Adoption and Implementation of the Decision Model and Notation Standard

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***Abstract*—In 2015, the Object Management Group published the Decision Model and Notation with the goal to structure and connect business processes, decisions and underlying business logic. Practice shows that several vendors adopted the DMN standard and (started to) integrate the standard with their tooling. However, practice also shows that there are vendors who (consciously) deviate from the DMN standard while still trying to achieve the goal DMN is set out to reach. This research aims to 1) analyze and benchmark available tooling and their accompanied languages according to the DMN-standard and 2) understand the different approaches to modeling decisions and underlying business logic of these vendor specific languages. We achieved the above by analyzing secondary data. In total, 22 decision modelling tools together with their languages were analyzed. The results of this study reveal six propositions with regards to the adoption of DMN with regards to the sample of tools. These results could be utilized to improve the tools as well as the DMN standard itself to improve adoption. Possible future research directions comprise the improvement of the generalizability of the results by including more tools available and utilizing different methods for the data collection and analysis as well as deeper analysis into the generation of DMN directly from tool-native languages.**

***Index Terms*— decision management, decision model and notation, adoption, tooling**

I. Introduction

Decisions are amongst the most important assets of an organization [1], [2]. A business decision (hereafter referred to as decision) is defined as: "A conclusion that a business arrives at through business logic and which the business has an interest in managing" [3]. An example of a decision is: determine whether someone is eligible for a loan. If an organization cannot consistently make and execute the right decision(s), larger risks can occur that eventually lead to severe consequences.

Decision management is receiving a lot of interest both from both research and practice [4], [5]. One development in the decision management domain is the introduction of the Decision Model and Notation (DMN) in September 2015, by the Object Management Group (OMG). The DMN standard focuses on modelling decisions and underlying business logic. The aim of DMN is to provide a common notation that is understandable by all stakeholders; business users and technical users alike. Furthermore, DMN is designed to be used alongside the BPMN standard and features integration mechanisms to integrate decisions and business logic with business processes. Business logic is defined as [6]: *"a collection of business rules, business decision tables, or executable analytic models to make individual decisions."*. Another benefit of DMN is the interchangeability it offers by utilizing XML as the underlying basis, which is a common standard in information systems design [7]. DMN recognizes two levels of abstraction for decisions: decision requirements and the decision logic. The decision requirements level is captured in a decision requirements diagram and is used to identify decisions, the input data and business knowledge needed to make the decision, and the knowledge source on which the decision logic is based. At the decision logic level, the business rules applied to make a decision are specified. The highest level of abstraction; represented with the Decision Requirements Diagram (DRD), recognizes four key concepts: 1) a decision, 2) business knowledge, 3) input data, and 4) a knowledge source. The decision logic level has no key concepts, as decision logic could be represented by different representations such as decision trees, decision tables, and/or natural or constrained languages. The representation selected to represent the decision logic does not influence the decision requirements level.

As DMN is classified as a standard developed by practice, its goal is to unify decision modelling as well as to improve the interchangeability of the modeled decisions and business logic between stakeholders. Practice has showed that a maturing market inherently seeks standardization. An important aspect of all these emerging standards is their interchangeability [8], [9]. For example, governmental organizations that implement and execute law and regulations often design and execute (parts of) the same laws and regulations. However, such organizations are often characterized by decentral IT strategy, which results in the implementation of very

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different tools to model decisions and business logic per organization, that could even differ per department in the same organization [10]. Situations like these highlight the cogency of a horizontally integrated standardized modeling notation or the availability of interchangeable components. This research aims to evaluate coherency between the languages and standards used in commercial tooling to further develop the interchangeability of DMN. This would lead to enhanced interchangeability and increased adoption throughout practice [8], [9]. Hence the following research question is stated: “How is the Decision Model and Notation standard adopted and implemented in current decision-management software?”

The remainder of this paper is structured as follows: in the next section, the background and related work, will elaborate on DMN and what constitutes a language, which will be the basis for our analysis. Then, the research method is presented. This is followed by the data collection and analysis, in which we elaborate how the data was acquired and how the analysis was performed. Next, the results of the analysis are presented and structured. Lastly, a conclusion is drawn, limitations are acknowledged, and future research directions are discussed.

II. Background and Related Work

The constructs of the DMN modelling language are elaborated in detail in the OMG standard [6]. However, to ground our work, a summary of the utilized modelling elements is provided in DMN modeling elements. OMG [6] recognizes two levels of abstraction for decisions: decision requirements and decision logic. The decision requirements level is captured in a DRD and is used to identify business decisions, the input data, the business knowledge needed to make the decision, and the knowledge source which denotes the authority for the decision logic.

For each decision in the DRD, the business knowledge represents the underlying business logic that is required to execute the actual decision. This can be performed by a human or a machine, from which the latter requires very strict specification and verification in order to function properly. The decision logic level has multiple key concepts which, according to the DMN standard, are described in two languages: The Friendly Enough Expression Language (FEEL) and the Simple FEEL variant (SFEEL). SFEEL is a subset of FEEL, tailored for simple expressions in conjunction to be utilized in decision tables. However, the same concepts of SFEEL and FEEL can be expressed in multiple other languages. The language selected to represent the decision logic does not influence the elements in the DRD. As each organization utilize different means to represent business logic, such as work instruction, business processes, and informal documentation, the decision logic layer is not addressed in this paper.

Decision Modelling (DM) notations can be categorized by their complexity and linguistic power [11]. Complexity refers to the ease of understanding the DM notation and linguistic power refers to the amount of results it can produce, indicating its richness [11], [12]. Five different types of DM notations can be recognized: 1) labels, textual markers, 2) graphical aids, symbols representing semantic constructs, 3) structured languages, semantic representations of logic, 4) constrained natural languages, ontology defined by base terms and grammar, and 5) pure natural languages, unbound syntax, see DM Notation categorization [11].

To give a better understanding of the different types of DM notations, examples are given to elaborate upon them. Since some categories are quite similar and would introduce difficulty if explored separately, some categorizations have been conjoined. Labels and Graphical Aids have been conjoined because they are similar in their visual representation and rarely used separately in decision-management tools and Constrained Natural Languages and Pure Natural Languages are conjoined because they are similar in usage and decision-management tools using only Pure Natural Languages are, to the knowledge of the authors, not available yet. The first category is labels and graphical aids. Examples of decision management tools using labels or graphical aids are Visual Rules, FlexRule, and Berkley Bridge. These types of languages make use of shapes and, incidentally, colors. The second category is structured languages. An example of this is Conceptual Modelling Language (CML) [13]. The ontology can be described as a meta model describing the structure of the domain knowledge. These kinds of languages dissect and categorize knowledge. The third and last category is constrained natural languages and pure natural languages. Constrained natural languages are most similar to programming languages, making it somewhat end-user unfriendly. These kinds of languages try to resemble decisions through (semi-)complete sentences, as if they were spoken out loud.

The myriad of available decision modeling tool introduces two problems. The first problem is seen in the selection of an appropriate tool. The high number of tools available, it is difficult to compare them with each other, making it difficult to differentiate between them. The second problem arrives arises after the purchase of a given tool. The difference between the tools, the interchangeability decreases, making it difficult to integrate existing decision requirements and business logic into a new tool [8], [9]. Due to these problems, this research does not discriminate the commercial offerings based on their respected language type choice.

Some terminology used in this research requires to be defined to avoid confusion. These terms might have various other definitions in other research area and might therefore be misinterpreted. The first term is interchangeability. Interchangeable software has increased flexibility. It enables a tool to integrate a standardized component which can also be used in other tools. A standardized component which can be integrated into a different tool is defined as interchangeable [14]. When a tool has similar aspects to other tools it is defined as homogeneity. It differs from familiarity because it is compares decision management tool to each other, while familiarity compares against different software in general.

III. Research Method

Information about the decision modeling tools was retrieved by a free search on the internet or through contact with the vendor [15], [16]. Two criteria were applied while searching for information. The first criterion was that the available information about the tool under analysis must be adequate. For example, in some cases, only a mere one-page document without any information about the inner workings of the tool and only a generic explanation of the possibilities of features was available. The information was deemed adequate if it allowed the researcher to evaluate the four aspects listed below. This allowed for each tool to be evaluated on the same aspects. The second criterion was that a tool should be able to facilitate modeling of decisions and business logic that fall in line with one of the three categories elaborated upon in the previous section. The tools were evaluated according to four aspects. In part, these aspects show the adherence of a tool to the DMN standard and their approach to business rules. Additionally, they provide a snapshot of the current commercial perspective on decision management which can be analyzed alongside coding families introduced by [17].

Aspect one: *Does the tool bare any similarities with the seven elements of DMN?* The adherence of a tool to DMN was assessed by concluding whether it included any of the seven elements of DMN.

Aspect two: *How does the tool approach decisions?* Each tool has a (slightly) different way of approaching decisions. One might focus on user-friendliness by enabling low-level end users to interact with the tool without having to program any code while others might focus on time-to-market for decisions by enabling the end users to test and deploy the decision as fast as possible.

Aspect three: *How does the vendor-specific approach/language differ from DMN?* The chance to reflect on what exactly the tool does differently than DMN can be of much value. The goal of this reflection is to explore more ways for DMN to potentially improve its interchangeability.

Aspect four: *Which elements of the vendor-specific approach/language are absent in DMN?* Elements have been observed with a broad interpretation. Elements in DMN are purely graphical. However, not all tools that are included in the dataset are graphical tools. Hence, some liberty has been taken to identify elements in certain tools. Knowing which elements are absent in DMN might provide new perspectives to which elements could be added to DMN, and possibly why these should be added.

IV. Data Collection and Analysis

The data collection comprised three stages. All tools that abided to both previous stated criteria were placed into our dataset, see Table I. This dataset was coded by answering four aspects. The first stage started with indexing all decision tools that adhered to the first criterion. In the second stage, information about the tools was retrieved via vendor webpages as well as third party sites such as community sites and forums. These searches yielded user guides, fact sheets, brochures, instruction videos, community forums, or wiki pages. The tools themselves were not accessed due to time constrains and because not all tools offer a demo/trail version of their software. If no information was retrieved via this method, the vendor was contacted to request the necessary information about the tool needed to code it. If neither of these methods provided reliable or adequate information about the tool, the tool was removed from the dataset. In total, 23 tools were included in the dataset, 3 were contacted for further information, and 8 were excluded due to lack of data. The tools and the forthcoming languages they offer are being used synonyms in this research due to their lack of semantic power in certain situations and because currently, there are few tools that adhere completely to any standard notation of found in decision management, meaning that a tool is very often vendor-specific.

After all the information had been gathered, the coding process began. The information about each tool was analyzed and, subsequently, the four questions were answered. For example, when analyzing the tool Berkley Publisher, we found no adherence to the elements of the DMN standard, as analyzed per aspect one. However, further analysis showed that the tool has partial matches with DRD elements. They allow for a decision node to be created in which the end-user can add business knowledge and input data through constrained language and add a knowledge source through, for example, linking to a website. The visual notation used in Berkley Publisher was not similar to DMN, they are both graphical but do not have the same elements. Besides the graphical difference however, they have the same approach to decision management, and both contain graphical elements. To further ensure the validity of the analysis, sample-wise reliability coding has been done. The reliability coding was executed by coding individually and sample-wise comparing the outcomes of the coding instances. By following the recommendation of [18], 10% of the content was subjected to sample-wise comparing.

V. Results

Each tool has been given a pass or fail with respect to the aspects analyzed, see Table 1. The order of the tools does not represent their importance to the research, and they should not be compared to each other based on this table. This table shows the adherence of commercial software to DMN.

The one-to-one adherence to graphical elements and concepts of DMN was evaluated according to aspect one. If a tool had all the same graphical elements of DMN, it is coded as "√", otherwise with "X". For example, Sparkling Logic fully integrated the DMN standard, this includes the graphical elements. If a tool contained graphical elements that did not adhere to the DMN standard they were coded as "X" in the "Adherence to graphical elements of DMN" column and coded as "√" in the "Contains graphical elements" column. This is done to show the preference of tooling for graphical or non-graphical vendor-specific languages.

TABLE I. ADHERENCE OF COMMERCIAL SOFTWARE TO DMN

Vendor	One-to-one adherence to graphical elements and concepts of DMN	Contains graphical elements	Adherence to DRD concepts	Different approach from DMN
ACTICO	√	√	√	X
Berkley Publisher	X	√	√	√
Bosch	X	√	√	√
CA Aion	X	X	X	√
Camunda	√	√	√	X
Corticon	X	X	X	√
Decisions.com	X	√	√	√
FlexRule	√	√	√	√
IBM	X	X	X	√
IDIOM	X	√	√	X
Microfocus	X	√	X	√
OpenRules	X	X	X	√
Oracle	X	√	√	√
Pega	X	√	√	√
Red Hat	X	X	X	√
SAP	X	√	√	√
Sapiens	X	√	√	√
SAS	X	√	√	√
Signavio	√	√	√	X
Software AG	X	√	√	√
Sparkling Logic	√	√	√	√
VisiRule	X	√	√	√
XpertRule	X	X	√	√

The adherence to DRD elements of DMN was also evaluated according to aspect one, but only with regards to the seven elements of the DRD. If a tool adhered to each of these elements, it was coded as "√" in the "Adherence to DRD concepts" column. This column helped us evaluate whether the tools differed in their approach to decision management than DMN. If the tool did not adhere to either the graphical elements and concepts of DMN or the DRD of DMN, or focused on a more technical implementation (e.g., the end-user needs to be able to code in a specific coding language), it was coded as "√" in the "Different approach from DMN" column. These last two columns were approached with the coding families of grounded theory, as described in [17]. The coding families applied are 1) interactive family, 2) consensus family, 3) strategy family, and 4) cutting-point family. These led to propositions about the current state of the commercial offerings of decision management tools.

In total, six propositions have been drawn from the analysis. These lessons are portrait as observations, improvements opportunities, or statements. The analysis is a snapshot of the market, making it time sensitive. It should, therefore, be noted that these lessons may change over time and are subject to change.

Proposition 1) The quest for homogeneity and familiarity. This is prevalent in all three categories of decision model notations. Tools often try to subject their vendor-specific languages to previously established standards like Business Process Model and Notation (BPMN), Unified Modeling Language (UML), and ArchiMate. Attempting to integrate (parts of) these existing standards can be beneficial for the interchangeability, familiarity, and homogeneity of the vendor-specific language. For example, in the tools Software AG and SAP, which integrated BPMN elements and features like swim lanes to improve the familiarity of their tool to user formerly known with the BPMN standard.

The interchangeability does not necessarily improve by adhering to these standards, simply because it has the same appearance does not mean it works the same way. However, it seems to be a step in the right direction. Increasing the interchangeability of tools helps the adoption of all compatible standards [8], [9].

By adhering to the aesthetics, principles, or techniques of certain standards, the end-users could find themselves in somewhat familiar surroundings, increasing the familiarity of the end-user towards the tool. Familiarity is a strong aspect to advance the user-friendliness and adoption of software [19]. Applying this knowledge to DMN, it would be beneficial to introduce an adequate amount of familiarity to the visual elements. This familiarity should be prevalent within the surroundings of the end-users. Since the current familiarity of (expert and novice) end-users, with respect to the graphical elements, to DMN is inadequate, incorporating it could lead to further adoption and improvement of the notation [20].

Proposition 2) The vendor-initiated propensity for features instead of traceability. This is prevalent in all categories, but mostly with tools using constrained- or natural languages. Many tools focus on letting the end-user create, test, and publish decisions as efficiently as possible. This means that most tools focus on features, somewhat neglecting traceability. For example, the tool AC Aion features a more technical implementation of decision management. A more technical implementation allowed for more features but decreased the traceability due to the complexity the number of features introduced, especially for less technical end-users.

Traceability is an important aspect of decisions that is often overlooked [10], [21]. Due to the lack of tools with integrated traceability, the ability for end-users to trace back the origin of a decision is decreased, vastly reducing the (optional) transparency of the results to all stakeholders [22].

Different notation standards are opting for their own attempt at increasing the traceability of their notation. The Decision Model (TDM) is a notation found in various tools. This notation enables end-users to supplement their results with information about debugging, explanations, conclusion metadata, and traceability purposes [23]. This trend, and the theoretical background of traceability, should provide ample motivation for vendor-specific languages to introduce traceability features in their tools.

Proposition 3) The divergence of supply and demand. Available tools seem to diverge from the theoretical demands as vendors tend to focus on more features and capabilities, while end-users are in need of traceability features and increased user-friendliness [22], [24]. If the user-friendliness of DMN, a graphical language, would be measured alongside its visual adequacy, research suggests the user-friendliness of DMN can be improved by adhering to various graphical standards [12] [25]. There seems to be no need for additional traceability features to be integrated into DMN since it already offers ample solutions. Additionally, vendors could decide to improve their tools according to the, through the literature perceived, theoretical demand, like traceability and user-friendliness [22], [26]. By incorporating more homogeneous features, interchangeability might also increase.

Proposition 4) The integration of existing techniques. Some tools opted to integrate proven and existing techniques. For example, some tools borrowed the "swimming lanes" concept of BPMN and adjusted it to support graphical representations of decisions. This enables end-users to simplify complex diagram by making it easier to perceive the responsible actor and improves their familiarity with the tool. For example, the tools Software AG and SAP integrated the BPMN standard and the tool Oracle integrated the UML standard.

DMN has no option to assign actors to specific decisions or rule families. This puts DMN at a disadvantage when confronting complex diagrams. So far, tools like SAP have integrated swimming lanes as a vendor-specific language aspect. However, since DMN is already designed to work with BPMN, it could be integrated into the standard as well [6].

Since swimming lanes are a graphical concept, purely constrained- or natural language would have no benefits from this. However, they could introduce actors and accompany it with user management. Some tools, like Sparkling Logic, already have user management integrated into their tools but are not transparent about which actors are responsible for which decisions.

Proposition 5) A closed marketspace. In this context, a closed marketspace is defined as a marketspace which offers little information about their tools on first inspection, requiring the need for information requests before allowing more insight into their tools. They often do not have the specific features listed or show little of the user interface that accompanies the tool. Since the data used in our analysis is retrieved from freely available sources only, this information might be made available for the user after requesting a quotation or getting a trial-license/demo (if available). However, in total, 8 tools have been removed from the dataset due to the available information being inadequate. For example, the tools Opentext, InRule, and Fico were removed due to the absence of available information.

Proposition 6) The separation of preferences. This ties in with proposition 5. It is noticeable that tools that have integrated a standard notation are open about this practice and are generally more open about their software, whilst other tools don't mention the existence of standard notations, preferring their vendor-specific language. This makes for an interesting separation of vendor-specific preferences. However, as with proposition 5, due to the limitations of this research, it is improbable that it has an influence on the openness of this system. Therefore, it must be considered as a general observation. For example, Camunda explain the DMN standard in full on the homepage of their website.

VI. Conclusion

In this research, 23 decision management tools were reviewed to assess their adherence to DMN. This review resulted into to six propositions. From a practical perspective, developers of decision management tools can use the propositions to improve their tool and map out future development directions for their tools. This would be beneficial for the adoption of decision management and would increase the adoption of standards in the decision management tool market, both maturing the market further. From a theoretical perspective, these propositions can be used to review decision managed tools, broaden one's view of the decision management market, and further develop DMN as an interchangeable standard. This last point is the focal point of this research, as conventional wisdom suggests that maturing markets naturally strive for standardization [9]. Additionally, these standards should be interchangeable to increase adoption throughout the market [8], [22]. Our research shows that even though many tools have not integrated DMN, they use similar elements to convey decisions to their end-users. This trend could, in a more mature market, translate to improved interchangeability in DMN and decision management tools.

VII. Discussion and Future Research

This research has several limitations. The analysis is conducted using secondary data, meaning the tools were not used, only the documentation identified and provided was used. This could limit the researcher's ability to know all the features a tool as to offer. Furthermore, it is possible not all secondary data that was available for a tool has been identified. Both have an impact on the reliability of the analysis. Furthermore, the market is low in maturity, meaning it is increasingly susceptive to change. This could influence the long-term relevance of the analysis; however, we argue that it provides a view of the current practices regarding the adoption of DMN. Our research also revealed several directions for future research. The first direction comprises the inclusion of additional vendors and languages to improve the generalizability of our findings regarding the adherence of DMN in the available tooling. We currently based our data collection and analysis on secondary data only, however, future research should also include the rationale behind the design choices behind not or partly adhering to the DMN standard, which could answer the 'why' question regarding the (non-)adherence to DMN. Deriving these rationales is imperative to understand the adoption and how to further improve the DMN standard to increase interchangeability in the future. Another future research direction would be the analysis of tools that allow for automatic transformation to the DMN standard.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

RP conducted most of the data collection and analysis that was part of this study. KS contributed mostly to writing this paper, while MZ was mainly involved in reviewing the analysis and paper itself. All authors approved the final version.

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