

# The Transparent Representation of Medical Decision Structures Based on the Example of Breast Cancer Treatment

D. Andrzejewski<sup>1</sup>, L. Tetzlaff<sup>1</sup>, J. DeBoer<sup>1</sup>, E. Beck<sup>1</sup> and N. Haeusler<sup>2</sup>

<sup>1</sup>University of Applied Computer Science Brandenburg, Department Informatics and Media,  
Magdeburger Straße 50, Brandenburg, Germany

<sup>2</sup>Städtisches Klinikum Brandenburg GmbH, Geburtshilfe und Frauenheilkunde, Brandenburg, Germany

Keywords: Medical Decision Structures, Representation, Decision Support, DMN.

Abstract: Choosing the appropriate treatment for patients have a direct influence on each patient's future. A doctor's expertise, the patient's preferences, and the current medical research have a highly influence on the choice of the treatment. Doctors shall be aware of their own decision patterns, the most influenced factors and the relevant literature by choosing the optimal patients treatments. By considering quality management and certifications, transparent representations of internal processes with simple decision-making notes are required. In support of the hypothesis, a decision analysis was conducted based on the S3 guideline for diagnosis, treatment and follow up care of breast cancer. A notation is required, which combines the process modeling and the representation of (medical) decisions.

## 1 INTRODUCTION

A transparent representation of processes is a useful gadget for physicians and other medical professionals, especially considering the requirements for quality management and certifications. Medical decisions are generally based on physicians' expertise, patients' preferences and the relevant recommendations based on the best available medical evidence. However, most decision structures are only "present in the medical experts head", which means, they are not at hand in a standardized, structured and thus "non-expert-understandable" form. The representation of decisions has been modelled in the past with The Decision Model (von Halle, Goldberg, 2009). In our partner clinic "Städtisches Klinikum Brandenburg GmbH" the representation of processes and decisions will be modelled mostly with Microsoft Visio. This representation has the main problem that the clarity and comprehension suffer. The Object Management Group developed the Decision Model Notation (DMN) as possibility to represent decisions transparently in an easy way of understanding and handling (Object Management Group, 2014). Therefore this paper tries to answer the question if a representation of medical decisions with DMN is

possible. Also the supporting data are required for a transparent decision representation.

## 2 MATERIAL AND METHODS

### 2.1 Decision Model Notation (DMN)

The Object Management Group (OMG) published in January 2014 the first Beta version of Decision Model Notation (DMN). The primary goal of this notation is design readable, understandable and transparent decision models for every kind of user.

DMN is a new standard to combine business decision design and decision implementation. Those decisions need to be analysed and represented (Object Management Group, 2014). The three aspects of modelling are as followed: Business Processes (e.g. modelled in BPMN), Decision Requirements Diagram (modelled in DMN) and the Decision Logic. A Business Process Model is e.g. a transparent representation of an internal procedure of a company. A Decision Requirements Diagram is a diagram to represent the decision with different elements (like knowledge elements or input data elements) and the Decision Logic represents the analysed rules in form

of a decision table. Figure 1 shows the three aspects of modelling.

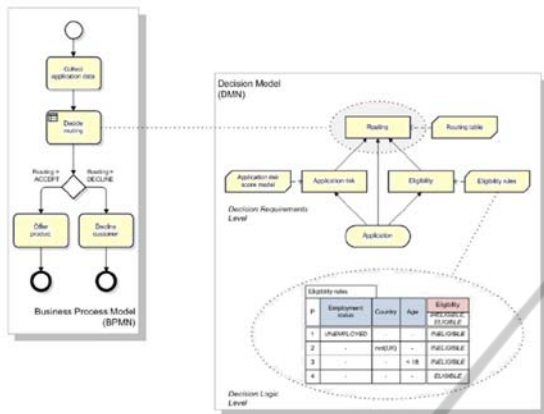


Figure 1: Three aspects of modelling (OMG, 2014).

It is very important to understand that there are two different standards for modelling decisions which are defined as followed:

- Business process modelling, using e.g. Business Process Model and Notation (BPMN).
- Decision logic, which defines business rules by the way of decision tables and can be used for individual decisions.

In BPMN it is possible to define business rules via the BPMN Business Rule task. This task is the link to the DMN notation. At this time there is currently no tool which combines the modelling with BPMN and DMN, except the Signavio Process Editor. The intension of DMN is to combine business process models and decisions logics (Object Management Group, 2014). The following three aspects of modelling are relevant:

- Business process models are defining tasks in procedures, which may include decisions to be reached.
- Decision requirements diagrams (DRDs) specify the kind of decision to be made and the information required. DRDs consist of different elements: the specified decision, required business knowledge, an Input-Data-Model, the knowledge source and the different connectors to model the flows which combine these elements (information, knowledge and authority requirements).
- Decision logics should represent the necessary decisions in such detailed manner that valid decisions in an automated fashion can be made details for validate decisions and automate the decisions also.

Figure 2 visualizes the elements of DMN:

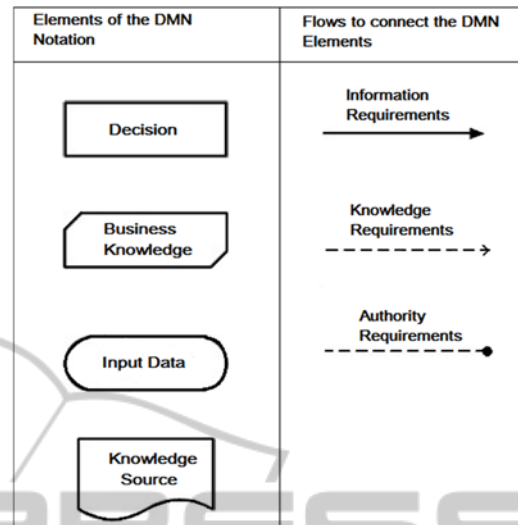


Figure 2: Elements of the DMN (OMG, 2014).

In summery a decision structure can be represented with a Decision Requirements Diagram (DRD) and a Decision Logic. Those can be combined also with a business process model in the relevant task.

## 2.2 Breast Cancer – Tumour Board and Relevant Decisions

Breast cancer is the most common malignant neoplasia in females in Germany, accounted for approximately 70.000 new cases per year. After confirming the diagnosis by histopathological examination, the attending physician will inform the patient about the further steps, which follow after diagnosis. In some cases prior to this, the patient’s case will be discussed in a pre-operative tumour conference. However, according to the S3-guideline (Kreienberg et.al, 2012) all cases will be discussed in the postoperative tumour board. The attending physician presents the individual case to the members of the board and recommends the patient-individual treatment choices. Then the board discusses the different options and finally decides which therapeutic regiment is the most promising, based on the recommendations of the S3-guideline. This decision will take place in form of a formal consensus. The decision is then formally documented and forms the basis for the further treatment. In figure 3 this process is visualized as BPMN model.

But which parameters are relevant for such a decision? According to Kreienberg et.al the patient’s age, her menopausal status, the expression of estrogen and/or progesterone receptor and HER2/neu status of

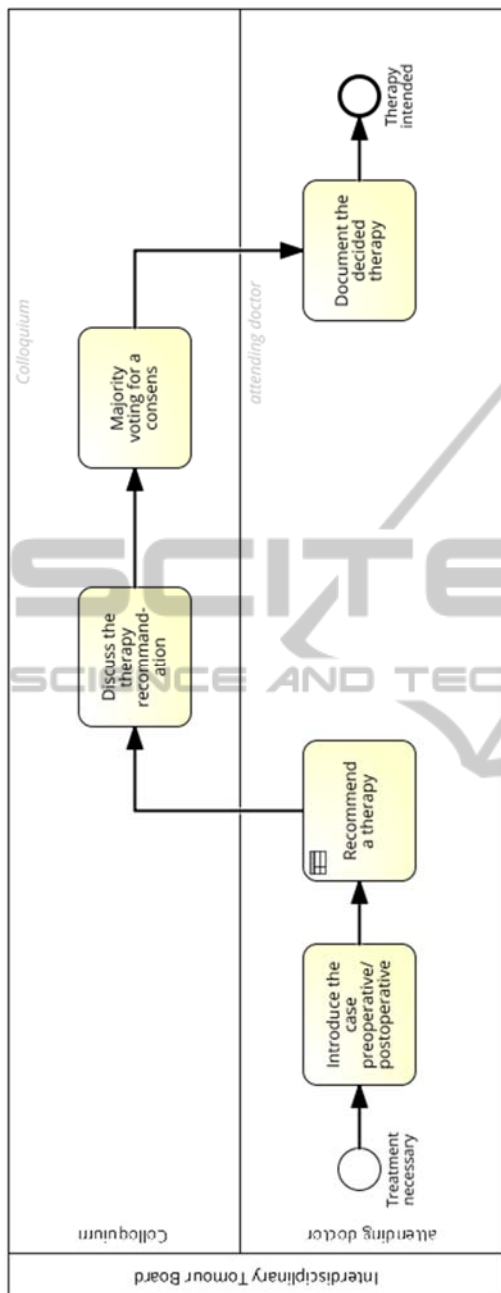


Figure 3: Tumour board modelled in BPMN.

the tumour, Grading and the tumour and lymph node classification are required.

For this paper the systemic treatment of the patient will only be considered – consisting of either chemotherapy or endocrine therapy, a combination of both modalities, and/or the anti HER-2/neu (Human epidermal growth factor receptor 2) treatment. Based on the above listed tumour and patient related

parameters according to Kreienberg R. et.al: the following rules concerning therapeutic decisions can be derived:

- The patient’s menopausal status is required for the choice of the endocrine therapy
- A primary (neoadjuvant) chemotherapy should be recommended in cases of triple negative breast cancer (i.e. estrogen receptor and progesterone receptor and HER-2/neu negative tumours)
- A primary (neoadjuvant) chemotherapy is mandatory in cases of inflammatory breast cancer or advanced tumour stages (T4)
- A primary (neoadjuvant) chemotherapy could be recommended in cases with a positive HER-2/neu status and/or a pathological tumour size of  $\geq pT1c$  and a high grading (G2 or G3, or a positive nodal status and/or a positive HER2/neu status and/or a positive or negative hormone receptor (HR) status.
- In cases of positive HR status and a grading of G2 further tests like uPA/PAI1 or gene expression signatures can be performed
- Endocrine treatment (ET) is required in cases of positive HR-status
- Anti HER-2/neu antibody treatment is required in cases with positive HER2/neu status (which is always applied in combination or sequential to a chemotherapy regimen).

Tumour related parameters are important to describe the biology and pathology of the tumour. Gathered with patient related parameters, as the patient’s age and menopausal status, they are required to model valid DRDs. These parameters are the basement of the breast cancer treatment and they are represented as Input-Data-Model in a DRD. The most relevant knowledge source is the S3 guideline, published by the German Cancer Society. The current statements of the guideline however may be modified by other relevant literature (Kreienberg R., 2012, Woecke A., 2010, Wolters R, 2011).

### 3 RESULTS

The results are represented in two major sections – the graphical representation of the treatment decisions for breast cancer modelled in DMN and a representation of the deduced rules in a decision table. For a representation of the treatment in DMN three elements are required: decision element, knowledge source and Input-Data-element. The decision element will be labelled with the name “(systemic) therapy

decision for breast cancer”, the two Input-Data-elements will be labelled with “Tumour and Patient related parameters” and the knowledge source will be labelled with “S3 guideline”. The following figure 4 shows the treatment of breast cancer in DMN.

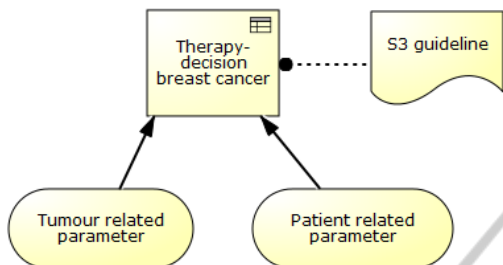


Figure 4: therapeutic decision model of breast cancer (DMN).

A draft of the decision logic is shown in table 1. Besides rather simple rules like: “If the patient’s tumour expresses HER-2/neu, then an anti HER-2/neu antibody treatment is required” and “If an anti-HER-2/neu treatment is indicated this has to be applied simultaneously or sequentially to chemotherapy”, there are a number of more or less complex rules. The example for the easy rules extending the decision elements to: hormone receptor status (positive or negative), HER2/neu status (positive or, negative), Grading (G2, G3) and therapy (chemo- and anti HER2 therapy (CT+T), chemo-, anti HER2 and hormone therapy (CT+T+ET)).

Table 1: example for easy rules.

ER/PgR status	HER2/neu status	Grading	Therapy
negative	positive	G3	chemo- and anti HER2 therapy
positive	positive	G2	chemo-, anti HER2 and hormone therapy
...	...	...	...

Examples of more complex rules are e.g. those, based on the current recommendation of the St. Gallen consensus meeting (Goldhirsch, 2011, Kreienberg 2012) as shown in table 2.

In cases of an intermediate grading (G2) and a positive HR-status the decision rules are modified by introducing the concepts of luminal A and B like tumors. Luminal B-like tumors are defined either by

Table 2: Risk and therapy decision on breast cancer subtypes based on (Goldhirsch, 2011).

Sub-type	Luminal A like	Luminal B like	Luminal B like	Non luminal	Triple negative
ER/PgR	+	+	+	-	-
HER2	-	-	+	+	-
Ki-67	Low < 14%/G1	High > 14%/G3	n/a	n/a	n/a
therapy	ET	CT + ET	CT + T + ET	CT + T	CT

ET: Endocrine Therapy, CT: Chemotherapy, T: Trastuzumab a positive HER-2/neu status or are Ki-67 proliferation index of > 14%. In cases of luminal A like tumors an endocrine regimen is sufficient, in cases of luminal B like tumors a combination of endocrine and chemotherapy is required. Table 3 transforms the criteria of the St. Gallen consensus in a clear cut decision table.

Table 3: St. Gallen Consensus meeting – decision table.

ER/PgR status	HER2/neu Status	Grading	Ki67	Therapy
positive	negative	G2	high	CT + ET
positive	negative	G2	low	ET
...	...	...	...	...

The example tables can be modelled as a decision table in DMN as decision logic. This DMN table representation is not considered in this paper.

## 4 CONCLUSIONS

A mandatory regarding the increasing complexity of clinical decisions as well as patient self-determination. This aim in our view can be achieved by modelling decision requirements diagrams using the Decision Management Notation. The representation of business rules is likewise achievable by means of defining a decision logic- therefore the decision rules must be analysed in the first instance

and then represented in DMN. DMN results from a combination of Business Process Management and Decision Management (OMG, 2014). Business Process Management is required for the transparent representation of business processes and procedures – the Business Process Model and Notation (BPMN) being one of the possibilities for modelling the processes. For the analysis of business rules a structured approach is required. According to Taylor there are four principles to be kept in mind when analysing decision rules (Taylor, 2011).

1. Model the decisions, which are in the experts head
2. Be flexible, transparent and agile for changes
3. Be predictable
4. Combine all three rules and continue with the first task

The recommendations are proven as good approach for the analysis of business rules. However, to our knowledge, there are no recent papers concerning this approach in medicine. Further work is now centred on the validation of our so far analysed and modelled decision rules. Physicians and other medical staff can benefit from transparent representation of the processes and the modelled decision rules.

## REFERENCES

- Kreienberg R. et al, (2012) *Interdisziplinäre S3 Leitlinie zur Diagnostik, Therapie und Nachsorge des Mammakarzinoms*.
- Goldhirsch et al, (2011) *Strategies for subtypes – dealing with the diversity of breast cancer: highlights of the St Gallen International Expert Consensus on the Primary Therapy of Early Breast Cancer 2011*.
- von Halle B und Goldberg L, (2009) *The Decision Model*, 1<sup>st</sup> Edition, 2009.
- Woecke A. et al, (2010) *Impact of Guideline Conformity on Breast Cancer Therapy: Result of a 13-Year Retrospective Cohort* (2010).
- Wolters R. et al, (2011) *Auswirkungen leitlinienkonformer Therapie auf das Überleben von Patientinnen mit primärem Mammakarzinom – Ergebnisse einer retrospektiven Kohortenstudie* (2011).
- Taylor J., (2011) *Decision Management Systems*, 1<sup>st</sup> Edition, 2011.
- Object Management Group (OMG), *Decision Model Notation (DMN) Beta Version 1.0*, 2014.