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# Ontology-based Visualization for Business Model Design

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**Abstract.** The goal of this paper is to demonstrate the feasibility of combining visualization and reasoning for business model design by combining the machine-interpretability of ontologies with a further development of the widely accepted business modeling tool, the Business Model Canvas (BMC). Since ontologies are a machine-interpretable representation of enterprise knowledge and thus, not very adequate for human interpretation, we present a tool that combines the graphical and human interpretable representation of BMC with a business model ontology. The tool connects a business model with reusable data and interoperability to other intelligent business information systems so that additional functionalities are made possible, such as a comparison between business models. This research follows the design science strategy with a qualitative approach by applying literature research, expert interviews, and desk research. The developed AOAME4BMC tool consists of the frontend, a graphical web-based representation of an enhanced BMC, a web service for the data exchange with the backend, and a specific ontology for the machine-interpretable representation of a business model. The results suggest that the developed tool AOAME4BMC supports the suitability of an ontology-based representation for business model design.

**Keywords:** Business Model Design · Ontology · Agile and Ontology-aided Meta-Modeling · Business Model Canvas

## 1 Introduction

Today, more and more competition takes place not only between products, services, or processes but between business models [15]. Therefore, companies continue to improve and innovate their current business model to sustain in today's fast-paced world [8,6]. Companies that have decided to undertake an innovative transformation of their business model have found themselves to be more competitive in today's market [54]. Several strategies on how to perform business model innovation exist [15,5,16,49] and all have in common that the current business model is defined in detail at first.

There are different tools to describe a business model, such as the Business Model Canvas (BMC) by Osterwalder and Pigneur [42] or Business Modeling Starter Kit by Breuer [5]. Nevertheless, there is missing a tool to describe the business model not only in more detail than the BMC but also in supporting the reusability of data and interoperability to other intelligent business information systems. This reusability of the specified business model would also allow the company to compare its business model to other business models and to gain knowledge out of it.

Graphical and text-based business models like BMC are intended for use by humans, who can easily interpret them. Having a machine-interpretable representation would increase finding and comparing similar business models. Ontology-based representations of enterprise knowledge are machine-interpretable [22]. Combining machine-interpretable and human-interpretable representation allows for using the same models both by humans and machines [29,21].

Thus, the goal of this research is to develop a machine-interpretable representation of the Business Model Canvas and combine it with the graphical representation to make business models comparable and the knowledge about business models reusable. The research has the objective to answer the following research question: how can business model design be supported by combining visualization and reasoning over the models? The developed ontology provides a systematic structure for business models. Furthermore, the approach provides an agile visual representation for a business modeler. Since the approach collects the business model based on an ontology's structure, the collected business models can be used for reasoning purposes to extract patterns of business models and enable a comparison of them.

The outcome of this research is used for a web-based tool, which supports businesses on their business model innovation process by providing previously collected business model innovation cases and match them to the company's individual business model. This process allows showing the impact the proposed new business model would have on the current one. This also allows providing information to estimate the business model transformation costs in detail. The challenge is to integrate the visual representation into the ontology and to allow the modeler to have an agile experience during the business modeling process.

This paper is organized as follows: state of the art is discussed in Section 2 and our applied research method in Section 3. Section 4 describes our concept of an ontology-based business model. The implementation of the ontology into a web-based agile visualization software is presented in Section 5 and evaluated in Section 6. The conclusion in Section 7 closes this research paper and outlines future research areas.

## 2 State of the Art

### 2.1 Business Model

There is no commonly used definition for the term business model within the literature [2,36,43,47]. Yet, researchers agree that a business model is a conceptual

model of different parts of a business, which can be seen as a blueprint [43,51]. Also, there has been done in-depth literature analysis regarding the elements of business models [47]. The outcome of that literature analysis provides the main elements of a business model, which are the features of the offering, customer interface including the market segments, financial aspects such as the revenue streams, as well as some mechanism to create value included within the element of infrastructure [42,43,47,51,9,45]. One can also classify the same business model elements into customer value proposition, profit formula, key resources, and key processes [26]. Another view is to distinguish the characteristics of a business model by aggregating four value types: value proposition, value delivery, value capture, and value creation [10]. While the features of the product or service are part of the value proposition, the market segment is part of the value delivery. The revenue streams are covered through the value capture and the value creation mechanisms can be mapped to value creation.

## 2.2 Business Model Visualization

There exist different forms to visualize a business model [17,19]. A business model can be visualized as a classification schema, in a transactional form, a cyclical form, or as a sequential model [17]. A classification schema of a business model consists of a set of components and thus, categorizes the business model [17]. An often-used tool for this visualization type is the Business Model Canvas by Osterwalder and Pigneur [42]. The drawback of it is that the value creation process is not visually shown to the viewer of the business model. A transactional business model is recommended for platform-based business model visualization, as it supports the visualization of exchange between the company, its partners, and its customers [24]. While a sequential form of a business model illustrates the model in a sequence of actions, a cyclical business model shows the model as a perpetual process [17]. The visualization form differs mainly concerning the type of information the business model should provide to a viewer. If the business model should deliver information regarding the different elements included within the business model, a categorized visualization is preferable [19]. However, if the business model should deliver information regarding the causal relationships between the business model elements, and thus, provide transformational information of a business model, it is usually illustrated using arrows between the different business model elements [18]. The understanding of the causal relationships between the different business model aspects is useful when it comes to e.g. the understanding of revenue generation [2,37].

A widely used approach to describe a business model in a structured and classified way is the Business Model Canvas (BMC) [42]. It is a tool to describe the business model of a company on a one-pager [14]. The model consists of nine building blocks: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure [42]. There exist several tools, which enable users to visualize their BMC online. A well-known online tool for BMC representation is the tool from Strategyzer AG, of which A. Osterwalder is a founding partner

[50]. Another online tool for BMC representation is the award-winning platform smartbusinessmodeler<sup>©</sup> (SMB) from Smart City Innovation Lab [48]. SMB is a result of academic research on sustainable business model patterns for business model innovation [33,34]. While the tool from Strategyzer is rather a simple virtual sticky-note-based whiteboard with the BMC as the background, the SMB is on the first glance very similar. Nevertheless, the SMB uses patterns from the entered value propositions within the business model to analyze it and find companies of similar value propositions. This information helps companies, especially start-ups, to identify possible competitors within their market. Yet, these solutions do not help in making the provided data of the business model machine-interpretable to treat it as knowledge of the company. Also, the data is not been reused further for analysis such as comparison with other business models for suggesting possible business model innovations.

### 2.3 Ontology-based Metamodeling

There is a clear gap between a human intelligible modeling language and a machine-interpretable language [21]. Humans prefer graphical or textual models, but computers require a formal language to interpret models. A possible approach is the usage of models that are “cognitively adequate for humans and processable by machines” [21].

A solution can be a variant to the Meta Object Facility (MOF) meta-modeling framework [41] where ontologies are used instead of UML as metamodeling language [21]. Through semantic lifting [1], a mapping is created to link graphical representation with the respective structure and semantics [23]. The ontology provides a formal semantics of the modeling language [25,28] such that related models are interpretable by machine.

Ontology-based metamodeling [23] allows the automatic linking of the graphical notation to the semantics in the ontology, generating models which are both machine-interpretable and human intelligible. Because of the automatic linking, ontology-based metamodeling is the basis for the solution presented in Section 5.

### 2.4 Enterprise Ontologies

Ontologies represent knowledge of a particular domain of interest that can be interpreted by machines and used for automated reasoning. An enterprise ontology is defined as “[...] the essential knowledge of the construction and the operation of the organization of an enterprise, completely independent of the ways in which they are realized and implemented” [12]. In the literature there are several examples of enterprise ontologies, some of the most well-known are in chronological order: the TOronto Virtual Enterprise (TOVE) [13], the Enterprise Ontology [52], Core Enterprise Ontology (CEO) [4], Context-Based Enterprise Ontology [32], and the ontology-based enterprise architecture [27].

The enterprise ontology ArchiMEO aggregates and semantically enriches the modeling language standards ArchiMate for enterprise architectures [22] and

BPMN for business processes [38,11]. In contrast to ontologies for single modeling language ontologies such as BPMN [42,43], ArchiMEO contains concepts of several disciplines allowing for cross-discipline applications like enterprise engineering, supply chain management, and risk assessment [10].

Among the different use cases and extensions of ArchiMEO, the interlinked case-based reasoning approach ICEBERG [35] for ontology-based case-based reasoning (OCBR) is relevant for reasoning over models. This extension of the ArchiMEO ontology enables an ontology-based design of a case-based reasoning system. It can be adapted for identifying and reusing known and successful business model innovations.

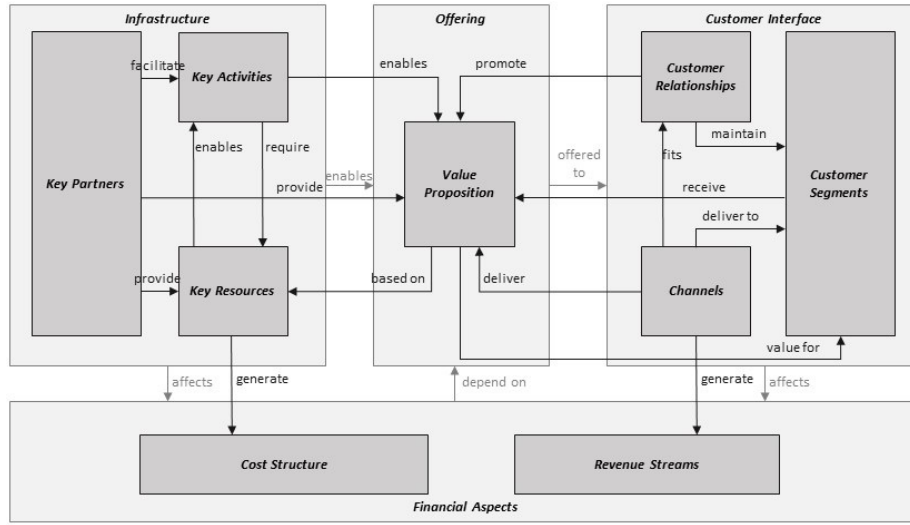
### 3 Research Method

The objective of combining the machine interpretability of ontologies with the widely accepted Business Model Canvas, has led to the decision to apply a design-oriented research approach. We follow the Design Science Research process model [20], which consists of five research phases: awareness of the problem, suggestion, development, evaluation of the artifact, and conclusion [53].

For the problem awareness, besides the literature research on business model design and ontology-based modeling, we collected 17 cases of business models through desk research and semi-structured interviews. The cases are from companies of different sizes and different sectors to have a diversified dataset for the analysis as well as for the evaluation of the ontology-based visualization for business model design. The results of this analysis in combination with the knowledge from the literature analysis, especially from Osterwalder's book regarding the Business Model Canvas [42], were used to build a concept of the tool. The procedure to develop the business model ontology was according to the approach of Noy and McGuinness [40]. The development and evaluation of the ontology and the business model visualization were done iteratively to create a sophisticated outcome. Once we extended the tool AOAME [29] with the ontology and the business model visualization, the artifact was applied to the collected business model cases to qualitatively evaluate the outcomes of the business models with the test use cases. The tool could formally populate the ontologies based on the BMC models. The research results were documented and will be used for further development on the tool. This research provide the grounding for the next extension of AOAME4BMC in which users will identify new business models and thus, improve their business model innovation via OCBR and/or other ontology-based reasoning technique.

### 4 Conceptual Solution of Ontology-Based Business Models

To integrate business model design in an ontology-aided modeling approach, we started by modeling the current well-known BMC as an ontology. The result of this BMC ontology is shown in Figure 1.



**Fig. 1.** The business model canvas ontology

The BMC was enhanced as the research has progressed since its release in 2010. One of the enhancements is regarding the key partnerships of a business model. Hereto the concept of an innovation ecosystem for creating innovations and also new business models was incorporated. Innovation ecosystems can be represented as quadruple helixes, which includes four types of partners: individuals, the government, academic institutes, and businesses [45,44,46] to declare for a business what kind of type their key partners are with which they do business. Also, it is simpler for a user to declare the type of their key partners, than to know why the partnership was done in the first place, as suggested by the BMC [42]. For the business model ontology, both views on key partnerships for businesses are included. Another enhancement of the BMC is the distinction between human interaction and non-human interaction when it comes to types of customer relationships. This distinction was done as in today's world, which is driving towards a high level of digitalization, the non-human customer relationship types enabled by new technological capabilities such as chatbots for customer counseling are emerging [7,39]. Thus, businesses can distinguish their way of interacting with their customers. Furthermore, the chosen customer relationship types can give inputs regarding the level of digitalization of a business. The concept of the final ontology for business model design is illustrated in Figure 2. In total, the developed business model ontology consists of 97 classes to define a business model in detail.

Both ontologies, the BMC ontology as well as the business model ontology, are required to run the developed online tool to create and represent the enhanced BMC. The BMC ontology acts as the language ontology and is required for the syntax of the tool, while the business model ontology represents the domain

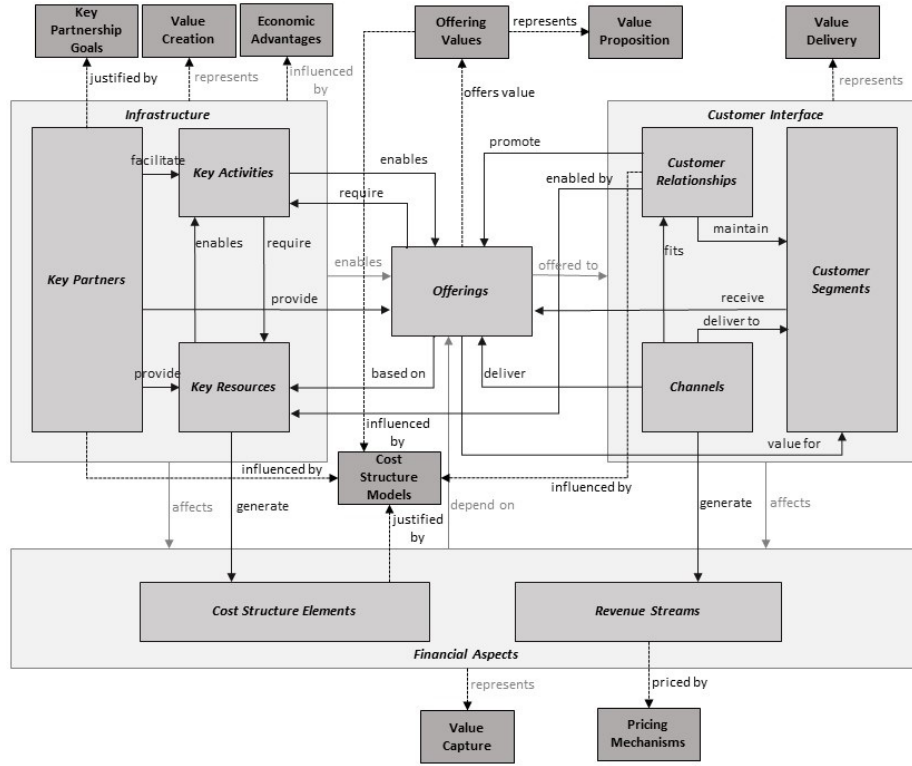


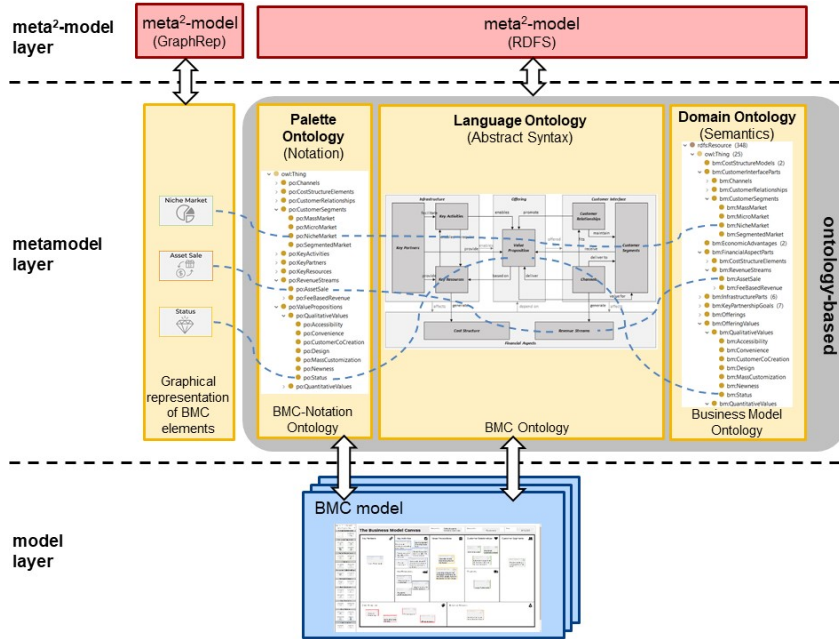
Fig. 2. The business model ontology

ontology and is required for the semantics of the tool. Also, a palette ontology for the BMC-notation was developed. The palette ontology represents the modeling notation [29]. For each BMC-notation a graphical element in the form of a sticky-note has been created. All three ontologies are based on the general language RDFS, thus, the ontologies can be reused in a modular way. The conceptual solution for the graphical representation of an ontology-based business model is shown in Figure 3.

## 5 Implementation of AOAME4BMC

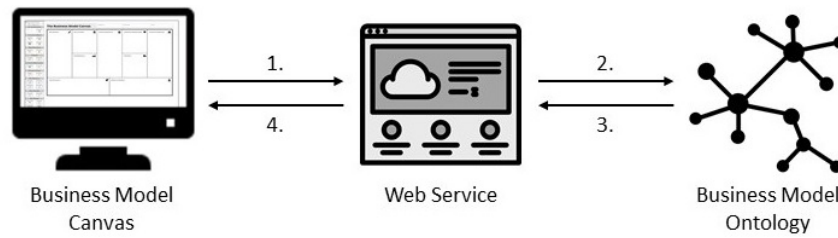
The resulting tool is called AOAME4BMC. It is implemented as an instantiation of the AOAME modeling environment [29] extending the ArchiMEO ontology with the above-mentioned business model ontology for the enhanced BMC. AOAME is implemented via a web service, a web application, and an ontology repository and shortly described in the following based on the work of [30]. The web service enables to create the link to the business model ontology and the web app. (1) The modeling environment through a web app calls the web service,





**Fig. 3.** Conceptual solution for a graphical representation of an ontology-based business model

(2) from which a query to the ontology is created. (3) The retrieved classes and instances from the query to the business model ontology (4) are shown graphically to the modeler. The interaction flow between the three players modeling environment, web service, and ontology is shown in Figure 4.



**Fig. 4.** Web service communication (adapted from [29])

Retrieving values from the ontology whenever the tool is launched ensures not only consistent modeling of business models but also the adaptability of the system. If new classes or properties are created within the ontology the modeler can directly use them within the modeling environment and vice-versa.

The user interface of AOAME4BMC for the modeler consists of a palette component and a model editor, as shown in Figure 5. It gets accessible after the modeler sets up the connection to the web service as described in the previous paragraph. The palette contains all the predefined graphical elements to fill the business model canvas, such as individual or government for key partnerships. These graphical elements represent the classes within the business model ontology and as such, there are also sub-classes as shown for Quantitative Values and its sub-class Performance in Figure 5. By clicking on the graphical elements in the palette, the related image for modeling appears in the model editor.

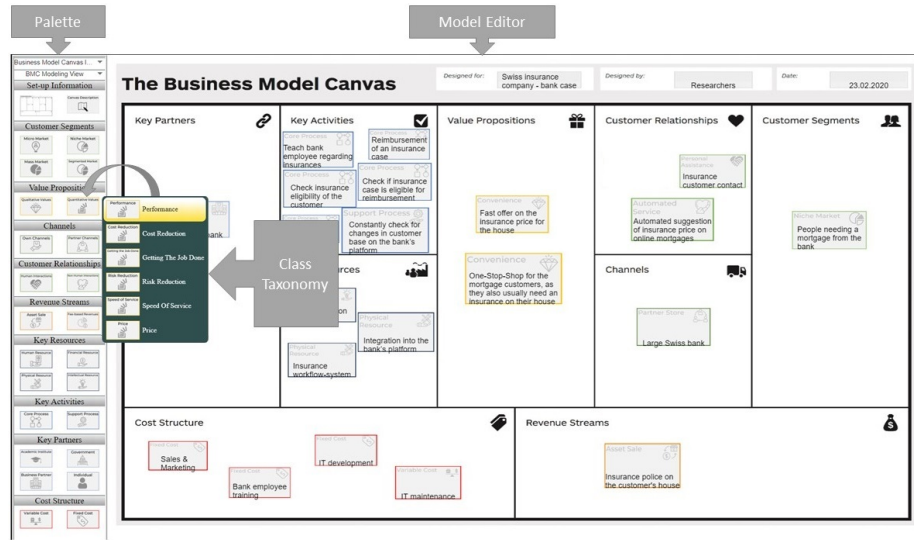


Fig. 5. View of the AOAME4BMC (adapted from [31])

## 6 Evaluation of AOAME4BMC

The evaluation of the ontology-based modeling approach for a BMC was performed qualitatively by modeling 17 previously defined business model use cases. This evaluation approach provides insights regarding the feasibility to have an ontology-based business model representation for machines to interpret the provided data from a user.

Seventeen business model cases were modeled to provide a heterogeneous data-set of different sectors and company sizes. Deeper insights are provided describing one of the use cases from the insurance sector, in the following section.

### 6.1 Description of the insurance use case

This insurance use case was developed through a semi-structured interview with a business architect from a big Swiss insurance company. The use case encompasses a specific business model for an insurance company, which has as its goal to partner with a financial institution to provide its insurance services directly to bank customers. Such insurance services can be household insurances, natural hazard insurance, or water damage insurance. The insurances are mainly relevant for real estate owners, which usually need a bank loan to buy their real estate. Therefore, the bank advisor would be the first person to know that a customer soon will become a real estate owner.

Since the bank advisor is the first person to get the information of new real estate owners, they are from an insurance sales perspective predestined to inform their customers regarding real estate related insurances. Thus, the Swiss insurance company decided to partner with a Swiss bank to have a new sales channel for their current insurance business model. This new sales channel not only affected their channel strategy but also new IT systems. New IT interfaces were required to provide real estate insurance information directly to bank advisors for their customer consultancy. Additionally, for bank advisors to provide qualitative insurance consultancy to their customers, the insurance had come up with a training concept and knowledge exchange between insurance advisors and bank advisors.

### 6.2 Application of AOAME4BMC on the insurance use case

Figure 5 depicts the representation of the business model within AOAME4BMC for the introduced insurance use case. For this use case, the key partner is a Swiss bank, which wants to offer to their customers an insurance coverage for their mortgage. The use case has two value propositions. First, an efficient way for a bank customer to get an offer for insurance regarding real estate topics, such as water damage insurance. Second, to receive all the relevant insurance information directly at the bank, which thus acts as a one-stop-shop for real estate owners.

The virtual sticky notes consist of three things to facilitate the identification of each sticky note for a modeler.

- On the background of the sticky note, the class of the building block is mentioned. The ontology guides the user in assigning the most specific class. For example, within the building block value proposition, there are two sticky notes of the sub-class qualitative value. Since qualitative value has sub-classes as well, the individual sub-class, in this case, the sub-class convenience, is mentioned on the sticky note.
- Each sticky note has an icon on the upper right corner depicted. This icon represents a class of each of the nine building blocks. For example, within the building block value proposition, since both sticky notes belong to the sub-class qualitative value, both sticky notes have the icon for qualitative value, a diamond.

- The sticky notes are color-coded based on the four domains of a business model and the color psychology for optimal web design by [3]. The domain infrastructure is colored in different shades of blue. The color blue should transmit the feeling of the firmness and the virtue of the backbone of the business model. The domain offering is colored in yellow because the value proposition should deliver success to the customer. The domain customer interface is colored in shades of green as the color of growth since the customer base of the company should grow through the business model. The fourth dimension, financial aspects, is colored in shades of red for signal cautiousness since the revenues should be higher than the costs.

The ontology allows for reasoning and semantic retrieval of information about business model. For example, when asking for qualitative value proposition, the two sticky notes from Figure 5 were retrieved, because "Convenience" is a subclass of the "qualitative value proposition". Also, more complex reasoning is possible. Asking for "Automated Services in a business model with qualitative value proposition" delivers "Calculation of insurance price".

## 7 Conclusion and Future Work

In this work, we highlight the feasibility of combining visualization and reasoning over models for business model design by combining the machine-interpretability of ontologies with the widely accepted business modeling tool, the Business Model Canvas, which is more adequate for human interpretation.

We have developed an ontology-based visualization tool for a business model design called AOAME4BMC, which supports the following three benefits: human interpretation, machine interpretation, and reasoning over models.

Regarding human interpretation, the tool AOAME4BMC serves a business modeler to create and represent an individual business model in a facilitated manner since the tool suggests different types of sticky notes for the canvas, which might be relevant for the modeler. Also, the evaluation has led to the conclusion that it is possible and helpful for the modeler to create and represent a business model in a facilitated manner using a specific ontology for business model design. The support of the modeling approach with the aid of color-coded business model building blocks, individual icons for each class, and the class name on the background of each sticky note facilitate the identification of each sticky note. This is for human interpretation since the modeler with a glimpse of an eye on a sticky note can identify to which building block of the business model the sticky note belongs, to which class within the building block. This helps for the representation as it supports an efficient understanding and interpretation of the created business model.

Machine interpretation is a benefit of ontology-based metamodeling, as it relies on an ontology for business model design, which is composed of 97 classes. Hereto future work will extend the business model ontology with the enterprise architecture ontology. This will provide an in-depth analysis of the business

model but also support decision making concerning the enterprise architecture on how to implement the business model.

The tool AOAME4BMC benefits of reasoning over models as it enables data and ontology reuse. Intelligent business information systems can be connected to the tool through which reasoning over the models can be conducted. Future work will include the combination of the AOAME4BMC tool with ontology-based case-based reasoning. This will allow us to compare different business models and to even recommend business models. If, for example, a business model is similar to the current situation except for the customer segment and channels, the approach could recommend business models that have the same infrastructure and the same features of the offering, yet for a different client base and through different channels.

Concluding, this research has shown that the previously defined research question can positively be answered. Supporting business model design by combining visualization and reasoning over the machine and human interpretable models is possible.

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