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A framework for context-aware heterogeneous group decision making in business processes

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ABSTRACT

In Business Process Management great attention is given to Computational Intelligence for supporting process life-cycle. Several approaches have been defined to support human decision making. The main drawback is that there are no solid criteria for determining optimal decisions since context, matter of discussion, and involved actors may differ at each execution. This work focuses on the definition of a framework to support and trace human decision making activities, in business processes, when heterogeneous decision-makers have to find a consensus to select most promising alternative to follow. The framework relies on Fuzzy Consensus Model and implements Reinforcement Learning algorithm to learn weight of the decision-makers through the analysis of past process executions considering context and performances of business processes. Context awareness relies on semantic web technologies enabling ontological reasoning to evaluate context similarity used to assign the right weight to the involved decision-makers also in the case when more general or more specific context occurs. The framework has been instantiated in the case study of Supply Chain Management. The analysis of the simulation results reveal that the proposed weight learning algorithm and the considered initial weight association strategies (*Starting Weight* and *Training Executions*), even if the cold start, give to decision-makers the chance to fill the gap with respect to more experienced decision makers.

1. Introduction and motivation

In complex business environments (e.g., organizations), Business Process Management (BPM) [1] provides an effective tool for managing processes. Business Processes (BP) include person-to-person work steps, system-to-system communications, or combinations of both. BPM integrates several disciplines like, for instance, process modeling, process simulation, process execution, process monitoring, etc. One of the most important concept underlying BPM is that process execution must be monitored in order to detect useful elements to improve next executions and providing value (e.g., for organization, customers, etc.). According to the above aim, a number of research works, focused on automatically or semi-automatically supporting human decision making activities, within a Business Process (BP), are recognizable in the specialized scientific literature. Many of them are based on the analysis of past process executions in order to derive decision criteria, transform them into rules and execute such rules to make decisions. This trend is motivated by the consideration that by means of existing machine learning algorithms it is possible to freeze past decisions (taken by humans) in form of rules and automatically apply them during new executions of the same BP without the intervention of humans. A drawback for the above-mentioned approaches is that there are no criteria that always determine optimal decisions since context and matter of decision may differ from situation to situation. Thus, it is crucial to investigate the definition of tools supporting human decision making within BP, which are capable of taking into account the context in which processes run. Moreover, approaches that completely replace human decision makers with automatic rules are not always applicable and, consequently, such approaches cannot be generalized and scaled to different and heterogeneous situations.

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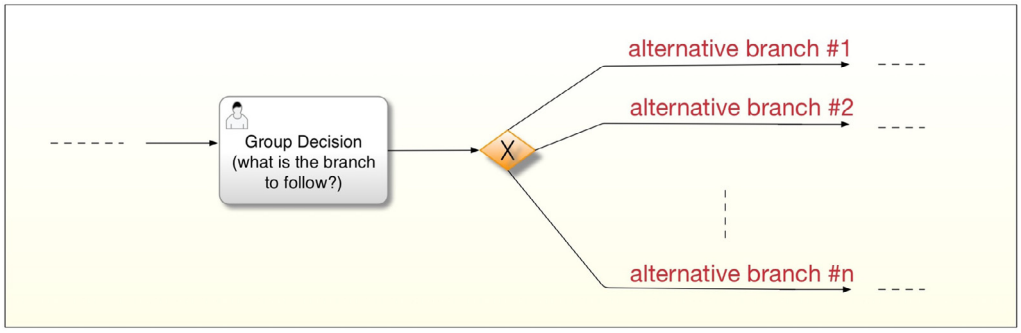

Fig. 1. BP fragments describing group decision making activities.

According to the aforementioned considerations, there is a need for definition of frameworks capable to support human decision making. In order to be effective, such frameworks must be:

- integrable smoothly into the practices of BPM in order to be portable across organizations which adopt standards and standards de-facto;
- based on a formal model to handle consensus achievement in the group of decision-makers in order to provide a trusted mechanism to moderate conflict resolution and, in general, decision making;
- context-aware in order to drive the consensus achievement process by also taking care of the impact of peculiar context features;
- adaptive with respect to the goodness of past decisions of the decision-makers in order to improve next processes.

These characteristics will foster *organizational learning* in the sense that the organization will learn from the level of success of the past decisions in order to improve new process executions by giving greater importance to those decision-makers who performed better in past processes executed in similar contexts.

Taking care of the above needs, this work focuses on the definition of a framework to support and trace human decision making activities, within BP, when more heterogeneous decision makers have to find a consensus to select one of a set of defined alternatives, as shown in Fig. 1.

Specifically, the proposed framework is based on the existing *Fuzzy Consensus Model* and on a *Reinforcement Learning* algorithm. The first one is used to find a convergence among a set of heterogeneous decision makers' opinions.[1] The second one is applied in order to learn the relative importance of the decision makers.

In literature, approaches assuming different weights for decision makers are recognizable [2]. For instance, authors of [3] introduce a trust-based approach to calculate weights.

This work proposes a novel approach to calculate such weights, by tracing the context of past experiences of people to make decisions. The relative importance of a decision maker is measured by considering the past successful decisions taken by him/her. The concept of relative importance is developed by considering the context in which such decisions take place. Contexts are modeled by means of semantic technologies enabling ontological reasoning and succeed in providing relative importance of decision-makers also in the case of more general or more specific contexts.

The manuscript is organized as follows: Section 2 provides an overview of the overall proposed approach; Section 3 defines fuzzy consensus model to support GDM and describes how it has been applied to face with heterogeneous issues related to the executions of BP in different contexts; Section 4 describes how the context has been modeled and used to assign heterogeneous weights to decision makers according to their previous decisions in similar contexts; and Section 5 describes how reinforcement learning algorithm has been used to update weights assigned to decision makers in the knowledge base according to the outcome of their decision. Section 6 provides the application of the proposed framework to a case study in the domain of Supply Chain Management. The results of such case study have been subsequently analyzed and discussed. Finally, conclusions and future directions close the paper.

2. Overall approach

The proposed approach is mainly focused on injecting a semi-automatic method to achieve a consensus into business processes when a Group Decision Making (GDM) problem is proposed. Specifically, the main idea in this work is to adopt the Fuzzy Consensus Model proposed in [4],[5] to face with GDM problem during business process execution. From the architectural viewpoint, Fig. 2 points out that the proposed Context-aware Group Decision Making has been modelled as a business process. Specifically, it consists of some phases/services that are orchestrated as shown in Fig. 2 by means of Business Process Model and Notation (BPMN). BPMN is a standard for business process modeling that provides a graphical notation for specifying business processes. So, the idea is aimed at demonstrating that the proposed framework could be easily integrated into the enterprises that already adopt standard systems, languages and practices for business process management for supporting the human decision making activities.

Thus, as shown in Fig. 2, it is suitable to model this kind of method by means of BPMN [6] in order to use it as a pattern when needed. In particular, when a GDM problem is proposed and represented, for instance, by means of the pattern provided in Fig. 1 it is possible to expand, at the BPMN level during the business process designing phase, the user task of Fig. 1 with the sub-process reported in Fig. 2. In particular, the aim of such sub-process is to formalize the GDM process and make it executable by means of a set of scripts implementing a structured approach we are going to explain. This approach consists of two different phases called consensus reaching and selection, which can be generally applied to several and heterogeneous domains. Although it is specific, the pattern of Fig. 1 is always possible to reconduce different gateway-based pattern to it in order to apply the approach we are going to propose.

A *consensus reaching process* in a GDM problem is an iterative process composed by several discussion rounds in which involved decision makers receive feedback that induce them to modify their preferences. The feedback is given by a moderator that is in charge to supervise and drive the consensus process to achieve the maximum possible agreement reducing the number of experts outside

[1] The convergence happens when the degree of consensus is higher than a fixed threshold, otherwise the decision will not be taken and other rounds take place.