Metamodeling for Business Model Design

Facilitating development and communication of Business Model Canvas (BMC) models with an OMG standards-based metamodel.

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Abstract

Interest for business models and business modeling has increased rapidly since the mid-1990's and there are numerous approaches used to create business models. The business model concept has many definitions which can lead to confusion and slower progress in the research and development of business models. A business model ontology (BMO) was created in 2004 where the business model concept was conceptualized based on an analysis of existing literature. A few years later the Business Model Canvas (BMC) was published; a popular business modeling approach providing a high-level, semi-formal approach to create and communicate business models. While this approach is easy to use, the informality and high-level approach can cause ambiguity and it has limited computer-aided support available. In order to propose a solution to address this problem and facilitate the development and communication of Business Model Canvas models, two artifacts are created, demonstrated and evaluated; a structured metamodel for the Business Model Canvas and its implementation in an OMG standards-based modeling tool to provide tool support for BMC modeling.

This research is carried out following the design science approach where the artifacts are created to better understand and improve the identified problem. The problem and its background are explicated and the planned artifacts and requirements are outlined. The design and development of the artifacts are detailed and the resulting BMC metamodel is presented as a class diagram in Unified Modeling Language (UML) and implemented to provide tool support for BMC modeling. A demonstration with a business model and an evaluation is performed with expert interviews and informed arguments.

The creation of a BMC metamodel exposed some ambiguity in the definition and use of the Business Model Canvas and the importance of graphical presentation and flexibility in the tools used.

The evaluation of the resulting artifacts suggests that the artifacts do facilitate the development and communication of the Business Model Canvas models by improving the encapsulation and communication of information in a standardized way and thereby the goals of the research are met.

Keywords

Business Models, Business Model Canvas, BMC, Business Model Ontology, BMO, Metamodels, Meta models, Meta-models, UML, OMG, Model-driven Architecture, MDA, MetaModelAgent, MMA, Design Science, Modeling
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List of Acronyms

BM: Business Model
BMC: Business Model Canvas
CWM: Common Warehouse Metamodel
DS: Design Science
DSL: Domain Specific Language
MDA: Model-Driven Architecture
MM: Metamodel or meta-model
MMA: MetaModelAgent
MOF: Meta-Object Facility
OCL: Object Constraint Language
OMG: Object Management Group
PIM: Platform Independent Model
PSM: Platform specific Model
RSA: Rational Software Architect
UML: Unified Modeling Language
Introduction

Background

The interest for business models and business modeling has greatly increased with the advent of the Internet from the mid-1990s both within academia and practice (Zott, et al., 2011). While this increase is clear in the number of published academic and non-academic articles, the definition of the business model concept and its modeling approach is not as clear (Zott, et al., 2011).

The concept of a business model (BM) is defined and used in many ways both in academia and practice where its role generally includes understanding and communicating, analyzing, managing, innovating or even patenting the business ideas of a company (Osterwalder, et al., 2005) (Pateli & Giaglis, 2003). The lack of clear definitions can potentially lead to confusion and limitations on the research progress and development of business models (Zott, et al., 2011) and numerous efforts have been made to conceptualize and structure what a business model is. The creation of the Business Model Ontology (BMO) by Osterwalder (2004) is a well-known and established effort in this direction where the business model concept is detailed by specifying and conceptualizing business model terms, elements, relationships and semantics based on analysis of existing business models literature (Andersson, et al., 2006). Formalizing business models can provide a conceptual foundation for developing new methods and tools to facilitate the creation and communication of business models (Osterwalder, et al., 2004).

After creating the BMO definition and building on its business model concepts, Osterwalder and Pigneur (2010) defined a modeling approach called the Business Model Canvas (BMC). The BMC is a high-level and semi-formal approach for creating business models and is frequently used for BM innovation and creation. According to (www.businessmodelgeneration.com, 2012) there are over 5 million users of BMC and while the use of BMC is rapidly gaining popularity, the existing tool support for BMC is limited and mainly focuses on visual creativity, high-level attributes and link collection and lacks formal modeling support (Fritscher, 2008) (Osterwalder & Pigneur, 2010).

Both modelers and users of BMC models could potentially benefit from more formal tool support for the creation, detailing, verification and communication of BMC models (Osterwalder & Pigneur, 2010). A more formal tool support may help business modelers by providing consistency checking and help removing ambiguity by providing integrity constraints and other modeling guidelines (Osterwalder, et al., 2004).

The communication between business modelers, requirements engineers, software architects and developers can also potentially benefit from a clearer and more formalized representation of BMC in a standardized modeling language. One approach to facilitate improved modeling options and communication could be the transition of a BMC model to an OMG MDA-based model, based on a metamodel of BMC.
Problem

The Business Model Canvas (BMC) provides a shared language for visualizing, describing and working with business models and supports innovative and quick sketching of business models (Osterwalder & Pigneur, 2010). While the BMC modeling approach is informal and can be used with a great level of freedom, it lacks computer-aided tool support (Osterwalder & Pigneur, 2010) which could help with the level of details, specificity and consistency of the model when interpreting or communicating the resulting BMC models (Osterwalder, et al., 2005). The lack of tool support and clear BMC definitions makes it difficult to create a fully detailed BMC model including all elements, attributes and associations defined in the ontology behind BMC and makes it difficult to utilize the full scope of BMC in a consistent way.

The informality and freedom of BMC can cause ambiguity problems for BMC modeling and transforming the information effectively from BMC to an industry standard modeling environment has limited support. A BMC model can have limited value if it cannot be used or understood properly by other than the business modeler.

The identified research problems are:

- The lack of a standardized formal definition (metamodel) of BMC for its elements, attributes and relationships.
- The lack of tool support for business modelers to create a BMC model which can efficiently encapsulate and communicate the information needed in a consistent and standardized way.

Research goal

The goal of this research is to create a metamodel for the Business Model Canvas (BMC) and implement in an OMG standards-based tool to provide tool support to facilitate the development and communication of BMC business models.

The BMC metamodel can facilitate the creation of a clearer and fuller representation of the BMC model within the MDA framework and thus support moving the BMC model a step closer to an industry standard modeling environment and towards process/software implementation.

Target audience

The main target groups are business modelers, software modelers, architects and developers who could benefit from the information and support this thesis provides for creating BMC business models with formalized tool support based on the BMC metamodel in an OMG-standards based environment.

Limitations

This thesis will focus on the Business Model Canvas (BMC) as business modeling approach as defined in (Osterwalder & Pigneur, 2010) which is based on the Business Model Ontology (BMO) as detailed by Osterwalder (2004). The implementation of the BMC metamodel in an OMG-standards based environment will be done using IBM’s Rational Software Architect (RSA) as a modeling tool and utilizing the MetaModelAgent plugin from Adocus. The implementation is academic in nature and performed to meet the goals of this thesis and is thus not fully ready or available for more general use.
**Disposition**

The first chapter contains introduction to the thesis including the background of the work, problem area, research question, target audience and limitations.

In chapter 2 the extended background is explained with more details to better understand the topics of this research.

Chapter 3 contains information about the methods used including motivation of why the methods were selected and how they were applied.

Chapter 4 describes the results and analysis of the research, the model artifact and its implementation in RSA along with the specification, development, demonstration and evaluation of the delivered artifacts.

Finally in chapter 5 this research and its results are discussed, conclusions made of the work done, how the research questions have been addressed and future research ideas listed.
Models and Business Models

Models represent reality while abstracting from details and can describe many different kinds of realities, including domains, systems or languages. (Aßmann, et al., 2006).

A model is basically a set of statements about a specific system, used to describe it. Models can generally be either descriptive, i.e. describing a system, or a specification for a system (Seidewitz, 2003). The concept of models either being controlling or describing reality is also called being prescriptive or descriptive models. Prescriptive models prescribe reality by specifying conditions of what reality should be after it has been constructed. Descriptive model describes the existing reality. For descriptive models the truth lies in reality, while for prescriptive models the truth is in the model itself (Aßmann, et al., 2006). While descriptive models are more common in traditional science disciplines, the prescriptive or specification models are more commonly used when constructing software (Seidewitz, 2003).

Models can furthermore describe behavior or structure. A structural model includes abstractions in concepts and their interrelation, structure and static domain semantics. Model rules or integrity constraints define valid configurations of the reality being modeled in a structural model. A behavioral model adds dynamic semantics to what structural models contain and can thus make behavioral assertions in either conceptual or transitional way. (Aßmann, et al., 2006)

Most system models have the underlying assumption that what has not been specified is either implicitly allowed or implicitly disallowed which is in contrast to an important property of ontologies where anything not explicitly stated is unknown (Aßmann, et al., 2006).

Business models are a specific type of models that have been increasingly popular in recent years and the range of business models usage and definitions is broad. The business model term is rather young as a research concept even though a couple of scientific papers used it as early as in the late 1950s and early 1960s. Its use first really started to rise during the internet boom from the mid-1990s and has since then increased rapidly both in general business talk, practice oriented journals and scientific research. (Burkhart, et al., 2011).

When discussing business models people often link either a firm or a brief description to models that epitomize a specific behavior, e.g. „low cost airline model“ or „Ryanair business model“ which maps business models to two different types of models in the form of scale models and role models. A scale model represents existing things while role models are models to be copied and these two models come together in many business models. (Baden-Fuller & Morgan, 2010). Business models can also function like recipes by providing a practical model which can be copied but is open for variations and innovation. Examples of this are e.g. ideal-type business models where an already successful model can be followed with the option of some variations without changing the model basics. The many aspects and options to use a business model make the concept challenging to define or grasp but also shows how potentially rewarding it is for management. (Baden-Fuller & Morgan, 2010)
Despite numerous scientific papers about definitions of business models there is still no generally accepted definition and there is a widely-criticized lack of theoretical consensus in the research field of business models. (Burkhart, et al., 2011) (Zott, et al., 2011)

In practice as well as in theory the business model concept is used for a wide range of formal and informal descriptions of core aspects of a business, including offerings, strategies, purpose, operations, policies and infrastructure. Some of the fuzziness about business model definitions can stem from this fact that authors writing about business models do not necessarily mean the same thing.

According to a literature review on business model generation performed by Zott et al (2011) the business model has at a general level been linked with many different concepts; a statement, description, representation, architecture, conceptual tool, structural template, method, framework and pattern, to name a few. This same literature review also surprisingly revealed that of over 100 reviewed business model publications, less than half of them explicitly explain or define what they mean by a business model and more than one third did not define the concept at all which opens up for many different interpretations for a concept that can have many interpretations. (Zott, et al., 2011)

Some effort has been put into better defining, understanding and consolidating the use of the business model concept. In 2004, an analysis on the business model literature was performed by Pateli and Giaglis (2004) where they tried to clarify the relation between business models and related concepts and identify gaps. Among their findings were that business model components relevance and relations have to be clarified better, further representation options and computer-aided design is needed and knowledge on evaluation criteria for ex ante evaluation needs to be built (Pateli & Giaglis, 2004).

A further review on business model literature and developments was performed in 2011 by Zott et al (2011) where they conclude among other things that business model development is conducted largely in silos where groups focus on their specific use of the concept and use their own definitions and detail them rather than increasing the consolidation of the concept. Authors attempt to explain and represent business models using a mixture of textual, verbal and graphical representations and the business model concept in its current use really stands for more than one concept, it represent many concepts depending on the focus of the user. The three main silos or interest areas identified by (Zott, et al., 2011) are related to; (1) e-business and the use of information technology in businesses, (2) the strategic issues of value creation, competition and performance, and (3) innovation and technology management. In all three areas the concept of value is still central and its creation or capture. At the same time they conclude that there are several emerging themes across the different silos of business model development, including the understanding of a business model as a new unit for analysis of the organizations business, distinct from its actual products, industry or network and with focus on the organization and the environment it works in. The business models focus on system-level holistic analysis to understand the business, the activities involved and the creation and capture of value. (Zott, et al., 2011).

Generally business models can be used as part of business management to help comprehend and analyze a company’s current business and options for future development of the business. A business model can serve as a means of communication by presenting the business ideas to stakeholders, it can be utilized for business and IT alignment and serve as part of solution developments e.g. as part of requirements analysis (Burkhart, et al., 2011). Amongst the most used roles for business models are to understand and share a business idea, analyze it, manage it, show prospects, or to patent a business models (Osterwalder, et al., 2005).
Osterwalder, Pigneur and Tucci (2005) defined three categories or levels of business models. The first category (Level 1) covers business models which act as an abstract overarching concept that can describe a business. This includes definitions of business models, what they consist of and the metamodels that conceptualize them. The second category (Level 2) covers taxonomies or abstract types of business models used for classifications to describe business with common characteristics. This contains several metamodel types or types of generic business models with common characteristics. The third and final category presents conceptualization of a specific or real world business model. These three categories may vary in rigor and are not mutually exclusive but are important to get a common understanding of business models. These levels can be hierarchically linked as shown in figure 1 below (Osterwalder, et al., 2005).

![Business Model Concept Hierarchies](image)

**Figure 1: Business Model Concept Hierarchies. (Osterwalder, et al., 2005)**

Many definitions have then been put forward to describe what a business model is as mentioned above, and the following definition was given by (Osterwalder, et al., 2005) and is based on the Business Model Ontology (BMO) by (Osterwalder, 2004):

„A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams. “

Osterwalder and Pigneur (2010) shortened this definition further in relation to the Business Model Canvas (BMC) approach which is at the heart of this research and their business model definition became:

„A business model describes the rationale of how an organization creates, delivers, and captures value. “
This later definition is shorter and sharper one, in a similar way as the BMC approach is shorter and sharper in its definitions than the underlying Business Model Ontology. The BMC business model fits on level 2 in figure 1 above and is described further in the section below.

One approach to further detail the definition of a business model is to build ontology of the business model domain. This can both provide better definitions and understanding of the selected business model and provide a fundament to use computer-aided tools to support creation of business models (Osterwalder, 2004). Some of the best established business model ontologies are REA, e³-value and BMO (Andersson, et al., 2006) (Samavi, et al., 2009). Those three ontologies and respective business modeling approaches were considered for this thesis and are briefly described below.

**Resource-Event-Actor (REA)**

The REA business model was initially created as a basis for an accounting model (McCarthy, 1982) focusing on the increase and decrease of value in an organizations but was later extended to base a foundation for enterprise information systems. REA is based on the core concepts of Resources (R), Events (E) and Actors (A) where a business transaction is seen as an Event where a Resource is exchanged between two Actors. At the heart of this ontology is the concept of duality where two events are linked in an exchange relationship where resources are exchanged. A conversion can also occur when an agent uses a resource to create another resource by an agent (Hruby, 2006). REA also addresses commitments through agreements between actors to execute events in well-defined future.

**e³-value**

The e³-value business model focuses on value exchanges in a multi-actor network and was designed to be easy to understand. It contains a minimal set of elements and relations and is thus a simpler conceptual model than REA (Andersson, et al., 2006).

The core of e³-value is the economic value and how the economically independent actors create, consume or exchange values. The e³-value also supports analysis of profitability which can help determining the sustainability of value networks. The core elements of the ontology are actors, value objects, value activities, value interfaces, value ports and value exchanges. A value object is exchanged between actors through directed value ports to or from an actor via a value interface through a value exchange in a value activity operation providing value for at least one actor. The e³-value has three different viewpoints which are the global actor, detailed actor and value activity viewpoint (Gordijn, 2004).

**Business Model Ontology (BMO)**

The business model ontology (BMO) was created to provide a rigid conceptual approach to business modeling and is much wider in scope than REA and e³-value. BMO addresses more than just modeling the value exchanges and includes marketing activities and channels, resource planning and internal capabilities (Andersson, et al., 2006).

BMO was based on a review of existing business model concepts in the early 2000’s and represents a synthesis of the main business models at that time (Osterwalder, 2004). BMO contains four main areas or pillars that a business model has to address and those are the Product, Customer Interface, Infrastructure Management and Financial Aspects. These four areas are represented by nine basic elements and their sub-elements which are the core of the ontology to cover the building blocks of a business model. The Product pillar contains one element which is the Value Proposition which represents a product or a service that is valuable for a customer.
The Customer Interface pillar contains three elements. The first is Target Customer representing customer segments which the company offers their value proposition. Next is the Distribution Channel element representing how to get in touch with the customers, and finally Relationship element which describes the links established between the company and its customers.

The Infrastructure management pillar contains three elements. The first is Partnership which describes voluntarily initiated agreements between two or more businesses to create value for the customer. Then the Value Configuration describes the activities and resources needed to create value for the customer. Finally the Capacity element describes the ability to perform actions needed to create value for the customer. The Financial Aspects pillar contains two elements of which the first one is Cost Structure, representing the money of the means employed in the business model. The second element is Revenue Model which describes how the company makes money via their revenue flows (Osterwalder, 2004).

An overview of the elements and relationships of BMO is shown in figure 2 below.

BMO takes the perspective of a single company which is different from the perspectives in REA and e3-value. BMO addresses both internal and external concerns for a company to meet its customers’ demands with a value proposition (Andersson, et al., 2006)

For this thesis, the BMC modeling approach based on the Business Model Ontology (BMO) was chosen, partly since the underlying BMO has a wider scope than the REA and e3-value ontologies and also because BMO is the newest business model ontology of the three. The limited computer-aided support existing for supporting the increasingly popular BMC modeling approach was also a deciding factor.
**Business Model Canvas (BMC)**

The Business Model Canvas (BMC) was created by Alexander Osterwalder and Yves Pigneur, based on their work on the Business Model Ontology and has been published in various stages as a blog, in articles and finally published in the book “Business Model Generation” in the year 2010.

The BMC is a hands-on tool that supports creativity, discussion, understanding and analysis of a business (Osterwalder & Pigneur, 2010). The Business Model Canvas (BMC) approach focuses on the business idea or value proposition as the initiator of the business, which is driven by customer needs and affected by the partners, cooperation, cost and revenue. BMC is a quite popular business modeling framework and is mainly intended for developing business models for for-profit organizations. BMC has an organization-centric viewpoint with much focus on customer transactions and a bit less detailed supplier transaction focus (Graves, 2010).

The BMC is a visual presentation of a business model and is based on the nine building blocks in BMO. The BMC is like a painter’s canvas with the 9 boxes pre-formatted with the 9 building blocks (Osterwalder & Pigneur, 2010). See figure 3 below.

The four pillars of BMC and BMO are the same and the nine building blocks are basically the same except for rephrasing of some of the concepts. The concepts used for the building blocks of BMC and BMO can be seen in table 1 below.

<table>
<thead>
<tr>
<th>Pillar</th>
<th>BMO building block</th>
<th>BMC building block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Value Proposition</td>
<td>Value Propositions</td>
</tr>
<tr>
<td>Customer Interface</td>
<td>Target Customer</td>
<td>Customer Segments</td>
</tr>
<tr>
<td></td>
<td>Distribution Channel</td>
<td>Channels</td>
</tr>
<tr>
<td></td>
<td>Relationship</td>
<td>Customer Relationships</td>
</tr>
<tr>
<td>Infrastructure Management</td>
<td>Value Configuration</td>
<td>Key Activities</td>
</tr>
<tr>
<td></td>
<td>Capacity</td>
<td>Key Resources</td>
</tr>
<tr>
<td></td>
<td>Partnership</td>
<td>Key Partnerships</td>
</tr>
<tr>
<td>Financial Aspects</td>
<td>Cost Structure</td>
<td>Cost Structure</td>
</tr>
<tr>
<td></td>
<td>Revenue Model</td>
<td>Revenue Streams</td>
</tr>
</tbody>
</table>

*Table 1: The 4 pillars and 9 building blocks of BMO and BMC (Osterwalder, et al., 2004) (Osterwalder & Pigneur, 2010)*

A graphical presentation of BMC contains the nine building blocks and each block contains several key questions and comments for assisting the user filling it out. The basic version of the canvas can be seen in figure 3 below and the key questions for each building block from the full canvas (from www.businessmodelgeneration.com) are listed in table 2 below.
<table>
<thead>
<tr>
<th>BMC building block</th>
<th>Key questions</th>
</tr>
</thead>
</table>
| Value Propositions | What value do we deliver to the customer?  
Which one of our customer’s problems are we helping to solve?  
What bundles of products and services are we offering to each Customer Segment?  
Which customer needs are we satisfying? |
| Customer Segments  | For whom are we creating a value?  
Who are our most important customers? |
| Channels           | Through which Channels do our Customer Segments want to be reached?  
How are we reaching them now?  
How are our Channels integrated?  
Which ones work best?  
Which ones are most cost-efficient?  
How are we integrating them with customer routines? |
| Customer Relationships | What type of relationship does each of our Customer Segments expect us to establish and maintain with them?  
Which ones have we established?  
How are they integrated with the rest of our business model?  
How costly are they? |
| Key Activities     | What Key Activities do our Value Propositions require?  
What Key Activities do our Distribution Channels require?  
What Key Activities do our Customer Relationships require?  
What Key Activities do our Revenue Streams require? |
| Key Resources      | What Key Resources do our Value Propositions require?  
What Key Resources do our Distribution Channels require?  
What Key Resources do our Customer Relationships require?  
What Key Resources do our Revenue Streams require? |
| Key Partners       | Who are our Key Partners?  
Who are our key suppliers?  
Which Key Resources are we acquiring from partners?  
Which Key Activities do partners perform? |
| Cost Structure     | What are the most important costs inherent in our business model?  
Which Key Resources are most expensive?  
Which Key Activities are most expensive? |
| Revenue Streams    | For what value are our customers really willing to pay?  
For what do they currently pay?  
How are they currently paying?  
How would they prefer to pay?  
How much does each Revenue Stream contribute to overall revenues? |

*Table 2: Questions for the building blocks of BMC (www.businessmodelgeneration.com, 2012)*

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Figure 3: The Business Model Canvas (Osterwalder & Pigneur, 2010)
BMC tools

The currently available computer-aided tools specializing in supporting BMC modeling are limited and mainly focused on supporting the visual presentation and ease of use by providing functions for drawing and documenting element attributes and associations as well as testing and sharing of models. Different tools can be used to draw and share BMC, e.g. Visio or PowerPoint, but those are not BMC specific and thus not discussed here.

The most prominent tools available specifically for BMC modeling are the “Business Model Toolbox for iPad”, a web-based tool called Strategyzer and a web-based tool called “BM|DESIGN|ER” from www.bmdesigner.com.

The Business Model Toolbox for iPad which is presented and sold from the www.businessmodelgeneration.com webpage provides a user-friendly interface to sketch a graphical BMC model with notes and a few support features. This tool is created and sold by the team behind BMO and BMC and this tool includes model sketching functionality with the practical methodology from the book “Business Model Generation”. It also contains features like revenue & cost formulas for the user to play with and test his business model based on his cost & revenue estimates. Furthermore the tool offers references, trigger questions and help for the 9 building blocks, report views, PNG and CSV exports and connections to a learning center. Currently there is only an iPad version available for this tool in full version but a more detailed web-based version is available and called Strategyzer.

The Strategyzer is another tool being developed and sold by the team behind the BMO and BMC and is currently in alpha version. The Strategyzer tool provides same features as the iPad version above with additional functionality. According to the Strategyzer website (www.strategyzer.com) this tool provides the ability to create unlimited workspace and canvases with estimates, financial reports and online co-operation features with your team e.g. through joint workspaces. According to the Strategyzer website, the alpha version of this tool has already got over 350.000 users which shows great interest and need for good tool support for BMC modelers.

The BM|DESIGN|ER is a web-based application where users can easily create a visual BMC model online and share with other users for feedback. This tool helps with documenting element attributes and associations, provides layers in the model and contains references, hints and help for the building blocks and elements in the canvas. (See www.bmdesigner.com)

None of those tools provides full modeling guidance based on BMC or BMO in a formalized modeling language or the option to create or export the business model in a format that could be used in OMG standards-based modeling tools.
**Metamodels**

The metamodel concept can be explained in several ways depending on the context and its usage. According to the Oxford English Dictionary a metamodel is a model intended to give a full and all-inclusive picture of e.g. a system or a process by abstracting from more specific individual models it contains within it (OED, 2013). A metamodel is an explicit specification of an abstraction and uses a specific language to express the abstraction. Examples of such languages are KIF (Knowledge Interchange Format) and MOF (Meta Object Foundation). A metamodel identifies the relevant concepts and relationships between them and additionally contains a set of logical assertions where needed to detail the rules in the metamodel (Bézivin & Gerbé, 2001). Metamodels can specify structure, attributes, associations and constraints to model a specific domain of interest with a set of rules and building blocks (Poernomo, 2006). A metamodel makes statements about what can be communicated by a selected modeling language for a valid model and can be interpreted as a mapping of its elements to the elements of the modeling language (Seidewitz, 2003).

In model-driven engineering (MDE) the instance-of relationship plays a specific role since when it is applied repeatedly, models specifying models can be defined which metamodels are. Metamodels specify and represent models by describing what can be expressed in a valid model of a specific modeling language. A metamodel is thus a prescriptive model of a modeling language. A language construct or concept is captured by a metaclass in a metamodel. The metaclass structure describes the static semantics of the language concepts and the metaclass methods define the dynamic behavior of the language concepts. A metamodel specifies models as valid instances of a modeling language and enables validation and control of models. (Aßmann, et al., 2006)

Several definitions of metamodels exist and their differences and details are affected by the context and usage intended as mentioned above. In this thesis the metamodel designed and built is based on the common basis for the Object Management Groups (OMG’s) metamodels which is the MetaObject Facility (MOF). MOF was created to enable a systematic interchange and integration between metamodels and models. (Poernomo, 2006) (Seidewitz, 2003).

The MOF specification is a foundation for OMG’s industry-standard environment where models can be created, transformed, exported or imported to/from applications and so on. The usage of MOF is not restricted to UML models and non-UML modeling languages can utilize MOF as long as they are MOF-based. MOF helps defining and using meta-models and has contributed significantly to OMG’s Model Driven Architecture (MDA). The need for the MOF framework resulted from the fact that many applications and vendors used proprietary metadata models which caused problems in e.g. data exchange and integration between applications. UML was one of many metamodel used in software developing and the different and incompatible metamodels being defined and evolving separately called for a broad integration framework for metamodels in the software developing industry. OMG stepped in and adopted MOF 1.1 in 1997 as a meta-metamodel to base UML and other metamodels on, e.g. the Common Warehouse Metamodel (CWM). The current version of MOF is 2.0. MOF provides technology which allows specification and manipulation of models through a model repository and encourages consistency when working with models in all phases of model driven architecture. (OMG, 2011) (OMG, 2003) (Bézivin & Gerbé, 2001)

The meta-principle can be used to define different levels of models and metamodels in a hierarchy linked by the instance-of relationship. Some OMG standards like UML 2.0 and MOF 1.4 have defined a standard meta-pyramid or a 4 level structure while MOF 2.0 allows any number of levels equal to or greater than 2. For the 4 meta-levels mentioned, the lowest level (M0) is the object or reality level,
then the M1 level contains models, the M2 level has meta-models or languages and finally the highest level M3 defines metameta-models or language description level. See figure 4 below.

In the OMG meta-level structure, level M3 utilizes MOF as a meta-metamodel to build metamodels on level M2 (Aßmann, et al., 2006) (OMG, 2011). Another approach to implement metamodels is to utilize UML Profiles to extend an existing metamodel like the UML metamodel and we will discuss UML profiles further in a later section. The 4 basic metamodeling architecture layers of OMG’s MOF standard framework are shown in figure 4 below and show how the levels connect from a modeled reality to a model to a metamodel and finally a meta-metamodel at level 3 or modeling level 3 (M3). The positioning of a UML Profile extension is also included in this figure and further explained in a following section.

![Figure 4: OMG's 4 basic meta-levels and structure](image)

BMC has been used in various domains and the interest and effort to map and/or transform it to or from other modeling frameworks and approaches has been seen in various domains. By utilizing a standardized metamodel in modeling and mapping BMC to or from other models the process can be automated and the control of the correctness of the BMC model and conceptual mapping is supported.
**Model-Driven Architecture**

Model-driven architecture (MDA) is a software design framework proposed by the Object Management Group (OMG) and is an approach to using models in development of software. MDA provides an approach for defining systems independently of platforms, specifying and choosing platforms for the system and transforming it to the chosen platforms. The main goals of MDA are interoperability, portability and reusability with architectural separation of concern. (OMG, 2003)

The MDA approach is based on models expressed in OMG modeling standards and those models are stored in a repository that is MOF compliant. (OMG, 2003).

Model-driven architecture (MDA) is an incarnation of model-driven engineering (MDE) which in turn is a variant of a refinement-based software development. Refinement-based development is about producing several models, going from abstract to more concrete and ending with implementation of the refined model. MDE models are not as loosely coupled as in refinement-based modeling and are connected in a systematic way and derive to more concrete models with the possibility of semi-automatic or automatic transformations. To be able to do this the models must be connected in such way that their elements are traceable from the abstract to the more concrete models and back. Metamodels make this possible by defining the valid models and possible transformations and exchanges (Aßmann, et al., 2006).

MDA is about constructing a model of a system which can then be transformed into a real thing. Models, both source and target are expressed in a language which exists at some abstraction level. A language has syntax and semantics. Semantics define the meaning of the syntax by linking it to a semantic domain. To define the model languages a modeling language syntax and semantics must be defined which can be achieved by creating a model of the modeling language, a so-called metamodel. All MDA metamodels can be expressed by using the OMG MOF (Mellor, et al., 2003).

In MDA the models can differ in the way how much platform information is included. The more abstract models contain no platform issues and as the models transform to more concrete models, more platform-specific information is added. MDA has basically three types of viewpoints on models. One is a computationally independent (CI) viewpoint where the system is seen from the customer’s viewpoint and is expressed in a computation-independent model (CIM) which contains a domain model defining domain concepts and relations, a business model defining the business and then requirements. Then the platform-independent (PI) viewpoint is from the designer’s viewpoint and is abstracted from platforms and is expressed in a platform-independent model (PIM). PIM basically contains an architectural model with generic platform issues. The third and final viewpoint is the platform-specific viewpoint where platform-specific extensions (PSE) are added and is manifested in a platform-specific model (PSM) which can either be executed directly or be used to generate code. (Aßmann, et al., 2006)

Transformation of models is a key part in MDA where models can be transformed from being computationally independent (CIM) to platform independent (PIM) and then platform specific model (PSM) on the way towards implementation (OMG, 2003).

The approach used in this thesis will be related to the MDA approach in the sense that a BMC model will be transformed from the standard BMC modeling approach to a MOF-based BMC model which will be computation-independent model (CIM) in the OMG MDA framework based on the MOF-compliant BMC metamodel.
UML and UML Profiles

The Unified Modeling Language (UML) is a standardized, general purpose, visual modeling language defined by the Object Management Group (OMG). UML 1.1 was adopted by OMG in 1997 where several popular graphical object-oriented modeling languages in the 1990’s were unified and has since then developed to be recognized as lingua franca for software development. (OMG, 2011a)

The current version of UML (v2.4) describes 14 diagrams where 7 are structure diagrams and 7 behavior diagrams. See figure 5 below. The structure diagrams present the static structure of a system’s object while the behavior diagrams show dynamic behavior of objects in a system. Among the structure (or static) diagrams is the Class diagram which can be used to describe the structure of a system by identifying the classes, attributes, operations and relationships of a system. The Class diagram can be used for general conceptual modeling (OMG, 2011b) and will be used in this thesis work.

![Figure 5: The taxonomy of UML2 structure and behavior diagrams (OMG, 2011b)]

The UML specification is built on the UML Infrastructure and UML Superstructure volumes. The infrastructure defines the core infrastructure and metamodel which the Superstructure is based on. The Infrastructure is represented by the PrimitiveTypes package and InfrastructureLibrary package which includes the Core and Profiles packages. The core package then contains a complete metamodel and serves as a common core for UML, CWM and MOF models and is seen as the architectural kernel of MDA as well. (OMG, 2011a).

The Superstructure defines notations and semantics for the UML diagrams and their model elements both for the structural, static constructs and the behavioral, dynamic ones. Additionally it contains a supplement defining additional constructs and the UML Profiles that can be used to customize UML. (OMG, 2011b)

The specification of UML uses a metamodeling approach where a metamodel specifies the UML model itself. Among the design principles for the UML metamodel is extensibility where UML can be extended by using UML Profiles to tailor the language for a particular platform or domain. (OMG, 2011a)

UML Profiles provide a mechanism to extend metaclasses from existing metamodels in UML for different purposes like customizing metamodels for domain specific modeling. The UML Profile
stereotypes extend the classes of the UML metamodel. UML Profiles are consistent with the Meta Object Family (MOF) extension mechanism but are more light-weight and restricted to make implementation and usage easier and more widely supported by tool vendors. UML Profiles are not considered first-class extension mechanism like MOF where existing metamodels can be changed but UML Profiles provide a straightforward mechanism to adapt existing metamodels for a specific task. In UML 2 the Profiles are defined as a specific metamodeling technique. (OMG, 2011a) (OMG, 2011b)

**Modeling environment and tools**

In this research a modeling tool extension called MetaModelAgent (MMA) is used to create the MOF compliant metamodel in the chosen modeling tool which in this case is IBM’s Rational Software Architect (RSA) v8.5. The choice of RSA and MMA was based on the fact that they are compliant with OMG modeling standards, the broad usage of RSA in companies developing standardized OMG modeled software and the support features for metamodels in MMA and access to MMA experts further supported this selection.

Other modeling and metamodeling tools considered included The Eclipse XML Meta-Modeling Tools project which provides editors and extended validation in eclipse as well as generators for developing domain-specific languages and xml based meta-models.

A few other modeling and metamodeling tools are available but RSA and MMA were chosen due to the reasons mentioned above.

The transformation from BMC to an OMG standards-based model will be done through manual creation of the BMC model in RSA where the BMC metamodel will support the creation of the BMC model. A UML Profile and the MetaModelAgent extension will be used to model a BMC metamodel in a descriptive way to be used as a specification for the creation of BMC models in an MOF-based modeling language similar to UML in terms of notations and concepts used. The Unified Modeling Language (UML) is part of OMG’s modeling standards and is based on MOF. (OMG, 2011b).
Method

This chapter positions the research work within a selected scientific field and explains the choice and application of research strategies, methods, techniques and ethical considerations.

Field of Science

This research has been carried out following the design science (DS) approach. Choosing DS as the field of science for this research is seen as appropriate since the research’s aim is not only to increase the understanding and knowledge of the problem domain but to create a solution for the defined problem through the development of a certain artifact.

Hevner et al (2004) claim that design science is a good fit where the research focus is on gaining both knowledge and understanding of a defined problem and its solution while creating and applying the artifacts identified. Thus the selection of DS as the field of study is seen as a good fit for this thesis. Furthermore Osterwalder (2004) used design science approach in his PhD thesis about BMO and showed that this approach is very appropriate when creating a new modeling approach for business models which further supports the use of design science in this thesis.

Other related fields of science that were considered included behavioral science which is more focused on the knowledge and truth in a research rather than developing a solution (Hevner, et al., 2004) and is thus not as applicable in this thesis.

Design Science

Design science is characterized by creation of artifacts to understand and improve a general or practical problem. In design science the understanding and knowledge of a problem and its solution are reached by building and applying the designed artifacts. A design science research involves rigorous process to develop artifacts to solve the identified problem, make research contributions, evaluate and communicate the results. The artifacts of design science can include constructs, models, methods and instantiations (Hevner, et al., 2004).

Design science research aims to solve a defined problem and meet identified needs through the artifacts produced and addresses research relevance by clear linkage of a solution to an identified problem. (Hevner, et al., 2004).

Hevner, et al. (2004) provide 7 guidelines for good design science research within the IS discipline, based on the fundamental principle that understanding and knowledge of a problem is acquired by building and applying artifacts. These guidelines include the requirement of creation of a useful artifact (guideline 1) for a specified problem or problem domain (guideline 2). To ensure the usefulness of an artifact a rigorous evaluation must be performed (guideline 3) and the artifact must contribute with new and innovative solution to the problem domain (guideline 4). The artifact must then be rigorously built and evaluated, based on existing knowledge base in the problem domain (guideline 5). Design science is iterative where the search for the solution may involve a cycle of design, building and testing of the solution and is as such a search process (guideline 6). Finally the research should be communicated clearly to both technical and managerial audience (guideline 7) (Hevner, et al., 2004).
Design Science Canvas

To get an initial overview and understanding of the research topic in the frame of DS, the Design Science Canvas by Johannesson & Perjons (2012) was used to structure and visually map out the main components needed for successfully performing the research.

The Design Science Canvas has 15 boxes, each containing a part of a design research. See figure 6 below.

The top six boxes should be filled with the definitions of the planned research in form of the research problem, problem background in practice, expected artifacts, artifact requirements, the knowledge base used, and main constructs used. These boxes are color-coded blue (Johannesson & Perjons, 2012).

The next line of five boxes contains methods and typical steps of a design research, i.e. explicate problem, define requirements, develop artifact, demonstrate artifact and evaluate artifact. These boxes are color-coded green. The communication of the research is not included in the design science canvas (Johannesson & Perjons, 2012).

The final row of four boxes has purple headlines and contains description of expected outcomes of the research which is categorized into construction, function, usability and effects (Johannesson & Perjons, 2012).

Each box of the DS Canvas template is filled with instructions to help the user filling in the needed information. The Design Science Canvas template can be seen in appendix A.

Figure 6 below displays the Design Science Canvas with basic information for this research. The color code of the boxes is displayed in the headline for each box. The more detailed text has been removed to make the presentation readable in this document.
Figure 6: Basic version of the Design Science Canvas for this thesis.

**Problem**
The Business Model Canvas (BMC) is a modeling approach for creating business models and is frequently used for innovation and creation. The existing tool support for BMC is limited and lacks formal modeling support. The current usage space of BMC can benefit from being extended to include more formal modeling support with clearer linkage to software modeling standards. This can make BMC models more specific and complete, and more efficient in linking to the IT structure supporting the business. The communication between business modelers, software architects, and developers can benefit from clearer and more formalized BMC representation in an industry-standard modeling environment based on OMG standards.

**Scope**
The metamodel will be OMG compliant and instantiated using Adocus MetaModelAgent in IBM Rational Software Architect and can also be used with IBM Rational Software Modeler. The metamodel will be based on BMO which is the ontology behind the visual BMC model.

**Explicate Problem**
Literature review needed to clarify the current state of using metamodels to support business modeling and the level of tools and support available for BMC use.

**Define Requirements**
To create a metamodel to support the creation of BMC in an OMG standards-based environment, a good approach and tool needed to be selected. A metamodel tool (MiA) was suggested by my supervisor which is compatible with IBM RSA. This defines some of the non-functional requirements. Literature review was performed to understand the details behind and usage of BMC and current BMC tools available. This helps clarify the requirements and the approach for creating a BMC model with support from the metamodel.

**Construction**
This work will include the creation of the metamodel based on BMO and implementation in IBM RSA using Adocus MetaModelAgent. This means it will be MOF v2.4 and UML2 compliant. The metamodel will consist of a UML class diagram including information in text with the structure and rules of the BMC metamodel.

**Function**
The main functions will include a metamodel which will be able to verify conformance to structure, attributes, associations, and rules of the BMC model created in RSA. The metamodel will work behind the scenes in RSA to verify and inform of corrections when required by user.

**Usability**
These artifacts will require the users to have basic knowledge of BMC modeling. UML modeling and IBM RSA knowledge to use them properly. The metamodel can be used to provide corrective guidelines and verification of the completeness and correctness of the business model.

**Knowledge Base**

**Demonstrate Artefact**
Create a BMC model for a selected example where the full metamodel in RSA is used and explain the process and result.

**Evaluate Artefact**
Evaluating if and how the artefacts meets the defined requirements and can solve the defined problem:
1. Informal argument from author used to show that all requirements are fulfilled and the result dev and communication of a BMC model is helped by the metamodel.
2. Expert evaluation where the metamodel is used by an BMC modeling expert to evaluate it in the creation of a BMC model in RSA.

**Constructs**

MDA: Model-Driven Architecture (MDA) is an OMG standard.
Research approach

Choosing a methodology or a process model can be helpful when performing a research under the design science paradigm in order to support the structure and quality of the work. For this research the design science method (DSM) by Johannesson & Perjons (2012) was chosen since it suggests, with well elaborated text and examples, how to carry out DS projects and offers a holistic approach to the work needed to be performed (Johannesson & Perjons, 2012).

Another method or framework considered for performing this DS research is the Design Science Research Methodology (DSRM) by (Peffers, et al., 2007) which is a consistent and well known approach for a design science research. DSRM was not selected since it does not have the same level of explanations and examples as is provided with DSM.

Thesis communication follows the procedures of master thesis work at DSV where the results are communicated through a written thesis report and presented in a final master thesis seminar at DSV.

Design Science Method (DSM)

The design science method (DSM) is a generic design science method which can be easily adapted to fit the needs of a research project and offers a framework to perform a design science research in structured way. The DSM contains 5 main activities in its framework which includes the problem investigation, then requirement definition, artifact development, demonstration and finally the evaluation. (Johannesson & Perjons, 2012).

The first activity is Explicate Problem which is the investigation and analysis of a practical problem. In this activity the problem should be formulated and motivated clearly to show it is of significance and general interest and even explain the underlying causes.

The second activity is Outline Artifact and Define Requirements where the solution to the defined problem is outlined as an artifact. The problem is transformed into defined requirements for the proposed artifact.

The third activity is Design and Develop Artifact where an artifact is designed and created to solve the explicated problem by fulfilling the requirements that were defined.

The fourth activity is Demonstrate Artifact which aims to use the resulting artifact in a scenario to demonstrate or proof that the artifact does solve the explicated problem.

The fifth and final activity is Evaluate Artifact which aims to determine how the artifact fulfills the requirements and how it addresses or solves the practical problem that was identified in the first step.

These DSM activities are not carried out in a sequential way but more in an iterative way between different activities. (Johannesson & Perjons, 2012).

This research is initiated from a defined problem while the work is very focused on the development and evaluation of artifacts. Due to the focus on development and evaluation, some of the other activities in DSM are treated more lightly. An overview of the DSM research approach and communication activity, including basic description of each activity is shown in figure 7 below and the possible research initiation entry points are shown in the box on the right side. The research problem-centered initiation is marked by bold text and an arrow from DSM activity 1 to that entry point.
Further details on how DSM is applied in this thesis and the choice and application of research strategies and methods are provided in following sections.
Ethical considerations

This research includes interviews with experts in the research field and thus certain ethical principles will be applied. This research will use guidelines from the Swedish Research Council (Vetenskapsrådet) which are recommended in social science research by following the four main requirements they propose. The four requirements and their application in the research are listed below (Vetenskapsrådet, 2002):

- **The information requirement** – The participants will be informed about the research content, purpose and goals and their expected participation and tasks. They will be informed that their participation is voluntary and the information collected during interviews will only be used for this research and that they can withdraw from the interview when desired.

- **The consent requirement** – All participants will be asked to give their consent on participating in the research voluntarily before they participate and without any pressure. The participants will be informed that they can withdraw their participation when desired without any negative consequences to them.

- **The confidentiality requirement** – All participants will be informed that if they wish the transcripts of the interviews will remain confidential and the participants will be kept anonymous. Some basic background information will be given on the background of the participants to support their role as experts but without giving too much information. Even though the information gathered is not expected to be ethically sensitive, the identity of the participants remains confidential.

- **The requirement of use** – The collected information will only be used in this research and will not be used commercially or given to third party.

Along with defining and explaining the ethical principles applied in the research, the participants will be informed in advance of how their participation is planned and how the gathered information is handled. By stating the confidentiality and handling of information the setup for their participation can potentially provide more open discussions.
Research Strategies and Methods

The selected research strategy, methods and techniques for collecting and analyzing data can be different for different DSM activities of a research (Johannesson & Perjons, 2012).

The selection and application of research strategies and methods for data collection and analysis is explained and motivated in this chapter and the organization of the chapter is based on the activities of DSM. The research strategies and methods in social science can be used in design science and the activities of the design science method (DSM) to provide tools for collection of empirical data. (Johannesson & Perjons, 2012) (Denscombe, 2010).

This research is development and evaluation focused which means that the problem explication and requirements definition activities are not performed in full detail where the identified problem is basically accepted as existing and only briefly explicated along with the artifact requirements for addressing the problem.

**DSM activity 1: Explicate Problem**

*Goal:* To clarify, formulate and motivate the problem and its background.

*Achieved by using:* Literature review, group discussions.

*Alternatives:* Survey or a case study using interviews or questionnaires. Action research.

The problem is basically accepted as is and only briefly explicated and motivated in the introduction chapter by referencing to existing knowledge through a brief literature review. Group discussions with supervisor and peers also supported the explication and motivation of the problem. Group discussions are an alternative form of group interviews or focus groups where the discussion can give reflections on different views and be more illuminating of the specific issue (Denscombe, 2010). No research strategy is specified in this activity of DSM.

The literature review was used as a data collection method with focus on modeling of business models, in particular BMC and its usage and use of metamodels, model-driven architecture, OMG standards and design science.

A systematic search approach was applied to find articles to review by starting broadly when searching reference databases and search engines like INSPEC, COMPENDEX, Scopus and IEEE through the KTH/SU libraries as well as Google Scholar to cover the major journals in this research area.

The list of keywords was updated and extended as the search for literature progressed and the focus and knowledge of the area increased. More detailed search was then performed at selected publishers that proved most active in this area which included the SpringerLink search and IEEE Xplorer websites.

Open queries, keywords and combination of keywords were used to find literature matching the information searched for. Examples of this are „BMC‟, „Business Model Canvas‟, „BMC case‟, „metamodel‟, „meta-model‟, „BMC metamodel‟.

When articles were reviewed the references to them were checked to evaluate their perceived importance in the research field. The quality of the article and journal where it was published was also considered when selecting what to use. The articles referenced from the reviewed articles and the
articles referring to the selected articles were browsed to search for further literature to use as well as a specified search was done on selected authors in this field.

Websites and forums where BMC and business models were discussed were also browsed in search for information and links to relevant information.

The applications that support computer-aided development of BMC were found through Google search and in the reviewed literature, and resulted in the three applications reviewed.

The data collection method in this activity is thus mainly on secondary data from the existing knowledge base.

The results from this activity is mainly provided in the introduction chapter of this thesis where the research problem is described and motivated as well as the positioning and background of the problem.

If the focus of this research would have been on clearly identifying and understanding the problem, a survey among modeling experts or a case study in organizations or companies where BMC is used would have been examples of suitable research strategies in addition to the methods mentioned. Action research could also be considered if aiming for a specific problem with a defined client (Johannesson & Perjons, 2012) which is not the case here.

**DSM activity 2: Outline Artifact & Define Requirements**

*Goal:* To identify and outline the artifacts to develop and define their requirements.

*Achieved by using:* Literature review, group discussions, expert interviews

*Alternatives:* Survey, case study using interviews or questionnaires. Action research.

The outlining of the artifacts and requirements are based on the explicated problem and lightweight literature review including BMC support tool review similar to the review in previous activity. Group discussions with supervisor and peers were used as research method to clarify the artifacts and their requirements. The evaluation activity also provides input to the requirements through expert interviews and thus makes part of the DSM activity process circular. The expert interviews will not be part of the initial outlining and definition of the requirements but only the evaluation part due to time limits and difficulties in accessing experts in the earlier stages of this thesis.

Furthermore, basic requirements from the Guidelines of Modeling (GoM) provided by (Becker, et al., 2000) were used to define requirements on the quality of the model being created and part of the evaluation will be based on those.

To meet the goal of this thesis, two artifacts were identified, the first one a model artifact in the form of the BMC metamodel and the second one an instance artifact in the implementation of the BMC metamodel in an OMG standards-based tool.

If the focus of this research was on clearly identifying and understanding the objectives for a solution, a survey among modeling experts or a case study where BMC is used would have been examples of suitable research strategies. Action research was also considered but is more focused or aimed at a specific problem with a defined client involved (Johannesson & Perjons, 2012) which is not the case here.
DSM activity 3: Design & Develop Artifact

Goal: To design and construct the artifacts to address the explicated problem and fulfill the requirements.

Achieved by using: Literature review, group discussions, expert interviews & UML modeling in RSA.

Alternatives: Observations, questionnaires, other modeling tools.

This activity builds on the problem identification, the research question and requirements explained above. The design and development activity is different from the other activities of the DSM since it does not primarily aim to answer the problem questions by creating descriptive knowledge but by prescriptive knowledge through the creation of an artifact (Johannesson & Perjons, 2012).

The approach taken for generating a solution contains literature review where definitions and use of BMC, BMO and BMC tools are reviewed after a search and selection process similar to the activities above. The BMC metamodel is based on BMC definitions in the book “Business Model Generation” (Osterwalder & Pigneur, 2010) with additional details from the BMO definition (Osterwalder, 2004) and input from the literature review. The BMC metamodel is thus a combination of reused, adapted and new BMC related definitions and solutions from the reviewed literature and BMC tools.

For the implementation, input from both RSA and MMA tool documentation and expert input from a MMA modeling expert was used. The MMA expert was interviewed informally for the design & development activity to discuss ideas and approaches in using MMA in this thesis. The informal MMA expert interview focused on both the actual metamodel and practical implementation issues in RSA for a metamodel.

Interviews with experts in the business modeling, BMC, metamodeling and modeling field were performed to get expert input for possible design and solution approaches. These interviews were performed as part of the evaluation activity due to time constraints. The design & development related feedback from the expert interviews was processed in an iterative and circular way where the design & development is revisited after the evaluation for possible updates.

The design and development of the metamodel was thus influenced by input from selected literature, existing BMC tools, peers and expert interviews. The expert interviews are described further in the evaluation activity.

Selected methods which were used in the reviewed literature and tools are incorporated in the process of developing the artifacts of this research. These include literature review, informed argument, expert interviews and group discussions.

The data collection methods include both secondary and primary data. The secondary data comes from the articles, books, and websites as described above. The primary data is collected through the interviews and feedback when demonstrating and evaluating the artifact.

Observations and questionnaires would also be appropriate in this activity to get more detailed hands-on input from experts in the field but those methods are not used due to time limits and difficulties in accessing a group of BMC, MMA and modeling experts in this stage of the research. Other modeling environments could also have been used but do not give direct addition to meeting the goal of this research where one OMG-based environment is used.
**DSM activity 4: Demonstrate Artifact**

*Goal:* To show that the artifacts function and solve some aspects of the explicated problem.

*Achieved by using:* An illustrative example based on a documented BMC model created in RSA with support from the created artifacts.

*Alternatives:* An example or an experiment with a real-life full example of BMC to show usage in a real-life environment. Case study and action research could also be used.

To demonstrate how the artifacts works, an example based on a selected BMC model is used. The selected BMC model is used as input to re-create that BMC model in RSA with support from the metamodel. The selected BMC for the illustrative example should contain elements in all boxes of the BMC to be able to demonstrate all functionalities and parts of the artifact and be challenging enough to offer a suitable testbed (Johannesson & Perjons, 2012). The demonstration gives both a descriptive knowledge of how the artifact works as well as explanatory knowledge in explaining why it works.

The demonstration uses a BMC model from the book “The Business Model Generation” by (Osterwalder & Pigneur, 2010) where the business of Skype is modeled. To test and demonstrate the artifacts, the Skype BMC business model is briefly explained and then recreated in RSA using the metamodel support. The Skype BMC model contains elements in all parts of the BMC so that the full functionality of the metamodel can be used and thus demonstrated in this activity. The process of using the metamodel and the outcome of the demonstration are explained in the results chapter by using screenshots and explanatory text to clarify the functions of the artifacts.

Other options for demonstration would be to use the artifacts in a well-documented real-life case of a business and BMC model to recreate using the artifact in a real-life environment, i.e. with BMC practitioners using it. A very detailed and well-documented published case where the full BMC is used is hard to find and access to BMC practitioners was not available within the scope of this study.

A case study or action research could also be used if more time was available.

**DSM activity 5: Evaluate Artifact**

*Goal:* To determine how the artifacts fulfill the requirements and to what extent they solve the explicated problem.

*Achieved by using:* Expert interviews and theoretical analysis through informed arguments.

*Alternatives:* Action research or a case study with interviews, questionnaires or observations. Interviewing more modeling experts and allow for hands-on use of the artifacts with real-life models.

A qualitative approach is used for the evaluation to get an in-depth view on the resulting artifacts of the study. The evaluation analyses both how the artifacts fulfill the defined requirements and to what extent the explicated problem gets solved. This includes using expert interviews and using an illustrative example from the demonstration step, where a basic real-world BMC model for SKYPE is re-created with help of the artifacts. Furthermore a theoretical analysis is used in form of informed arguments to evaluate and explain how the defined requirements are fulfilled, including evaluation of
how the model fulfills the requirements based on the guidelines of modeling (GoM) defined by (Becker, et al., 2000).

Informed arguments were seen as a fitting and practical approach to evaluate how the requirements are fulfilled by explaining the creation of the artifacts (Johannesson & Perjons, 2012).

The interviews were chosen to get a deeper view of opinions and perception about using the created artifacts by modeling experts and thus possible users of the solution. Interviews can be biased due to the interviewees’ subjectivity and furthermore they may hold back critical comments to be polite in the interview (Johannesson & Perjons, 2012). The expert interviews do include specific questions about both cons and pros of the solutions to address this.

The main evaluation is an ex ante strategy since the interviewed experts may not be able to use the artifact or only partially and their feedback will mainly be based on their general knowledge and experience with similar solutions (Johannesson & Perjons, 2012).

The expert interviews are semi-structured to allow for a mixture of specific questions and open discussions to elaborate on interesting points (Denscombe, 2010). The interviews are partially based on the defined requirements for the artifacts which include the guidelines for evaluation models from the Guidelines of Modeling (GoM) by (Becker, et al., 2000). This structure is selected to provide a published and systematic structure to evaluate models to increase their quality, and even though this approach was not designed for business model evaluation, the basic modeling aspects are similar for the metamodel and thus seen as applicable here (Becker, et al., 2000).

The selection of participating modeling experts was constrained by the difficulty of getting access to experienced BMC modelers using BMC in their daily work. The experts were found and selected through referrals by identifying individuals with expert knowledge of business models, BMC and modeling and who are willing to participate in this study. The experts were also asked to recommend further participants to contact for this study and this sampling approach is called snowball sampling (O’Leary, 2004). This sampling approach is convenient to quickly build a sample but the representativeness of the population by the participants is not guaranteed to be good (O’Leary, 2004).

This approach provided two experts willing to participate and both work as researchers and teachers at the Department of Computer and Systems Sciences at Stockholm University and Royal Institute of Technology in Stockholm, Sweden. Both have extensive knowledge of business models, metamodels and modeling approaches and their theoretical knowledge is vast while the practical knowledge of using BMC in a practical environment is somewhat limited.

By using snowball sampling and only have two experts to participation the evaluation feedback can be biased and this limits the generalizability of the results since the sample is not representative for the general population of BMC users. This can also result in a lower external validity of the study (O’Leary, 2004).

Ideally this evaluation would have included BMC practitioners from different backgrounds, using BMC regularly as part of their work to get more practical feedback added to the more theoretical feedback from the currently available expert interviews. Furthermore providing hands-on use of the artifacts for more real-life models would have been ideal.

The evaluation provides feedback into the specification, development, demonstration and evaluation of the solution and could trigger changes to the solution in an earlier DSM activity and thus trigger an iterative approach in the artifact development until an acceptable solution is reached.
Other options for evaluation would include using a case study to get a broader and/or deeper evaluation which could result in a more generalizable knowledge using interviews, questionnaires or observations. Action research could also be used for a specific focus area. These research methods were not selected due to time limits and the difficulties in getting access to the needed resources.

**Communication**

*Goal:* To communicate the results of this study to the research & practitioners community.

*Achieved by using:* Written report and presentation at the department of Computer and Systems Sciences, DSV.

*Alternatives:* Submit a paper, poster or article to a conference or journal.

The DSM does not specify communication as a numbered activity in a Design Science research like e.g. (Peffers, et al., 2007) does in DSRM but the communication step is included here. The results of this thesis will be communicated through this written thesis and a presentation of the thesis according to the guidelines of the Department of Computer and Systems Sciences (DSV) at Stockholm University and The Royal Institute of Technology (KTH) under which this thesis is written.

Further possible communication options would be to write and submit a paper or poster to a conference or a journal under guidance of the supervisor of this thesis.
Results & Analysis

In this section the BMC metamodel requirements, design and creation is explained and its implementation in IBM’s Rational Software Architect (RSA) with the MetaModelAgent (MMA). The demonstration and evaluation with analysis of the result is performed and finally the communication of the work is explained. The structure of this section is in line with the choice of method where we follow the activities of the Design Science Method (DSM).

Problem identification & Motivation

The identification and motivation for the research problem and its background is delivered in chapter 1 of this thesis and basically identified the following problems:

- The lack of a standardized formal definition (metamodel) of BMC for its elements, attributes and relationships.
- The lack of tool support for a business modeler to create a BMC model which can efficiently encapsulate and communicate the information needed in a consistent and standardized way.

Define the objectives for a solution

To meet the research goals and contribute to a solution to the identified problems, two artifacts have been identified. One is a model artifact in the form of a BMC metamodel to provide a standardized and formal definition of BMC. The second one is an instance artifact delivered by the implementation of the BMC metamodel in an OMG standards-based tool to provide tool support for BMC modeling.

These two artifacts shall represent the original BMC modeling approach in a complete and correct way to be useful for BMC practitioners. This leads to several basic requirements, e.g. the metamodel should cover the full BMC model in terms of elements, attributes and relationships based on a thorough coverage of the BMC definitions and the BMC related literature reviewed. Also a BMC model created with support from the BMC metamodel must comply with the definitions of a BMC model and fully represent details with no information lost.

Furthermore the implemented metamodel must run without errors in RSA using MMA and be flexible in the enforcement of constraints, meaning that it should support both mandatory and optional constraints on the elements and their relationships to keep the basic flexibility of BMC intact.

This research aims to facilitate improvements in developing and communicating BMC models generally and the chosen development standards and development environment puts certain requirements on the approach. This results in several non-functional requirements for the development of the metamodel, including using a UML class model for structuring and modeling the basic metamodel. Other requirements derived from the literature review and are briefly explained in this section.

The artifacts should also fulfill basic model qualities as defined in GoM (Becker, et al., 2000) as mentioned in the Methods chapter. Those are qualities like correctness, relevance, efficiency, clarity, compatibility and systematic design.
The definition of artifacts and requirements were reached by analyzing the defined problem and goals of this study along with discussions and informal reviews from supervisor, peers and the MMA and modeling experts interviewed in order to reach a complete and clear list of requirements. This resulted in the following list of 11 requirements which the artifacts should fulfill to meet the goals of this thesis, by contributing to a solution for the defined research problem. Please note that some requirements shall be fulfilled by both the BMC metamodel and its implementation, while other requirements are only for the implemented BMC model artifact. When discussing requirements for the implemented BMC metamodel, the artifact implementation in RSA is being discussed which also affects the created BMC models using this artifact and the demo is given as example. See table 3 below:

<table>
<thead>
<tr>
<th>General Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R01</strong> <em>Completeness:</em> The BMC metamodel and its implementation shall be complete, meaning that they must include and handle all elements, attributes and associations of BMC using the BMC definitions supplemented by BMO definitions.</td>
</tr>
<tr>
<td><strong>R02</strong> The BMC metamodel and its implementation shall be based on OMG standards and documented as a UML class diagram.</td>
</tr>
<tr>
<td><strong>R03</strong> The implemented BMC metamodel shall be able to run in IBM RSA using the MetaModelAgent.</td>
</tr>
<tr>
<td><strong>R04</strong> The implemented BMC metamodel shall be able to support the creation of a BMC model in RSA through explanatory suggestions (mandatory or optional) on the structure, elements, relationships, attributes and content of the BMC model.</td>
</tr>
<tr>
<td><strong>R05</strong> The implemented BMC metamodel shall be able to identify errors in a BMC model and give guiding information related to the errors.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirements based on GoM (Becker, et al., 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R06</strong> <em>Correctness:</em> The BMC metamodel and its implementation shall be correct both syntactically and semantically based on the BMC definitions.</td>
</tr>
<tr>
<td><strong>R07</strong> <em>Relevance:</em> The BMC metamodel and its implementation shall be relevant to the problem definition and background and only contain relevant elements and features and approaches.</td>
</tr>
<tr>
<td><strong>R08</strong> <em>Efficiency:</em> The BMC metamodel and its implementation shall be created in an efficient way by use and re-use of existing knowledge and solutions.</td>
</tr>
<tr>
<td><strong>R09</strong> <em>Clarity:</em> The BMC metamodel and its implementation shall be clear and understandable.</td>
</tr>
<tr>
<td><strong>R10</strong> <em>Comparability:</em> The BMC metamodel and its implementation shall be comparable with the BMC model definitions and existing knowledge and tools supporting BMC where possible and explain where it is not.</td>
</tr>
<tr>
<td><strong>R11</strong> <em>Systematic design:</em> The artifact design and relationship between the artifacts themselves and to the problem background shall be structured and clear. This is required for both artifacts.</td>
</tr>
</tbody>
</table>

*Table 3: Requirements for the artifacts.*

This list of requirements will not only be used as input in the design & development section but also used for the evaluation section.
Design & Development

The creation of the BMC metamodel is detailed in this section and its implementation in RSA with the MetaModelAgent extension which includes the creation of a BMC UML Profile.

The BMC metamodel artifact is a prescriptive knowledge-based metamodel, developed to facilitate the development and transition of a traditional BMC model to a corresponding BMC model in an OMG-standards based modeling environment. This metamodel is of the model artifact type. The implementation of the BMC metamodel in RSA creates a usable tool to support solving the explicated problem. The implementation creates a Design Science artifact of the instance type.

BMC Metamodel creation

The creation of the BMC metamodel is done in four steps where input and details from different sources are incorporated and discussed. The definition of the BMC metamodel is mainly based on the BMC definitions in the Business Model Generation book (Osterwalder & Pigneur, 2010). The metamodel is created by first defining the classes of the metamodel and their attributes and then relationships between them. The drafted metamodel is then refined using input from the literature review and finally enumerations are added and transitive or excessive relationships removed to make the metamodel ready for implementation.

The four steps to create the BMC metamodel here are:

Step 1: Draft the initial conceptual BMC metamodel strictly from the text and examples in the Business Model Generation book (Osterwalder & Pigneur, 2010).

Step 2: Update and refine the BMC metamodel where applicable with input from the definition of BMO (Osterwalder, 2004).

Step 3: Update and refine the BMC metamodel with input from the literature review.

Step 4: Review and refine the metamodel and define enumerations.

Step 1: Initial draft of the BMC metamodel

The 9 building blocks of BMC and their basic attributes and relationships are described in the Business Model Generation book by Osterwalder and Pigneur from 2010 and provide the basis for the initial BMC metamodel. The description of and relations between the 9 building blocks is mainly derived from the text on pages 16-17 in the book and also descriptions for each building block in the following sections (Osterwalder & Pigneur, 2010). Further details on e.g. relationships is added from the BMO definition in step 2 which is similar approach as was used by (Meertens, et al., 2012) when mapping BMC to ArchiMate.

Each BMC building block is represented by a single class in the metamodel to keep the metamodel simple and close to the actual BMC model layout. Analysis of different abstraction layers, possible generalization or use of groups and sub-groups in the metamodel is left for possible future research.

The approach taken for the initial BMC metamodel here is similar to what Nick Malik started out with when suggesting a BMC metamodel in his blog on the Microsoft Developer Network (Malik, 2012). The resulting metamodel here is though different e.g. since we do not add new classes to the 9 basic
BMC classes in the metamodel. Instead we create attributes within some classes to represent the different types which otherwise could possibly be sub-classes.

All identified element attributes from the Business Model Generation book (Osterwalder & Pigneur, 2010) are included. The BMC metamodel classes and their attributes are summarized and briefly explained in table 4 below. Note that the class names are in singular form to follow UML standards.

<table>
<thead>
<tr>
<th>BMC metamodel class</th>
<th>Attributes identified</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>All classes</em></td>
<td>Name</td>
<td>All BMC classes contain this attribute as a text string stating the name of the element instance.</td>
</tr>
<tr>
<td><em>All classes</em></td>
<td>Description</td>
<td>All BMC classes contain this attribute as a text string stating the description given for the element instance.</td>
</tr>
<tr>
<td>Value Proposition</td>
<td>-</td>
<td>No attributes specified for the Value Proposition class in this step since no clear attributes are mentioned in the text which just mentions different contributions to the customer value creation. The descriptions do partly resemble the attributes defined for VP from the BMO definition later in this section.</td>
</tr>
</tbody>
</table>
| Key Partnership              | PartnershipType       | This attribute can take one of the following four values (Osterwalder & Pigneur, 2010):
|                              |                       | strategic alliances between non-competitors, strategic alliances between competitors, joint ventures, buyer-supplier relationship. |
|                              | MotivationType        | This attribute can take one of the following three values (Osterwalder & Pigneur, 2010):
|                              |                       | optimization and economy of scale, risk reduction, resource and activities acquisition. |
| Key Activity                 | ActivityCategory      | This attribute can take one of the following three values (Osterwalder & Pigneur, 2010):
|                              |                       | production, problem solving, platform/network |
| Key Resource                 | ResourceType          | This attribute can take one of the following four values (Osterwalder & Pigneur, 2010):
|                              |                       | physical, intellectual, human, financial |
|                              | OwnershipType         | This attribute can take one of the following three values (Osterwalder & Pigneur, 2010):
|                              |                       | owned, leased, acquired from key partners |
| Customer Relationship        | Motivation            | This attribute can take one of the following three values (Osterwalder & Pigneur, 2010):
|                              |                       | customer acquisition, customer retention, boosting sales (upselling) |
|                              | Category              | This attribute can take one of the following six values (Osterwalder & Pigneur, 2010):
|                              |                       | customer acquisition, customer network, customer retention, customer retention, customer acquisition, customer network |

33
<table>
<thead>
<tr>
<th>Channel</th>
<th>ChannelType</th>
<th>This attribute can take one of the following five values (Osterwalder &amp; Pigneur, 2010): sales force, web sales, own stores, partner stores, wholesaler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ChannelPhase</td>
<td>This attribute can take one of the following five values (Osterwalder &amp; Pigneur, 2010). A channel can though cover some or all of these phases and thus the sixth value multi-phase is added. awareness, evaluation, purchase, delivery, after sale, multi-phase</td>
</tr>
<tr>
<td>Customer Segment</td>
<td>SegmentType</td>
<td>This attribute can take one of the following five values which are named as examples in (Osterwalder &amp; Pigneur, 2010). The sixth value “other” is included too since the first 5 values are mentioned as examples and possibly not a full list from the authors of BMC. mass market, niche market, segmented, diversified, multi-sided platform, other.</td>
</tr>
<tr>
<td>Cost Structure</td>
<td>CostStructureType</td>
<td>This attribute can take one of the following two values (Osterwalder &amp; Pigneur, 2010) below. Additionally the third value combined is added since many business models can fall between the other two extremes. cost-driven, value-driven, combined</td>
</tr>
<tr>
<td></td>
<td>CostStructureClass</td>
<td>This attribute can take one of the following four values (Osterwalder &amp; Pigneur, 2010): fixed costs, variable costs, economies of scale, economies of scope</td>
</tr>
<tr>
<td>Revenue Stream</td>
<td>StreamType</td>
<td>This attribute can take one of the following two values (Osterwalder &amp; Pigneur, 2010): transaction revenues, recurring revenues</td>
</tr>
<tr>
<td>PricingMethod</td>
<td>This attribute can take one of the following eight values (Osterwalder &amp; Pigneur, 2010): fixed list prices, bargaining, auctioning, market dependent, volume dependent, yield management, product feature dependent, customer segment dependent.</td>
<td></td>
</tr>
<tr>
<td>GenerationType</td>
<td>This attribute can take one of the following seven values (Osterwalder &amp; Pigneur, 2010): asset sale, usage fee, subscription fees, lending/renting/leasing, licensing, brokerage fees, advertising</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: BMC element attributes
Relationships between the classes in the BMC metamodel draft are defined where they can be derived either directly or indirectly from the text in the Business Model Generation (BMGen) book by (Osterwalder & Pigneur, 2010). The definition of relationships and their multiplicity is quite vague in the mentioned book and both explicit and implicit indications from the text are used and explained in table 5 below. Each building block of the BMC model is represented in the table below with its acronym to better fit the text, e.g. Value Proposition is VP, Cost Structure is CoS, Customer Segment is CS, Key Partnership is KP and so forth. The relationships are listed in table 5 as between a class at relationship “End 1” and another class at “End 2”. The multiplicity on each end is listed and a brief text explanation on the relationships and multiplicity. Figure 8 below displays the basic concepts used for the relationships in table 5.

Figure 8 Basic concepts for relationships in the BMC class diagram.

The table starts explaining the relationships to/from the Cost Structure (CoS) class which connects to all of the 8 other classes in the BMC metamodel. Relationships to/from successive classes in the table are not repeated in the table below when reading top-down since they have already been defined.

<table>
<thead>
<tr>
<th>Associated end BMC class</th>
<th>Multiplicity</th>
<th>Relationship explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>End 1</td>
<td>End 2</td>
<td>E1</td>
</tr>
<tr>
<td>CoS</td>
<td>KP, KA, KR, VP, CR, Ch, RS, CS</td>
<td>1..*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There is always a Cost Structure (CoS) in the model and all other BMC classes result in it. The CoS can consist of different cost elements which can connect to 0 or more of each class to get a full CoS for the model. (pages 16-17) (Osterwalder &amp; Pigneur, 2010)</td>
</tr>
<tr>
<td>KP</td>
<td>KA, KR</td>
<td>0..*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additionally to the relationship defined for KP in the line above, some Key Activities (KA) and Resources (KR) may be acquired outside the enterprise from the Key Partnerships (KP) and are thus related. (pages 16-17) (Osterwalder &amp; Pigneur, 2010)</td>
</tr>
<tr>
<td>KR</td>
<td>KA, VP, CR, RS, Ch, CS</td>
<td>1..*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adding to the defined relationships of KR above, the multiplicity is indirectly specified in the text where KA, VP, CR, RS, Ch and CS are created by KR’s and must link to at least one KR. KR’s can exist without linking to KA, VP, CR, RS, Ch and CS but it would imply that the resource is not well used while it links to the Cost Structure (CoS). (pages 16-17) (Osterwalder &amp; Pigneur, 2010)</td>
</tr>
<tr>
<td>KA</td>
<td>CR, Ch, VP, RS</td>
<td>1..*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The multiplicity is indirectly specified in the text where CR, Ch, VP and RS are created or reached by KA’s and must link to at least one KA. KA’s can exist without linking to KR, VP, CR, RS or Ch. (p.36-37) (Osterwalder &amp; Pigneur, 2010)</td>
</tr>
<tr>
<td>VP</td>
<td>RS,Ch</td>
<td>1..*</td>
</tr>
</tbody>
</table>
| | | Value Propositions (VPs) can connect to one or more RS, depending on the way it is sold. RS can connect to 1 or more VP. (p,30-31). VP is
communicated, sold and delivered by different Channels and must have at least one. Channels exist for selling, communicating or delivering one or more VPs. (pages 16-17) (Osterwalder & Pigneur, 2010)

| VP | CS | 1..* | 1 | VPs are created for a specific CS. CS can have one or more VPs. (pages 22-23) (Osterwalder & Pigneur, 2010) |
| CS | CR | 1 | 1..* | CS has 1 or more CRs defined for them. A CR is created for a specific CS. (pages 16-17, 20-21 & 28-29) (Osterwalder & Pigneur, 2010) |
| CS | Ch, RS | 1..* | 1..* | CS has 1 or more Chs or RSs defined for them. A Ch and RS have 1 or more CSs. (pages 20-21, 26-27, p.30-31) (Osterwalder & Pigneur, 2010) |

Table 5: BMC metamodel relationship summary.

The initial BMC metamodel draft after step 1 is shown in figure 9 below.

Figure 9: Initial draft of the BMC metamodel after step 1.
**Step 2: Update BMC metamodel with input from BMO definition.**

In this step the BMO definition (Osterwalder, 2004) is reviewed to look for further details and updates to the initial BMC metamodel from step 1.

BMC is based on BMO even though the detailed mapping for all elements, attributes and relationships from BMO to BMC is not explicitly stated in the reviewed literature. The overall mapping of elements and attributes from BMO to each BMC element is though quite clear as shown in table 1 above and is used here for updating the metamodel with BMO input. The more detailed attributes of sub-elements and inherited attributes in BMO are omitted to keep the BMC metamodel simpler and close to the BMC model detail level.

The multiplicity of each element in BMO is stated in its definition and all the 9 main elements mapping to BMC elements have multiplicity 1..n except Partnership which has 0..n. This basically means that 8 of 9 elements in BMC are mandatory according to the underlying BMO definition and this is in sync with the multiplicities of the BMC metamodel drafted in step 1 above.

The relationships in the BMC metamodel are based on the relationships defined between the BMO elements in (Osterwalder, et al., 2004). The relationships included in the BMO definition (Osterwalder, 2004) are not fully consistent in the BMO definition and thus not fully consistent with the relationships extracted in step 1 above. In the BMO definition the element relationships are stated in several different ways. This includes a graphical illustration of the whole BMO, a presentation of its pillars, individual elements or in the definition and explanation text of the BMO definitions (Osterwalder, 2004). This gives a detailed overview of relationships in BMO through the different levels of graphics but as stated earlier there are a few cases where relationships in BMO are not fully clarified or consistent. An example of this is the Value Proposition which is shown with no direct relationship to the Customer element but indirectly through Relationship and Channel in figure 21 in (Osterwalder, 2004) while it is presented with direct relationship to the Target Customer but not to the Relationship or Channel elements in Figure 23 and Table 20 a few pages later in that same reference (Osterwalder, 2004).

The way it is dealt with in this thesis is to include the relation if it is mentioned or depicted in any of the explanations of BMO in the paper by (Osterwalder, 2004) and compare it with the relationships in step 1 and decide on possible updates. Similarly each BMC element is compared to the corresponding BMO definitions and possible updates are explained in the following text.

**Value proposition**

The BMC Value Proposition element maps to a BMO element with the same name which is a part of the Product pillar in BMO. The Value Proposition in BMC represents the products and product offerings as the BMO Value Proposition does and the attributes from BMO which are not specifically mentioned in the BMC definitions are included here to help clarifying and defining the Value Proposition in BMC. See figure 10 below.
In BMO the Value Proposition and Offering elements are related to the Target Customer, Capability, Relationship, Distribution Channel, Value Configuration, Partnership and Revenue elements. This is similar to the relations in the metamodel in step 1 except the relation to Cost Structure is not explicitly defined in BMO and BMO includes relationship between Value Proposition/Offering elements and the Relationship/Mechanism elements (Osterwalder, et al., 2004) . This relationship between the Value Proposition and Customer Relationships is added to the BMC metamodel to show that the customer relationship is not independent of the products offered to the customers. The multiplicity is not specified in BMO but set the same way as the Value Proposition relationship with Channels since it is a similar element in terms of connecting Value Proposition to Customer Segments.

The class representing Value Proposition in the BMC metamodel is also updated to include four new attributes from the BMO elements mentioned above, summarized in table 6 below.

### Customer Segments
The BMC Customer Segments element represents the Target Customer from BMO which is part of BMO’s customer interface pillar. No new attributes are added to this element from BMO in this step.

In BMO the target customer elements are related to the Value Proposition, Relationship, Channel and Pricing elements. These relationships are already included in the BMC metamodel and no updates are required here.

### Customer Relationships
The Customer Relationship element represents elements from BMO’s customer interface pillar and maps to the BMO element Relationship. The Customer equity attribute in BMO maps directly to the motivation attribute in the BMC Customer Relationships element and no new attributes are added from BMO to the BMC Customer Relationships element.

The BMO Relationship elements promote a Value Proposition and are maintained with a Target Customer. The corresponding relationships are already represented in the BMC metamodel between Customer Relationships and Value Proposition and Customer Segments.
Channels
The BMC Channels element maps to the Channel element in BMO’s customer interface pillar with its basic attributes. The Customer Buying Cycle attribute from BMO is already represented within the Channel Phase attribute in BMC and thus no new attributes are added.

The BMO Channel element delivers one or more Value Propositions to one or more Target Customers and can also have Revenue Streams in BMO. Thus we add a relationship between Channels and Revenue Streams into the BMC metamodel in figure 11 below.

Key Resources
The Key Resources element in BMC maps to the Capability element in BMO which in turn includes a sub-element called Resources. No new attributes are added to the Key Resources element in the BMC metamodel here.

The relationships in BMO relate Capability to Value Proposition, Key Activities and Key Partners. No new relationships are added to the metamodel for this element since they are already there from step 1.

Key Activities
This BMC element maps to the Value Configuration element from BMO’s infrastructure management pillar. The Value Configuration in BMO has an attribute called Configuration Type which can take the values “value chain”, “Value shop” or “Value network”. This is not mentioned on BMC at all and will thus not be added, to keep the BMC metamodel structure simple and not add details unless it directly relates to the BMC definition.

In BMO the Value Configuration element makes the Value Proposition possible, relies on Key Resources and can be provided or executed by an external actor through the Key Partners. These relationships are already present in the BMC metamodel from step 1.

Key Partnerships
The Key Partnerships element maps to the Partnership element in BMO’s infrastructure management pillar. The Partnership element in BMO has a sub-element called Agreement with several attributes which will not be added to the BMC metamodel to keep the model simple and as close to BMC definitions as possible and these attributes are not seen as significant for the BMC model.

The Partnership in BMO helps providing the Key Activities and Key Resources needed to deliver the Value Proposition. In BMO the Partnerships element is related to the Key Resources, Key Activities and Value Proposition elements. This supports adding a relationship between the Key Partnerships and Value Propositions in the BMC metamodel to reflect the associations from the underlying BMO elements.

The Partnership element in BMO has a multiplicity defined as 0..n which means that the business model should contain zero or more Key Partnership elements. This is the only element in the BMC model which BMO does not require to exist. Even though partnerships can be important, they are not necessary and are not required in the BMC metamodel.

Relationship between Value Proposition and Key Partnerships is added to the BMC metamodel.
**Cost Structure**
This BMC element maps to the BMO Cost Structure element from BMO’s financial aspects pillar. No new attributes from BMO elements are added for this element in the metamodel.

The Cost Structure related elements in BMO are not directly related to any other elements in BMO and thus do not add any relationships to the BMC metamodel here and none are removed.

**Revenue Streams**
The BMC Revenue Streams element maps to the Revenue Model element in BMO’s financial aspects pillar. No new attributes are added from BMO here.

In BMO the Revenue Model and its sub-element are related to the Value Proposition, Customer Segments and Channels elements. These relationships are already included in the BMC metamodel from step 1.

**Summary of updates in step 2**
The added attributes and relationships based on BMO to the BMC metamodel from step 1 are summarized in tables 6 and 7 below.

<table>
<thead>
<tr>
<th>BMC metamodel class</th>
<th>Attributes added</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value Proposition (BMO)</td>
<td>Reasoning</td>
<td>States why a company believes the ValueProposition is valuable for the customer. It can take one of the following three values (Osterwalder, 2004): use, risk, effort</td>
</tr>
<tr>
<td>ValueLevel (BMO)</td>
<td>Measures the utility for the customer and the level of value the ValueProposition offers compared to competitors. This attribute can take one of the four following values (Osterwalder, 2004): me-too, innovative imitation, excellence, innovation</td>
<td></td>
</tr>
<tr>
<td>PriceLevel (BMO)</td>
<td>Compares the ValuePropositions price level with the competition’s price levels. This attribute can take one of the four following values (Osterwalder, 2004): free, economy, market, high-end</td>
<td></td>
</tr>
<tr>
<td>LifeCycle (BMO)</td>
<td>Captures at which stage of the value life cycle the ValueProposition creates value to the customers. This can take one of the following five values (Osterwalder, 2004): value creation, value purchase, value use, value renewal, value transfer</td>
<td></td>
</tr>
</tbody>
</table>

*Table 6: New attributes added to the BMC metamodel in step 2.*
The review of the BMO definition results in three relationships being added to the BMC metamodel from step 1. See table 7 below.

<table>
<thead>
<tr>
<th>Associated end BMC elements</th>
<th>Multiplicity</th>
<th>Relationship explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>End 1 End 2 E1 E2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VP  KP</td>
<td>1..* 0..*</td>
<td>The BMO definition has a direct relation between the Key Partners elements and Value Proposition elements. This supports adding a relationship between the Key Partnerships and Value Propositions in the BMC metamodel to reflect the associations from the underlying BMO elements. The Partnership element in BMO has a multiplicity defined as 0..n which means that the business model should contain zero or more Key Partnership elements that are related to one or more Value Proposition (Osterwalder, 2004).</td>
</tr>
<tr>
<td>VP  CR</td>
<td>1..* 1..*</td>
<td>The BMO definition includes a relationship between Value Proposition/Offering elements and the Relationship/ Mechanism elements (Osterwalder, 2004)</td>
</tr>
<tr>
<td>Ch  RS</td>
<td>1..* 1..*</td>
<td>The BMO definition includes a relationship between the Channel element through its Link sub-element and the Revenue Streams elements through its Pricing sub-element (Osterwalder, 2004)</td>
</tr>
</tbody>
</table>

Table 7: New relationships added to the BMC metamodel in step 2.

**BMC metamodel diagram**

Step 2 results in an updated BMC metamodel with added attributes to the Value Proposition element and three new relationships between classes.

In figure 11 below the relationships of the updated BMC metamodel have been color coded to show the origin of each relationship. Relationships that are defined both in BMC and BMO are shown as green lines, relationships defined from BMC only are shown as black lines and finally the relationships defined only from BMO are drawn as red lines in figure 11 below. The added attributes are prefixed with “BMO” to show they have been added directly from the BMO definition.
Step 3: Update the BMC metamodel with input from literature review.

In this step the drafted BMC metamodel is updated with input from literature review where a BMC metamodel has been suggested by other authors. There are limited references available for BMC metamodels and only two were found where a formal BMC metamodel is drafted. Neither reference has extensive explanations or arguments for a full BMC metamodel.

The first BMC metamodel reviewed is in figure 12 below and was created as a class diagram with proposed extensions (Iacob, et al., 2012). This conceptual BMC metamodel is actually based on BMO more than the actual BMC even though it is called a BMC metamodel. The dotted lines are suggested extensions for the BMC metamodel from the BMO definition. All relationships from this metamodel are included in the drafted metamodel we have after step 2, except the suggested added relationship between Customer Relationships and Channels. Iacob et al (2012) suggest this additional relationship to make explicit the resources, in this case Channels, needed for Customer Relationships (Iacob, et al., 2012). This relationship is not mentioned or indicated in the Business Model Generation book (Osterwalder & Pigneur, 2010) or the BMO definition (Osterwalder, 2004) and will not be included here. Furthermore we have the Customer Relationships class related to the Key Resources class to represent the resource use. No new classes or attributes are identified from this BMC metamodel to add. No multiplicities are defined while basic navigation and relationship names are specified which can be used for refining navigation in our metamodel. This metamodel is more readable than the one we have after step 2 and will be used as input for refining and pruning the metamodel in step 4.
The second BMC metamodel reviewed is from a blog on the Microsoft Developer Network (MSDN) where the author, Nick Malik, looks at integrating BMC into his own Enterprise Business Motivation Model (Malik, 2012). Malik starts out with creating a basic conceptual model with the basic BMC elements and then defines relationships between them from the text in the Business Model Generation book (Osterwalder & Pigneur, 2010). Then Malik looks for missing relationships and adds them to his diagram in his work. In this process Malik balances the connections to the Revenue Streams element to match the connections to the Cost Structure. Furthermore he adds relationship between Channels and Customer Segments, which is actually stated quite clearly in the Business Model Generation book, but he has somehow missed it and adds it later for different reasons. Finally transitive relationships are removed. Malik’s resulting BMC metamodel is shown in figure 13 below where the black lines show relationships that Malik found directly from the BMC definition and the red lines and the relationships he found missing and added himself.

This metamodel is used as input to revise the BMC metamodel of this thesis in terms of navigation. No new classes, attributes or relationships are added from Malik's metamodel. Further revisions by Malik aim towards integrating BMC into another model and those changes are not relevant to the work here. The green boxes in figure 13 below represent the 9 BMC building blocks while the red boxes refer to sub-types from the text that are not modeled as separate classes. The yellow boxes represent elements that are referred to by the other BMC elements but not captured directly in BMC. The yellow boxes are basically integrated in the Customer Segments element in our BMC metamodel. The base colored box is an addition from Malik to specifically model the products or services that are needed for the customers. This element is not modeled specifically in our BMC metamodel but is contained in the Value Proposition.
The results of reviewing these two metamodels reveal no changes to classes or attributes for the BMC metamodel draft. No changes in relationships or their multiplicity are added either.

The two reviewed metamodels are not specified in strict UML and show an abstract flow of events and how the elements affect each other. This presentation of relationships shows the flow of resources to make it easier to read and understand in terms of the business model and does thus not give direct input to strict UML definitions including navigation, dependency or other specific relationships.

This leaves the BMC metamodel unchanged from step 2 above. The metamodel is still rather complex to read or implement and is reviewed and simplified in step 4 below.

**Step 4: Review and simplify the metamodel.**

In this fourth and final step the BMC metamodel is reviewed and simplified where possible to increase the readability and simplify implementation. Since no new classes were added to the 9 basic BMC elements, the draft metamodel will not be abstracted further in terms of classes and their attributes. This abstraction level is seen as appropriate for this metamodel to keep it close to the BMC model it reflects and at the same time easy to read and understand. The relationships are complex and some transitive relationships are removed in this step for simplification without losing the underlying meaning of the model. This may lose some detail but at the same time make the model more approachable and usable. The simplification of relationships by removing some of them is explained in the text below. Any missing enumerations are also specified for the attributes before implementation.
The direct relationships between KeyActivity (KA) and Customer Relationship (CR) and Channel (Ch) are removed since CR and Ch stand for their own specific activities between the Value Proposition (VP) and the Customer Segment (CS) and can also relate through both the VP and Key Resource (KR).

The direct relationships between KeyActivity (KA) and Customer Segment (CS) are also removed as excessive relationship where KA can relate to CS both via KR and VP via CR or Ch.

The Key Partnership (KP) relationship with VP is removed on basis of transitivity since they are related via both KA and KR.

The relationship between VP and CS is removed on basis of transitivity since these classes are related through both CR and Ch.

The relationships between the CostStructure (CoS) and all other classes except Key Resource (KR) are removed due to transitivity through KR. I.e. all classes except the Customer Segment are directly related to KR and by that their resource use can cover their cost with the KR connection to CoS.

We have taken the approach to let KR represent the cost in the model with their direct relation to the Cost Structure. At the same time the VP and CS provide the Revenue Stream (RS). Thus the VP and CS are the only elements directly related to a RS class and other relationships to it are removed.

After this simplification and removal of excessive transitive relationships we reach the suggested final version of the BMC metamodel as displayed in figure 14 below. This is the BMC metamodel we present as our result and will implement in RSA to use for BMC modeling.
Figure 14: The resulting BNC metamodel.
To cater for the attributes defined in the metamodel and explained for each class in the preceding text, the following enumerations are defined to detail the metamodel. The suggested final enumerations are presented in figure 15 below.

![Figure 15: Suggested enumerations for the BMC metamodel](image)

Now that we have created our BMC metamodel including definitions for each model element, attributes, enumerations and relationships, the next step is to implement it in our chosen modeling environment using UML to provide tool support for BMC modeling and test and evaluate it.

We create a UML Profile to represent this metamodel since we see it as simpler and more appropriate approach for this work than creating a MOF extension. This fits well with the use of the MetaModelAgent which requires a UML Profile to build the metamodel and thus using the MMA wizard in the following sections.
UML Profile creation for the BMC Metamodel

This section describes the creation of a UML Profile to represent the BMC metamodel created above and the implementation of this profile in Rational Software Architect (RSA).

The approach taken to create the BMC UML Profile is to first define the stereotypes and map to UML metaclasses to represent the BMC elements. Then new attributes are defined as tags followed by creation of enumerations.

Stereotypes are used to tag the elements of the model and thus giving them a new set of semantics. This is done by associating properties with each used stereotype to provide additional information that otherwise would not have been available in the model. For the BMC UML profile, only the Model and Class metaclasses of UML are extended.

The enumerations in the profile are standard enumerations without any need for metaclass extensions and represent the new available tagged values for the BMC model elements. All the BMC enumerations in Figure 15 above are defined for the profile and further details are provided in the following section when implementing the profile in IBM RSA.

Table 8 below summarizes the stereotypes used and the UML metaclasses they extend.

<table>
<thead>
<tr>
<th>Stereotype</th>
<th>UML metaclass extended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Model</td>
</tr>
<tr>
<td>ValueProposition</td>
<td>Class</td>
</tr>
<tr>
<td>KeyPartnership</td>
<td>Class</td>
</tr>
<tr>
<td>KeyResource</td>
<td>Class</td>
</tr>
<tr>
<td>KeyActivity</td>
<td>Class</td>
</tr>
<tr>
<td>CustomerRelationship</td>
<td>Class</td>
</tr>
<tr>
<td>Channel</td>
<td>Class</td>
</tr>
<tr>
<td>CustomerSegment</td>
<td>Class</td>
</tr>
<tr>
<td>CostStructure</td>
<td>Class</td>
</tr>
<tr>
<td>RevenueStream</td>
<td>Class</td>
</tr>
</tbody>
</table>

Table 8: Summary of stereotypes for the BMC UML Profile

When the stereotypes and enumerations have been defined the profile can be implemented. The profile implementation is described below.
Implementing the BMC UML Profile in RSA

This section describes the implementation of the BMC UML Profile in RSA through explanatory text and screenshots.

To create the profile in RSA, a profile project is created in a selected workspace.

1. Click File > New > Project
2. In the New Project window, expand Modeling, then expand UML Extensibility and select UML Profile Project and click Next. See figure 16 below.

3. Specify a project name (BMCProfile) and click next twice.
4. Type in a profile name and specify a file name and then click Finish. See figure 17.
5. The new BMC UML Profile Project 2012 and the BMCProfile are now created and can be managed from the Project Explorer.

Next the enumerations and stereotypes are specified with attributes and associations with the UML model elements.

We start with defining the enumerations:

1. Expand the profile project and right-click on the newly created BMCProfile folder and click Add UML>Enumerations. Specify a name and press Enter.
2. On the Properties tab, click on Literals to add enumeration literal name and value specification.
3. Repeated this for all enumerations as specified in figure 15 above.

Next the stereotypes and their attributes and appearance is specified:

1. Expand the profile project and right-click on the newly created BMCProfile folder and click Add UML>Stereotype.
2. Specify a name and press Enter.
3. In the Properties view of the stereotype, click the Extensions tab.
4. On the Extensions tab, click the Add Extension and then select the model element to extend and click Ok.
5. Right-click on the stereotype and click Add UML>Attribute. Type the name of the stereotype’s attribute and click Enter. Set the attribute type in the Properties tab.

6. On the General tab, an icon can be specified for the stereotypes to use in the project explorer view and a shape image can also be specified to be used in the diagrams for each stereotype if needed.

After the creation of all stereotypes, enumerations and other profile items, the profile can be browsed in the project explorer. See figure 18 below which shows part of the profile tree.

![Figure 18: BMCProfile in the RSA project explorer tree view.](image)

Figure 18: BMCProfile in the RSA project explorer tree view.
A class diagram representing the BMC UML Profile is presented in figure 19 below:

Figure 19: BMC UML Profile implemented in IBM RSA.

This BMC UML Profile can now be used when creating the BMC Metamodel in IBM RSA with the MetaModelAgent (MMA) plugin. After testing the profile is released in RSA so it can be used without allowing any further updates to it.

Implementing the BMC metamodel with MetaModelAgent in RSA

This section describes the implementation of the BMC metamodel with the Adocus MetaModelAgent plugin in RSA through screenshots and supportive text. This implementation provides the actual tool support for BMC modeling.

After installing the MetaModelAgent plugin in RSA, the BMC metamodel can be created in the RSA modeling environment by running the following steps:

2. Name the model project “BMC metamodel” and click next to create a model from a standard template. See figure 21 below.
3. Select the MetaModelAgent category and the Meta Model Template and set the File name to match the model name and click Finish. See figure 22 below.

![Model Project](image)

**Figure 22:** The new model uses the Meta Model Template from MMA.

This creates a new basic metamodel named “BMC metamodel” in the selected project folder structure based on a basic MMA metamodel template which needs to be updated to reflect the BMC metamodel being implemented. The basic MMA metamodel template is shown in figure 23 below.

![Basic MMA MetaModel Template](image)

**Figure 23:** Basic MMA MetaModel Template
4. Open the new MetaModel Foundation class diagram and re-arrange items to make the diagram more readable, e.g. move the foundation items up and to the sides. Then update the multiplicity from „The Model“ to „Meta Model Instantiation“ since there will be only a single BMC metamodel for the BMC models to use. Same for the multiplicity to Type Library Import.

5. Re-name the existing stereotype items: „The Model“ -> „BMC Model“ and „The Meta Model“ -> „BMC MetaModel“.

6. Add attributes to the model stereotype class to require the name and documentation of it to be specified, and the BMC Profile to be used.

7. Now start adding the elements representing our actual BMC Metamodel to the diagram. This means the classes representing the BMC elements and the relationships between them and attributes. This is done by adding stereotyped classes for the nine BMC elements and creating the required attributes within each one of them. Each stereotype class must be associated to the BMC Model model stereotyped class with aggregated relationship where each element must exist in one BMC Model and each BMC Model can contain 1 or more of each BMC element. Finally create associations including association ends between the BMC elements to represent the BMC metamodel from above. Each association end must specify the type of the opposing association end. Figure 24 below shows the metamodel after these initial steps including creation of basic versions of the ValueProposition and KeyActivities Stereotyped classes and association between them reflecting the cardinalities for the BMC model and basic attributes.

Figure 24: A partial BMC Metamodel after initial updates including steps 1-7 above.

Now the remaining BMC elements and their associations need to be added and further attributes and details added. Each BMC element is represented with a stereotyped class as explained earlier and the attributes are defined and their rules and documentation to use as guidelines during the creation of the
BMC model. Figure 25 below shows a screenshot of a detailed Value Propositions stereotyped class. All metaclass attributes have the stereotype set to either <<key>> or <<rule>>. The <<key>> stereotype means that the class must have an instance of Value Propositions in the model. The <<rule>> stereotype means that the attributes must exist for each Value Propositions class. The type is set for each attribute and most of them are defined by enumerations. The Reasoning attribute is given the default value „use“.

![Value Propositions stereotyped class with attributes](image)

Figure 25: Value Propositions stereotyped class with attributes

The implemented BMC metamodel classes, attributes, enumerations and associations contain guiding documentation which can assist the user when creating a BMC model using the BMC metamodel. This documentation is created as a property for each element and is displayed when using the MMA wizard in creating, updating or correcting the BMC models. An example of a help text is displayed in figure 26 below showing the help text for the Reasoning enumeration attribute in the Value Proposition stereoclass.

![Help text for the Reasoning attribute in the Value Propositions class.](image)

Figure 26: Help text for the Reasoning attribute in the Value Propositions class.

The enumerations need to be defined in the BMC Metamodel to match the enumerations in the BMC UML Profile. By doing this the MetaModelAgent can use the enumerations when creating each BMC model. The enumerations in the BMC metamodel as shown in figure 27 below.
The final/full BMC metamodel is too big to fit on an A4 page in a readable format. An image of the full BMC metamodel implemented in RSA is included in appendix D to give an idea of how its implementation looks in RSA with the MMA extension.

As a final step, the resulting metamodel is reviewed and manually cross-checked to ensure that it fully matches and covers the BMC metamodel and thus the BMC canvas itself for completeness and correctness of concepts.

The BMC metamodel is now fully implemented and next step is to demonstrate how its implementation works as tool support for BMC modeling and verify if it fulfills the requirements put forward. See the following section.
Demonstration

To demonstrate how the artifacts works, an illustrative example based on a selected BMC model is used. The selected BMC model is used as input to be re-created in RSA with support from the metamodel. The selected BMC must contain elements in all boxes of the BMC to be able to demonstrate all functionalities and parts of the artifacts. At the same time the selected BMC model should be simple enough to easily be understood and usable for this purpose. This section will both give a descriptive knowledge of how the artifacts work and explanatory knowledge by explaining why they work.

The BMC model we use here is taken from page 98 in the book “The Business Model Generation” by (Osterwalder & Pigneur, 2010) where the business of Skype is modeled in BMC. See figure 28 below.

![Skype BMC Model](image)

*Figure 28: BMC model for Skype (Osterwalder & Pigneur, 2010)*

The BMC model for Skype is briefly explained in the book as an example of a *Free* business model while additionally it has elements where the users pay for certain services (the specific free elements are color coded with red while the paid-for are green.). Figure 28 does not display much detail on the Skype business model and the accompanying text with it shares little further detail. No associations or attributes are available here in this standard BMC model representation and this needs to be addressed when re-creating the Skype BMC model with the artifacts in the following text.

Creation of a Skype BMC model in RSA using the MetaModelAgent and the BMC Metamodel:

1. Open RSA and click File->Other-> (or CTRL-N) and select the MetaModelAgent enabled Model and click Next. See figure 29 below.
2. Select the „BMC MetaModel“ in the list of Metamodels and review the information text about the BMC MetaModel and then click Next. See figure 30 below.

Figure 29: Create a new BMC MMA enabled model in RSA

Figure 30: Select the BMC MetaModel for the BMC model creation.
3. Enter the model file details by specifying destination folder, model file name and select the „BMC Model“ as the top element of this model and click Next. See figure 31 below.

![Figure 31: Entering model file details for the BMC model](image)

4. Now set the properties for new BMC model itself. The only required property is the name of the model. The mandatory nested items to be added, lists the elements that must exist in the BMC model and includes the 9 building blocks of BMC along with two MMA specific elements. Deselect the last two elements and click Next. See figure 32 below. By clicking on the name of the mandatory nested items in this window, a guiding text is available in the help/information box on the right. See figure 33 where the „Key Resource“ is explained.
5. Now the MMA Wizard goes through the mandatory nested items and basically requires the user to create all mandatory elements and associations as defined in the underlying BMC metamodel. Only one class is created for each BMC element and if more are required, they can only be added after finishing the wizard. This is a known limitation of the MMA wizard and may be updated in later versions from Adocus. Creation of elements after this initial wizard run is explained later in this section. Now set the properties for each of the new elements required in the following steps.

The wizard starts with requiring creation of the „Cost Structure“ element and its attributes. The specific CostStructure properties (costStructureClass and costStructureType) can be set to the values listed in the respective enumerations. In this Skype BMC model there are two Cost Structures; „Software Development“ and „Complaint Management“. As explained before, the MMA agent only allows you to create 1 class for each of the 9 basic BMC building blocks in the wizard so the other will be added afterwards. Here we start by creating the „Software
Development“ cost structure and name it accordingly. The properties are set and an optional descriptive text is put in the „Documentation“ part. The mandatory association reference is deselected. Informative text is displayed on the right-hand side of the wizard window to explain the selected element. See figures 34 and 35 below. When all properties have been set, click Next.

Figure 34: New Cost Structure element created for the demo model.

Figure 35: Guiding text for a mandatory association in the demo model.

6. Next a Revenue Stream element is created and as before, the name and properties are required before continuing to the next BMC element. There are 3 RevenueStreams (RS) in the Skype model and here we create the „Skypeout pre-paid or subscription“ element and set its properties. Again we deselect the mandatory association references before clicking Next. See figure 36 below.
7. Customer Segment is the next element and we create the „People who want to call phones“ customer segment and set its properties to our best knowledge. The Stereotypes property is automatically set to the corresponding stereotype from the BMC Profile for all the BMC building blocks. See figure 37 below.
8. The Key Resources are created next and here we create the „Software Developers“ resource and set its properties. See figure 38 below.

![Figure 38: New Key Resource element created for the demo model.](image)

9. The Key Activities are next and the Skype model used has only one Key Activity listed and it is created now. See figure 39 below.

![Figure 39: New Key Activity element created for the demo model.](image)
10. Customer Relationships are next up and here we create the „Mass customized“ relationship and set its properties. See figure 40 below.

![Figure 40: Creating the Customer Relationship element for the demo model.](image)

11. Channels are next and we select to create the „Skype.com“ channel. See figure 41 below.

![Figure 41: Creating the Channel element for the demo model.](image)

12. The Value Proposition is now created and we select the „Cheap calls to phones (skypeOut)“. See figure 42 below.
13. The last BMC element that is processed in the MMA wizard is the Key Partnership and here we select to create the „Payment Providers“. When we press the „Finish“ button, the actual BMC metamodel is created. See figure 43 below.

14. The basic BMC model for Skype has now been created, but only with 1 instance of each BMC class for the Skype model since we can only create one of each element type with the current version of the MMA wizard. The model elements created in this initial run of the MMA wizard can be viewed in the Project Explorer in RSA. Note that most of the BMC elements have a red
box with a white „x“ on its icon. This indicates a MMA problem, i.e. that this element does not fulfill the requirements of the underlying BMC metamodel. This is due to the missing association which will be created later. See figure 44 below.

![BMC_v3 Example Models](image)

Figure 44: The initial demo model elements in the RSA Project Explorer.

15. Now we need to create the remaining BMC elements for the Skype model, e.g. the Key Partnership for „Telco Partners“ and more. To do this we can right-click on the new BMCModel in the Project Explorer and select „MetaModelAgent -> Add -> Key Partnerships“ or select the guided addition by selecting „MetaModelAgent -> Add -> Guided Addition...“. We choose the latter in this step and we get a window where we can select the valid element/class types we can create. See figure 45 below. After selecting the Key Partnership and clicking „Next“, we get to the same window as in step13 above where we created the first Key Partnership for this model.
16. After creating all the remaining building blocks for the Skype BMC model we can see in the Project Explorer that all 18 BMC building blocks for Skype have been created. See figure 46 below. Most of the elements still have a small red square with an “x” within, which indicates there is a modeling error related to that element. This is due to the missing associations which are mandatory for these BMC building blocks according to the BMC metamodel. The only BMC building block that does not need to connect directly to another element is the Key Partnership element, thus it has not an error icon.
17. Now we look at creating the required associations between the building blocks of the demo model. Since we deselected the mandatory association creation in the MMA wizard, the MMA displays a list of problems where the missing associations are listed. See figure 47 below.
18. We can use the MMA problems list to quickly create the missing mandatory associations by right-clicking on a problem in the list and select to add it through the MMA wizard. As an example we add an association between the Skype.com Channel element and the Software Key Resource element. See figure 48 below. During the creation of association we get the opportunity to document the relationship in a documentation box. Where there is more than 1 element available to connect to we get a list to choose from, see figure 49 below where a Key Resource needs to be selected for the association. The MMA problems list is automatically updated when problems are either solved or created in the model.
Figure 48: A missing association is created from the MMA Problems list.

Figure 49: Selecting the “Software” Key Resource to associate to in the demo model.
Continuing through the MMA Problems list we add all the missing associations until the list is emptied and the full Skype BMC model fulfills the metamodel requirements. The project explorer shows the added classes and associations. See figure 50 below.

Figure 50: RSA Project Explorer showing element list for fully updated demo model.
20. A class diagram can be created to visualize the Skype demo model, by right-clicking the Diagrams folder and select Create Diagram->Class Diagram. Then select all the demo model elements in the Project Explorer and drag & drop into the new class diagram tab. The diagram needs some manual re-ordering for improved clarity and is shown in figure 51 below. Due to its size it can be difficult to navigate but it shows that all mandatory elements and associations are created. The Key Partnership elements are not associated to any other elements since it is not set as mandatory in the BMC metamodel. Additional elements and associations can be added at will, as long as they do not clash with the underlying BMC metamodel.

![Diagram of the demo model](image)

*Figure 51: A Class diagram for the demo model.*
Creating the Skype BMC model in this demo shows how the BMC metamodel and its implementation as a tool can support a creation of a BMC model in the selected environment with IBM’s RSA and Adocus’ MetaModelAgent. Further examples of support which is not shown directly in the demo example are that the MMA will identify any excessive or undefined items in the BMC model which the BMC metamodel does not define. These will be listed as a problem in the MMA problem list. This means that e.g. if a user creates a UML association between instances that the metamodel does not support, the MMA problem list will contain lines to show that the new association are unknown to the metamodel and offers the user to remove the association or ignore the problem.

The demo also shows that this implementation of a BMC metamodel introduces some limitations for the user when creating a BMC model. By assisting the user with requiring mandatory instances, associations and attributes, the metamodel at the same time ties the hands of the user to certain extent. This can be seen e.g. in the mandatory attributes and pre-defined values in the enumerations which may not always fully fit the users model. To accommodate this, the metamodel could add new values to cover all ‘other’ options or change from mandatory to recommended attributes types. Creation of a visual presentation of the BMC model is a bit cumbersome and the resulting class diagram needs some manual work to be structured in a readable format. The limitations are also due to the selection of technical environment, e.g. the MMA wizard only allows creation of 1 instance of each class during the initial run and you cannot control the sequence of creation of the class instances. Furthermore the associations must be created after the initial run as shown in the demo.

This concludes the demonstration of the BMC metamodel and its implementation in RSA using MMA and gives input to the next section where the artifacts are evaluated.
Evaluation

Evaluation of the results of this work is presented in this section.

The evaluation analyses both how the artifacts fulfill the defined requirements and if the goals of the thesis are met and thus to what extent the explicated problem gets solved. The main structure of the evaluation is based on the defined requirements from table 3 above and each requirement is evaluated to see how and if it is fulfilled. By fulfilling the requirements we argue that the goals are met and a contribution towards solving the explicated problem is delivered. The evaluation consists of an informed argument by the author and expert evaluation through interview with two modeling experts.

Informed arguments

The evaluation of the BMC metamodel and its implementation is first performed with informed argument where the fulfillment of requirements is analyzed.

The requirements defined earlier in section 4.2 are listed and evaluated in table 9 below by explaining and arguing for the fulfillment of each requirement.

<table>
<thead>
<tr>
<th>Req.</th>
<th>Requirement Description</th>
<th>Requirement fulfillment evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>R01</td>
<td>Completeness: The BMC metamodel shall be complete, meaning include and handle all elements, attributes and associations of BMC using BMC definitions supported by BMO.</td>
<td>All 9 building blocks of the BMC and their respective attributes are fully covered in the BMC metamodel. The creation of all 9 BMC building blocks and their attributes are required in the metamodel as defined and argued for in the sections above. All associations between the elements are handled fully according to the BMC definition with input from BMO and the literature and is explained in the text and demoed to work in the Demonstration section above. &lt;br&gt;&lt;i&gt;Evaluation: This requirement is fulfilled.&lt;/i&gt;</td>
</tr>
<tr>
<td>R02</td>
<td>Correctness: The BMC metamodel shall be correct both syntactically and semantically based on the BMC definitions.</td>
<td>The syntax of the BMC metamodel follows the BMC definition and matches its structure. Semantically the elements, attributes and associations are explained and enforced accordingly. &lt;br&gt;&lt;i&gt;Evaluation: This requirement is fulfilled.&lt;/i&gt;</td>
</tr>
<tr>
<td>R03</td>
<td>Relevance: The BMC metamodel shall be relevant to the problem definition and background and only contain relevant elements and features and approaches.</td>
<td>The BMC metamodel contributes to a solution for the problem defined in full accordance to the problem background. The BMC metamodel is almost a true copy of the BMC model with the semantic and syntactic additions a metamodel delivers to a model and no non-relevant additions &lt;br&gt;&lt;i&gt;Evaluation: This requirement is fulfilled.&lt;/i&gt;</td>
</tr>
<tr>
<td>R04</td>
<td>Efficiency: The BMC metamodel shall be created in an efficient way by use and re-use of existing knowledge and solutions.</td>
<td>The BMC metamodel is based on the BMC definition and underlying BMO definition with input from a BMC literature and tool review. The approach taken was to use a development tool which assisted in the metamodel creation. A standard UML Profile was created to support the structures of the resulting metamodel.</td>
</tr>
</tbody>
</table>
### Evaluation of results using informed arguments

<table>
<thead>
<tr>
<th>Requirement (R)</th>
<th>Description</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>R05</td>
<td>Clarity: The BMC metamodel shall be clear, understandable and useful</td>
<td>The BMC metamodel structure and abstraction was kept simple and close to the actual BMC model which gives clarity. The MMA wizard can use the information in the BMC metamodel to help users understand and use the metamodel to create fuller BMC models. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R06</td>
<td>Comparability: The BMC metamodel shall be comparable with the BMC model, BMO and other existing tools and knowledge supporting BMC where possible and explain where not.</td>
<td>The BMC metamodel is true to the BMC model definitions and BMO definition where they match, and any discrepancies were handled and explained as needed. The BMC model can now be created as a UML diagram using this new UML standard based BMC metamodel. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R07</td>
<td>Systematic design: The artifact design and relationship between the artifacts themselves and to the problem background shall be structured and clear.</td>
<td>The artifacts here are the BMC metamodel and its implementation including the BMC UML Profile in a UML based modeling environment. These artifacts map directly to the problem definition and its background by providing an approach to ease and structure the creation of a BMC model in a standards-based modeling environment. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R08</td>
<td>The metamodel shall be based on OMG standards and documented as a UML class diagram.</td>
<td>The metamodel is based on a UML Profile and UML modeling and presented as a UML class diagram. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R09</td>
<td>The metamodel shall be able to run in IBM RSA using Adocus MetaModelAgent</td>
<td>The BMC metamodel runs in IBM RSA using the Adocus MetaModelAgent plugin as was shown in the Demonstration section. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R10</td>
<td>The metamodel shall be able to support the creation of a BMC model in RSA through explanatory suggestions on the structure, elements, relationships, attributes and content of the BMC model.</td>
<td>This was explained and demoed in the Demonstration section and further details are included in the artifacts. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
<tr>
<td>R11</td>
<td>The metamodel shall be able to identify errors in a BMC model and give guiding information related to the errors.</td>
<td>This was explained and demoed in the Demonstration section above and further details are included in the artifacts. <strong>Evaluation: This requirement is fulfilled.</strong></td>
</tr>
</tbody>
</table>

*Table 9: Evaluation of results using informed arguments.*
With informed arguments we come to the conclusion that all the defined requirements are fulfilled. The goal of this research was specifically defined as to create a metamodel for the BMC and implement in an OMG standards-based tool to provide tool support to facilitate and communicate BMC models and these goals have been fully met by fulfilling the requirements as argued above. These results clearly contribute to solving the explicated problem.
**Expert evaluation**

This part of the evaluation is based on expert interviews where the work and results were presented and discussed in detail. Both interviewees have research/lecturing positions at the Department of Computer and Systems Sciences (DSV) at Stockholm University and several years of experience with modeling including business models, metamodeling and formal research in the field. They both have published several reviewed scientific articles on modeling related research and have supervised research work at master-level related to this field of work. Thus they are seen as experts in the field.

The interviews were done in July 2013 and transcripts of the recorded interviews are in appendix C.

The results and analysis of the expert evaluation is documented and performed in a similar structure as the informed argument evaluation above and can be seen in table 10 below and following text. The answers and discussions from each interview are mapped to the defined requirements and a summarizing analysis is added for each requirement in table 10 below.

<table>
<thead>
<tr>
<th>Requirement R01 - Completeness</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>There seem to be no concepts or notions missing.</strong></td>
<td>There seem to be completeness in the intermediate artifacts, the metamodel derived and the implemented one seems to be addressing all the elements that are in principle available in the canvas itself.</td>
<td>The procedure is very good and all main concepts are covered. There are also some concepts added which probably makes the results more complete than the basic BMC, so yes it is complete. The question is also how complete is this when it comes to practical use of BMC since the canvas is more free in its form. So this is complete at least from theoretical point of view but not as clear from the practical standpoint.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**

According to both interviewees there seem to be completeness in the artifacts which address all the elements and concepts available in the BMC itself in a clear way. Interviewee 2 raised a point regarding practical use and how complete this is in terms of ease of use. This is a valid point but outside the defined scope of this thesis where the focus is on taking a drafted BMC model and create in a formalized and supported way.

*Evaluation: This requirement is met for the scope of this work.*

<table>
<thead>
<tr>
<th>Requirement R02 - Correctness</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The artifacts look complete but that doesn’t necessarily mean they are correct.</strong></td>
<td>By looking at the models and the procedure you followed it can lead to good results. So what I can say from what I have seen is that the model captures all the main concepts from BMC and the created metamodel seems to be correct and should be useful.</td>
<td></td>
</tr>
<tr>
<td><em>Still, from the text and demonstration available, the</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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artifacts do seem to be both complete and correct.

**Summary and analysis:**
Both interviewees mention the limitation of only seeing one example or demonstration of using the artifacts and that further examples and implementations would be good to better evaluate correctness. Still both agree that from what they have seen here the artifacts seem correct and fulfilling this requirement.

**Evaluation:** This requirement is met.

<table>
<thead>
<tr>
<th>Requirement R03 - Relevance</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Both the artifacts and their use are relevant to the problem definition with the reasoning behind it and the used modeling environment is relevant as well. The artifacts are essentially relevant for all the defined problems and no excessive elements and all relevant elements exist. The approach is clear and these results should be treated like living/evolving artifacts.</td>
<td>Yes I think the results are relevant to the defined problem and goals. All main concepts from BMC have been created and further relevant concepts that were missing are added from BMO definition which makes the results richer which I think is very good as well. There are no irrelevant concepts in the artifacts, the selected elements are all relevant for this model and you can’t really make the model smaller/simpler without losing details.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**
Both interviewees agree that the results as well as the problem definition and process towards the results are relevant and does not contain excessive elements or lack any.

**Evaluation:** This requirement is met.

<table>
<thead>
<tr>
<th>Requirement R04 - Efficiency</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This work did not start from scratch and the steps followed in this work are efficient in using the sources of existing knowledge, solutions and tools. And the work is effective for sure since it arrives to a solution.</td>
<td>The work done here is what is expected and this is an excellent process used with the steps and iterations, where details are added until a saturation point is reached. The efficiency of using the tool is good if the requirements there are clear on strictness and formal use of UML, but not so efficient if you are just trying to create a canvas.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**
The interviewees agree that the process towards creating the results is efficient and the resulting artifacts as well for the defined scope of the work.

**Evaluation:** This requirement is met.

<table>
<thead>
<tr>
<th>Requirement R05 - Clarity</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>There is clarity from a modeling perspective and both the artifacts as well as the process followed are clear.</td>
<td>The procedure described and the steps are clear. For the metamodel itself I might be a bit tricky to follow due to UML in the metamodel, e.g. the associations.</td>
</tr>
</tbody>
</table>
may be difficult to understand for some with less UML knowledge. But on the other hand the users of this tool are probably not looking at the metamodel itself but using the wizard in the tool and I think that is clear enough for them to understand, while the UML Profile and metamodel are not as easily understood for end users.

**Summary and analysis:**

The interviewees agree that the creation of the artifacts is clear and the artifacts as well. Interviewee 2 mentioned that the artifacts may not be clear to users unless they are experienced modelers in UML but at the same time the end-users will not work with the underlying metamodel or profile and thus this is not an issue in the scope of this work where the intended audience also has modeling experience or knowledge.

*Evaluation: This requirement is met.*

<table>
<thead>
<tr>
<th>Requirement R06 - Comparability</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>According to the interviewee the BMC model work is comparable. The comparability with other tool is unclear, but not really in scope here.</td>
<td>Yes, that is the target of metamodeling to make the created models comparable. I.e. use the metamodel to create comparable models. This may also adhere more to the created BMC model, i.e. the M1 level model and the comparability of it to the reality it models.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**

The interviewees agree that the comparability for the results in this work is adequate, i.e. the BMC metamodel is comparable with the BMC canvas, the BMC implementation is comparable to the metamodel and the canvas and finally the demonstrated BMC model of Skype is comparable to the artifacts as well as the BMC model is based on.

*Evaluation: This requirement is met for the scope of this work.*

<table>
<thead>
<tr>
<th>Requirement R07 – Systematic design</th>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The work is presented stepwise and it is very clear that there is some systematic design. It is difficult to evaluate the level and depth of it since I only see the outcome. But from the steps presented and described here it is generic and systematic enough for anyone to follow to replicate even if they choose different development environment.</td>
<td>The systematic design is very clear and I can see a very clear line between the BMC and the results. The structure is good in the way you created the metamodel.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**

The interviewees agree that the systematic design is very clear from start to end and other should be able to follow this work to replicate if needed.

*Evaluation: This requirement is met.*
### Requirement R08 – OMG/UML standards

<table>
<thead>
<tr>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the examples seen, the interviewee believes this requirement is met. The starting point of using a UML Class diagram is a good starting point. Only question is whether the UML Profile was needed only for the tool implementation.</td>
<td>I think you have used UML well and selected to use the meta-mechanism of profiles which seems to be appropriate for what you are trying to do here. No further additions needed so this looks very well.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**

The interviewees agree that the use of OMG/UML standards is good, both clear and used in an appropriate way. The UML Profile is needed for the tool implementation of the metamodel and is thus a good and clear usage of UML.

**Evaluation:** This requirement is met.

### Requirement R09 – Run in IBM RSA with MMA

<table>
<thead>
<tr>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to the demo and description the BMC metamodel runs in IBM RSA using Adocus MetaModelAgent as was shown in the Demonstration section.</td>
<td>Looks so according to the demo.</td>
</tr>
</tbody>
</table>

**Summary and analysis:**

The interviewees agree that the demonstration and screenshots show that this requirement is met.

**Evaluation:** This requirement is met.

### Requirement R10 – Support the creation of a BMC model

<table>
<thead>
<tr>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, when used as explained in the thesis, the artifacts support the information capturing and modeling and could be further enhanced by adding a graphical representation. So the information is captured and using the described process of using the tool (not creating it from scratch) then this is really helpful and supportive. This gives you a control to control for errors and check if you have missed something or violated rules and is a good mechanism or tool to check your modeling work. The main advantage here is the reasoning like the checkpoints and checking of all information put into the BMC model and the checking of the logic and completeness of the model as seen by the interviewee. The main disadvantage is the graphical interface is missing and it is too early to evaluate the practical use</td>
<td>Yes, this can support BMC modeling and best to use after the initial model is created where a canvas or a whiteboard is easier to use. What you have added here is to make the model useful after it is initially created by following the modeling principles and UML standards and thus can connect it to other models and I actually think that is one of the main advantages here. This supports creating a very well-structured model which can then connect to other models for use e.g. to create some software based on it. You will get a BMC model that is well structured and can thus be fed into a tool for further use and connect to other models and so on. Again the graphical limitations of the tool means that the user is better off with the canvas or whiteboard to</td>
</tr>
</tbody>
</table>

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Summary and analysis:

Both interviewees agree that these results and artifacts generally support the creation of a BMC model. They also both mention the limitation of the graphical representation of the tool, i.e. the lack of a visible canvas is limiting. This is in accordance to the scope of this thesis, i.e. this is meant to support the canvas use, not replace it.

The main advantages includes the capturing of information in a structured way and a mechanism to control and check for errors. The artifacts check the logic and completeness of the model which helps in creating a fuller/better model. This also results in a very well-structured model which then can be feed into various other activities like software generation. Both interviewees evaluate the results to be stable and useful support for BMC modeling.

Evaluation: This requirement is met.

Requirement R11 – Identify model errors and suggest actions

<table>
<thead>
<tr>
<th>Answers from Interview #1</th>
<th>Answers from Interview #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes it seems to do that and it is one of the main advantages of this tool according to the interviewee.</td>
<td>Yes it seems to do that.</td>
</tr>
</tbody>
</table>

Summary and analysis:

Both interviewees agree that the artifacts seem to fulfill this requirement and see it as one of the main advantages of this research.

Evaluation: This requirement is met.

Table 10: Evaluation of results using expert interviews

The evaluation based on informed arguments and expert interviews shows that all the defined requirements have been met and by doing that the artifacts and results of this work fulfill the goals of the thesis in contributing to the solution of the explicated problems. A formal BMC metamodel has been provided and its implementation in RSA provides tool support for BMC modelers.
Communication

Communication is done through the writing of this thesis report and the presentation of it as explained in the Methods chapter.
Discussion

The focus of this research is on the development of specific artifacts in order to contribute to a solution for the explicated problem. A formal metamodel was successfully created for the Business Model Canvas (BMC) and implemented it in an OMG standards-based tool in order to provide tool support to support the BMC modeling work in a structured and standardized way.

Based on the performed evaluation the results contribute to the defined problem by facilitating development and communication of BMC business models. This is done by improving the encapsulation and communication of the information in a BMC model between a free-form canvas on a business/strategy level to a UML-based model with formal structure and standards for the process/software level in a consistent way. The artifacts support the detailing of a BMC model by suggesting and explaining all facets of the BMC model in a consistent and controllable way. The results have been evaluated as being helpful for BMC modelers wishing to get support in formalizing and detailing their BMC models and create a standardized UML-based BMC model at the same time.

The evaluation of the results was a combination of informed arguments and expert interviews which leads to the conclusion that all defined requirements have been met, the goals of the thesis have been fulfilled and thus this work does contribute to a solution for the explicated research problem.

The demonstration gives a basic internal validity by testing the artifact in a controlled demonstration where the usage conditions are clear. By modeling existing BMC models with the artifacts and verifying that the results are fully covering the input model in a correct way, a basic internal validity is reached. The demonstration case is a mixture of a real life and fictive case and provides a basic external validity by showing how a real BMC model is implemented and enriched when using the artifacts. The external validity or generalization is still low since the external use is very limited here and expert evaluation is used with ex ante approach. An ex ante evaluation is not a strong evaluation but still it gives a clear indication of the contribution provided to solve the defined problem. Using theoretical analysis in form of informed arguments is useful to verify that the artifacts fulfill the requirements and the internal properties aimed for.

The evaluation highlighted the importance of a clear and intuitive graphical interface to work with BMC models. The BMC canvas is very graphical and easy to use and automatically gives a clear overview of the model. The lacking graphical presentation of the artifacts and tool support presented here is a limitation on its use but at the same time fits within the defined scope of this work where it supports transforming a drafted BMC model into a richer and more structured UML-based BMC model in a standardized tool.

The reliability of this research is fair in terms of a neutral and objective approach in creating the artifacts and evaluating them as well as through the consistency the artifacts provide for all users when creating a BMC model. The artifacts and the tool usage are fully consistent in them and produce the same results for all different occasions of its use with all other things being equal. At the same time the artifacts will obviously not prevent the different interpretations of its input or output from the users’ side but help in that direction.

The certainty of our conclusions within the limitations of the work is fair but would benefit from further external validations where more real life examples and real end users would test and evaluate the use of the artifacts as well as for more complex and larger BMC models. This could be an
interesting area for further research to better understand both the certainty in terms of internal and external validity, and reliability of the results.

The lessons learned from this research are several. Including the importance of the freedom and ease of use of the BMC canvas and a replication of that freedom would be useful in the artifacts and tools here to make them more useful and approachable to end users. At the same time this freedom in using the canvas results in some ambiguity. This is quite clear in the way e.g. relationships can be defined in the model. The resulting artifacts were created with a balance in mind between the freedom and free form of BMC and the benefits of more control and supportive structure. This was bound to result in some limitations in the metamodel itself where the relationships between elements are limited somewhat and the attributes and attribute values as well. Still when using the implemented metamodel in the modeling tool, the modeler can add undefined features, but not as easily as the defined ones.

The chosen implementation tools were helpful in terms of implementing a UML-based metamodel and using it through a wizard with help text for the elements, relationships and attributes of the model being created. At the same time these tools presented limitations on the user interface and graphical output and thereby limited the important simplicity of using BMC. If a free modeling environment had been chosen rather than RSA, it could have eased certain challenges and possibly made the results of this work available for a larger audience but at the same time missed out on the functionality we get with the MetaModelAgent extension. It would have been interesting to interview the creator of BMC, Osterwalder himself on BMC and discuss the suggested metamodel to better understand the depth and details of BMC but the waiting time for an interview proved to be too long to be practical here.

Using the design science approach fitted the work well and supported the approach at the same time. The methods chosen worked well with the limitations of this thesis work. The expert evaluation was voluntary and anonymous and full background information and confidentiality was provided.

From the literature and tool review performed, no BMC metamodels were found with such details as presented here and no implementations of such a metamodel or the set of supportive features presented. This research does add certain originality in the approach of supporting the creation and improvements of BMC models and the benefits it brings for the explicated problem shows that this work has some significance for the millions of current BMC modelers.

The social and ethical implications of this research are few and limited. This research can generally assist people in understanding, creating and communicating BMC business models without directly affecting their privacy or security of data and information. The required change of work to utilize the artifacts will initially require some additional time from the modeler while using BMC and the artifacts of this research is free and no copyright issues are involved. The accuracy and standardization of the BMC modeling is generally improved when using the artifacts but at the same time it limits the freedom of the modeler by requiring stricter BMC modeling standards. The modeler can still easily choose to ignore the recommendations of the artifacts if needed. The popularity of the current alpha version of Strategyzer shows clear need and great interest for added tool support for BMC modeling.

Ideas for future research in this area include developing a graphical user interface to use with the underlying functionality presented in this study for the general public. Further analysis and evaluation with case studies and involvement of more BMC modeling experts and end-users would be very interesting to better understand how this structured approach and support works in a real-life environment. The creation of more detailed metamodel including layers to capture different views of the same business being modeled or adding further flexibility into the underlying support would also be interesting to better understand if it could broaden the use of this type of BMC modeling approach.
References


### Appendix A – DS Canvas

<table>
<thead>
<tr>
<th>Problem</th>
<th>Artifact</th>
<th>Knowledge Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe a practical problem to be addressed. Formulate it in a precise and concise way. Motivate the problem by explaining why it is of general interest, significant, challenging and possibly original. Specify the stakeholders.</td>
<td>State the type of artifact: Construct, Model, Method, or Instantiation. Describe the artifact and how it is to be used in its intended practice. Explain why and how it can address the problem.</td>
<td>Describe the knowledge base that is used as a foundation for the work. The knowledge base may include theories and models as well as existing artifacts. Explain how the knowledge base has been utilized.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice</th>
<th>Requirements</th>
<th>Constructs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the practice in which the practical problem exists, in particular its purpose, main activities and participants.</td>
<td>Describe requirements on the artifact. Include requirements pertaining to function as well as construction and environment. Justify the requirements by relating them to stakeholder interests.</td>
<td>Describe the most important constructs that are used in the work.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Explicate Problem</th>
<th>Define Requirements</th>
<th>Develop Artifact</th>
<th>Demonstrate Artefact</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the nature and context of the practical problem that is important for the stakeholders? Describe and justify the methods used.</td>
<td>What artifact can be a solution for the problem and which requirements are important for the stakeholders? Describe the methods used.</td>
<td>Create an artifact that addresses the explicated problem and fulfills the defined requirements. Describe and justify the methods used.</td>
<td>Can the artifact be demonstrated to solve some aspects of the explicated problem in one case? Describe and justify the methods used.</td>
<td>Does the artifact fulfil the defined requirements and can it solve the explicated problem? Describe and justify the methods used.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Construction</th>
<th>Function</th>
<th>Usability</th>
<th>Effects</th>
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</thead>
<tbody>
<tr>
<td>Describe the internal structure of the artifact, i.e. its components and their relationships and interactions. Discuss design rationale.</td>
<td>Describe the functions offered by the artifact and how its construction gives rise to the functions. Discuss how the functions contribute to fulfilling the requirements.</td>
<td>Discuss the usability of the artifact and how it can be improved, in particular processes and guidelines that can make it easier to use the artifact.</td>
<td>Discuss the effects of the artifact, to what extent it can solve the original problem and what other benefits and disadvantages it can bring, including ethical and societal aspects.</td>
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Appendix B – Interviews

The outlines of the expert interviews held as part of the evaluation activity is explained briefly here as a complement to the description in the Methods chapter. The interview questions are listed here while the interview transcripts are documented in a following appendix.

The interviewee got an excerpt from the thesis emailed before the interview to allow him time to get acquainted with the work and the artifacts to be evaluated. The email explains that the participation is voluntary and performed to the requirements of this work. This includes explaining that this is part of an individual master thesis at KTH/DSV and the interview answers will be used in the evaluation of the thesis and possibly as input to improved design and development as well.

The interviews will be performed online (using Skype) and the interview part is recorded and transcripted. The interview will start by explaining the research and the results to be evaluated to ensure the interviewee has the information needed for the evaluation before the interview questions are asked. Then the semi-structured interview is performed, and includes the following questions:

Q1: **Completeness:** Looking at the artifacts and demo, how well do you think the BMC metamodel and its implementation covers the BMC model and the creation of one? (E.g. in terms of handling all elements, attributes, associations and usage)

Q2: **Use of OMG standards:** How well do you think the OMG UML standards are utilized in creating the BMC metamodel? Would you suggest any different usage of UML (e.g. different models, different elements or properties) or even different modeling standards?

Q3: **BMC modeling support:** In your opinion, how do the BMC metamodel and its implementation support the creation of a BMC model? (E.g. by providing the problem list, prompt creation of mandatory elements, attributes and associations, etc.)

Q3-1: What do you see as the main Cons and Pros with using this BMC metamodel and its implementation for the creation of BMC models?

Q3-2: What suggestions would you give for improving this BMC metamodel or its implementation?

GoM based questions:

Q4: **Correctness:** Discussing the correctness of the resulting artifacts, both syntactic and semantic correctness as well as consistency between models.

Q4-1: In terms of *syntactic correctness*, how do you rate the metamodel and its implementation as well as the created BMC demo model? (*Syntactic correctness* means that the model is consistent and complete against its definition. E.g. discuss how consistent and complete the BMC metamodel is against the BMC definition, the BMC metamodel implementation is against the BMC metamodel and finally how consistent and complete the demo BMC model for Skype looks against the BMC metamodel).
Q4-2: In terms of *semantic correctness*, how do you rate the metamodel and its implementation? (*Semantic correctness* means the metamodel structure and behavior is consistent with the real world.)

Q4-3: Do you have any suggestions or comments on correctness of the approach and results of the BMC metamodel creation and implementation?

Q5: **Relevance**: How relevant do you rate the resulting artifacts in their current form? (Relevant meaning that only relevant items are included (no irrelevant elements should be there to keep the model minimal). Also how relevant the chosen modeling technique is and use of existing knowledge).

Q5-1: Do you rate the artifacts relevant, and relevant to the problem and problem background?

Q5-2: Do you rate the artifacts only containing relevant elements and features (keeping the model minimal, i.e. no unnecessary items/elements included)?

Q5-3: Is the approach to the solution relevant, e.g. modeling technique and design approach?

Q5-4: Any other suggestions or comments on relevance of the study and results?

Q6: **Economic efficiency**: Is the creation of the artifacts done in an economically efficient way, e.g. by using existing reference models, re-use models and using appropriate modeling tools?

Q6-1: Do you rate the use and re-use of existing knowledge and solutions used efficiently?

Q7: **Clarity**: Do you think the resulting BMC metamodel, the implemented BMC metamodel and the BMC demo model, are clear, understandable?

Q8: **Comparability**: How do you rate the comparability between the metamodel and the problem background as well as the implemented metamodel? (Comparability demands consistent use of guidelines (e.g. comparable layout, naming conventions, etc.)

Q8-1: How do you rate the comparability of the original BMC model used for evaluation and the resulting BMC model created with support from the artifacts?

Q8-2: Any other suggestions or comments on comparability?

Q9: **Systematic design**: How clear is the relationship between the resulting artifacts and the problem background, BMC and the BMC models used?

Q9-1: Any other suggestions or comments on systematic design?

Q10: **Cons and Pros**: Please explain what cons and pros you see with this approach to define and solve the explicated problem and the resulting artifacts.

Q11: **Open discussion**: Any other comments or suggestions?
Appendix C – Interview transcripts.

Transcript of the interview with interviewee #1. Interview date was July 3rd, 2013.

Q1: Completeness:

Answer: In this case the artifacts we look at are the canvas itself, the metamodel you have put together and proposed and then and the implementation and instantiation of it. There seems to be no concept or notion missing. There seem to be completeness in the intermediate artifacts, the metamodel derived and the implemented one seems to be addressing all the elements that are in principle available in the canvas itself.

Q2: Use of OMG standards:

Answer: Yes from the examples I have seen yes it looks so. Though there is a question mark whether there is a really need for using the profile itself. Whether this is valid for the tool implementation chosen or whether this is generally needed. The UML Profile seems trivial in this case, there is not really a need to show that every notion is a class and every association is an association. It would add more clarity to the work to show the reason why the profile is used is required by the tool. Otherwise the other option would be that it is not needed. I think that the starting point of using UML Class Diagram is a good starting point. Make sure you have all the content and notions there like constraints and associations. From there you could go and use other models if you like.

Q3: BMC modeling support:

Answer: Yes, when using it like explained in the thesis the artifacts supports the information capturing and modeling and it could be further enhanced by adding a graphical representation. But yes of course the information is captured and using the described process of using the tool, not creating it from scratch then yes I agree that this is really helpful and supportive. Gives you a control to control for errors and check if you have missed something or violated something so it’s a good mechanism or tool to check yourself.

The main advantage is the reasoning like the checkpoints and checking of all the information you are feeding the canvas, checking logical and at the end the complete modeling of the canvas. The disadvantages are again that the graphical interface is missing, that is the main disadvantage. It is too early to discuss practical evaluation in the field and practical utility of the tool.

Not any particular. The implementation is dependent on the environment and there is probably a reason, practical reason for that. Another suggestion would be using Eclipse as a tool more people are using. Or the OpenModel initiative so again more people could be using it. For the metamodel as I said earlier it looks complete so anything else could be done for particular uses e.g. if you want to derive process modeling from it you could build up from this implementation. So at this stage it looks like a stable and sustained and complete artifact.

GoM based questions:
Q4: Correctness:

**Answer:** Complete model does not need to be correct. The fact that you have all the items there does not necessarily mean they are correct. When asking an expert this typically is a kind of a face validation. Is this all you are aiming at to have a face validation or for correctness isn’t there another way to check the correctness e.g. if you say you have instantiated 10 analysis it looks like a correct instantiation and if you ask 10 experts if this looks correct and complete. This goes partly also for some other GoM requirements. From what I saw from one implementation and one example of the Skype example and as far as it goes it looks complete. To demonstrate correctness, my main suggestion is to demonstrate more examples to demonstrate correctness with many different cases and also for completeness to see if you have missed something. Not only a missed concept and if everything suggested from the canvas has been represented in the same way and no information is missing or no rule missing and if it is interpreted and modeled in a proper way.

So again having said and having seen what I have seen in respect of being correct and complete, yes it looks complete and correct as well.

I can say as a modeler myself; I can assess the completeness and the way you have done it. But for a particular case like e.g. Skype, you would need the assessment of the person that defined the canvas, so when you show them your outcome of the Skype canvas they can tell you if you have done it correctly. Then you can claim correctness for your results.

Ideally you have someone who has defined the canvas to tell you if it is a correct presentation of their canvas or not.

Q5: Relevance:

**Answer:** The artifacts are to the essential elements of the canvas and the implementation as well. I do think the artifacts are relevant to the problem definition with the reasoning behind it and the modeling environment and modeling implementation is essentially relevant for all three problems defined. There are no excessive elements from what I have seen and complete since all elements are there.

Yes the approach is straight forward and you have looked first into the literature, and looked into examples and refining it to the examples and usage of the canvas to derive a stable model. If you treat this artifact as fully complete, it may be problematic since you can’t be certain you have treated ALL the features and all variants. If you treat this as a living artifact that evolves, then it is fine I’m sure.

I cannot comment much on that since I haven’t read the details in your thesis.

Q6: Economic efficiency:

**Answer:** Efficiently you have not started from scratch and the steps you have followed are efficient to use the source of the knowledge and solutions that exist because you have looked into other tools as well. And effectiveness for sure because you to arrive to something as solution.

Q7: Clarity:

**Answer:** Yes from a modeling perspective it is clear both the artifacts as well as the process you have followed so I don’t have any issues there.

Q8: Comparability:
Answer: Yes, for the BMC model I would say its comparable yes. But for the existing tools, that is something you haven’t compared, i.e. compared your implementation with the existing tools. But they could be compared if that was a question, but again the comparison should take place within the scope of some intention.

This comparability is a term from Becker, because to me it is not very clear how comparability and relevance and correctness and completeness are very different, because the way we describe it, it is not very different. There seem to be some overlap.

Q9: Systematic design:

Answer: You have presented it stepwise. With only 4 steps to follow and it is very clear so there is some systematic design. Now regarding the level and depth of it, I only see the outcome of these steps because I don’t have the whole thesis in front of me. Then one expects you to describe all those steps in a systematic way so that others can follow the same. Even though there is a variation in the tool environment those designs should derive at it as well and I think from the steps you have described it is generic and systematic enough for anyone to follow.

Q10: Cons and Pros:

Answer: The definite pros I see are that such a modeling tool and modeling limitation will definitely allow the use of the canvas to relate to other types of models like process or requirements models and will bring closer the use of the canvas itself to enterprise modeling.

At the same time there is an obvious restriction, not your problem but general problem, on the tool environment you are using. What is also a small drawback, but again this is a thesis not a project. There is no working environment where we can expect anyone using this as for their models. I don’t see any drawback there; I am fond of this kind of work personally so I am a bit biased. What would be interesting is to look at the effect of using such an implementation and how it could be combined with other aspects. E.g. being a bridge from strategy. How can the canvas be related to strategic notions cause it is to some extension a strategic level method. For the tool itself I only am missing is actual application, that is the only thing otherwise it is clear. That would be the strongest evaluation you could have. A face validation cannot go so far. Like if you have a concept and designed product where all the experts say it is nice but if nobody ends of using it.. That’s often the thing we forget. At the end of the day we are building something for some reason. If that gives utility for some state of affairs. If that utility is not achieved, that’s it. No matter how correct, relevant, efficient, clear and comparable it is. That’s it, otherwise, no I like the work and I think it is complete. It is a complete circle of artifact generation so that’s cool.

Q11: Open discussion:

Answer: No comments/suggestions on updates to the work or interview.
Transcript of the interview with interviewee 2. Interview date was July 17th, 2013.

Q1: Completeness:

**Answer:** You have a very good procedure so you cover the main concepts. You also add some concepts which probably make it more complete or containing more concepts than the BMC, so yes it is complete. The BMC canvas is more like a painting canvas where users can add whatever they like. So the question is also how complete is this when it comes to practical use of BMC. So this is complete from the theoretical point of view. A question mark if this is complete from practical standpoint which it seems to.

Q2: Use of OMG standards:

**Answer:** I think you have used UML well. You selected to use the metamechanism of profiles which seems to be appropriate for what you are trying to do here. You don’t need to add more concepts here. So that looks very well I would say.

Q3: BMC modeling support:

**Answer:** Yes it can, but I think it is not best to create initial model where you could do better with the canvas or whiteboard. What you have added here is that you make the model useful after it is created by following the modeling principles and UML standards you can connect it to other models and I actually think that is one of the main advantages of using your tool here. You don’t create just any kind of a model but a very well structured so you can connect it to other models and maybe create some software based on it.

The main pros are clear that you will get a model that is well structured so you can feed the model in a tool for further use and connect to other models and so on. The cons would be that if you like to use the tool as a sort of a drawing board you will probably get a lot of errors which means the users won’t use this tool if the customer only want to get the model on a canvas or whiteboard without doing anymore with it. If the goal is to create a reusable model to use for create software for example, this is the way to go.

The output of the modeling tool isn’t very graphical when the main benefits of the canvas are that it is very graphical. It is really nice to show to customers that are not putting a value on UML models. A possible add-on would be to improve the graphical output, that would add value.

GoM based questions:

Q4: Correctness:

**Answer:** It’s a difficult question without doing the same procedure that you have done. I can assess the correctness by looking at the models and the procedures you have followed and it can lead to good results. So that is what I can say and from what I have seen is that the model captures all the main concepts from the BMC. You have created a metamodel that seems to be correct and should be useful.

Q5: Relevance:

**Answer:** Yes I think the results are relevant to the defined problem and goals. You have created all the main concepts from BMC and added relevant concepts that were missing in BMC from BMO which makes the results richer which I think is very good as well because you need added structure when you create this metamodel. Otherwise it would be a simple model and less strict model if you wouldn’t do
these add-ons. No irrelevant concepts there, the selected things are all relevant for this model and you can’t do this really smaller without losing details.

Q6: Economic efficiency:

**Answer:** I think you have done what is expected. First you have created first draft of main concepts and then you go into iteration where you add detail from BMO and then from the literature until you come to a point of saturation where you don’t add anymore and then you stop. You have some iterations and then you come to a point where you don’t do anything more. So yes that would be excellent process. In terms of efficiency in using the tools I think you need to have clear requirements on the process to be strict and formal using UML and being compliant and then this would be efficient. But if you are just trying to create a canvas this would not be so efficient.

Q7: Clarity:

**Answer:** I would say that the procedure you described and the steps are clear. When it comes to the metamodel itself, it might be a bit tricky to follow actually and I think that is due to UML in the metamodel, e.g. the associations are not for everyone. But on the other hand the users of this are probably not looking at the metamodel but are using the wizard in the tool and then I think it is clear enough for them to understand but for the UML Profile it is not as clear.

Q8: Comparability:

**Answer:** Yes, that is the target of metamodeling to make the created models comparable, i.e. use the metamodel to create models that are easy to compare. This is more related to the M1 models than the metamodel itself, i.e. the reality is a model which the metamodel is based on.

Q9: Systematic design:

**Answer:** Systematic design, that is very clear. I can see a very clear line between the BMC and the results you have come to.

Q10: Cons and Pros:

**Answer:** I think the structure is good in the way you created the metamodel. Maybe you could explain better why you need to do this, you say there are no(limited) tools available for this. I think there is much more to it than that. In order to make the model useful to other tools, not only modeling tools but some other form of tools, then you need the model to be structured, e.g. if you want to have a database with models and want to make it searchable its easier with a structured model rather than a big bucket of canvas. So maybe the problem definition could be more elaborated to explain more what can be done, e.g. search ability within models.

Q11: Open discussion:

**Answer:** GoM seen as the best available framework for evaluating models. This is good work and clearly contributes to the problem. Make it clear which part of the work (process, metamodel, implementation or resulting use and created BMC models are being evaluated/discussed)
Appendix D – BMC Metamodel class diagram
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