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Business Process Flexibility and Decision-aware Modeling

The Knowledge Work Designer

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Abstract This chapter describes the Knowledge Work Designer, a modelling method for knowledge work. It is based on two principles: (1) the separation of business logic and process logic and (2) the support of both structures and unstructured knowledge. Process logic can be represented in a structured way in BPMN and in a non-structured way with CMMN. For real processes there is no strict separation between structured processes and cases. Therefore the Knowledge Work Designer offers a deep integration of BPMN and CMMN. Business logic can be represented in a structured way using decision tables. Unstructured business logic can be represented in documents. The separation of business logic and process logic allows for simpler process model and easier maintenance.

1 Introduction

Already in 1969 Peter Drucker (1969) coined the term knowledge work. He distinguished between knowledge workers and manual worker. He insisted that new industries will employ mostly knowledge workers. Nowadays we can see that many workers are knowledge workers. Rosen (2011) even regards every worker as a knowledge worker. For Davenport (2010) knowledge workers are the key to innovation and growth in today's organization.

The objective of the Knowledge Work Designer is to model business processes that cover a broad spectrum of knowledge work. It is based on the following two principles:

- Balance between process logic and business logic
- Support of knowledge work with different degrees of structure

1.1 Balance between Process Logic and Business Logic

In a business process we distinguish between process logic and business logic (see Figure 1).

- Process logic is the knowledge *about* the process, in particular the process flow with events and activities, the involved participants and resources. The process logic is typically represented in a business process diagram.
- The business logic is the knowledge *in* the process. It corresponds to the practice aspect of Davenport (2010) and Brown and Duguid (1991) and is about how the work is actually done. Understanding business logic means to understand how individual workers or applications respond to the real world of work and accomplish their assigned tasks.

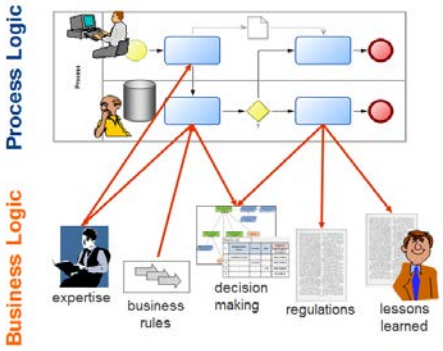

Fig. 1. Distinguishing process logic and business logic

The balance between process logic and business logic is an important consideration for anyone attempting to address knowledge work (Davenport 2010). Business process modeling tools focus on the process flow. Decision criteria are typically represented as gateways leading to unnecessary complex process models. The Knowledge Work Designer, however, contains model types for both process logic and business logic. This allows to model decision-aware business processes as introduced by von Halle and Goldberg (2010). A decision-aware business process is a process "that is designed to distinguish between tasks that perform work (i.e., process tasks) and tasks that come to conclusions based on business logic (i.e., decision tasks)" (von Halle & Goldberg 2010, p.66).

1.2 Degree of Structure

According to a survey about 60% of a knowledge worker's day is spent in unstructured and often unpredictable work patterns, while only about 40% is structured, predictable and automatable (Palmer 2011). The different degree of structure is a characteristic of both business logic and process logic.

Davenport (2010) distinguishes four types of knowledge work (see Figure 2). The distinction is based on two dimensions: level of interdependence and complexity of work. Process logic determines the way of collaboration while business logic corresponds to the knowledge work of individual actors. The Knowledge Work Designer offers modelling languages for both structure and non-structured knowledge work on individual and collaborative level.

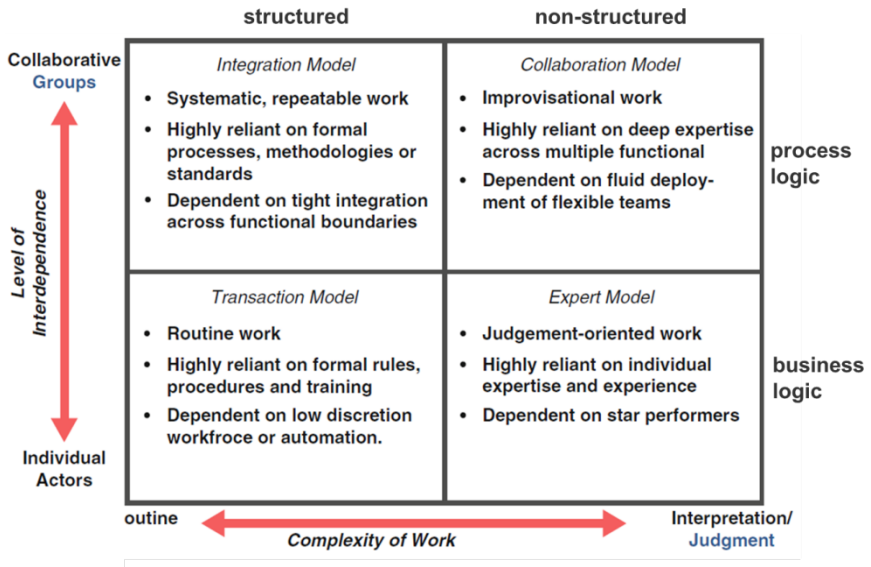

Fig. 2. Four approaches to knowledge work, from (Davenport 2010)

Gadatsch (2012, p.43) distinguishes three instead of two types of processes with respect to their degree of structure (Figure 3).

- For structured processes the activities and the conditions for their execution are known in advance.
- Ad hoc processes consist of activities, not all of which are known in advance. New tasks can be added on the fly and the people have a lot of freedom when to do which tasks. This means that the process flow cannot be modelled.
- Case processes contain both structured and ad-hoc parts. There are tasks for which the conditions for their execution can be specified in advance. Not all

tasks, however, can be embedded in a sequence flow. Human judgement and external events determine at runtime which activities need to be performed.

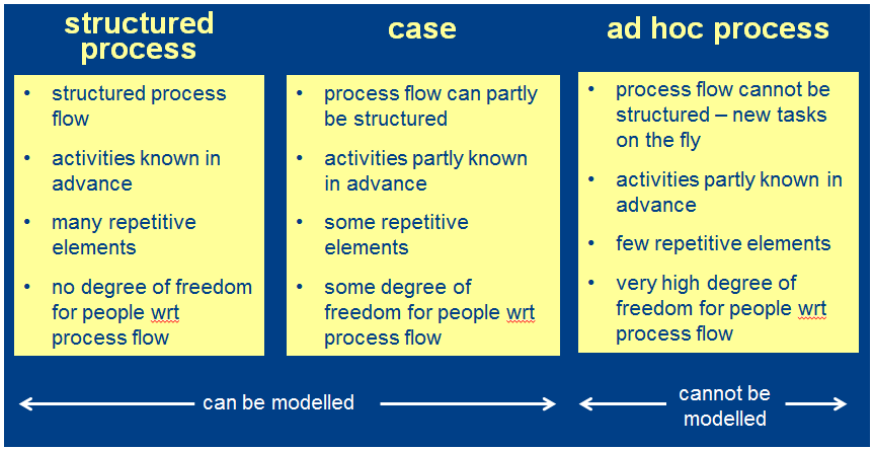

Fig. 3. Distinguishing processes by their degree of structure - translated from (Gadatsch 2012, p.43)

For real processes there is no strict separation between structured processes and cases. While the OMG defined two separate standards for the modelling of business processes and case management - BPMN (OMG 2011) and CMMN (OMG 2014) - the the Knowledge Work Designer offers a new modelling language BPCMN which deeply integrates structured business processes and case parts.

In addition, the Knowledge Work Designer allows to model structured and non-structured business logic. The formal rules and procedures of transaction work can be represented as decision models and decision tables, which allows to embed them in computer-based applications. Knowledge of expert workers, however, typically cannot be modeled in detail. High-level guidelines, checklist, sample outputs of templates are more appropriate. For these, the document model is offered.

2 Method Description

The Knowledge Work Designer comprises standard modelling techniques for business processes (BPMN), case management (CMMN) and decisions (DMN). These modelling approaches, however, are not sufficient to model knowledge work appropriately. Therefore the Knowledge Work Designer makes extensions and modifications on several aspects of the modelling technique:

- Modelling language:
  - In order to be able to model any degree of process structure, an integration of business process modelling and case modelling is provided. The new modelling language is called Business Process and Case Management Notation (BPCMN).
  - A document model type is used, which serves two purposes: It can be used to represent the context of a case and it serves to model unstructured aspects of business logic
- Modeling procedure:
  - The concept of decision-aware business processes separates process logic and decision logic.

2.1 Business Process Modelling

For structured business processes all possible paths are defined in advance. Control flows from one activity to the next. There is an incoming sequence flow and an outgoing sequence flow relation for every activity. The control flow is explicitly represented and visualized using events and gateways. The Knowledge Work Designer uses the Business Process Model and Notation BPMN 2.0 (OMG 2011) to model business processes.

2.2 Case Management Modelling

Adaptive Case Management (ACM) has been proposed as an alternative approach for the management of unstructured and often unpredictable work patterns (Palmer 2011). Case management processes are not predefined or repeatable, but instead, depend on evolving circumstances and decisions regarding a particular situation. Human judgment is required in determining how to proceed (McCauley 2010). Depending on their individual knowledge and skills, people approach the same problems differently. Therefore it must be possible to plan tasks at run-time.

The OMG published the new Case Management Model and Notation (CMMN), a modelling language specific for case management (OMG 2014). A case plan model contains plan item tasks and discretionary tasks. Plan item tasks are part of pre-defined segments; they correspond to the structured part of a case. Discretionary tasks are available to the Case worker, to be applied in addition. They can be added to the plan of the case instance at run-time (see Figure 4). The execution of the discretionary tasks depends on the context as well as the skills, experiences

and preferences of the individual worker. This is how human judgment is supported by CMMN.

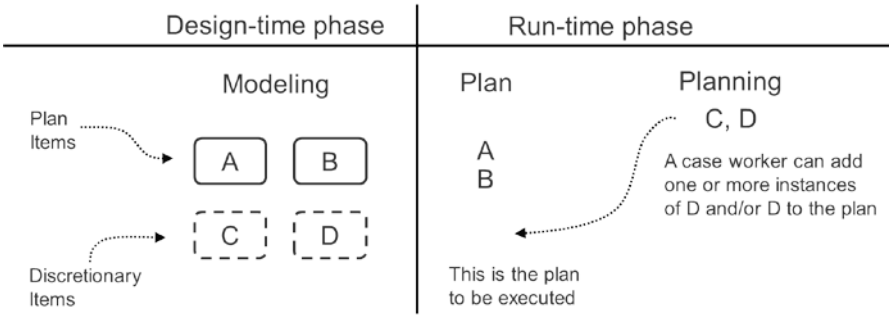

Fig. 4. Design-time modelling and run-time planning with discretionary tasks (OMG 2014)

2.3 Document Modelling for representing Case Files

Case execution is driven by events, context and content. While activities occur, information is created and added to the case. This information together with the context around it determines the state of a case. Thus, a case evolves over time toward achieving a goal. It requires the ability to jump forward and backward or to repeat activities depending on the circumstances of the case (see Figure 5).

Fig. 5. Evolvement of case execution depending on information in case file (Palmer 2011)

All information that is required as context for managing a case is defined by a case file. The state of the case is determined by the content within the case file. The case file is not a single file but a kind of virtual folder with references to information in different formats and media: text documents, spreadsheets, emails, reports, databases, systems of records, voice mail etc.

The Knowledge Work Designer uses the document model to represent the case file. A document in a document model can refer to any kind of structured and non-structured information sources.

2.4 Business Process and Case Modelling

While case management is often considered as different from conventional business process management (Palmer 2011), in reality they cannot be strictly separated. A structured business process can contain parts which deal with non-routine cases requiring additional investigation by different people. Silver (2011) gives the example of dispute resolution as part of a structured payment process. When a customer disputes a charge or demands a refund, case management is usually required. Another example is underwriting, which is part of a structured process, but might require dealing with exceptions or requiring additional input.

On the other hand there can be situations where a case management process contains structured elements. Project management is a typical example. Although it is composed of unanticipated tasks, it can contain structured process parts like financial reporting.

The only connection between process modelling and case management that is supported by the BPMN and CMMN standards is by referencing. CMMN has a special process tasks which can be used to call a business process. In a similar way BPMN can be extended to call a CMMN case as a subprocess. This is done in the Knowledge Work Designer as shown in Figure 6.

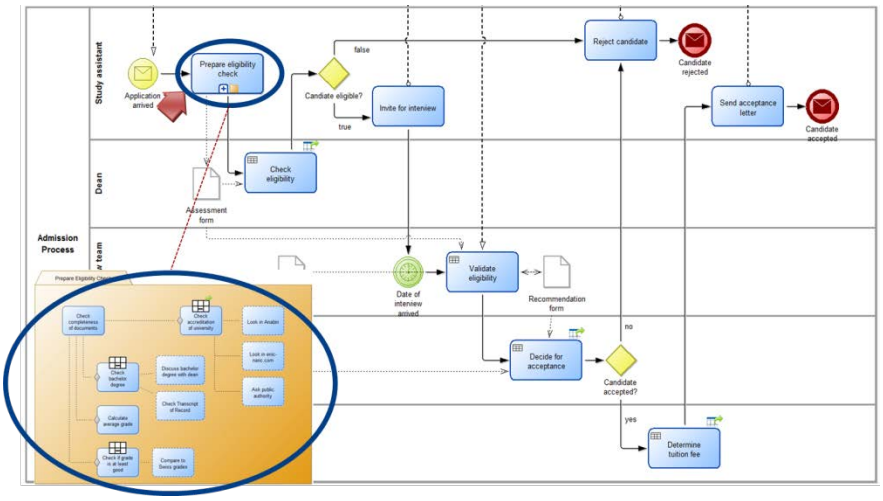

Fig. 6. A CMMN case as a subprocess of a BPMN model

This referencing, however, has some drawbacks. A process has to be broken into small fragments, which then are modelled using either BPMN or CMMN, depending on the level of structure. This makes sense, if there are larger parts, which can be isolated. In real processes, however, there are situations, in which there are discretionary tasks just for single activities in a structured process. On the other

hand side, even for case models it can make sense to make the control flow between some tasks explicit.

This is why the Knowledge Work Designer contains a new model type called BPCMN (Business Process and Case Management Notation), which deeply integrates process modelling and case modelling. The integration is based on a comparison of BPMN and CMMN. The main aspects of the comparison are shown in Figure 7. The first column lists the aspects that should be modelled. The second and third column show, how these aspects are modelled in BPMN and CMMN, respectively.

	BPMN	CMMN
Tasks	Tasks	Tasks
Process hierarchy	Subprocesses, Call Activities	Process Tasks, Case Tasks
Events	Events: start – intermediate – end catching – throwing	Event Listeners, implicit Events, Milestones
Control Flow	Gateways/Events	Sentries
	Sequence Flow 	Sentry with empty condition 
Planning	--	Discretionary Tasks
Responsibilities	Lanes	Role attribute
Process Container	Pool 	Folder 

Fig. 7. Contrasting elements of BPMN and CMMN

From Figure 7 we see that most of the aspects can be modelled in any of the modelling languages. The advantage of BPMN is that it allows visualizing the control flow, which is helpful for communication between stakeholders. CMMN, on the other hand, supports planning at run-time which is missing for BPMN. A combination of control flow elements of BPMN and discretionary tasks and planning elements of CMMN could be a suitable language to deal with any kind of process.

Silver (2014) claimed that BPMN covers about 90% of what is needed for business processes. Furthermore, BPMN is more widespread. Thus, for BPCMN we started with BPMN and added the necessary case aspects.

2.5 Decision-aware Business Processes

The term "decision-aware business process" was coined by von Halle and Goldberg (2010, p.66ff). They define a decision-aware business process as process that is designed to distinguish between process tasks and decision tasks. A basic idea behind this distinction is to separate the modelling of business logic from the modelling of decision logic, the latter being a special kind of business logic.

Separating business decisions from business process tasks simplifies the business process model and allows managing business logic in a declarative form.

- A business process model is a *procedural* solution because it prescribes a set of tasks that are carried out in a particular sequence.
- A decision table is an example of a *declarative* solution consisting of a set of typically unordered rules. A declarative solution only specifies what needs to be done, with no details as to how, in a step-by-step manner, it is to be carried out, because sequence is irrelevant to arriving at the correct result (von Halle & Goldberg 2010, p.67).

By separating business logic from business process logic, the process model become much simpler. Figure 8 shows on the left side a business process where decision logic about discount calculation is modeled with gateways. On the right side the same process is shown as a decision aware process. The rules for the discount calculation are described in a separate decision model. From the point of view of the business process, the decision logic is a black box evaluating conditions and reaching a conclusion. It can be viewed, managed, and executed independent from the process.

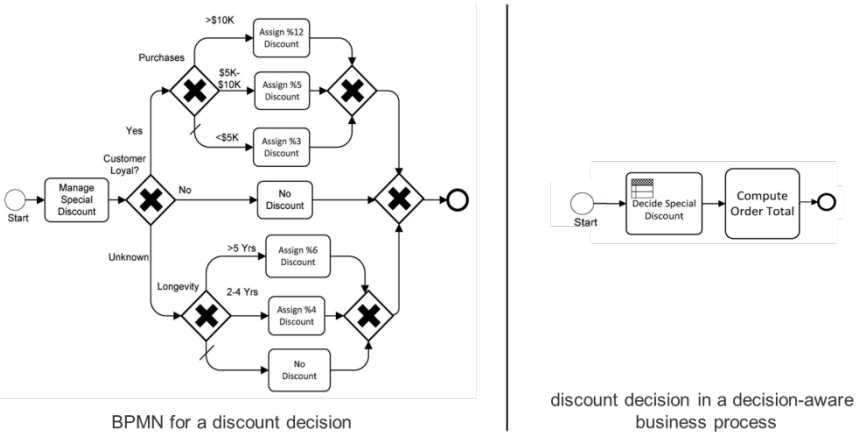

Fig. 8. Discount decision in BPMN and as a decision-aware business process (Debevoise & Taylor 2014)

The separated modeling of business logic and process logic improves agility by making changes easier. It permits changes in the decision model without changing the business process model and vice versa. Furthermore the decision model or individual decision tables and rules can be easily reused in several business processes.

2.6 Modelling Business Logic

To model business logic, the Knowledge Work Designer has a focus on decision modelling. The primary modelling method is the Decision Model and Notation (DMN) from the OMG (2015). A DMN model consists of the Decision Requirements Diagram and the decision logic.

The Decision Requirements Diagram consists of four elements: Decision, Business Knowledge, Knowledge Source and Input Data.

Figure 9 illustrates the elements and the requirements. The key element is the Decision. The Decision invokes a Business Knowledge model, which contains the decision logic. The Knowledge Sources represents the authority for a decision or a business knowledge. An example for a knowledge source can be a regulation which determines the rationale for the decisions. The link between the business knowledge and its source provides traceability and a way for impact analysis.

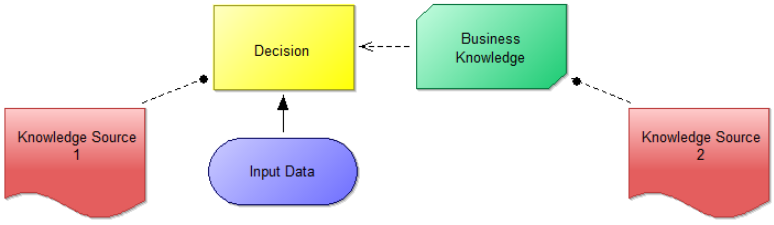

Fig. 9. DMN Elements and Requirements in a Decision Requirements Graph (OMG 2015, p.13)

The Decision and the Business Knowledge contain references to the decision logic. The Knowledge Work Designer supports three ways to represent decision logic:

- A decision table is a boxed expression to represent decision logic in a structured way as a set of rules.
- A language called FEEL allows transferring decision logic into executable expressions.
- Not all decision logic can be modelled in a structured way. In particular for the expert knowledge worker guidelines, checklists, sample outputs or templates are more appropriate. These can be modeled as documents in the document model.

This satisfies the requirement that business logic can be represented in a more or less structured way: structured decision logic can be represented as decision tables, unstructured decision logic can be described as documents. Since the document model can have references to any kind of information, this approach is flexible enough to represent any kind of business logic.

3 Method Conceptualization

The model types of the Knowledge Work Designer are shown in Figure 10. There are model types for both process logic and business logic. For both of them there are model types for different degrees of structure.

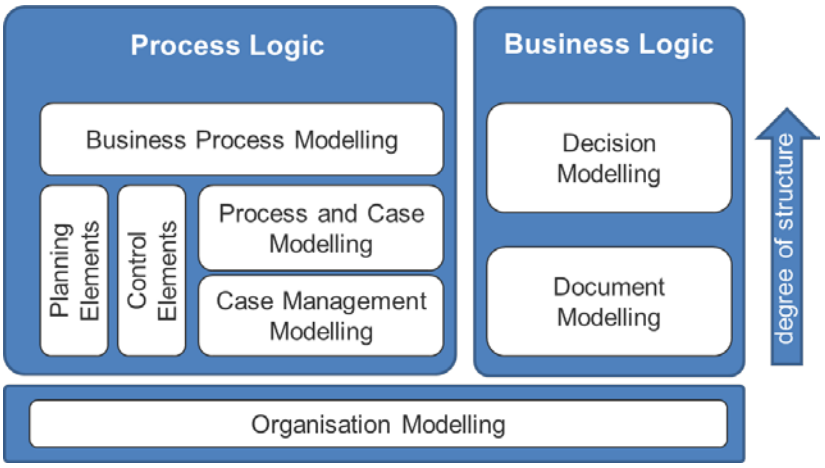

Fig. 10. Model types of the Knowledge Work Designer

The Knowledge Work Designer has been implemented in ADOxx (http://www.adoxx.org). Figure 11 shows the interface with a BPMN sample process.

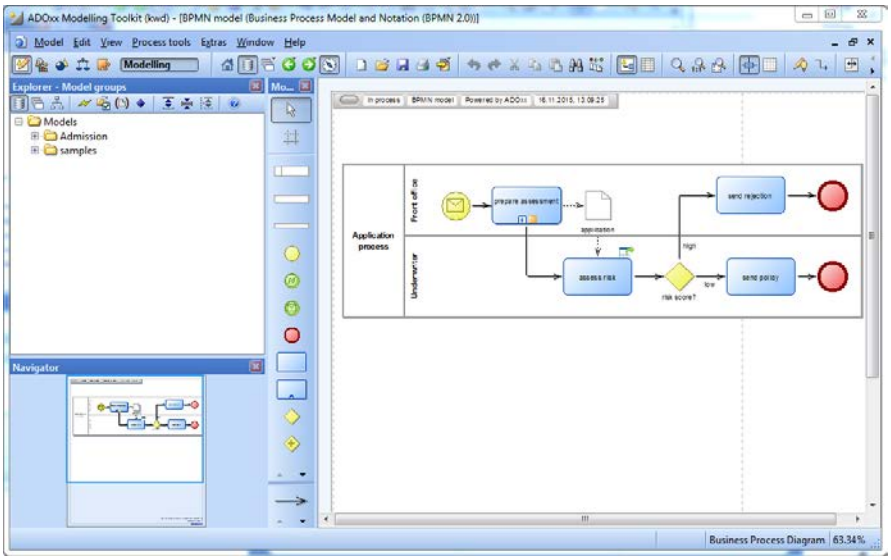

Fig. 11 . Screenshot of a business process model in the Knowledge Work Designer

3.1 Case Management Modelling

Figure 12 shows an example of a case management model. The modelling languages implements CMMN 1.0. It allows modelling both tasks and discretionary task. The latter are modelled with dashed borders. They can either be assigned to tasks. If they are not assigned to tasks, they can be executed at any time during the case execution.

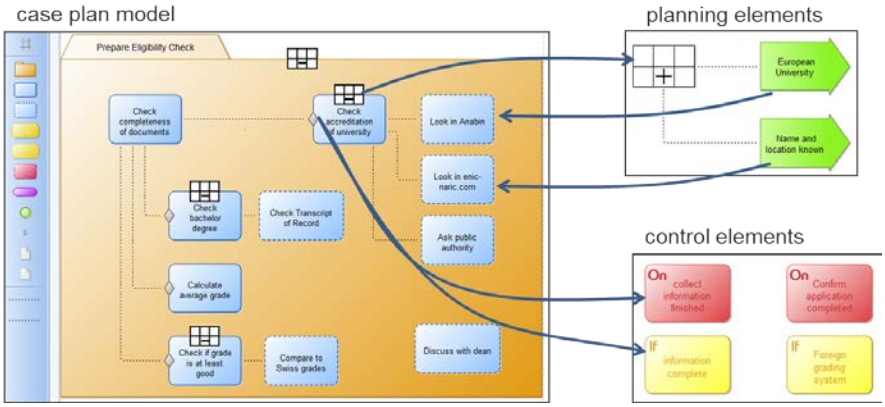

Fig. 12. A sample case plan model for preparing the eligibility check

The diamonds on the boundaries of tasks are sentries. Sentries define the criteria according to which the plan items are enabled and terminated. A sentry is a combination of an event and/or a condition.

– An On-Part specifies the event that serves as trigger.
– The If-Part specifies a condition that evaluates over the Case File.

In order to enable reuse, conditions and events of sentries are modelled in a separate model type - the control elements model. There is a link from the sentry in the case plan model to the corresponding on parts and if parts in the control elements model.

The case worker is supported in his/her planning by applicability rules. If the applicability rule for a discretionary task evaluates to true, the task is shown to the worker. The applicability rules are assigned to planning tables and modelled in a separate model to enable reuse for different discretionary tasks.

3.2 Business Process and Case Modelling

The Business Process and Case Modelling Notation BPCMN extends business process modelling with features of case management modelling. Figure 13 shows an example of a BPCMN model.

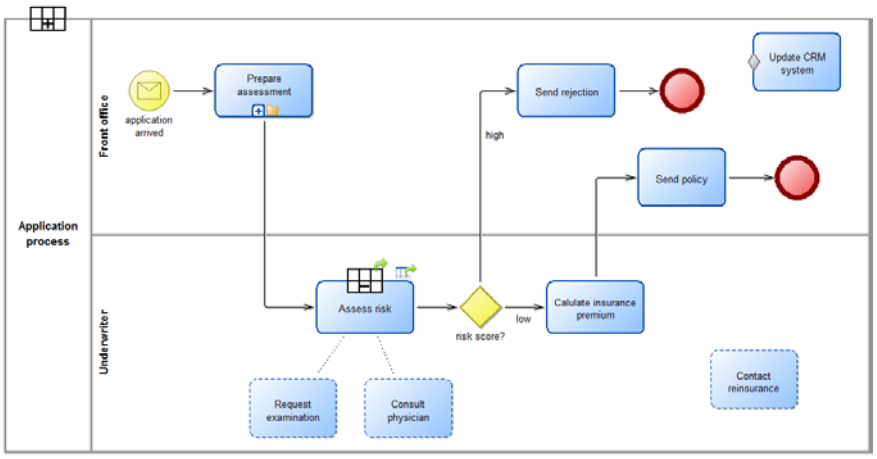

Fig. 13. Example of a BPCMN model

The process contains a structured part consisting of activities which are connected via sequence flow relationships as well as unstructured elements.

- The task "Assess risk" has two discretionary tasks associated to it - and a planning table which refers to applicability rules.

- The task "Update CRM" system is not embedded in the sequence flow. Its execution is determined by the sentry that is connected to it.
- There is a discretionary task "Contact reinsurance" is not associated to a task and thus can be executed at any time. The planning table for this task is attached to the pool, which is the container of the process.
- The subprocess "Prepare assessment" calls a case model - as indicated by the small folder icon at the bottom of the element.
- The task "Assess risk" is a business rules tasks. It has a reference to a decision model. Thus, this is an example of a decision-aware business process.

3.3 Modelling Business Logic

As explained in section 2.6, business logic can be represented in a structured and non-structured way. The left part of Figure 14 shows a decision model for the risk assessment of an insurance. The decision uses the data from the application as input and determines a risk score. The decision logic is assigned to the business knowledge element "Insurance Rules". They are based on the Insurance terms which are a reference to an element in the document model.

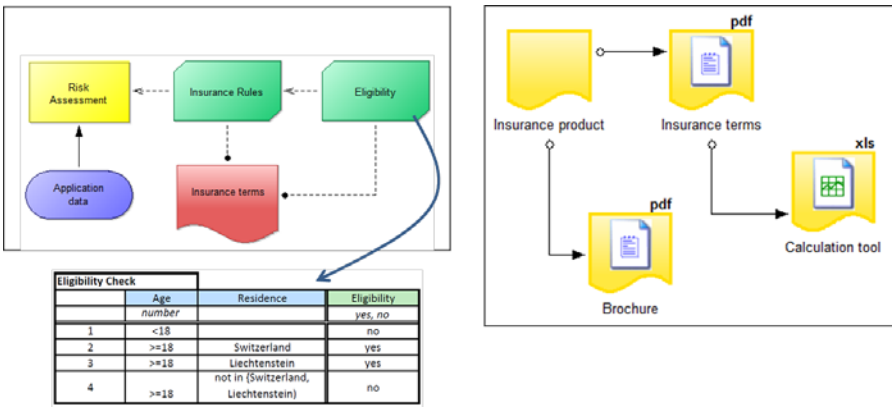

Fig. 14. Decision model and document model for representing business logic

The insurance rules can be represented in many different ways. A decision table is a formal representation, which can be interpreted by humans and can be translated into code for a rule engine. The document model can be used to represent non-structured business logic, knowledge sources and documents of a case file.

4 Proof of Concept

The Knowledge Work Designer has been applied to the admission process of the Master of Science study programs at School of Business FHNW. This is a description of the process:

- The process starts when we receive the application from a candidate. First the study assistant prepares the eligibility check of the candidate. The study assistant makes sure that all information is available to assess eligibility.
- It is determined whether the bachelor degree is regarded as equivalent to Information Systems, Information Technology or Business Administration. The study assistant may check the transcript of record if he/she is unsure.
- It is checked whether the university, from which the candidate got the bachelor degree, is accredited. If the university is unknown to the study assistant, the study assistant typically looks in the Anabin database or on enic-naric.net. The study assistant can also ask public authorities to confirm the status of the university.
- It is checked whether the average grade is at least “good”. If the average grade is not mentioned in the transcript, it is calculated by the study assistant. For unknown grading systems one has to find out how it compares to the Swiss grades.
- The study assistant can discuss with the dean at any time.
- The candidate is registered in the administration system.
- When all information is available, the dean checks the eligibility of the candidate.
- Candidates who obviously are not eligible are rejected.
- The other candidates are invited for an interview, which is made by the interview team. The output of the interview is a recommendation which is then input for the admission committee.
- The admission committee decides whether the candidate is accepted.
- For accepted candidates the administration determines the tuition fee.
- The study assistant informs the candidate about acceptance and tuition fee.

A first analysis has shown that neither BPMN nor CMMN alone are appropriate to model the process. The process is structured but it contains tasks, whose execution depends on the individual worker. For example, a university might be unknown to one study assistant, while another study assistant might know. Thus, the check in the database only depends on the individual worker and the time when the assessment is made. The same is true for the translation of foreign grades.

A first solution was to identify those tasks which need human judgment and model them as a CMMN subprocess, while the main process in modelled in BPMN. The resulting model is shown in Figure 6. The CMMN subprocess is shown in Figure 12.

The disadvantage of this model is that for the CMMN subprocess the control flow is not visible. Furthermore there is no visualisation of the roles of the participants who are involved in the CMMN subprocess. These disadvantages can be overcome with the BPCMN model as shown in Figure 15.

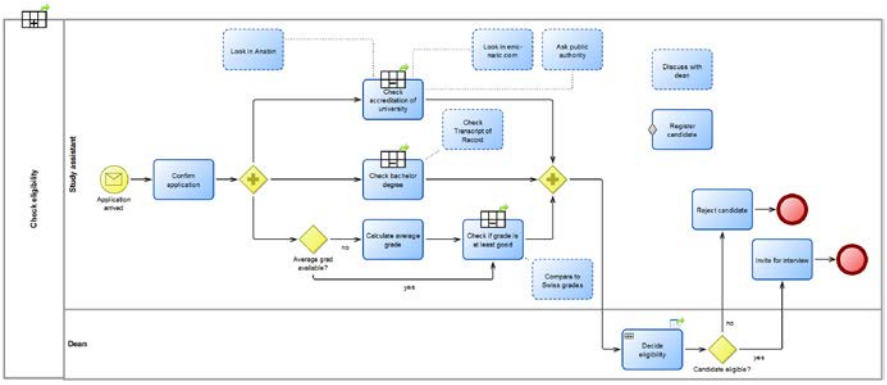

Fig. 15. A BPCMN model for eligibility check

In the model of Figure 15 the control flow of the process is visualized. It can easily be seen that there are three parallel paths, but the task "Calculate average grade" is executed only if the average grade is not available. In the corresponding CMMN model in Figure 12 the control flow is hidden in the conditions of the sentries. This declarative representation allows to model any level of complexity. In reality, however, people are used to think about process flow.

Flexibility of process execution is represented by

- the discretionary tasks, whose execution depends on the judgment of the individual participant
- the task "Register candidate", which is not part of the sequence flow and is executed as soon as its sentry evaluates to true.

The gateways in the process model determine the process flow but do not refer to any business logic. The business logic for the eligibility of the candidate is modelled separately in a DMN model (see Figure 16).

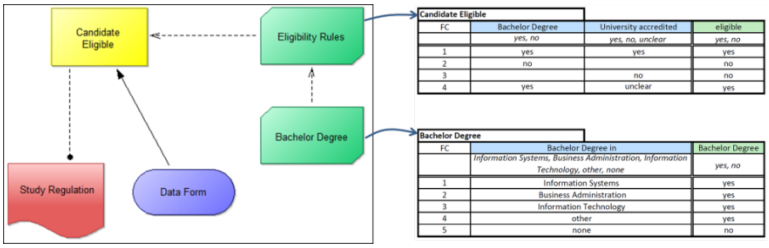

Fig. 16. Decision model for the eligibility check

The decision model contains the structured part of the business logic. The Study regulation refers to the corresponding document in the document model.

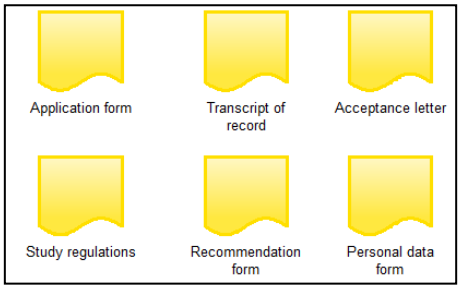

Fig. 17. Documents of the admission process

The document model not only contains the unstructured business logic but also documents and data which determine the state of the process execution.

5 Conclusion

The Knowledge Work Designer is a modelling tool for flexible, decision-aware business processes. It includes a *combination* of modelling languages for both structured and non-structured process logic and business logic as well as a new *integration* of business process and case modelling (see Figure 18).

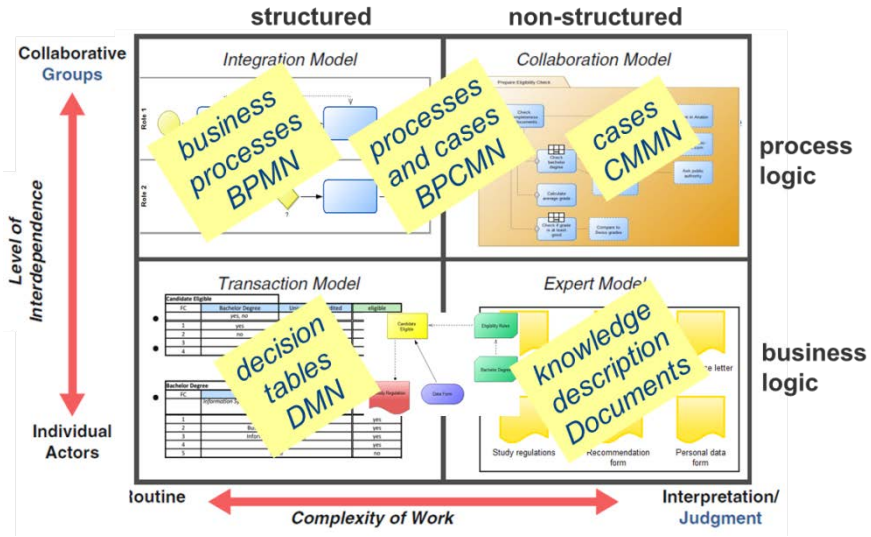

Fig. 18. Knowledge Models and Model Types in the Knowledge Work Designer

Process logic can be represented as a structured business process using BPMN, as a non-structured case plan in CMMN or as a combination of both called BPCMN. The document model allows referencing any information, being it structured data or any kind of documents. Decision tables of DMN are currently the only representation formalism for structured business logic. Any other business logic can be stored in a file and referenced via the document model.

Future versions of the Knowledge Work Designer will include support for other types of visual knowledge representation like class diagrams, semantic networks or ontologies.

Acknowledgement I thank Arianna Pierfranceschi, who implemented the BPCMN model type. She put a lot of effort in the attractive design of the model elements and the scripts, which make modelling in the Knowledge Work Designer enjoyable.

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