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Analysis and Evaluation of Business Process Modeling Adoption in Collaborative Networks

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Abstract: Besides, knowledge and information enterprises can share Business Processes (BPs) within Collaborative Networks (CNs). Each enterprise has a set of BPs that it can perform, and through developing integrated BPs in the CN they deploy their capacities and capabilities. Selecting and adopting the appropriate BP modelling languages (BPML) for the purpose of formalizing BPs are challenging, because of the variety of existing methods, tools, and standards with different strengths and weaknesses. In surveys published so far on BP modeling mostly, a set of general features of the main BP languages and standards are compared. However, they have not paid attention to the level of different categories of BPMLs. Furthermore, there are no surveys analysing and evaluating the prerequisites to fulfil CN's requirements. This paper first proposes a set of categories for the main BP languages and standards. Then a novel BP evaluation approach, in CN context is introduced. Finally, different categories are discussed and analysed by addressing their suitability to support CNs.

1 INTRODUCTION

Adopting Business Process Modeling Languages (BPMLs), including the introduced standards, tools, and techniques, have greatly influenced enterprises toward capturing opportunities, reducing costs, and increasing productivity.

The BP technologies themselves however have also been affected by high demand of market, as well as the step-wise maturity of Business Process Management (BPM) theories. This has caused rapid changes in the last decade developed BPML tools and standards, while creating challenges for the BP modeling selection and adoption in networked enterprise. (Camarinha-Matos and Afsarmanesh, 2008).

Most of these aproaches are founded on Service Oriented Architecture (SOA), apply the formalized BPs, performed at every enterprise, to facilitate service interoperation and enterprise collaboration (Papazoglou and Heuvel, 2006). formalized BP are therefore important for effective cooperation among different enterprises within the Collaborative Networks (CNs), and without formalized representation of their BPs, enterprises cannot effectively share their competencies and capabilities.

The BPMLs differ from each other in their modeling approaches for design, analyzing, and enacting of BPs. Focusing on the purpose of supporting enterprises, with their collaboration within the CNs, the selection and adoption of a suitable BPML is critical, while challenging. Published surveys on BPMLs e.g. Roser and Bauer (2005), LU and Sadiq (2007), also Ko, S.Lee and E.Lee (2009) have already tackled the comparison between a certain features of the main BPMLs tools and standards.

Most contemporary surveys focus on comparing a set of two or more BPML standards and tools. So, there is a lack of emphsis on comparing different categories of BPMLs, to which these standards or tools may belong. For instance the distinct features aimed by their design, such as to evaluate and emphasize their graphical, ontological, executional, etc. aspects of the BP modeling, is not assessed for this purpose.

Moreover, demonestrating a set of categories for BPMLs classification, in order to perform analysis and evaluation of BPMLs for their adoption in support of CNs, a novel analysis method is introduced to manifest CN's characteristics and to assess different BPML categories against them.

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Hence, we first review the main concepts of CNs and BPs, identifying the role of formalized BPs in CN (in Section 2). Then, based on a systematic reviewing approach, and considering the existing categorizations of the main BPMLs, we introduce our BPML categorization (in Section 3). In Section 4, founded on collaboration purposes, we specify a number of most relevant criteria for comparing the introduced BPML categories, and analyzing them for the aim of supporting enterprise collaborations. Finally, our analysis and evaluation approach is discussed (in Section 5), and our conclusions are presented (in Section 6).

2 ROLE OF BPs IN CNs

Within the collaborative-networked environment the enterprises have the opportunities to share their resources through collaboration, including knowledge, information. This can be best achieved, by means of formalized BPs (Camarinha-Matos and Afsarmanesh, 2008). Collaborative BP integration is aimed by enterprises to accomplish value-added business services, beyond the capabilities of their individual organizations.

Besides integration, in most approaches for instance presented by Papazoglou and Heuvel (2006), BPs constitute the building blocks for establishment of SOA, through BPs implementation as web services. In this section, after reviewing related definitions for CNs and BPs, we present an analysis of the BPMLs from the CN requirements point of view.

2.1 Principal Definitions

A general definition of Collaborative Network is presented by Camarinha-Matos and Afsarmanesh (2008) as: "*an alliance constituting a variety of entities that are autonomous, geographically distributed, and heterogeneous in terms of their operating environment, decision making, culture and social capital, that cooperate/collaborate to better achieve common/compatible goals, and their interactions are supported by the computer networks.*"

The two main forms of CNs are the: Virtual Organization (VO) and VO Breeding Environment (VBE). In a VO, partners choose co-working and sharing their BPs and other resources to accomplish their common goals. The motivations for this coalition are commonly formed around specific market targets or innovation purposes. VBEs, which establish long-term alliances of organizations, capture and save BPs of partners in their directories. The VO broker, who seizes the opportunity and chooses the participants for the VO in the VBE context, considers selecting and integrating BPs of different organizations to shape new VOs responding to achievable opportunities. (Afsarmanesh et al. 2011).

Related to our research, a set of standard definitions for the BP notions exist that is provided by Workflow Management Coalition (WFMC, 1999) and is addressed below.

A typical definition of BP is: a series of one or more linked procedures or activities, which collectively realize a business objective or policy-related goal. Workflow Management System (WFMS) can automate and control the execution of the BPs. The notion of BPM comprises concepts, methods, and techniques to support organizational aspect of processes, which are needed for the design, administration, configuration, enactment, and analysis of BPs (Weske, 2007). It also covers the "*diagnosis*" aspect of the BPs further to the WFMS lifecycle (Van der Aalst, 2003).

Havey (2009) outlines the focuses of BP modeling on design and execution aspects of the BPs. BP Modeling aims at representing an abstract but meaningful demonstration of the real business domains. This goal is achieved through provision of appropriate syntax and semantics in BPMLs, to meet the BP's requirements. (Lu and Sadiq, 2007).

2.2 Chronological View of BPMLs in Support of Collaboration

Here we address the evolution of BPMLs from collaboration point of view. In the 80s, the necessity of process-awareness was recognized, beyond the level which was required for development of Management Information Systems (MIS). Furthermore, besides understanding the flow of operations in MIS, organizations and business domain experts needed to also understand the information aspects of the BPs in MIS (Delvin and Murphy, 1988).

The WFMSs, which initially were intended to facilitate automatic transformation of electronic documents, was then introduced as the new tools to enable business analysts in designing and expressing BPs, at the beginning of 90s. For the purpose of depicting information exchange among systems, the behavioural concepts (i.e. the sequence and merge) were then used in BP modeling (Georgakopoulos, 1995).

Afterward in the 90s, applying the Business Process Re-engineering as well as embedding the best business practices in the market, vendors were able to integrate and aligned separate software modules, under the so-called Enterprise Resource Planning (ERP) systems. To support ERPs, the BPMLs have focused on dynamic aspects of the BPs. Nevertheless the interactions between the designed modules were not so easy to achieve within the ERPs (Van der Aalst, 2009).

Responding to the proliferation needs of the integrating legacy systems into customized applications and ERP modules, the Enterprise Application Integration (EAI) (Lee and Siau, 2003) have tried to remedy the problem of inefficient BPs' integration. So, interaction-enabling entities (e.g. messages) gained significance. This level of collaboration provided an infrastructure for cooperation of enterprises through resource sharing, while preserving their heterogeneity.

The more maturity in deployment of XML, in the late 90s, resulted in better integration of applications, and changed the co-working intensity of enterprises to an advanced level, called business to business (B2B) (Havey, 2009).

Coordinating the BPs adopted by companies, concluded in integrating autonomous and independent applications, via loosely coupled mechanism of SOA (Zdun et al., 2006). SOA approach tries to establish orchestration and choreography of web services, to achieve their successful cooperation.

Nowadays, BP related topics e.g. the BP mining (Van der Aalst and Dustar, 2012) and diagnosis approaches that address BP monitoring and their continuous improvement constitute promising research lines.

3 CATEGORIZATION OF BPMLs

Aiming to cover various BP modeling tools and standards, which are introduced in the main related publications, we focus on a specific set of attributes and specifications of the BPMLs for their categorization. Our categories basically focus on recognizing the BPML's capabilities as well as the suitability features in each category, in support of criteria for collaboration. Therefore, we first study related scientific DB and conferences, then classify the existing categorization publications into two classes of: "General Review", and "Particular Evaluation".

In this section, first we review the results presented in published surveys, from the point of view of our two classes addressed above, and further classify a set of minimal relevant BPML categorization approaches. Finally, we introduce our more detailed categorization.

3.1 BPML Categorization Review

As mentioned before, we divide the contemporary reviews of BPMLs into two main classes of "*General Reviews*" and "*Particular Evaluation*". "General Reviews" are mostly focused on general uses, and on encompassing the main specifications of the BPML categories. For instance the work of Havey (2009) that focuses on *presenting good BP Modeling Architecture*, where it first addresses aspects of BP modeling applications (i.e. design, run, monitor, etc.), and then introduces the four categories of BPMLs, including: *notation* languages (e.g. BPMN), *execution* languages (e.g. BPEL), *choreography* languages (e.g. WS-CDL), and *process administration* languages (e.g. BPQI). Also, classification presented by Ko et al. (2009) and Mili et al. (2010) are instances of this category.

But, publications in the "Particular Evaluations" class focus on BPML categorization for specific purposes. The works of Roser and Bauer (2005), Lu and Sadiq (2007), and De Nicola et al. (2007) are instances in this category. For example, in (De Nicola et al., 2007) the categories are introduced around the subject of "introducing an ontological approach for BP modeling", including Descriptive (e.g. BPMN), Procedural (e.g. XPDL), Formal (e.g. PSL), and Ontology-based (e.g. OWL-s).

3.2 Introduced BPML Categories

Using the "general review" and "particular evaluation" criteria as the base, we introduce a more comprehensive framework including six classes: "graphical", "formal", "executional, "ontological", "inter-operational", and "monitorial", that together capture all kinds of addressed BPMLs.

The main characteristic of each of these six categories, and their main representative example BPMLs are briefly (due to space limitation) described in the following subsections. Also, a set of popular BP languages and standards are named below as the example of each category.

Although it is possible for a BPML to be categorized in more than one category, but here we have placed each BPML in its most representative category only. They could be adopted and utilized by CN members based on their category's

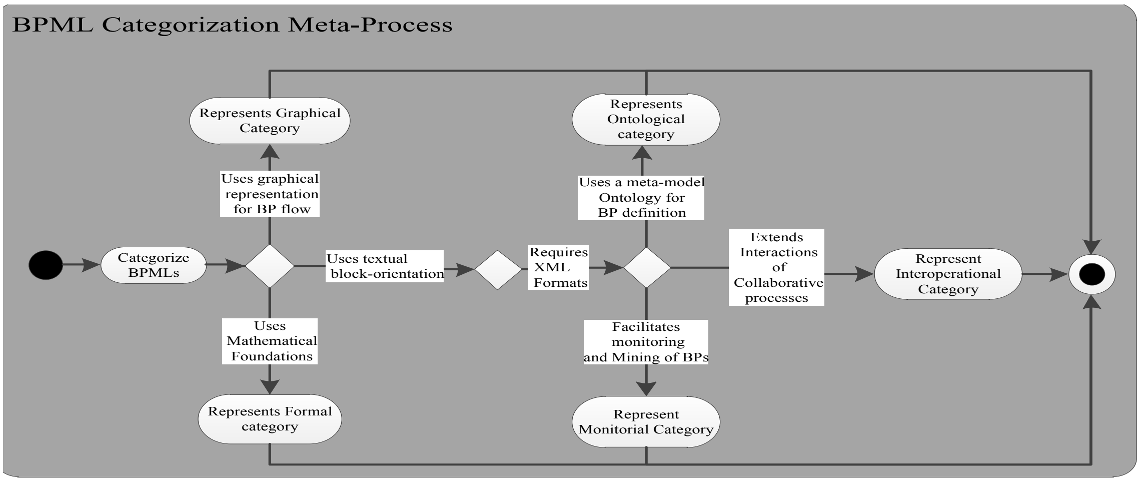

Figure 1: The BPML categorization meta-process method.

characteristics.

The meta-process adopted by our categorization method and how we reached the six specific classes is briefly depicted in figure1.

3.2.1 Graphical BP Languages

Rooted in graphical picturesque format, this classical generation has appeared. BP modeling languages in this category mostly emphasize illustrating the system behaviour and its abstraction. These languages are not typically formal. (e.g. IDEF, EPC, UML 2.0, BPMN).

3.2.2 Formal BP Languages

Formalization in this category is founded upon mathematical principles. Although, adoption of graphical symbols is possible in some of these languages, but difficulties in user's understanding hold them mostly at theoretical and mainly academic utilizations. (e.g. Petri-Net, Pi-calculus, PSL, Reo).

3.2.3 Executional BP Languages

The idea of automatic execution of BPs by software engines, support the formation of this category. The XML structure plays an important role in deployment of this category, and clarifies BPs by their computerized semantics. Besides, the popularity of BP modeling and service invocation in industries are other important issues in the category. (e.g. BPEL, WS-CDL, XPDL, YAWL).

3.2.4 Ontological BP Languages

Likewise the ontology approach, which studies the things that exist and tries to describe them, this category addresses semantic capture and tries to constitute the base for an increasing number of BP modeling languages, through proposing different meta-models. The ontological layer in these languages clarifies the roles, entities, and interactions. This category has also the advantages of using XML formats. (OWL-s, WSMO, BPDM).

3.2.5 Interoperational BP Languages

Rooted in business-to-business interaction, this category focuses on modeling public sharable processes of partners, among many business partners. To accomplish this key concern in inter-operational category, XML standards are elaborated as the main enablers. (e.g. RossettaNet, eb-XML/BPSS).

3.2.6 Monitorial BP Language

As we discussed previously (in section 2), modern business process modeling trends to address the diagnosis iteration of the BP Lifecycle. Focusing on the Business Activity Monitoring (BAM) point of view, the emphasis is on monitoring and resolving the deadlocks or problems in flow of BPs. Furthermore, extract and unambiguous approach for recognizing BP modeling based on a dynamic logging of process behaviour, the so-called process mining is still promising (van der Aalst and Dustar, 2012), (e.g. BPRI and BPQI).

4 SUPPORTING CN - BPML EVALUATION

The evaluation framework should be concise and descriptive. Having emphasis on categories and not every BPML, multi-aspect evaluation of a phenomenon requires a methodology, to support maximal coverage of the target area. For the purpose of appraising BPMLs in supporting CNs requirements, we should consider both the BPs and the CNs aspects simultaneously. Therefore, our designed evaluation methods as well as our evaluation process are discussed in following sub-sections, respectively.

4.1 Proposed Evaluation Method

Several BP modeling goal-settings have been introduced based on different approaches. For instance a set of five generic software process modeling objectives have been specified in (Curtis et al., 1992) as follow: "to support process improvement", "to facilitate human understanding and communication", "having automated guidance in performing process", "to support process management", and "to automate execution support". Also, for the non-functional BP modeling requirement (Chung and Do Prado, 2009) has presented a series of objectives (e.g. the support for discovering of dependencies of processes, the support for changing management, etc.). These context-aware objectives still hold today. In our point of view for supporting more effective BP collaboration in a CN, we can further add, "to support enterprise collaboration" into this context.

Rooted in the debate in Section 2, our primary aim is to focus on supporting collaboration through formalized BPs and evaluating BPML categories for this purpose. Therefore, we first follow a goal-based approach (also known as the objective-based approach) explained in (Goldkuhl and Lagsten, 2012) to extract the collaborative intention issues within CN's concept.

Our goal-based approach has focused on a number of qualitative criteria and indicators, related to set goals, systematically. As the evaluation method, we adopt Critical Success Factors (CSFs) method. CSF is a classical flexible method to maximize goal achievement, through selecting, working, and monitoring a few certain factors, which are vital for success. So, we follow the requirements of achieving established objectives, by running a Critical Success Factors Analysis described and explained in (OASIS, 2008) and partially in (Trkman, 2010) and (Sudhakar, 2012). After CSF identification, a set of requirement indicators for monitoring them is provided by CFA.

The CFA constitutes following elements:

- **Objectives**: Those are directed by customers and are hard to measure.
- **CSFs**: including between three to six sub-goals, which without their direct support, achieving goals are unattainable.
- **Requirements Indicators**: represented key performance indicators, which are measurable and directly support CSFs.
- **CFA Diagram**: for better illustrating the measurable context, CFA diagram is used.

For supporting characteristics of CNs to achieve their goals and to better describe the particularities of the CN context, especially for VOs and VBEs, we use the Reference model for Collaborative Networks" (ARCON). The ARCON model explains aspects, approaches and elements of the CN's environment (Camarinha-Matos and Afsarmanesh, 2008).

Eventually, we hold a CFA study to find out CN-compliance CSFs, and the vital requirements indicators for achieving our goal. These issues are provided based on systematic technical reviews and experts opinions. We then discuss, the BPML's categories versus the recognized requirements indicators, and represent the conclusions.

4.2 Evaluation Process

Regarding the (ARCON) model introduced by Camarinha-Matos and Afsarmanesh (2008), and our discussion in section 2, VO/VBE need to manipulate formalized BPs.

Also, regarding CN's definition (in 2.1) the following aspects indicate the main constitutional objective themes in the CN discipline:

- **Goal-orientation** [focusing on goals through business interactions]
- **Infrastructure for Commonality** [supporting co-working and coordination toward goals]
- **Node Heterogeneity** [non-uniformity in different properties, i.e. operational processes]
- **Network enabling** [support by computer networks]

The four above-mentioned objective themes are the main CN realization's objectives, extracted from its standard definition. To attain these objectives, defining and aligning a set of CSFs are inevitable.

The supporting CSFs for CN are as follows: first, to enable successful collaboration, BP modeling tool should provide enough "comprehensibility" for partners (BP Analysts, IT experts, etc.). The "ease of use" is another issue, which supports convenient interoperation through CNs. "expressiveness for behaviour", is another challenging issue for enactment of BPs in CNs. For cost-effective achievement of goal in CNs, "accessibility" of BP documents and standards has to be considered. The coverage of CN's objective and the introduced CSFs are illustrated in table 1. The "C" in the box at the intersection of rows and columns represent the minimal *coverage* between our CSF and CN's constitutional objective elements.

Table 1: Intersection of CN's objectives and CSFs.

CSFs \ **CN's Objectives**	Goal-Orientation	Commonality	Heterogeneity	Network enabling
Comprehensibility		C	C	
Ease of Use		C	C	
Expressiveness for behaviour			C	C
Accessibility	C			

The last step of our evaluation, is finding a series of generic required indicators from BP modeling context to appraise the suitability of BPML's categories for CN's. They have been extracted from the literature and the standards (ISO, 2010E):

Understandability: is the ease of interpretation and capture by which under specified circumstances, the user can interpret an instance, model, analyse, and develop the BP model (Mendling et al., 2007).

Expressability: explains the capability to represent the process model's attributes like: control, resources, flow structures, in an unambiguous way (Kiepuszewski, 2002).

Flexibility: is defined as the ease with which in BP modeling the modifications are possible in types and instances, based on incomplete level of abstraction (Lu and Sadiq, 2007). So, partial effects of changes, does not necessarily imply completely replacement of BP models (Schonenberg et al., 2008).

Availability: comprises amount and degree to which business process modeling documents in specific formats, and standards are accessible and adoptable. They are ready-to-use for desired collaboration by the organizations (Milanivic, 2008).

Enactability: is defined as the ambition of acquiring capability to completely execute of the BP model directly and without exploiting extra tools and information (Russell, 2007).

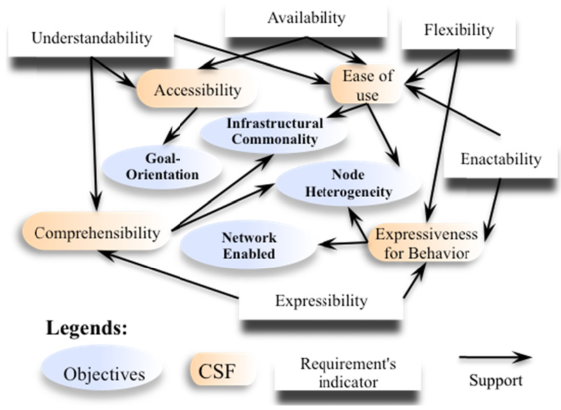

Figure 2: Interconnections in CFA diagram.

Figure2 represents CFA analysis as the interactions of different CN's objectives, supporting CSFs and monitoring requirements indicators and the types of effect between different entities in CNs (which is represented in the figure by the support arrow). In the next section we address and evaluate each of BPMLs categorization against the five standard criteria.

5 DISCUSSION

Our evaluation comprises a two-dimensional descriptive evaluation. The first dimension consists of BPML categories. Six comprehensive categories are introduced and defined. Please note that we focus on novel BPML categories – as the aimed origins – instead of the languages, so there could be a number of choices from BPML's members in each categories for CNs.

5.1 Availability

Availability has its roots in reliability notion, which implies, ratio of the time that users have received the service according to prior level of agreements (ISO, 2010E). Unavailability of a modeling BP language happens when we don't have "steady-state", "intervals", and "user-perceived" availability (Milanivic et al., 2008). For our evaluation, we assume availability as the existence of BPML documents within the context of CNs.

There is an annual research of BPM Market since 2005, by Wolf and Harmon (2012), thoroughly surveying the BPM trends. From their 2012 report, they state that the rate of availability for graphical BPMLs is at the highest level. For example the BPMN is used by more than 60% of all organizations. Meanwhile, there is less availability for ontological BPMLs (e.g. BPDM). Although, the debate on the timely development of trends is not the focus of this paper, but decrease in attraction level of BPEL during recent years is noticeable. Even interest and availability of UML and EPC slightly decrease. Also according to that survey the pervasiveness of the rest of BPML categories (e.g. interoperational, formal) are the lowest in usage ranking. So, it is expected that organizations initiate collaboration in CNs applying graphical BPMLs, and especially BPMN.

5.2 Enactability

The enactability is an important phase in BPM life cycle. According to (van der Aalst et al., 2003), after accomplishing "process design" and "system configuration" at the third step of the BPM's lifecycle "process enactment" is located right before the "diagnosis" step. The more independent is the BPML from the technology and vendor executable environments, the better enactability has in CNs.

Using the formal semantics for more effective enactment (ter Hofstede et al., 2010) supports – and does not contradict the increase in understandability in support of the requirements in CNs. Executional BPMLs enable the enactments of BPs, for sharing BP's information and automatically executing them through block-based and machine understandable structures. But, despite their common executional capabilities, they have their particularities.

Within Executional category, BPEL describes behaviour of BPs within interaction between process and its partner, and efficiently supports orchestration. WS-CDL executional aspect consists of peer to peer collaboration of partners from a global point of view for supporting choreography.

But, in this category some of the languages such as BPEL have restrictive syntax (Recker and Mendling, 2006), which is a limitation for this popular language, and some (e.g. YAWL) have exact executional syntax (ter Hoftstede 2010).

The formal category languages - except embedded notions like (pi-calculus in WSCDL) provide graphical enactability interface, e.g. in reo and Petri net. Ontological BPMLs, because of their XML supporting structures have convenient level of enactability.

Executional issues in interoperational BPML category, where XML enactability is embedded, have some difficulties e.g. naming and XML reusability in RosettaNet (Damodaran, 2004) or deficiencies in event handling during interactions (Green et al., 2007). Ontological BPML category focuses on semantic aspects (e.g. OWL-s), and runs enactment in an abstract level.

5.3 Expressability

The importance of expressability in CNs arises from the way we wish to express the BPs, so that they can be shared among partners. This expressive power of modeling language represents the possibility of expressing constructs in direct or indirect manner (Kiepuszewski et al., 2002). These constructs comprise: control, resources, data, organization, execution, and behaviour of a business models. Expressability encompasses the notion of suitability, which focuses on modeling and implies conformance of the BPML with for instance 43 workflow patterns introduced in (Russell et al., 2006). Although, the evaluated domain in that paper does not focus on BPML categories, but provides a general inception for comparison of BPML categories.

As we map BPMLs' evaluation in Russell, ter Hofstedeh and van der Aalst, (2006) to our proposed categories, a number of these patterns e.g. "discrimination", "milestone", "partially join", etc. are the kind of patterns which languages and standards have difficulties in expressing them.

We could state that, commonly, the graphical BPML category has better compatibility, while in executional category- except for YAWL- languages have some deficiencies, for example for supporting "Arbitrary Cycle", because of their rigidity in capturing real-world abstraction.

Based on evaluation of Russell et al., (2006) the of formal languages category members have good capability of expressiveness, because of their mathematical foundation, e.g. Petri-Net; expressive power (van der Aalst et al., 2003) used in workflow pattern design, or constraint Automata is used in Reo. Ontological languages use logical basis for instance in OWL-s for representing better expressiveness (W3C-OWL-s, 2004).

5.4 Flexibility

Supporting the dynamicity of CNs, the flexibility issues in BPMLs for describing BP's interaction is necessary. BPMLs focus to sustain their dynamicity in coping with expected and unexpected changes, through adopting flexibility. In (Schonenberg et al., 2008) four types of flexibility are presented as:*" design", "deviation", "underspecification"* and *"change"*.

The flexibility support, mostly in two first above-mentioned types, BPMLs rely on their pre-design notations and are abstract from flexibility concerns. On the other hands, the block-based (rule-based) BPMLs could manage the flexibility in higher level (e.g. deviation or underspesification) (Lu and Sadiq, 2007).

The flexibility in the graphical BPML category, within different languages and standards is considered in different ways. In BPMN, by predicting three types of diagram for collaboration, and for the concepts of Pool and lane, the decomposition for changes is possible. The Frame and Frame Heading techniques in UML 2.0 Activity Diagram let the elements of the languages to be defined and described in a modular and flexible structure. So, "design and deviation" are supported.

Likewise in formal category, mathematical concepts help to retain model identity; for instance the structure of Atomic and Complex activities in PSL, besides graphical representation in Petri-Net and Reo simplifies the modification flexibilities. So, "design and deviation" are supported.

Based on XML structures, which usually support flexibility in design and changes, and even underspesification, to certain extent (Schonenberg 2008). YAWL, BEPL (inter-relations), and WSCDL (choreography) support various types of flexibility. Even RosettaNet PIP techniques, channelizes the modifications. This benefit supports within block-based structure. Ontological BPML category considers flexibility at convenient level, which let modification to be based on primary definition of BPs (e.g. process model definition in OWL-s).

5.5 Understandability

The understandability shall facilitate the BP acquisitions and interactions among CN's stakeholders. This notion has been reviewed and analysed during several works especially verses the complexity as the other extreme. Generally, understandability comprises the following two aspects mentioned in (Mendling et al., 2007):

- Model-related factors, which affect the understandability, e.g. unambiguity, simplicity.
- Person-related factors, which have close relations to knowledge and experience of participants

Although, the understandability has been reviewed several times, and there is a number of guidelines e.g. the smaller size of the model makes it better for understanding; or the higher degree of input and output to one element causes the more complexity of understandability, etc. But, the ease of "comprehension of a model", "presenting without error", and "labelling less ambiguous" (Mendling et al., 2010) constitute main understandability's principles in BPMLs.

Generally, the graph-based languages are more understandable than rule-based ones (Lu and Sadiq, 2007). That is also the reason why they become more popular at enterprises. However, within graphical standards, BPMN is more complex for understanding compared to UML and EPC (Indulska et al., 2009).

On the other hand, Executional and ontological BPML categories because of having less cooperation with human side, their understandability is under criticism. Also, the interoperational standards (e.g. the PIP technics knowledge in Rosettanet) are at a more abstract level of understandability ((Damodaran, 2004), (Green et al., 2007)).

5.6 Comparing Results

Through the discussion, we analysed the adoption of BPML in regards to the set of requirement indicators, which represented for evaluating BPML categories at the second level of our evaluation. Grounded in our goal-based approach and by using a CFA method, we identified six requirement criteria that helped us, to measure the collaboration-aware adoptability of BPMLs. The result of our extensive evaluation in previous sections is summarized in Table 2.

Table 2: Summary of evaluation.

Requirements indicators in Support Of CN / BP Modeling Languages Categories	Understandability	Expressibility	Enactability	Availability	Flexibility
Graphical	S	A	A	S	A
Formal	M	S	A	M	A
Executional	A	A	S	M	A
Ontological	A	S	A	A	A
Interoperational	A	A	S	A	A
Monitorial	N	N	N	N	N
Comments: S: Strong support A: Advanced support M: Moderate support N: Not Addressed					

As showed in that table, we use four levels of supports as: *Strong*, *Advanced*, *Moderate* and *Not addressed* levels, from CN's member relative points of view. Because of analytical theme of paper, we opt qualitative survey method.

Regarding discussions in our previous sections, the graphical category has advantages of understandability and availability. Executional category is strong in enactability, also flexibility of BPs, besides the importance of less ambiguity in modeling real world should not be disregarded, although lacks of interactive graphical depiction needed for less technical users is serious criticism yet.

Due to complexity of their user interaction, the formal languages are not pervasive, but should be considered as the supporting layer for soundness for graphical modeling languages. Ontological languages, because of their well-defined semantics, and their focus on graphical and executional aspects, are desirable but not yet sufficiently mature and popular.

BP adopting in interoperational BPML category, which isjust used for support of collaboration, mostly emphasize on interactions instead of abstract BP modeling from real world, also their flexibility level and understandability problems for users are serious concerns. Monitorial BP Languages are not practically fitting in this context to evaluate, but promising.

6 CONCLUSIONS

In our paper, we presented an analysis and evaluation of the Business Process Modeling Languages categories in support of Collaborative Networks. We review their suitability for supporting collaboration among enterprises.

To ensure a systematic and methodological approach in our review process, we have reviewed publications addressing categories of business process modeling in the context of BPMLs. Then, we have discussed different BP languages, and from a language-independent perspective, we have introduced our six categories of BPMLs.

Additionally, we have identified a set of criteria required for adopting BPs among enterprises in CNs. Based on these defined set of criteria, the six BPML categories are further analysed, regarding how they fulfil the collaboration requirements for CNs.

As we have employed a partially qualitative analysis approach, our analysis is not fully objective. Although, based on the results showed in table 2, the most suitable categories of BPMLs, especially for adoption in Virtual Organizations and VO Breeding Environments, are represented.

The elaborated results achieved through our evaluation of BPMLs in the context of CNs, indicate that depending on the requirements, the domain experts may preferably select BPMN or OWL-s for the purpose of their BP integration.

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