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# Management and AI: Towards An Intelligent Decision Support System For Strategic Management

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# Abstract

Case-Based Reasoning (CBR) is a problem-solving paradigm that uses knowledge of relevant past experiences (cases) to interpret or solve new problems. CBR systems allow for easily generating explanations as they typically organize and represent knowledge in a way that makes it possible to reason about and thereby generate explanations. An improvement to this paradigm is ontology-based CBR, an approach that combines, in the form of formal ontologies, case-specific knowledge with domain-specific knowledge in order to improve the effectiveness and explanation capability of the system. Intelligent systems as an applied domain of artificial intelligence (AI) include the processes, methodologies, and techniques of employing AI for real-world problem-solving. In this way, intelligent systems enhance management processes at all levels, operational and strategic. The business model represents a concept that has recently entered scholarly discussions within the fields of strategic management, entrepreneurship, and innovation. It is considered a strategic tool and a cognitive framework that helps strategy practitioners and endows entrepreneurs with a template for integrating and organizing strategically relevant elements in order to successfully exploit a business opportunity and remain profitable in the long run.

With this vision, the purpose of this project is to propose a new generation of intelligent decision support systems for Business Models that have the ability to provide explanations to increase confidence in proposed solutions. The performance results obtained show the benefits of the proposed solution with different requirements of an explanatory decision support system. Consequently, applying this paradigm to software tools for business model development will have great promise for supporting business model design and innovation. We have enriched research in the branch of intelligent systems for BM by developing a conceptual design for the intelligent decision support system for strategic decision-making by proposing an intelligent technique. This study is part of a growing body of research on tools for Business Model design; this project will contribute to future research on similar topics.

**Keywords:** decision support system; business model; case-based reasoning; ontology; explanation.

# Résumé

Le Raisonnement à partir de cas (RàPC) (nommé en anglais case-based reasoning (CBR)) est un paradigme de résolution de problèmes qui utilise la connaissance d'expériences passées pertinentes (cas) pour interpréter ou résoudre de nouveaux problèmes. Les systèmes CBR permettent de générer facilement des explications, car ils organisent et représentent généralement les connaissances d'une manière qui permet de raisonner et donc de générer des explications. Une amélioration de ce paradigme est le CBR basée sur les ontologies, une approche qui combine, sous la forme d'ontologies formelles, des connaissances spécifiques au cas avec le domaine afin d'améliorer l'efficacité et la capacité d'explication du système. Les systèmes intelligents en tant que domaine appliqué de l'intelligence artificielle IA, y compris les méthodologies de processus et les techniques d'utilisation de l'IA pour la résolution de problèmes du monde réel. De cette façon, les systèmes intelligents améliorent les processus de gestion à tous les niveaux opérationnels et stratégiques. Le modèle économique (Business Model) représente un concept qui est récemment entré dans les discussions élaborées dans les domaines du management de la gestion stratégique de l'entreprise et de l'innovation. Il est considéré comme un outil stratégique et un cadre cognitif qui aide les praticiens de la stratégie, et dotant les entrepreneurs d'un modèle pour intégrer stratégiquement des éléments pertinents, afin d'exploiter avec succès une opportunité commerciale et de rester rentable à long terme. Dans cette vision, le but de ce projet est de proposer une nouvelle génération de systèmes intelligents d'aide à la décision pour Business Model ayant la capacité de fournir des explications pour accroître la confiance dans les solutions proposées. Les résultats de performance obtenus montrent les avantages de la solution proposée avec différentes exigences d'un système explicatif d'aide à la décision. En conséquence, l'application de ce paradigme pour les outils logiciels de développement de modèles économiques sera très prometteuse pour soutenir la conception et l'innovation de modèles économiques. Nous avons enrichi la recherche dans la branche des systèmes intelligents pour le BM, en développant une technique de conception conceptuelle pour le système intelligent d'aide à la décision pour la prise de décision stratégique en proposant un système intelligent. Cette étude fait partie d'un ensemble croissant de recherches sur les outils de conception de modèles d'affaires. Ce projet contribuera à de futures recherches sur des sujets similaires.

**Mots clés:** SIAD, Plan d'affaire, Raisonnement à base de cas, ontologie, explication.

# ملخص

الاستدلال المستند إلى الحالة (CBR) هو نموذج لحل المشكلات يستخدم المعرفة بالخبرات السابقة ذات الصلة (الحالات) لتفسير المشكلات الجديدة أو حلها، تسمح أنظمة (CBR )بتوليد التفسيرات بسهولة لأنها عادة ما تنظم المعرفة وتمثلها بطريقة تؤدي إلى سهولة الشرح والتفسير.

كتحسين لهذا النموذج ظهر (CBR) القائم على الانطولوجيا، وهو نهج يجمع بين المعرفة في المجال والمعرفة بالخبرات (الحالات) من أجل تحسين فعالية وقدرة تفسير النتائج في النظام الذكي.

تعتبر الأنظمة الذكية كمجال تطبيقي للذكاء الاصطناعي (AI)، الذي يحتوي على مناهج وتقنيات استعمال الذكاء الاصطناعي في الحياة اليومية، وبهذه الطريقة تعزز الأنظمة الذكية عمليات الإدارة والتسيير على جميع المستويات التشغيلية والإستراتيجية.

يمثل نموذج العمل مفهوما ظهر مؤخرا في المناقشات العلمية في مجالات الإدارة الإستراتيجية وريادة الأعمال والابتكار، يتغير نموذج الأعمال بمثابة أداة إستراتيجية وإطار عمل معرفي يساعد المسيرين الإستراتيجيين، ويمنح رواد الأعمال نموذجا لدمج وتنظيم العناصر ذات الصلة إستراتيجيا، من أجل استغلال فرص العمل بنجاح والحفاظ على الربحية على المدى الطويل.

في هذا السياق، الغرض من هذا البحث هو اقتراح جيل جديد من أنظمة دعم القرار الذكية لديها القدرة على تقديم تفسيرات وشروحات لزيادة الثقة في الحلول المقترحة، تظهر نتائج الأداء التي تم الحصول عليها فوائد الحل المقترح مقارنة مع المتطلبات المختلفة لأنظمة دعم القرار.

وبالتالي تطبيق هذا النوذج للأدوات والبرمجيات لتطوير نماذج الأعمال والابتكار سيسهم في التقدم الكبير في مجال تصميم نماذج الأعمال.

لقد قمنا بإثراء البحث في فرع الأنظمة الذكية من أجل نموذج الأعمال من خلال اقتراح تقنية ذكية. هذه الدراسة جزء من مجموعة متزايدة من الأبحاث حول أدوات وبرمجيات تصميم نموذج الأعمال وسيساهم البحث في مشاريع البحث المستقبلية حول مواضيع مماثلة.

**الكلمات المفتاحية:** الأنطولوجيا، التفكير بالحالات، أنظمة دعم القرار، نموذج العمل التجاري، التفسير.

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## Internationnal Journals

- Basma Hamrouni, Abdelhabib Bourouis, Ahmed Korichi, and Mohsen Brahmi. **Explainable ontology-based intelligent decision support system for business model design and sustainability**. *Sustainability*, 13(17):9819, 2021.

## Internationnal Conferences

- Basma Hamrouni, Ahmed Korichi, and Abdelhabib Bourouis. **IDSS-BM: Intelligent decision support system for business models**. *In Proceedings of the 7th International Conference on Software Engineering and New Technologies*, pages 1–5, 2018.

# List of Abbreviations

| | |
|---|---|
| AI | Artificial Intelligence |
| ANN | Artificial Neural Networks |
| BI | Business intelligence |
| BM | Business Model |
| BMDT | Business Model Development Tools |
| CBR | Case Based Reasoning |
| DB | Data Base |
| DSS | Decision Support Systems |
| GA | Genetic Algorithms |
| IS | Information System |
| KICBR | Knowledge Intensive CBR |
| KICBR | Knowledge Intensive Case Based Reasoning |
| KMS | Knowledge Management Systems |
| NBR | Narrative-based reasoning |
| NLP | Natural Language Processing |
| OBR | Ontology-based reasoning |
| RBR | Rule-Based Reasoning |
| SBM | Sustainable Business Model |
| SBMO | Strategic Business Model Ontology |
| SDG | Sustainable Development Goal |
| SVM | Support Vector Machines |
| XAI | Explainable Artificial Intelligence |

# Chapter 1

# General Introduction

Chapter 1

# General Introduction

## Contents

## 1.1 Introduction

Today, decision-making requires considering an a plethora of data, information, and knowledge of many types and characteristics in the company's various activities. Their analysis and optimal exploitation highly influence the company's competitiveness. For that reason, managers are increasingly using Decision Support Systems (DSS), which are considered interactive computer-based systems that assist decision-makers to exploit documents, knowledge, models, communications technologies, and data for problem-solving and decision-making. Their purpose is to improve an individual's or a team's abilities to make decisions [1].

The business model framework is the basis for the decision-making process. It is considered by entrepreneurship as a cognitive device. The integration and organization of strategic objectives are done by this cognitive device to remain profitable in the long run and benefit from the business opportunities [2, 3, 4]. Due to the fast transformation in the business environment, companies are required to assess their Business Model (BM) in order to stay competitive [5], since the BM is essential to the success of any organization [6]. It offers a solid framework for comprehending, analyzing, communicating, and managing strategic decisions [7, 8, 9]. Business model research is a rapidly developing field that is still in its early stages and in need of a conceptual underpinning. The literature on BM originates in a wide variety of study areas, including information systems [10], technology and innovation management [11] and strategic management [12].

Nowadays, The integration of Artificial Intelligence (AI) in Decision Support Systems (DSSs) has aided in expanding the scope of ongoing research and application in information processing and analysis. As a consequence, the systems become more intelligent, efficient, flexible, and capable of assisting humans in making decisions.

For decades, Artificial Intelligence (AI) has been a concept that is part of the public debate [13]. Most activity sectors have adopted new information technologies and artificial intelligence (AI) techniques [14]. Currently, the learning, reasoning, and adaptation capabilities of intelligent machines are impressive [15]. However, with these unprecedented advancements, the lack of transparency is the principal disadvantage. Indeed, powerful predictions are allowed by these black-boxes systems, but they do not provide explanations.

For this reason, a new debate on the explainable AI (XAI) field has accelerated. This branch is recommended for AI to continue making progress without interruption, improving transparency and trust of AI-based systems. Explanations are also indispensable to effectively understanding, trusting, and managing puissant artificial intelligence applications [16].

However, several scholars have made contributions to the field of business model design [17, 18], and innovation [19, 20]. In the literature, there are many calls for additional tools to assist in the development and assessment of BM. As a result, computer-based tools were developed. Research in the Information Systems (IS) discipline and adjunct disciplines concluded the necessity of developing business model development tools (BMDT) [21], that contribute to the development of strategies and products. During the process of ideating, software-based tools allow the integration and documentation of information from various sources easily [22]. According to academics, a software-based business model data tool

(BMDT) is useful for designing and innovating business models, particularly when using AI techniques and machine learning [23, 24, 25]. However, these AI-based DSS systems do not offer enough trust to allow extremely accurate decisional guidance. The potential of an intelligent system to produce an explanation that is meaningful for its decisions is a critical aspect in determining the system's acceptability [26]. For that reason, systems must provide explanations to encourage end-users to understand, trust, and manage these systems effectively.

Moreover, existing BM design tools (BMDTs) must place emphasis on assisting the users to be creative, which has been ignored from subsequent research. Incorporate functions for exploring business model patterns were argued by [22]. In addition, The challenge inherent in designing innovative business models and the limits to creativity in the practices of BM-related education are stated in [27]. The author argued that the idea is to create a virtuous learning loop that combines explanation and experience-based learning methodologies.

A new generation of intelligent decision support systems for business models is prposed in this thesis. They are capable of providing explanations for suggested solutions, hence increasing trust in them.

Unfortunately, little attention has thus far been paid to ontology-based CBR regarding the incorporation of BM ontologies. Thus, the incorporation of the BM ontology into an ontology-based CBR framework may be seen as the natural progression in the realm of business applications. As a result, this thesis proposes intelligent decision support for business models. It allows more accurate decision support by integrating explanations for designing and innovating BMs with a CBR technique that leverages domain knowledge from the BM domain.

## 1.2 Motivation

The technological trend allows alignment between the real and digital worlds so that technology will be omnipresent everywhere. Artificial intelligence will be a tool to improve decision-making, user experiences, create new ecosystems, develop new business models, and it will occupy the majority of digital operations in the future. Therefore, all applications will soon integrate a layer of artificial intelligence and use virtual assistants, so the AI will enrich these applications or generate new ones.

Currently, the learning, reasoning, and adaptation capabilities of intelligent machines are impressive [15]. However, with these unprecedented advancements, the lack of transparency is the principal disadvantage. Indeed, powerful predictions are allowed by these black-box systems, but they do not provide explanations. For this reason, a new controversy has emerged and sped up in the field of explainable AI (XAI). This branch is recommended for AI to keep progressing without interruption, improving transparency and trust of AI-based systems. Explanations are indispensable to effectively understanding, trusting, and managing puissant artificial intelligence applications [16].

Furthermore, intelligent decision support systems belong to such applications, which are defined as valuable systems usable in complex situations and analyzing multiple data sources

[28]. However, several works shed light on the use of intelligent decision support systems by senior management for operational rather than strategic decision-making [28]. The few developed systems are still in their infancy [24, 29].

## 1.3 Context and Problematic

Decision-making becomes more and more complex, especially in a rapidly changing environment with many alternatives and a huge amount of information, so the use of Decision Support Systems (DSS) is required. DSSs have been developed to assist decision-makers in their partially structured activities. In order to build the most usable systems possible, DSSs have been enriched by techniques from artificial intelligence.

The fusion of AI and DSS offers tremendous extra computing support to humans as they expand their aptitudes in today's complicated and distressing environments. DSS attempts to help humans make a better decision from a set of accessible options based on explicit or implicit criteria. As a result, smarter and more efficient systems were developed, providing better support for human decision-making.

However, intelligent decision support systems use tacit inputs, and their decisions are established on complex rules in addition to other artificial intelligence techniques. These decisions are seldom apparent to users. The loss of user acceptance, confidence, and satisfaction results from the lack of these systems' intelligibility. Nevertheless, explanations about their decision process should be automatically provided to resolve this problem.

Thus, the role of IT tools in supporting a company's business model innovation and design process has been overlooked to a great extent, which is startling because they are supposed to facilitate the development of new business models for companies [30]. These tools improve organizational routines and reduce transaction costs when ordering several companies' activities. The importance of designing new IT business models has been emphasized because this business model is still a young concept and the contribution is focused on the tools and concepts that help the manager understand, communicate, design, analyze, and innovate. Some of the business model missions mainly make sense if they are digitized, such as visualization, design, comparison, and simulation of economic models [8, 31]. However, the proposed IT tools in the literature are focused on the design step with supporting visualization and do not leverage the high class of IT tools [24].

The aim is to develop a new intelligent DSS for business models that has the capability to explain its reasoning in order to strengthen confidence in its proposed solutions.

## 1.4 Theoretical background

### 1.4.1 Decision Support Systems

Various kinds of computer-based information systems (IS), including decision support systems, have been designed to assist decision-making [28]. In 1970, the first DSSs were developed and widely used with the arrival of personal computers. DSSs can be considered as computer-based systems that assist decision-makers tackle ill-structured problems by interaction with analysis models and data [32]. They allow the investigation of huge amounts of quantitative data efficiently, with increased speed and accuracy of data analysis, while reducing costs. They were first created as management tools. Nevertheless, they were gradually accepted by a large number of non-management staff, including salesmen and purchasing officials. DSS is useful in situations when decision-makers want to analyze data from various sources [28]. Decision support techniques are intended to aid in the decision-making process for a wide variety of situations. When the difficulty is in analyzing a large number of often contradictory decision criteria [33, 34].

The long progression timeline of DSS research was respected in this section. First, the model-driven DSS was presented, then the data-driven DSS, and finally the communications-driven DSS. Thus, the consequence of the developments in search engines and document storage technologies has led to the apparition of document-driven DSS. Finally, the web-based systems that were widely available are presented [35].

#### 1.4.1.1 Model-driven DSS

The first model-driven DSS was the production planning management decision system developed by [35], and the production scheduling application by [36].

Optimization, simulation, and financial models were used. These model-driven DSS access and manipulate simple quantitative models and provide elementary functionality. Generally, model-driven DSS uses a limited amount of data [37].

Authors in [38] proposed the first versions, known as model-oriented DSS, and then computationally-oriented DSS were developed by [39]. After that, the solver-oriented and spreadsheet-oriented DSS were exposed in [40].

The first commercial tool was IFPS, developed by Gerald R. Wagner and his students in the 1970s. It uses quantitative and financial models and is an interactive financial planning system. In 1983, another DSS engine for building specialized systems using the Analytic Hierarchy Process, known as Expert Choice, was proposed in [41].

Authors in [42] presented a review of 15 years of model-driven DSS research. They stated that research associated with using financial planning systems and models for decision support was satisfying but had some negative aspects. Later, studies were interested more in enhancing more diverse models used in DSS, such as simulation, optimization, and multicriteria models.

In the late 1980s, the model-driven spatial decision support system (SDSS) is elaborated [43], and by 1995, the SDSS view had been deeply embedded in the thoughts of researchers, together with data-driven spatial DSS [44].

#### 1.4.1.2 Data-driven DSS

Data-driven DSS uses and manipulates a company's internal, external, and real-time data. The initial functionality offered was access to simple file systems using retrieval tools and queries. In data warehouse systems, data is manipulated with computerized tools. Online Analytical Processing was offered by [45], where a considerable volume of historical data was analyzed.

Retrieval-only DSS by [40], Analysis Information Systems and data-oriented DSS [38] were the types of the early data-driven DSS, and also the Executive Information Systems DSS [37].

The MIDS Management Information and Decision Support system was the leading Executive Information Systems (EIS) that applied pre-defined information screens managed by analysts for senior executives [46]. This involvement results from the establishment of relational database tools and single-user model-driven decision support systems.

Data warehousing and On-Line Analytical Processing (OLAP) in 1990 initiated another category of data-driven DSS [47]. Sales information and retail scanner data were connected in the proposed DSS by Procter & Gambles in 1985. Business intelligence (BI) is defined as a set of methods and concepts to improve business decisions. In 1989, Howard Dresner of the Gartner Group promoted the BI. These BI systems are data-driven DSS using report and executive information systems and query tools.

Relational database technologies appeared and were proposed by Bill Inmon, who is considered the "father of the data warehouse". The data warehouse architecture was defined by [48]. DB2 and Oracle were used to build decision support systems. Later, web-based scorecards and dashboards were developed.

#### 1.4.1.3 Communications-driven DSS

In this DSS, communications technologies and networks were used to facilitate communication and collaboration. The main dominant architectural components in these systems were the communication technologies. Video conferencing, Groupware, and computer-based bulletin boards are the tools used in these communications-driven DSS [37].

GDSS is a Group Decision Support System developed by scholars to support group decision-making [49, 50]. The SAMM system, developed by the University of Minnesota, and Group Systems, developed by Arizona University researchers, were early Group DSS. A Ph.D. student, Brent Gallupe from the University of Minnesota, decided in 1984 "to program his own small GDSS system in BASIC".

Groupware, bulletin boards, and audio and video conferencing were the dominant technology for communications-driven decision support. A few years ago, video and voice were added to synchronous communications-driven DSS via the Internet protocol.

#### 1.4.1.4 Document-driven DSS

In this DSS, analysis and document retrieval are provided using computer storage and processing technologies. These documents are images, sounds, videos, scanned documents, and hypertext documents. Additionally, these systems have been referred to as text-oriented DSS [50]. The search engine tool is provided with these DSS [37].

Document-driven DSS uses documents such as product specifications, catalogs, corporate historical documents, and policies and procedures, including minutes of correspondence and meetings. Authors in [51] proposed the first review of document-based systems for control and management planning. The development of document-driven DSS was pushed by the world wide web technologies and enhanced document accessibility.

#### 1.4.1.5 Knowledge-driven DSS

In general, suggesting and recommending actions to managers is the principal role of Knowledge-driven DSS, with specific problem-solving skills. The knowledge about a specific domain is the "skills" or "expertise", allowing tackling some of these problems, and comprehension of problems within that domain [37]. This category of systems is known as knowledge-based DSS [52]. The contributions of Artificial Intelligence (AI) techniques to DSS have been studied and presented in [53].

Scheduling manufacturing operations has been done by expert systems. Numerous diagnostic systems in the literature use AI techniques. Some artificial intelligence systems have been designed to assist in the detection of fraud and the expeditious processing of financial transactions.

The large deployment of knowledge-driven DSS has been achieved thanks to integrating expert systems technologies and relational databases with the web-based front end. Authors in [54] reviewed the technologies for knowledge modeling and technologies for reasoning implementation used in knowledge-driven DSS systems.

##### 1.4.1.5.1 Technologies for Knowledge Modeling:

Clustering and ontology are the two types of knowledge representations [54]. In clustering modeling, the knowledge is divided into several classes or knowledge classifications. Several papers use this kind of technique [55, 56, 57]. The cluster represents similar rules to this technique, and time is reduced with an extensive knowledge base. Ontology modeling is a way for collecting the knowledge adopted by a group. Ontology includes presenting and processing information and reasoning about it. [58, 59, 60].

#### 1.4.1.5.2 Technologies for Reasoning:

The five inference or reasoning technologies are : Rule-based reasoning (RBR), Case-based reasoning (CBR), Ontology-based reasoning (OBR), Mining approaches (Min), Optimization (Opti), Genetic Algorithms (GA) and Simulation (Simu) technologies, and finally Narrative-based reasoning (NBR).

Case-based reasoning technology solves new problems by considering previous and comparable situations. It's a way of automating the classification of previous lessons and making best practice cases accessible.

The case-based reasoning process comprises several steps: interpretation, retrieval, reuse, revision, and retention. KBDSS that used CBR are presented in [61, 62, 63].

Traditional RBR, rule verification to guarantee the high quality of recommendations embedded in KB-DSS as rules, and the Logical Elements Rule Method for evaluating and formulating clinical rules are all examples of rules modeling types. This technology is used in [55, 64].

Authors in [59] and [65] proposed implementing an ontology reasoning system (Ontology-based technology). Ontology navigation is used to implement knowledge. The 4K4Care project provides a formal description of all healthcare concepts, relations, and constraints between concepts in the form of a chronically ill patient Case Profile Ontology.

Narrative-based Reasoning KBDSS has been proposed in [66]. Lessons learned and experiences for decision-making from stories are shared. This kind of system uses unstructured narrative information.

Genetic algorithm Knowledge-based DSS with a coevolutionary genetic algorithm for detecting gamma-ray signals was proposed by [67]. Other authors used optimization and simulation technologies. A single-objective optimization technique has been used in [68] and a multi-objective optimization approach in [69].

#### 1.4.1.5.3 DSS Architecture

According to [54, 70], generally, the components of a DSS may be grouped into 5 separate parts:

- A model base management system: stores and sorts the organization's quantitative models;
- A database management system: organizes, stores, sorts, and returns the data of decision-making;
- A user interface: a common component in many systems;

- The knowledge base and the inference engine: that generate solutions after the recognition of problems using functions related to solving the problem process;
- A user: that is a part of the problem solving process.

The evolution of a technological branch adapted from artificial intelligence appears in the architecture of these systems by incorporating knowledge modeling into the problem to be solved. In the 1990s, with the arrival of artificial intelligence techniques, the knowledge base was integrated into the system's architecture, which allowed enhancing systems reasoning [71]. Decision Support Systems (DSSs) are currently enriched with Artificial Intelligence (AI) techniques that have helped extend applications and research in information processing and analysis. Consequently, systems become more efficient, more intelligent, and improve human decision-making.

### 1.4.2 Case-Based Reasoning

umans commonly solve problems using case-based reasoning. As a result, this approach is widely used in business, even when people are unaware that they are doing so. Researchers asserted that the approach of case-based reasoning, as incorporated in information systems, may be efficiently applied in business [72]. It is an appropriate experience management methodology for assisting those who must accomplish hard and knowledge-intensive activities.

Case-based reasoning CBR mimics the way humans think, comprehend, and predict. It is based on the human cognitive model. The CBR technique solves a new problem by using a previous similar situation and by reusing information and knowledge from that situation [73]. Because of its psychological plausibility, it has been used in a variety of successful applications [74]. The principal idea of CBR systems is to store people's experiences in the knowledge base as cases. When there is a new problem, we can search the knowledge base, finding past similar problems and their solutions. Hence, we can have an acceptable case as a reference. If the user is unsatisfied with the case, it can be adjusted to suit the current situation. Finally, the user stores the revised case in the case base [18]. The Case representation is a description of the current problem input to the system.

CBR problem-solving process is composed of a four-step and illustrated in Figure 1.1:

1. Case Retrieval: the system retrieves (similar) past cases from the case base relevant to solving the current problem.
2. Case Adaptation: the system uses the solution used for the precedent case to generate a target situation for the current problem.
3. Case Revising: the user validates the solution.
4. Case Retaining: the user stores the validated solution in the case base to solve future problems.

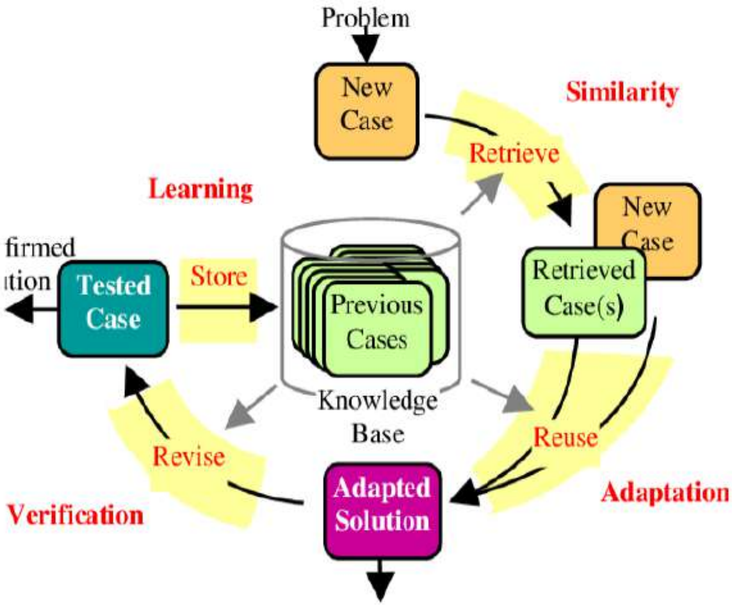



*Figure 1.1: The CBR process [73].*

### 1.4.3 Explanation of system decisions

Furthermore, it is commonly known that in everyday human-human interactions, transmitting information to understand one another is well done by explanations. Explanations enhance the knowledge of the communication partners in such a way that they accept certain statements and allow them to make informed decisions. It has long been recognized that to increase user trust about the decision of the intelligence system, he should comprehend system reasoning [75]. CBR systems provide natural explanations. Unlike other methods such as neural networks, the outputs of CBR systems outputs are intuitively explained by presenting the cases on which decisions are based and then comparing the solution to the prior cases to assess their applicability. Some CBR work considered the case as a sufficient explanation; recent work is developing a richer view [76]. Elements affecting conclusions are examined, such as the contribution of similarity calculations fulfilling explanation [77].

### 1.4.4 Business Model

The business model literature is rooted in several fields, such as information systems [78], technology and innovation management [11], and strategic management [12]. Research on business models is a rapidly growing field that is still searching for a strong theoretical foundation. Business models are determined as systems based on identifying principles, elements, patterns, and configurations of profitable business models [18].

Therefore, there are various definitions of the business model concept. It is described as an abstract representation of business logic [79], supporting decision-makers communicating business ideas, designing and serving as a reference framework [24, 29, 78]. It serves as a holistic framework for a company's economic model [80, 81]. Generally, this model is focused on how value is created, and captured [82, 83].

As a result, the business model depicts the logic "by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit" [84]. Thus, the business model may be defined as the organizational design choices that define "an architecture for service and information flows, a product including a description of the various business actors and their roles" [85] and examines "the content, structure, and governance of transactions designed to create value through the exploitation of business opportunities" [81, 83].

Although, the business model is "a statement of how a firm will make money and sustain its profit stream over time" [86]. Thus, it organizes the operational logic of a company, such as its internal operations and strategy [83, 87].

The business model is established as an interface between the strategic and operational layers [8], as shown in figure 1.2. By establishing an unified communication platform, it connects corporate strategy and business operations.

This section gives important information related to the BM concept. Understanding the different views on BM and the dimensions incorporated into BM concepts is essential. In literature, definitions of BMs may vary tremendously, but there are There are crossing points that nearly all BMs contain. Consequently, five main dimensions with a total eleven sub-dimensions exist, which are also regarded in the BMC [35, 36]. These dimensions emerged as a strategic point of view and are are further explored. These primary and sub-dimensions are shown in figure 1.2 [88].

**Product/Service:** The Business Model establishes the structure for a company's products and/or services [85]. These are the primary contributions to the customer and are crucial for a company's value creation. The company has the opportunity to produce higher customer value, for example, by differentiating itself or by means of a low-cost product or service [89].

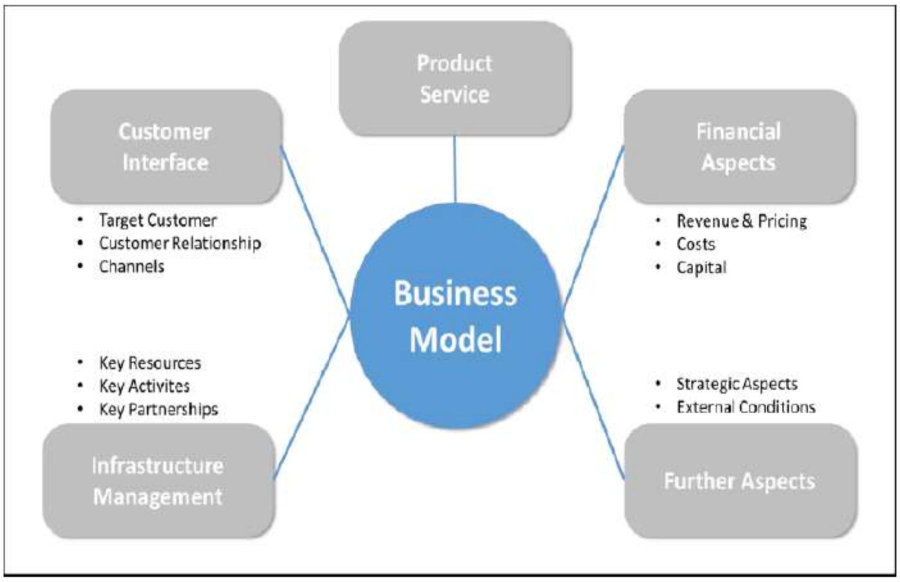



*Figure 1.2: The five BM dimensions and its eleven sub-dimensions according to [90].*

**Customer Interface:** Customers are at the heart of any BM, and no company can operate continuously without them. Meeting the diverse demands of its consumers or customer groups constitutes a challenge for any organization. Consequently, several sub-categories are essential for the apprehension of value creation: the prospective client, the client relationship, and the channels to serve the client [91].

**Infrastructure Management:** The business model also takes into account fundamental factors of the company's infrastructure. According to the Porter's Value Chain [92], this "is the set of activities which a firm performs, how it performs them, and when it performs them" [89]. This comprises all of the organization's critical vital activities, key partnerships, and key resources.

**Financial Aspects:** This generally refers to the performance of the BM's many components. As indicated before, an organization's collection of activities is evaluated in terms of "how it performs them." [93]. Consequently, a BM is also the "description of the benefits for the various business actors" [85]. Specifically, this includes costs, revenue and pricing, and capital as three sub-characteristics.

**Further Aspects of BMs:** According to the BM level and the perspective on value creation, strategic considerations might also be crucial, as can external conditions. In particular, these aspects are essential for BMs with a very abstract viewpoint on the value creation of the whole industry [94].

The Business Model Canvas describes a business model as composed of nine elements (value proposition, customer segments, and revenue streams). Figure 1.3 shows the business model canvas for insurance company and figure 1.4 illustration of the Business Model Canvas using Google Business Model. The book that presented the Business Model Canvas [68] has sold about one million copies [95], and has received more than 6000 citations (according to Google Scholar).

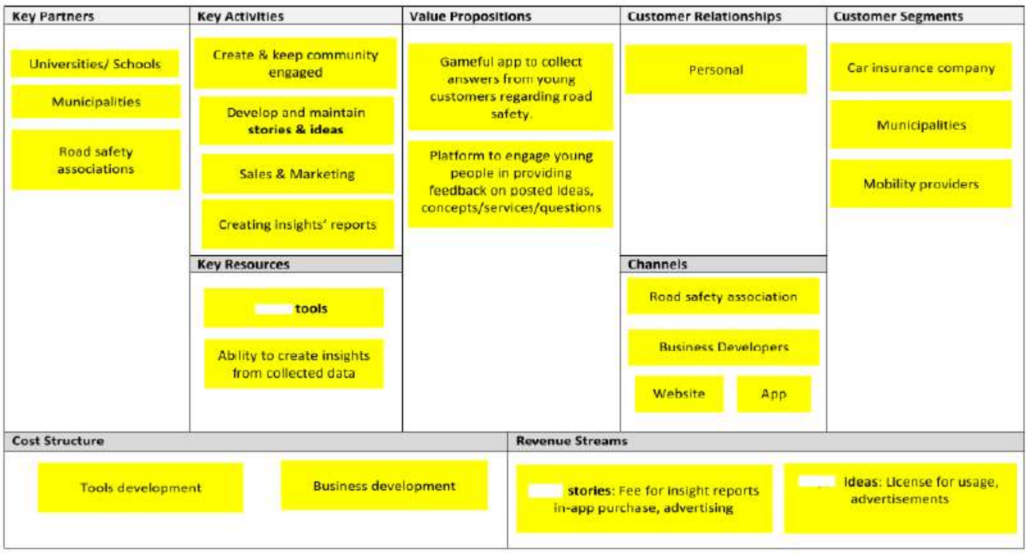



*Figure 1.3: Business Model Canvas for insurance company from [25].*

However, proposed IT tools in the literature are focused on the design step with supporting visualization and do not leverage the high class of IT tools [24]. However, recent research stated that these computer-aided business modeling tools should evolve into an own class of high-level decision support tools" [31, 97]. This implies that software tools support not

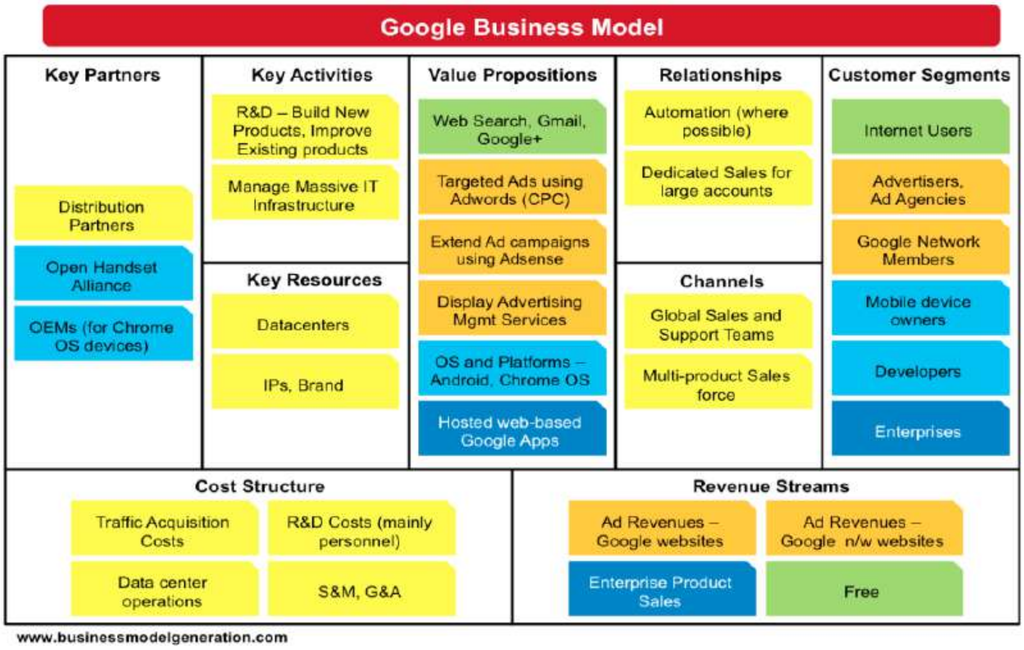



*Figure 1.4: Illustration of the Business Model Canvas using Google Business Model [96].*

only design but the overall process. Business model knowledge was represented in scholars by ontologies [31, 74], structured text [31, 98], morphological representation [82], informal text [31, 99], ad hoc graphical representation [100], and conceptual models with defined semantics and dedicated graphical representations [72].

## 1.5 Objectives and Contributions

This thesis aims to develop an intelligent decision support system for business models and strategic decision-making by adopting artificial intelligence techniques, ontologies, and explanation techniques. This thesis originates from research on strategic decision-making and intelligent decision-support systems. The objectives and contributions of our research are:

- Exploring the strategic decision-making field and investigating the decision support systems branch with artificial intelligence techniques. This examination of the problem was required to develop a suitable solution that aids strategic decision-makers. The comparison of existing DSS for strategic decision-making with reviewing the current artificial intelligence techniques and XAI techniques led to establishing our research's state of the art.

- Proposing the conceptual model of the intelligent system using the artificial intelligence technique, the ontology-based CBR (case-based reasoning) paradigm, which is capable of managing the decision-making process extremely efficiently.

- The development of a new generation of intelligent decision support systems for Business Model called "Explainable Intelligent Decision Support System for Business Model" that takes highly accurate decisional guidance into account by integrating explanations for designing and innovating business models. We also presented a domain-independent CBR platform. A new CBR system is developed by providing its domain ontology. Our proposed solution can be used for two parallel objectives: to capitalize on knowledge about BM and to provide support to experts and business students to design, innovate, and validate their BMs. Experts can use any concept or instance of the domain model to describe their cases.

## 1.6 Structure of the thesis

The thesis is presented as follows:

- Chapter 1: The Introduction Chapter, as the name suggests, introduces the thesis, including the research objective and goals, motivation, as well as a brief background on the topic in general.
- Chapter 2: this chapter provides all basic information, which is necessary to understand the BM concept and the state of the Art of tools and DSS used in the BM design.
- Chapter 3: This chapter presents the CBR technique with all the principal information and exposes case-based reasoning frameworks and tools.
- Chapter 4 describes the BM-ONTO Business Model ontology and provides a detailed description of its concepts. It also presents the developed Explainable Intelligent Decision Support Systems for Business Model Design, EIDSS-BM, and provides a detailed description of its architecture.
- Chapter 5 presents the evaluation method and the evaluation of the EIDSS-BM. This chapter introduces the experimentation results and evaluation.
- Chapter 6 presents the synthesis of our contributions and demonstrates to what extent our objective has been achieved. We will then present the perspectives and possible future work to deepen this study.

# Chapter 2

# Business Model Design and Decision Support Systems

Chapter 2

# Business Model Design and Decision Support Systems

## Contents

## 2.1 Introduction

The business model concept has appeared recently, reaching its first peak at the same time as the Internet hype at the beginning of this millennium. In the year 2003, the Business Source Premier database of scholarly business journals included the business model term 144 times in abstracts and 29 occurrences in the titles of articles [101, 102].

The business model framework is the basis for the decision-making process. It is considered by entrepreneurship as a cognitive device. The integration and organization of strategic objectives is done by this cognitive device to remain profitable in the long run and benefit from the business opportunities [2, 3, 4]. Rapid changes in the business environment force organizations to rethink their business models in order to stay competitive [5]. This is because a company's business model (BM) is critical [6]. It offers a solid framework for comprehending, analyzing, communicating, and managing strategic decisions [7, 8, 9]. Business model research is a rapidly emerging discipline that is still in its early stages of development and lacks a conceptual basis. Business model literature can be found in a variety of domains, including information systems [10], strategic management [12], and technology and innovation management [11].

The expression "business model" is related to both business and models. The result of a search in the online version of the Cambridge Learner's Dictionary [103] for the entire combined "Business Model" phrase is negative, but the meanings for the two distinct terms according to [102] are as follows:

**Business:** the activity of buying and selling goods and services, or a particular company that does this, or work you do to earn money.

**Model:** a representation of something, either as a physical object which is usually smaller than the real object, or as a simple description of the object which might be used in calculations.

The term "business" in the expression "business model," according to the first definition, refers to "the activity of buying and selling goods and services" and "earning money." From the second definition, the expression "model" is associated with "a representation of something as a simple description of the object that might be used in calculations." As a result of integrating the two terms, the first easy idea is that a business model is a representation of how a corporation buys, sells, and generates money [102]. The main goal of constructing a model is to explore a simplified representation of a certain entity or phenomena in order to describe, understand, or anticipate how things work in the real world. Similarly, a business model can assist managers in comprehending, defining, and predicting a company's "activity of purchasing and selling goods and services" and "making money" [102].

Mainly, the aim of creating a model is to help describe, understand, or predict how things work in the real world by exploring a simplified representation of a particular entity or phenomenon. Similarly, in the case of a business model, the model helps managers understand, describe, and predict the "activity of buying and selling goods and services" and "earning money" of a particular company [102].

The business model literature is rooted in several fields, such as information systems [78], technology and innovation management [11], and strategic management [12]. Business model research is a fast-expanding topic that currently lacks a solid theoretical base. Business models are defined as a system based on discovering profitable business models' ideas, elements, patterns, and combinations [18].

The fusion of the enterprise ontologies field and the ideas in business model research creates an opportune foundation to develop a range of different management tools or IS requirement engineering tools in the business field [104].

## 2.2 The Business Model's place in the company

The Business Model is defined by [105] as the logic of a "business system" for creating value that interconnects various activities. A business model serves as the framework for implementing business processes and IT systems, as well as the architectural and conceptual implementation of a business strategy.

As indicated in the diagram in figure 2.1, the business model is established as a layer in between the strategy and the operational layer [8]. By establishing a uniform communication platform, it connects corporate strategy and business processes.

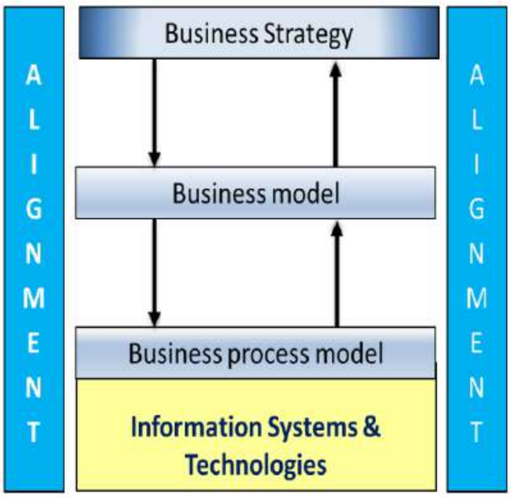



*Figure 2.1: Business model environment based on [39].*

## 2.3 The Business Model Concept

The concept of a business model is defined as an abstract representation of business logic [79] that assists decision-makers in expressing business concepts and creating and functioning as a reference framework [24, 29, 78]. As a result, there are many distinct definitions of the concept of a business model. It provides a complete framework for a firm's economic model [80, 81]. This approach is primarily concerned with how value is created and captured [82, 83].

As a result, the business model presents the logic "by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit [...]" [84]. Thus, as a result, the business model can be defined as choices in organizational design that define the firm "[...] an architecture for service and information flows, a product including a description of the various business actors and their roles [...]" [85] and explores "[...] the content, structure, and governance of transactions designed to create value through the exploitation of business opportunities [...]" [81, 83].

Although the business model is "[...] a statement of how a firm will make money and sustain its profit stream over time, [...]" [86]. It is therefore necessary to arrange the operational logic of a firm's internal procedures and strategy [83, 87]. As indicated by Figure 2.1, the business model is established as a link between the strategy and the operational layer [8]. By establishing a uniform communication platform, it connects corporate strategy and business processes.

The business model was applied for classifying companies [6, 81], so similarity between BMs was defined. This thesis is related to the exploitation of business model similarities where I examined the effect of using similarities between BMs and where I employed CBR approaches to give guidance on ideation and suggestion of a BM design.

## 2.4 Use of Business Models

Pertinence has to be proven in the business model field, which is a relatively immature research branch. As stated, few tools and concepts allow managers to share, capture, comprehend, design, transform, and investigate the business logic of the company. Understanding and sharing, assessing control, prospects, and patenting business models are the five categories of functions highlighted in this article [102]. However, in order to construct software-based tools that assist managers in BM, an ontological approach is required to fulfill these five roles [102].

**Understand and Share:** The first area in which business models can help is in interpreting and sharing a company's business logic.

**Capture:** a company's business model is a simplified picture of its business logic. Business models are mental models that managers and people use to make decisions. However, communicating this business model clearly and easily is difficult in numerous cases [106]. Furthermore, managers' minds contain a variety of mental models, so understanding the same view of the BM is difficult. For that, it is essential to use an ontology to describe business models.

**Visualize:** visualization allows a decrease in the complexity of handling systems [107]. For that, the ontology that captures business models should be presented graphically, and this can be done with a little supplementary effort [18].

**Understand:** important elements and the relationships between them are well understood and identified [108]. In addition, the success factors and the relationships between the components of the business model are not always clear. As a result, creating a visual representation of a business model can help with comprehension.

**Communicate and share:** expressing business models in a tangible way helps managers communicate and share their understanding of a business with other stakeholders [109].

**Analyze:** The second area where the business model concept might help is in examining a company's business logic. They can, for example, better measure, observe, and compare a company's business logic.

**Measure:** corresponding to the Balanced Scorecard Approach [110] a business model allows monitoring areas in a specific business. Therefore, identifying important measures to improve management after the step of capturing and formalizing the BM is clearer.

**Observe:** Uncertain environments and other conditions inside the company engender constant changes in the business logic of companies. With a structured approach to business models, determining which aspects have changed over time is simple.

**Compare:** using the structured method, companies can compare their business models to those of their competitors. Because the comparison is more effective if the BM is understood and captured in the same manner. Therefore, this comparison between the BMs of companies from different industries spurs business model innovation.

**Manage:** The third area in which business models can help is improving firm management. Business models can be designed, planned, changed, and implemented using the business model concept. Furthermore, the business model approach enables organizations to respond more quickly to changes in the business environment. Finally, the business model can improve the alignment of strategy and company organization.

**Design:** it's not easy to optimize and reinforce entire aspects of the business model in order to meet the design's requirements. The business model ontology, which represents all elements of the BM and their relationships, makes it easier for managers to design BMs.

**Plan, Change & Implement:** Changing and adopting business models with formalization and visualization will enhance planning, change, and implementation.

**Prospect:** A fourth area where business models might help is through simulations of the company"s future.

## 2.5 Enterprise Ontologies

The ontology field has influenced this dissertation, and a number of related works are discussed in this section.

Authors in [111] clarify the definition of the ontology by referring to RKB (Shared Reusable Knowledge Bases).

Ontologies are agreements about shared conceptualizations. Shared conceptualizations include conceptual frameworks for modeling domain knowledge; content-specific protocols for communication among interoperating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary. A very simple case would be a type hierarchy, specifying classes and their subsumption relationships. Relational database schemata also serve as ontologies by specifying the relations that can exist in some shared database and the integrity constraints that must hold for them.

Ontologies are increasingly used in IS and IT. Applying ontologies in IS allows for shared understanding in a specific domain to solve a problem [111]. Therefore, the author of [112] defines IT ontologies as "logical supersets that combine metadata, taxonomies, and semantics into formal systems that can be encoded in software, enabling diverse Web applications to truly understand one another." He stated that the logical step in the IT industry's standardization of hardware is software and communication technologies. Furthermore, he also stated, "require the systematic management of business terms and their usage."

Two different types of ontologies are defined in business. Primarily, ontologies that present the concepts of nature and business enterprise structure. The second type of ontology is transaction-related ontologies, which aim to improve and automate business transactions [109].

### 2.5.1 The Toronto Virtual Enterprise (TOVE)

The Toronto Virtual Enterprise introduces a model for model-driven enterprise design, analysis, and operation [113]. Concepts, properties, and relations are defined rigorously and explicitly. The TOVE ontology uses formal semantics, theorems, and proofs [111].

### 2.5.2 Business Engineering Model (BEM)

To support interoperability among operational and data warehousing environments' metadata, this model presented a set of formalisms [114]. UML was used to describe concepts. This model captured information on corporate goals, the organization, business processes, and business regulations.

### 2.5.3 The Edinburgh Enterprise Ontology

An enterprise ontology was presented in the work of the Edinburgh Group [111], defining general concepts that describe enterprises in general. This model represents a foundation for specifying software requirements [114]. This Enterprise Ontology allows communicating, integrating, and representing the different concepts of an enterprise. It provides tools for modeling businesses and procedures. The Enterprise Ontology used two types of representation in a semi-formal manner (Ontolingua) and an informal way (text version).

### 2.5.4 The e-Business Model Ontology

The e-Business Model Ontology is an approach that displays the relationships between the main concepts in e-business models [102]. The motivation and reference for this e-business model ontology came from several enterprise ontology initiatives described in research (Toronto Virtual Enterprise, Enterprise Ontology, and Core Enterprise Ontology) [114].

By defining the elements of a domain and the interactions between them, an ontology effectively provides a common understanding of that domain. According to [104], the following are some of the benefits of employing e-business models:

1. Using ontology as an e-business model or to model social systems allows for the understanding and identification of key elements in the field as well as the relationships between them [111].
2. Using the formalized e-business models allows managers communicating and sharing their understanding of an e-business with stakeholders [109].
3. Changes and modifications to an existing e-business model can be made easily by business model designers [105].
4. Similarly to the Balanced Scorecard Approach, relevant measures of e-business can be identified [110].
5. e-Business models allow doing risk-free experiments by simulating e-businesses, without endangering an organization [115]. The ontology of e-business models is built on four basic components (figure 2.2).

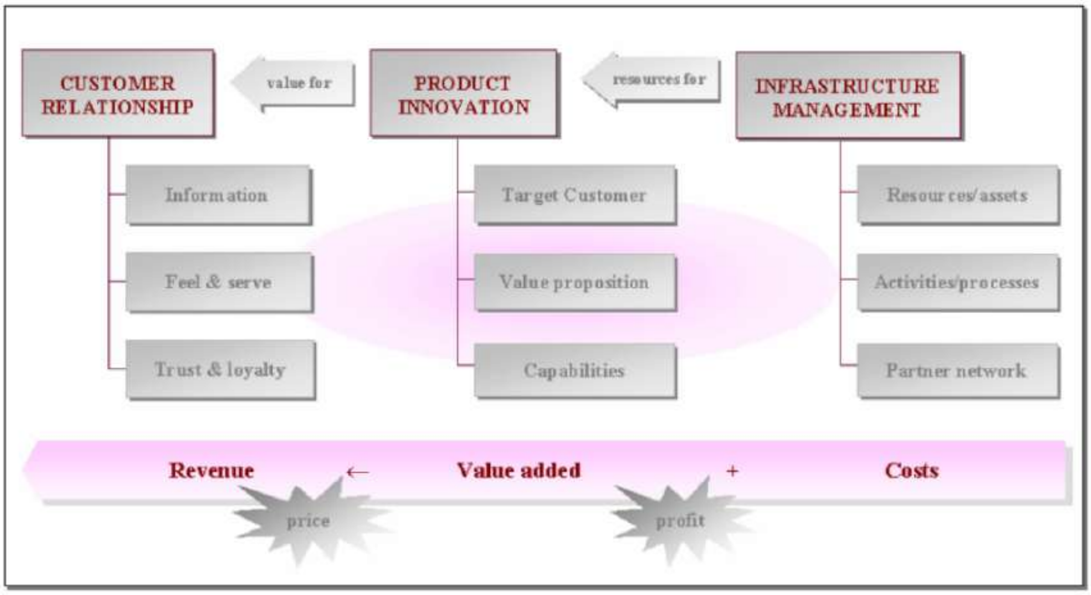



*Figure 2.2: e-business model framework [104].*

(1) The goods and services that a company provides that are of significant value to the customer and for which he is willing to pay.

(2) The network of partners and infrastructure that are essential for creating value and maintaining long-term customer relationships.

(3) The customer relationship capital that the company builds and maintains in its customers' satisfaction and produces long-term income. Finally, but certainly not least,

(4) Financial aspects, such as cost and revenue structures, are crosscutting and can be found in all three previous components.

### 2.5.5 The Business Model Caneva BMC

The Business Model Canvas (BMC) by Alexander Osterwalder [102] is the most famous representation approach. It achieves two important goals. The BMC is an easy-to-use template. It is composed of nine key dimensions: value propositions, activities, key partners, resources, channels, customer segments, customer relationships, revenue streams, and cost structure.

Figure 2.3 depicts the specified BMC template and its main categories. Definitions of different categories of the BMC from the book of Osterwalder and Pigneur [91] called "Business Model Generation" are the following:

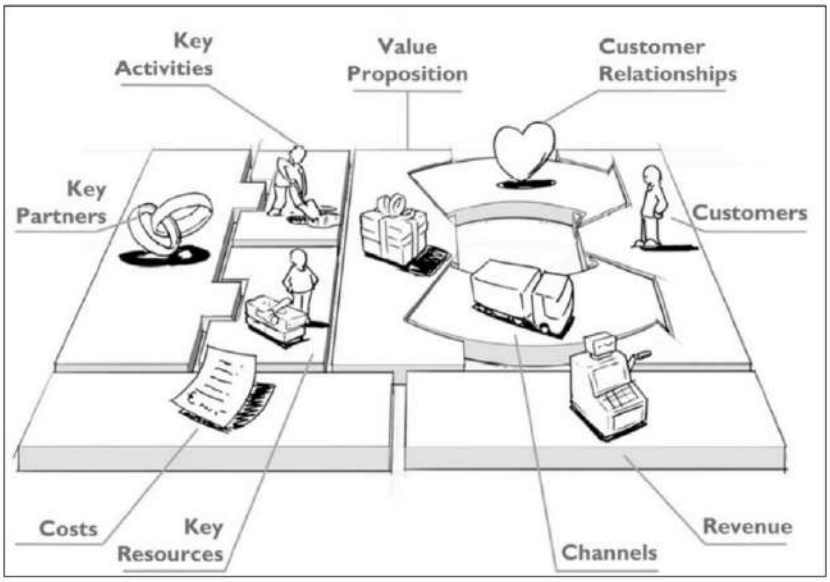



*Figure 2.3: Business Model Canvas [91].*

- **Value proposition:** This element includes services and products provided by a company. The most important mission of any enterprise is the generation of added value for the customer.

- **Customer segments:** customers are clustered into groups to satisfy the different special needs of each group of customer, such as niche market or mass market.

- **Channels:** A channel describes, in what way, a company to attain a customer segment to deliver a product or a service. This category links the value proposition with the several customer segments. There are external channels through a partner channel (as wholesale distribution) and internal channels in the organization (as a website or retail store), or mixed based on the customer segment.

- **Customer relationships:** There are several types of relationships according to the customer segments, such as personal assistance and extremely automated impersonal service.

- **Key resources:** this category concludes human, intellectual, financial or physical resources for the value creation of the company.

- **Cost structure:** Conclude principal costs generated by the value creation.

- **Revenue Streams:** define that amount of money that will pay the customer segment for the value proposition offered by the company as asset sale and licensing.

- **Key partnerships:** Important key partners who their activities related to the organization as buyer- supplier relationships and joint-ventures.

- **Key activities:** The important activities for the value creation are presented in this category as supply chain management, production,

A famous conceptual representation for BMs was presented in Osterwalder's ontology for BMs [91, 102]. As in the past, for strategy implementation, the balanced scorecard concept was widely applied [116]. The four dimensions of Osterwalder were extended to nine dimensions in his BMC [102]. This work is mentioned many hundreds of times, and this ontology prepares a new way of business modeling [117].

## 2.6 Visual Representation of Business Models

Good visualization is a focal point for the value generation of a company. Like the BMC, which is quickly understandable and easily filled out [91], there are other non-intuitive BM approaches that don't present an exhaustive vision of value creation and other dimensions like environmental details and business processes [118, 119]. Visual BM representations enhance understanding, and they are used in a common communication platform that is very beneficial for managers.

So people from different backgrounds, managers, and developers share the same view and have the same understanding [8]. Authors in [18] state that with these visualizations, the accuracy of an organization's potential profitability is increased. In addition, it serves as a base for requirement engineering. Different experiments and simulations can be done to simulate several possibilities for future business models [120].

A number of scholars presented BM representations, and an entire classification framework of visual representations has been presented in [121], as illustrated in figure 2.4. In total, ninety-five (95) visual business model representations were presented in the literature review by [120].

The study published in [120] reveals cognitive characteristics for BM representations with constraints to organizations in dynamic changes.They pointed out that current BM representations vary in their aspects of the notion of the BM.

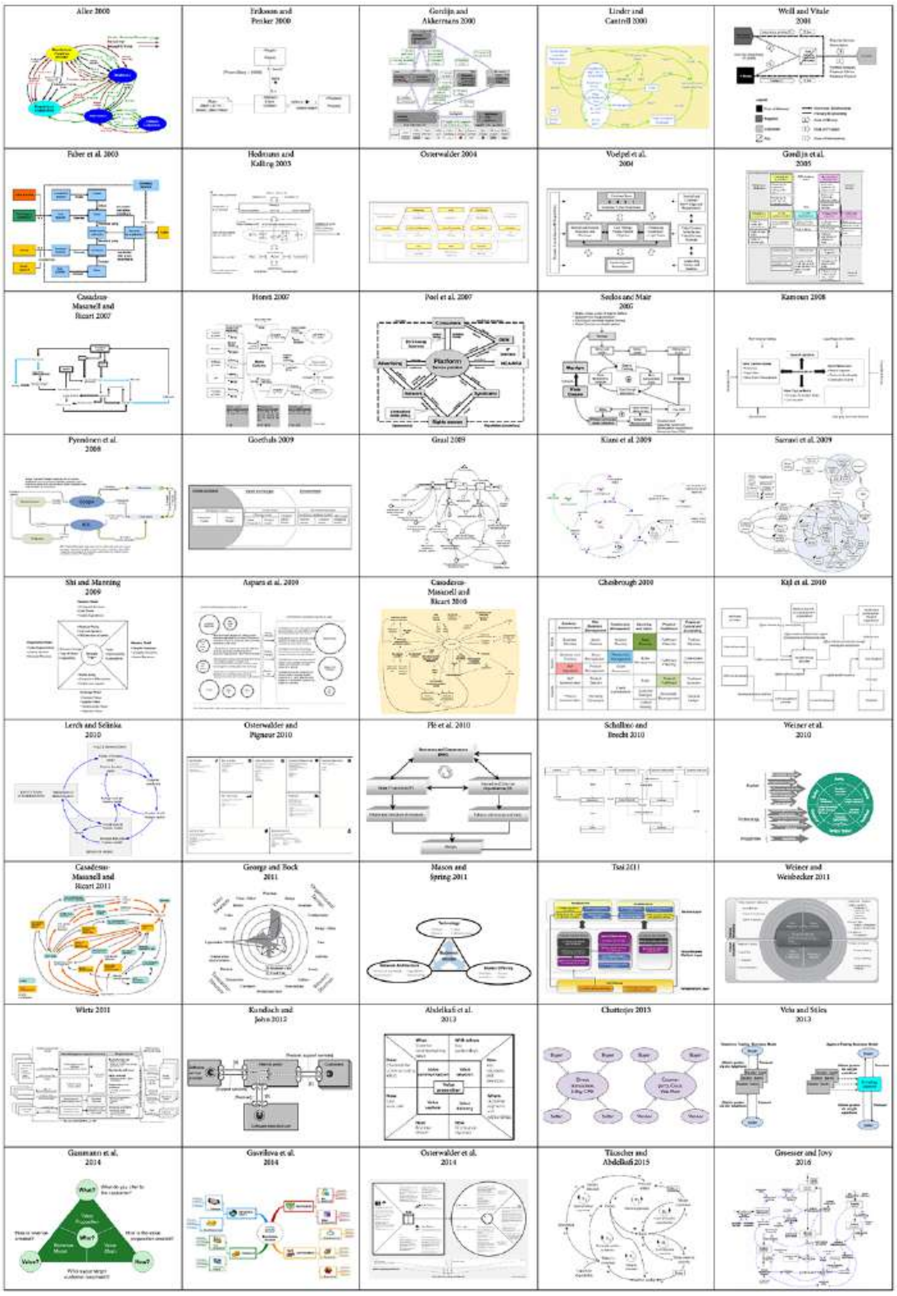


*Figure 2.4: Visual business model representations in academic sources* [14].

## 2.7 Literature review of DSS for Business Model Design

An important axis of the contribution of business models is building a base for computer-assisted management tools. Management scholars are important actors that generate models and concepts.

However, rarely are these concepts translated into software-based tools, which could deliver huge value to management. Several functions of the business model can be understood if digitized. In addition, software-based tools accomplish some operations much more quickly than manual methods like visualization, comparison, and design.

These ontologies appear as efficient tools for describing, integrating, comparing, and classifying business models. However, the highly creative task of business model innovation is not effectively supported by these studied tools that do not support the ideation phase.

They admit that most of these approaches are fill-in-the-blank tools where information is added manually. In most cases, users need knowledge and information about how to fill in the different elements of the BM. Furthermore, current methods must focus on assisting users in being creative, which has been ignored in recent studies. The authors of [22] argued that functions for exploring business model patterns should be included. In addition, difficulties in prototyping new business models and limits to creativity in the practices of BM-related education are stated in [27]. The author argued that the solution is to merge explanation and experience-based learning approaches into a virtuous learning cycle. Therefore, methods of creative task and ideation should also be included, and this is precisely one of the dissertation's goals.

Research has handled the development of software tools that support BM, which is still interesting, especially by facilitating the visualization of a BM during the design phase [24]. Nowadays, there is a call for more sophisticated tools that evolve into high-level decision support tools [31].

### 2.7.1 Modeling languages

A number of scholars have proposed modeling languages, visual notation, and vocabulary as provided by these tools for capturing and presenting information on business models (e3value [18]; the strategic business model ontology [122]; The Business Model Canvas [31]). The visualization of all components of the business model is allowed with these modeling languages, and business model ideas are explicit and more appreciable.

A business model simplifies activities such as communicating and understanding business logic [122]. These languages are defined as a favored domain for the IS branch [24, 123], and have presented a major theme in past IS business model research [81]. The Business Model Canvas has had the most impact on academic studies and practice and is regarded as the quasi-standard representation [95, 124, 125]. The related book [91] has sold about one million copies [95, 126].

**The Business Model Canvas:** The most complete framework, having the highest number of components, is the Business Model Canvas proposed by [91]. It is composed of nine components: key activities (KA), key resources (KR), key partnerships (KP), cost structure (C$), value propositions (VP), channels (CH), customer relationships (CR), customer segments (CS), revenue streams (R$).

It is defined as a visual chart for developing new or documenting existing BMs. It's a visual representation for creating new or documenting existing business models [8]. The

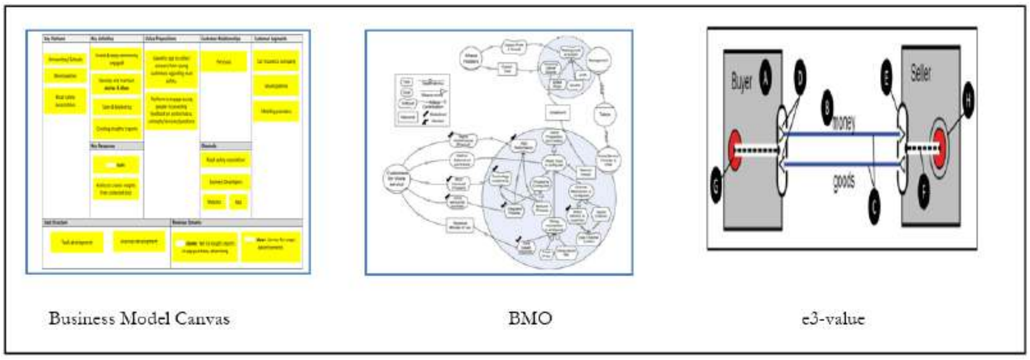



*Figure 2.5: Selected Business Model Modeling Languages.*

BMC is a schematic representation that presents how a company will deliver, capture, and create value. The BMC is the basis of many frameworks and IT tools because it offers the ontology of the business model domain and provides the domain's ontology for business models. that allow using computer assistance.

The building of software-based tools can start when the elements and relationships of the business model notion have been proposed to simplify the lives of managers. Software-based tools have been proposed for visualizing, designing, and comparing business models [102].

**E3 value:** The "e3-value" language was proposed by [18]. It allows evaluating and capturing BMs from a financial point of view. The e3-value allows evaluating and clarifying an idea. This approach begins with an e-commerce idea to build a value model. The e3-value methodology has been used in different domains such as banking, energy, entertainment, and telecommunications [71]. The main concepts of e3-value are actors, value ports, value exchanges, and value objects. Identifying involved actors is the first step to designing an e3-value model and the value exchanges that appear with these actors. After that, the value exchanges are valued financially to determine which economic performance each actor in the network is expected to have. The E3 value provides an initial idea of the economic attractiveness of the business model by automatically generating profitability sheets, which include the number of incoming and outgoing value objects and their value. Calculating the sum of an actor's inflows and outflows to calculate cash flow for a given period [118]. These main concepts and their relations are part of an ontology that has been formalized in the Unified Modeling Language (UML) [18].

**Strategic business model ontology (SBMO):** The decision-making process is completely expressed by the SBMO ontology by capturing the communication and cooperation with several stakeholders outside and inside a company. In the operational view, actors are represented by their tasks, relationships, and (operational) goals. The strategic view visualizes how these operational goals are linked to strategic goals [126].

### 2.7.2 Digital Tools that represent and change business models

Various software tools have been proposed for supporting the application of the existing modeling languages [22, 78, 127], in research [23], and practice (Strategyzer, BM Designer[1],

[1] BM Designer: https://bmdesigner.com/

Canvanizer 2.0[2]).

These tools enable making changes to business models and represent and allow collaborative development that is not even possible with "pen & paper" tools [23]. In addition, these tools can support their users more efficiently in performing some actions such as versioning and annotating business models than with the "pen & paper" versions of the modeling languages. Some of these tools have already gained considerable popularity in practice, as indicated by, for example, more than 100,000 downloads for the app Business Model Canvas & SWOT, and more than 1,000,000 business model projects in the browser application Canvanizer [125].


*Figure 2.6: Selected Business Model Modeling Languages from practice.*

**Tools in research**

**Ebel et al., 2016:** Ebel developed a BMDT that would allow SAP and its stakeholders to determine new market segments and further actions. This BMDT enables employees from all over the world to contribute to their business model innovation process, thereby improving coordination and reducing transaction costs. This BMDT helps SAP to realize collaborative business modeling with their stakeholders, resulting in an outcome with a sufficient degree of quality. As Ebel put it, "technology can facilitate online collaboration and, as a result, improve the overall quality of knowledge contributed".

Finally, these tools use a fill-in-the-blank method, so information is entered manually by the user; they are click-and-fill-out tools, but users requested explanations of what the elements (or building blocks) mean and examples of how they can be filled out [25]. This is because some prefilled software tools were developed.

**Athanasopoulo et al. 2020** for the field of the Internet of Things (IoT), the author developed a prefilled BMs tool for BM development used utilizing so-called solution-based patterns [97].

From a technical view, the architecture of these was different: client/server, client-only, client application, and web-based. In addition, data exchange captures functions that allow exporting and importing of a business model, allowing the continuation of working on a business model developed by another user or developed with another tool [125].

[2]Canvanizer 2.0: https://canvanizer.com/

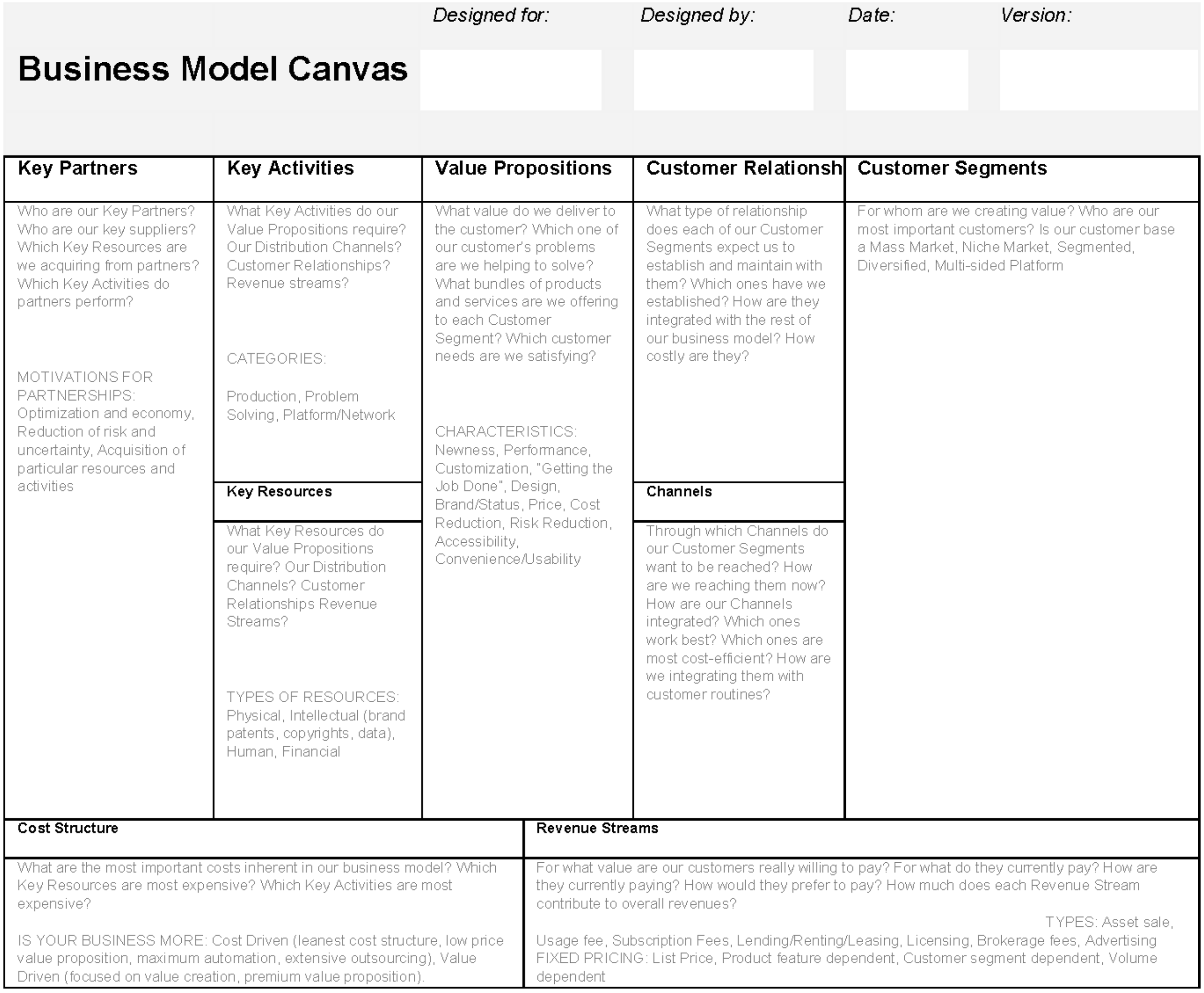



*Figure 2.7: The Business Model canvas.*

Accordingly, many scholars indicated the great support of these software tools for innovating business models, but additional research is necessary [22, 23, 24, 31].

**Online repositories and online platforms** are available, such as BMToolBox.net and BusinessMakeover.eu, which present different business model tools, supporting users in satisfying their demands [128].

### 2.7.3 Business model patterns that stimulate analogical reasoning

The description of successful BMIs supports the ideation of novel business models. Recent research has shown that generating ideas for new business models is possible with two cognitive processes: conceptual combination and analogical reasoning [99]. Patterns of BM are identified to stimulate analogical reasoning, which has gained increasing interest in business model ideation methods [82, 98, 120, 129].

**The Gassmann's 55 patterns** [82]: this catalog of BM inspired managers and entrepreneurs of all sorts to creatively develop or imitate solutions by recombining existing patterns. The

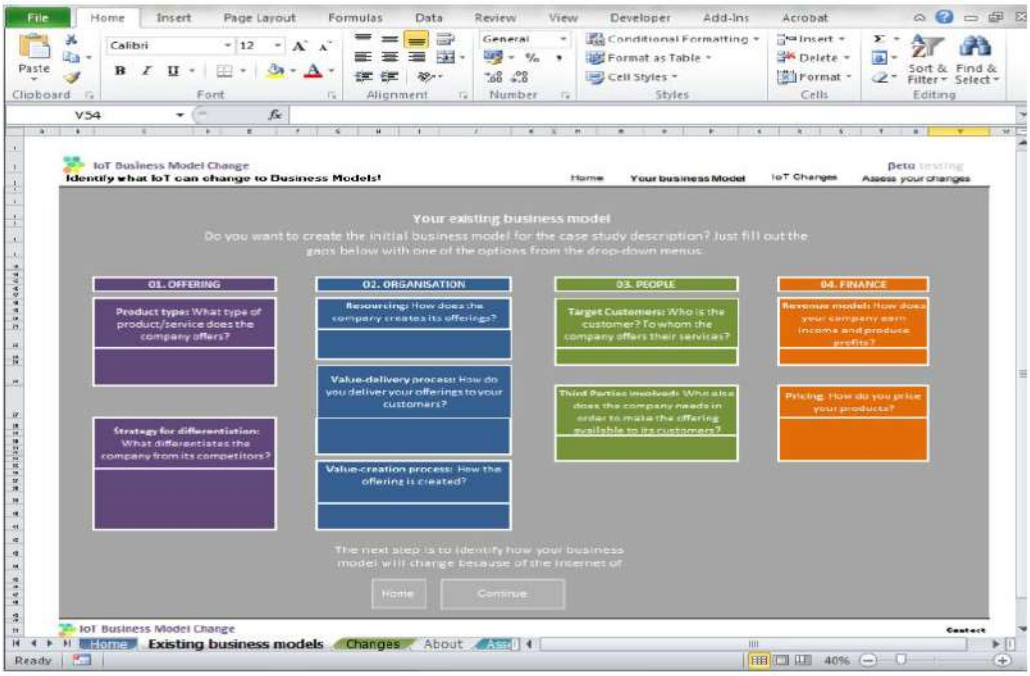



*Figure 2.8: The developed prototype [97].*

authors use a "who-what-how-why" framework to describe these patterns. However, this classification lacks a meta-structure that brings order to the 55 patterns [130]. To support business model innovation, this approach is widely recommended. It refers to the process of "generative cognition," which is envisioning future business models in the sense of seeing with one's mind.

**Remane et al.** (2017) [129]: utilizing the Business Model Canvas to develop a database of 182 patterns and describe pattern characteristics. The author proposed a strong approach to define patterns among these scholars. The author explains that different problems can be solved with the generalization and combination of these patterns in different domains. The elements that describe a problem-solution combination are: problem statement, solution statement, pattern name, context description, examples, and explanations.

**Abdelkafi et al., 2013** [98]: the author introduced a new framework in which a business model denotes a value-focused concept with five value dimensions: value proposition, value communication, value creation, value delivery, and value capture. The framework enables the classification of business model patterns, identified in the literature, into five categories. The combination of patterns from different dimensions can lead to the systematic generation of business model innovations.

**Business Model Gallery** [131]: The largest business model database that is a publicly available database on business models, as a resource for learning about differ ent BM designs. In this database, BMs from all kinds of industries are explained, allowing to learn about various patterns. This project aspires to capture the power of analogies by being a place for inspiration.

These tools explicitly follow a pattern-theoretical approach [130].

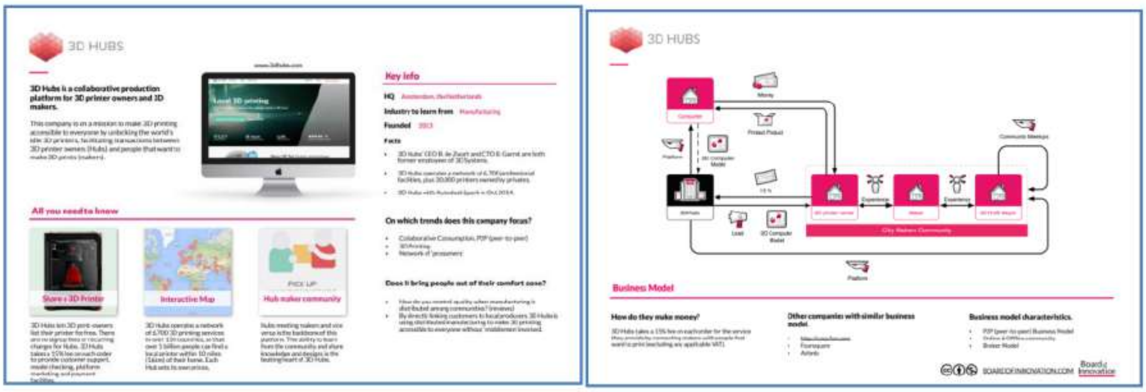



*Figure 2.9: 50 Business Model examples [82].*

## 2.7.4 Analytical Methods

### 2.7.4.1 Modeling, Simulation Tools and Stochastic analysis

Another research stream focused on validating the BM with analytical methods such as modeling and simulation [132, 133]. Business model adaptations can be done with simulations to comprehend the results without exposing the organization to risk [128]. To predict the viability of the business model decisions, quantitative and qualitative scenario analysis were adopted.

Daas et al. (2013) [133] presented a tool that supports the evaluation of alternative business models by incorporating market analysis data. The tool helps analyze alternative BM solutions. The DSS uses flexible spreadsheet-based technology. The DSS is composed of three parts: (1) the business model design, (2) market analysis, and (3) decision analysis. Figure 2.10 shows the conceptual design of the DSS. Each worksheet provided a dashboard, including design parameters and evaluation indicators tailored to a particular decision-maker within the business units of the SaaS providers or within a structural partner's organization.

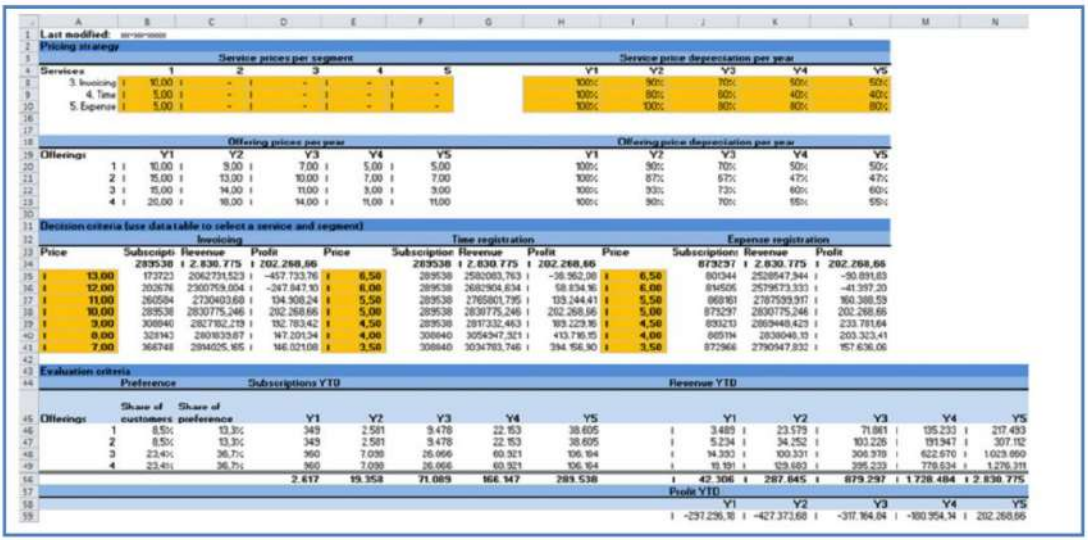


*Figure 2.10: Service pricing dashboard [133].*

Bouwman et al. (2008) [134] used scenario analysis to test the robustness of the BM choices. The scenarios represent the different probable future changes in the environment, consumer attitudes, and towards IPTV service and industry structure. Telecom operators can realize economic benefits and deliver customer value with the selection of the optimal business model.

Zoric et al [134]: A techno-business modeling approach was discussed in this work for quantitative analysis of services and platforms. The roles, responsibilities, and incentives of collaborating business actors in service delivery and provision were used in business analyses and valuations.

Pagani et al. [135] developed an operative planning tool with scenario evaluation and analysis through Repeated Cross-impact Handling. This tool generates quantitative and qualitative scenarios.

In other studies, the principal drivers of the financial performance of financial models were identified by using stochastic analysis.

Euchner et al. [136] used stochastic methods to quantify the probability of business success and identify the variables that are likely to have the most effect on the success (or failure) of the business model. They used a tornado diagram.

Latora et al. [137] proposed a (BM-DST) Business Model Decision Support Tool. He used a Multiple Criteria Decision Analysis (MCDA) called the Analytic Hierarchy Process (AHP) to estimate the business solutions.A software application was implemented by using a common spreadsheet in order to prove the "lean" characteristic of the Business Model Decision Support Tool (BMDST), which is easy to implement in any business context.

#### 2.7.4.2 Simulation tools

The alternatives and changes of an actual BM to a future one are defined in the tool BM Road Mapping, proposed by [138]. The viability of a BM in front of the BM, value network, and regulations and standards is achieved using the Viability Radar BM tool [139].

The robustness of a BM under several scenarios is experimented with using the BM stress-testing tool proposed by [132];

An example of insurance was used to explain the method. It is a structured method that combines scenario planning and BM design. Strengths and weaknesses of the BM appear in the heat map to communicate the BM's robustness. The company can then select the optimal alternative. Therefore, the author advised applying this approach in the early stages of BMI after formulating an initial idea.

Gudiksen et al. (2015) [140] proposed a tool that used games for playful experimentation with ideas the user had about BM. The authors claim that using tangible tools assists in creating new ideas.In addition, he concluded that BM's design games had two significant benefits: (1) the rules that participants should follow are clearly defined, and (2) the tool allowed for experiential learning.


*Figure 2.11: The tool BM stress-testing [132].*

This tool encourages an experimental, game-oriented culture and the freedom to improvise, play, and test BM concepts [140, 141]. With rapid changes in the business environment, firms are forced to experiment with BMs.

## 2.8 DSS Based AI

Dellermann et al. designed a hybrid system that allows the integration of human input into an artificial intelligence system throughout the systems' life cycle in order to develop, complement, and evaluate the systems' capabilities [26]. According to the authors, combining the strengths of artificial intelligence and human intelligence will result in a more intelligent system than either one alone [142].

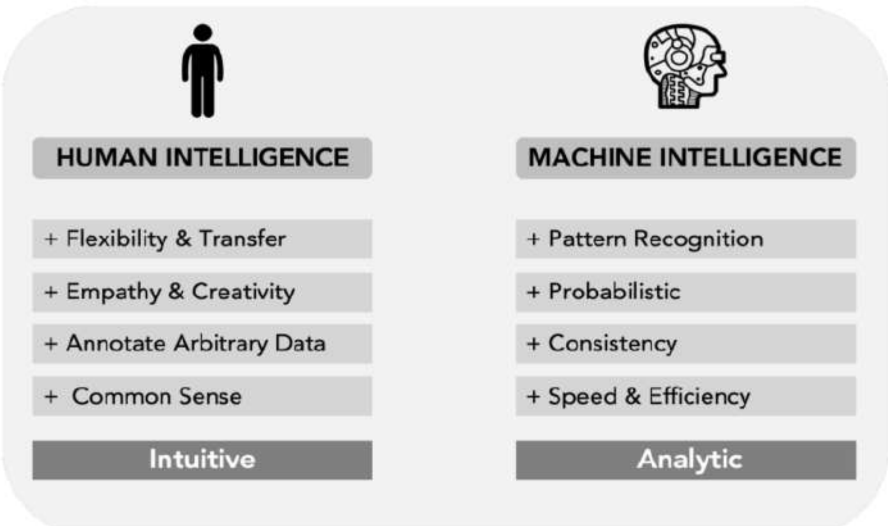



*Figure 2.12: Complementary Strengths of Humans and Machines [83].*

Dellerman proposed a prototype version of the HI-DSS artifact as a cloud-based web service. The prototype of the artifact consists of a graphic user interface (GUI) that allows the input and visualization of the entrepreneur's business model. He developed a web application in Angular [3].

A standardized representation of the business model was used in a dynamically adaptable format. The entrepreneur makes choices for each element of the business model: value

[3] Angular: https://angular.io/

proposition, value delivery, value creation, and value capture dimensions of the business model. Information about startup business models that is publicly available was used to train the machine learning algorithm. The open-source machine learning framework TensorFlow[4] was used to develop the machine learning part of the prototype.

## 2.9 Discussion and future issues

First, we investigated the BMDTs with regard to the features and characteristics of intelligent systems. The features of intelligent systems are selected from different sources of intelligent systems, including referential journals published by AIAA and books by the Institute of Electrical and Electronics Engineers (IEEE) [143, 144]. For this, we counted the BMDTs that provide particular features, thereby indicating how often these features are included in the BMDTs. In so doing, we aim to identify which tools belong to the high class of intelligent systems. We summarize the results in Table 2.1.

The state of the art of decision support systems for Business Model is reviewed, evaluated, and criticized. The proposed models have many limits and drawbacks, which open a wide door of challenges and issues.

Secondly, we investigated the BMDTs with regard to the explanation purposes found in the studies in Table 2.2.

*Table 2.1: The intelligent system features of studied business model development tools.*

| | Latora et al 2018 [137] | Pagani 2009 [145] | Bouwman et al 2008 [134] | Remane 2017 [129] | Gassmann 2014 [82] | Athanasopoulo 2020 [25] | Canvanizer 2.0 | BM Designer | Daas 2013 [133] | Ebel 2016 [23] | Dellerman 2019 [26] | EIDSS BM 2021 [146] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sensing/perception | | | | | | | | | | | | |
| Information compression | | | | | | | | | | | X | X |
| Extrapolation | | | | | | | | | | | | |
| Learning | | | | X | X | X | | | | | X | X |
| Adaptability | | | | | | X | | | | | X | X |
| Robustness | X | X | X | | | | X | X | X | | | |
| Deliberating/planning | | | | | | | | | X | X | X | X |
| Collaboration | | | | | | | X | | | X | | |
| Improving efficiency | X | X | X | | | | X | X | X | X | X | X |
| Metabolizes | | | | | | | | | | | | |
| Systems that perceives, reason, learn | | | | | | | | | | | X | X |

Software tools have shown great potential in supporting business model innovation and development. They also seem to be effective tools for describing, integrating, comparing, and classifying business models. However, the software under consideration does not appear to

[4]TensorFlow: https://www.tensorflow.org/

*Table 2.2: The Explanation Purposes Identified in Studies [147].*

| Purpose | Description |
|---|---|
| Transparency | Explain how the system works |
| Effectiveness | Help users make good decisions |
| Trust | Increase users' confidence in the system |
| Persuasiveness | Convincing users to buy or try |
| Satisfaction | Increasing the enjoyment and the ease of use |
| Education | Allowing users to learn something from the system |
| Scrutability | Allowing users to tell the system if it is wrong |
| Efficiency | Help users make decisions faster |
| Debugging | Allows users to identify that there are defects in the system |

*Table 2.3: The explanation purposes of studied business model development tools.*

| | Latora et al 2018 [137] | Pagani 2009 [145] | Bouwman et al 2008 [134] | Remane 2017 [129] | Gassmann 2014 [82] | Athanasopoulo 2020 [25] | Canvanizer 2.0 | BM Designer | Daas 2013[133] | Ebel 2016[23] | Dellerman 2019[26] | EIDSS BM 2021 [146] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transparency | | | | | | | | | | | | X |
| Effectiveness | | | | | X | X | X | X | X | X | X | X |
| Trust | | | | X | | | | | X | X | | |
| Persuasiveness | | | | | | | X | X | | | X | X |
| Satisfaction | | | | | | | X | | | | | |
| Education | | | | | X | X | | | | X | | X |
| Scrutability | | | | | | | | X | | | | X |
| Efficiency | X | X | X | | | X | | | | X | | X |
| Debugging | | | | | | | | | | | | |

be particularly helpful during the ideation phase, making it difficult to support the highly creative task of business model innovation.

We concluded that the most common approach used in business model tools is fill-in-the-blank, where information is added manually. In most cases, users need knowledge and information about how to fill in the different elements of the BM. Existing tools supported creating alternative models but did not sufficiently facilitate the decision-making process.

What we realized from Table 2.2 and Table 2.3, is that scholars have stated that software-based Business Model Data Tool BMDTs provide important assistance for designing and innovating Business Models, specifically with employing machine learning and other AI techniques. However, trust is not offered by these AI-based DSS systems to allow extremely accurate decisional guidance. Meanwhile, the capability of an intelligent system to provide a meaningful explanation of its actions is a crucial factor affecting the acceptance of the system [102].

For that reason, systems must provide explanations to allow end users to trust, understand,

and effectively manage these systems.

## 2.10 Conclusion

As referred to, the BM is a powerful concept used as an intermediary level in the company between both strategic and operational considerations [7] must be considered. Consequently, the foundations and backgrounds of BMs are important and should be well understood to utilize them in an appropriate manner. Several definitions of BMs are presented in the literature [85, 91]. The overall goal of these BMs is to secure the profitability of an organization. In general, the BM concept is very powerful, especially as a management tool [6].

In particular, the Business Model Canvas of Osterwalder and Pigneur [91] became very famous as such a management tool in both theory and practice. Many further developments are based on this approach, and it is often used because of its degree of abstraction and fast modeling process [119].

Some practical tools use this approach as well. However, BM research is not as far as it could be, at least concerning the development of BM tools [118]. Several gaps exist for future research, like the improvement and further development of existing BM artifact approaches to business modeling.

Next to this, and because there is little work to support decision-making and implementation, is the development of artifacts and, in particular, tools from existing research to support decision-making and implementation.

In summary, there is great potential in the field of BM artifacts [23], and both practice and theory will benefit from the realization of existing and new knowledge in this field. Existing methods have to focus on providing assistance to the user in being creative, which has been neglected in recent research. As argued by [22], functions for exploring business model patterns should be incorporated. In addition, difficulties in prototyping new business models and limits to creativity in the practices of BM-related education are stated in [27]. The author argued that the solution is to combine explanation and experience-based learning approaches into a virtuous learning cycle. Therefore, methods of creative task and ideation should also be included, and this is exactly one of the aims of this dissertation.

# Chapter 3

# The CBR Approach

Chapter 3

# The CBR Approach

## Contents

## 3.1 Introduction

Case-based reasoning is a popular problem-solving strategy used by humans. As a result, this style is widely used in business, even if most individuals are unaware that they are doing so. Scholars have pointed out that case-based reasoning, which is commonly used in information systems, may be successfully employed in business [72]. It is an appropriate experience management methodology for workers who must conduct complicated and knowledge-intensive activities.

Case-based reasoning CBR mimic the way of human thinking, comprehend and predict, it is founded on the human cognitive model. CBR technique solves a new problem by using a previous similar situation and by reusing information and knowledge of that situation [73]. It has been used in many successful applications due to its psychological plausibility [74]. The principal idea of CBR systems is to store the experiences of people in the knowledge base as cases. When there is a new problem, we can search the knowledge base, finding the past similar problem and the problem solution. Then, we can have an acceptable case as a reference. If the user is unsatisfied with the case, it can adjust the case to suit the current situation. Finally, the user stores the revised case in the case base [18].

## 3.2 Case-Based Reasoning

Case-based reasoning is a subfield of artificial intelligence .Knowledge-based systems, cognitive science, and machine learning are therefore the foundations of CBR [148]. Case-based reasoning (CBR) was defined by [149] as a "reasoning by remembering" or "reasoning from reminding" [150]. "Case-based reasoning is both [...] the ways people use cases to solve problems and the ways we can make machines use them" [151]. According to Aamodt and Plaza [73] CBR is "[...]a recent approach to problem-solving and learning". Case-based reasoning was influenced strongly by the cognitive science, the initial idea was originated from the researches about the human brain [152].

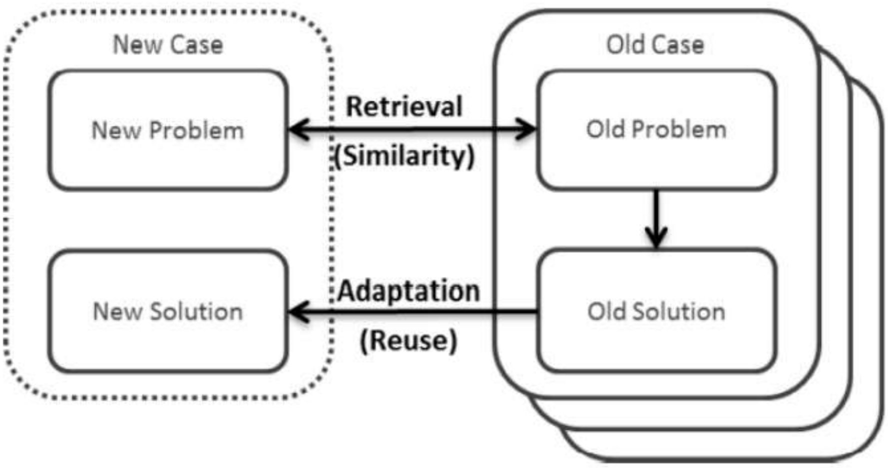



*Figure 3.1: Case-based Reasoning Reuse Principle [153].*

The figure 3.1 shows the essential reuse principle of case-based reasoning. To offer a solution (reuse) to a new situation, knowledge of previously experienced situations (cases containing old issues and old solutions) is used (new problem). The comparison between the new problem and the old problems based on the similarity is the base of the suggestion made by the CBR system [73]. This principle is related to the following assumption of CBR, "[...] similar problems have similar solutions" [154]. From the CBR terminology, a case consists of a problem space describing a certain solution space [72]. A case, in CBR terminology, is made up of a problem space and a solution space.

The CBR cycle, as illustrated in figure 3.2, is composed of the following steps:

1. Case retrieval: the system searches the case base for (similar) previous cases that are useful to solving the current problem.
2. Case adaptation: to generate a solution for the present problem, the system uses the solution applied in the previous case.
3. Case Revising: the user validate the solution.
4. Case Retaining: the user stores the validated solution in the case base for solving problems in the future.

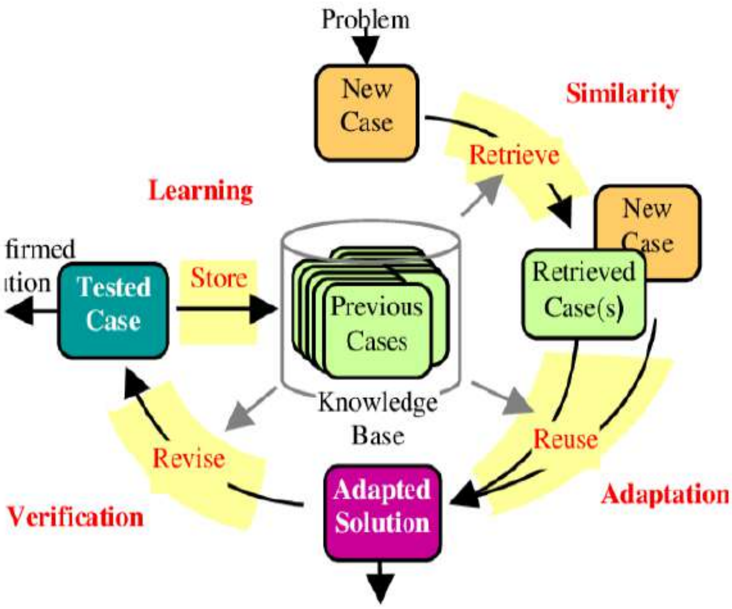



*Figure 3.2: The CBR process [73].*

### 3.2.1 The Case structure

As used in cognitive science, the principle idea of the concept of the case is capturing information to assist in problem-solving [155]. Generally, a CBR system case description comprises of a problem and a solutions part. The concept of the problem and solution view is enlarged by the characterization part and the lesson part [72]. "The case characterization part describes all facts about the experience that are relevant for deciding whether the experience can be reused in a certain situation" [72].

A case is defined as "[...] in case-based reasoning is a contextualized piece of experience" [155]. The following general definition is given here: "A case in case-based reasoning consists of at least one experience/knowledge item that is contextualized."

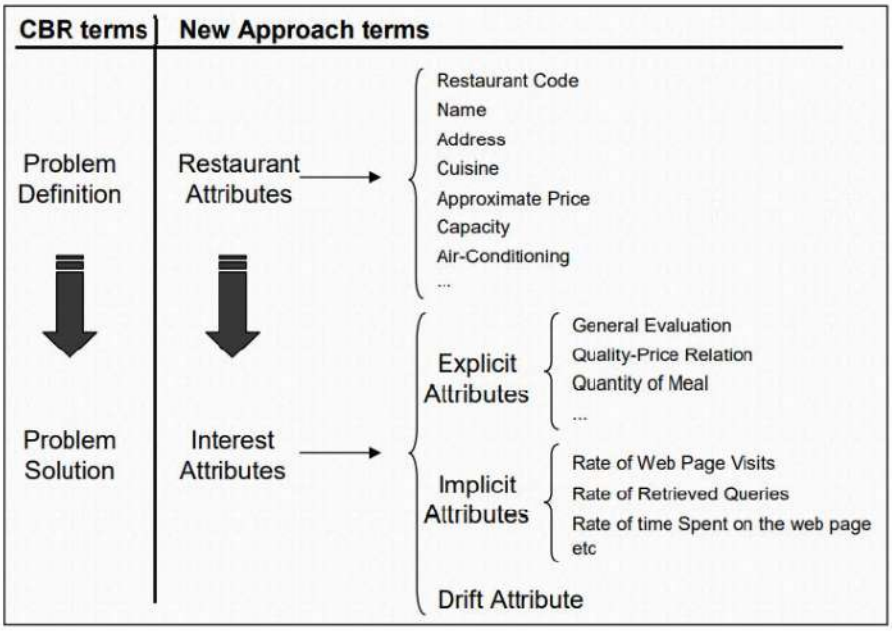



*Figure 3.3: An Example of Case Representation in the Restaurants Domain [156].*

### 3.2.2 Case-Based Reasoning Processes

The approaches for supporting the CBR process are strongly influenced by the case representation approaches described in the preceding sections.

#### 3.2.2.1 CBR Similarity (Retrieve)

Similarity metrics are used in case-based reasoning to retrieve similar cases. The majority of the metrics originate from the field of information retrieval studies. In addition, depending on the domain and case representation, appropriate methods/metrics are utilized to define similarity. Some of these metrics are mathematical functions like Euclidean, Cosine, and Manhattan [157], while others are ad hoc and developed according to the domain's requirements.

As illustrated in Figure 3.4, the local similarity is calculated for each feature. [158] define local similarity as "Local similarity deals with the values of a single attribute or feature". The global similarity or object similarity measurement is the outcome of calculating a global similarity value by combining several local similarity values. The author of [158] defines global similarity as "[...] represents a holistic view of the cases". Global similarity might be "derived" from local similarity measures, he argued. "The relative importance of attributes can be reflected by weights but additionally, the relative position in a hierarchy, as well as general background knowledge, can be incorporated" [158]. Figure 3.4 shows that the global similarity (object similarity) is calculated over different local similarity features. The object similarity (global similarity) is computed using various local similarity features. The weights are may pre-defined by users or domain experts, or obtained by an adaptive learning algorithm [152].

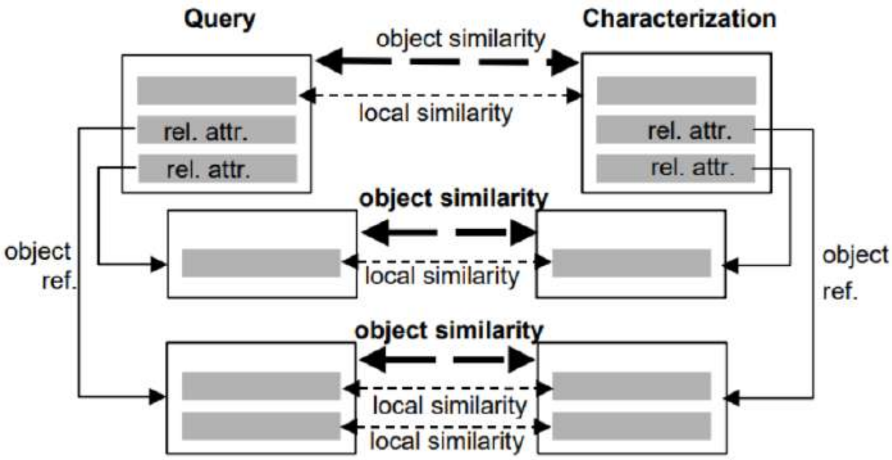



*Figure 3.4: Sketch of the Similarity Computation [158].*

#### 3.2.2.2 CBR Adaptation (Reuse)

An essential task in CBR is the adaptation of historical knowledge to a new situation. Therefore, it is stated that: "[...] the success of a CBR system often critically depends on its ability to adapt the solution of a previous case to suit a new situation" [159].

#### 3.2.2.3 CBR Evaluation (Revise)

The revision and reuse steps of the CBR-cycle are strangely related. It is stated that "Adaptation can also be used when feedback about a proposed solution indicates that a repair is needed; this is part of the revise stage in the CBR cycle" [152].

#### 3.2.2.4 CBR Learning (Retain)

This step is the final one in the CBR process. It is stated that the the retaining (learning) step in CBR can be completed in a variety of ways [158]. It makes use of either simple storage of all fields of an updated case or advanced machine learning techniques and case-based reasoning maintenance methods. Many systems store a case's solution in their case base on the supposition that it was useful, while others include further information about the problem and the solution [152].

## 3.3 Ontology-based CBR

Integrating domain knowledge to the case-based reasoning system is adventageous, to minimize the knowledge acquisition bottleneck to minimize the time it takes to acquire knowledge. "The more knowledge is embedded into the system, the more effective [it] is expected to be" [160]. Ontologies can provide this knowledge. Combining Case-based Reasoning system with ontologies allow using the power of ontologies. Structured CBR can enhance ontology-based systems and vice versa [158, 161]. Ontology-based CBR "[...] can take advantage of this domain knowledge and generate more accurate findings," according to [160]. There exist several approaches [162, 163, 164].

## 3.4 Case-based Reasoning Frameworks and Tools

Different frameworks for CBR exist. Among them, there is myCBR [164], COLIBRI [162] and jCOLIBRI2 [163], CAKE [165].

### 3.4.1 myCBR

The initial version of the myCBR is designed as a rapid prototyping tool and similarity retrieval engine by [164]. It is developed as a CBR plugin to the ontology editor Protégé.

myCBR is composed of three important features: retrieval editor provides an interface to the conceptual and backward-explanations. The description of the retrieval process, including the local and global similarity features, is offered by the backward-explanations. The similarity measure editor provides a possibility for editing local and global similarity measurements. concepts are described by the explanation editor, which will be used as case characterization.

XML files can be created by the Protégé based editor, containing the similarity and domain model, used in a Web application containing an engine of CBR [164]. A Web-based CBR application was developed by [164].

A kit written in Java to build CBR applications is offered by the version 3 of myCBR software development [166]. This approach is used in diagnosis and information composition [167] and decision support, configuration (computer settings).

### 3.4.2 jCOLIBRI and jCOLIBRI2

For creating CBR systems, the jCOLIBRI framework was presented by [162]. It is a multi-layer application. The jCOLIBRI framework is implemented in Java. Offering a reference platform for developing CBR applications were the main goal of jCOLIBRI [163].

Two principal components are presented, the jCOLIBRI and the COLIBRI studio. The jCOLIBRI engine offeres the CBR several functionalities for textual CBR, including information extraction functionalities. A persistence layer is used by this engine to provide connectors to relational databases, plain text and ontologies using an ontology bridge

In addition, the studio component can be used to design, construct and configure a case-based reasoning application.

### 3.4.3 CREEK

This CBR system was introduced by [168]. TrollCreek is the Java-based implementation of CREEK, it has been used in the petroleum industry [148]. It is defined as "a knowledge intensive approach to problem-solving and learning" [168].

### 3.4.4 COBRA

It's a CBR (Conversational Ontology-based CBR plAtform) application platform with an eclipse-based editor [169]. COBRA takes advantage of certain of jCOLIBRI's features. It uses inference rules to align the cases with a domain-specific taxonomy. A layer has been added to support heterogeneous case bases [169].

### 3.4.5 CAKE

Collaborative Agent-based Knowledge Engine (CAKE) was introduced a by [165]. It is a generic collaboration support architecture. The CAKE provides a collection of agents and (sub-)processes utilizing CBR technology. knowledge-intensive application domains use CBR architecture by merging workflow, agent, and structural CBR technologies [148].

### 3.4.6 CBR Shell

The AIAI CBR Shell is a closed source presented in demonstration form for polling fields automatically for sensitivity to goal finding [170]. The tool shows the threshold retrieval and K nearest neighbor, weight learning and genetic algorithm multiple diagnostic algorithms, and cross-platform implementation.

## 3.5 Conclusion

Case-based reasoning can be applied successfully in Business Model field. According to a recent study, managers can deliberately originate new business model ideas by employing two cognitive processes: conceptual combination and analogical reasoning [99]. Innovators in both processes translate an external stimulus from a different setting (for example, a business model from another industry) into a creative concept for their own context. While analogical reasoning is concerned with recognizing and adapting relationships between objects (i.e., business model components), conceptual combination is concerned with recognizing and adapting variations in quality between stimuli and their own design challenges [99].

In its sophisticated decision-making process, business model creation frequently necessitates the knowledge and expertise of people's ability to handle enormous amounts of data, and the availability of skilled decision-makers, on the other hand, is frequently constrained [171]. The typical working style of the expert (which is based on his/her knowledge of past records) in dealing with BM design could be reproduced using the CBR technique.

# Chapter 4

# EIDSS-BM Design

Chapter 4

# EIDSS-BM Design

## Contents

## 4.1 Introduction

According to a recent study, managers can deliberately originate new business model concepts by employing two cognitive processes: conceptual combination and analogical reasoning [99]. Designers in both stages adapt an external stimulus from a different environment (for example, a business model from another industry) into a creative concept for their own context. While analogical reasoning focuses on identifying and adapting relationships between elements (i.e., business model parts), conceptual combination concentrates on detecting and adapting distinctions in features between the stimuli and the own design problem [99].

## 4.2 Using CBR technique in Business models Design

In its sophisticated decision-making process, business model creation frequently necessitates the knowledge and expertise of people's ability to handle enormous amounts of data. The availability of skilled decision-makers, on the other hand, is frequently constrained [166]. The typical working style of the expert (which is based on his/her knowledge of past records) in dealing with BM design could be reproduced using the CBR technique.

CBR is an artificial intelligence technique, as explained in the first chapter. There are numerous definitions of "CBR technique" in the literature:

As mentioned in the chapter one, CBR is an artificial intelligence technique. From the literature, there are several definitions about "CBR technique":

- Making a decision based on previous cases
- To solve, analyze, or understand a new situation by referring to prior, similar cases.
- Using historical events as a model.
- Using appropriate solutions to recent problems to solve new ones, the CBR approach differs from other techniques (such as rule-based/black box methods) in that it uses a concrete knowledge base or experimental facts to infer knowledge.

## 4.3 The Overall Structure of EIDSS-BM

In an increasingly competitive and global market, most businesses agree that knowledge is a critical asset for success and survival. This awareness has been one of the main factors in the exponential expansion of knowledge management over the last few years. Our approach to BM design is founded on ontologies, and it intelligently makes knowledge assets available to individuals in organizations, where information previously resided exclusively in people's minds.

The system enables decision-makers to evaluate, comprehend, measure, change, discuss, or even simulate their business models, as well as introduce modifications and experiment with them to learn about emerging opportunities.

On the one hand, the system provides a visualization tool for a firm's actual business model, but on the other hand, it also allows for the representation of almost all imaginable business models. This would assist managers in understanding competitors' business models, which would help them innovate. The previous cases of BM are carefully cataloged and arranged, making it easier for decision makers to create the BM. Then, based on the CBR system's adaption phase, a new business model could be recommended. Managers can conduct risk-free experiments without risking their organization by employing a number of iterations for learning.

The system aids decision-makers by offering knowledge about environmental production and logistics processes, hybrid products (integrated and associated services), concentrating on sustainability ideas in order to open up new markets for sustainable products, and innovations about how businesses maintain, and enhance the use of natural resources and ecosystem integrity.

This is a pioneering work to develop a case-based ontology for CBR systems in the business domain (business models). The Intelligent Decision Support System for Business Models (IDSS-BM) concept was discussed in [146, 172].

For BM design, we contributed to an explainable and intelligent DSS (EIDSS-BM). This is motivated by the difficulty of representing and instantiating unstructured intangible experiences and information, which makes knowledge transfer and sharing difficult. This system introduces a new CBR paradigm based on ontology. It consists of reusing, revising, and retaining cases and has been shown to be successful in retrieving information and knowledge from previous experiences. The system handles well the integration of the BM success prediction with further explanation and guidance for the decision-maker.

Ontology-based CBR is an approach that combines, in the form of formal ontologies, case-specific knowledge with domain one in order to improve the effectiveness and explanation of the system. The authors of [173] combined CBR, Rule-Based Reasoning (RBR), and ontology to develop a solution retrieval system for fault diagnosis. An ontology-based CBR information retrieval system method that integrates CBR and natural language processing (NLP) techniques for metro accident case retrieval has been proposed in [169].

Consequently, case-based reasoning system can benefit from ontology-based knowledge representation. This gives the possibility to reuse existing domain knowledge about business models during the execution of the case-based reasoning cycle. Applying this paradigm to software tools of business model development has great promise for supporting business model design and innovation. Moreover, case semantic retrieval algorithms can be improved by using case-base and domain background knowledge in the form of ontologies, and our approach uses the Business Model Canvas for this purpose.

### 4.3.1 Architecture of EIDSS-BM

Many CBR architectures have been presented in the literature [73, 163, 174]. Inspired by these architectures, the EIDSS-BM architecture is composed of three layers: a data layer, a processing layer, and an application layer as shown in Figure 4.1. The data layer contains three main containers: vocabulary, case base, and similarity measures. In knowledge-intensive CBR systems, ontologies play an important role in representing these containers. They can be used as the vocabulary to describe cases and/or queries, as a knowledge structure where the cases are located, and as a knowledge source to achieve semantic reasoning methods for similarity assessment [175]. The vocabulary and the case base rely on two knowledge models, the domain and case models, which are respectively presented above. The processing layer is the core part of the system. The proposed system aims to design BM and aid managers in their decisions. Many types of contextual information are not easily inferred [176]. Based on the BM ontology model, the CBR module is used to suggest the design of BM in the following four steps: feature selection, case retrieval, case matching, and case updating. The CBR module is able to obtain the different alternatives of the BM because it exploits historical cases that actually happened.

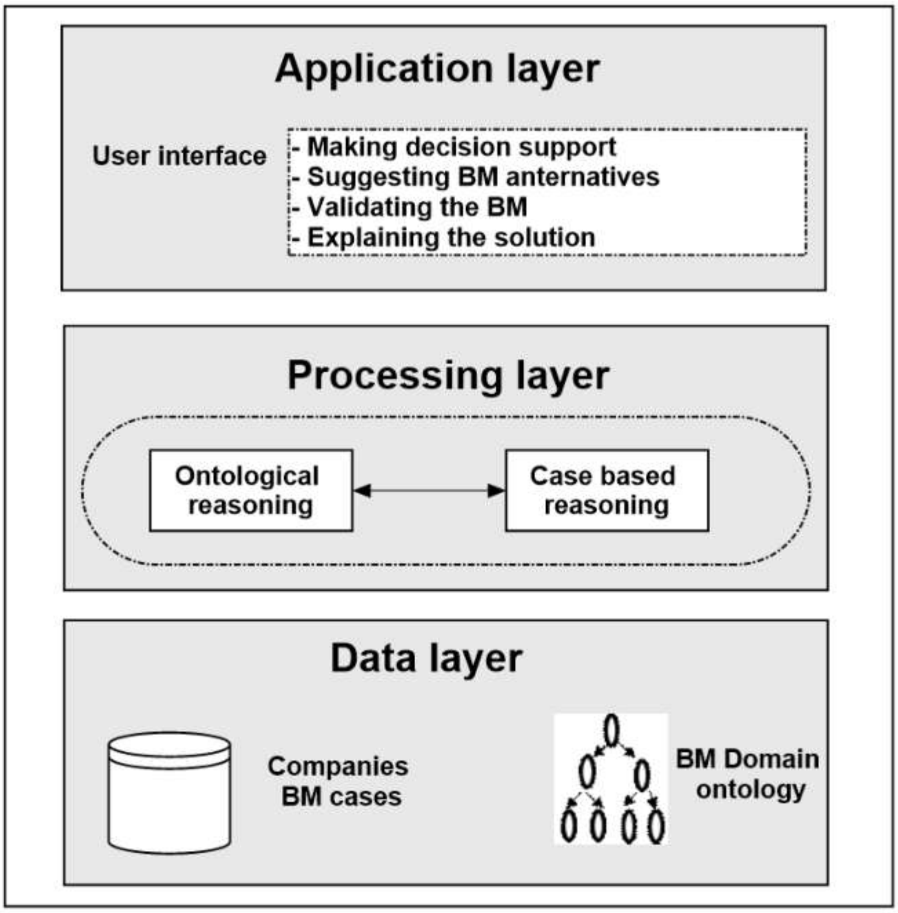



*Figure 4.1: EIDSS-BM architecture [146]*

### 4.3.2 Domain Model

In the CBR system, ontology plays two main roles: the first as case base and the second as domain ontology. The combination of ontologies for domain and case base will achieve the Knowledge-Intensive CBR (KICBR) [17]. The domain model is represented by ontologies which contain the vocabularies, concepts, and relations for representing knowledge concerning Business Models. Following the classification proposed in [177], we have developed two types of ontologies: a core ontology that contains the different parts of the business model in more detail for a deeper understanding such as the value proposition that is the central characteristic of a business model. This ontology provides the formalization of elements, relationships, vocabulary, and semantics of the essential knowledge about BM domain. This ontology is built on BMO and illustrated in Figure 4.2. It contains knowledge about the four main pillars of a BM which are the products and services that a firm offers, the infrastructure and the network of partners, the relationship capital, and the financial aspects [178].

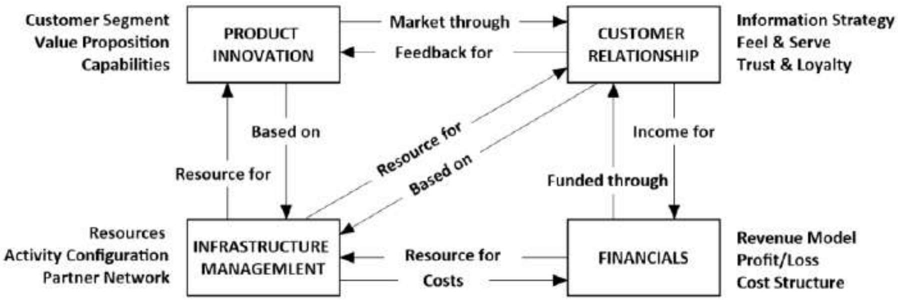



*Figure 4.2: E-Business Model Ontology e-BMO [94].*

The value proposition settles the value that is delivered to the customer, which can be a product, a service, or a combination of both [6]. Nevertheless, when choosing which value should be delivered, the customer and provider have to rely on their competences and resources. The organization model analyzes the capabilities or skills and the firm's role in the value chain. If the provider is not able to take over the tasks or services he is obliged to by the value proposition, he cannot offer a certain business model. Therefore, value proposition and organization model have to be considered at the same time as they form the backbone of a business model [179]. A domain ontology describes the domain of BM Components. This part of the ontology is built on the BM ontology BMO [102], which is an important contribution to the theory and practice of business models. Its concepts are specializations of other concepts of the core ontology, after collecting information about the business model of startups and technology companies, including attributes and relations of companies, people, and investments. Moreover, the reuse of ontologies from a library also benefits from their reliability and consistency. The more knowledge is embedded into the system, the more effective it is expected to be.

**Case Model:**

In this study, BM experiences are viewed as cases in the sense of case-based reasoning. The CBR framework can be used to obtain historical BM from an ontology-based knowledge base called the Case Base. It is based on the BMO business model ontology [102], which is a significant contribution to business model theory and application. According to the methods stated in [180], the suggested BM- ontology comprises the important terms required for the characterization of cases in CBR systems.

In general, a case is described by a pair (problem, solution) that includes both problem and solution aspects. As a result, the problem part of our model corresponds to the enterprise description section, whereas the BM component belongs to the solution part. As a result, there are two primary parts: a description part that describes the setting and the enterprise, and a BM part that describes the various possible values of the BM components. In order to improve communication between the case base and the domain model, the case model is represented within an ontology that integrates the domain model, as suggested by CBR ONTO [180]. The main concepts in this ontology, as shown in Figure 4.3, are as follows:

CBR-CASE, which includes all of the system's possible case types;

CBR-DESCRIPTION, which includes the firm description (name, number of employees, country) and BM components from the case (value proposition, customer segment, key resources, customer relationship, key activities, cost structure, key partners, revenue stream).

CBR-INDEX enables the domain model concepts required to define cases to be integrated . The value proposition is a key feature of a business model that has been recognized in the literature. Most scholars who study business model components look at it [181]. The value proposition establishes the value that is supplied to the consumer, which might be in the form of a product, a service, or a mix of the two. When deciding which value to supply, both the customer and the provider must rely on their own competencies and resources [102, 179].

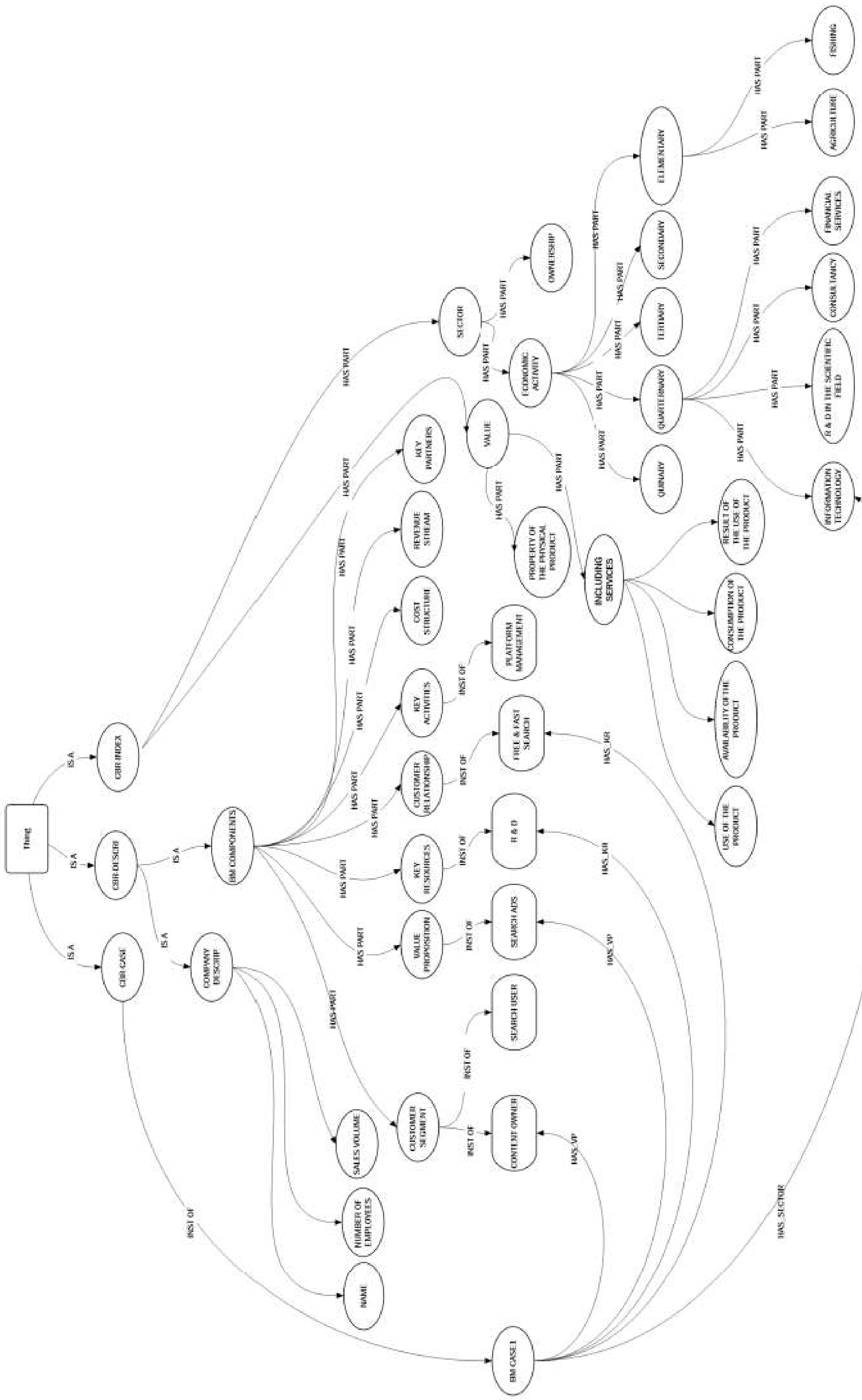



*Figure 4.3: The case model ontology* [146].

## 4.4 The CBR Process

The CBR, proposed in [182], can imitate human cognitive processes and integrate knowledge from several domains into a single format [32]. The CBR can design BMs that are both effective and precise. Because CBR can obtain and suggest BM components and innovation methods as long as instances can be effectively matched in the case base, In addition, CBR can use past cases that have actually occurred and been resolved to assure accuracy. Figure 4.4 depicts the CBR-based EIDSS-BM method. For determining case similarities in the case base, feature indices such as industry, year of foundation, number of employees, and country are selected. The project has been chosen as a must-have feature. The BM components of the matched case are displayed directly if case matching is successful. The case update is then assessed, and if successful, the case base is updated; otherwise, the CBR process is terminated. The system will fail and the process will stop if the similarity value is less than the target value. [102, 174] are two examples of resources.

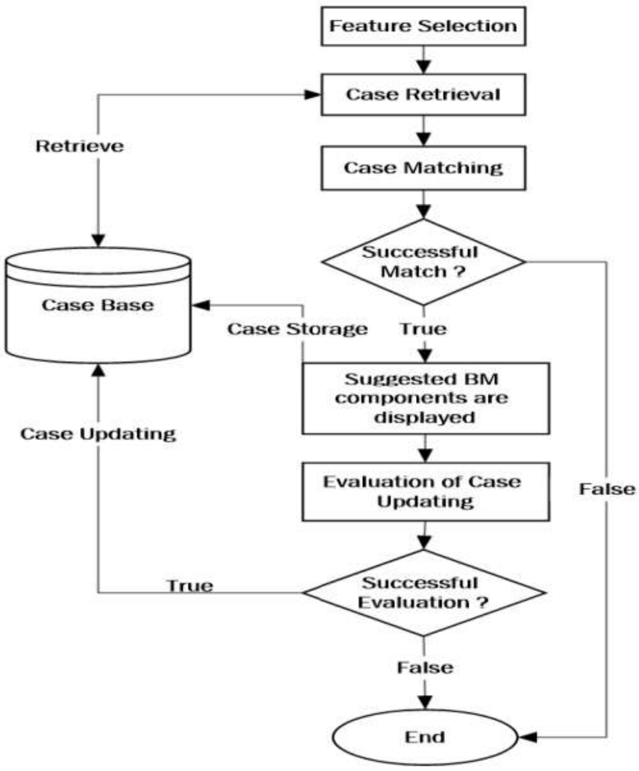



*Figure 4.4: The CBR Process in EIDSS-BM [146].*

### 4.4.1 Case Retrieval

Case retrieval refers to searching the business model case base based on Industry, Country, and Year of foundation. The system uses ontologies as a persistent media for the cases. The ontology defines the type and values of the attribute of the case. User defines the problem by entering information regarding Industry, Country and Year of foundation. The case retrieval engine module takes the created semantic query vector generated and searches for the most similar k cases in the case base ontology. The solution space consists of a list of alternatives of business models for the current project type, results and benefits with each of them.

### 4.4.2 Case Matching

The similarity value was calculated using the nearest neighbor technique [173]. Equation 4.1 gives its formula.

$$Sim(C_i) = \sum_{j=1}^{m}(w_j \times Sim(C_{ij})) \tag{4.1}$$

where $i$ is the case's sequence number in the case base. The similarity value between the target and ith cases is $Sim(C_i)$. The feature index's sequence number is $j$. The value $m$ denotes the total number of feature indexes. The jth feature index's weight is $w_j$. $Sim(C_{ij})$ is the similarity value between the ith case's jth feature and the target case's jth feature.

$Sim(C_i)$ has a threshold of $Sim(C)$, which means that case-matching is invalid when $Sim(C_i) < Sim(C)$;

Otherwise, case-matching is successful. The value, $w_j$, is directly defined by system experts together with domain experts.

### 4.4.3 Case Updating

When case matching is completed successfully, the actual business model results can be saved into the case base.

### 4.4.4 Explanation

The ability of any software system is improved by increasing its understandability, which in turn can be supported by appropriate explanation capabilities [183]. We follow Schank [182] in considering explanations the most common method used by humans to support understanding and their decision-making. In everyday human-human interactions, explanations are an important vehicle to convey information in order to understand one another. Explanations enhance the knowledge of the communication partners in such a way that they accept certain statements.

They understand more, allowing them to make informed decisions. Ease-of-use is of high priority for the development of myCBR applications, integrating explanations into the user interface. In order to increase transparency and trust in the retrieval process [184], myCBR creates an explanation object for each case during similarity calculation.

Increased user understanding of system reasoning may increase user confidence in an intelligent system's decisions, thanks to CBR systems cases that provide a natural vehicle for explanation.

In case-based reasoning, conceptual explanations are used to explain the vocabulary knowledge container. Backward explanations make clearer and justify the outcome of a particular retrieval result and provide means for understanding the results of a similarity calculation [185].

#### 4.4.4.1 Conceptualization Goal

A conceptual explanation is a comprehensive description of a concept. It answers questions about concepts, about terms and concepts of ten arise for the end user when he or she is not familiar with the application domain. It consists of a definition, some examples, and references to further characterizations, for which any kind of medium can be used (e.g., text, images, audio, and video). Conceptual explanations are inherently static, because concepts usually do not change. However, there are good reasons to consider the context in which the concept is used and the user's personal level of knowledge [164].

#### 4.4.4.2 Transparency Goal

The user could ask how the system reached the conclusion presented, and an explanation in the form of a reasoning trace from the system would be presented. This allows the users to check the system by examining the way it reasons and allows them to look for explanations for why the system has reached a surprising or anomalous result. The use can ask the question "How did the system come to the similarity assessment of a particular case?" when he/she wants to retrace the procedure of similarity assessment, thus achieving the transparency goal.

#### 4.4.4.3 Justification Goal

The justification goal is closely related to the transparency goal. Where transparency is concerned with presenting the reasoning trace, justification deals with the ability to explain why an answer is good. Justification is often preferable over transparency, as simply displaying the reasoning trace is not always sufficient and can even be counterproductive [98, 186]. With regard to Explainable Artificial Intelligence (XAI), CBR is particularly interesting because similar cases can be used as examples for justifying the reasoning of the system. This can be considered as an interpretable model. However, in terms of explanations, most CBR systems are limited to the display of similar cases. Compared to "black box" algorithms such as deep learning, the responses of CBR systems can be justified easily using similar cases as examples. The user can have in mind the question "Which are the most similar aspects of a case? Which are the least?", so the answer explains in which way the case is similar to the query and thus achieving the transparency goal.

## 4.5 Conclusion

We've provided and explored a strategy for combining explanations and case-based reasoning to assist managers with their business models in this part. Because of this ability to explain, the user is more inclined to accept the system's conclusions, suggestions, or findings. As a result, it has been discussed how explanations play a significant role in business model design decisions. This technique contributes to the creation of intelligent systems by utilizing knowledge management to enhance managers' missions, allowing decision-makers to define and produce hypotheses in uncertain situations, as well as validate and evaluate their hypotheses.

# Chapter 5

# Experimentation and Evaluation

Chapter 5

# Experimentation and Evaluation

## Contents

## 5.1 Introduction

The CBR tasks need the use of an interactive software program. Different CBR tools are available for applying the method to domain-specific challenges and problems. The 4Re process, which includes retrieving the most similar case(s), reusing its/their knowledge to solve the problem, revising the suggested solution, and retaining the experience, should theoretically be supported by the CBR tool. My CBR was chosen as a CBR software tool based on the technologies and frameworks listed above. This program aims to assist application designers in developing and prototyping interactive CBR systems.

### 5.1.1 Overview

myCBR is an open-source plug-in for Protégé [187], an open-source ontology editor. Protégé is a Java-based extensible tool with a plug-and-play environment, making it a useful platform for quick prototype and application development [188]. It provides an object-oriented definition of classes and attributes. It also keeps records of instances of these classes, which myCBR interprets as cases [187]. As a result, Protégé already takes care of the vocabulary and case database. The myCBR plug-in includes numerous editors for defining ontology similarity metrics as well as a testing retrieval interface [189]. MyCBR's major purpose is to reduce the time and effort required to develop CBR applications that use knowledge-intensive similarity metrics.

## 5.2 EIDSS-BM Implementation

Various programming tools, both free and commercially available, can be used to construct a CBR system. The most extensively used and well-known frameworks for teaching and academic research are myCBR and jCOLIBRI. MyCBR contains a lot of capabilities and makes developing case-based reasoning apps very simple. It enables rapid prototyping and the integration of reduced CBR capabilities. It can be used as a standalone application or as a Protégé plugin.

### 5.2.1 Implementation

A CBR application must be developed in three steps:

- Modeling similarity metrics.
- Creating case representations.
- Retrieval functionality testing.

Case representations are created in the following way: One of myCBR's most useful features is the ease with which cases can be represented using the CSV data import module

[189]. CSV files are commonly used to store raw data in a pure ASCII format that is based on attribute values. The user can use the CSV importer to import data instances into an existing Protégé data model or to automatically generate a new model based on the raw data. The Business Model dataset is organized in a CSV file as shown in Figure 5.1. Protégé can also be used to manually add slots to myCBR. Figure 5.2 displays the myCBR screen after importing the dataset into a new Business Model class, which will be used as the query and case values for the retrieval stage.

Modeling similarity measures: After having generated the case representation by using the CSV importer, the main task for creating a CBR application with myCBR is the definition of an appropriate similarity measure. Here, myCBR follows the local-global approach, which divides the similarity definition into a set of local similarity measures for each attribute. A set of weights, and a global similarity measure for calculating the final similarity value. Figure 5.3 shows one of the implemented similarity measures.

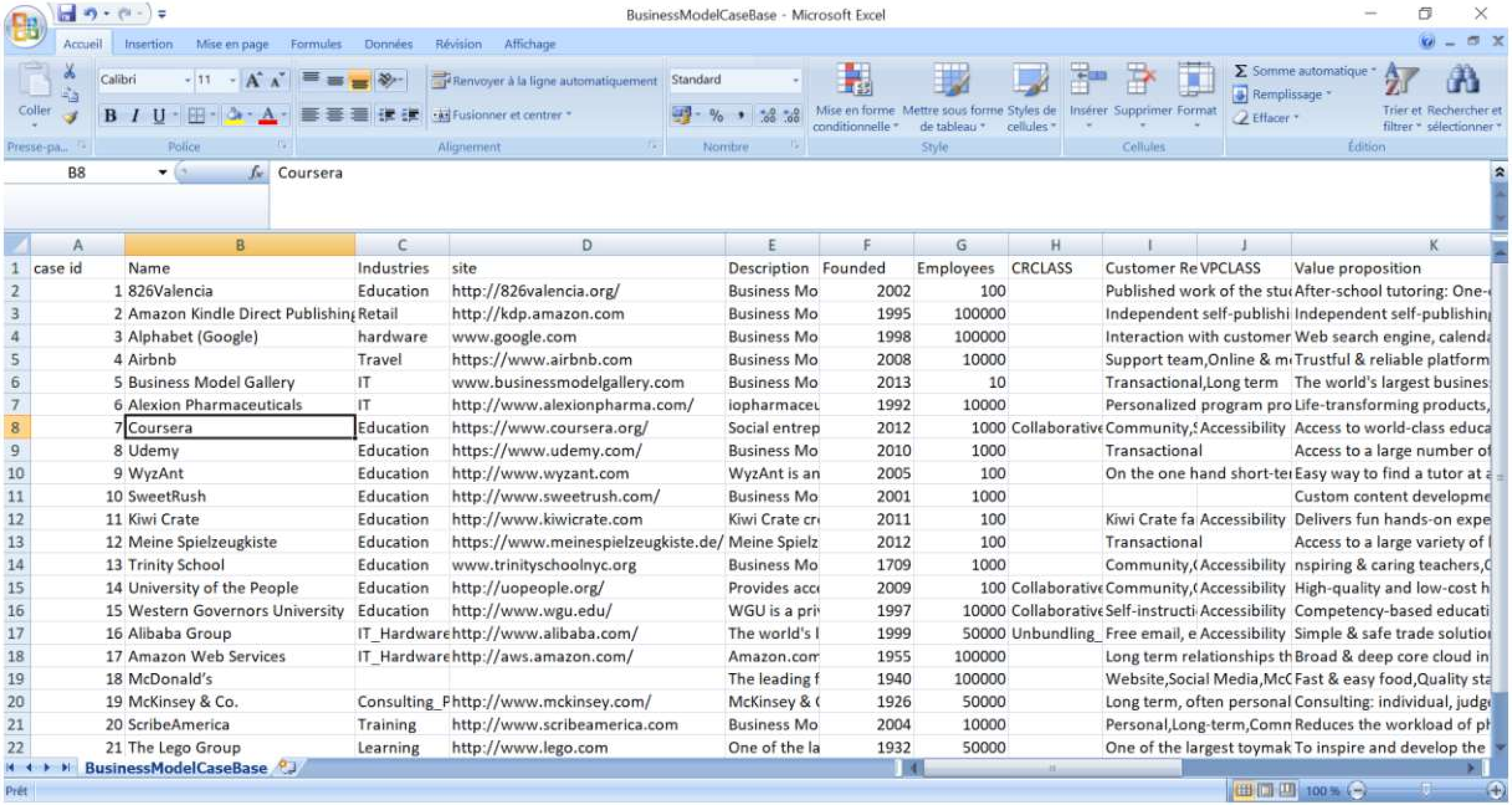
There are several similarity modes, to choose between, depending on the type of the slot. In our example, the slots values of the industry can be arranged in a hierarchical form and the taxonomy as similarity mode was used. The resultant structure specifies parent-child relations through the position of the objects in the taxonomy. This means that a node has at least the same attributes its parent node has. For instance, "Learning" is also "education" and the real-world sectors are "learning" and "training". Therefore, "education" is an abbreviation for all companies with "industries" being "Learning" or "Training". This choice enhances the retrieval results.

Testing of retrieval functionality: Figure 5.4 gives a schematic overview of the Retrieval GUI. The names of the classes' attributes are presented with the rows of the table. The area is divided into several columns. The left most column is used for query specification. The others are used to show the retrieval results. The rightmost column lists all cases of the case base, ordered by their similarity to the query.

myCBR includes an easy-to-use GUI for performing retrievals and for analyzing the corresponding results. By providing similarity highlighting and explanation functionality, after the initial knowledge model was created, a number of retrieval experiments using the myCBR were performed. We tested the 22 records that are in the case base and only one missed case is obtained. Figure 5.4 shows one query of these records after retrieving the most similar cases.

### 5.2.2 Enhanced retrieval using ontology

A domain-specific ontology or user-defined ontology represents specific domain knowledge or relation between words using class and subclass [190]. Terms of a case can be compared with other cases by exact matching. However, some slots like the "industries" of the company can have a relationship with other synonyms or industries. The weight of such terms can be increased automatically using a domain specific ontology defined by experts. For example, the term "education" is related to "learning" and "training", and it is more similar to some industries, so that enhance the result of the user query.



| case id | Name | Industries | site | Description | Founded | Employees | CRCLASS | Customer Re | VPCLASS | Value proposition |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 826Valencia | Education | http://826valencia.org/ | Business Mo | 2002 | 100 | | Published work of the stu | | After-school tutoring: One- |
| 2 | Amazon Kindle Direct Publishing | Retail | http://kdp.amazon.com | Business Mo | 1995 | 100000 | | Independent self-publishi | | Independent self-publishin |
| 3 | Alphabet (Google) | hardware | www.google.com | Business Mo | 1998 | 100000 | | Interaction with customer | | Web search engine, calend |
| 4 | Airbnb | Travel | https://www.airbnb.com | Business Mo | 2008 | 10000 | | Support team,Online & m | | Trustful & reliable platform |
| 5 | Business Model Gallery | IT | www.businessmodelgallery.com | Business Mo | 2013 | 10 | | Transactional,Long term | | The world's largest busines |
| 6 | Alexion Pharmaceuticals | IT | http://www.alexionpharma.com/ | iopharmaceu | 1992 | 10000 | | Personalized program pro | | Life-transforming products, |
| 7 | Coursera | Education | https://www.coursera.org/ | Social entrep | 2012 | 1000 | Collaborative | Community,S | Accessibility | Access to world-class educa |
| 8 | Udemy | Education | https://www.udemy.com/ | Business Mo | 2010 | 1000 | | Transactional | | Access to a large number of |
| 9 | WyzAnt | Education | http://www.wyzant.com | WyzAnt is an | 2005 | 100 | | On the one hand short-te | | Easy way to find a tutor at a |
| 10 | SweetRush | Education | http://www.sweetrush.com/ | Business Mo | 2001 | 1000 | | | | Custom content developme |
| 11 | Kiwi Crate | Education | http://www.kiwicrate.com | Kiwi Crate cr | 2011 | 100 | | Kiwi Crate fa | Accessibility | Delivers fun hands-on expe |
| 12 | Meine Spielzeugkiste | Education | https://www.meinespielzeugkiste.de/ | Meine Spielz | 2012 | 100 | | Transactional | | Access to a large variety of |
| 13 | Trinity School | Education | www.trinityschoolnyc.org | Business Mo | 1709 | 1000 | | Community,( | Accessibility | nspiring & caring teachers,C |
| 14 | University of the People | Education | http://uopeople.org/ | Provides acc | 2009 | 100 | Collaborative | Community,( | Accessibility | High-quality and low-cost h |
| 15 | Western Governors University | Education | http://www.wgu.edu/ | WGU is a pri | 1997 | 10000 | Collaborative | Self-instructi | Accessibility | Competency-based educati |
| 16 | Alibaba Group | IT_Hardware | http://www.alibaba.com/ | The world's l | 1999 | 50000 | Unbundling_ | Free email, e | Accessibility | Simple & safe trade solutio |
| 17 | Amazon Web Services | IT_Hardware | http://aws.amazon.com/ | Amazon.com | 1955 | 100000 | | Long term relationships th | | Broad & deep core cloud in |
| 18 | McDonald's | | | The leading f | 1940 | 100000 | | Website,Social Media,McC | | Fast & easy food,Quality sta |
| 19 | McKinsey & Co. | Consulting_P | http://www.mckinsey.com/ | McKinsey & ( | 1926 | 50000 | | Long term, often personal | | Consulting: individual, judge |
| 20 | ScribeAmerica | Training | http://www.scribeamerica.com | Business Mo | 2004 | 10000 | | Personal,Long-term,Comn | | Reduces the workload of ph |
| 21 | The Lego Group | Learning | http://www.lego.com | One of the la | 1932 | 50000 | | One of the largest toymak | | To inspire and develop the |

Figure 5.1: Business Model Dataset in a CSV [146].

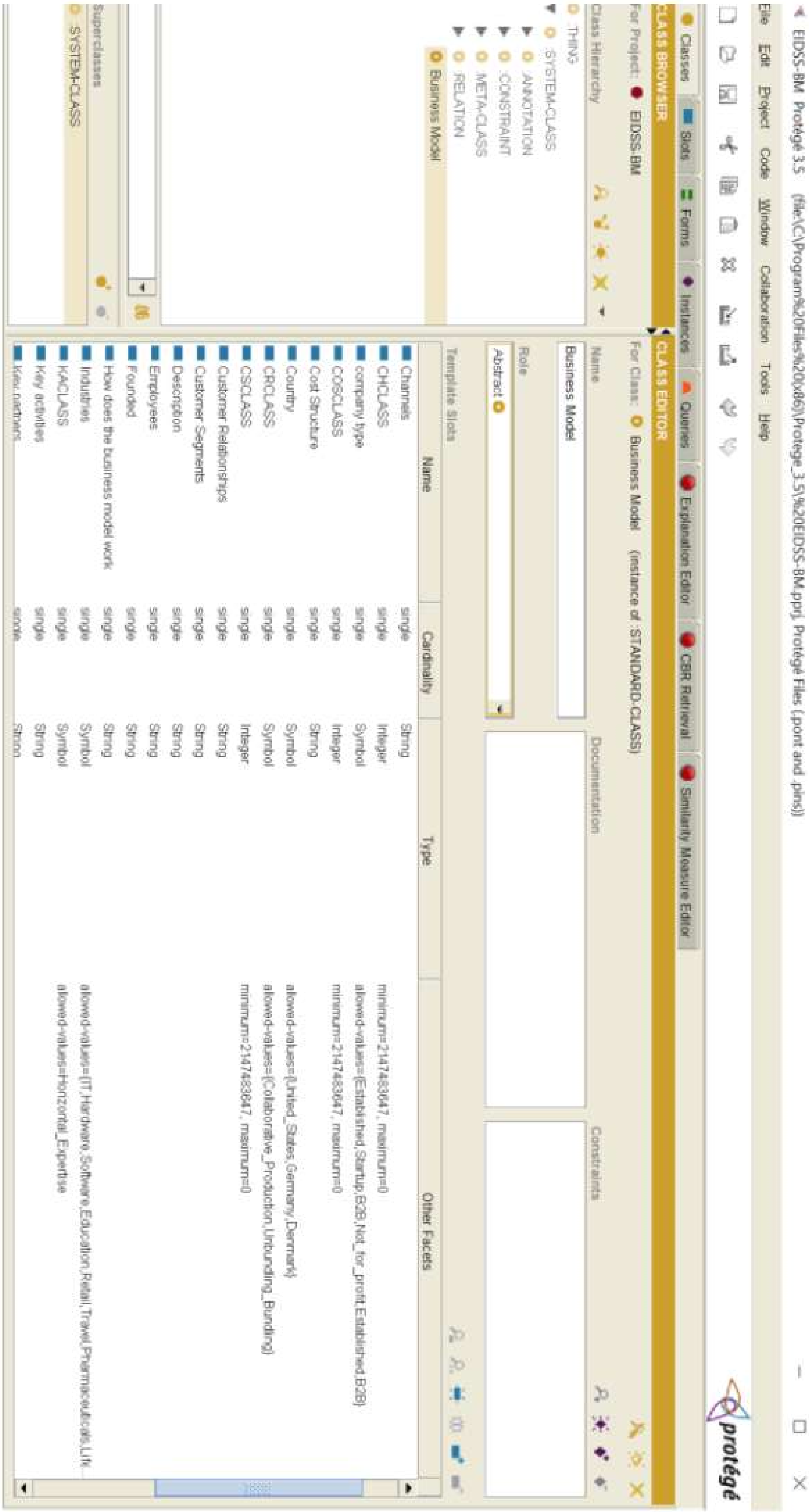



*Figure 5.2: Business model Case Data Representation in myCBR [146].*

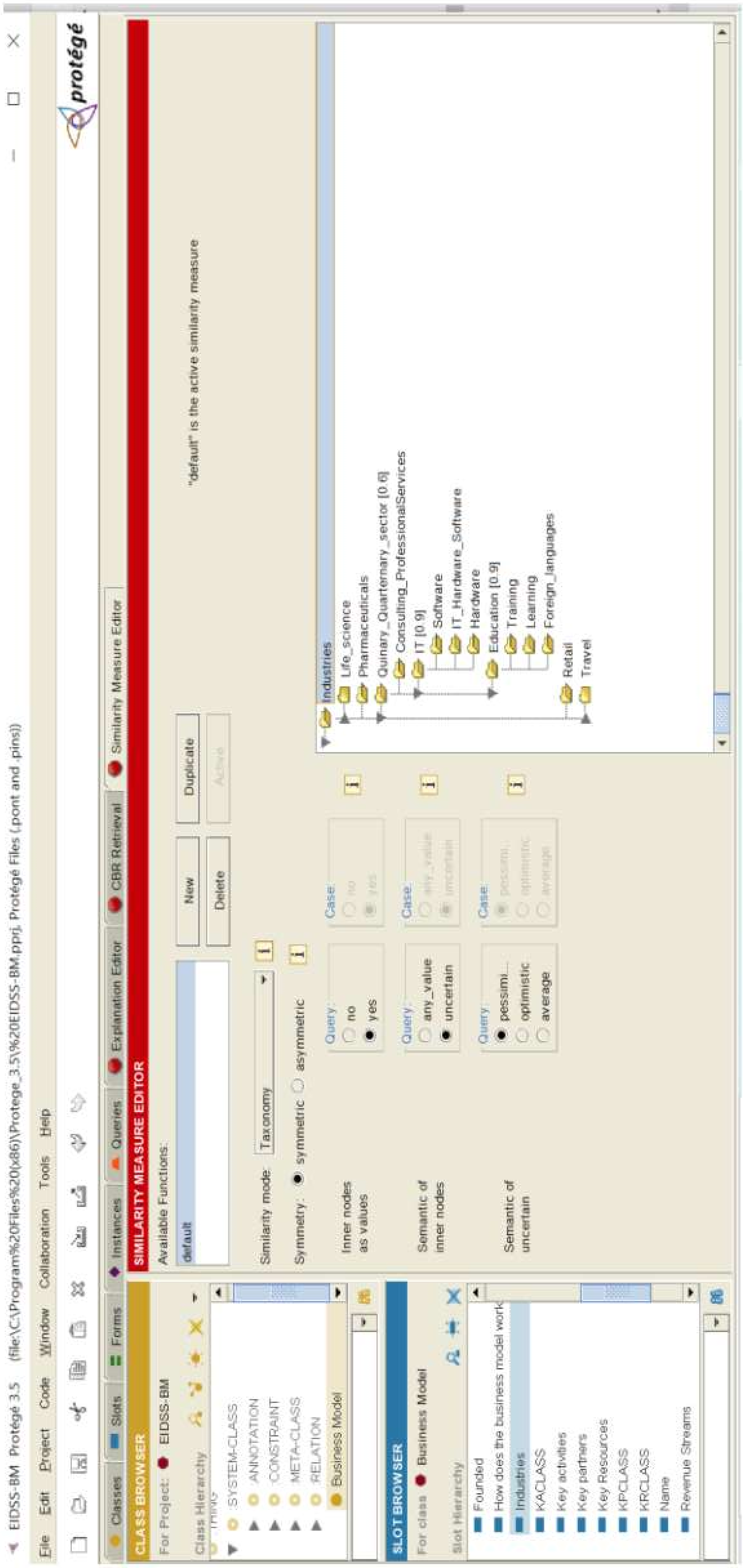


*Figure 5.3: Similarity editors for symbolic attributes with taxonomy editor [146].*


*Figure 5.4: Retrieval of a case query [146].*

### 5.2.3 Implementation of Conceptual Explanations

End-users of the system are addressed by way of conceptual explanations. They want to find the cases that are the most similar to their queries. When the user hovers the mouse over a table cell at the bottom of the retrieval GUI, conceptual explanations appear, as shown in Figure 5.5. Complicated algorithms are not used in conceptual explanations. At its core, the required functionality is a static mapping of concepts to explanations.

The figure 5.3 describes all ontology concepts. On the right-hand side, you can edit your description, including a brief description and a list of URLs to additional documents. For example, Wikipedia or Google define what it means to "start up."

#### 5.2.3.1 Implementation of Backward Explanations

**5.2.3.1.1 Implementation of Transparency Goal**
For a query, the system gives a ranking of the case base. However, the retrieval result may be rather surprising and will need some explanation. To answer this question: "How did the system come to the similarity evaluation of a given case?" The technology delivers a thorough recording of the retrieval process. Therefore, every stage of similarity computation may be traced. To promote transparency, myCBR provides an explanation object for each case during the retrieval. This tree-like data structure contains global and local similarity values as comments for each attribute.

**5.2.3.1.2 Implementation of Justification Goal** The answer to the question: "Which are the most similar aspects of a case? Which are the least?" The notion of aspect must be clarified, an aspect is one single attribute. The similarity of an aspect is then a local similarity value and can be displayed with myCBR.

## 5.3 Testing and Evaluation

After implementing the proposed EIDSS-BM, its performance has been evaluated. The purpose of the evaluation process is to get the end user's views on the significance and usefulness of the system.

The primary data used in this research are based on the dataset of the "Business Model Gallery" [131] that is a publicly available database on business models, as a resource for learning about different BM designs. In this database, BMs from all kinds of industries are explained, allowing to learn about various patterns. This project aspires to capture the power of analogies by being a place for inspiration, but this system do not use the case-based reasoning. It provides a variety of details including the company information about the industry, employees, foundation, country, company type, the annual revenue, and the different values of the BM components.

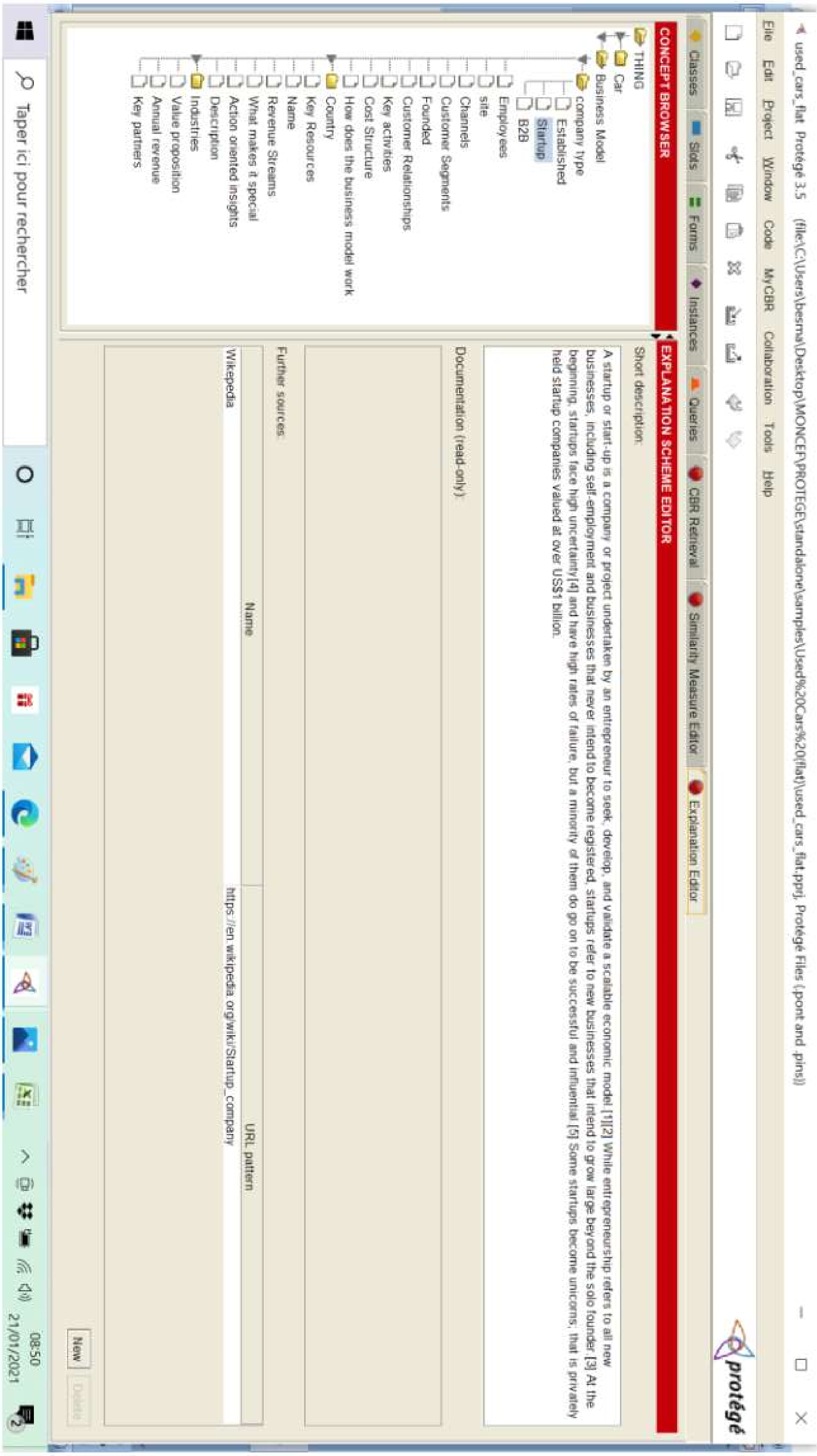



Figure 5.5: Conceptual explanations [146].

### 5.3.1 Performance Metrics

For system evaluation, we employ the following performance metrics:

1. $\mathbf{N_{Cases}}$ : The number of cases in the case base over time has a significant impact. Enriching the case base while maintaining or perhaps improving precision is desirable. For efficacy, we looked at the relevance of the retrieved examples given a test case, as we did in [191].
2. **Precision** : As stated in Equation 5.1, the percentage of retrieved cases that are similar to the new case ($N_{Correct}$) outweighs the total number of retrieved cases ($N_{Correct} + N_{False}$).
3. **Recall** : As stated in Equation 5.2, the percentage of retrieved cases that are similar to the new case ($N_{Correct}$) is among the total number of cases really similar to the new case in the case base ($N_{Total}$).

$$Precision = \frac{N_{Correct}}{N_{Correct} + N_{False}} \tag{5.1}$$

$$Recall = \frac{N_{Correct}}{N_{Total}} \tag{5.2}$$

The total number of tagged cases that are similar to the new case is $N_{Total} = N_{Correct} + N_{Missed}$, and the number of retrieved cases that are similar to the new case is $N_{Correct}$. The number of retrieved cases that are dissimilar to the new case is given by $N_{False}$, and the number of tagged cases that are similar to the new case but not retrieved is given by $N_{Missed}$.

### 5.3.2 Comparison between the EIDSS-BM and the Business Model Gallery

The system's performance has been evaluated in terms of precision and recall, which are two common metrics used to estimate the efficiency of information retrieval in a CBR system. Precision is the fraction of a search output that is relevant to a particular query.

To evaluate the correctness of the retrieval function, the CBR retrieval test is performed. For that test, relevant BM cases (from the case base) should be identified for each test case. For identification of relevant cases, test cases are given to the domain expert in order to assign possible relevant cases (from the case base) for each one. Then, the precision and recall are evaluated. Table 5.1 summarizes the results of this process where test cases are Case 7, Case 40, Case 51 and Case 62 and for each one, the set of relevant cases identified by the expert (from the case base).

The retrieval function's performance is evaluated after the relevant cases have been found and allocated to the test cases. A threshold value is used to calculate the precision and recall values of the CBR system's retrieval function. The similarity interval [0.6 to 1.0] was used in this study.

| Test case | Relevant cases from the case base |
|---|---|
| Case 7 | Case9, Case 10, Case 8 |
| Case 40 | Case 18, Case 22, Case 7, Case 8, Case 9, Case 10, Case 11, Case 12, Case 13, Case 14, Case 15, Case 20, Case 21, Case 3, Case 5, Case 6, Case 16, Case 17, Case 19 |
| Case 51 | Case 53, Case 54, Case 61, Case 68, Case 75, Case 81 |
| Case 62 | Case 55, Case 57, Case 69, Case 72, Case 71, Case 59 |

*Table 5.1: Relevant Cases Assigned by Domain Experts for Sample Test Case [146].*

This indicates that the threshold is set to 0.6, and examples with a global similarity score of more than 60% are retrieved. The evaluation was done in the second phase to judge the system's performance in retrieving relevant cases. The precision and recall are calculated by comparing the Business Model Gallery against our retrieval method enhanced with knowledge. Table 5.2 shows the results of the comparison between the two systems in terms of precision and recall, with 0.6 as the threshold value. The results show that the Business Model Gallery's average precision of four test cases is 81.5%, whereas our upgraded system has a precision of 95%. Similarly, EIDSS-BM has a 95.5% average recall, whereas the Business Model Gallery has a lower score of 46%. Overall, the results imply that the enhanced system performs better in this CBR system in terms of precision and recall. The results showed that CBR is an excellent method for solving and recommending BM. More advanced features will be investigated in this area as the study progresses.

| | EIDSS-BM [146] | | Business Model Gallery [131] | |
|---|---|---|---|---|
| | Recall | Precision | Recall | Precision |
| Problem 1 | 94% | 100% | 52% | 100% |
| Problem 2 | 94% | 100% | 31% | 33% |
| Problem 3 | 94% | 100% | 68% | 93% |
| Problem 4 | 100% | 80% | 33% | 100% |
| Average | 95.5% | 95% | 46% | 81.5% |

*Table 5.2: Experimental results comparing two systems in terms of precision and recall [146].*

## 5.4 Conclusion

In this project, we are interested in the AI contributions to the explainable intelligent system for BM design. Therefore, digital technologies can help designing BMs, increasing productivity, reducing production costs and emissions, decreasing the intensity of production process resources and improving correspondence in markets. This manuscript has presented the first version of the CBR-based EIDSS BM. Our approach to the explainable decision support system for BM design is based on ontologies, and makes knowledge assets intelligently accessible to people in organizations, that knowledge resided in the heads of people only. The valuable knowledge of experts in past business models for many case studies is capitalized, which enables reusing existing domain knowledge as well as the transferring and sharing of knowledge. Consequently, applying this paradigm for software tools of business model development will make great promise for supporting business model design and innovation sustainability.

We presented our contribution which led to the development of new generation of intelligent decision support systems for Business called "Explainable Intelligent Decision Support System for Business Model" that takes highly accurate decisional guidance into account by integrating explanations for designing and innovating business models. We presented also a domain-independent CBR platform. The development of a new CBR system is done by providing its domain ontology. Our proposed solution can be used for two parallel objectives: to capitalize knowledge about BM, and to provide support to experts and Business students to design, innovate, and validate their BMs. Experts can use any concept or instance of the domain model to describe their cases.

# Chapter 6

# Conclusions And Future Work

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# Conclusions And Future Work

## Contents

## 6.1 Conclusions

To finish the thesis, in this last chapter, we present the outcomes of our research study. We summarize the contributions and limitations of this work. We also identify some research perspectives to extend and enrich our research theme.

### 6.1.1 Review of the realized study

Software tools have been demonstrated to be useful for describing, integrating, comparing, and classifying business models, as well as for enabling business model creation and development. Nevertheless, the highly creative activity of business model invention is not well supported by the technologies under consideration; they do not appear to be very helpful during the ideation stage.

The AI contributions to an explainable intelligent system for BM design are the focus of this project. As a result, digital technologies can aid in the development of BMs as well as increase productivity, lower production costs and emissions, reduce the intensity of production process resources, and improve market correspondence. Our main contribution is the first version of the EIDSS BM based on CBR.

Our technique leads to an explainable decision support system for BM design based on ontologies, and it intelligently tends to make knowledge assets available to people in companies where knowledge previously resided solely in people's minds. For too many research papers, the valuable knowledge of specialists in previous business models is captured, allowing for the reuse of existing domain knowledge as well as the transmission and sharing of knowledge. As a result, trying to apply this paradigm to business model development software tools holds great promise for improving business model design and innovation.

In this context, we first identified the context of our study; the field of Intelligent Decision Support Systems with Business Models. The concepts and the main characteristics of this field are discussed.

In the second chapter, we provided the State of the Art and background knowledge in areas related to this research, it contains an overview of decision support systems, artificial intelligence, explainable AI, case-based reasoning, and the business model.

In the third chapter, we exposed our contribution, which resulted in the development of a new generation of intelligent decision support systems for business called "Explainable Intelligent Decision Support Systems for Business Models," which integrates explanations for designing and innovating business models and tends to provide highly accurate decisional guidance. We also illustrated a domain-independent CBR platform.

The domain ontology is provided as part of the development of a new CBR system. Our proposed method can be utilized to achieve two goals: capitalizing on business model expertise and assisting professionals and business students in designing, innovating, and validating their BMs. Experts can explain their cases using any notion or instance of the domain model.

In the fourth chapter, we presented the evaluation method and the evaluation of EIDSS-BM, this chapter introduces the accomplished experimentation results and evaluation.

Finally, the fifth chapter presents the synthesis of our contribution and show to what extent our objective has been achieved. We present the perspectives and possible future work to deepen this study.

### 6.1.2 Limitations and extensions

Our research axes are very complex domains with diverse concepts, theories and tools. Each domain has its difficulty and challenges. Explainable Artificial intelligence is a new emerging branch, techniques and standards. This area of research has a lot of potential for increasing the trust and transparency of AI-based systems. It is considered the foundation for AI to keep on making solid progress without interruption.

Intelligent systems for Business Model are a challenging domain that requires highly class of Business Model Development Tools. Visualization techniques are important for more providing highly accurate decisional guidance, which has a lot of factors, theories, and points of views. The difficulties that we then experienced were mainly related to relating methods and approaches belonging to the different research fields to build a coherent whole towards the end. Our propositions are good contributions in the intelligent systems' domain, which may be enriched and extended in the future. It is still many directions and points which can be developed.

## 6.2 Future work

We propose to develop a Rule-Based Reasoning module to forecast the success of early-stage BMs as a future research direction. Based on the analysis of classes and properties in the BM ontology model, the SWRL language can be used to represent the determinants of the success of organizations' rules. To be sure, ontology development is a time-consuming process, but the groundwork has already been done.

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