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BPMN4CP Revised – Extending BPMN for Multi-Perspective Modeling of Clinical Pathways

Richard Braun
TU Dresden, Germany
richard.braun@tu-dresden.de

Hannes Schlieter
TU Dresden, Germany
hannes.schlieter@tu-dresden.de

Martin Burwitz
TU Dresden, Germany
martin.burwitz@tu-dresden.de

Werner Esswein
TU Dresden, Germany
werner.esswein@tu-dresden.de

Abstract

Clinical Pathways (CPs) can be seen as business processes of hospitals or clinical institutions. Modeling these pathways is an emerging field of research, as it provides promising benefits for systems integration, quality management and documentation. The Business Process Model and Notation (BPMN) provides a range of process-related concepts but naturally lacks in representing specific aspects from the CP domain. Therefore, the BPMN extension BPMN4CP was designed in a previous research project. In accordance with research guidelines from Design Science, the extension ran through an iteration based on its practical application within a telemedical project. Based on several new requirements, the extension was revised regarding to the integration of resources, documents, objectives and quality indicators. These concepts were assigned to particular perspectives and diagrams in order to support model complexity management and provide appropriate diagrams for respective stakeholders. In order to provide a commonly usable extension, these enhancements were implemented as BPMN meta model extension.

1. Introduction and Motivation

Conceptual models have established as a key instrument in the field of business information systems engineering [47], [15]. For instance, conceptual models are used for enterprise architecture management, software customization or business process reengineering [13]. In the healthcare sector, conceptual modeling becomes increasingly important for process optimization and standardization efforts in the context of Clinical Pathways (CP). CPs are specific, standardized descriptions of clinical processes for defined combinations of symptoms, which are adapted to clinical conditions [14]. They are geared to the whole multidisciplinary care process of a certain patient type. As Panella and Vanhaecht (2010) stated, CPs are more than only the structure of a care process and a part of the electronic patient records. A CP is understood as a “patient-focused concept, a tool to model the care, a quality and efficiency improvement process and a product in the patient record” [32].

Based on a meta-review, Kinsman et al. (2010) derive five constitutive characteristics [24]: First of all there is a need for an integrated, multidisciplinary plan of care. Furthermore, CPs should be used to foster the adaptation of Clinical Practice Guidelines (CPG) or other sources of evidence into local structure. Thirdly, the treatment processes of CPs have to be described in their essential steps. Fourthly, timeframes or criteria, which lead to alternative treatment procedures depending on the patient characteristics, are implemented and CPs are finally characterized by the aim to standardize care for a specific indication in a population [24]. The major impact of CPs is to foster the organization of complex medical treatment processes for similar patient types. This supports clinics in terms of economic processes and quality orientation. It also facilitates control and coordination of the treatment chain, and ensures the straightforward treatment for the patient based on treatment standards.

CP modeling comprises two purposes. On the one hand, CP models should enable computer-based process interpretation and workflow support in order to enhance decision management [1], [23], [44], [17]. On the other hand, CP models should facilitate clinical process management and standardized communication between different stakeholders. Common modeling languages like BPMN [25], [27], UML, ARIS or dedicated domain languages like CPmod [10] are proposed for CP modeling. We follow the adaptation of the Business Process Model and Notation (BPMN, [29]) for CP modeling in order to take advantage of its prevalence and acceptance both in academia and industry [12]. BPMN is defined as official ISO standard [22] and provides a well-defined meta model facilitating model exchangeability, tool integration and unambiguous language interpretation. Further, BPMN supports the derivation of computer-interpretable

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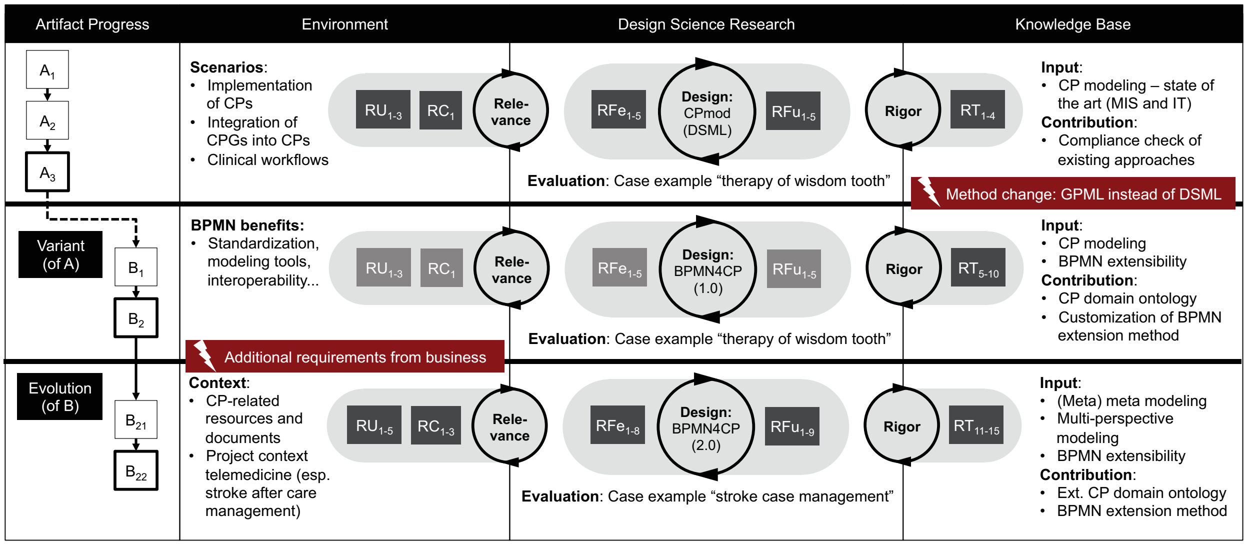

Figure 1. Incremental research process of designing a conceptual modeling language for CPs

workflow models (cf. [12], [29]) and defines a lightweight mechanism for language extension, which is a great plus in comparison to other languages [5]. This level of standardization goes hand in hand with the existence of numerous BPMN modeling tools. Motivated by the stated benefits of BPMN, we recently introduced a CP modeling extension of BPMN, called BPMN4CP [2], [4], which conceptualizes the CP domain and adds respective domain concepts to the meta model of BPMN [42], [2].

In the meantime, the extension was applied in real-life projects, which discloses valuable insights regarding to its usefulness and aspects for improvement. Hence it became necessary to revise and extend the initial BPMN4CP extension in order to satisfy the identified user needs. Both the design process and the final artifact (BPMN4CP 2.0) are elaborated and presented in this research paper.

The structure of this article is as follows. Section 2 outlines the underlying construction-oriented research approach [20], which is grounded on requirements-based Design Science Research [8]. Section 3 presents the preparation of the extension design by elaborating required domain concepts and discussing the topic of multi-perspectivity in the context of the process modeling language BPMN. Additionally, an integrated BPMN extension procedure is proposed in order to enable a straightforward and rigorous extension design. Section 4 covers the designed BPMN meta model extension by presenting its abstract and concrete syntax. In Section 5, an example process from the field of stroke care demonstrates the application of the extension. The article ends with a short summary and the consideration of further research topics.

2. Research Approach

2.1. Requirements-Driven Design Science

Design Science (DS) is the innovative construction of artifacts for the solution of relevant problems from theory or business by the reasonable application of appropriate methods and techniques as well as the consideration of the theoretical and practical state of the art knowledge [20], [21], [34]. Conceptual modeling languages like BPMN are artifacts in the form of methods, which consist of statics parts (syntax and semantics) as well as procedural parts in form of the modeling procedure [19], [35], [47]. Consequently, also extensions of modeling languages are perceived as artifacts and require the consideration of syntax and semantics [7]. The initial BPMN4CP version was therefore designed in accordance to the DS paradigm based on a set of identified requirements and previous versions [4], [10] in order to ensure domain appropriateness (semantics) and a correct meta model (syntax). Revising the BPMN extension inevitably causes the consideration of appropriate methodical support from the DS research discipline in terms of artifact evolution.

Despite the fact, that DS is generally perceived as a highly iterative and incremental research approach, which encompasses the repetitive exchange between theoretically driven artifact design and practical application (cf. [20], [45], [11]), there is a remarkable lack regarding to the realization of required design actions in specific DS projects, which impedes rigor and might also compromise the quality of artifacts (cf. [8]). In order to overcome this issue, we conduct the recently presented requirements-driven DS approach of

Braun et al. (2015). The authors propose a set of requirement types in order to specify the capabilities and features of the aimed artifact from a goal perspective [8]. Requirements are thereby divided into the class of problem-oriented requirements and solution-oriented requirements (cf. [48]) in order to cover both the relevance cycle and the rigor cycle in DS studies [20], [11], [18].

2.2. Requirements for BPMN4CP Revision

We conduct the stated requirements-driven approach in order to explicate the capabilities of the aimed artifact and demarcate the artifact from its previous versions. In other words, a particular requirements set should justify the need for revising an existing artifact by indicating its missing features. Figure 1 represents the long-term process of building a conceptual modeling language for CPs. First, a dedicated Domain-Specific Modeling Language (DSML) was designed based on an initial domain requirements set (CPmod [10]). Then, the same requirements set served as base for developing an extension of the General Purpose Modeling Language (GPML) BPMN in order to exploit its standardization benefits (BPMN4CP 1.0 [4]). This step provoked a variant of the initial artifact. Additional requirements from practical application then revealed the need for integrating CP-related resource concepts and documents, which caused an evolution of the first BPMN version (BPMN4CP 2.0).

In accordance to the DS paradigm, Figure 1 also considers the particular relevance cycles and rigor cycles [20]. Relevance refers to the respective practical application or reasonable scenarios. Rigor reflects the theoretical knowledge base (e.g., the BPMN extension method of [42]) as well as resulting contributions to the research community (e.g., the CP domain ontology in [10]). The underlying requirements for BPMN4CP 2.0 are as follows:

User Requirements: RU_4: Each stakeholder group should only see those modeling concepts, which are helpful for their work. RU_5: Representation of CP-related resources and documents.

Contextual Requirements: RC_2: Documentation obligations by law. RC_3: CP-related resource types and document types from literature.

Feature-related Requirements: RFe_6: Complexity reduction by the creation of perspectives. RFe_7: In-detail modeling of resource and document structures. RFe_8: Integration with CPs.

Theory-based Requirements: RT_{11}: Multi-perspective modeling [16] and separation of concern. RT_{12}: Integration within the modeling method [19]. RT_{13}: Procedural transparency [33]. RT_{14}: Classification of resources and medical documents. RT_{15}: User-specific set of BPMN concepts [3].

Functional Requirements: RFu_6: Perspectives (resources and docs). RFu_7: Resources, resource types, bundles, resource associations, document types. RFu_8: Extending BPMN meta model for specifying perspectives. RFu_9: Perspectives in extension methods.

Further, mainly reused requirements can be found in our previous works [10], [4]

3. Consequences for Extension Evolution

The analysis of requirements leads to three aspects, which have to be considered in detail during the extension design: Domain concepts, the issue of multi-perspectivity in BPMN and the extension procedure.

3.1. Required Domain Concepts

This aspect covers all required concepts of the BPMN extension, leading to an extension of the BPMN meta model with additional classes, properties or property values [29]. The need for such concepts comes from users (RU_5), the problem domain by itself (RC_3) and is finally consolidated in a set of functional requirements ($RFu_{1-5,7}$) and one theory-based requirement (RT_{14}). Figure 2 represents the CP domain ontology, which constitutes as extended version of a previously defined CP ontology in [4]. With respect to the limited space of this article, we only discuss those concepts in detail, which are added based on the revised requirements set. The process perspective is reduced to the central anchor element *Activities*. Further CP concepts for this perspective can be found in [4].

Resource Concepts: Generally, CPs consume a variety of different resources. Hence it is necessary to represent those aspects within a CP model in order to allow an integrated analysis and provide valuable information for particular stakeholders (e.g., administrative management). In order to reduce the entire model complexity and avoid model overloading (cf. [16], [19]), we proclaim the specification of a separate resource perspective in BPMN4CP. This perspective facilitates a specific view on resources and their interdependencies. Particular resource objects are integrated with CPs, i.e. the process perspective. A *Resource* is understood as any consumable or usable object that is necessary for the fulfillment of CP activities. Resources can be assigned and composed to *Resource Bundles* (e.g., a bundle of resources of an operating room). Resources can have *Resource Relations* (e.g., complementary or substitutional). As depicted at the bottom of Figure 2, resources can be specified by different types. *Human Resources* represent humans or organizations, which are needed for the execution of particular activities (e.g., nurses or medical technical assistants). *Transportation Equipment* stands for all resources that are required for patient transport or mobility. The *Medicine* concept encompasses all medical drugs, which can be administered. *Rooms* encompass all specific building entities (e.g., X-ray room, exam room). *Equipment* stands for all medical-related material (e.g., surgical instruments). *Consumption Resources* describe resources, which are consumed within patient treatment (e.g., dressing). *Auxiliaries* refer to all other resources, which are not primarily intended for treatment but needed for equipment, rooms or machines.

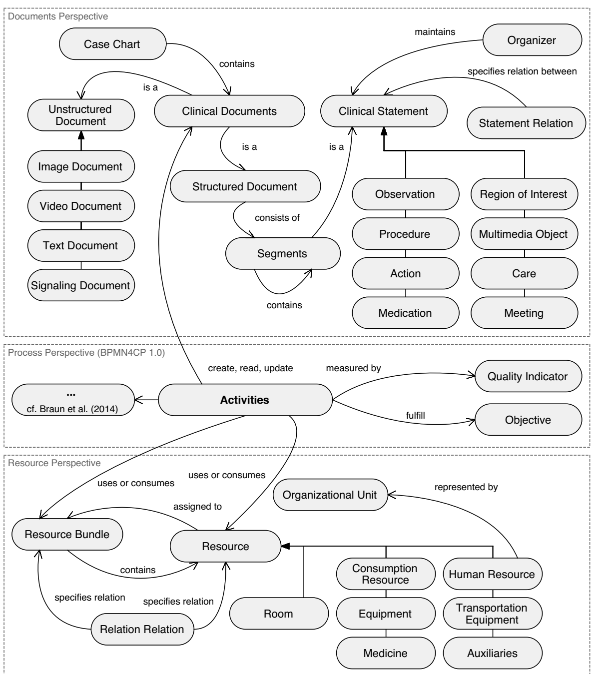

Figure 2. Extended CP ontology

Document Concepts: Similar to the resources perspective, it seems to be necessary to consider documents separately, since CPs are markedly document-oriented processes due to statutory requirements, quality purposes or other administrative rules (cf. RC$_2$). We therefore aim to provide a document perspective within BPMN4CP. A *Case Chart* describes a container in which different *Clinical Documents* for a specific case (patient) are gathered. A clinical document can be constituted in an unstructured or structured format. *Unstructured Documents* contain not commonly definable document structures like *Images*, *Videos*, unstructured *Text Documents* or *Signaling Documents* (e.g., data streams from electrocardiogram machines). In contrast, a *Structured Document* consists of contents (*Segments*) that are arranged according to defined rules or specifications. Structured documents also provide meta information of containing elements. A particular segment can be a *Clinical Statement*, which describes single records of a document that can be seen as atomic part. Those statements can have specific types: *Actions* represent the execution of procedures. *Meetings* refer to discussions or conversations (e.g., patient anamnesis). *Observations* represent particular impressions from treatments or examinations. *Medication* represents the prescription or administration of drugs. *Multimedia Objects* refer to embedded unstructured data like videos, which are relevant for treatment. *Procedures* describe single treatment steps. *Care* covers all situations where some sort of care is applied to a patient. *Region of Interest* can be seen as helper concept for tagging and marking specific parts of multimedia objects.

3.2. Multi-Perspectivity in BPMN

As stated above, the requirements analysis for the revision of BPMN4CP reveals a need for stakeholder-specific diagrams, which provide only selected aspects for particular model users in order to avoid cognitive overload and misinterpretations (cf. RU$_4$). This aspect is closely linked to the issue of complexity reduction in models by building single diagrams, while single concepts are integrated in different diagrams in order to act as connecting elements (cf. RFe$_{6\text{-}8}$). The technique of multi-perspective modeling facilitates user-specific views to the complex entirety of all meta model concepts, i.e. the vocabulary of a modeling language (cf. RT$_{11}$, RT$_{15}$). By the building of views, the modeler can describe the entire information system using the views like a structuring framework, but he can also consider specific aspects of the information system by using the views for an aspect-specific model application (cf. [39], [41]). This helps to gain a better understanding of the domain, its concepts, and their relationships.

Consequently, BPMN should provide meta model concepts for the definition of the required perspectives (e.g., resource perspective) and diagrams (e.g., resource bundle diagram). However, BPMN as a process-centered modeling language lacks in the provision of such concepts (like many MOF-based languages [5]). It is therefore necessary to define respective meta model concepts for the definition of perspectives and diagrams in BPMN (cf. RFu$_8$) and their consideration in extension design (cf. RFu$_9$). Both issues are addressed in a recently published work of Braun & Esswein (2015). We respect to the rather application-oriented focus of this paper, we only refer to their work and reuse respective meta model mechanisms [9].

3.3. Extension Procedure

With respect to design-oriented research, particular operations and procedures need to be transparent and replicable (cf. RT_{13}). Consequently, also the process of building (multi-perspective) BPMN extensions should be integrated within a comprehensive modeling method (cf. RT_{12}) in order to ensure well-defined BPMN extensions and avoid ad-hoc designs. However, the BPMN specification only provides four meta model concepts and lacks in terms of providing procedural guidance for their application [6]. Stroppi et al. (2011) address this issue by defining a procedure model for the development of standard-conform BPMN extensions [42]. In short, the approach consists of the initial design of a domain class model (CDME), which is then transformed into a valid BPMN extension model (BPMN+X). While the approach is very useful for straightforward design of the abstract syntax of the BPMN extension (meta model), it omits a deeper consideration of the initial domain analysis before CDME definition. In particular, there is no comparison between the semantics of domain elements and BPMN elements, which implies the risk of redundant extension elements and missing exploitation of BPMN expressiveness. Thus, designing the CDME depends solely on the creativity of the extension designer, which could impair design rigor. We therefore propose a broader extension method, which partly builds on previous investigations [2].

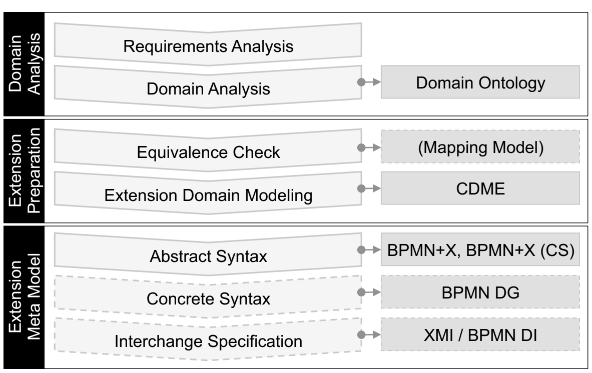

Figure 3. Integrated BPMN extension method

Figure 3 outlines the method consisting of three main parts: *Domain Analysis*, *Extension Preparation* and *Extension Meta Model*. The first step covers the initial consideration of general, user-related requirements. At this point, is has to be decided, whether BPMN is an appropriate modeling language for the particular purpose. Thereafter, an in-depth-analysis of the problem domain is conducted in order to identify concepts, properties, rules and constraints of the domain. Both steps were already applied in Sections 2.2 and 3.1. Afterwards, all domain concepts are compared to original BPMN elements during the *Equivalence Check* in order to identify real need for extension and identify points for adaptation or reuse. Three result types are possible: *Equivalence*, *Conditional Equivalence* and *No Equivalence* [2].

In addition to previous works, we want to specify the *Equivalence* type: If a concept can be represented as sense-making and valid composition of original elements, it is referred as *Equivalence by Composition*. The *Equivalence by Specification* type covers domain concepts, which can be seen as specifications of BPMN elements by adding domain-specific properties or semantics. It has to be emphasized that each concept has to be examined regarding to its general conformance to the essential semantics of BPMN in order to avoid a defacement of the language [7]. The results of the equivalence check can be explicated in a table or a separate mapping model in order to prepare the CDME model.

The next step *Extension Domain Modeling* corresponds to the CDME modeling step from Stroppi et al. (2011), which is supplemented by the suggestions of Braun & Esswein (2015) in order to integrate perspectives. Afterwards, the CDME is translated into the valid BPMN extension model, serving as the abstract syntax of the extension [42], [43], [9]. Then, the Diagram Definition standard from OMG should be used for the definition of the concrete syntax [30], [9]. Finally, the interchange format of the extension can be specified using XMI model interchange specifications and the Diagram Interchange (DI) definition [30]. Due to page space limitations, the last two steps are not examined in detail in this article.

4. Extension Design

This section describes the syntax and the semantics of the revised BPMN extension. First, the required syntactical concepts are motivated by a semantic comparison of required domain concepts and BPMN elements in Sections 4.1 and 4.2. Thereby, the semantics of extension elements are implicitly expressed. In Sections 4.3 and 4.4, the syntax of the extension is presented (cf. [35]).

4.1. Equivalence Check

As abovementioned, the revised BPMN extension is designed based on several requirements and domain concepts. Each concept is examined regarding its semantic equivalence with BPMN elements based on element descriptions within the BPMN specification [29].

Table 1 depicts the equivalence check of those elements, which are supplemented to the initial BPMN4CP version (especially from the resource and document perspective). As result of the equivalence check, a classification as *BPMN Concept* or *Extension Concept* is made for each concept. Additionally, we emphasize the need for new diagrams in order to represent perspectives on resources and documents.

Table 1. Equivalence Check

Concept	Equivalence Check and Result
Evidence Indicator Indicator that can be bound to activities, decisions, process parts and the entire process [36], [37].	**Equivalence (by specification):** The *Property* element of BPMN "acts as container for data associated with flow elements" ([29], p. 210) and can be assigned to *Processes*, *Activities* and *Events*. Hence, it can be applied as it provides additional information on those elements. As *Properties* have no further features, additional specification is necessary. → Extension concept and specified BPMN concept
Objective Goal of activities.	**Equivalence (by specification):** see Evidence Indicator → Extension concept and specified BPMN concept
Quality Indicators Measurement of quality.	**Equivalence (by specification):** see Evidence Indicator → Extension concept and specified BPMN concept
Resource Defining different kinds of resources , which can be assigned to process activities in order to represent input for their execution.	**Equivalence (by specification):** BPMN *Resources* specify resources that can be referenced by *Activities* ([29], p. 95). However, the intended resource concept needs to be specified in terms of its sub types and particular references. → Extension concept and specified BPMN concept
Resource Bundle Composition of single resources to an entire bundle that can be used by activities, too.	**Equivalence (by specification):** This concept provokes a special consideration. As bundles can be used by *Activities*, they have the same semantics as the above stated *Resources* concept. However, its composition semantics have to be considered separately. → Extension concept and specified BPMN concept
Resource Relation Specified relations between resources.	**No equivalence** → Extension concept
Organizational Unit Unit that can be represented by human resources.	**Equivalence:** *Lanes* are concepts for modeling internal roles, systems or departments ([29], p. 306) → BPMN concept
Case Chart Container for patient documents.	**Equivalence (by specification):** This can be seen as kind of a data collection, which leads to a specification of the *Data Object*. → Extension concept and specified BPMN concept
Clinical Documents Documents for medical and administrative purposes.	**Equivalence (by specification):** This concept can be seen as data input or data output of CP parts. Hence it is an appropriate specification of the *Data Object* with respective detailing. → Extension concept and specified BPMN concept
Segments Parts of structured documents.	**Equivalence (by specification):** *Data Object* → Extension concept and specified BPMN concept
Clinical Statements Representation of atomic records of a structured document with a medical topic.	**Equivalence (by specification):** Similar to the above stated concepts, clinical statements inherit from *Data Object* and specify their particular features additionally. → Extension concept and specified BPMN concept
Statement Specified relations between statements.	**No equivalence:** → Extension concept

4.2. Extension Domain Model

The CDME model was created based on a detailed analysis of each required concept (cf. Figure 4). Extension elements are marked by the *Extension Concept* stereotype. BPMN elements (extended subset of [4]) are marked by the *BPMN Concept* stereotype and are colored gray for a better visual differentiation. Several classes specialize the *Data Object* class as our revised BPMN extension explicitly takes documents into account: *Case Chart*, *Clinical Document*, *Segment* and *Clinical Statement*. A *Case Chart* is composed of different *Clinical Documents*, which are divided into *Unstructured Documents* (and its corresponding sub types) and *Structured Documents*. A *Structured Document* consists of different *Segments*, which are characterized by a respective code, a title and some textual information.

It is also possible to create hierarchies between *Segments*. Single *Segments* can refer to *Clinical Statements* (e.g., *Observations*, *Meetings* or *Procedures)*, which describe specific types of informational statements within a CP. A *Statement Relation* enables the flexible definition or respective relations or dependencies between single statements. A statement can have a specific owner or *Organizer* that is possibly related to a *Human Resource*.

Basically, the BPMN class *Resource* was specified by the newly added *CP Resource* class and its corresponding sub types (e.g., *Equipment*, *Medicine* or *Room*). Also the *Resource Bundle* class inherits from *Resource* as it can be assigned to *Activities*, for instance. The *Resource Relation* class allows the specification of relations between resource-related elements. Additionally, the specification of *Human Resources* is possible. Particular *Participants* can represent objects of this class.

4.3. Abstract Syntax

The presented CMDE model was translated into a valid BPMN+X meta model by applying a set of transformation rules [42]. Similar to the initial version of BPMN4CP [4], this was accomplished within a generic meta modeling tool in order to define the meta model precisely and enable a straightforward derivation of model instances. With respect to the increased number of extension elements in the current BPMN4CP version and the resulting large extend of the BPMN+X model, we eschew the dedicated representation of the entire BPMN+X model.

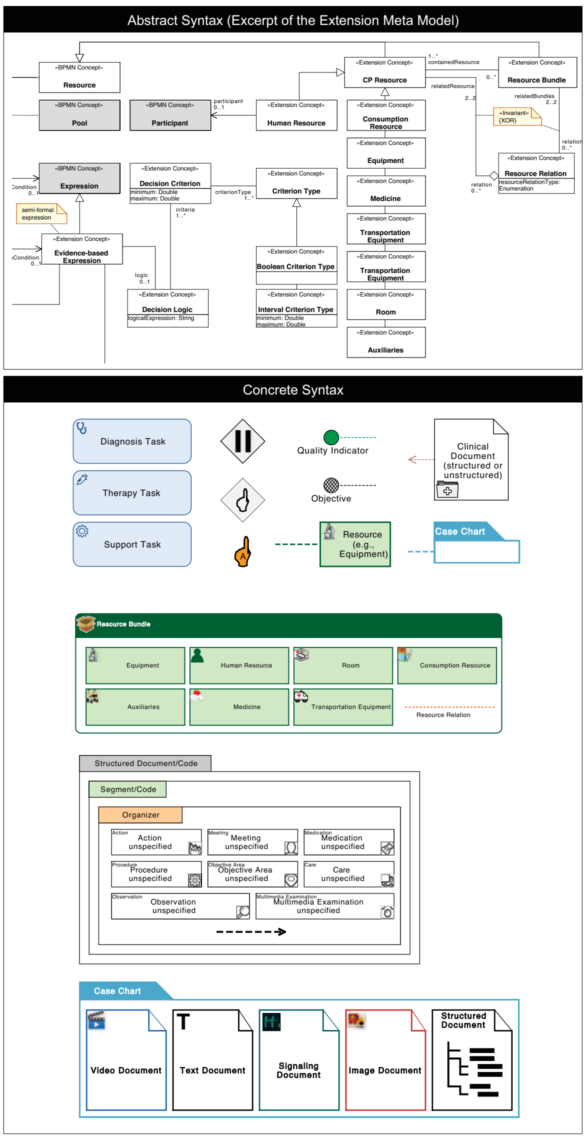

Figure 4. Parts of the extension syntax

However, the definition of the new *Resource Diagram* and *Document Diagram* should be emphasized, since both the BPMN specification and the procedure model of Stroppi et al. (2011) do not provide any advice on that (cf. [9]). As already stated, we made use of the *BPMN Diagram* class in order to add new diagrams to the BPMN meta model. Thus, the added diagrams are instances of that class and all containing graphical elements are instances of *BPMNPlane*, *BPMNShape*, *BPMNEdge* and so on.

4.4. Concrete Syntax

The concrete syntax of the developed extension is presented in Figure 4. Within the BPMN collaboration diagram, the *Task* class is specified with new markers for representing particular task types from the CP domain. A *Clinical Document* is depicted as specified *Data Object* with an icon on the left side that reflects the selected document type of the element. Further, the graphical representations of the *Simultan Parallel Gateway* and the *Evidence-based Gateway* are provided [4]. An *Evidence Indicator* is depicted as orange hand containing the respective level of evidence. *Quality Indicators* and *Objectives* are designed as labeled circles that can be annotated to corresponding elements. *Case Charts* and *Resources* are depicted in the same style as they are represented in their in-detail diagrams in order to enhance recognition and integration.

A *Resource Diagram* mainly consists of different *Resource Bundles*, which are composed of single *Resources* in its inner shape. An appropriate marker icon on the left top of the element specifies each resource type. The labeled *Resource Relation* can connect single *Resources*. The *Document Diagram* has two main features. First, it provides capabilities for the representation of *Case Charts* and its containing elements. Second, it is possible to specify *Structured Documents* graphically by nesting its *Segments* and *Clinical Statements* such as *Observations*.

5. Demonstration: Stroke Case

The term *stroke* covers several different cerebrovascular diseases (e.g., cerebral infarction). These diseases have a significant impact on the national economy (cf. [26]) and drastic effects to the life of the patient. Subsequent to the insult a complex therapy and extensive rehab measures, coordinated by a case management, are necessary to improve the patients' quality of life. A case manager leads the case management. A neurologist usually carries out the treatment of the stroke patient. Owing to comorbidities that were previously present or resulting from the stroke, an interdisciplinary therapy is often required. Due to this interdisciplinary treatment, it is reasonable to coordinate the disease in an integrated care network. CPs are helpful to describe and manage cross-departmental treatment processes [14].

The CP section given in Figure 5 illustrates the follow up treatment process for stroke patient that is used in the *Stroke Network of Eastern Saxony*. The Stroke Network was founded to assure a fast decision-making, to improve stroke care, and to provide expert diagnosis in the rural region. At present almost all regular hospitals of the regions are a member of the network. The core of the network is telemedical system, which allows stroke experts of the University Hospital Dresden assisting the acute treatment in smaller hospitals. Currently, this system is extended by ICT supported pathway, which should help case managers to monitor the patient in outpatient treatment stage, especially during the rehab phase. Foundations of the task management are CPs, which are specified in a business model. The CP model acts as a planning and controlling instrumentation for the health care professionals as well as a tool for the coordination and documentation of the treatment. Beside the process-oriented information, the model moreover contains connections to involved participants, necessary documents, physical resources, time-constraints and quality indicators.

The process in Figure 5 starts with the first contact between stroke patients and the case manager, which should be conducted within the first two days after insult. Within the first three days the patient has to be included in the case management program. Therefore, the case manager conducts an initial admission interview. The results of the admission are documented to assessment document and the declaration of consent is stored too. Afterwards, he checks whether the cognitive assessment, called MOCA test, is already carried out. If it is missing, the test will be requested. In the next step, the decision for the kind of rehab has to be done. Depending on the seriousness of the case, it is differed between no rehab, inpatient rehab or outpatient rehab. If the rehab is planed, the case manager prepares the application and monitors this according cost absorption, time schedule and others. All patients get an individual stroke case chart, in which all treatments, observations and administrative aspect are documented. The stroke case chart is also used to attend the patient in rehab.

6. Conclusion and Further Research

This research article is a revision of our first approach that adapts BPMN to CP modeling. We

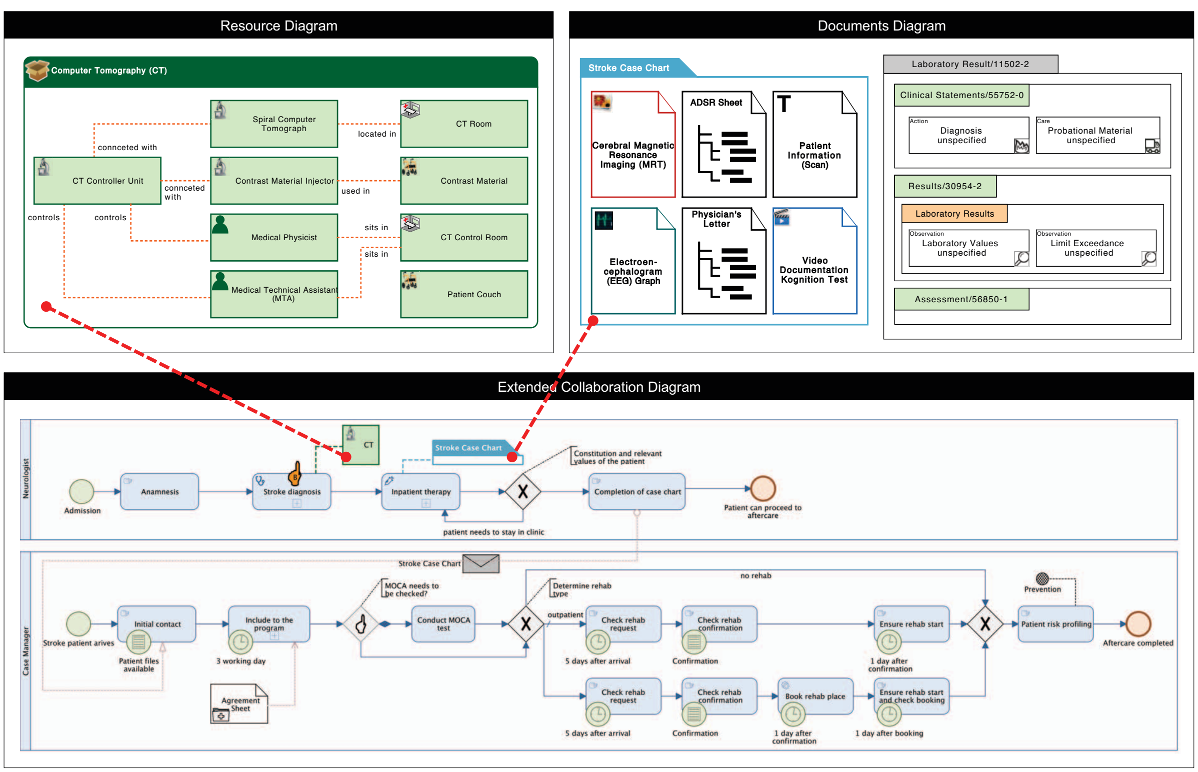

Figure 5. BPMN4CP demonstration model presenting parts of a (simplified) stroke CP as well as required resources and documents, which are described in separate diagrams

found that BPMN covers a lot of requirements from the CP domain but lacks in representing special restrictions and CP-related resources and documents. Hence, we have designed a revision of our previously introduced BPMN4CP extension based on our proposed BPMN extension method, which serves as integration and extension of existing approaches.

The contributions of this research article are as follows: Firstly, we provide a valid BPMN extension for CPs that can be applied by domain experts or customized by model engineers. The extension explicitly provides separate diagrams for resources and documents in order to enable stakeholder-specific perspectives for complexity reduction. Secondly, we also provide an extended CP domain ontology that can be reused or adapted for various purposes, not limited to the field of conceptual modeling. Thirdly, the article provides theoretical implications in the field of domain-specific method engineering by introducing an integrated extension method for BPMN, which is grounded on a comprehensive set of requirements [8]. The underlying requirement types clearly explicate the features of the aimed artifact and facilitate both distinctions from previous artifact versions as well as the derivation of design tasks. The proposed extension method may enhance domain understanding in extension design and can support a straightforward development.

There remain some aspects for further research: For instance, we have identified problems in modeling role across (shared) activities. In BPMN, exactly one task performer executes a specific task. However, in healthcare often more than one performer (e.g., several physicians) are required for task completion (see also [27]). It should be investigated, whether the BPMN semantics should be slightly adjusted regarding this issue. Generally, further investigation in the field of conceptual modeling in healthcare is required, as medical processes have a high potential of deviation during process run-time, while traditional business processes have a higher degree of standardization and repeatability. A promising approach addressing this issue is the recently published Case Management Model And Notation (CMMN) [28], which focuses on modeling processes that can react ad-hoc on changing (case-specific) conditions. Finally, research on extension methods and dialect building in general seems to be necessary due to the perceived need for language adaptation (e.g., for BPMN [3]).

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