Cognitive Information in Business Process - Decision-Making Results

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***Abstract* — The performed work in business processes in organizations can be defined as situated activity, fundamentally, surrounded by a context. Contextual knowledge resides not only in the activities, conditions, facts and situations, which occur during a task performance. Contextual knowledge also resides in people's mental activities of thinking, reasoning and judging. In other words, contextual knowledge also resides in people's cognitive processes. We argue that the cognitive process of decision-making can be considered a contextual element, since it could explain how a decision was made and how its outcomes were reached. We presented an approach for capturing and representing individual cognitive decision-making process as contextual knowledge in decisions activities of business process. This paper presents an approach for using decision results as contextual information for new decisions within business process.**

Keywords - Decision-making result; Context; Business Process; Knowledge Management; Organisational Learning

I. INTRODUCTION

The work performed by people can be defined as situated activity, fundamentally, surrounded by a context [2]. Business processes, which represent the way organizations work, consist of sets of activities through which information and knowledge are generated, transferred and converted. In this sense, for business process actions and events total understanding, all relevant contextual information involved in particular situations should be available. Besides, learning with past tasks and how to deal with changes that arise might create opportunities for reusing content produced in previous circumstances [7][20].

A formal definition for context is provided by [1]: context is a set of circumstances which surrounds an event or subject and the structures of mental models which represent knowledge. Contextual elements may refer to group members, task planning, interactions which led to a conclusion and the environment where a task was carried out. Thus, the contextual knowledge resides not only in the activities' conditions, but also in people's cognitive processes as thinking, reasoning and judging, for instance.

We argue that decision-making cognitive process can be considered a contextual element, since it could explain how an activity was performed as well as the outcomes reached. We presented [13][15] a meta-model and a set of guidelines to support meta-model instances creation. This proposal goal was to capture and to represent individual cognitive decision-making process as contextual knowledge in business process activities.

This paper proposes to extend [13] meta-model including other important information related to the decision consequences and moreover about the process goals achievement. The goal of this paper is to discuss the approach of using decision results records as contextual information. Besides, we also discuss how retrieving registered decisions results would help making new decisions.

The paper is organized as follows: Section 2 describes the concept of cognitive information and context in business process and how decision results could be argued as part of contextual information. Section 3 presents related work. Section 4 describes the improved model proposed. Section 5 discusses new results obtained. Section 6 concludes the paper.

II. COGNITIVE INFORMATION AS CONTEXT IN BUSINESS PROCESS

According to Rowlands [19], cognitive processes are those essential to performing information acquisition and usage. Lima and Borém [8] affirm that cognitive processes include the mental activities of thinking, imagining, remembering, problem-solving, perceiving, recognizing, conceiving, judging, reasoning, etc., occurring differently for each individual, depending on his skills. Thus, the outcome of each process is different, depending on experiences, abilities and knowledge of whoever carries it out.

This emphasizes the relevance of describing cognitive processes information and making them available. For Lima and Borém [8] and Maximiano [9], mental activities recognition is important for understanding a situation, since each person has a particular perception about a problem.

Contextual knowledge is the experience of each worker, device, as well as activities, conditions, events and situations which occur during a job performance [1]. So, we regard cognitive processes as contextual information. Besides that, context cannot be disjointed from its use (business

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processes). The information about the context of past activities performed by an individual can help other people to understand current situation. So, we aim to promote OL (Organizational Learning) by completing knowledge spiral model [14] alternating between tacit and explicit knowledge.

Our research focuses on problem-solving cognitive process description, i.e., decision-making. We emphasize the decision-making cognitive process, because we believe that making this information explicit allows people to learn from it, helping them making new decisions.

According to Brézillon [1], context only exists in a given focus, for instance, when someone performs a task or any problem solving activity. At this moment, three types of knowledge related to context [18] emerge: proceduralized context, context knowledge and external knowledge. Proceduralized context is directly related to the focus and is used to carry a task out. Contextual knowledge is not directly used but it covers all available information that remains. External knowledge covers all other knowledge that is not relevant to the current focus. Since context is directly related to focus, in our case, business process activities, it changes dynamically through time.

For example, context identification of a task performance or an artifact generation can answer questions like: "Why did we do that?", "What would happen if we stopped doing this and that?", "Has this problem been solved before?", "Did anyone considered using a different approach?". These are questions that make people deal with subjects that have been already addressed before. The analysis of social, cultural and organizational issues should be done, since they are all related to the context and provides greater meaning to the action taken, increasing learning chances. We include cognitive processes, such as decision-making, among those issues, which can answer questions like: "Which belief or feeling influenced the decision?", "Any past experience influenced the decision?".

In the decision-making process, for instance, we evaluate every alternative and the weight of each criterion carefully when we are not used to making such decision. On the other hand, we carry out this process automatically, upon this situation becoming commonplace, without stopping to think how we have reached a conclusion, or why we have started from a premise [16]. In spite of how automation of these processes happens, it is important to identify decision components, in order to understand its result and the cognitive process used to achieve it.

In previous papers [13][15], we described a model to represent the cognitive decision process. We extended this model including decision consequences. We argue that it would improve its characterization as process contextual information.

III. RELATED WORK

Some proposals aim to make explicit the decision-making process [5]. Others focus on helping people making better decisions by defining criteria [18]. Others try to help people by applying methods [12] or providing Computer-based systems [11][3].

Montibeller et al. [5] propose to explain decision-making process by using Causal maps. McMurray [12] proposes some methods to expand people decision-making skills. The proposed methods are brainstorming, nominal group technique and the Delphi technique. These techniques are pointed out because they provide a structured format that helps increasing the quantity and quality of participant responses. The author believes that these methods can be important resources for tasks such as developing courses, setting departmental goals and forecasting trends for planning purposes. This proposal was applied for nursing staff development educators.

According to Roy [18], multiple criteria decision-making proposals aim to enable people to enhance conformity degree and coherence between the decision-making process evolution and the value systems and objectives of those involved in this process. The author states that the purpose of decision-aid is, therefore, to help people make their way even with ambiguity, uncertainty and bifurcations. Multiple criteria decision-making proposals aim to help people to make better decisions. However it focuses on objectivity, neglecting subjective factors.

As stated by Menzel et al. [11], it's necessary to identify the most appropriate IT solutions for Cloud Computing. So, their proposal comprises a generic, multi-criteria-based decision framework and an application for Cloud Computing, the Multi-Criteria Comparison Method for Cloud Computing ((MC2)2). Their framework and method allow organizations to determine what infrastructure best suits their needs by evaluating and ranking infrastructure alternatives using multiple criteria. Their proposal includes a way to distinguish infrastructures not only by costs, but also in terms of benefits, opportunities and risks.

Yigitcanlar [3] affirms that the computing tools and technologies are designed to enhance the planners' capability to deal with complex environments and to plan for prosperous and livable communities. So, he examines the role of IT (Information Technologies) and particularly Internet GIS (Internet Based Geographic Information Systems) as spatial decision support systems to aid community based local decision-making. The paper also covers the advantages and challenges of these internet based mapping applications and tools for collaborative decision-making on the environment.

According to Steiger and Steiger [17], the decision-maker first determines values for key factors and then applies his/her mental model to evaluate the alternatives based on them, estimate potential output and make the best decision. They propose a mining architecture based on cognitive instances (ICM - Instance-based Cognitive Mining), which integrates several technologies to capture and express decision maker mental model. However, Steiger and Steiger [17] do not investigate the decision in the person's mind and do not try to find what causes or influences it.

To maximize the total reward people receive over a fixed number of trials, Steyvers et al. [4] argue that they must choose between a set of alternatives, each with different unknown reward rates. So, with the aim of helping people maximize the number of rewards, Steyvers et al. [4] use a

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Bayesian model of optimal decision-making on the task, in which the way people balance exploration with exploitation depends on their assumptions about the distribution of reward rates. They do not consider the individual's way of thinking.

Some researches on systems are already customized for a specific domain while others are too generic and difficult to customize. There are researches focusing on supporting decision-making. However, they do not care about past decisions neither decision's context.

Other important aspects to be considered are the decision-making components. Some elements of decision-making that should be informed are indicated by Montibeller et al. [5], but they do not set up how each piece of information is related to each other. Similarly, Steiger and Steiger [17] ask only for the key factors in decision-making and their respective weight, they do not even describe what they are. Steiger and Steiger [17] are interested in representing the decision-making process, however, they do not discuss which individual's values are considered. They do not care about cognitive processes.

IV. REVISED DECISION-MAKING META-MODEL

A. Meta-Model Source and Goal

Nunes´s knowledge management (KM) model [10] proposes four macro steps, as following: 1) capture context information; 2) associate this information with activities in a business process; 3) store this information in a repository - Organizational Memory (OM); and 4) retrieve information anytime, filtering by similar contexts. They argue that it is possible to make inferences from a model, identifying new information and supporting the understanding of process activities instances.

Pereira and Santoro [13][15] approach extended [10] KM model considering executor context, highlighting the decision-making cognitive process [5]. Pereira and Santoro [13][15] proposal focus on steps one and two: information capture and association with business process. It did not cover storage nor retrieve in OM (steps three and four).

Pereira and Santoro [13][15] proposal was a meta-model for capturing and representing individual cognitive decision-making process as contextual knowledge in business process activities. The meta-model proposed was structured by the development of an ontology, which provides structure for the OM [21]. Pereira and Santoro [13][15] also proposed a set of guidelines to support meta-model instances creation.

The meta-model goal is to explicit how a work process activity executor thought while making a decision. This can be done by instantiating [13][15] context meta-model. This provides a basis for a work process activity executor to describe how his own decision was made; thus the meta-model should draw together all relevant cognitive decision-making process elements and their relationships, which are stored in the OM. The benefits to the decision making process occurs every time someone has to make a new decision, because he will be able to retrieve past decisions with similar context information. This retrieve is done by a reasoner, but is not scope of this research.

B. Meta-Model New Classes

We analyzed Pereira and Santoro´s survey results on decision reuse [13], which was carried out among people of managerial level who are used to make decisions. All interviewees stated that what happens after a decision is very important and makes difference when he wants to retrieve decisions recorded, with the purpose of helping him to make new decisions. We realized that it was not possible to register what happened after the decision by creating an instance of [13] meta-model because it didn't cover decision consequence as context information.

In order to make it possible to record decision result and to make it available for new decisions, we identified new classes and we extended [13] decision-making meta-model underlining decision consequences, aiming make explicit what happened after that decision. We added the classes Result and Consequence, as pointed out by a rectangle in Fig. 1.

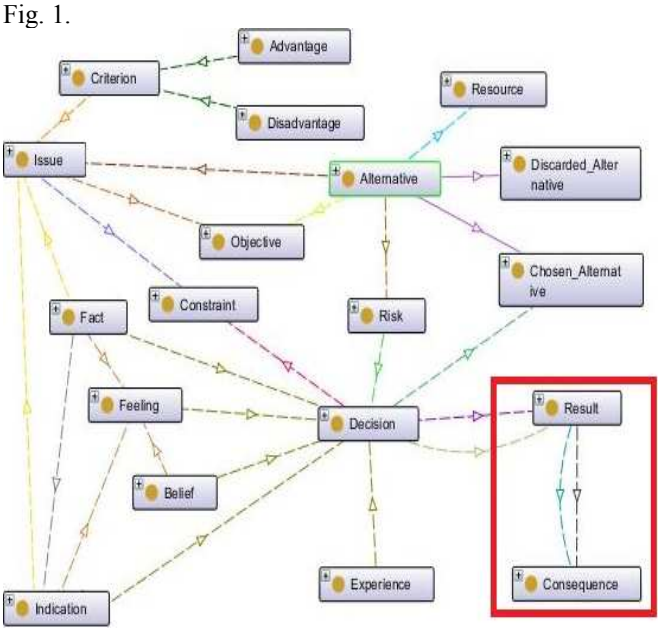

Figure 1. Extended Cognitive Decision-Making Meta-Model – Highlighting Decision Results

The Result class represents how the decision results were regarded by those who made the decision, for example: an executive director decided to reward some employees by giving them a car. He believes that it was a successful decision because it brought more comfort on employees' way to work. It was above his expectation and he is really satisfied, because those employees had better performance, since they were not so tired because of the traffic jam.

There is also a relationship called Results_in between the Decision class and the Result class. This new relationship represents what the decision made resulted. Result class properties are: Rating, Reason_Rating, Expectation, Satisfaction_Degree and Reason_Satisfaction.

The Rating property indicates how successful the decision was. It may take the following values: Successful, Neutral or Unsuccessful. The Reason_Rating property describes the cause for that success or lack of it.

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The Expectation property reports how decision result met what the decision maker looked forward while making the decision. It may assume the following values: Above, Met, Below; representing if decision result exceeded all expectations, if it met expectations or if it was below expectations, respectively.

The property Satisfation_Degree indicates how pleased the decision maker was with decision result. It may take the following values: Satisfied, Neutral or Dissatisfied. The Reason_Satisfation describes the cause for this feeling.

Decision result brings consequences, which led to Consequence class creation and to the relationship Brings between them, which represents what happened due to the decision results. The Consequence class represents what happened after the decision. There may have an instance for each consequence identified, continuing the example above: the decision of giving a car had a positive impact of saving employees' time in traffic jam, however it had a negative impact of wasting more money with reward. Consequence class properties are: Impact and Description.

The Impact property reports if the consequence was Positive or Negative. The Description property explains the benefits achieved or the undesired effects. There is also a new relationship between Result and Consequence classes. It is called *Brings*. There is no new relationship between Consequence class and others.

Table 1 shows a brief description of new classes and Table 2 shows new classes summary presenting their properties and the range of some properties can assume.

TABLE I. NEW CLASSES' DESCRIPTION

Class Name	Description
Result	What results from decision
Consequence	Good or bad effects obtained with the decision

TABLE II. NEW CLASSES' SUMMARY

Class Name	Properties	Range
Result	Rating	Successful / Neutral / Unsuccessful
	Reason_Rating	-
	Expectation	Above / Met / Below
	Satisfaction_Degree	Satisfied / Neutral / Dissatisfied
	Reason_Satisfaction	-
Consequence	Impact	Positive / Negative
	Description	-

V. TOWARDS RE-USING THE DECISION-MAKING

We performed 4 cases studies to assess whether new classes, their properties and relationships were enough to explain decision-making consequences details. All participants occupied a leadership position.

The case study focused on identifying what happened after a decision and identifying decision result relevance for making new decisions. Besides we applied a survey that aimed at identifying decisions context similarities comparing them.

These cases studies were based on cases studies results performed by [15]. We asked participants to report decision result reported in the previous case study, which led to the creation of an instance of the cognitive decision-making process meta-model. The decision result was recorded, in order to complement the meta-model instance.

Besides that we carried out a survey recording other context information needs. Moreover, this survey also assessed new decisions of the same context made by that person, in order to identify context similarities and to discuss the approach of using recorded decision results as contextual information for new decisions within business process.

A. Ontology New Instances

In this subsection we describe and assess new instances obtained from participants' responses. To better convey our explanation, we refer to participants as A, B and C.

Participant A reported that the decision recorded in the previous study case happened again. He pointed out that the following classes were presented in both decision instances: Experience, Feeling and Consequence.

Participant A said that decision's context is very important because it makes the difference while identifying alternatives. However, in his opinion, context is never the same. Only some pieces of information are repeated from one decision to another. He informed that there are some things that would lead the decision to a different way. Some of these things are related to his mood. Depending on how he feels, his decision may be different.

Participant A also stated that he could learn from other decisions things that should not be done, because they led to an unsuccessful situation or did not achieve the goal. He reported that having access to his previous recorded decision would change just a little bit his new decision. He also reported that having access to recorded decision of similar context would help him just a little bit to make new decision.

Participant B decision result is shown in Fig. 2. He reported that the decision recorded in the previous study case is recurrent. He pointed out that the following classes were present in both instances: Advantage, Consequence, Feeling, Objective and Risk. He states that accessing his registered decision would not change the new one, because his judgment criteria have been refined through experience.

He believes the context in which he makes decision is essential, despite his wide expertise on making decisions or his judgment criteria. He also believes that those criteria are usually permanent, because they come from people ethical and moral values. However, he stated that having access to recorded decisions of similar contexts would help him to make new decision. He highlighted that these records would help him only because they have similar context to the one he is experiencing.

Participant C reported that the issue of the decision recorded in the previous study case is recurrent, as well as the following classes: Experience, Consequence, Criterion, Objective, Result and Risk. He believes that accessing his recorded decision or any other recorded decision with similar context would change just a little bit his new decision.

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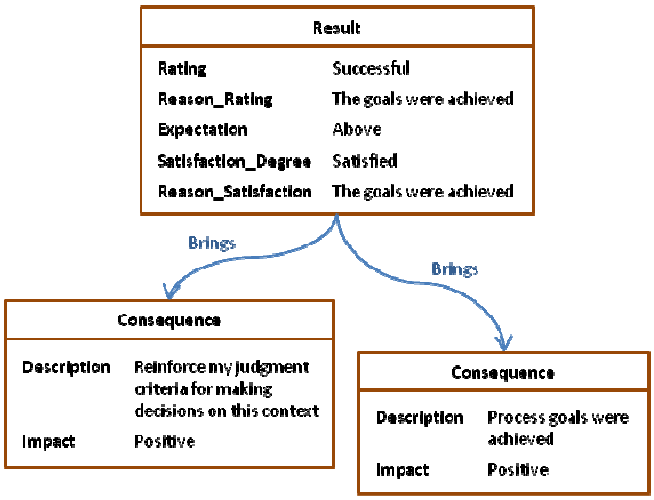

Figure 2. Detailed Recording Activity (focusing on decision's results)

Analyzing those answers we could realize that being aware about other people failure may avoid our own failure, because we can learn by observing someone else experience or by our own experience. This kind of information is provided by Result and Consequence classes. Participants also highlighted the importance of context information. They stated that a historic decision is only valuable if it is contextualized, otherwise it would be useless.

B. *Recording Activity*

This proposal should be applied at companies that seek to improve their practices in decision-making, sharing information and knowledge. Our research suggests an approach that enables companies to accomplish it through the analysis of historic decisions that were recorded during the process perform.

According to Pereira and Santoro [15], process manager should identify in which work process important decisions activities are made. Once these activities are identified, process manager reviews work process where these activities are, in order to add a further step related to reflection activity and another to decision-making cognitive process recording, for example, the executive manager of the example above is also "Recognition and reward" process manager. Revising this process he realized that rewarding is a very important activity for the company. As he would like to have past decisions registered to learn with them and to help him at the present time to make his own decision, he believes it's a good idea to register his own decision about it to help next "Recognition and reward" manager process to make decisions about it, when he leaves office. So, he reviews "Recognition and reward" process adding the step "Reflect about award" before the activity "Select an award" and after it he adds the step "Register decision about award".

Pereira and Santoro [15] argued to add the activity in the work process focused only on the decision's record. Regarding the scenario above, we extended the concept of this new activity by splitting it into 4 tasks, as shown in Fig. 3.

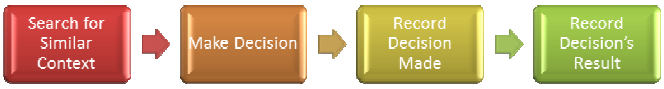

Figure 3. Detailed Recording Activity

The first task is to search for decisions in the OM which context is similar to the one he is experiencing at that moment. To support this task there should be a recovery mechanism able to identify actual context, to mine similar recorded contexts and to compare them, in order to bring out similar context decisions. Contextual information about decision's consequences may also be recovered.

The second task is to make the decision. This task is going to be performed based on similar context decisions recovered in the previous step.

Then, the third task is to record the cognitive process that occurred while making the decision. Record it means to store context information, associated with the business process activities, in OM, in order to be available for future research.

The fourth and last task occurs some time later because it records decision's result. As decision consequences are also context information, they will be stored in OM, so it might be recovered later.

C. *Application Scenario*

A model was built with some classes focusing on decision's result, as shown in Fig. 4. These classes came from responses from a case study participant, in order to illustrate how recording activity steps must be performed.

Whenever the worker carries out a decision-making activity, a reasoner (search engine) would compare recorded scenarios (in OM) with the one the worker is reporting or he is living at that time. The worker could choose from which context information the search engine would mine data. Regarding the example shown in Fig. 4, he could choose to retrieve information from OM using criterion "lowest price" or issues related to suppliers' selection and hiring. However, as decision result he reported was unsuccessful and he was dissatisfied with it, he would prefer to recover decisions which result was successful or even where Expectation was "Above" or Satisfaction_Degree was "Satisfied". Then, the reasoner would recover decisions records where the scenario matches.

Then, based on the information about past decisions recovered, the worker would carry out the second task of this activity. By recovering the OM, the worker would be able to analyze recorded events which context information is similar to the one he lives or he reported. It is going to support him to make his own decision. He would analyze these events and realize that the criterion chosen was not good. The research result would indicate that the selection and contracting of suppliers must be based on technical, professional and ethical criteria, but not only on price. However, in this case, he would not be able to use another criterion because this one was a legal requirement. Even so he could look for decisions that have used this same criterion to learn how they avoided or even eliminated the risk of getting a poor quality service or product. He could realize that some people bypassed this risk by specifying a technical

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requirement. Afterwards finishing his analysis he would finally make the decision.

Immediately after, he would accomplish the third task registering how he thought to make that decision. He would provide information about the issue to be decided, such as its goal, the fact or indication that led to the need to make that decision and the constraint imposed to its resolution. Next, he would report the alternative selected, as well as the advantages and disadvantages of performing such an option and the risk of carrying this option out. He would also report how this alternative influenced on the decision, the resources used and its goal. Afterwards, he would report each one considered, but rejected alternatives, reporting the same type of information reported in the alternative chosen. Afterwards these pieces of information would be stored in OM.

After a while the worker could report context information about the result of his decision. He could classify if the result was successful or not, how it met his expectations and how pleased he was with it. He could also report its consequences and indicate if it was positive or negative. These are important information because there could be cases where only good results matter. Or even, there could be a working group interested in unsuccessful events results, in order to identify theirs reasons to avoid theirs recurrence. The model shown in Fig. 4 illustrates an example of unsuccessful decision. By analyzing its decision's result, we could realize that legal requirement hindered suppliers' selection and hiring process.

VI. CONCLUSIONS AND FUTURE WORK

In our research, we have discussed that decision-making process description can be considered an important context information to support future decision-making, and consequently to improve business process. We proposed a meta-model to represent cognitive decision-making process and a set of guidelines to support workers creating instances of it.

This paper presents an extension of this model that improves the results obtained before, after the instantiated decisions. The goal was to show how this information could be used in practice. In this sense, new case studies have provided information about decision consequences within the process. This result worked as basis to build a scenario that described contextual information possible usage.

We concluded that ontology instances associated with the business process activities might allow the identification of correlation between a decision made and a process outcome. This is a first step towards the effective use of this information as context to promote learning among participants and process improvement. However, the decision-making cognitive meta-model as a whole is quite complex and in many cases reflects subjectivity and individuality. This is an important issue to be deepened, so that it can be addressed in our proposal more effectively.

This paper contribution is the possibility to concentrate all related information about decision-making cognitive process at a unique meta-model, which can be instantiated anytime to register decisions, transforming tacit into explicit knowledge, exteriorization. Once meta-model's instances were crated it can also be used to promote OL by transforming explicit into tacit knowledge, internalization. Knowledge spiral model [14] can be completed even if there is no computational support to automatize recording and retrieving.

We can also observe that a clear limitation of this proposal is the computational support requirement to help identifying similarities among the ontology instances. This feature would make possible to deal with processes that have a big number of cases to be analyzed.

In our future work, we are going perform more case studies at companies where the most relevant decisions-making processes are mapped, and evaluate the models generated in real situations where we presume people will learn with them.

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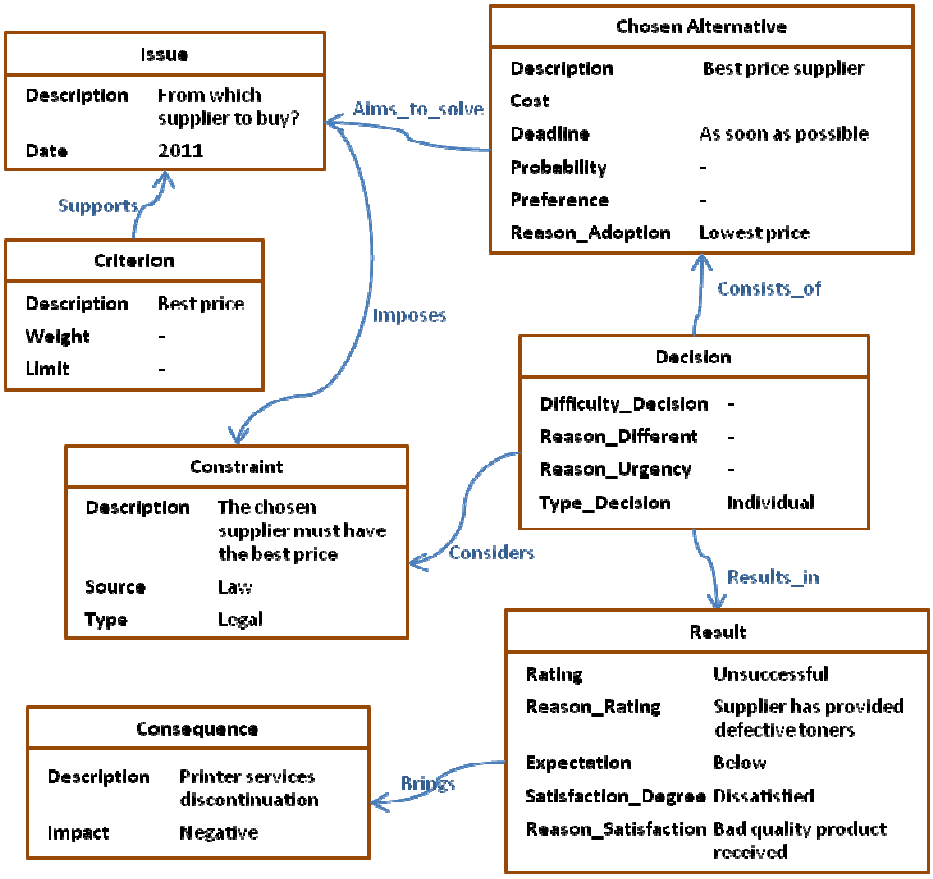

Figure 4. Instance Cognitive Meta-Model Decision-Making Result