

Analyzing Model Element Labels of BPMN Diagrams Provided on the Web

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Abstract— The Business Process Model and Notation (BPMN) is the de-facto standard for process modeling. It provides four types of diagrams to cover different aspects of process modeling, ranging from process specifications itself to the specification of the interactions between the involved participants at different level of abstractions. These different types of Diagrams are Process Diagram, Collaboration Diagram, Choreography Diagram and Conversation Diagram. For all BPMN models of any of these diagram types, it is important that they are understandable to all stakeholders. The Web provides many examples of these different diagrams types. Enterprises and consultants, who offer technical solutions (i.e., BPMN tools) or consulting services for BPMN, provide these examples. Since such models are provided on the Web as introductory learning examples, such examples can also influence novice BPMN modelers. Therefore, it is worth to examine if such examples have the same quality standards as suggested in the literature. This paper, therefore, focuses on the analysis of such BPMN examples. Particularly, it focuses on the labels of model elements, since these labels represent the relationship between a BPMN model and a certain domain. Hence, this paper shows results of the analysis of model element labels that appear in Process Diagrams Collaboration Diagrams, Choreography Diagram and Conversation Diagrams.

Keywords— Business Process Model and Notation (BPMN); Labels of Model Elements; Collaboration Diagrams; Choreography Diagrams; Conversation Diagrams

I. INTRODUCTION

As an extension to [1], this paper discusses the labels of additional Business Process Model and Notation diagrams and their model elements. The Business Process Model and Notation (BPMN) is the de-facto modeling language standard for documenting processes. For the list of model elements of BPMN, see e.g., the BPMN poster on the Web [2]. In BPMN, four different diagram types exist [3]. The most used type of diagram is the Process Diagram. It specifies the details of a single process. The other types of diagrams are Collaboration Diagram, Choreography Diagram and Conversation Diagram. With these four diagrams, a modeler can model different aspects. This ranges from the modeling of interaction of participating systems to the detailed description of the process within one of the participating systems. Even the Process Diagram itself is intended for both high-level organizational processes and lower level processes that a workflow engine can execute. A good analysis and documentation is necessary in order to

understand the internal behavior of a system like an enterprise, its interaction to other participants (e.g., customers or suppliers) and to implement process automation well.

For a good documentation of all aspect of process modeling, which is understandable by all stakeholders, skills in modeling with BPMN are very relevant. Today, reading books about BPMN or visiting BPMN courses are not the only ways to obtain these skills. Instead, it is often much easier and cheaper to click through the Web, looking and reading the diagrams, as well as the enclosed explanations. Thus, Web examples can be taken as surrogates for examples in professional literature (e.g., specialist books). Actually, the BPMN and Business Process Management (BPM) community (e.g., tool providers and consultants) also have the aim to present BPMN examples on the Web to give either an introduction of the tool features for BPMN modeling or to show modelers how these diagrams look like and how they should be modelled. Hence, a look at such Web examples and their quality for being a standard for novice modelers can be useful.

There are different aspects of how modeling quality can be defined (e.g., syntactical correctness; adequate drawing of models; adequate color and shape of model elements; adequate labels of model elements, etc.).

This work focuses on the labels of model elements. Whereas the previous work [1] focused on important model elements of Process Diagrams only, this extended version also considers the labeling styles of the three other types of BPMN diagrams. Labels on model elements (e.g., “send application” as a label example of a BPMN Activity) are important since they relate the model to the observed reality. They represent the semantic bearing parts of a domain giving the model elements and thus the whole BPMN model a certain meaning in a specific domain. Therefore, if the labels are not well chosen, a model can be more confusing than understandable and this can lead to a wrong interpretation of models. Unfortunately, if modeling tools would analyze such labels, they will not be able to give exact results if a label is correct or not. The reason is obvious. Natural language labels do not follow those strict syntactic patterns like the model elements in an artificial modeling language like BPMN. Furthermore, there are many natural languages. A certain syntactic pattern that makes up a good labeling style in English must not necessarily be applicable in another language. Therefore, tools can only make suggestions. However, if these tool suggestions do not fit with introductory learning examples (e.g., taken from the Web), they will be worth for nothing. Hence, such learning

examples are still important and the labeling style therefore has to be carefully chosen by the creators of such examples.

While labeling guidelines already exist in literature for the important model elements of Process Diagrams, no quality guidelines exist for the other three types of diagrams. However, the model elements introduced in these diagrams have a purpose. Therefore, it can be assumed that this restricts and determines the way these elements are labeled. Additionally, these new model elements are derived from model elements, which already exist in Process Diagrams. In this latter case, it can be assumed that the kind of label is oriented on the label of the model element, from which this new element is derived.

The goals of this work, therefore, are twofold. For Process Models the goals are the following:

- Check if the introductory learning examples for Process Models provided on the Web by BPMN experts (e.g., enterprises that offer BPMN tools and consultants offering consulting services) follow the label quality guidelines mentioned in literature.
- Examine if in these examples, the labels are at least well chosen. That means: Even if the labels do not exactly match the guidelines, nevertheless, they make sense in a specific context. In order to answer this, the analysis of the examples on the Web has been done on a sample extracted from the Web.

For Collaboration Diagrams, Choreography Diagrams and Conversation Diagram, the goals of this paper are the following:

- Check if the new model elements introduced in these three additional diagrams follow the assumptions mentioned above regarding to their labeling styles.
- Check if the labeling styles of model elements, which both can be modelled in Process Diagrams and the other three diagrams stay the same.

Therefore, the paper is structured as follows. In Section II, an overview of related work is given and labeling styles together with literature recommendations of good labeling styles are presented. Section III describes the preparation of the sample of Web examples for this work. Section IV focuses on the labels of model elements for BPMN Process Diagrams. It describes, which kinds of labels are used and compares these labels with labeling style recommendations in literature. Section V focuses on the three additional types of BPMN diagrams (Collaboration Diagram, Choreography Diagram and Conversation Diagram). It discusses the labels used in the model elements of these diagrams. The paper is summarized in Section VI.

II. RELATED WORK

All aspects of the quality of process models are in the focus of the research community. In [4] the visual notations of model elements in any conceptual modeling language are examined. The author discusses the influence of this visual notation on the good or bad readability of conceptual models. Issues of deficiencies in BPMN are stated in [5] and [6]. In [7] and [8], the authors focus on the quality of BPMN

models. A literature survey about business process modeling quality is given in [9]. Seven guidelines for process modeling are proposed and verified with user studies in [10]. The research in [11] focuses on the modeling language part of BPMN for describing Choreographies. The authors introduce a quality framework for checking the quality of this BPMN language part.

Some researchers have thought about automating the labeling process of business process modeling and aggregation of process models to support the comprehension of such process models [12] [13]. It was even analyzed how the style, color and arrangement of label parts on a model element improves readability [14] [15].

A. Related Work with respect to Labels of Model Elements

More detailed work on labels of BPMN model elements itself was done in [16] - [18]. These research works are based on data sets of process models from industry. Good labeling styles of Activities, Events and Gateways for three different natural languages were proposed and recommended in [16]. There, violations of these labeling styles are described. Table I gives an overview of the labeling styles, which will be discussed in detail afterwards.

TABLE I: OVERVIEW OF LABELING STYLES

Model element category	Labeling style
Activity	<ul style="list-style-type: none"> • Verb Object Style • Action Noun Style • Descriptive
Gateway	<ul style="list-style-type: none"> • Question with Noun and Verb in Past Participle • Infinitive Verb Question • Object with Adjective Question • Equation Question
Event	<ul style="list-style-type: none"> • Verb in Past Participle Style • Predicative Adjective Style • Categorization Style

Activities subsume Sub Processes, Tasks and Call Activities. In all cases, the working step within a process, are described. For the labels of Activities, the following styles were found in this literature:

- *Verb Object Style*: A label that starts with a verb expressing the activity followed by an object, on which this activity is executed (e.g., “create document”).
- *Action Noun Style*: This style has three sub styles: a) A label that has either a nominalized verb only or a compound noun consisting of a verb as the head of this compound noun (e.g., “creation”, “document creation”). b) The Noun can also be a noun phrase with the preposition “of” in between (e.g., “creation of document”). c) Finally, the *Action Noun Style* can also start with a gerund followed by a noun (e.g., “creating document”).

- The style called *Descriptive* is a style consisting of a subject, a verb in third person singular and an object (e.g., “author writes book”).

Beside this, there are also labels that do not follow a good style at all. These are labels with nouns only and no verbs at all (e.g., “error”). According to literature [17], the *Verb Object Style* is the most recommended style that should be used for modeling Activities.

With Gateways, a workflow can be divided into several paths, but different paths can also be merged. Most recommended Gateway labeling styles in literature have in common that they should end with a question mark (“?”). Thus, the literature assumes that these kinds of styles are mainly used for Exclusive (XOR) and Inclusive (OR) Gateways since in these Gateways a decision is made, which can be expressed as a question. On contrary, a Parallel (AND) Gateway does not need such a label since no decision is made. Such questions in Gateway labels can be expressed in one of the following styles:

- *Question with Noun and Verb in Past Participle* (e.g., “document created?”)
- *Infinitive Verb Question* (e.g., “approve contract?”)
- *Object with Adjective Question*: A phrase consisting of an object followed by an adjective or an auxiliary and an adjective (e.g., “parts available?” or “parts are available?”)
- *Equation Question*: A phrase consisting of an object followed by a logical operator and a value (e.g., “amount is greater than \$ 200”).

A counter example for good quality again is a noun only (e.g., “result?”). It is not possible to derive a clear decision from such a kind of label. For Gateways, the most recommended labeling style is *Question with Noun and Verb in Past Participle* [17].

Finally, events that can occur within a process are modelled with the model element Event.

Labeling styles for Events can be classified as followed:

- *Verb in Past Participle Style*: This can be characterized by an object followed by a verb in past participle or followed by a (modal) auxiliary and a verb in past participle (e.g., “document created”, “document has been created”, “document is created”, “document must be created”)
- *Predicative Adjective Style*: Here, a noun together with a predicative adjective is used to label an Event (e.g., “document correct” or “document is correct”).
- *Categorization Style*: Two nouns are related with a verb (mainly the verb “is”) in order to express that the term specified with the first noun can be categorized according to the term expressed with the second noun (e.g., “person is author”).

Modelers also use labels that better should not be used for Events at all, since they do not provide sufficient information to a reader. For instance, they use a noun only (e.g., “inquiry”). The *Verb in Past Participle Style* is the one, which is most recommended as a labeling style for Events [17].

Beside simple labels, it has also been examined in

literature that modelers use complex phrases and sentences for Activity labels instead of drawing more model elements with simpler, so called canonical labels. Especially in [18], these kinds of inconsistent use of labeling, so called non-canonical patterns, are examined. Three categories of complex, non-canonical label patterns were detected:

- *Complex control flow label*: The label of an Activity consists of a sequence of verbs, each describing an Activity, which are concatenated with “or” or “and”. This verb sequence, however, implicitly expresses a decision (in the case of “or”) or a parallel respectively a sequential execution of several Activities (in the case of “and”). It does not express an atomic working step. Thus, instead of one Activity with a complex label, several Activities with simpler labels together with control flows can also be used. Other complex labels of that kind are phrases, which end with “as required”, “as / if needed”, as well as sentences or phrases expressing an iteration (e.g., “while ...”, “repeat until ...”, “for each ...”).
- *Extra specification of data, resources and time*: In this category, the label of the model element not only contains the necessary information, but also additional information that is often given in some sorts of brackets (e.g., “clear differences (inventory management)”). Most often, either this extra information should be itself explicitly modelled with a model element like an Event, Activity or Gateway or this extra information is useless.
- *Implicit Action and Decision*: Here, the label and the model element do not fit. For instance, the label of an Activity is expressed in terms of a pattern that is typically used for an Event (e.g., “order received” instead of “receive order”).

In literature, these categories of non-canonical labels are seen as patterns that can confuse the reader of a model.

The guidelines for labeling discussed in literature are focusing on model elements for Process Models. No explicit guidelines exist for typical model elements of Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams. However, the model elements of these three Diagrams have either a very specific purpose (e.g., Pools, Lanes) or the model elements of these Diagrams can be derived from model elements that already exist in Process Diagrams. If model elements have a specific purpose, then this can restrict the way in which they can be labeled. If they can be derived from model elements that already exist in Process Diagrams then also the labeling styles and guidelines of the existing model elements can be applied to these “new” model elements (e.g., model elements of Choreography and Conversation Diagrams).

B. Focus of this Work with respect to Related Work

In this work, the labels of the model elements are also examined. For analyzing the labels of model elements in Process Diagrams, this work does not only consider Activities, Gateways and Events as such, but also explores different types of Activities, Gateways and Events in detail.

In addition to previous work in the related literature about labeling guidelines for Process Diagrams model elements, the main emphasis of this work can be characterized as follows: Instead of working with data sets from industry, the aim of this paper is to look for BPMN examples on the Web. Existing results of labeling guidelines in literature are taken as a reference. With this as a basis, the Web examples are examined and compared with the given guidelines.

Furthermore, the focus is not only on model elements of Process Diagrams as in previous literature. In addition, it also focuses on the label analysis of new model elements, which appear in Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams. Once again, the Web was taken as a resource for analyzing the modelled examples of these diagrams.

III. PREPARATION OF THE WORK

In order to check how different enterprises, which sell BPMN modelling tools, as well as consultants, provide BPMN diagram examples, the following procedure was executed to get the sample.

For Process Diagrams, in the first step, the search term “BPMN” was entered into the search field of Google. This search engine was used as a means to choose the sample. In order to get diagrams first and not descriptions of BPMN, the image result list of the search engine was used. Here, it was expected to get various images of BPMN diagram examples. Once the search engine generated the list of diagrams, in the second step the list was manually examined. For each image, it was first decided if this image is really a BPMN diagram example in English provided at a Web site or if it is not. If it was indeed such a diagram, then the link to the respective Web site, from which the search engine listed the image, was collected. For this purpose, the link was entered into a file in order to generate a list of Uniform Resource Locator (URL) links. At the end of this URL collection step, a list of URL links, each containing at least one image of a BPMN diagram was collected in the file. In the third step, the file with these links was further examined. For doing this, the file with the URL link list was automatically scanned and each link was grouped to a Web domain.

In the fourth step, each link, as well as the additional link to the more general Web domain, was once again further examined. From all these sources, images of BPMN Process Diagram examples were downloaded and collected on the local file system. The aim of this fourth step was to find more BPMN images provided at this Web domain. Much more images were found and collected.

In the fifth step, all these collected images were manually examined and the individual BPMN model elements together with their features and labels for each diagram and domain were transcribed into a database. This data set was then analyzed according to the aim of this work.

In total, 43 Web domains and the BPMN 2.0 by Example document of Object Management Group (OMG) [19] were examined. The BPMN 2.0 by Example document was included, since this is also an important information resource about BPMN on the Web. During this collection phase, images, which were not readable, were filtered out. Images

that are used as BPMN counter examples (i.e., how a BPMN diagram should not be modeled) were filtered out too, since the focus is on models that are seen as correct by the provider. The remaining examples, which in total are 346 diagram images of BPMN model examples were used for this work. Furthermore, only distinct labels were analyzed. This should avoid that a certain labeling style appears too often just because the same label (e.g., “order product”) is used in many examples.

For Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams in the first step the names of these Diagrams were explicitly entered into the search text field of the search engine in order to prevent results that show Process Diagrams only. Once again, the image result list was examined. Since there were not so many of these diagrams found on the Web, the rest of the collection and analysis procedure was done manually. Once the diagrams were collected, the labels of the model elements on each of diagrams were examined. Particularly, the labels were checked if there are any modeling preferences regarding a certain given labeling style. Once again, only distinct labels were analyzed.

IV. PROCESS DIAGRAM

The BPMN Process Diagram is the most used type of the four BPMN diagrams. A BPMN Process Diagram specifies the flow of the working steps for processes that usually appear in enterprises in order to produce a value (e.g., a product or a service). However, it also can be used to model any kinds of processes. For example, computer-supported parts of processes (workflows) can also be modeled with this diagram. Therefore, it is obvious that this type of diagram is very important. Figure 1 shows an excerpt of such a diagram. Here, the first two possible steps in the process of how to write a thesis are specified.

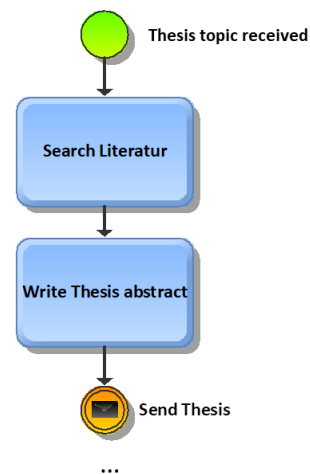


Figure 1. Excerpt of Process Diagram

In the Subsections A to D, the analyzed distinct labels of important kinds of model elements specified in Process Diagram examples on the Web are introduced and discussed. They are discussed with respect to the recommendations in

literature mentioned in Section II. These model elements have the characteristics that

- quality guidelines already exist in literature and
- they appear in nearly every introductory example of a Process Diagram.

Especially, this holds for Tasks as a subset of Activity and Events. Gateways on the other hand have to be used as soon as a process model does not have only a single sequence, but the specified process in the process model branches to several paths. Thus, in most process models, except the most trivial ones, Gateways are important. Furthermore, these labels are analyzed in detail according to the specific model element, since for different model elements different labeling strategies are needed. In addition to these more important types of model elements, also model elements of minor importance will be discussed in Subsection E. However, since these types of model elements in Subsection E do not play an important role, no labeling quality guidelines exist, to which the label of these model elements can be compared.

A. Labels of Activities

As mentioned in Section II, Activities are the working parts in a process. Activities can be divided into the following categories: Task, Sub Process and Call Activity.

A Task is a single atomic working step of someone or something within the process. It is atomic since it cannot be split into smaller pieces. The OMG BPMN specification lists the following Task types: Task with no specific type (untyped Task), Send Task, Receive Task, User Task, Manual Task, Script Task, Service Task and Business Rule Task (see Figure 2 for the graphical notations).



Figure 2. Task types in BPMN

These Task types have different meanings. For instance, a User Task is a Task, where a human performs this Task with the assistance of a software application. A Manual Task is a task that is also done by a human but without any assistance of a software application. A modeler can model a task as a Send Task, if during this Task any kind of information or thing is send. S/he can model a Task as a Receive Task if any kind of information or thing is received within the process. The Script Task executes predefined scripts. In a Service Task, a predefined business logic is executed. In a Business Rule Task, predefined decisions are made. If the modeler do not want to give the modeled Task a certain semantic, then s/he models an untyped Task. After the examination of Process Diagrams, it turned out that the untyped Task was the dominating task type. About two third

of all tasks were untyped Tasks. The next frequent Task was the User Task. About a fifth of all the Tasks were User Tasks. The rest were Service Tasks, Manual Tasks, Send Tasks, Receive Tasks and Script Tasks. Business Rule Tasks appear very seldom in the sample.

Sub Processes are parts in a process, which can be splitted into smaller pieces. These pieces can be itself Tasks or Sub Processes. Hence, Sub Processes represent processes within the whole process. They establish a nested hierarchy of working parts. Sub Processes can be divided into the following categories according to the OMG: Untyped Sub Process, Event Sub Process, Transaction or Ad hoc Sub Process. Figure 3 shows the graphical notations of the different types of Sub processes.

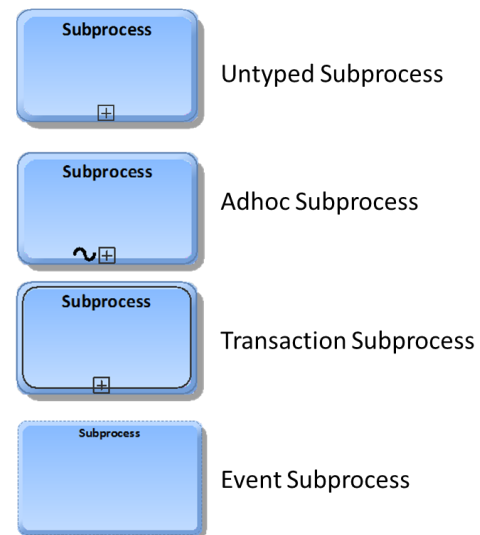


Figure 3. Sub Process types in BPMN

An Event Sub Process is a Sub Process that is triggered by Events. A Transaction Sub Process is a process that must reach a consistent state. In an Ad-hoc Sub Process the parts of it (i.e., Tasks, other Sub Processes) do not have a causal dependency on each other. They can even be executed in parallel. Once again, if the modeler do not want to specify the specific category of a Sub Process, then s/he uses the untyped Sub Process.

In the given sample, this untyped Sub Process is the category that is mostly used. More than 80 % of all modeled Sub Processes are untyped Sub Processes.

Finally, a Call Activity (see Figure 4 for the graphical notation) refers to a Sub Process that is globally specified once, instead of directly embedded into the overall process.

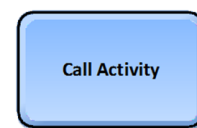


Figure 4. Call Activity

To summarize, Activities represent those parts of a process where somebody or something should act in order to progress the process. Therefore, an active verb, which is the best word category for acting, should be used to label these model elements. In literature, the *Verb Object Style* is preferred. An object itself can be a noun (simple ore compound) or a noun phrase.

In the sample, 944 distinct Task labels were found. The majority of these distinct Task labels (75 %), , follow this *Verb Object Style*, where the object is a noun and the direct object of the verb (e.g., “specify vacancy”, “ship item”, “review results”). In some cases, an article is added (e.g., ”select a pizza”). Only in 2 % of all cases, a single verb or a verb together with an adverb is the only label for a Task (e.g., “publish”, “rate negatively”). In 13 % of the cases, the Task labels extend the suggested *Verb Object Style* a little bit. In these labels, the object is a noun phrase (e.g., “nomination form” in “send nomination form”). In addition, cases were found, where the object is an indirect object (e.g., “communicate to customer”) or there are two objects (direct and indirect object) following the verb (e.g., “deliver books to customer”). In 10 % of the Task labels, the modeler used other labeling styles for Tasks. For instance:

- They used nominalization of a verb (e.g., “delivery”).
- They used full sentences (e.g., “why have you bought so many sticks of sausage?”).
- They concatenated verbs (e.g., “add paperwork and move package to pick area”).
- They used a condition phrase (“check if extra insurance is necessary”).

To summarize, the *Verb Object Style* preferred in literature is also used in the majority of cases on the Web (see Figure 5).

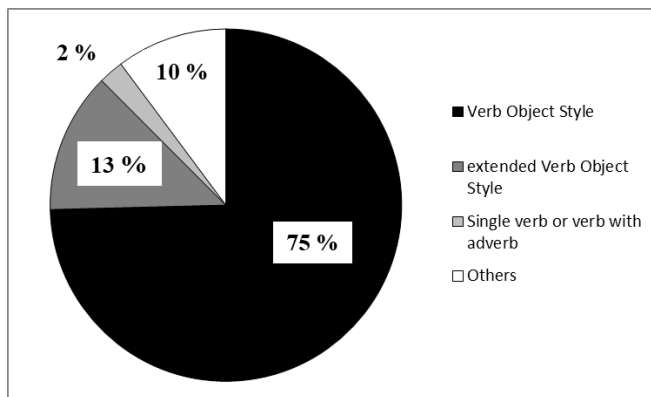


Figure 5. Percentage of Task labeling styles.

For Sub Processes, the situation is as follows: From the 85 distinct labels of normal Sub Processes, 42 % have a nominalization of the verb (e.g., “ordering”, “creation”) as their label (i.e., *Action Noun Style*). In 55 % of the cases, Sub Processes follow the *Verb Object Style*. Either the rest does not have a label or it is a complex sentence (e.g., “send out

application forms & reminders”). Hence, no definite labeling preference can be found in these examples from the Web.

There are not enough Event Sub Processes and Transactions in the sample. Therefore, here it is hard to make a good proposition. In these few examples, the labels follow the *Verb Object Style*. There are also not so many Call Activities in order to make a proposition. Therefore, it can only be observed here that modelers prefer the *Action Noun Style* instead of the *Verb Object Style*.

B. Relationships between Labels and Specific Task Types

Since about a fifth of all modeled Tasks are modeled as User Tasks, it is interesting to see, what is modeled as a User Task. Especially, it is interesting to see, what is modeled as a User Task in comparison to what is modeled as a Manual Task. Therefore, the labels of the two Tasks are further analyzed.

From the point of view of the BPMN specification [20], there is a clear distinction between a User Task and a Manual Task. A person performs a User Task but a software application assists this person. A Manual Task is also performed by a person, but without assistance of a software application system.

It could be expected that labels for Tasks that represent a software application support differ from the labels of Manual Tasks. However, according to the labels it is not always possible to differentiate between a User Task and a Manual Task. Of course, labels with a verb were found that fit with the purpose of a User Task (e.g., “edit 1st level ticket”, “fill in purchase form”, “book flight”, “find student’s position”). On the other hand also labels were found, which do not perfectly fit with the purpose of a User Task (e.g., “hire staff”, “plan interview”, “read book”, “rent office”, “ship book”, “train new employee on job specifics”, “discuss nominations”, “announce Nobel prices laureate”, etc.). The labels for User Tasks and Manual Tasks are set arbitrarily. One interpretation can be that it is the modelers decision to see something as a Manual Task (without software application support) or a User Task (with software application support) and it depends on the purpose of the model (i.e., whether it is a workflow model or not). Particularly, a User Task can be more than a simple user interaction with the Information System. Thus, if a workflow for a workflow engine is specified with BPMN then it seems that every Manual Task can also become a User Task. A second interpretation can be that modelers of these introductory learning examples do not really want to distinguish between User Tasks and Manual Tasks at all. Therefore, they prefer to model a User Task even in a situation where a Manual Task would be the right choice.

The frequency of other task types is very low and, except for Send Tasks, no relationship between labels and these Task types were found. For the 38 distinct labels of Send Tasks, in this sample it turned out that 53 % of the distinct Send Task labels start with the verb “send”. Further, 26 % have a verb like “email”, “inform”, “notify”, “distribute”, “post”, “submit”, “order”. All these other label examples can be seen as variants of sending. Thus, it can be concluded that

labels of a Send Task are in accordance with the purpose of this Task type.

C. Labels of Events

The next important model element of BPMN is the Event. BPMN distinguishes between the following categories: Events that start a process (Start Event), Events that finish a process (End Event) and Events that can happen during process execution (Intermediate Event). There is also a special type of Event, which can be placed on the boundary of an Activity (Boundary Event). Furthermore, in each of these categories an Event can have different types. Some of these types are untyped Event, Message Event, Timer Event, Error Event and Conditional Event. If the modeler do not want to model a specific type of Event, then s/he models an untyped Event. Finally, for some of the specific Event types, it can be distinguished whether an Event is triggered (throwing Event) or an Event is received (catching Event). The semantic of a certain Event depends on the combination of the aforementioned category, type and if it is a throwing or catching Event. For instance, an Intermediate catching Message Event means that within a process, the process execution waits until the process receives a message, an information or thing. After it has been received, the process continues. A throwing Intermediate Message Event means that at a certain state in the process, a message, information or thing is sent to a recipient that has to catch this message information or thing respectively. Immediately after sending it, the process execution continues with the next process step. With a Timer Event, anything that is related to time (e.g., a certain point in time, a duration etc.) can be specified. For more explanations of the different meanings of Events, the reader is referred to the OMG BPMN specification [19] [20]. Figure 6 shows some Events. This list however is not complete since there are many other types of Events, which can occur in the combination of a Start- Intermediate- or End Event and whether they are catching or throwing. For a detailed list, the reader is referred to [2].

Start Event	Intermediate Event	End Event
untyped	untyped	untyped
Message (catching)	Message (catching)	Terminate
Timer	Timer	Message (throwing)
Condition (catching)	Message (throwing)	Error (throwing)

Figure 6. An excerpt of Event categories and types

When talking about labels on Events, firstly, it has to be examined if Events have labels. While BPMN modelers always give labels for Tasks, they are not so systematic if they have to specify labels for Events. From all the Start Events found in the diagrams of the sample, 46 % do not have a label. From these, most of the Events (86 %) are untyped Events (i.e., Events that are not further classified to a specific type). However, a few cases were also found with

Link Events, Message Events and Signal Events that have no labels. For Intermediate Events, fewer cases with no labels exist. Only in 14 % of all Intermediate Events, no labels were detected. Particularly, the Intermediate Timer Event and Message Event are those types with no labels. These two Event types also had a high frequency within the Intermediate Events types. There are 38 % of all Boundary Events, which do not have a label. There are 56 % of all End Events, which do not have a label. From these End Events with no label, 81 % are untyped Events.

To summarize this, for the examples provided on the Web, the modelers responsible for these examples especially do not see the necessity to label Start and End Events. Particularly, this happened if these Start and End Events are untyped Events. Unlabeled model elements, however, cannot be understood well. If novice process modelers see such unlabeled model element examples on the Web, they might take it as a standard although they should avoided it.

After the examination of Events with no labels, it is interesting to see what kind of labels Events have. It is expected that specific Event types have specific types of labels. For example, Message Events and Timer Events are labelled in different ways. For this analysis, six Event types were further examined, since these Event types cover 87 % of all Event types in the sample. These Event types are: Timer Event, Message Event, Signal Event, Compensation Event, Terminate End Event and the untyped Event.

All labels of the Timer Event have, of course, in common that they specify time. However, this is done in various ways. Table II presents a list of representative Timer Event labels. In this list, the grouping of the individual labels, suggests label patterns of similar structure.

From the examples, it can be seen that they are not in accordance with the Event labeling style recommended in literature (*Verb in Past Participle Style*). Nevertheless, in the context of a Timer Event, many of these labels are appropriate.

TABLE II. TYPICAL LABELS OF TIMER EVENTS

<ul style="list-style-type: none"> • wait until next business day • 24h; 10 min; 60 minutes; one week; 2 weeks; 24 hours; 14 days; 48-hours • september year n-1 • wait 6 days; wait some time; wait until thursday, 9am • 1st day of month; 20th of each month • 3 business days • friday at 6 pm pacific time; friday, 6 pm pacific time 	<ul style="list-style-type: none"> • timeout; time out (1 week); order timed out • content expired (5 days) • delay 6 days; delay 6 days from announcement • < 60 min; > 60 min • expires at set deadline • auction over • 10 min wait • 12 o'clock • start time; finish time • on next Wednesday • start on Friday • every 10 minuts; every 24 hours
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For a Message Event, it has to be distinguished between a throwing Message Event and a catching Message Event. Usually, it could be expected that a catching Message Event follows the *Verb in Past Participle Style*. However, the found catching Message Events have a greater variety. Beside the typical *Verb in Past Participle Style*, also catching Message Events were found that consists of

- a noun (compound noun) or noun phrase only (e.g., “payment”, “complaints to customer service”)
- a complete sentence (e.g., “where is my pizza”)
- a verb in past participle only (e.g., “paid”).
- a noun with an adjective (e.g., “assignment complete”)

Unfortunately, not so much throwing Message Events were found. Most of these throwing Message Events had no labels at all. Based on the remaining throwing Message Events with labels, it can be said that throwing Message Events use the *Verb Object Style* as it is usual in Task labels. Since a throwing Message Event can be used as an alternative for a Send Task, this labeling style is adequate. The literature recommends the *Verb in Past Participle Style* for an Event but does not consider the specific type of Event.

The found Signal Events (catching or throwing) follow the *Verb in Past Participle Style* to a large extent. Beside this, the following interesting label examples were also found: “on alert”, “undeliverable”. According to literature, these examples would be out of the scope of the recommendations.

Many of the Compensation Events do not have a label. Those that have a label, mainly follow the *Verb Object Style* (e.g., “cancel reservation”, “undo book travel”). Many of these labelled Compensation Events are throwing Events. Once again, this is out of scope of the recommendation in the literature, which in general prefers the *Verb in Past Participle Style* for Events. However, in this special case of throwing Events, which rather express an active action than a passive reaction, the *Verb Object Style* makes sense.

Most of the Terminate End Events do not have a label. The few remaining Terminate End Events with labels follow the *Verb in Past Participle Style* or just have the label “terminate” or “end”, respectively.

The analysis of untyped Events is split into the analysis of Intermediate Events, Start Events and End Events. Untyped Boundary Events with labels do not appear in the sample. This analysis provides the following results. Untyped Intermediate Events follow the *Verb in Past Participle Style*. The labels of untyped Start Events do not only follow this style. Instead, some of them only have

- a noun, compound noun or noun phrase (e.g., “application”, “existing process”),
- an adjective (e.g., “hungry”)
- phrases starting with an adjective (e.g., “hungry for pizza”),
- simple sentences (e.g., “the store opens”).

The labels of untyped End Events follow the *Verb in Past Participle Style* largely.

D. Labels of Gateways

BPMN distinguishes seven types of gateways: Exclusive (XOR) Gateway, Parallel (AND) Gateway, Inclusive (OR) Gateway, Event-based Gateway, Complex Gateway and two special Gateways that should be modelled at the beginning of a process. Particularly, these are the Exclusive Instantiating Event-based Gateway and the Parallel Instantiating Event-based Gateway. For those types that appear most in the sample, the meaning will be explained. In Figure 7, the graphical notations of the most important types of Gateways are listed.



Figure 7. Most important types of Gateways

In general all gateways control, which of the several branching paths in a process are executed. The Gateways listed in Figure 7 also control how these paths can be merged together in a process. They do it however in different ways. A Parallel (AND) Gateway activates all following paths. This kind of Gateway also waits until all paths are executed if the paths are merged together. Only if all the paths are executed, the process execution after the merge continues. The Exclusive (XOR) Gateway depends on a condition expression. On the basis of the condition, it is decided, which of the several path is executed. Only one of these paths can be executed. During the merging of the paths, the Exclusive (XOR) Gateway just continues the process execution for every paths that was executed before. The Inclusive (OR) Gateway also depends on conditions but a subset of all the several paths and even all the paths can be executed. This depends on the conditions, which become true. During the merging-point the Inclusive (OR) Gateway knows the paths that were executed before and waits until all executed paths are finished before the process continues after the merge-point of an Inclusive (OR) Gateway.

With respect to the analysis of labeling, of course only the Exclusive (XOR) and Inclusive (OR) Gateways were analyzed. It is not necessary to analyze Parallel (AND) Gateways, since in these Gateways all the following branching paths are executed. Therefore, a label that specifies a condition is not necessary. In addition, none of the three Gateways (Parallel, Exclusive, and Inclusive) is analyzed at the merging-point, since they usually also do not have a label. Hence, it is only interesting how the conditions that should appear as labels on Exclusive (XOR) Gateways and Inclusive (OR) Gateways look like.

The labels of these Gateways vary. The style *Question with Noun and Verb in Past Participle* is not the only one. Again, additional patterns exist:

- nouns, compound nouns and noun phrases,
- verbs in past participle only,
- states of an object (i.e., where the state is represented by an adjective or by the word “ok”),
- comparisons with mathematical operators (e.g., “>”, “<”) or with words (e.g., “above”).

What is common to many labels is the character “?” at the end of the label. Many Exclusive Gateways and Inclusive Gateways even do not have a label although they branch the process into two or several paths. Such cases once again can be seen as a contradiction to the recommendations in literature.

Beside the label of the Gateway itself, it is also important to analyze the labels on the Sequence Flows, which leave the Exclusive Gateways and Inclusive Gateways. About a fifth of all these labels are the words “yes” and “no”, respectively. The rest varies. These variations can be seen in Table III, where some of these labels are listed.

TABLE III. LABEL EXAMPLES ON SEQUENCE FLOWS

<ul style="list-style-type: none"> • “1” • “>=20” • “40 % “ • “yes” • “2nd level issue” • “50 % education training” • “all items available” • “allow extension” • “bicycle costs >= 500 usd” • “capacity & parts available” • “capacity not available” 	<ul style="list-style-type: none"> • “capacity ok” • “employee is ready for work” • “fix in release” • “in stock” • “is junk mail” • “no more responses” • “not accepted” • “payment received == false” • “purchase 1” • “put on hold” • “ready with request” • “simple”)
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Process Diagrams intended for workflows also have Gateway labels like “ $\{\text{order.price} \leq 250\}$ ” or “ $\{\text{!approved}\}$ ”.

E. Labels of Data Object, Data Store, Text Annotation

Model elements that play a minor role in Process Diagrams are Data Object, Date Store and Text Annotation. A Data Object is any data that is processed in Activities. If data is taken from a certain storage (e.g., a file or database table), then this can be modeled with the model element Data Store. Finally, if the modeler would like to add any additional textual information to the process model, s/he can do it with the model element Text Annotation. Figure 8 shows the graphical notations of these model elements.

In labels of Data Objects also noun phrases appear. They can be complemented with verbs in participle or adjectives in order to express the state of an object (e.g., “job description”, “job description [endorsed]”). Some modelers extend this verb in participle with brackets. Nouns and noun phrases are the typical labels for Data Stores. Sometimes, the

abbreviation “db” or the word “database” complements the label. Since Text Annotations are just comments or additional information given by the modeler, the modeler can use any phrase or sentences to label a Text Annotation.

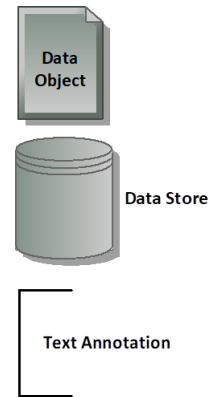


Figure 8. Data Object, Data Store and Text Annotation

V. COLLABORATION DIAGRAM, COREOGRAPHY DIAGRAM AND CONVERSATION DIAGRAM

As already mentioned in the introduction, BPMN offers three additional diagram types. These diagrams types are Collaboration Diagram, Choreography Diagram and Conversation Diagram. The following subsections describe these diagrams. First, the new model elements in these diagrams will be explained. Afterwards, the labels of these model elements will be discussed.

A. Collaboration Diagram

Whereas, a process modeler can specify the flow of activities within a single process, s/he cannot specify how two or more systems interact. Such information is modelled with a Collaboration Diagram. Therefore, the Collaboration Diagram is an extension of a process diagram. For specifying the flow of activities within each of the processes, the same model elements are used (Activity, Event, Gateway). In addition to that, the following new model elements appear in a Collaboration Diagram: Pool, Lane, and Message Flow. A Pool is a system or the role of a system in an interaction scenario that embeds a specific process. For instance, if a modeler wants to specify the surrounding system of a process, which contains this process (i.e., a department, an enterprise, a technical system or role of a system) then s/he uses the model element Pool to model it. If this system is more complex and contains subsystems then these subsystems are modeled using the model element Lane. A typical example of a complex system can be an enterprise, which is modelled as a Pool. If it is necessary to model certain departments of that enterprise, then these departments are modeled as Lanes. In order to specify the interaction between the processes, the Pools can exchange messages. This is modelled with the model element Message Flow. Messages Flows represent simple messages, information exchanges or even material things (e.g., certain products)

Hence, a Message Flow represents anything from a simple information to a more complex domain entity like a product, contract or money that is transferred from one Pool to another. Figure 9 shows two Pools exchanging Messages. In this example, the Pools are collapsed. However, Pools in a Collaboration can also be expanded. Then each pool contains its specific process modelled with the model elements of a Process Diagram.

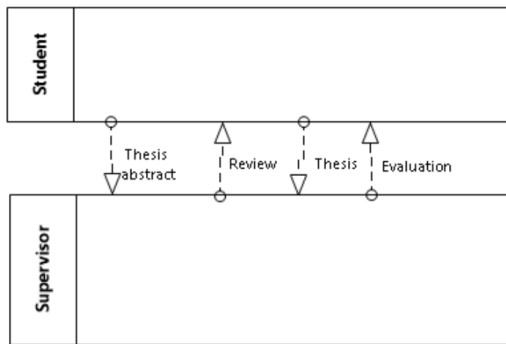


Figure 9. Collaboration Diagram with collapsed Pools

Looking at the labels of the model elements used in Collaboration Diagrams, the following can be said: The model elements that are already in use in Process Diagrams are labeled in the same ways as described in the section about Process Diagrams (Section IV). The model elements Pool, Lane and Message Flows are labeled as follows:

Nouns and noun phrases dominate the labels of Pools and Lanes. In 88 % of the cases, a label of a Pool is a noun phrase. For Lanes it is even 100 % in the sample. Typical labels on Message Flows are nouns or noun phrases only. In 69 % of the cases, a label of a Message Flow is a noun or a noun phrase. However, the labels of Message Flows can also follow other styles. Such a style for instance is *Verb in Past Participle Style*. An example for this style is e.g., “letter received”. Some Message Flows follow the *Verb Object Style* (e.g., “send letter”). Message Flows can have the following labels as well: “100\$”, “give me 100\$”, “here is your medicine”, “pickup your medicine and you can leave”. In these special cases of whole sentences, modelers use message flows mainly to represent the concrete oral communication between persons represented by the Pools. In some Collaboration Diagrams, the Message Flows do not have a label. In these Diagrams, the modelers seem to assume that the semantic of message in the Message Flow can be derived from the involved Events.

B. Choreography Diagram

The Choreography Diagram was introduced in Version 2.0 of BPMN. A Choreography Diagram focuses on the interaction of messages between Pools. Here Pools are also called participants. It is based on a Collaboration Diagram but instead of presenting all interaction details between pools, as well as all the process details within each pool it describes the interaction in a more compact manner. Therefore, this diagram introduces the new model element:

Choreography. Figure 10 shows a simple example of a Choreography Diagram. It contains two Choreographies connected by a Sequence Flow.

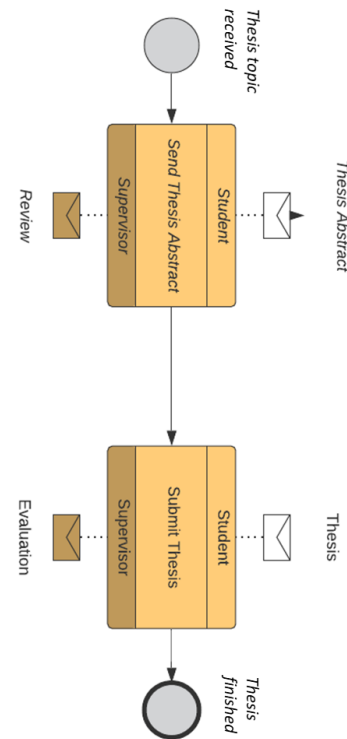


Figure 10. Choreography Diagram

The Choreography is a rounded rectangle, which consists of three sections. The outer sections represent the involved participants (Pools) in this Choreography. The section in the middle represents the activity that triggers or receives the messages. This activity can be either a Choreography Task or a Sub Choreography. Sometimes also the messages itself are presented with a letter-envelope icon related to the Choreography. A Sequence Flow can connect each Choreography to other Choreographies. Similar to Process Diagrams, such a Choreography Diagram can split into several paths. These paths can also once again merge somewhere in the diagram. Therefore, a Choreography Diagrams contains Gateways too. In addition, such a Diagram can also contain Events. At least one start Event and one End Event are mandatory.

An examination of several Choreography Diagrams found on the Web provides the following results about the labels.

The outer sections with the participants (Pools) involved in a Choreography always have a noun as a label. In the middle section where the activity is defined, the following was found. In 73 % of the cases, the section, representing the activity (Choreography Task or Sub Choreography), is labeled with the *Verb Object Style* (e.g., “confirm order”). In 10 % of the cases, the *Action Noun Style* (e.g., “order rejection”) is

used. In 11 % of the cases, these labels were also nouns, noun phrases or nouns with an adjective (e.g., “insufficient credit”). In addition, a few cases (6 %) used non-canonical patterns (e.g., “pick and drop Customer”) or other labeling styles (e.g., “payment ok”). Unfortunately, far too few Sub Choreographies exist in the sample. Therefore, the analysis and analysis results do not distinguish explicitly between Choreography Tasks and Sub Choreographies. However, in these rare cases of Sub Choreography examples, it was examined that the *Verb Object Style* also dominates.

In some cases, it was also interesting to see a switch of labeling style in the same diagram. The creator of this diagram used the *Verb Object Style* to a large extend but then used noun or noun phrase only. Since this middle section of the model element Choreography is derived from a Task or Sub Process, which are modelled in a Collaboration Diagram, then the *Verb Object Style* should be used. If it would be derived from a Sub Process, both the *Verb Object Style* and *Action Noun Style* would be appropriate. However, other kind of labeling patterns do not fit in this middle section of a Choreography.

For most of the Messages related to a Choreography, nouns or noun phrases were used as labels. In one exceptional case of a diagram, such a label is a whole sentence.

Nearly in all Choreography Diagrams, the Start Events and End Events had no label, since they just represent the trivial fact that the Choreographies have a start and an end. The few Intermediate Events that appeared in the diagram had similar variants of labeling styles like the Intermediate Events in Process Diagrams. Those kinds of Gateways, which appeared in the Choreography Diagrams and express a decision like Exclusive (XOR) Gateway or Inclusive (OR) Gateway, were also labeled in an adequate manner. The labels indicate the decision that has to be made. Particularly, similar variants of labeling styles like for the Gateways used in Process Diagrams (e.g., the labeling style *Question with Noun and Verb in Past Participle*) are used here too. Parallel (AND) Gateways do not have a label in these Diagrams. However, like in Process diagrams, there is also no need for a label on Parallel (AND) Gateways, because the sequence-flows split and all outgoing paths have to be taken. Hence, there is no need to label this splitting point for expressing a decision that has to be made at this point.

C. Conversation Diagram

The Conversation Diagram was also introduced in Version 2.0 of BPMN. A Conversation Diagram describes the exchange of messages between participants. Once again, these participants are just a continuation of the concept Pool. The graphical notation is a little bit different. Instead of tall rectangles, these participants are modelled with smaller rectangles. The new model element, which is introduced in a Conversation Diagram, is the Conversation and the Conversation Link. The Conversation defines the message exchanges between the Pools. The modeling notation for a Conversation is a hexagon. BPMN distinguishes between normal Conversations, Sub Conversations and Call Conversation. The latter is a reference to a globally defined

Conversation or Sub Conversation. Graphically, a Call Conversation is also drawn as a hexagon but the margins are bolder. In order to specify, which participant is connected, to which other participant via a Conversation, the Conversation Links (two parallel lines) connect the participants with Conversations. Figure 11 shows a simple example of a Conversation Diagram.

Since in Conversation Diagrams the participants represent Pools, the modelers mainly use nouns or noun phrases to model these participants. It was also observed that two styles dominate the labels for Conversations. About 42 % of the distinct labels are nouns or noun phrases. In 30 % of the labels, the *Verb Object Style* is used (e.g., “run advertising campaign”, “invoke service components”).

Additionally, other labeling preferences appear. About 16 % of the labels follow the *Action Noun Style* (e.g., “book reservation”). In the remainder of the cases, the modelers preferred labels, which mainly follow non-canonical label patterns (e.g., “recruitment and training”, “delivery/dispatch”).

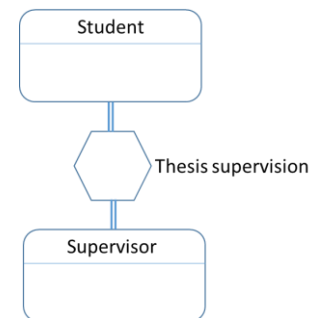


Figure 11. Conversation Diagram

Unfortunately, *Sub Conversations* were rarely used and *Call Conversations* were not used at all in the sample. All that can be said about Sub Conversations is: A dominant labeling style does not exist in this sample.

Since a Conversation represents message exchanges, labeling using a noun, noun phrase or the *Action Noun Style* is more natural. Conversation Links are not labeled. However, this is according to BPMN, which also does not enforce labeling of Conversation Links.

VI. CONCLUSION AND FUTURE WORK

This paper described how BPMN model examples are presented on the Web. Particularly, the labels of the model elements of all the four types of BPMN diagrams (Process Diagram, Collaboration Diagram, Choreography Diagram and Conversation Diagram) were examined. In summary, the following can be said about the BPMN model element labels used in Web examples.

For the labels of atomic Activities called Tasks, there is common consensus to follow the recommended *Verb Object Style*, since the majority of the label examples for model elements on the Web follow this style. For non-atomic Activities (i.e., normal Sub processes), two ways of labeling are preferred: Nominalization of a verb (*Action Noun Style*)

and the recommended *Verb Object style*.

In the case of Event types, it turned out that the labeling styles vary depending on the Event type used. Additionally, within the same Event type, variations of labels exist. For some of these labeling strategies, existing literature would even state that these labels have deficiencies. Therefore, it would be good that both providers of such examples and readers of these examples have a more critical look on them. However, it also has to be said that some of the label examples for Events (e.g., Timer Event) are appropriate with respect to the certain type of Event.

If Gateways have a label, then it is quite well understood that a question mark (“?”) should close the label, as it is suggested in literature. However, this is the only accordance with literature. Since many of the Gateways do not even have any label. This can be also interpreted as follows. The community, who posts process model examples on the Web, does not yet understand labeling of Gateways as an important feature for a better understanding of the process paths.

It is of common understanding that the Pools (participants) used in Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams as well as the Lanes in Collaboration Diagrams represents systems or role of systems and subsystems, respectively. Therefore, they should be labeled with a nouns or a noun phrase.

In Choreography Diagrams, the labels of the new model element Choreography are consistent with its basis. As already described, the outer sections of a Choreography that represent participating Pools are labeled with nouns or noun phrases. The middle section, which represents the activity triggering or receiving a message, is labeled with the most common labeling styles used in Activities. Namely, it is labeled with the *Verb Object Style* or *Action Noun Style*.

Many of the labels used in the new model element Conversation are either nouns and noun phrases, respectively or they follow the *Verb Object Style*. However, nouns and noun phrases seem to be more natural.

Hence, the new model elements, which appear in Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams, have labels that mainly represent their purpose.

As a future work, it would be interesting to examine Web examples of Process Diagrams, Collaboration Diagrams, Choreography Diagrams and Conversation Diagrams that are modeled with labels in another language than English.

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