EXTENDING THE EPC AND THE BPMN WITH BUSINESS PROCESS GOALS AND PERFORMANCE MEASURES

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Keywords: Business process modelling, metamodel, Event Driven Process Chain, Business Process Modeling Notation.

Abstract: The Event-Driven Process Chain (EPC) and the Business Process Modeling Notation (BPMN) are designed for modelling business processes, but do not yet include any means for modelling process goals and their measures, and they do not have a published metamodel. We derive a metamodel for both languages, and extend the EPC and the BPMN with process goals and performance measures to make them conceptually visible. The extensions are based on the metamodels tested with example business processes.

1 INTRODUCTION

Business process performance measurement is an important topic in research and industry (Casati F., 2005). However, current conceptual Business Process Modelling Languages (BPMLs) do not mirror these requirements by providing explicit modelling means for process goals and their performance measures (List, B., Korherr, B., 2006). The goal of this paper is to address these limitations by

- enhancing the expressiveness of the most widely-used BPMLs, namely the Event-Driven Process Chain (EPC) and the Business Process Modeling Notation (BPMN) by deriving metamodels for both, and by
- extending their metamodels with business process goals and performance measures to make them conceptually visible.

EPCs have become widely-used for business process modelling in continental Europe, in countries where SAP is a leading Enterprise Resource Planning (ERP) system. EPCs are inspired from Petri nets, incorporate role concepts and data models like ER models or UML class diagrams.

The BPMN is wide spread in the US and in countries where US companies dominate the ERP system market. The BPMN was developed by the Business Process Management Initiative (BPMI) with the goal to provide a notation that is easily readable and understandable for all business users (BPMI/OMG, 2006), who design, implement or monitor business processes. Thus the BPMN aims to bridge the gap between business process design and its implementation.

According to the evaluation in (List, B., Korherr, B., 2006), the EPC and the BPMN belong to the most advanced BPMLs beside the UML 2 Activity Diagram (OMG, 2006). Although the EPC offers notation elements for business process goals, it does not provide elements that make performance measures visible. BPMN does not provide elements that make business process goals or performance measures visible at all. In a previous work (Korherr, B., List, B., 2006), we have extended UML 2 Activity Diagrams with performance measures and goals to make them conceptually visible. We want to extend all three languages with goals and performance measures, but different mechanisms will be used. At UML 2 Activity Diagrams a UML profile was created, and at the EPC we will introduce a new view, as well as at BPMN we will establish a new category.

The BPMN only provides notation elements and no official metamodel published e.g. from the Business Process Management Initiative (BPMI) or the Object Management Group (OMG), while the EPC provides metamodels for its views, but not an integrated metamodel that contains all views in one model.

We derive a metamodel for the EPC and the BPMN based on the Meta-Object Facility (MOF), the OMG's meta-metamodel (OMG, 2006). We

extend the metamodels with business process goals and performance measures, and thus, provide the following contributions:

- Modelling goals and performance measures allow to better structure the process design and to better understand the broader implication of the process design.
- Performance measures quantify business process goals, and thus help to evaluate the process design and the operating process. The extended EPC and BPMN make the evaluation criteria for a business process conceptually visible.

In the remainder of the paper, the role of business process goals and performance measures is briefly discussed in Section 2 and the generic metamodel extension will be described in Section 3. The metamodel of the EPC and the BPMN with its extensions for process goals and performance measures is described in Section 4 and 5. The extension of the EPC and the BPMN is tested with an example business process in Section 6. We close with related work (Section 7), followed by a conclusion (Section 8).

2 PERFORMANCE MEASURES

With business process reengineering Davenport, Hammer and Champy encouraged a new discipline at the beginning of the 1990s and provided the theoretical background for business process modelling. In the business process modelling community attention has so far only been given to the modelling of certain aspects of processes (e.g. roles, activities, interactions) rather than goals or measures. The former theoretical aspects are mirrored in several business process modelling languages (BPMLs), i.e., in BPMN (BPMI/OMG, 2006), EPC (Scheer, A.-W., 1999), the UML 2 Activity Diagram (OMG, 2006), etc.

A business process is defined as a "group of tasks that together create a result of value to a customer" (Hammer, M., 1996). Its purpose is to offer each customer the right product or service, i.e., the right deliverable, with a high degree of performance measured against cost, longevity, service and quality (Hammer, M., 1996). Although process goals and performance measures lack the visibility in conceptual BPMLs, they are used in process theory.

According to Kueng and Kawalek (Kueng, P., Kawalek, P., 1997), the modelling of goals is a critical step in the creation of useful process models, for the following reasons:

- We need to be able to state what we want to achieve so that we are then able to define the necessary activities which a business process should encompass.
- A clear understanding of goals is essential in the management of selecting the best design alternative.
- A clear understanding of goals is essential for it to be possible to evaluate the operating quality of a business process.
- A clear expression of goals makes it easier to comprehend the organisational changes that must accompany a business process redesign.

For all the reasons described above, we capture the business process goals and represent them graphically in a conceptual BPML, namely the EPC and BPMN. Furthermore, Kueng and Kawalek recommend in (Kueng, P., Kawalek, P., 1997) to define to which extent the process goals are fulfilled, to measure the achievement of goals either by qualitative or quantitative measures, and to define a target value for each measure. Target values are also very important for Service Level Agreements (SLAs) as well as for business process improvement.

3 GENERIC METAMODEL EXTENSION

As a first step according to the missing concepts found out in the evaluation of List et al., we capture goals as well as measures and represent them graphically in two conceptual BPMLs, namely EPCs and BPMN.

The metamodel of the EPC and the BPMN will be extended by a small generic metamodel of goals and performance measures shown in Figure 1. The big advantage of that generic metamodel is that it can be integrated in every BPML at that point where it is needed. It contains two core concepts, namely *Measure* and *Process Goal.* While these two concepts do not appear as notation elements in BPMN, the process goal is a part of EPC. Often it does not appear in the graphical notation of a business process modelled with EPCs, and there are no measures available for quantifying a goal.

A process goal describes the specific intension of a business process and is quantified by at least one measure. Furthermore the goal can be refined

by one or more sub goals. A measure is an abstract metaclass, and can be classified and implemented as *Quality, Cost* or *Cycle Time*. A measure is responsible for the concrete quantification of different goals as well as for measuring the performance of a business process.

Quality has the aim to measure the quality of a business process, which can be expressed e.g., by a low number of complaints or a high customer satisfaction, described in Fig. 1 through the attributes *maxComplaints* as well as *avgComplaints*. The attribute maxComplaints shows the total number of complaints, and the attribute avgComplaints shows the average allowed number of complaints measured for instance during the time period of a month.

Cost represents the expenses a business process requires for instance for its execution. Its attributes *maxCost* and *avgCost* are necessary for comparing for example the average values like the total and monthly average cost of a certain process. The performance measures of quality and cost are in contrast to the measures of the cycle time often more focused on the type level of a process, as the required data is often not available on instance level.

The measure cycle time presents a time based measure and defines the processing duration of a business process instance, or part of it. Cycle Time can be specialised as *Working Time* or *Waiting Time*. Working time presents the actual time a business process instance is being executed by a role. Waiting time shows the time the process instance is waiting for further processing. Moreover, cycle time has two attributes *maxDuration* and *isDuration* for representing the target value and the actual value of the process duration or a part of it.

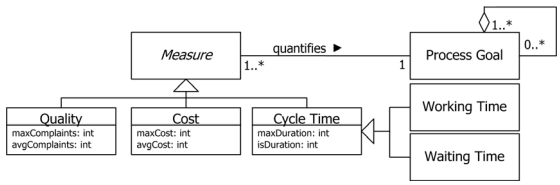

Figure 1. Generic metamodel of goals and performance measures

4 THE EPC

The EPC (Scheer, A.-W., 1999) has been developed within the framework of the Architecture of Integrated Information System (ARIS) and is used by many companies for modelling, analysing, and redesigning business processes. The ARIS concept (Scheer, A.-W., 1999) divides complex process models into separate views, in order to reduce the complexity. The views can be handled independently as well as related. There are three views focused on functions, data, and the organisation (see Fig. 2), and an additional view focused on their integration.

The *Data View* contains events and statuses. The *Function View* contains the description of the activities that have to be performed. The *Organisation View* represents the organisational structure. This includes organisational units, employees and roles as well as their relationships. The *Control View* links functions, organisation and data. It integrates the design results, which were initially developed separately.

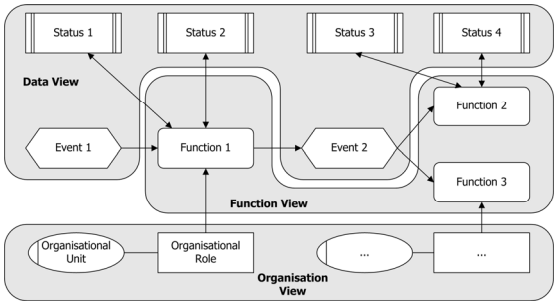

Figure 2. ARIS Views

4.1 The EPC Metamodel

The metamodel of the EPC is described in Figure 4. An EPC consists of functions, events, control flow connectors, logical operators, and additional process objects. Each EPC consists of one or more *Functions* and two or more *Events*, as an EPC starts and ends with an event and requires at least one function for describing a process. A function can be either an *Elementary Function* or a *Complex Function*, and the latter is refined by at least one function. A function is connected with two *Control Flow Connectors* and has to fulfil at least one *Process Goal*. A process goal can be refined by one or more sub goals. Control flows link events with functions, but also events or functions with *Logical Operators,* which can be either an *XOR, OR* or *AND*. It is connected at least with 3 control flows, one or more incoming as well as outgoing connectors.

A *Deliverable*, an *Information Object,* an *Organisational Structure* as well as *Process Goals* are called additional process objects and are connected with functions. All these types of additional process objects are assigned to one or more functions.

4.2 The extended EPC Metamodel

The metamodel is extended by introducing a new view, the so called performance measure view. It is shown with the performance measure elements high-lighted in grey in Figure 4. The relationship between goals and measures in a so called goal measure tree is illustrated in Figure 3 in the context to the examples in section 6. A goal can have several sub goals, and each goal has at least one measure and is connected with one or more *Measure Flow Connectors*. Its main process goal is *good process performance*. This goal has three sub-goals: *low processing costs, short process duration,* and *high customer satisfaction*. Furthermore each goal is refined by measures. The goal low processing costs is fulfilled, when the *average processing costs per month* are under 15 Euros. The measure *cycle time* indicates that the process duration has to be less than four days. Moreover the goal high customer satisfaction is achieved, if the *average percentage of complaints per month* is less than five percent.

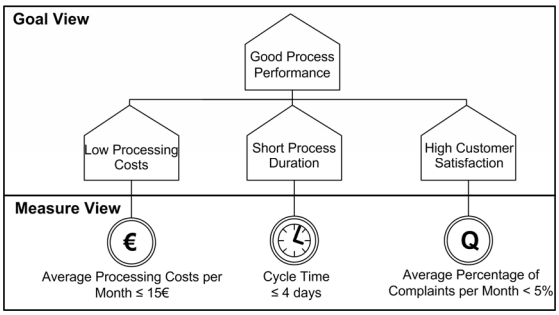

Figure 3. Goal Measure Tree

5 THE BPMN

The BPMN was developed by the Business Process Management Initiative (BPMI) with the goal to provide a notation that is easily readable and understandable for all business users (BPMI/OMG, 2006), who design, implement or monitor business processes including a transformation into an execution language, namely the Business Process Execution Language, (BPEL) (IBM, 2003). Thus the BPMN aims to bridge the gap between business process design and its implementation. The main concepts of BPMN are similar to UML 2 Activity Diagrams (AD) (OMG, 2006). But in contrast to ADs, the BPMN has no official metamodel, just a mapping to the Business Process Definition Metamodel (OMG, 2004) which is not fully developed yet.

5.1 The BPMN Metamodel

We derived the BPMN metamodel from the core elements of BPMN ((BPMI/OMG, 2006)) which is shown in Figure 5. It includes process goals and performance measures (in grey). The metamodel was developed according to the specification of BPMN. The BPMN metamodel consists of four different categories: *Flow Objects, Connecting Objects, Swimlanes, Artifacts* and the newly introduced *Performance Measures*.

The elements *Activity, Process, Sub-Process, Task* as well as *Events* and *Gateways* are Flow Objects, which define the behaviour of a business process. A process consists of one or more activities. The activity is the main part of a BPMN, and is specialised through sub-processes that consist of at least one task. An event is something that "happens" during the execution of a business process. There are three types of events, based on when they affect the flow: *Start, Intermediate*, and *End*. Also the *Time Event*, which can be a start or an intermediate event, is part of the metamodel because it is required for presenting the measure of time. It belongs to the complete set of elements, which displays a more extensive list of the business process concepts that could be depicted through BPMN. A *Gateway* is used to control the divergence and convergence of a sequence flow. Markers within a gateway show the type of that flow object, it will determine between the logical operators *XOR, OR,* and *AND*, which stand for the *Exclusive (XOR)*, *Inclusive (OR)* and *Parallel (AND)* gateway. Furthermore the type *Complex* indicates complex conditions and situations, for instance that three paths out of five have to be chosen.

The connecting objects *Sequence Flow, Message Flow* and *Association* describe the ways of connecting the flow objects to each other. A message flow can be connected to at most two activities, or occur between an activity and a pool, or between two pools to illustrate the exchange of messages. A sequence flow shows the order in which activities are performed in a process, and relates activities, gateways and events to each other. An association is used to associate information to activities, and associates a *Data Object* to a flow or connects it to an activity.

Data objects as well as a *Group* and *Text Annotations* belong to the category of artefacts. They do not have any effect on the process flow at all. A data object can be used to represent many different types of objects, both electronic and physical, and provides information about what the process does. A group groups elements of a business process informally, and it is also used to

assign process goals to a business process. A text annotation is a mechanism for a modeller to provide additional information for the reader of a BPMN Diagram, and is not integrated in the metamodel for sake of simplicity.
A *Pool* represents a participant in a process and belongs to the category of swimlanes, and it groups a set of activities for identifying activities that have some characteristic in common. A pool can be connected with other pools or activities by a message flow. A *Lane* is a sub-partition within a pool.

5.2 The extended BPMN-Metamodel

The metamodel is extended with performance measures as a new category according to the specification (BPMI/OMG, 2006), with regard to the fact that an extension is not allowed to change the basic shape of the defined graphical elements and markers. The extensions are marked with the term "is presented through" in the metamodel, to sign that an extended metaclass is graphically described through a core element of BPMN.

The *Organisational Structure* explicitly describes *Organisational Units* and *Roles* within a business process. This could be for example the department or an employee of a company. They are presented through a pool, because they are a concrete specification of a pool and so far also part of the category swimlanes. An organisational unit has one or more roles, and a role belongs to at most one unit. The metamodel extended with the new introduced category of performance measures are highlighted in grey in Figure 5. A *Measure* is distinguished between a measure on *Type Level* or *Instance Level*, because the type level of BPMN can be executed with a mapping to BPEL according to the specification ((BPMI/OMG, 2006). Since the EPC is not executable, therefore the BPML does not need a distinction in its metamodel between type or instance level. *Cost* and *Quality* belong to the type level, and cycle time to instance level. Cost and quality are in contrast to cycle time more focused on the type level of a process, as the required data is often not available on instance level. A measure is represented by a pool, because an organisational structure has to act on measures. If the measure is *Cycle Time*, then it is represented through a *Time Event*. Furthermore an organisational structure can be triggered by an event alert, if an action or a group of actions is not executed within its performance measures.

6 EXAMPLES

We demonstrate the practical applicability of the extension of the EPC and the BPMN with business process goals and performance measures in Figure 4 and 5 with the example business process of an insurance company: the Processing of Automobile Claims business process (Fig. 6). The business process in both diagrams is decomposed into three hierarchical levels to improve the structure and clarity. The main difference in the graphical notation of the extension of both BPMLs is that EPC uses new graphical notation elements for presenting the performance measures, while BPMN uses no graphical notation elements and integrates them into the existing elements. In BPMN, extensions to notation elements can be made by means of new markers or indicators associated with the current graphical elements. It is recommended to use the existing graphical notation elements, and to keep away from changing them. In the examples in Figure 6 we introduce additional labels to the graphical elements of BPMN, for instance for a pool the label “Organisational Role” which corresponds to the homonymous metaclass in the metamodel.

At the first hierarchy level, the overall goal of the complex function of the EPC and the collapsed sub-process in BPMN with the label *Process of Automobile Insurance Claim*s is to fulfil the process goals *High Customer Satisfaction, Short Process Duration* and *Low Processing Costs.* The process has to meet three measures, costs, cycle time and quality. The average processing costs per month have to be 15€ maximum and the number of complaints should not exceed five percent. In case of the BPMN it is also possible to introduce alerts in a diagram with time events (BPMI/OMG, 2006). In our example, if the cycle time is over four days, then the *Claim Manager* receives an alert, and gets a report about that specific case.

At the second hierarchy level the organisational role *Financial Claim Specialist* is responsible for the complex function in EPC and for the collapsed sub-process in BPMN respectively, labelled with *Assertion of the Claim*. The organisational role of the *Claim Administrator* is responsible for the *Compensation of the Claim* in both BPMLs. Furthermore assertion of the claim has to fulfil its tasks within a cycle time of one day, and compensation of the claim within three days.

At the beginning of the process at the third hierarchy level, the organisational role *Financial Claim Specialist* is responsible for the functions/tasks *Record the Claim* and *Calculate the*

Insurance Sum. After a waiting time of two days maximum, the organisational role of the *Claim Administrator* has to follow up with the process. If the insurance sum is a major amount, then the claim administrator has to *Check History of the Customer*. Otherwise, when the insurance sum is a minor amount, then no additional function for EPCs respectively task for BPMN is required and the organisational role of the claim administrator starts immediately to *Contact the Garage*. After contacting the garage for the reparation, the *Examination of Results* has to begin with the decision whether the payment for the damage is positive or negative. If the examination is positive, then the insurance has to *Pay for the Damage*, and the case is closed.

Figure 6 shows that a business process in EPC and BPMN with its hierarchical levels based on extended metamodels can be grasped at a glance. The extensions of the metamodel illustrate the requirements of a certain business process better and enhance the expressiveness of the model.

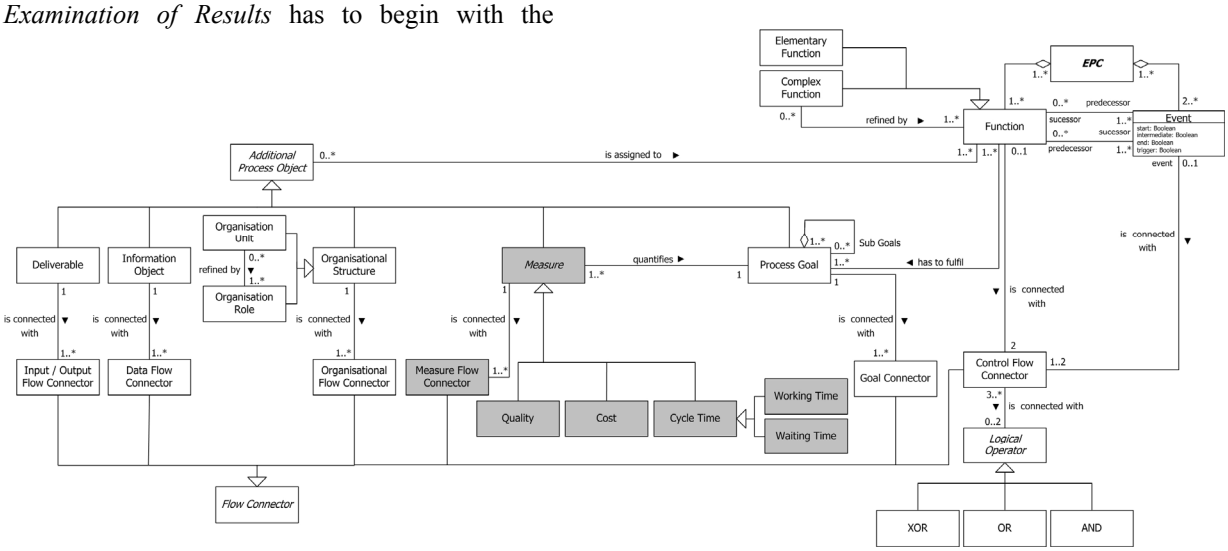

Figure 4: Extended EPC metamodel with performance measures

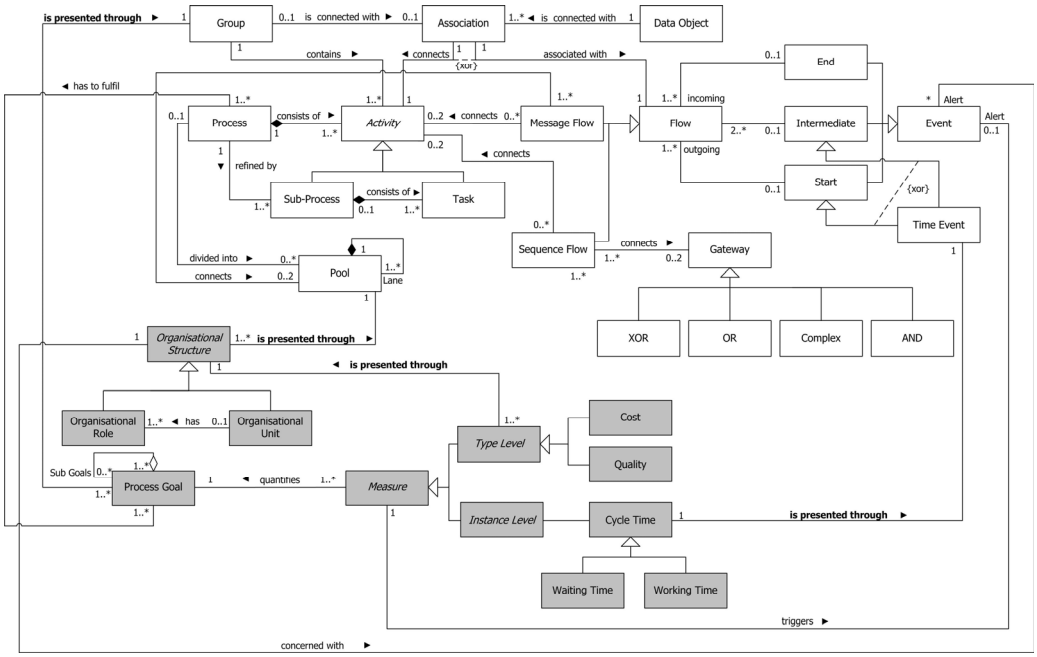

Figure 5: Extended BPMN metamodel with performance measures and goals

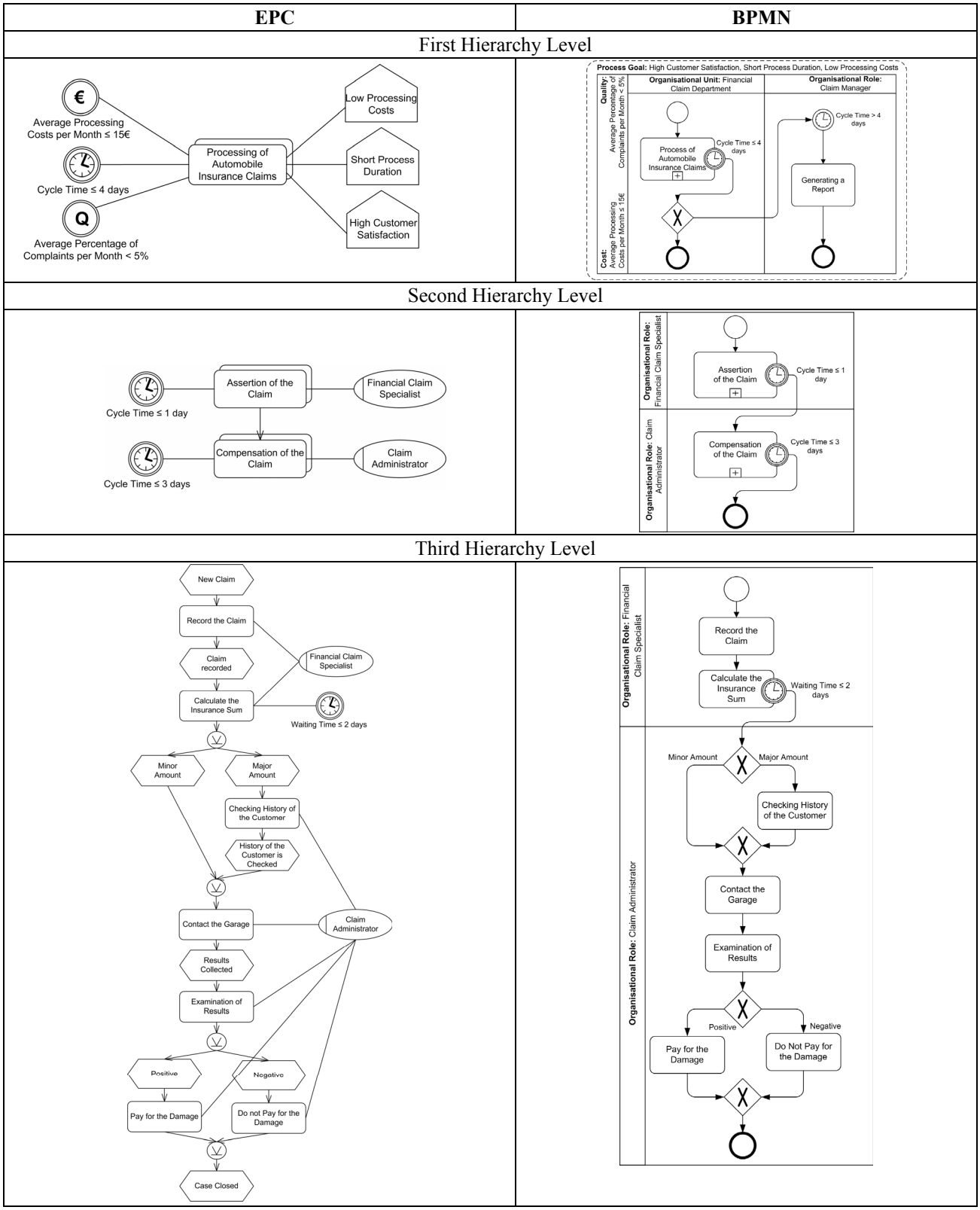

Figure 6. Example business process of Processing of Automobile Claims for EPCs and BPMN

7 RELATED WORK

Several approaches exist in the global area of goal-oriented business process modelling. A couple of works will be presented here.

Korherr et al. (Korherr, B., List, B., 2006) presented a UML 2 profile for integrating business process goals and performance measures time, cost, and quality into UML 2 Activity Diagrams. Furthermore, it is possible to show the organisational structure that is concerned with alerts that belong to a measure. The profile also is mapped to BPEL.

Neiger et al. (Neiger, D., Churilov, L., 2004)) focus on the problem that business process management frameworks are able to represent various aspects of the business process, but they do not meet the requirements of goal-oriented business process modeling. To solve this problem, the authors establish links between EPCs and its additional goals with the "value focused thinking" (VFT) framework to address the gaps in the existing methodologies and tools, without looking at the measurement of the goals.

Anderson et al. (Andersson B., Bider I., Johannesson P., Perjons, E., 2005) developed a formal definition of goal-oriented business process patterns for making a formal comparison of business processes. This approach is very high level, because the authors focus on business processes, and not on a specific business process modeling language.

Aguilar et al. (Aguilar, E. R., Ruiz, F., Garcia, F., Piattini M., 2006) developed a set of measures to evaluate the structural complexity of business process models on the conceptual level. The authors use BPMN for their evaluation. The evaluation of performance measures like time or cost is not important for their work, the focus lies on measuring the complexity of BPMN.

8 CONCLUSION

EPC as well as BPMN belong to the most well-known languages, but both are not able represent performance measures. In this paper, we have presented the metamodels with its extension to integrate business process goals and performance measures into these languages. The extension of both languages provides an explicit illustration of the goals a business process must achieve, as well as an integration of the performance measures time, cost, and quality, because without measuring the process goals it is not possible to assess if a goal is fulfilled or not. These extensions better illustrate the requirements of a certain business process and enhance the expressiveness of a model. Furthermore the organisational structure – a concept that is already available in EPCs – is integrated in BPMN, which is concerned with alerts that belong to a measure for a possible transformation to BPEL. The extensions of both languages were tested with an example business process.

ACKNOWLEDGMENTS

This research has been funded by the Austrian Federal Ministry for Education, Science, and Culture, and the European Social Fund (ESF) under grant 31.963/46-VII/9/2002.

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