Extending Sensitive Business Process Modeling with Functional Dimension for Knowledge Identification

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Abstract: This paper presents a rigorous conceptual specification of sensitive business processes (SBPs) to improve the localization and identification of crucial knowledge mobilized and created by these processes. It covers all relevant aspects relating to business process modeling and knowledge management (BPM-KM), i.e. the functional, the organizational, the behavioral, the informational, the intentional and the knowledge dimensions. In this research work, we focus more specifically on the description of the « Functional Dimension», which represents the core dimension in SBP modeling. Precisely, we present BPMN4FM, an extension of the most suitable business process modeling formalism BPMN 2.0 to explicitly represent, integrate and implement the functional dimension of SBP, exploring the collaboration, interaction and knowledge aspects. Besides, we evaluate the relevance of BPMN4FM concepts through a real SBP scenario from medical domain.

1 INTRODUCTION

Nowadays, modern organizations have become aware of the necessity to identify and model the Sensitive Business Processes (SBPs) to improve the management of their individual and collective knowledge. These processes are characterized by a high number of critical activities with intensive acquisition, sharing, storage and (re)use of very specific knowledge «crucial knowledge», high degree of internal/tacit knowledge created and exchanged among experts (who carry out actions with high levels of expertise, creativity and innovation), diversity of knowledge sources consigning a great amount of very important heterogeneous knowledge, high dynamic conversion of knowledge and high degree of collaboration and interactions (intra/inter-organizational) between a wide range of agents. In addition, an SBP is typically an unstructured or semi-structured BP, requires substantial flexibility, encompassing a highly dynamic complexity. Besides, its contribution to reach strategic objectives of the organization and its cost are very important. However, the BP type typically lacks a rigorous conceptual specification and clarity in the representation of its important features. BPM formalisms that are widely-followed in current research and practice scenarios (such as RAD, eEPC UML AD, BPMN 2.0.2, KMDL 2.2 and DCR Graphs) did not include all the required characteristics to describe an SBP, as discussed in (Ben Hassen et al; 2016b; Ben Hassen et al., 2017).

In order to improve a SBP representation, we propose a generic BP meta-model common to these BPM formalisms which ensures the best suitability to model SBP, entitled «BPM4KI: Business Process Meta-Model for Knowledge Identification». BPM4KI describes the key concepts and relationships that characterize an SBP. It integrates all relevant aspects/dimensions relating to BPM-KM, i.e. the functional, the organizational, the behavioral, the informational, the intentional and the knowledge perspectives. BPM4KI is semantically rich and well-based on «core» domain ontologies (Gangemi and Borgo, 2004) (which are based on top of the DOLCE foundational ontology (Masolo et al., 2004)).

In this research work, we focus more on the description of the «Functional Perspective» which represents the central aspect of SBP modeling, exploring the collaboration, interaction and knowledge aspects and all relevant SBP elements. We point out that this dimension (supporting the new SBP modeling requirements) has not yet, however, explicited and fully supported by BPs models and BPM formalisms. So, we aim at

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incorporating this dimension in SBP models. In this paper, we propose to extend one of the best known modeling formalism, the Business Process Modeling Notation (BPMN 2.0) (OMG, 2013), with the functional dimension in order to explicitly incorporate all relevant interaction aspects within SBPs models to improve the localization and identification of crucial knowledge mobilized and created by these processes activities. The proposed extension, called «BPMN4FM» is designed methodically by application of the extension mechanisms of BPMN 2.0. Furthermore, we develop a specific plug-in based on the Eclipse platform, called K4BPMN Modeler, implementing and supporting the BPMN4FM.

The remainder of this paper is organized as follows: section 2 presents a specification of SBP, describing its main characteristics. Section 3 presents the central concepts that describe the functional dimension of SBP modeling. Section 4 presents the proposed approach for extending BPMN 2.0 with the functional dimension. Section 5 illustrates the application of some BPMN4FM concepts based on a real case study. Section 6 concludes the paper and underlines some future research topics.

2 SENSITIVE BUSINESS PROCESS SPECIFICATION

In order to enhance the SBP modeling, we propose a semantically rich conceptualization for specifying a SBP organized in a new generic meta-model of BP representation, the Business Process Meta-model for Knowledge Identification (BPM4KI). The enriched meta-model serves two purposes: (i) to deepen the elements and dimensions defining a SBP, by offering a coherent conceptual specification for this BP type, and (ii) to develop a rich and expressive graphical representation of SBPs to improve the localization and identification of crucial knowledge mobilized and created by these processes. The new extended BPM4KI, which is a continuation of previous works (Ben Hassen et al., 2016a), is well founded meta-model whose concepts (and the relationships between them) are semantically enriched by the «core» domain ontologies (Masolo et al., 2004; Gangemi, 2006).

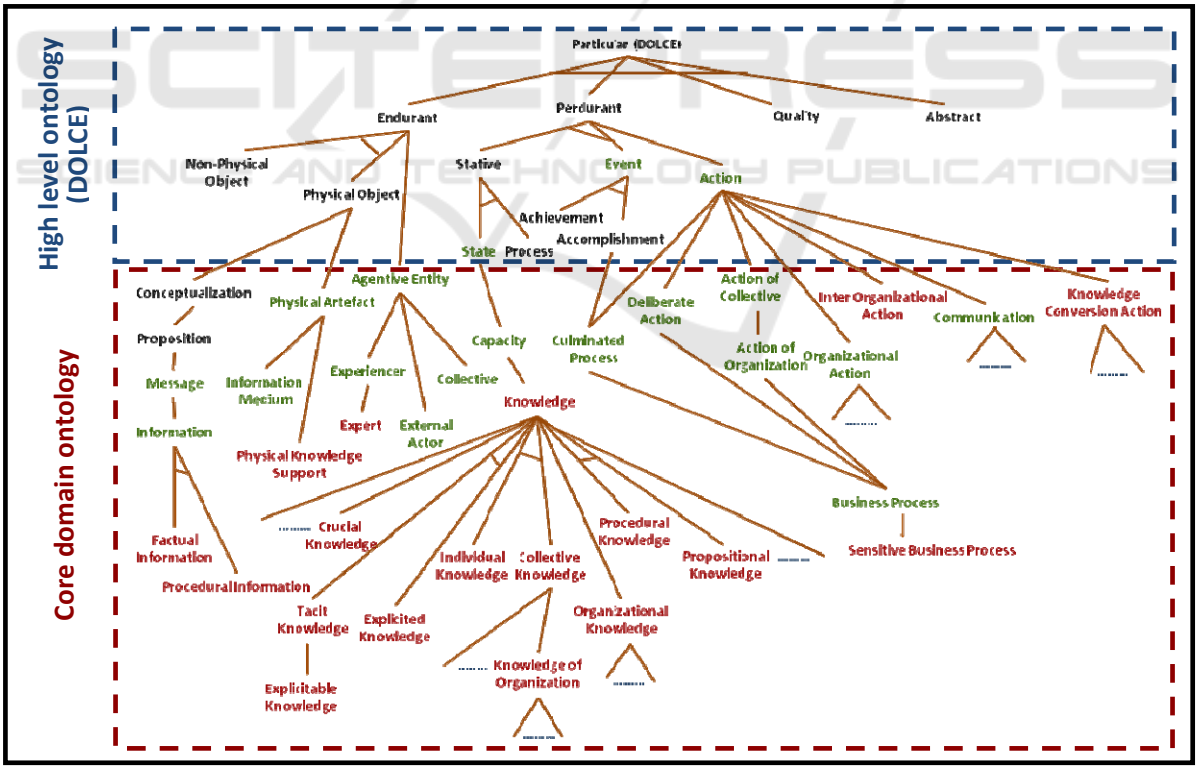


Figure 1: An extract of taxonomy of the main concepts defining our ontological framework to build BPM4KI. A descending edge between two concepts represents a subsumption link. A horizontal line between edges from a father concept indicates that the sibling concepts are incompatible.

2.1 Our Reference Ontological Framework

To conceptualize SBPs and build our BPM4KI meta-model, we adopted a formal approach multi-layer and multi-component already used to structure the ontological resources of the OntoSpec method (Kassel, 2005). The set of all these resources constitutes a global and consistent ontology (named by the same name of the method). The OntoSpec ontology is indeed organized into sub-ontologies (modules) situated at different levels of abstraction. Schematically, three levels are identified: (1) At the most abstract level, the foundational DOLCE ontology (Masolo et al., 2004) (see http://www.loa-cnr.it/DOLCE.html) provides a set of abstract concepts and relations for structuring (by specialization) any domain. Indeed, DOLCE's domain is that of `Particulars`, that is to say entities that cannot be instantiated rather than universals. Four sub-domains of `Particulars` are distinguished:
`Endurants`, `Perdurants`, `Qualities` and `Abstract` (see Figure 1). (2) At an intermediate level, 'core' domain ontologies (Gangemi and Borgo, 2004) define, for each domain concerned, a minimal set of generic and central concepts. (3) Lastly, at the most specific level, core domain ontologies are in their turn refined to introduce, by specialization, domain specific concepts. Our proposal is based on the reuse and the specialization of concepts defined in different OntoSpec's ontological modules (http://home.mis.u-picardie.fr/~site-ic/site/spip.php?article53):
Particular-OS (DOLCE), *Action-OS*, *Action of Organization-OS*, *Partcipation-role-OS*, *Agentive Entity-OS*, *Organization-OS*, *Function & Artefact-OS*, *Capacity-OS*, *Artefact-OS*, *Resource-OS*, *Communication-OS*, *I&DA-OS (Information and Discourse Acts)* and *Action Model-OS*. The new ontological modules used to construct BPM4KI specialize concepts presented in OntoSpec's modules situated at the foundational level and the intermediate level. The concepts that are used in the BPM4KI perspectives (dimensions) are marked in green. Besides, the new extended concepts related to the SBP notion are marked in red (see Figure 1).

Concretely, our approach for building the new extended version of BPM4KI meta-model is jointly supported, on the one hand, by the specialization of the *DOLCE* foundational ontology (Masolo et al., 2004), to specify and define the invariant generic BP concepts, including SBPs, and on the other hand, by the conception of *Ontological Design Patterns* (ODP) (Gangemi, 2006) which are based on the reuse and the specialization of ontological modules relating to the «core» domain ontologies (Kassel, 2005; Gangemi, 2006; Kassel, 2010; Kassel et al., 2012; Turki et al., 2016) (see Figure 1). These ontologies offer repositories of generic concepts and relationships semantically rich and consensual which we reused, firstly, to broaden and deepen the elements of SBP definition, and on the other hand, to characterize the useful concepts for a rigorous specification and an enriched SBP modeling.

2.2 Our BPM4KI Meta-Model

The current version of BPM4KI offers a referential of generic and central concepts and semantic relationships relevant to the BPM-KM domain for conceptualizing SBPs in various contexts. It is categorized in six perspectives (see Table 1) represented in the form of Ontological Design Patterns (ODP). The different BPM4KI perspectives are complementary and essential for a comprehensive and expressive characterization and representation of an SBP. With respect to the limited space of this paper, the definition of core BPM4KI concepts from several perspectives cannot be presented.

A whole class of BPs and activities, especially the complex, collaborative and knowledge-intensive ones, as SBPs, depend on (human) interactions, which are responsible to a high degree for knowledge development in an organization. Therefore, in this paper, we focus on the analysis of the functional dimension/perspective which represents the core and the most relevant aspect in SBP modeling, exploring the collaboration and dynamic aspects of SBPs (e.g. collective dimension of activities, knowledge intensive activities, collaboration and interaction among collective of human agents with exchange, transfer and creation of knowledge and/or information, knowledge conversion actions, etc.) in greater detail. These aspects are useful and required to characterize the SBPs, due to, for instance, the high degree of knowledge exchanged and developed and shared among agents through intra/inter-organizational collaboration, also due to its frequent evolution along time. However, we point out that the functional dimension (supporting the new SBP modeling requirements) is not yet, however, fully supported and integrated neither in BP meta-models, or in any of the BPM formalisms (e.g. EPC, UML AD, BPMN 2.0) and knowledge modeling approaches and notations (e.g. GPO-WM, PROMOTE, KMDL 2.2).

Table 1: SBP specification: the six BPM4KI perspectives (dimensions).

BPM4KI Perspectives	Description	BPM4KI concepts
Functional Perspective	Represents the BP elements which are being performed	Action, Deliberate Action, Individual Action, Action of Collective, Action of Organization, Organizational Action, Communication, Knowledge Conversion Action, Organizational Critical Activity, etc.
Organizational Perspective	Represents the participants invoked in the execution of BP elements as well as the agent types that interact during a SBP.	Agentive Entity, Collective, Organization, Informal Group, Organization Unit, Human, Experiencer, Expert, Internal Actor and External Actor.
Behavioural Perspective	Represents why and how the several executions of a SBP vary. It depicts the concepts that effect, trigger or control the flows of activities.	Flow Element, Control Flow, Flow Node, Connecting Object, Association, Sequence Flow, Message Flow, Contingency, Conditional Control Flow, Control Node, Exclusive Decision, Complex Decision, etc.
Informational Perspective	Describes the informational entities that are generated, consumed and exchanged in a BP. It represents inputs and outputs of a BP, messages or communications/conversations exchanged between different agentive entities involved in the BP.	Data, Data Object, Information, Factual Information, Procedural Information, Information Medium, Message, Physical Artefact, Input, Output, Data Association, Material Resource, Immaterial Resource, Event, Contingency, Artefact of Communication, Discourse, Informal Exchange, etc.
Intentional Perspective	Provides an overview perspective of the process and describes major BP characteristics. It captures important BP context/intentional information.	Intention, Objective, Distal Intention, Collective Objective, Culminated Process, Client, Sensitive Business Process, Knowledge Intensive Process, External Process, Core Process, Strategic Process, etc.
Knowledge Perspective	Addresses all relevant aspects related to KM. It describes the organizational and individual knowledge mobilized and created by a BP, the knowledge flow and the dynamics of acquisition, conversion, transfer, sharing, development, and (re) use of knowledge within and between BPs/organizations.	Crucial Knowledge, External Knowledge, Internal knowledge, Tacit Knowledge, Explicited Knowledge Explicitable Knowledge, Individual Knowledge, Collective Knowledge, Organizational Knowledge, Procedural Knowledge, Propositional Knowledge, Strategic Knowledge, Operational Knowledge, Physical Knowledge Support, Knowledge Flow, etc.

3 FUNCTIONAL DIMENSION REPRESENTATION IN SENSITIVE BUSINESS PROCESS MODELS

To address the different issues in SBP modeling, this section presents an extended version of the « Functional Perspective» related to the proposed BPM4KI meta-model, considering all relevant SBP elements. We aim at incorporating relevant issues at the intersection of KM and BPM to enrich the SBP representation and improve the identification of crucial knowledge.

In particular, we apply our ontological framework and specialize some concepts present in different core domain ontologies (i.e. *Action-OS* and *Action of Organization-OS COOP*), in order to specify and define new concepts related to the SBP notion (see Figure 2). Our proposal, presented in the form of a Functional ODP (see Figure 3) reuses and specifies the central generic concepts (and the relationships between them) defined in different OntoSpec ontological modules: *Action-OS*, *Action of Organization-OS*, *COOP* (*Core Ontology of Organization's Processes*), *Participation-role-OS*, *Organization-OS*, *Function &Artefact-OS*, *Artefact-OS*, *Resource-OS*, *Communication-OS*, *Action Model-OS* and *I&DA-OS*. Figure 3 organizes and explicit the central concepts of the functional perspective (marked in gray), in addition to inter-aspects relationships (the various concepts are recognizable by their thicker borders) giving a view of all relevant aspects of the BPM4KI meta-model as a whole. (The new extended concepts related to the SBP notion are marked in blue). In this meta-model, an Action can be either `Individual Action`, `Action Of Collective`, `Deliberate Action`, `Communication`, `Inter Organizational Action` or `Knowledge Conversion Action`.

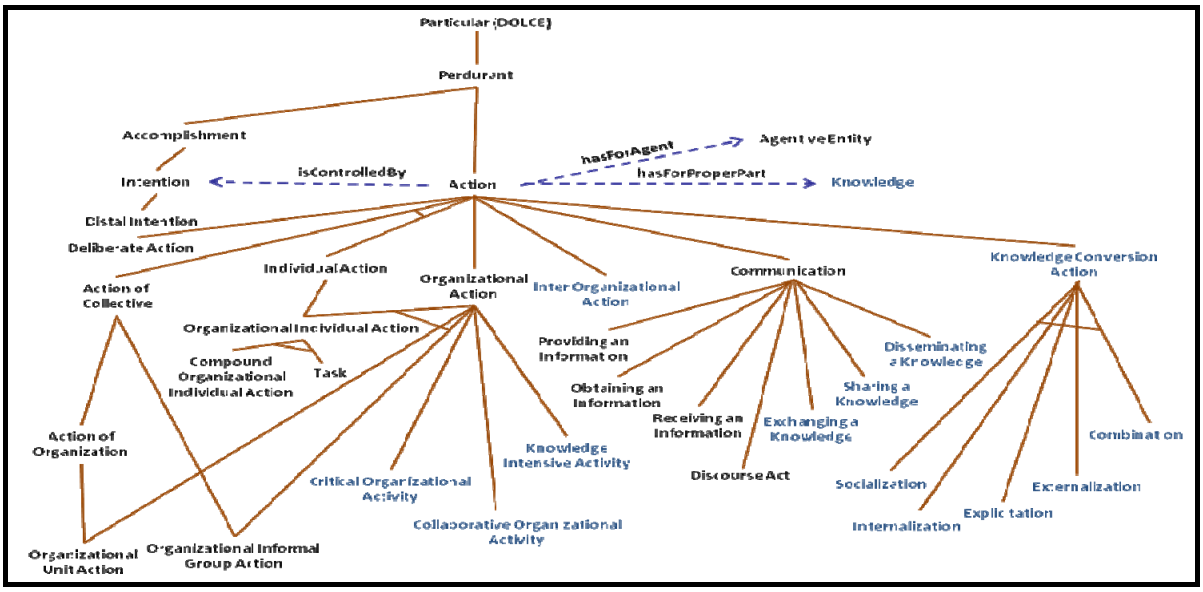


Figure 2: Extension of the ontological module Action OS for modeling the functional dimension of SBP.

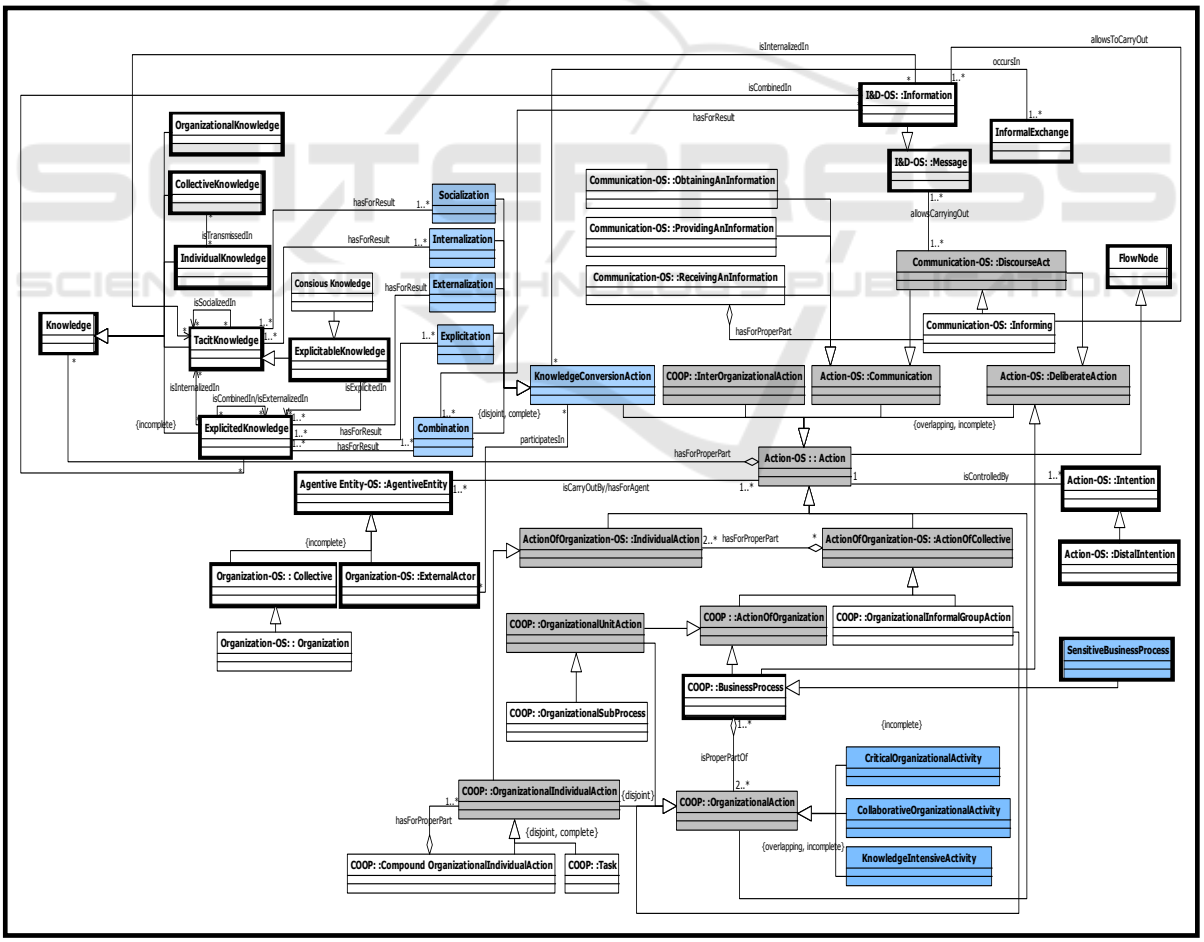


Figure 3: BPM4KI Meta-model: Conceptual Ontology design Pattern relating to the Functional Perspective/Dimension of SBP (with inter-aspects relationships).

Moreover, in SBPs, humans collaborate/cooperate through interactions. The different interactions and the coordination of SBP activities occur with the exchange and transfer of knowledge and information. This is form the basis for knowledge creation and sharing. The `Knowledge Conversion Action` concept is required to model, on the one hand, humans interactions in SBP, and on the other hand, the dynamics of knowledge, i.e., all of conversion, transmission, sharing, and creation of knowledge among the different sources and SBP activities. Table 2 presents the core functional perspective concepts definitions.

Besides, it is important that an appropriate BPM formalism provides explicit representation of the different issues related to the functional dimension in BPM. In this context, the SBPs can be graphically represented, using the well-known standard for BPM, BPMN 2.0.2 (OMG, 2013), in order to localize and identify the knowledge that is mobilized and created by different activities of these processes. BPMN 2.0 was selected as the most suitable BPM notations for SBP representation, because it addresses the highest representation coverage of the set of BPM4KI concepts and incorporates requirements for SBP modeling better than other formalisms (Ben Hassen et al., 2016b; Ben Hassen et al., 2017). However, BPMN 2.0 diagrams are not adequate for the new SBP modeling requirements. So, to overcoming the shortcomings of BPMN 2.0, some of its concepts must be adapted and extended to be convenient for a rich and expressive representation of SBPs, including all or at least most of the relevant issues at the intersection of KM and BPM. The following section explains our extension proposal for including the functional dimension in SBP modeling.

4 BPMN4FM: BPMN EXTENSION FOR MODELING THE FUNCTIONAL DIMENSION IN SBP

While importance of interaction and collaborative aspects related to the functional dimension is well recognized, there is no clear theoretical background and successful practical experiments of inclusion, support and implementation of this dimension in BP meta-models and BPM approaches/formalisms. Existing formalisms do not specify how do interactions occur in a SBP. Indeed, extending BP models with the functional dimension would provide the following benefits:

- Possibility to differentiate individual action from collective action during BP modeling. In fact, this dimension is very important in our research context, the localization and identification of knowledge. This knowledge taken in the action may be either individual or collective (tacit or explicit).
- Opportunity to enable modeling the critical and knowledge intensity dimensions of organizational activities to determine the crucial knowledge mobilized and created by these activities.
- Opportunity to consider the roles of humans in BP activities, be it as humans or collective, etc., who interact, communicate, exchange, share and create knowledge and/or information.
- Ability to model collaborative BPs (including the visualization of human interactions), during which the agents interact and exchange information and knowledge, share knowledge and generate new ones.
- Possibility to model the collective distal intentions to achieve a collective objective.
- Possibility to specify the different opportunities of knowledge conversion actions.

Despite its expressiveness, BPMN 2.0 does not yet explicitly represent the key concepts of the Functional perspective (such as `Action of Collective`, `Critical Organizational Activity`, `Knowledge Conversion Action`, etc.). So, in order to remedy at this lack, in this section, we try to extend this specification to include all or at least most of the relevant SBP elements.

4.1 Mapping BPMN&BPM4KI Meta-models: Analysis of BPMN Support for the Functional Dimension Concepts

As shown in Table 2 BPMN lacks support for several concepts of the functional aspect meta-model (Figure 3). Therefore, to overcoming existing limitations, we define an extension of the BPMN specification, called BPMN4FM, which introduces the functional dimension aspects and provides a rich and expressive representation of SBPs to identify and localize the crucial knowledge mobilized by these BPs. In fact, we argue that an extension should widely make use of standard elements in order to exhaust the vocabulary of BPMN and reduce new

elements to a minimum. Based on both the specific SBP domain concepts and requirements, the comparison with standard BPMN is conducted in order to identify a reasonable need for extension. According to the presented functional ODP (Figure 3), each concept is examined regarding its semantically equivalence with standard elements. Therefore, the respective element descriptions, rules and explanations within the BPMN specification (OMG, 2013) were analyzed in-depth. This leads implicitly to the derivation of the BPMN4KM meta-model and its stereotypes. According to (Braun et al., 2015), the following rules are defined for the equivalence check (correspondence between concepts of the functional perspective meta-model and the BPMN meta-model):

- Equivalence: There is a semantically equivalent construct in the BPMN in the sense of a permitted combination of elements or just a single element. In this case, no extension is necessary and the domain concept is represented as BPMN concept.

- Conditional Equivalence: There is no obvious semantic matching with standard elements, but rather situational discussion is necessary in order to provide arguments for a possible mapping or to explain why it is not feasible. This situation is caused by the partial under specification of BPMN elements (OMG, 2013). Consequently, the concept is either treated as equivalent concept or as non-equivalent concept.

- No Equivalence: There is no equivalence to any standard element for three reasons: First, the entire concept is missing. In this case, the domain concept is represented as Extension Concept in the BPMN4FM meta-model. Second, a relation between two concepts is missing. Therefore, an association between the affected concepts is constructed in the BPMN4FM meta-model. Third, properties of a concept are missing. Then, an owned property is assigned to the element in the extended model.

Table 2 provides the conducted equivalence check and its implications for the extended BPMN meta-model. As result of the correspondence check, the concepts of the BPMN4FM meta-model are classified/characterized as *BPMN Concepts* or as *Extension Concepts*. Note that, due to space limitations, the concepts semantics and the equivalence check is limited to the functional dimension.

4.2 Abstract Syntax: The BPMN4FM Meta-Model

The BPMN meta-model can be extended by integrating new domain-specific concepts to standard and predefined BPMN elements. This is supported by a standard extension mechanism consisting of four elements: (1) `ExtensionDefinition`- defines and groups additional attributes that can be added to BPMN elements. (2) `ExtensionAttributeDefinition` - defines new attributes that can be added to BPMN elements. (3) `ExtensionAttributeValue` - contains the attribute value. (4) `Extension`- binds/imports an `Extension Definition` element and its attributes to a BPMN model definition.

Despite the fact that BPMN offers a well-defined extension interface, only very few BPMN extensions make use of it (Braun and Esswein, 2014), what hampers comprehensibility, comparability between developed extensions and impedes the straightforward integration of extensions in modeling tools. We suppose, that the missing procedure model for extension building in BPMN causes this lack of rigor. Based on the model transformation rules stated in Stroppi et al. (2011), we define the BPMN4FM extension model (BPMN+X model). Figure 4 below presents the resulting extended BPMN meta-model. In this figure only the relevant standard BPMN classes are shown in white. The BPMN4FM concepts are shown in grey. We associate `Action` concept with the `RootElement` of the BPMN specification. The semantics and the abstract syntax of the BPMN4FM elements are based on the specification of the BPMN extension mechanism. *BPMNElement* allows representing an original element of the BPMN meta-model. *ExtensionElement* allows representing a new `Action` concept with the `RootElement` of the BPMN specification. The semantics and the abstract syntax of the BPMN4FM elements are based on the specification of the BPMN extension mechanism. *BPMNElement* allows representing an original element of the BPMN meta-model. *ExtensionElement* allows representing a new element in the extension model which is not defined in the BPMN meta-model (such as `Distal Intension`, `Knowledge`). *ExtensionDefinition* allows specifying a named group of attributes which are jointly added to the original BPMN elements (such as `Action Of`

Table 2: Analysis of the BPMN support for the Functional dimension ODP/ meta-model (with relevant inter aspects relationships) and derivation of concepts for the Extended BPMN meta-model.

Functional Perspective Concepts	Semantics	Equivalence Check/BPMN Concept	Support Level	Extended BPMN Meta-model
Action	Accomplishment that exemplifies the intention of an agent (Masolo et al., 2003).	Conditional equivalence → Activity	Partly	Extension Concept
Deliberate Action	An Action premeditated which isControlledBy a Distal Intention (Kassel et al., 2012).	No equivalence	-	Extension Concept
Individual Action	An Action which isCarriedOutBy (performed by) a single individual (a Human).	No equivalence (no appropriate Marker)	-	Extension Concept
Action of Collective	A group of several individual actions combining their effects (Kassel et al., 2012). It isCarriedOutBy a Collective, controlledBy a Collective Intention and hasForProperPart at least two Individual Actions contributing to it (Turki et al., 2016). It can be either an Action Of Organization, or an Informal Group Action.	Conditional equivalence → Process. Process cannot be used to specify the actions that can be carried out collectively by the individuals making up the Collective.	Partly	Extension Concept
Action of Organization	An Action of Collective which isCarriedOutBy by a group of individuals affiliated with the organization. It isControlledBy an Organizational Distal Intention.	Equivalence → Process	+	BPMN Concept
Informal Group Action	An Organizational Action performed by an Informal Group and which contributes to an Action of Organization (it is an Organizational Action).	No equivalence		Extension Concept
Organizational Unit Action	An Action performed by an Organization Unit and which contribute to an Action of Organization (it is therefore an Organizational Action).	Conditional equivalence → Sub Process, Lane Set	Partly	Extension Concept
Organizational Sub Process	An Organizational Unit Action (which isCarriedOutBy an Organization Unit) which is aProperPartOf a Business Process.	Equivalence→ Sub Process, Lane	+	BPMN Concept
Organizational Activity	An Action which is aProperPart of an Action of Organization. It can be either an Organizational Individual Action or an Organizational Unit Action.	Equivalence → Activity, Task, Sub Process	+	BPMN Concept
Organizational Individual Action	An Action which isCarriedOutBy a Human affiliated to the Organization (it is an Individual Action) and which contributes to an Action Of Organization (it is an Organizational Action).	Conditional equivalence → Activity, Task	Partly	Extension Concept
Compound Organizational Individual Action	An Organizational Individual Action which hasForProperPart at least one Organizational Individual Action.	No equivalence	-	Extension Concept
Task	An Organizational Individual Action which hasn't for proper part any Action (it is an Atom).	Equivalence → Task	+	BPMN Concept
Critical Organizational Activity	An Organizational Action which hasForproperPart different types of Knowledge (which may be crucial): (i) imperfect individual and collective knowledge (i.e. missing, poorly mastered, incomplete, uncertain, etc.) which are necessary for solving critical determining problems; (ii) a great amount of heterogeneous knowledge recorded on diverse knowledge sources (dispersed and sometimes lacking accessibility); (iii) rare knowledge held by a very small number of experts; (v) flexible knowledge owned by experts; (iv) very important tacit organizational knowledge.	No equivalence	-	Extension Concept
Collaborative Organizational Activity	An Action of Collective carried out collectively by the individuals making up the Collective (at least two Humans), internal or external to an organization, that collaborate to achieve an Objective intentionally defined. This activity mobilizes, shares and exchanges Information and Knowledge and generates new Collective Knowledge through interactions between Agentive Entities.	Conditional equivalence → Activity, Choreography Activity, Collaboration	Partly	Extension Concept

Table 2: Analysis of the BPMN support for the Functional dimension ODP/ meta-model (with relevant inter aspects relationships) and derivation of concepts for the Extended BPMN meta-model (cont.).

Functional Perspective Concepts	Semantics	Equivalence Check/BPMN Concept	Support Level	Extended BPMN Meta-model
Knowledge Intensive Activity	A special type of process activity that is not enough specified to be systematically executed. Its execution is based on previous experiences and tacit knowledge from its executor, may comprise innovation, or may involve complex making decisions. It is unpredictable and defined at runtime (Netto et al., 2013).	No equivalence	-	Extension Concept
Communication	An Action (which can be either Receiving an Information, Obtaining an Information, or Providing an Information) is a transfer of Information (which is a Message) between two or more Agentive Entities that affects their knowledge state.	Conditional equivalence → Activity, Send Task, Receive Task, Choreography Activity	Partly	Extension Concept
Receiving An Information	A Communication which hasForProperPart an Informing such that the *agent of* the Receiving An Information is the *addressee of* the Informing.	Equivalence → Receive Task	+	BPMN Concept
Knowledge Conversion Action	An Action during which different types of Agentive Entities (playing the role of Senders and Receivers) interact, exchange and share different types of Knowledge through Messages, contributing to the creation and acquisition of new Knowledge from the Message content. Every Knowledge Conversion Action is a Deliberate Action which can be either a Socialization, an Internalization, an Externalization or a Combination.	No equivalence	-	Extension Concept
Socialization	A Knowledge Conversion Action (which is a Deliberate Action) which hasForAgent a Collective (which hasForProperPart at least two Humans) and hasForResult new Tacit Knowledge (mental models). It may involve the participation of External Actors. During a Socialization, Individual Tacit Knowledge isTransmittedIn Collective Tacit Knowledge through practice, sharing of experiences, constructive discussions or in a learning-by-doing situation.	No equivalence	-	Extension Concept
Internalization	A Knowledge Conversion Action which is a Deliberate Action converts Explicited Knowledge (Individual and/or Collective) to Tacit Knowledge. That leads to an integration of experiences and competences in your own mental model. Internalization hasForAgent an Agentive Entity (an Human or a Collective), which hasForResult Tacit Knowledge.	No equivalence	-	Extension Concept
Externalization	A Knowledge Conversion Action which is a Deliberate Action, during which several Tacit Knowledge areExternalizedTo to divers Collective Explicited Knowledge (or Information) and leads to detached knowledge (as seen from the perspective of the human being). Collective Explicited areBorneBy organizational memory systems (i.e., Physical Knowledge Supports)). Externalization hasForAgent an Human or a Collective and hasForResult Collective Explicited Knowledge.	No equivalence	-	Extension Concept
Combination	A Knowledge Conversion Action which is a Deliberate Action, which combines existing Explicited Knowledge in new forms (complex). Combination hasForAgent one or more Humans, and hasForResult new Explicited Knowledge (Individual and/or Collective). Explicited Knowledge of several Humans are exchanged, combined to produce, by induction and deduction new Explicited Knowledge.	No equivalence	-	Extension Concept
Discourse Act	A Discourse Act (Authorizing, Asking, Defining, Describing or Informing) is a Communication, which is a Deliberate Action, which consists in creating a Discourse, that is an Expression which expresses a Message (Fortier and Kassel, 2004).	Conditional equivalence → Send Task, Receive Task, Choreography Activity	Partly	Extension Concept
Inter Organizational Action	An Action which isCarriedOutBy at least two Organizations.	No equivalence	-	Extension Concept

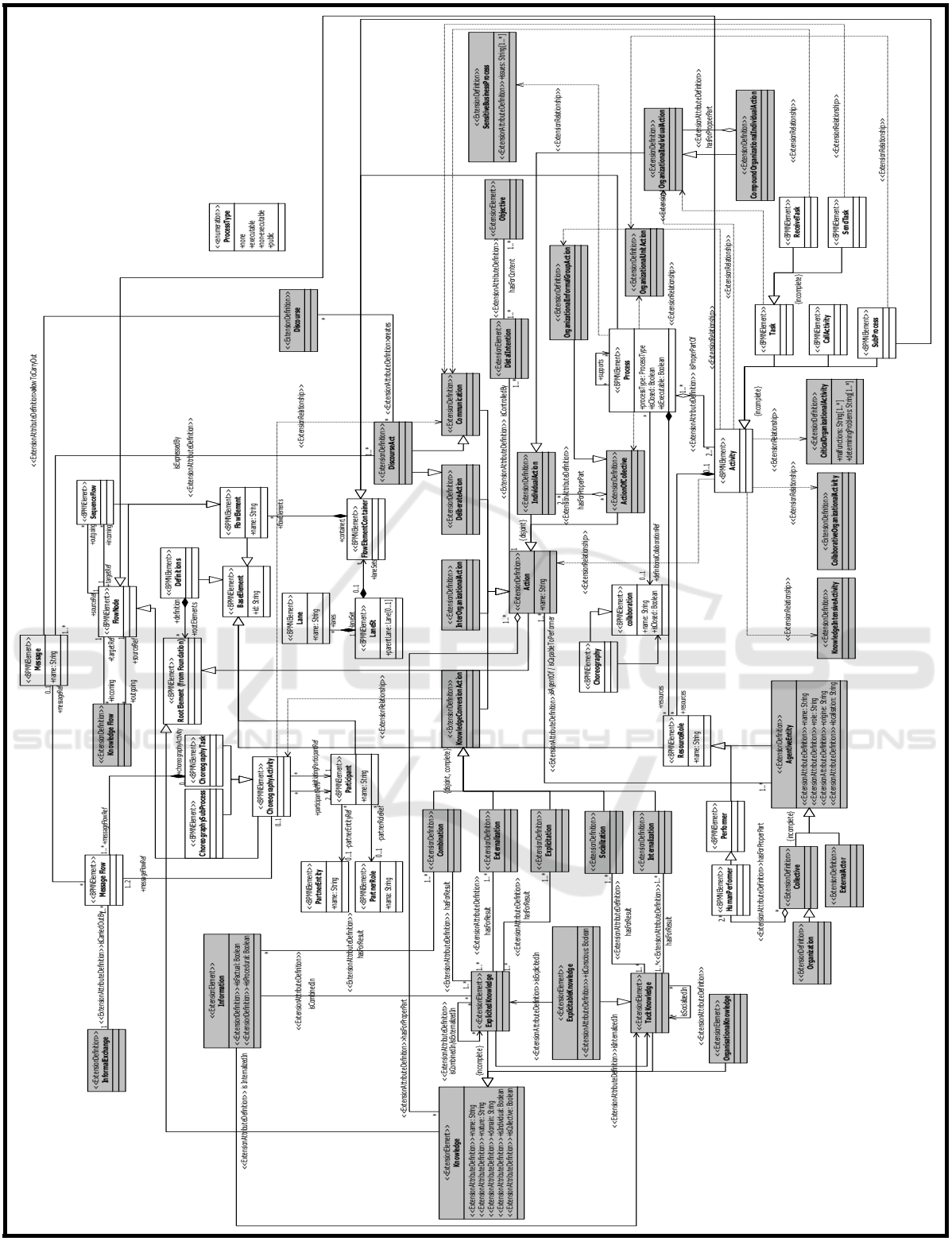


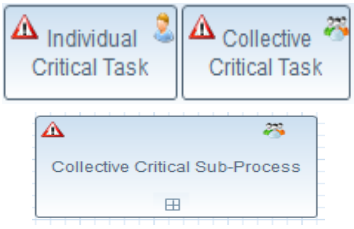
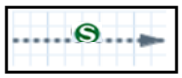
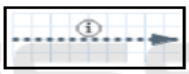
Figure 4: Abstract syntax of the BPMN4FM extension.

Collective, Inter Organizational Action, Critical Organizational Activity, Collaborative Organizational Activity, Knowledge Conversion Action, Socialization, Sensitive Business Process, Collective, etc.). *ExtensionDefinition* has the same meaning than the ExtensionDefinition element of the BPMN metamodel. The semantics defined by the *ExtensionAttributeDefinition* element of the BPMN meta-model is captured by the Property metaclass of the UML metamodel. Thus, ExtensionAttributeDefinition is represented in BPMN4FM models by UML properties, either owned by the ExtensionDefinition elements or navigable from them through associations. The properties of *ExtensionDefinition* and *ExtensionElement* elements can be typed as a *BPMNElement*, *ExtensionElement*, *BPMNEnum*, *ExtensionEnum* or UML primitive type. Finally, *ExtensionRelationship* specifies a conceptual link between a *BPMNElement* and an *ExtensionDefinition* element aimed to extend it. The BPMN extension mechanism cannot express the BPMN element to be extended by an extension definition. Thus, the definition of an *ExtensionRelationship* does not produce any effect in the resulting BPMN extension. *ExtensionRelationship* is provided to help conceptualizing extensions since extensions are generally defined to customize certain elements of the BPMN meta-model. With respect to the limited space of this paper, the application of each applied transformation rule cannot be presented.

4.3 Concrete Syntaxes and Editor

We proposed an advanced concrete syntax that defines new and specific graphical representation for the new concepts of BPMN4FM as illustrated in Table 3. For instance, the Action element is specified by new markers for representing Individual Action, Action of Collective and Critical Organizational Activity. Furthermore, we have incorporated new notational elements with specific properties for Knowledge typologies, for Knowledge Conversions Flows, Physical Knowledge Supports and Agentive Entities.

Table 3: Concrete syntax of BPMN4KM.

BPMN4FM Elements	Modeling Notation
Organizational Critical Activity (Individual/ Collective)	
Collective	
Tacit Knowledge	
Explicit Knowledge	
Knowledge conversion/ creation Socialization (Flow)	
Internalization (Flow)	
Explicitation (Flow)	
Externalization (Flow)	
Physical Knowledge Support (Individual/ Collective)	

We have implemented an editor supporting this syntax as shown in Figure 5. More precisely, we have developed a specific Eclipse plug-in, entitled « K4BPMN: Knowledge for Business Process Modeling Notation », to integrate and represent all relevant aspects related to the knowledge dimension in SBP models (to improve the localization of crucial knowledge that is mobilized and created by these processes). This plug-in extends the open source editor Eclipse BPMN2 Modeler plug-in (BPMN2 Modeler, 2016): it completes this later by integrating new attributes, properties, elements and specific icons for introduce new SBP semantics.

5 ILLUSTRATIVE EXAMPLE OF THE USE OF EXTENDED BPMN4FM

The research project presented in this paper has been done in the context of the Association of Protection of the Motor-disabled of Sfax-Tunisia (ASHMS) (Ben Hassen et al., 2017). This organization is characterized by highly dynamic, unpredictable, complex and highly intensive knowledge processes. We intend to apply some concepts proposed by BPMN4FM meta-model to evaluate their practical utility and suitability in providing an expressive representation of an SBP. Particularly, we are interested in the early care of the disabled children with cerebral palsy (CP). An depth analysis of this care has been made by Ben Hassen et al. (2017). The created knowledge stems from the interaction of a large number of multidisciplinary healthcare professionals with heterogeneous skills, expertise and specialties (such as neonatology, neuro-pediatrics and physical therapy). The global care process of the disabled children with CP consists of a succession of many actions in the form of medical and paramedical examinations and evaluations of children with cerebral palsy in different specialties. The different sub-processes (e.g. process related to neonatology care, process related to neuro-pediatric care, etc.) require certain medical information and knowledge. In this study, we take into consideration the results of experimentation of the multi-criteria Sensitive Organization's Process Identification Methodology (SOPIM) proposed by Turki et al. (2014) which was validated in the ASHMS and aims at evaluating and identifying SBPs for knowledge localization. We have opted for the SBP « Process of initial neuro-motor evaluation of a child with CP». In Figure 5, we illustrate an extract of BPMN SBP model of the initial evaluation process extended and enriched with some extended concepts related to the functional and knowledge dimensions. During our experimentation, we have identified different types of medical knowledge mobilized and created by each critical activity related to the SBP. For instance, the knowledge A2Kp2 related to « Result of the evaluation of neuro-cognitive, psycho-cognitive and sensory development of the young children with CP and their disorders» is produced by

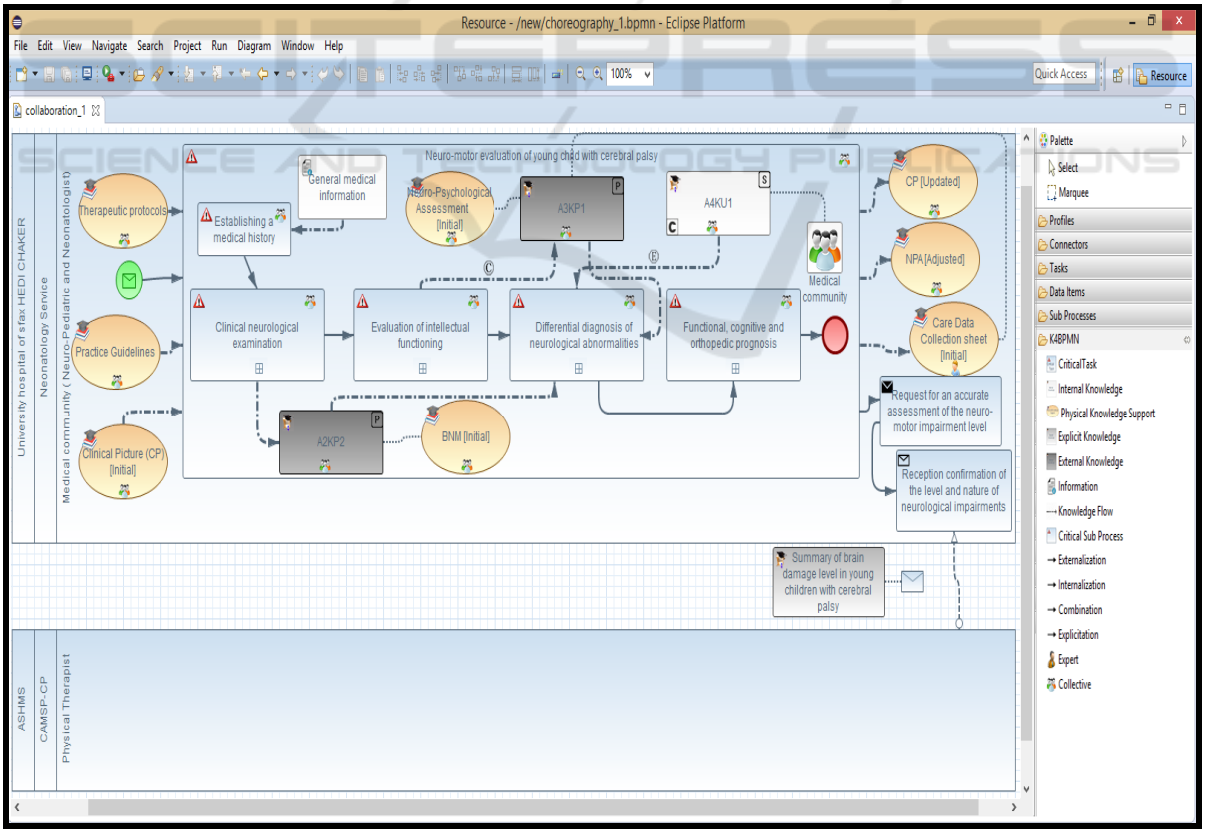


Figure 5: Fragment of SBP model related to the initial neuro-motor evaluation of a child with CP using Extended BPMN2 Modeler.

the critical activity A2 «Clinical neurological examination». A2Kp1 is an external and propositional knowledge which is collective. It is stored in the following physical media: the neurological and neuro-motor assessment sheets (BNM).These physical media of knowledge are located within the Neonatology service unit in the University Hospital Hedi Chaker. A2Kp2 is of a scientific and measure nature which is related to patients. A2Kp2 is mobilized by the activity A4 «Differential diagnosis of neurological abnormalities».

It is important to mention that not all Functional Perspective concepts are applicable and must be instantiated in every SBP scenario. The graphical representation of SBP is in its experimental stage.

6 CONCLUSION AND PERSPECTIVES

This research work presented, firstly, BPM4KI-a generic BPs meta-model that covers all relevant perspectives for a complete and precise conceptualization of SBP. We focused, specifically, on the description of the «Functional Perspective», exploring the collaboration, interaction and knowledge aspects in greater detail. The SBP modeling dimension is semantically rich and well-based on «core» domain ontologies. Secondly, we presented BPMN4FM: a BPMN 2.0 extension, integrating all relevant aspects related to the functional dimension in SBP models in order to improve the localization and identification of crucial knowledge mobilized and created by these processes. Furthermore, we developed a specific Eclipse plug-in implementing BPMN4FM. Besides, we illustrated the application of some extended concepts on a model of medical care process. Our current research activities focus on achieving the implementation of aspects related to all BPM4KI dimensions. As further work, we aim at proposing a framework based on MDA (Model-Driven Architecture) to automatically generate SBP models and enhance the knowledge identification.

REFERENCES

Ben Hassen, M., Turki, M., Gargouri, F., (2016a). A Business Process Meta-Model for Knowledge Identification Based on a Core Ontology. In *International Symposium on Business Modeling and Software Design*. Revised Selected Papers (Book Chapter). Lecture Notes in Business Information Processing, 257, Springer, pp.37–61.

Ben Hassen, M., Turki, M., Gargouri, F., (2016b). Choosing a Sensitive Business Process Modeling Formalism for Knowledge Identification. Procedia Computer Science, vol 100 (2016a) 1002–1015.

Ben Hassen, M., Turki, M., Gargouri, F., (2017). Sensitive Business Processes Representation: A Multi-Dimensional Comparative Analysis of Business Process Modeling Formalisms. In *International Symposium on Business Modeling and Software Design*. Lecture Notes in Business Information Processing, Springer, pp. 83-118.

Braun, R., Esswein, W., (2014). Classification of Domain-Specific BPMN Extensions. In F*rank, U., Pastor, O., Petrounias, I. (Eds.) Lecture Notes in Business Information Processing*, 197, pp. 42-57.

Braun, R., Schlieter, H., Burwitz, M., & Esswein, W., (2015). Extending a Business Process Modeling Language for Domain-Specific Adaptation in Healthcare. In Wirtschaftsinformatik, pp. 468-481.

BPMN2 Modeler. [Online]. Available: http://www.eclipse.org/bpmn2-modeler/

Fortier J.-Y., & Kassel G. (2004). Managing knowledge at the information level: An ontological approach. In *Proceeding of the ECAI'2004 workshop on knowledge management and organizational memories*. Spain, pp. 39–45.

Gangemi A., Borgo S. (Eds.), (2004). Proc. of the *14th International Conference on Knowledge Engineering and Knowledge Management*, Workshop on Core Ontologies in Ontology Engineering.http://ceur-ws.org (Vol-118).

Gangemi A., (2006). *Ontology Design Patterns: A primer, with applications and perspectives*. Tutorial on ODP. *Laboratory for Applied Ontology Institute of Cognitive Sciences and Technology CNR*, Rome, Italy.

Kassel, G., (2005). Integration of the DOLCE top-level ontology into the OntoSpec methodology.

Kassel, G, Turki, M, Saad, I, Gargouri, F., (2012). From collective actions to actions of organizations: an ontological analysis. *In Symposium Understanding and Modelling Collective Phenomena*, University of Birmingham, England.

Kassel, G., (2010). A formal ontology of artefacts. Applied Ontology 5(3-4) pp.223-246.

Masolo, C., Vieu, L., Bottazzi, E., Ferrario, R., Gangemi, A., Guarino, N., (2004). Social roles and their descriptions, In *Dubois D., Welty C. (eds.), Proc. of the Ninth International Conference on the Principles of Knowledge Representation and Reasoning*, pp. 267-277.

Netto, J. M, Franca, J. B. S., Baião, F. A., Santoro, F. M., (2013). A Notation for Knowledge-Intensive Processes. In *IEEE 17th International Conference on Computer Supported Cooperative Work in Design*,Vol.1, pp.1–6.

OMG (2013). Business Process Model and Notation (BPMN), Version 2.0.2 http://www.omg.org/spec/BPMN/2.0.2/pdf/

Turki M., Saad I., Gargouri F. and Kassel G., (2014). *A Business Process Evaluation Methodology for Knowledge Management based on multi-criteria decision making approach*. Information systems for knowledge management. ISBN: 978-1-84821-664-8, Wiley-ISTE.

Turki, M., Kassel, G., Saad, I., Gargouri, F., (2016). A Core Ontology of Business Processes Based on DOLCE. *J. Data Semantics*. 5(3), pp.165-177.