. Changes are propagated to the partners, which in turn, calculate the impacts on their respective public and private processes and goals. Process Model scores before and after changes for each criteria are stored in an excel file to be used for the change negotiation part. Students were guided during change propagation and used the propagation techniques defined in [3]

Change Negotiation. The process models and proposals for changes have been elaborated and evaluated according to the three criteria of time, expense and reliability by the students from the workflow systems area. However, the negotiation part was conducted by both students from the computer science and business administration separately. Using the different objective functions, and the respective expenses of the changes students were asked to negotiate in order to find an agreement on which change to implement. During the negotiation, each partner should define its preference with respect to the aforementioned criteria; e.g., using weights. In order to negotiate changes, students can conduct face-to-face meetings or use other tools like Skype or emails. Also students were asked to argument their choices for the change alternatives and report the concessions they made during the bargaining process, and their personal evaluation of the outcome of the negotiation; wether they are satisfied with the agreements or not.

5.2. Data Processing

In total, the experiment was conducted with 13 teams of students from the workflow systems area and 7 teams from the business administration area. Each team produced an excel file that includes all values indicating the before and after effects on each criteria. We apply the scaling methods discussed in section 4 on the data set, allowing us to have comparable criteria values among different partners of the same change scenario (see *”Normalization”* step in Fig. 7).

Next, following Equation 2, we calculate the utilities for each change alternative split by criteria and additionally add an aggregated version we call *”combined”*. The generated artifact is called a *utility chart* (cf. Figure 8), which plots the utility values of a change alternative in respect to the affected partner further split by the criteria. These utility charts may give insight into the actual impact a change alternative has on each partner. Thus, given a chosen alternative, it is possible to identify who had the greatest gains (or losses) on the criteria utility values. It is possible to derive concessions partners made as well as identifying dominating partners during negotiations. Given the calculated utility values, it is now possible to exploit them in two ways. First we can derive the fairness and efficiency score (cf. Equations 4 and 3) of each change alternative per criteria, allowing us to plot each according to these dimensions. Second we can apply the ranking methods mentioned in section 3 (cf. Equations 5, 6 and 7) to sort the change alternatives, again split by criteria. The former results in artifacts called *fairness/efficiency charts*. These allow us to quickly identify alternatives not suitable for negotiation (cf. Figure 9), by simply scanning the lower left section of the chart (both low fairness and efficiency).

The latter generate artifacts called *ranking charts* (cf. Figure 10), which can be utilized for identifying alternatives maintaining a good balance between fairness and efficiency (for the RKS case), and those alternatives focusing on efficient solutions (for the Nash bargaining and additive case). In combination, *ranking charts* give insight into whether teams considered fairness into their negotiation process or purely focused on the best possible outcome disregarding the

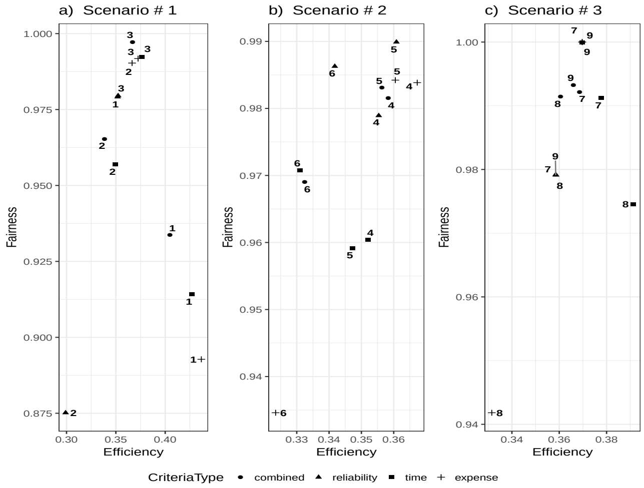

Figure 9. Fairness/Efficiency Chart (for change scenarios 1 to 3 in collaboration 3)

fair distribution of payoffs. In parallel to these calculations we can extract the actually chosen change alternatives by teams for each scenario. All of these artifacts serve as input for the final analysis.

5.3. Analysis

We have chosen a subset of the available data to conduct the following analysis. It concerns a collaboration between three partners (called collaboration 3), where both business administration students as well as computer science students performed change negotiations based on the same data set, allowing us to compare the teams. All of the previously defined *utility chart* (see Fig. 8), *fairness/efficiency chart* (see Fig. 9), and *ranking charts* (see Fig. 10) are reused for this section, as they contain the three change scenarios for the particular collaboration. Each change scenario contains three different alternatives in consecutive order. As such, alternatives 1 to 3 represent the available alternatives for change scenario 1. Alternatives 4 to 6 belong to change scenario 2 and so on. Alternatives are only comparable inside the same scenario. For this reason, we analyze the change alternatives incrementally by change scenario.

Business Change Negotiation Scenario #1 Starting with the *fairness/ efficiency chart* (see Fig. 9), we can identify which change alternatives are suboptimal for consideration. For scenario 1 this would be alternative #2 due to its relatively low efficiency as well as low fairness in terms of reliability. Alternative #3 is a natural contender for becoming the chosen alternative, as it dominates alternative #2. Change alternative #1 could be a possible candidate due to a more efficient solution in terms of time and expense criteria if the team is willing to accept lower payoffs in reliability and also accepts the misappropriate allocation of payoffs among the members. Specifically, looking at the *utility chart* we can identify the single role of *Supplier* gaining most of the benefits through change alternative #1. The *ranking charts* confirm the choice between alternative #3 and #1, depending on the group preference of fair allocation of payoffs (e.g. fairness or RKS ranking) or most efficient payoff (additive ranking). Observing the actual chosen alternatives (see Fig. 11) for scenario #1, all teams who have come to a successful negotiation picked alternative #3. These teams preferred the fair allocation of payoffs, and didn't consider the increased payoffs in terms of expense and time to be worthwhile for deviating from a fair solution.

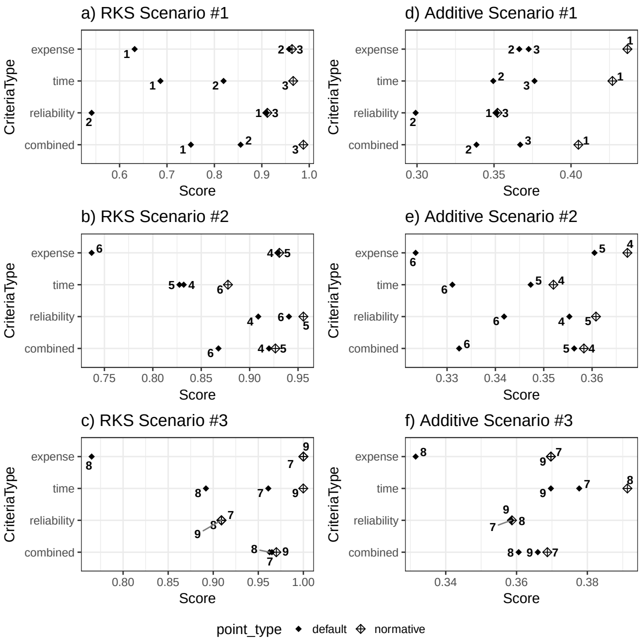

Figure 10. Ranking Chart (for change scenarios 1 to 3 in collaboration 3)

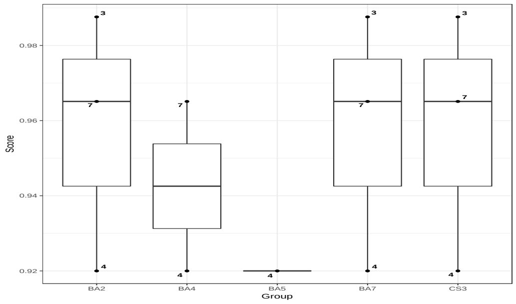

Figure 11. Team Solutions Chart (Collaboration 3)

Thus the *ranking charts* show a more efficient solution alternative #1, with the outcome being the supplier enjoying better decreased expenses and time. To compensate the bigger payoffs, the supplier might renegotiate business terms with the manufacturer and assembler, for them to consider this alternative. None of the teams have considered alternative #1 as a possible solution. Another interesting question is why the two business administration teams BA4 and BA5 neither considered #3 nor #1 as a possible solution. Reading through the reports of BA4, this team did not consider any of the alternatives #1 to #3 to be fair for consideration. BA5 had interpersonal problems between the partners due to assembler already denying a previous change request, and in turn not coming to a successful negotiation for scenario #1.

Business Change Negotiation Scenario #2 For this scenario, the *fairness/efficiency chart* identifies alternative #6 to be dominated by the other alternatives, and as such is not eligible. Of the remaining alternatives the *ranking charts* indicate that #4 returns a slightly efficient solution in terms of expense and time criteria. In turn a lower payoff in reliability (mainly for the manufacturer according to the *utility chart*). Thus a winning alternative #4 indicates the willingness of the manufacturer to accept a less reliable process, but in turn gain in time and expense criteria. A winning alternative #5 would indicate the reverse, where reliability is more preferred. Looking at the chosen alternative for scenario #2, we can see that indeed #4 has been the preferred solution by all teams. This scenario highlights the case where a less fair solution has been accepted by the teams.

Business Change Negotiation Scenario #3 In this scenario only two partners (Assembler and Manufacturer) are involved. According to the *fairness/ efficiency chart* alternative #8 is a non-eligable solution in regards to expenses (both Assembler and Manufacturer being affected), but gives the best payoff in terms of time (for the Assembler). A winning solution of alternative #8 would indicate a higher preference of time over expenses for the assembler. A fair solution would be alternative #9. The actual winning solution #7 deemphasizes fairness, and prefers the higher payoff in time, which in this case is applicable for all teams coming to the same conclusion.

6. Related Work

Business process modeling techniques, i.e., State Charts, have been applied to model e-negotiations (cf. [13]). However, the focus was on describing different negotiation protocols and not on collaborations and change. Negotiations typically take place during the web service discovery phase [14]. In addition, negotiation is an instrument used for building process choreographies (different partners have to agree on how their process interact). Hence, negotiations can be part of contracting [15] and the interface design [16], [17]. On top of process choreographies, service level agreements (SLA) can be formulated. To find and agree on SLA negotiations can be utilized. For this, [18] present negotiation protocols and strategies. Over the last decade, a multitude of approaches addressed change in collaborative processes [2], [3], [8]. Most of these approaches focus on identifying change impacts without considering the negotiation process. More recently, [5] presented an approach, which applies a simplistic model from the group decision making domain to the change negotiation problem. This paper extends the model to multi criteria, multi objective and multi party problem, and utilizes subjectivity for a better relative scaling. To the best of our knowledge, this approach is among the first to address the interfaces between all three areas, i.e., process choreographies, change, and negotiation.

7. Conclusion

In this paper we extend our previously defined [5] simple model for group decision making to address change negotiation in collaborative business processes by formulating and integrating multi criteria, multi objective and multi party negotiations. In this context the issue of scaling of heterogeneous criteria values become crucial for comparing alternatives among partner preferences. Through a series of experimental studies we apply the proposed concepts to gain insight into negotiations conducted by computer science and business administration students and thus show the applicability of the approach for post-evaluation of conducted group decisions in collaborative business processes. Future work will comprise a comparison of the behavior of participants with different background.

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