Mediating Ideas in an Agent-based Team for Business Process Reengineering:Toward a Linguistic Ontology

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ABSTRACT

This statement first outlines the main requirements for the application of the ontologies and of the agent-based technology to Business Process Reengineering (BPR). Then it tries to motivate the need for a new type of mediation for BPR, namely the *mediation of ideas* (instead of services, as the existing facilitators provide), in order to automatically collect, compare, combine, analyze ideas and, then, infer upon them, during the brainstorming meetings. The statement also presents, as a possible solution to the ideas mediation and ontology integration, the intended steps in the construction of an upper-level ontology with linguistic features.

1. INTRODUCTION

Business Process Reengineering (BPR) means the rethinking and redesign of the business processes, mainly by the analysis and design of the *team-based work flows and processes* within and between organizations. The (manual) methodology proposed in [2] (and used as the methodological background in our research project) is a guide for the integration and interpretation of the TQM (Total Quality Management) instruments, aiming at BPR. TQM is a team-based technology with techniques for creating effective teams, for organizing ideas (brainstorming, multivoting, affinity diagram, etc), for statistical analyses upon the target processes and upon the data collected during the BPR process.

For the automation of this metodology, a *virtual team of software agents* is intended, where the agents work either on behalf of the users (BPR personal assistants and the mediator agent) or of other software agents (ontology agent) (see Fig. 1). At present, results with respect to the application of multi-agent systems (MASs) to BPR are not known in research and production. But, there are two related domains where MAS applications are in progress: the teamwork and workflow (i.e. organizational) technologies.

The ontologies are a communication tool in a MAS, besides the transport protocol and the agent communication language. Unfortunately, the ontology specification for MASs has not yet a standardized solution. So far, [3] is the most important specification that deals with ontologies for MASs.

Section 2 reveals the types and roles of the ontologies for BPR automation. Section 3 enumerates the main requirements for ideas mediation and for ontology integration. They refer to a BPR-dedicated MAS, but they could be extended to any teamwork-oriented one. Section 4 points out the coordinates of the upper-level ontology with linguistic features intended for ontology integration aiming at BPR.

2. TYPES AND ROLES OF THE ONTOLOGIES FOR BPR

The ontology-based comunication among the members of the BPR team is needed because they usually have different specializations and approaches on the target processes and they need to arrive at a common understanding of the concepts, actions, solutions etc and, eventually, at a common language to express their ideas.

The communication between the software agents for BPR is supposed to rely on three ontologies: (1) domain ontology and (2) BPR ontology, for the content of the messages; (3) the communication ontology, for the communication protocol. These ontologies will have the following roles in BPR:

1. *Domain ontology* (e.g. for manufacturing, education, insurance, etc) ascribes the meaning to the concepts/ symbols in the agents' messages regarding the target domain. In [2], the brainstorming manual implementation relies on 'operational definitions' of the domain-specific concepts. For the brainstorming automation, these definitions, and also the rules for their extension and interpretation, are supposed to compose the domain ontology and must be *dynamically created* by the BPR team.
2. *BPR ontology* describes the BPR specific terms and methodology (e.g. concepts for TQM statistical diagrams description and interpretation, for the diagram creation/ modification, for the implementation of the methodology steps, etc). BPR ontology is *predefined* and should be *logically correlated with the domain ontology* (e.g. the correlation between certain results in the statistical analyses and the steps in the BPR methodology).
3. *Communication ontology* helps for the description and interpretation of the communicative acts and of the dialog between agents.

All these ontologies are supposed to be *explicit:* declaratively represented in an ontological knowledge base and managed by a dedicated ontology agent.

The automatic reasoning for BPR will mainly be with and upon the concepts in the three ontologies. Each user will be assisted in the creation and interpretation of his ideas in terms of these ontologies.

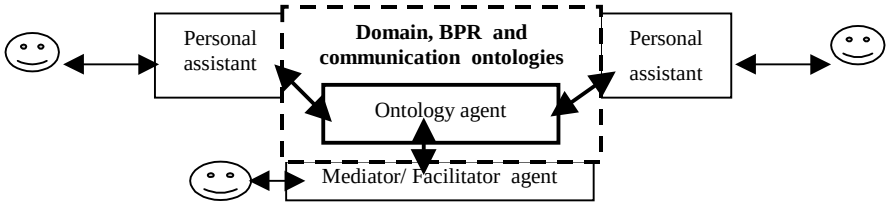

Fig. 1 Types of agents and ontologies in a multi-agent system supporting a BPR team

3. MEDIATION OF IDEAS AND ONTOLOGY INTEGRATION FOR BPR

During a brainstorming meeting, the ideas are required by the human (and implicitly, the agent) mediator, with respect to the topic of the meeting. Each member of the BPR team submits (by messages) his own ideas regarding that topic. The mediator agent is in charge with the acquisition of the ideas and with their mediation and negotiation, in order to help the human mediator to organize and synthesize them and to make appropriate decisions upon them. The reasoning that should support the mediation of ideas must be directed to the ideas' *automatic comparison, sorting, correlation, grouping, combination, negotiation*.

The reasoning for idea mediation will be simplified if the ideas are expressed in a predefined structured form (e.g. predefined questionnaires) in terms of the vocabularies of the domain and BPR ontologies. However, this approach substantially restricts the creativity and innovation that are expected from the brainstorming meetings.

A much more free expression of the ideas in BPR entails the following *requirements regarding the ontology representation and integration*:

- a BPR and, if possible, a domain *ontology for both object and processes*, that is either (1) the extension of the existing ontologies with explicit definitions and rules on activities and processes (e.g. [6]) or (2) the combination of an object-oriented ontology with a process-oriented one (e.g. KIF and PSL (Process Specification Language) that have a similar underlying grammar);
- the *conceptual integration* of the domain, BPR and communication ontologies;
- a *representation language common to all three ontologies*, that is to be used as both content and communication language for the agent implementation (e.g. the Interagent Communication Language in [4] that unifies the content and the communication language).

The ontology integration could be achieved either

- by an *upper-level ontology;* or
- by a *translation algorithm* between ontologies [3].

The disadvantage of the latter is that this algorithm will be mostly encoded and the ontology integration cannot be performed in the conception phase, as recommended.

4. TOWARD AN UPPER-LEVEL LINGUISTIC ONTOLOGY

The practical reason for choosing natural language (NL) as inspiration source for an upper-level ontology is its *universality*, as well as its *morphological and syntactic stability* and, implicitly, its *integration ability*. A linguistic ontology can be used for representing objects, processes and communicative acts, as well as the correlation between them, in simple, compound and complex sentences, with the semantics and interpretation borrowed from NL. The existing *lexical ontologies*, e.g. WordNet and FrameNet, mainly emphasize the relations inside the lexical categories, without any concern about the composition, interpretation and correlation of the sentences (i.e. of the ideas).

Instead, the construction of the ontological sentences in the intended upper-level ontology will follow five steps:

1. Association of the words in the ontology's vocabulary with the *morphological categories* they belong to. In NL, the main morphological categories are nouns, verbs, adjectives, adverbs. Their counterparts in the intended ontology are:
   - *active objects*, standing for the nouns directly involved in the verb's action.
   - *application specific or generic activities* (operations), standing for verbs. A particular kind of activities are the communicative acts in the communication ontology.
   - *attributive objects*, standing for adjectives (or other linguistic categories with the role of noun modifiers);
   - *adverbial objects*, standing for adverbs (or other linguistic categories with role of verb modifiers).
2. Composition of the ontological *simple sentences*, by means of the *syntactic roles* of the objects relative to the action of the operations. At least three roles must be, implicitly or explicitly, considered: *agent* (who produces the action), *patient* (object upon which the action operates) and *recipient* (receiver of the action's result).
3. Correlation of the elements inside or between the morphological categories by *semantic relations* (e.g. synonymy, antonymy, hyponymy, hypernymy, meronymy, holonymy etc, see WordNet [5]).
4. Correlation of the activities (i.e. verbs) by *intersentential relations* across simple sentences. These relations help us build the ontological *compound* or *complex sentences*.
5. Correlation of the objects in different sentences by *coreferences* (anaphoric references).

NL simple sentence, used as inspiration source for building the ontological simple sentence, is summarized below:

Simple sentence = *Subject* + *Predicate*, with **(I)**
Subject ∈ {Noun Phrase, Noun Substitute, Verbal Phrase, Clause, Indefinite/ Formal Subject}

Predicate = Finite-Verb + Verb Determiners + Adverbial Modifier(s)

where Verb Determiners are:

Link-verb + Subject Complement /
Direct Object /
Direct Object + Direct Object /
Indirect Object + Direct Object /
Prepositional Object /
Object + Object Complement

Subject/ Object Complement gives information on the subject/ object. Link-verb is a finite verb that expresses *being/ passing/ remaining/ seeming* or *appearing* in a certain state. Indirect/ Direct Objects are in dative/ accusative case.

The semantic networks combined with the semantic roles in the case grammars have been proved to help for the translation of NL morphology, syntax and semantics into a stylized form of NL, without the ambiguities of the pure NL [1].

The intended *ontological simple sentence*, that abstracts the pattern (I) above, will have the format:

Ontological Simple Sentence = *Agent* Phrase + *Operation* Phrase
Agent Phrase = AGNT + Object Phrase
Operation Phrase = (OPERATION) +
+ {<role> + Active Object Phrase} ...
+{<adverbial role> + Adverbial Object Phrase}
Object Phrase = [Object_Type: Individual]+
+ Object Determiner(s)+ Object Modifier(s)

The ontological simple sentence will be used to define and describe BPR and domain specific objects and activities, generic operators (e.g. for object and activity definition, qualification, semantic correlation) as well as the communicative acts. So far, the intended communicative acts are 'query', 'reply' and 'notify' (or 'inform').

In NL, the compound sentence joins independent simple sentences by coordinating conjunctions (copulative, disjunctive, adversative, resultative, explanatory conjunctions) or adverbs or asyndetically (without conjunctions). The complex sentences are composed of *dependent* (subordinated) *sentences* (noun/ adverbial/ relative/ appositive subclauses) correlated to a *main sentence* (clause).

Examples of intersentential relations for constructing *ontological compound sentences* (practically, relations between activities defined and described by simple sentences) are: ‘and’, ‘or’, 'not', ‘cause/ for’, etc.

In a *complex sentence*, the activities must be correlated by subordinating relations like: ‘if-then-else’, 'while', subordinating 'cause', 'event' ‘purpose’, ‘consequence’, ’before’, ‘after’ , 'case', etc.

For each kind of user (member or mediator) and for each BPR step, the BPR ontology comprises a scenario like an ontological complex/ compound sentence.

The predefined ontological (simple and compound/ complex) sentences represent the set of axioms upon the objects/ processes/ communicative acts in the three ontologies. Their logic and the inference upon them can be consistently transposed to first order predicate calculus [1]. Like in NL, the extension of the ontology is natural, by new types of objects, operations, roles and relations.

The ontological sentences will also be used for assisting the users in expressing their ideas on objects and processes. The syntactic and semantic roles and relations facilitate the sentence comparison, classification and integration, i.e the integration of the ideas they represent.

5. CONCLUSIONS

This position statement focused on the need for a new type of mediation in a MAS, namely the *mediation of ideas* (instead of services as provided by the existing facilitators: matchmakers or brokers). It has arisen during the requirements analysis for the automation of a modern BPR methodology, where the brainstorming sessions have a central place.

Ideas mediation and the ontology integration requirements entail the need for an upper-level ontology with linguistic features, as this statement tries to motivate. The main steps in the construction of a linguistic ontology and its general advantages are briefly presented at the end of the statement.

Regarding the implementation of the ontologies in a MAS for BPR, the conclusion is that the standardization and integration of the two technologies (software agents and formal ontologies) are still in incipient phases and do not encourage and help their use in BPR automation.

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