KU LEUVEN

FACULTY OF ECONOMICS AND BUSINESS

From Strategic to Operational Agility

Exploring the Conceptual Anchoring of Elements Leading to Reactive and Flexible Software Development

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by
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Acknowledgements

I shall be telling this with a sigh
Somewhere ages and ages hence:
Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

Robert Frost, The Road Not Taken, 1916.

I remember the first time I caught myself thinking that I wanted to do a PhD. I may not recall the exact chain of events that led me to that "revelation", however, I do remember the precise moment that I silently admitted to myself that an academic trajectory as such, would probably fit me. The way I see it, the factors that led me to such a realization were probably related to my upbringing, my personality traits, my attitude towards education and vocational achievements, and perhaps my core values and beliefs. Another factor was related to my sheer admiration for those who had gone through this journey, mastering a knowledge area so well that others referred to them as "Doctors" in that specific field or domain of application. I am now in the final stage of that very same doctoral journey, and I need to offer my gratitude to the people who have supported me and have made the end of my PhD journey very real.

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In closing, I would like to thank everyone who has helped, either with a positive or a negative contribution in my life, in shaping me into the person who always has and always will take the road less traveled by. That road is difficult; it has many hidden thorns along its path; it will present you with many character-building moments; but trending on that road makes all the difference!

Konstantinos Tsilionis

Abstract

The practice of developing software has been continuously evolving for the past 20 years. Taking the decision, at governance-level, to develop a large software system according to predefined and hardly vacillating specifications is not to be considered as a mainstream practice anymore. Nowadays, most software packages are being released following short and iterative development cycles when sources of value have been hitherto identified at management-level; these packages are then deployed as fast as possible to effectively capitalize on this value. As a consequence, there is a substantial need for flexibility in the adoption patterns of Information Technology (IT) driven solutions. Indeed, organizations are seeking IT solutions that they can be expeditiously adopted and effortlessly integrated in their extant infrastructural and software ecosystem. This being the case, IT solutions in general and software in particular are being progressively packaged as services. While commodity services need to be incorporated in the simplest way possible following standard cost-benefit analyses, differentiating services are required to holistically support business processes in order to help organizations maintain a competitive advantage; such services are also expected to be aligned with the enacted business and IT strategies to seek for a better long-term positioning of the organization. Thereby, the facilitation of rapid evaluation processes for new technologies (as imperatively defined in contemporary innovation management tenets) as well as the implementation, integration, and deployment of software development customs are not easy to conciliate with traditional IT governance practices. At the bare minimum, traditional business and IT alignment mechanisms need to be re-envisioned to fit a contemporary business context where operational- and tactical-level ideas are more than often implemented and immediately deployed than reported to the strategic board. The present thesis purports on the elaboration of a scientific approach intended to study the adopted software development techniques that can be felicitous to organizations operating in a highly dynamic business context. It does so by reporting on (i) the application of conceptual models, (ii) the validation of the frameworks they are included in, and (iii) their applicability in various contexts. All of these individual contributions aim to give a new perspective or departure point for the furtherment of ways in which agility can be conciliated with proper IT governance in an Everything-as-a-Service context. As a whole, the present work can be seen as an essay rethinking the position of software releases (built-up in an agile fashion) to be deployed in mature IT environments while the latter being in need of flexible structures allowing for an optimal integration within their current infrastructure.

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Part I

Introduction

Chapter 1

Introduction

1.1 Research Context

Over the last few years, the practice of developing software as well as its integration into the infrastructural ecosystem has drastically changed. While the transition from a pure waterfall approach to a development style incorporating an iterative lifecycle approach can be placed chronologically in the 90s, it is the introduction of agility in the early 2000 that managed to focalize software development efforts on the design (and deliberation) of high added-value features as fast as possible in the entire development process [192, 68]. Even more recently, the DevOps approach [12] prescribes to the creation of such features in a rapidly deployable fashion. Nowadays, given that a large variety of 'off-the shelf' software is readily available for the deliverance of packaged commodity features, a higher level of maturity has been reached in approaching software development (or software upgrade) projects[1] solely based on the design of such features since they are often adopted as-is. Instead, the challenge has been transposed to the organizational integration of such features (i.e., how to evaluate and efficiently deploy them to ensure their highest performance delivery for the organization) rather than their mere technical or software development proposition. Indeed, highest added-value features (so the ones delivering high rewards once deployed) are mostly differentiating ones meaning that they are furnishing a competitive advantage to the organization once adopted. Adoption delay should be ideally anticipated so that the cycle from initial idea to conceptualization, implementation and deployment needs to be as short as possible. We are thusly in need of techniques to ease and accompany the development of innovative ideas, transform them into code, and deploy them rapidly and flexibly in the current business environment that regards digital technologies (i.e., technologies basically driven by software) as the source of competitive advantage.

The Information Technology (IT) governance function is drastically affected by this new setting. On the one hand, conventional IT governance structures can easily provide for the decision-making mechanisms to accommodate the development of a new package of commodity features requiring the exertion of a

[1] Projects typically encompassing Enterprise Resource Planning (ERP) systems and other related packages.

significant amount of resources on behalf of the organization. For example, for large software adoption projects like ERP systems, the nature of the features and their organizational implications are rather predictable; in these kind of situations, the governance board has the liberty to anticipate the pros and cons of the solution, calculate the return on investment and, more importantly, evaluate the overall alignment with the business and IT strategies. Nevertheless, the evaluation, engagement, and treatment of new technological developments encapsulating a true innovational value remain sometimes fuzzy. For example, when software is being developed on a more empirical basis (i.e., serving as a test platform for innovative ideas without being explicitly prescribed by the governance layer) the risk is to lose track of what has already been developed and the current state of the software ecosystem. This might not only lead to a potential mismatch between the strategic vision and the daily operational function; more importantly, such a state of organizational misalignment could drive the misexploitation of potential sources of income (not relayed from the managerial level to the strategic one) or the lack of exploration of new strategic opportunities by having the managerial layer only focused on short term driven innovations. All in all, a situation as such might entail a lack of strategic vision driving (but also nourished by) the managerial layer.

1.2 Positioning the Present Work and Primary Research Question

While innovation, experimentation, empirical testing, and bottom-up technological propositions should be at the core of a modern business environment, the relevance of the strategic and the management levels as the coordinators of the entire technological ideation process within an organization should not be dismissed [106, 99, 96]. In that context, we need mechanisms to bilaterally mediate between these levels efficiently. Former studies have negotiated the form of such a connection. For example, the Strategic Alignment Model (SAM) [62] studies the general interconnection between Business and IT in a strategic and operational level. Nonetheless, the SAM can be regarded as static in nature since its goal is to aid organizations better comprehend the alignment of their internal Business and IT modes in order to configure (or leverage) their operating processes accordingly in the setting of their everyday activities. Other frameworks have been also proposed; we can briefly mention the Generic Framework for Information Management [105], and the Traditional Alignment Model [190]. However, these represent essentially an extension of the SAM in the context of providing a general understanding of pre-established organizational settings that are likely to affect the operational capacities of the entire enterprise.

In certain aspects, the present thesis is also trying to approach the conundrum of how to better achieve, represent, and visualize an anchoring pathway between the governance and the management levels in an organization via the exploration of of IT solutions. Nevertheless, the differentiating element between the theoretical presuppositions that are stipulated in the present work and the ones mentioned in the aforementioned frameworks, is related to the

dynamicity of the nature of the organizational governance and management layers. Presently, we consider these layers to be dynamically fluctuating to stimulate the bidirectional (i.e., top-down and bottom-up) flow of innovation through the use of abstract in-nature and componentized services. At the same time, the adherence to long-term (and thusly more formally defined) strategic objectives must be respected. The visualization of such inter-layer pathways is being presently performed with the use of conceptual modeling. The latter is being mostly associated to the use of abstract methodologies (i.e., not limited by the use of specific tools or techniques) for the development of information systems. Nonetheless, conceptual models can also be used to represent particular organizational configurations for the provision of strategic insights capable of leading the organization to an enhanced competitive position in the long-term [185]. Therefore, these models can be proven useful in bringing the linkage of this strategic-to-management layer to better maturity. In fact, conceptual modeling can be utilized to study the nature of some of the pivotal elements that can be traced within these layers in order to formalize their in-between synchronization mechanisms. Each of the steps within the centerpiece of this thesis are guided in correspondence to this research question: *How can we use conceptual models to evaluate through traceability the alignment of the governance and management levels in a business context where IT developments are driven by ad-hoc, disruptive or experimental concerns?*

1.3 A Description of the Main Methodological Aspects

To furnish an answer to this question, different methodological approaches have been realized and combined in the context of the present thesis. The reader will most probably observe a prominent use of Design Science Research (DSR) principles [194] (see Chapters 2, 3, and 5). The utilization of the latter is justified due to its capacity to provide directions for the investigation, development, and validation of solutions in the form of methods, artifacts, or fully-materialized technological solutions addressing the treatment of specific problems in a particular domain [67]. In our case, the DSR cycles for *Relevance* (i.e., investigation for problems and/or opportunities in the application domain), and *Rigor* (i.e., provision of solutions addressing the problems identified in the Relevance-cycle) [66] were instantiated with the development and elaboration of model-driven artifacts. These were meant to (i) provide an instant snapshot of the current business and IT convolutions that are experienced at the strategic level within the organizational premises, and (ii) help organizations leverage the dynamicity of their internal and/or external environment to introduce innovative technological solutions, so they can reach a more competitive state in relation to their business antagonists. These model-driven artifacts have been applied to a case study (see Chapter 2), have taken the form of an evaluating parameter in an exploratory study (see Chapter 4), and have acted as the intervention medium in an action research investigation within an organization facing a particular software-related problem (see Chapter 6). We consider this combination of different methodological approaches as complementary to each other and aimed at ultimately supporting and enhancing the DSR cycle for *Design* (i.e., design

and evaluation of the created solutions) [66]. Additionally, the conduct and use of a controlled experiment (see Chapter 8) as well as the search, retrieval, and utilization of the expertise of application domain experts in agile development processes (see Chapters 9 and 10) denote additional elements supporting the level of empirical research that is being conducted in the present thesis given the scarcity of academic studies attempting to answer the previously posed research question.

1.4 Structure of the Thesis and Individual Contributions in Answering the Research Question

The present thesis is organized as follows: **Part I** introduces the context, motivation, and general structure of the entire dissertation. **Part II** investigates the gaps and limitations when studying the state of the business and IT alignment within the educational sector. This part introduces *Chapter 2* entitled *'Achieving Business and IT Alignment in Higher Education Institutions Using Conceptual Modeling: A GDPR Implementation Project as Case Study'*. This chapter depicts the application of a conceptual modeling-based strategic framework to study the business and IT alignment in a Belgian higher education institution in the context of a GDPR implementation project. The previously developed Model Driven IT Governance (MoDrIGo [176]) framework is applied to an original case study which allows to depict the state of the use of conceptual modeling for the alignment of software development initiatives with the business strategy. This work has been done in collaboration with Amandine Chagniot and Yves Wautelet; it has been published within the proceedings of the Research and Innovation Forum 2020 (RIIForum 2020).

Part III explores the connection between strategic and operational agility within a modern organizational context. This is performed in a fragmentary way. In particular, this part is inaugurated by *Chapter 3* entitled *'A Model-Driven Framework to Support Strategic Agility: Value-Added Perspective'*. This chapter describes the elaboration of a model-driven framework to support strategic agility. This framework is called StratAMoDrIGo and focuses on the value attribution at a strategic-, stakeholder-, and user- level. The framework as a whole brings the traditional concepts of agility to the strategic (governance) level for a quick adoption of the so-called strategic opportunities. We can consider as a strategic opportunity any new IT service, software system, or a single mobile application. What matters is that the development (or adoption) of a strategic opportunity requires a significant amount of effort and resources and is capable of impacting the organization's performance in the long run. StratAMoDrIGo can be distinguished from MoDrIGo through its focus on different types of value and the broader focus on strategic opportunities brought by IT (rather than on business IT services only). In this context, StratAMoDrIGo is to be considered as a diagnostic tool to be used for quick decision-taking. This work has been done in collaboration with Yves Wautelet and has been published in the 141^{st} volume of the Information and Software Technology (IST) Journal.

Apart from the provision of the research context, the literature gaps, and the methodology responsible for the establishment of StratAMoDrIGo, Part III

describes also the adopted research approach in terms of evaluating the applicability of this framework. This is performed in *Chapter 4* entitled *'Strategic Agility In Practice: Experts' Opinions On The Applicability of StratAMoDrIGo'* which gives more insights about the practical use and adaptation of the StratAMoDrIGo framework. The chapter starts by presenting an empirical exploration of the most utilized strategic agility definitions within contemporary organizations. This is done via the conduct of semi-structured interviews of experts implicated within strategic agility implementation projects. Secondarily, the chapter utilizes the interview data to prescribe specific connotations in the notion of strategic agility while searching simultaneously for the key differentiators between the notions of strategic and operational agility. Finally, the practical applicability and ease of use of the StratAMoDrIGo framework (the latter resulting from the application of a methodical DSR application as explained in Chapter 3) are being investigated with the use of these experts' opinions. This course of action is meant to provide with an additional level of assessment for the evaluation of the StratAMoDrIGo framework. The work described in this chapter has been realized in collaboration with Lena Truyers, Yan Din, and Yves Wautelet.

Chapter 5 entitled *'From Service-Orientation to Agile Development by Conceptually Linking Business IT Services and User Stories: A Meta-Model and a Process Fragment'* documents how high-level conceptual structures typically found into IT governance processes can be conceptually linked to the requirements description entities usually used in agile software development in order to ensure business and IT alignment. This is performed via the Agile-MoDrIGo framework; the latter furnishes a model-driven way of supporting a round-trip synchronization between the strategic and operational layers within organizations. This synchronization entails the combination of top-down service-based developments (as part of the implementation of traditional IT governance processes) with bottom-up agile software development approach based on the gathering and specification of user stories. This work has been conducted in collaboration with Yves Wautelet and has been published within the proceedings for the 23^{rd} Conference on Business Informatics (CBI 2021).

Chapter 6 entitled *'An Action Research Investigation into the Applicability of Agile-MoDrIGo Within A Medical Device Manufacturer'* describes the application of an action research exercise that is purposed to provide some lessons about the applicability of the Agile-MoDrIGo framework. Overall, the aim is to investigate whether Agile-MoDrIGo could be of assistance in terms of offering some practical solutions in the quest for solving some real-context organizational problems. Similarly to the approach followed in Chapters 3 and 4, the presented chapter is meant to provide a supplementary methodological proposition to support the validation of the Agile-MoDrIGo method (introduced in Chapter 5). This work has been performed in collaboration with master graduate David Tupili and Yves Wautelet.

Part III concludes with *Chapter 7* entitled *'Further Discussions on the Developed Frameworks'*. Even though the StratAMoDrIGo and Agile-MoDrIGo frameworks express some commonalities in their attempts to represent strategic concerns, they nonetheless present differences in their intended purpose and

scope. This chapter is meant to elaborate on the link and complementarity of the two methods based on a number of evaluation parameters. This comparative approach is also extended to other industry-accredited approaches in order to present a broader sketch of the pool of practices that negotiate a strategic and value-driven perspective for efficiently developing software. The chapter also presents a discussion on the scalability and applicability areas of the frameworks while examining the fields of highest relevancy for their application. The work presented in this chapter has been prepared in collaboration with Yves Wautelet. To a large extent, Part III studied the conciliation of different approaches that can be used to stimulate the bidirectional flow of agile-driven (i.e., value-focused and innovation-oriented) practices within the vertical layers of organizations, when new IT solutions need to be evaluated and docked on their existent infrastructure.

Contrastingly, **Part IV** is purposed to investigate the use of conceptual modeling-based techniques to explore specific issues that may be impeding the traceability between the requirements elicitation and validation phases attached to the agile development of (business and IT) aligned software solutions. In that aspect, Part IV appropriates a more operational-oriented approach via the study of specific notations and templates that supposedly function as the means of better calibrating the entire agile requirements engineering process to facilitate the deployment of the techniques described in the previous parts. For instance, the Agile-MoDrIGo framework explicitly points out the *User_Story* class in its meta-model (see Figure 5.1), therefore, it is sensible to further study the options for structuring these user stories around Epic user stories in order to evaluate how practitioners can best understand the software problem in order to optimize the entire alignment process with the strategic structures within an organization. Also the same meta-model points out the *Acceptance_Test* class which is associated with the *User_Story* one. Such tests, in agile development, mostly take the form of Behavior Driven Development (BDD) scenarios. The latter, in relation to conceptual modeling, have been poorly studied in the literature. To form a more consistent conceptual paradigm, we can thusly further investigate how BDD can be unified to build guidelines that are meant to deliver a more solid testing structure to validate user stories, as well as creating meta-data at building time that can be possibly used for strategic alignment purposes. The premises developed to achieve this goal strengthen the global approach of the thesis and pave the way to future work.

In this regard, Part IV starts with *Chapter 8* entitled *'Conceptual Modeling Versus User Story Mapping: Which is the Best Approach to Agile Requirements Engineering?'*. This chapter depicts a controlled experiment realized with the participation of novice modelers in the field of software engineering (master-level students). The scope of the experiment is to identify the actual performance of a specific conceptual modeling-based method in delivering understandability to a requirements specification problem when input is provided in the form of a complex user stories' set. This work has been performed in collaboration with Joris Maene, Samedi Heng, Yves Wautelet, and Stephan Poelmans; it has been published within the proceedings for the 15^{th} International Conference on Research Challenges in Information Science (RCIS 2021).

Part IV continues with the furnishment of two complementary studies. *Chapter 9* entitled *'A Unified Ontology Supporting the Creation of Behavior Driven Development Scenarios'* consolidates the work related to the assemblage of multiple BDD test scenario templates that exist and the different keywords that these templates use for their syntax. This chapter has been built on the premise that there is a lack of semantic interpretations that can be attributed to these keywords; this makes the creation of BDD test scenarios not self-evident. Scripting BDD test scenarios that do not reach, neither fulfill, their intended purpose (so the proper validation of the desired functionality described in a user story) does not only compromise the integrity of the backlog before the commencement of an agile-driven sprint cycle (at the operational level); rather, the deliverance of incomplete, incongruous, and/or incoherent BDD test scenarios can have severe strategic implications within an organization by debilitating the creation of valuable features for an IT solution that is being developed/adopted with the intention of contributing to the attainment of strategic objectives. In that context, the chapter describes the methodological steps in search for a unified ontology that could facilitate the creation of BDD test scenarios and would directly map these scenarios with their corresponding user stories to enhance the entire requirements validation process. This chapter has been prepared in close collaboration with Yves Wautelet, Samedi Heng, and Charline Faut. The forerunners of this work have been included in the proceedings for the 29^{th} IEEE International Requirements Engineering Conference (RE 2021) and the 23^{rd} International Conference on Product-Focused Software Process Improvement (PROFES 2022).

Chapter 10 entitled *'Building User Stories and Behavior Driven Development Scenarios with a Strict Set of Concepts: Ontology, Benefits and Primary Validation'* is meant to continue the line of work presented in the previous chapter. More specifically, the work described here is meant to provide the validation rationale for the BDD test scenarios' ontology that was already prescribed. This is performed by accessing a well-known platform that hosts software-related projects (GitHub) and by examining a number of these projects incorporating a manifold of BDD test scenarios. Next, the chapter examines the merger of two ontological structures: the one for BDD test scenarios and another one that is used for user story elements' representation. The linkage of both ontologies is meant to serve as a guide to the treatment of the requirements specification phase at the start of a software development project (performed in an agile manner). This chapter has been prepared in close collaboration with Samedi Heng and Yves Wautelet, and is to be included in the proceedings for the 38^{th} ACM/SIGAPP Symposium on Applied Computing. This chapter concludes Part IV.

Part V regards this thesis from a broader perspective to encapsulate some of its contributions, to project some of its encountered limitations, and to discuss some future research directions as the natural progression of the described work. This part concludes this thesis.

Part II

Current State of Affairs within the Business-IT Alignment Domain and Limitations

Chapter 2

Achieving Business and IT Alignment in Higher Education Institutions Using Conceptual Modeling: A GDPR Implementation Project as Case Study

Higher education institutions have typically a multifaceted mission. Besides their educational activities, they also aim to support research activities and provide collective services while ensuring that the institution breaks-even financially (as a non-profit organization). These varying domains can actually be translated in a set of strategic objectives that need to be achieved in the long term. At the same time, new IT developments and projects can contribute to (or occasionally hamper) the realization of an institution's strategy. Such IT developments suggest indeed new functions that could potentially support the individual achievement of one or many of the institution's long-term strategic objectives. This chapter depicts a conceptual model evaluating the business and IT alignment of a Belgian university college from the French community with the assessment of the strategic fit of a new GDPR implementation (IT) project serving as case study. The purpose of the case is twofold as it aims to illustrate the generic strategy of this organization and to show secondarily how the alignment between the GDPR implementation project and that strategy can be identified, represented, and evaluated.

The research outlined in this chapter has been realized in collaboration with A. Chagniot and Y. Wautelet. Results have been published in [155]. The chapter is organized as follows: Section 2.1 provides the state-of-the-art regarding the business and IT alignment domain especially within the sector of higher education. Section 2.2 describes the research context motivating the development of this chapter. Section 2.3 describes the case study. Section 2.4 presents the application of the model-driven IT governance framework at the Belgian university college for the introduction of a new IT project targeting the institution's compliance to GDPR. Section 2.5 further discusses the lessons learned through the case study while Section 2.6 concludes the paper.

2.1 Introduction

Higher education institutions have begun employing IT solutions to improve educational and research activities as well as the efficiency of their administrative processes ranging from curriculum (re)design to facility management [18, 170]. However, IT systems need to be continuously evaluated and aligned with the needs of students, academic and administrative staff. Likewise, different systems and platforms used by employees in different departments are not always integrated and when re-engineering and/or new IT projects are considered, the alignment with the institutional objectives should be envisaged to identify business value at a strategic level [5].

Goal-oriented conceptual models can represent the business and IT strategies as a set of (long-term) objectives. The design of information systems can then be seen as a pivot that traces back and forward from the strategic objectives to the physical implementation through code (see for example [86, 183] for an alignment between human organizational behavior and an e-learning system). More precisely, goal-based models can be used to assess the impact of organizational changes on the realization of these strategic objectives and evaluate the state of business and IT alignment [185, 120]. Wautelet [176] proposes MoDrIGo, a model-driven corporate and IT governance framework allowing to evaluate the alignment of an organization with strategic (business and IT) objectives. MoDrIGo suggests supporting the governance layer by modeling the (long-term) business and IT objectives and studying their operational support. The business and IT objectives are determined by interviewing C-level executives and traced with operational execution representations through business IT services to determine added business value of the latter to the former(s). This approach is (at least partially because we do not use the notion of business IT service for synchronization) applied in this chapter to align the strategic objectives of an higher education institution with an IT project concerning the GDPR implementation. MoDrIGo has formerly been applied in various sectors and notably in the field of healthcare (see [186, 176]).

Assessing and sustaining the strategic alignment of business and IT objectives in higher education is not an easy task [123], especially after the continuous deployment of new IT developments. This chapter introduces firstly a conceptual model depicting the (business) strategy of a higher education institution called *Haute Ecole Léonard de Vinci* (this university college will be hereafter called *HE Vinci*) in terms of business objectives; this serves here as full case study. This artifact is further used to evaluate the university college's strategic objectives' alignment with the goals of a specific IT project. The latter is intended to support GDPR compliance to this strategy. We manage to visualize, delineate and decompose the IT project's goals into sub-goals and operationalized goals while assessing how their realization contributes to the fulfillment of higher education missions expressed through strategic objectives. In particular, our approach:

- Assesses the business and IT alignment in the sector of higher education using the *Model-Driven IT Governance* (*MoDrIGo* [176]) approach and more specifically the Non-Functional Requirements (NFR [28]) framework

for visual representation at a strategic level. Business and IT alignment has not received as much attention in higher education institutions compared to traditional market-oriented organizations [21]. For this reason, we provide a graphical structure that layers distinctively the strategic and broadly-based missions of a higher education institution as well as its operationalized project-objectives. Our model-driven approach ensures the traceability between rather stable (long-term) mission objectives and fast-evolving project goals;

- Acts as a common reference for managers, strategists, academics, planners, computer scientists and legal advisers educated to GDPR. In that sense, our approach can be perceived as a first point towards stakeholder-based governance by mapping the needs of various faculty stakeholders and partnering institutions to maximize shared value;

- Creates an archetype for the evaluation and establishment of any newly-introduced IT project in higher education while maintaining uninterrupted the daily mode of operations for such institutions. This is achieved through the use of conceptual modeling acting as an analysis 'blueprint' before starting any actual project-related development and coding;

- Provides a method for the constant refinement and re-evaluation of strategic objectives and IT development-related goals at any given moment through the use of the MoDrIGo approach (with the NFR tree). The latter visualizes a system of inter-dependencies from top to leaf-level strategic objectives while casting a path to them from project operationalizations (goals).

2.2 Research Context

2.2.1 Business and IT Alignment in Higher Education

Business and IT Alignment (BITA) is being studied extensively for over three decades now [80]. Early research focused solely on aligning business and IT strategies in a top-down manner [4]. However, the Strategic Alignment Model by Henderson & Venkatraman [62] incorporated a cross-domain alignment perspective considering simultaneously the strategic layer and operational integration. Luftman, Papp & Brier [104] identified that well-prioritized IT projects as well as IT involvement in (business) strategy development are some of the enablers that influence BITA but Tallon & Kraemer [147] support that organizational alignment will vary according to the strategic value placed within the IT function of each organization. In any case, there is consensus that organizations are bound to perform better when key IT resources (i.e. systemic competences, infrastructural components and IT skills) are aligned with the business strategy [104, 30].

There is nevertheless still a missing roadmap that would help organizational actors operationalize, measure and assess their BITA status [123, 30, 80]. This gap has profound implications in sectors where technological repercussions are

neither benign nor transparent and they are always attached to social, cultural, organizational and political reverberations; such is the sector of higher education [143].

Tertiary-level institutions have diverse business goals supporting an academic dimension, moderated by financial constraints. Indeed, higher education institutions primarily support pedagogical excellence while striving for balanced revenues and costs (as non-profit organizations). The multifaceted mission of such institutions complicates the reconciliation of technological necessities with other institutional priorities and demands of various faculty stakeholders [123, 199, 5]. For instance, higher education institutions are time-pressured to choose and deploy technologies not proven to add value to education. This is further exacerbated by the incompatibility between the monthly (even weekly) cycles of technological advancements and the annual (or biannual) planning cycles in academia. Under these circumstances, Luftman & Kempaiah [103] rank the education sector very low in terms of BITA maturity compared to other industrial sectors while the study of Byungura [20] reports findings indicating a strong misalignment between IT and the provided services in higher education institutions.

2.2.2 The Haute Ecole Léonard de Vinci (HE Vinci)

HE Vinci is an institution of higher education based in Brussels, Belgium (and Louvain-la-Neuve); it is subsidized by the Belgian French Community. It was formed in 1995 through the grouping of a number of pre-existent institutions and it is currently functioning as a non-profit organization collaborating with other educational institutions in Belgium. HE Vinci[1] offers short cycle (bachelors), long cycle (masters) and specialized tertiary education in fields like Health, Human and Social Sciences and Science/Technology. HE Vinci is considered as a university college meaning that it is a state-funded institution of higher education belonging to one of the three Communities of Belgium, and is not specifically a university.

2.2.3 GDPR Implementation Project at HE Vinci

General Data Protection Regulation (GDPR) came into effect in 2018 aiming to reinforce the rights of EU/EEA's citizens to informational privacy. These regulations require organizations with more than 250 employees to maintain records of personal data processing activities. Accordingly, higher education institutions have to reevaluate and adapt their data privacy procedures considering that they process not only personal data about past, current, and prospective students/employees but several other sensitive data entries related to collaborative projects, research initiatives and educational activities [107]. In essence, higher education institutions are urged to assume the role of *data control centers* overseeing internally the objectives of (personal) data processing activities while reporting them externally to other civic, data safeguarding agencies [54].

[1]More information about its structure can be found: https://bit.ly/3N3SMKD

Article 30(1)[2] of the GDPR reports that, at minimum, the records of processing activities should include:

- the name and contact details of the data controller and, where applicable, the joint controller, the controller's representative and the data protection officer;
- the purposes of the processing;
- a description of the categories of data subjects and of the categories of personal data;
- the categories of recipients to whom the personal data have been or will be disclosed including recipients in third countries or international organizations;
- where applicable, transfers of personal data to a third country or an international organization, including the identification of that third country or international organization and the documentation of suitable safeguards;
- where possible, the envisaged time limits for erasure of the different categories of data;
- where possible, a general description of the technical and organizational security measures referred to in Article 32(1)[3].

The HE Vinci wishing to comply with this new regulatory obligation, has set up a GDPR working group since September 2017, comprised of computer scientists, data managers and a legal division employing a Data Protection Officer (DPO) and the GDPR project leader. The first objective of this group was to be able to create and support records of (personal) data processing activities. Within this scope, a database (Project 'Médor') was developed to support the HE Vinci with the maintenance of these records. The GDPR working group decided to develop this database internally 'from scratch' as one of the recurrent problems encountered on the market at that particular time was the lack of availability of data inventories adapted to the field of higher education. Even though the database was developed for internal use, the establishment of a partnership with the HE 'Galilée' in 2018 has made the database (as well as its inventories) available to the partnering institution. Since then, other HEs asked to join the database development project. In May 2019, a second partnership was established with Namur University (UNamur) in Belgium. This partnership is based, among other things, on the joint effort to enrich the inventories supporting the records of processing activities.

Aside from rendering the data controllers (HE Vinci at first and the collaborating institutions in a later phase) predominately accountable for any

[2]Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[3]More information about the Article 32(1) can be found here: https://bit.ly/3H8mzhz

personal data they possess, Project Médor is meant to infuse an end-to-end, privacy-oriented viewpoint. Therefore, the working group had to develop a database that would provide not only a generic overview of the processing of personal data in the context of the HEs' activities, but also an overview of the high-end services, processes, actors, and storage locations involved in the treatment of these records. At the end of January 2018, the working group decided to develop the database internally. The requirements' analysis phase was carried out by the GDPR working group's data managers since they would be the main database users. The order for its development was then placed within the IT department. The working group established that the tool had to be based on ten inventories (developed in advance) whose elements had to meet a defined terminology. These inventories were developed in parallel with the database between February and March 2018. The first version of the Médor database was available in March 2018.

2.2.4 Research Paradigm

Our primary goal is to help alleviate the remissness of BITA in the section of higher education through the use of goal-oriented modeling and the NFR framework in particular. In this perspective, our study follows the paradigm of design science [67] combined with case study research [129].

This research follows the paradigm of design science in the sense that it uses artifacts developed previously in [176, 28] and instantiates them on a real-life case. This allows to bring further validation to these artifacts and study the lessons learned. Based on these instantiations, we suggest improvements for BITA-evaluation notably in higher education.

Case study research provides the opportunity to compare different theories and observations from empirical data [166, 109] and fits particularly well for software engineering research. Case study research has been applied here in the sense that a complete case has been performed and studied in its entirety by the research team.

2.3 Research Method and Steps

2.3.1 Data Collection and Validation

In order to understand the nature of the personal data being processed within HE Vinci's daily activities, an interview phase was organized in two constituent HE Vinci institutes (the 'Marie Haps' Institute and the 'Parnasse-ISEI'). The data managers prepared a comparative analysis from the results of the two 'pilot' institutes between July and September 2018. The purpose of this analysis was to detect all preliminary differences in processing practices for HE Vinci and gather them in a summarizing document. The first analysis of this document was carried out in January 2019 and it prioritized on the processes relating to academic affairs. The institutional pre-registration and registration processes were the first ones to be addressed, then the validation phase.

2.3.2 Determining the Business Objectives

Since one of our first major goals in this case study research was to represent the generic (business) objectives of the HE Vinci, we had to search and analyze the legal texts that regulate the field of higher education in the Belgian French Community. At that time, we also went through an internal document of the institution called *Priorities of the HE Vinci going towards 2020* describing its strategic objectives as they were established by HE Vinci's top management. The legal texts that were identified[4] mention that higher education in the Belgian French Community is a public service of general interest; they stipulate that one of the missions of higher education institutions is to "transmit, both through the content of the teaching and through other activities organized by the establishment, humanist values, creative and innovative traditions, as well as the artistic, scientific, philosophical and political cultural heritage, the historical foundations of the teaching content, while respecting the specificities of each individual". In short, legal compliance by higher education institutions is more of an obligation than a mission. This legal compliance of any public service is reinforced by the fact that higher education institutions have a mission to transmit philosophical and political values. Our analysis is based primarily on the 'Decree of March 31th 2004' (also known as the "Bologna Process") and secondarily to the 'Decree of November 7th 2013' (also known as the "Paysage Decree") since they are the mandates that dictate the missions in higher education. The former describes the stipulations regarding the integration of higher education systems across Europe into a single European Higher Education Area (EHEA) while the latter document specifies the landscape of higher education and the academic organization of studies within the Wallonia-Brussels Federation in Belgium. We started reviewing, codifying, comparing and identifying the missions of higher education described in these legal texts along with the strategic objectives included in the *Priorities of the HE Vinci going towards 2020*. Table 2.1 presents the main points of both decrees. We determined eventually that they converge in three primal mission objectives: (i) *Provide high-quality education*, (ii) *Provide services to the community* and (iii) *Participate in research activities*.

2.3.3 Determining the Strategic Objectives and the GDPR Implementation Project Goals

Besides the generic mission objectives that can be instantly accessible to anyone, there are long-term objectives that shape the business strategy of the institution and are internally confined to C-level management. The HE Vinci keeps an internal documentation of these objectives forming the strategic plan of the institution. The elements identified and refined in the mentioned documentation have been the subject of reflection with the top management of HE Vinci. Our final summation of these elements was validated by the director of the institution; so this was done internally at HE Vinci.

As far as the IT project is concerned, we determined its initial broadly-based goals with the exclusive contribution of the top management of HE Vinci and the

[4]They are presented in Table 2.1

Decree 31th march 2004	**Decree 7th November 2013**
Institutions have to offer high quality initial and continuing education, according to their habilitations, and thus certify the skills and knowledge acquired by their graduates.	Institutions have to offer initial and continuing higher education and training courses, corresponding to levels 5 to 8 of the French-speaking framework of qualifications, and to certify the corresponding knowledge and skills acquired at the end of the study cycles, or by valorization of personal, professional and training achievements; Institutions also have to transmit - both through the content of teaching and through other activities - humanistic, cultural, artistic, scientific, philosophical and political values, as well as be responsible for creative and innovative traditions.
Institutions have to participate in research and/or creative activities in their discipline.	Institutions have to participate in individual or collective activities of research, innovation or creation and thus ensure the development, conservation and transmission of knowledge and cultural, artistic and scientific heritage.
Institutions have to provide services to the community, in particular through collaboration with the educational, social, economic and cultural world.	Institutions have to provide services to the community through their specialized expertise and their duty of independence, listening to societal needs, in collaboration or dialogue with the educational, social, cultural, economic and political communities.

Table 2.1 Relevant Decrees Taken As Input in the Research

GDPR working group. At a later stage, we organized interviews and participated in working meetings with various internal and external stakeholders (to HE Vinci) in order to define the requirements of the Médor software. During this phase, members of our research team worked together with various project stakeholders from the partnering institutions of HE Vinci, HE Galilée and UNamur with previous experience in software engineering and data processing inventories. We collected data through semi-structured interviews and working meetings organized with prospective users of the Médor software from the partnering institutions. We focused our attention on members responsible for developing and maintaining the records of processing activities. The information from the working meetings was compared and combined with the resulting material

from the organized interviews (specific to the collection and prioritization of requirements). Table 2.2 summarizes the organization of these meetings for the determination of the IT project objectives and the elicitation of the software-specific requirements.

Partnering Institution	**Participating Member**	**Date and type of data collection**
HE Galilée	Lawyer	4th of July 2018 (informal exchange of information)
HE Galilée	Lawyer	30th of July 2018 (meeting discussing the requirements of the Médor software and the data inventory management)
HE Galilée	Computer Scientist	19th of August 2019 (meeting discussing the requirements of the Médor software and the data inventory management)
UNamur	DPO	23rd of November 2018 (meeting regarding the requirements of the Médor software)
UNamur	DPO	29th of January 2019 (meeting regarding the requirements of the Médor software)
UNamur	DPO	14th of May 2019 (meeting regarding the data inventory management)
UNamur	DPO	2nd of August 2019 (semi-structured interview)
HE Vinci	GDPR working group	7th of February 2019 (meeting with the GDPR working group with the exclusive participation of Data Managers)
HE Vinci	GDPR working group	6th of November 2018 (meeting with GDPR working group with the exclusive participation of Data Managers/Project Leader/DPOs)
HE Vinci	GDPR working group	18th of February 2019 (meeting with GDPR working group with the exclusive participation of Data Managers)
HE Vinci	GDPR working group	31st of July 2019 (semi-structured interview with the Data Managers)
HE Vinci	GDPR working group	13th August 2019 (semi-structured interview with the Project Leader)

Table 2.2 Performed Meetings and Interviews

2.4 Model-Driven Business and IT Alignment Evaluation of the GDPR Implementation Project

This section introduces the application of the MoDrIGo approach to the HE Vinci's GDPR implementation project case study. Section 2.4.1 introduces a generic representation of the strategic objectives of higher education institutions in the French community of Belgium. While the latter representation is valid for all of these institutions, the representation built in section 2.4.2 depicts the strategic objectives of HE Vinci. These are further decompositions of the general strategic objectives and are specific to HE Vinci. Finally, section 2.4.3 depicts the GDPR implementation project's specific goals and traces their impact on HE Vinci's strategic objectives for BITA evaluation.

2.4.1 General (High-Level) Mission of Higher Education Institutions

This section builds a conceptual model to depict a representation of Belgian French Community's higher education institutions' highest level objectives in the form of a set of strategic objectives. The relevant concepts to understand the representations made in this section are summarized in Figure 2.1. Our representation can be applied to any higher education institution whose mission is shaped by the 'Decree of March 31th 2004' promoting the integration of higher education systems across Europe into a single European Higher Education Area (EHEA). Using this mandate as a legislative source, we have prioritized three main higher education mission objectives: (i) *Provide high-quality education*, (ii) *Provide services to the community*, and (iii) *Participate in research activities*.

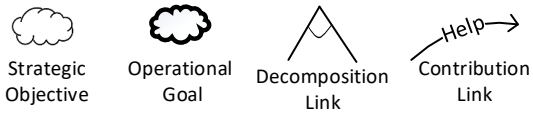


Fig. 2.1 Relevant Concepts and their Icons.

The first mission objective prescribes the pedagogical excellence that any EHEA-incorporated institution is compelled by law to deliver; it can be further decomposed in two sub-objectives:

- *Respect the right to privacy.* All the phases that a prospective student has to undergo during his/her educational journey (i.e. registration to a particular educational curriculum, exam registrations, receiving individual exam grades etc.) must be (it is a legal obligation) organized considering the student's right to privacy. The same right covers all personnel and various faculty stakeholders involved in the provision of educational services;
- *Transmit philosophical and political values.* The provision of teaching or other educational activities within the specialized domain of every higher education institution must include the transmission of political and philosophical values and its historical foundations.

The second mission objective stipulates the provision of services that such institutions aspire to offer though international and intercommunity-level collaborations. It can be further decomposed in the following sub-objectives:

- *Set up collaborations with partnering institutions.* EHEA-institutions have the freedom to establish collaborations and partnerships with other institutions and organizations in order to reinforce and augment their teaching, research, communicative and skill-augmenting abilities of its students and personnel;
- *Manage collaborations with the educational, social, economic and cultural community.* The establishment of collaborations is followed by the responsibility to manage and sustain them in the best possible way.

The third mission objective ensures the fulfillment of the academic identity of higher education institutions through their expectation to participate in high quality research activities. This top-level objective can be further elaborated in two distinct sub-objectives:

- *Participate in research and innovation activities.* A higher education institution has to fundamentally cultivate innovation and engage in high quality research in one or several domains;
- *Ensure knowledge development.* Higher education institutions have to create the structures, processes and mechanisms encouraging the continuous development, conservation and dissemination of knowledge for their academic, research and administrative personnel.

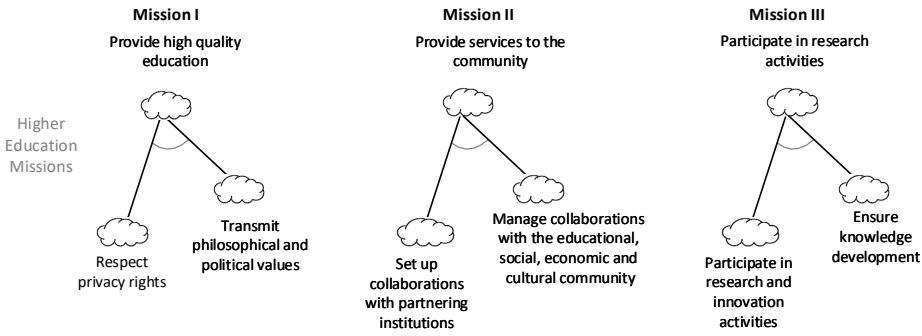


Fig. 2.2 General High Level Mission of Higher Education Institutions

Figure 2.2 represents the generic strategic missions of higher education institutions; these need to be further refined and instantiated to specific higher education institutions.

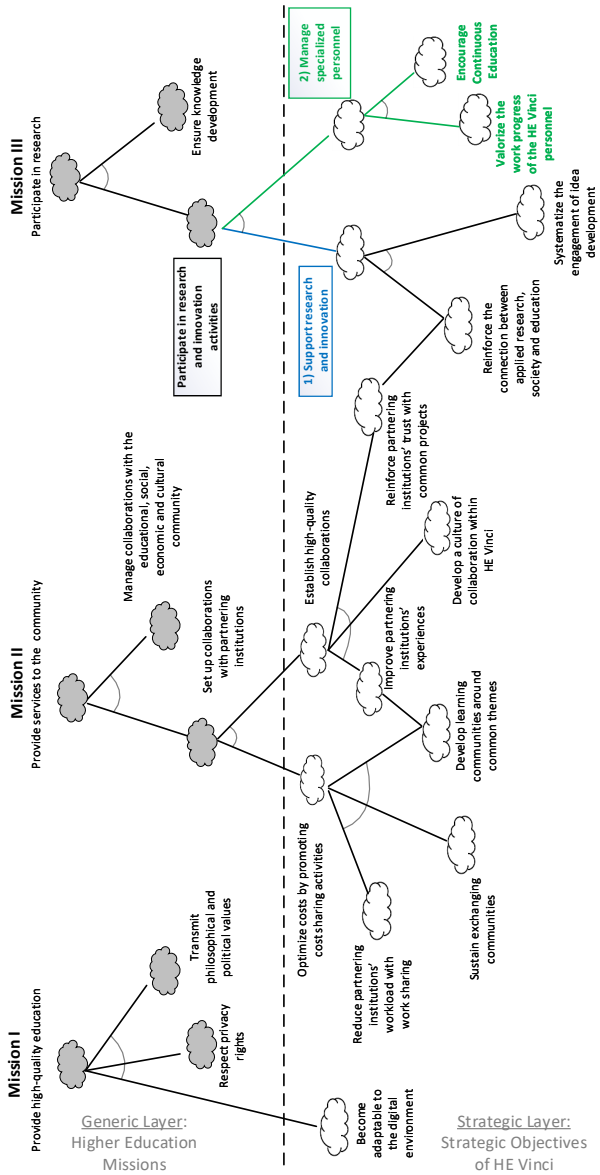


Fig. 2.3 Representation of the Overall Strategy of HE Vinci.

2.4.2 Modeling the Strategic Objectives of HE Vinci

Compliance-wise, HE Vinci has to be aligned primarily with the 'Decree of March 31th 2004'[5] and secondarily with the 'Decree of November 7th 2013'[6]. The latter follows the legislative spirit of the former while specifying the landscape of

[5]More details on the 'Bologna Process' can be found on: https://bit.ly/3oBUuIS
[6]More details on the 'Paysage Decree' can be found on: https://bit.ly/3mYQcei

higher education and the academic organization of studies within the Wallonia-Brussels Federation in Belgium. The overall (business) strategy of HE Vinci is considered complete when the three broadly-based mission objectives are elaborated further to fit the specificities of its strategic objectives.

Strategic objectives are part of the business or IT strategy pursued by an organization; they are perceived as targets that the organization aims to reach within a long time horizon in order to gain and/or sustain a competitive position [176]. In our case, all the strategic elements were extracted from an internal document[7] detailing the strategic plan of HE Vinci towards the year 2020. These strategic objectives were identified and validated by the top management of the institution; their decomposition is represented in the strategic-level diagram of Figure 2.3.

We observe that parent-level elements within the strategic layer are the outcome of higher level decompositions. Illustratively, the generic sub-objective *Participating in research and innovation activities* can be achieved through satisficing the *1) Support that will be placed into these research and innovation activities* and the *2) Management of specialized personnel*. Satisficing the latter would entail the strategic *Encouragement of continuous education* as well as strategically *Valorize the work progress of the HE Vinci personnel*. So realizing the participation in research and innovation activities entails the realization of each of the strategic objectives mentioned previously.

2.4.3 Business and IT Alignment of the GDPR Project

This section describes the alignment between the business objectives discussed in the previous section and the IT project that aims to support GDPR compliance at HE Vinci. Figure 2.4 illustrates the newly-introduced project objectives as operationalizations assisting the achievement of the targeted business objectives and examines their inter-dependencies with the previously recognized strategic objectives.

What follows next is the instantiation of some of the project objectives as illustrative examples describing the fulfillment of the three generic missions and their accompanying strategic objectives for HE Vinci.

The working group involved in this particular endeavor identified the *Rendering of the HE Vinci compliant with the GDPR* as the primal project objective. This can be further decomposed into various sub-objectives which describe, among others, the maintenance of a record of processing activities or updating the institution's documentation in terms of the new GDPR legislation. We have to note at this point that are many more project sub-objectives that can be derived from this primal objective; these have been identified during the consultation phase with the top management and the GDPR working group but they have not been added in the formal diagram because of readability issues. We have decided to add significant sub-objectives that can support this design science exercise without compromising the letter and the spirit of the project's implementation goals.

[7]Internal documentation 'Priorities of the HE Vinci going towards 2020'

Hence, the above-mentioned primal project objective can be decomposed into sub-objectives, among which we distinguish here: (i) *Adapt the institution's official documents to the new GDPR* and (ii) *Develop and support the record of processing activities for HE Vinci*; the latter yields two direct satisficing objectives:

- *Reduce the number of personal data breach incidents* **(Fulfillment of Mission I)**;
- *Ensure the accuracy within the records of processing activities* **(Fulfillment of Mission I)**.

Even though the project was originally purposed for the institution's internal use, it was decided at a later stage to be shared among various educational institutions[8] in Belgium with the intention to create a cost-sharing and innovative consortium. Hence, the *Develop and support record of processing activities* sub-objective can be further elaborated in (i) *Set up a collaboration among partnering institutions around the Médor project* **(Fulfillment of Mission II)** and (ii) *Propose an innovative solution for the amelioration and support of the records of processing activities* **(Fulfillment of Mission III)**. The latter yields two direct satisficing goals:

- *Improve the Médor software.* An optimized software tool accelerates firstly the identification of personal data utilizing resources and secondly the gradual automation in the encoding of the records of processing activities. The latter enables the records' maintainability in the long run by saving time and effort from the personnel having to develop and maintain them manually. The satisficing of that goal influences directly the fulfillment of the strategic objective *Valorize the work progress of the HE Vinci personnel*. As seen in section 2.4.2, the latter is elicited indirectly from the *Participation in research and innovation activities*;
- *Improve inventory management.* This goal facilitates the content management of the inventories that support the records of processing activities. This enables long-term time savings and workload reduction for the personnel responsible for the maintenance of these inventories. The satisficing of that project goal influences directly the fulfillment of the strategic objective *Valorize the work progress of the HE Vinci personnel* stemming from the higher education sub-objective calling for *Participation in research and innovation activities*.

The previous illustrations support the alignment between business and IT project-related objectives in distinct stages. We observe that the realization of specific project objectives contributes positively to the realization of broadly-based higher education (business) objectives.

[8]The higher education institution 'Galilée' and the University of Namur.

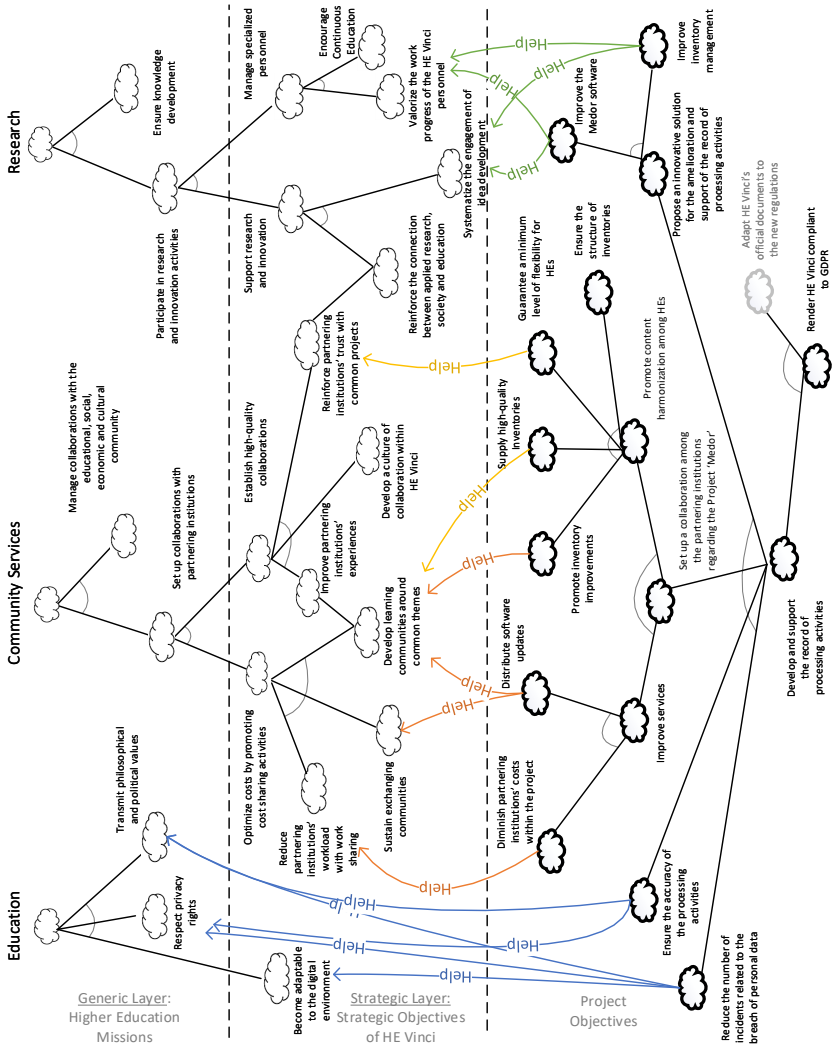


Fig. 2.4 Representation of the Alignment Between the Long Term Strategic Objectives and the GDPR Implementation Project's Operational Goals at HE Vinci

2.5 Discussion

2.5.1 Benefits in Creating a Consortium for the IT Project

The above delineation of the strategic objectives and IT-project goals allows us to think critically of the initial state of loose collaboration among the partnering institutions in terms of managing the IT project. Under that form of collaboration, HE Vinci had the primal role in developing (and maintaining at a later stage) the software solution while bearing the projects' accompanying costs.

The partnering institutions could provide a secondary contribution to the project without pooling their efforts and benefiting from the latest updates in the data inventory management process. It is indicative that at some point, HE Vinci was considering sharing the data inventories with its partners in an Excel format making them practically unmanageable. However, the strategic representation and project evaluation of Figure 2.4 demonstrates that the achievement of the majority of goals relies on the establishment of a collaborative form that entails the exchange of innovative solutions for the development and amelioration of the software tool. This condition is not only in alignment with the second mission objective, but it also facilitates the reconciliation between the IT project objectives and the generic business objectives in the middle layer. In general terms, Barringer & Harrison [10] converge that consortia (as collaborative forms) are able to:

- enable the pooling of efforts and costs in terms of software development and maintenance;
- guarantee the neutrality of a specific IT project;
- allow for an independent mode of governance with its overall IT strategy temporarily oriented towards technology and innovation. In our case, the use of novel technologies such as machine learning and augmented reality could be regarded as opportunities supporting the continuous fulfillment of the projects' objectives.

The above considerations necessitated the creation of a consortium of collaboration among the partnering institutions around the IT project, instigating a signed agreement between HE Vinci, Unamur and HE Galilée. These agreements stipulate that the Médor software is made available to the partnering institutions, free of charge, in exchange for their contributions in terms of inventories and software development and maintenance. They also detail that HE Vinci remains the owner of the software and its accompanying inventories but these can still be used by the partnering institutions. When it comes to the procedure of sharing the data inventories among the partnering institutions, a proposal for the development of a contemporary inventory management system has been placed by the data managers of the HE Vinci. The validation of the proposal is still ongoing.

Of course, the establishment of such a collaboration would render it in a constant state of 'coopetition'; this refers to the state of simultaneous cooperation and competition allowing the partnering institutions to increase combined welfare through cooperation while maximizing individual gains through competition [120]. Therefore, the consortium would have to create change management mechanisms to handle the dynamic nature of collective and individual member objectives over time. Resolution processes would also need to be considered to alleviate a potential mismatch between the consortium members' objectives and the interests of partnering institutions' stakeholders that do not directly participate in it, or even network members pursuing partly conflicting objectives [196]. Future studies could determine how do these partnering institutions handle this constant state of coopetition.

2.5.2 More Lessons Learned from the Case Study

The case study in higher education has been mostly driven by the business strategy. The IT strategy of such institutions is something that is still not a formal element in this development. The incorporation of a formal IT strategy next to the business one would have created more complex representations that would be harder to deal with. Similarly, we could have pushed the analysis further by restructuring the IT offer in terms of Business IT Services like suggested in [184, 176]. This would nevertheless have introduced unnecessary complexity for the purpose of the study; at the end, we chose to go through with a holistic goal representation for this specific project rather than a more complex service structuring.

Finally, while performing the case study we understood the importance of having a supporting Computer-Aided Software Engineering (CASE) tool supporting the model-driven representations. We will be consequently entering the process of extending the Descartes-architect tool [85] for full method support.

2.6 Conclusion

This chapter provided a case study for BITA evaluation in a higher education institution. Even though we describe an IT project with a specific aim (supporting GDPR compliance), the developed representations can serve as pattern to be customized by any higher education institution (i) sourcing its mission objectives from the Decree of 31th March 2004 (and beyond) or (ii) even more generally higher education institutions having the triple mission of providing education, conducting research, and being engaged in community services. To this extent, we contribute to BITA research by offering practical directions and prerequisites whose satisfaction guarantees BITA in the section of higher education. We also negotiate ways of further enabling BITA with the creation of the consortium and the prerequisites that such a form of collaboration should satisfy.

Our representations also allow to study the dual positioning of higher education institutions as publicly subsidized institutions that need to break-even financially. This is interesting considering that BITA concerns are mostly addressed in literature one dimension at a time.

Part III

Conciliating Strategic Aspects with Operational Agility

Chapter 3

A Model-Driven Framework to Support Strategic Agility: Value-Added Perspective

The Covid-19 pandemic has shown the entire world that the habits of work, freedom, and consumption can change quickly and significantly for an undetermined amount of time. A dynamic environment as such, prompts organizations to move fast in order to leverage changing circumstances as sources of opportunity rather than deadly threats. Drastic changes in work organization, consumption habits, compliance, etc., may require firms to quickly adopt new technology delivering all sorts of added value. The development and adoption of new technology –structurally impacting the way the organization conducts its activities– requires a considerable amount of effort in a short time frame, thus rendering it a governance decision where the alignment of the technology's adoption and use to the long term strategy needs to be evaluated. The short time frame requiring fast response implies that agility should not remain a development (operational) or a management concept but should also be adopted onto the strategic layer. This chapter details the application of design science research to build-up a framework supporting strategic agility in a model-driven fashion; this framework is called *Strategic Agile Model Driven IT Governance* (StratAMoDrIGo). Within the present chapter, the relevance-, rigor-, and design-cycles [66] of design science have been applied and exhibited. StratAMoDrIGo is based on the identification of sources of value for the organization's strategy, its stakeholders and the users of the implemented/adopted technology. Relevant concepts are consolidated in an ontology of which the application uses the Non-functional Requirements Model [28] at strategic-level and the i* Strategic Rationale Model [201] at management-level.

The research presented in this chapter has been realized in collaboration with Y. Wautelet. Results have been published in [160]. The rest of the chapter is structured as follows: Section 3.1 explains the notion of conceptual modeling and the value that can be brought by its use in terms of furnishing support to organizational strategies. Section 3.2 gives some background information about strategic agility and stakeholder-based governance. Section 3.3 gives the context of the research, more specifically the application of design science through the

relevance, rigor and design cycles. Section 3.4 depicts the ontology on which our framework (StratAMoDrIGo) is based. Section 3.5 documents the models that our framework is constituted of. Section 3.6 depicts a process fragment that can be applied in order to use StratAMoDrIGo. Section 3.7 depicts the application of the framework on a case for evaluation/validation. Section 3.8 compares the framework with other state-of-the-art approaches and discusses some practical aspects related to agility and applicability as well as the threats to validity. Finally, Section 3.9 concludes the chapter.

3.1 Introduction

Governance and strategic decisions often face a lack of concrete data or formalisms supporting them [148]. Unstructured and fragmented information leads to a vision limited in many ways. Such information indeed fails to provide an *ex ante* evaluation of the consequences of IT adoption on the long term competitive position of the organization and the fulfillment of stakeholders' best interests. Furthermore, all type of IT related decisions (including strategic ones) need to be taken on short notice because of the rapidly changing socio-economic environment. Indeed, recent years gave rise to unexpected events deeply impacting the economy and stakeholders' (e.g. customers, employees, shareholders, ...) behavior in a very short time frame and without any notice. For example, we can cite (i) the Covid-19 pandemic stipulating new ways of working/consumption habits, (ii) the 2008 financial crisis impacting the budget formulation processes and overall financial management of organizations, or (iii) random terrorist attacks disrupting civil liberties and worker mobility. When taking place, such events act as game changers and reactive measures, impactful on the organizational strategy, need to be assessed and implemented almost in real-time.

Conceptual modeling involves building a representation of selected phenomena in some domain [114]. Some conceptual models to support strategic decision making based on goal-driven representations (e.g. [17, 8, 69, 176]) have been developed and validated lately. Such models are able to incorporate organizational goals at a very high level of abstraction but also the goals of a wide variety of stakeholders together with their intentionality. Their use is significant to highlight, study, and evaluate the global impact of a new software or system development and deployment.

This particular chapter depicts the research aimed to build a framework, instantiated through conceptual models, allowing to quickly evaluate (when the business context changes rapidly) the impact of IT adoptions in terms of strategic, stakeholder and user value. By strategic value we mean, in the context of this chapter, every development, adoption, deployment of technology that enhances the long term position or the organization's products and services. Similarly, stakeholder value refers to any kind of support resulting from technology that increases the level of quality of life of the stakeholder in a specific business context. Finally, user value essentially concerns furnishing functional and non-functional elements to an end-user helping him/her to more efficiently perform its private or business activities. Since the framework depicted in this

chapter focuses on the evaluation of the impact of technology adoption on an extended range of values on the one side and on rapid development/deployment in changing environments on the other side, it is aimed to support *strategic agility* through conceptual models.

The developed framework extends the *Model Driven IT Governance* (*MoDrIGo*) one of [176] to include a broader range of potential technologies on which governance-level adoption decisions need to be taken. These are purely based on (added) value evaluation to sustain agile principles; we thus call it *Strategic Agile MoDrIGo*, in short *StratAMoDrIGo*. MoDrIGo uses conceptual modeling to support the IT governance process especially for business and IT alignment evaluation when adopting IT services. In that sense, StratAMoDrIGo is more general (not focused on IT services only but on a broader range of (significant) technological adoptions) but also covering more aspects (because it allows to overview the impact of the adoption on stakeholders and users) while being also flexible (different configurations can be edited beforehand). StratAMoDrIGo is intended to be applied "on the fly" when the business context changes and new technologies can be adopted while MoDrIGo is applied in a classical service portfolio approach when IT services are to be developed to replace decommissioned ones or address new needs. The main research questions the chapter is answering to is: "*How could conceptual modeling be applied to highlight strategic, stakeholder and user value within technological adoptions in a fast moving business context*". The chapter's main contribution is the enhanced framework (StratAMoDrIGo).

The proposal is applied on the case of a hospital facing the Covid-19 situation. This hospital has been used for full validation of a previous framework in which the one presented in this chapter takes roots (see [176]). We here study the impact of the development of 2 (software) applications driven by the Covid-19 pandemic on the hospital's strategy, stakeholders and application's users. The impact of the pandemic on the hospital strategy has been, for the research team, an opportunity for the development and validation of the framework. An expert has also been consulted for the evaluation of the strengths and weaknesses of the framework. StratAMoDrIGo also went through a comparison with other agile development and value-driven methods using strategic agility as the dimension of evaluation.

3.2 Background

3.2.1 Defining, Characterizing and Positioning Strategic Agility: from Concepts to Implementation

Haakanson et al. [58] define strategy as the *... pattern of activities which has an impact on the achievement of the organizational goals in relation to its environment.* By adjusting the offer of products and services through an adequate strategy, a better competitive positioning should quickly be achieved when the environment changes drastically. Indeed, environmental changes induce strategic opportunities. A strategic opportunity involves the acquisition of resources at a price below their rent generating capacity [9]. The opportunity

is outside the scope of the organization so the latter cannot influence it but it can make use of it for its own benefit [58]. All in all, it is an opportunity if it brings more value that the invested resources and we consider it being *strategic* when it leads to a competitive advantage through the mobilization of the resources it involves. Operational measures can mostly be taken on the fly, but the existence of game-changing events necessitate the swift evaluation/implementation of strategic (governance) level decisions as well; the latter are described as the ones having a structural impact on the organization, its finances and its stakeholders.

Agile practices require the set-up of enterprise-wide, top-down and bottom-up collaboration and communication mechanisms that identify, promote and reinforce initiatives encouraging a rapid response to internal/external organizational challenges [168, 159]. However, despite the proliferation of the importance of agility when crafting organizational goals, the former does not necessarily constitute a panacea to every issue related to organizational effectiveness and efficiency. For one thing, agility is by nature a multipurposed conceptual term, open to many definitions and action strategies even within the same organization [1]. Sambanurthy et al. [132] illustrate the multidimensionality of agility by differentiating between some of its co-variants such as *customer agility* (leveraging customer insights to expedite innovation), *partnering agility* (exploiting strategic partnerships and business networks to discover competitive opportunities) and *operational agility* (swift redesign and co-creation of business processes with the synergies of customers/developers for maximized business value delivery). The last variant has become prominent in the field of software development after the emergence of the so-called 'Agile Manifesto' [13] invoking the simplification of certain code-producing principles/attitudes and the disavowal of plan-driven rigidity for the attainment of user-oriented functions that yield maximized value. Operational agility lies into the use of the existing business model (i.e., improving the accuracy and quality of software to deliver a better product or service), however, upscaling operational agility towards the achievement of strategic agility (i.e., creating new software developments, exploring new markets, making new products by the exploitation of opportunities [34]) is not self-evident.

Progressively, there has been a lot of seminal work in the effort to chart the notion of agility in a wider organizational perspective by customizing and compelling the adoption of specific top-down indoctrinated mechanisms to software development teams i.e., setting-up specific Key Performance Indicators (KPIs), interventions and team coordination tactics [26, 171]. However, works as such do not consider how agility can be adopted at strategic level.

Approaches found in literature to achieve strategic agility are most often a collection of advices or practices to be implemented (see for example [35]) or inherent qualities – like *strategic sensitivity*, *resource fluidity* and *leadership unity* [37] – to have to make the organization's environment agile at a strategic level. According to several authors (e.g. [151, 150, 149, 92], dynamic capabilities – that were originally defined for sustaining a competitive advantage in an increasingly interdependent environment – can be used for achieving strategic agility. Ordinary capabilities are operating routines concerning the business processes of an organization [203] while dynamic capabilities are more abstract

ones implying a modification of the operational processes and enabling the business to evolve and expand using innovation [203, 149]. Strong dynamic capabilities are required when organizations are facing highly uncertain environments in order to favor strategic agility [149]. A dynamic capability can be defined as *the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments* [151]. Dynamic capabilities do represent key elements for an organization's *capacity to innovate, adapt to change, and create change that is favorable to customers and unfavorable to competitors*; they are a specific type of organizational and managerial skills [149]. Glesne et al. [49] highlight that three main types of dynamic capabilities are relevant for strategic agility, i.e. *the capacity to sense and shape opportunities* (*sensing*), *the capacity to seize opportunities* (*seizing*) and *the capacity to maintain competitiveness through reconfiguring the enterprise's assets* (*shifting*). The framework developed in this chapter is aimed provide support to these dynamic capabilities. The inclusion of the framework in the organization's practices is intended to enhance the sensing (by creating an opportunity-aware culture), its use concretely helps the seizing (by offering a concrete way to evaluate the organizational impact of opportunities' adoption) and finally supports the shifting (by highlighting how organizational resources and structures can be reconfigured for the adoption of the opportunities). All in all, the framework is intended to furnish support to reasoning for strategic agility; this is done through the use of conceptual models.

As already discussed, strategic agility has been mostly explored in strategic management sources in a very abstract manner via the exploration of qualities an organization should have to be strategically agile or via the experimentation of specific practices. To the best of the authors knowledge, no formal framework has been proposed favoring agility independently at a strategic level. The SAFe 5.1 framework [84] drives operational developments by value streams identified at strategic level but does not see agility as an independent aspect/quality of the organization. Also, SAFe's software developments are driven by strategic value flows but no ex-ante evaluation of the development's impact can be realized with the framework. A comparison between SAFe and StratAMoDrIGo in terms of their contributions to enabling the level of strategic agility in an organization can be found in Section 3.8.1. At operational-level, methods like Scrum and XP favor agility in software development; however, such frameworks do not include conceptual models natively and focus solely on the employment of user stories for requirements elicitation [29]. Thereby, the goal, as presented in the present chapter, is to build a framework allowing to represent business/organizational situations in which rapid change is necessary by focusing on the delivered value (the key component of agility). Thereby, the framework is purposed to evaluate the consequence of the adoption of strategic opportunities (mostly new technology) onto the organizational setting as a concrete approach of how to deal with a changing environment. Traditional (IT) governance frameworks also exist; frameworks like ISO/IEC 38500 [75] or Cobit 5 [74] provide guidance for a proper IT governance but do not encompass principles/processes/concepts to deal with changing environments and recommending immediate action. The framework developed in this chapter covers these two gaps by being driven by

conceptual models and allowing an integration of the strategic, tactical, and operational levels; strategic and operational agility can ultimately come together with the support of a structured approach.

3.2.2 Towards Stakeholder-Driven Governance

The key concept of stakeholder-based governance lies on the fact that strategic decisions are not taken to maximize value for shareholders only but rather for all of the stakeholders of the organization [48]. The group of stakeholders is, by definition, much larger that the shareholder one since it may include C-level executives, middle and lower-level managers, users of an IT system, administrative employees, clients, suppliers, etc. Proper stakeholder-based governance means that when fixing strategic objectives and taking decisions to fulfill them, all of these individual groups should be taken into account to maximize shared value.

Samavi et al. [131] highlight that most modeling techniques that are used to draw useful business insights may be focusing on maintaining and reinforcing the existing structure and functions of transactions in a value-driven network. They, however, do not engage in a fully-fledged *stakeholder-based governance* which would imply, by definition, the consideration of the intentional dimensions of the stakeholders participating in a business. This may lead to representational inefficiencies given the fact that creation and exchange of value in a business ecosystem is triggered and influenced by the goals/intentions/motivations of a multitude of stakeholders.

3.2.3 Related Work

Lara et al. [90] regard governance from a design science perceptive where they discover that most software modeling constructs favor the portrayal of elements from the strategic apex in full concretization without necessarily incorporating their operational-layer technologies. As a solution, the authors introduce a set of new modeling elements which essentially extend ArchiMate [52]. This enables a better operational imprint of the Enterprise Architecture (EA) but increases by far the number of inter-and cross-layer connections without providing a clear contribution in improving the business and IT strategic decision-making structures when facing rapidly evolving requirements. Comparatively, Souza & do Prado Leite [144] try to bridge the representational disassociations across strategic, tactic and operational layers by proposing a model-driven methodology which merges i* [201] and BPMN [117]. In this way, inter-layer traceability is ensured by using relationships in places where these modeling languages intercept each other. The authors claim that integrating fit-for-purpose modeling constructs for each organizational level is bound to improve their in-between alignment, at least in a vertical perceptive. However, their contribution seems to be entailing a meticulous up-front design effort for all organizational tiers. This is seemingly at odds with the paradigm of using strategic opportunities where only coarse-grained features are defined to allow businesses to react rapidly to internal or external change.

Juhnyoung et al. [77] propose a value-centric, model-driven approach that is meant to identify business and IT gaps during the exploration of new business opportunities. The approach strives to map IT functions and capabilities to business performance while facilitating the demonstration of the delivered value of IT and services. It is comprised of these key modeling elements: first, a multi-layer model represents the linkage between business and IT semantics and enables IT and services to reflect their yielded business value. Second, a business modeling component provides a strategic-level business view of the entire enterprise and enables business analyses based on value and risk assessment elements such as KPIs and other operational metrics. Even though the approach aspires to yield an end-to-end integration of business value with the main IT enablers, the former is defined only in terms of cost metrics influencing the corporate governance view from the perceptive of the shareholder.

Thomas & Vom Brocke [154] describe a conceptual modeling-based methodology to assess and determine valuation metrics of Service-Oriented Architecture (SOA) deliverables. The study aspires to traverse the gap between the flexibility that a SOA brings to IT integration and the leverage of the former to achieve (business) strategic objectives by providing support to those responsible for the design-decision of these services. Conceptual models provide with individual, factually documented, design alternatives evaluated with regard to their long-term economic viability. There are some points of attention with this approach with the first one being that value is considered solely insofar to its economic significance, disregarding in that sense some service which may be costly to design/implement but holds nonetheless the potential of solving crucial functional and/or strategic concerns. Second, the methodology describes the setup of a governance decision-support center for the design of specific services but does not depict the framework by which this center transmits the design-decision implications to the other layers of the organizational spectrum.

Khurum et al. [81] acclaim that the existing value-construct contributions act in isolation from each other in software product development processes. Consequently, the study presents a consolidated software value map which introduces essentially a balanced scorecard approach that considers various internal/external factors before a final software product development decision can be taken. Similarly, Mendes et al. [110] detail a methodology that calls upon the improvement of decision-making activities associated with the development processes of software intensive products and services. This methodology can be described as an amalgamation of knowledge creation processes and the use of Bayesian networks purposed to elicit the knowledge of key stakeholders in terms of the most significant factors that should be used as input to a Web-based value-assessing tool employed to support decision making. Both of these approaches seem to be detailing the value-centric decisions that need to be deliberated during the planning phase of the development process and do not offer concrete suggestions on the alignment between strategic and operational aspects during the running phase of the process. Overall, to the best of the authors' knowledge, there is no consolidated work up until now that explores value aside from the economic viability of technological adoptions in the business context while clearly demonstrating (with the use of conceptual modeling tools)

how the best interest of a wide range of stakeholders can be supported by rendering the workings of the organization in a state of strategic agility.

3.3 Research Paradigm, Method, and Approach

This research follows the precepts of the Design Science (DS) paradigm [67]; DS is meant to build generic solutions for identified issues. The output of a DS-driven research can be a solution in the form of an artifact, terminology, methodology, engineering tool, and so forth. In the present research, an attempt has been made to build artifacts to improve the handling of strategic opportunities for the benefit (i.e., provided value) of all stakeholders in a highly dynamic business context. These artifacts aim to solve an unresolved issue or a problem considered being in a precarious state. More precisely, we furnish a tool to overview the impact of the adoption/deployment of strategic opportunities on (i) strategic objectives (to evaluate strategic value), (ii) stakeholder goals (to evaluate stakeholder value), and (iii) technological features (to evaluate user value). To answer the research question given in the introduction and, in accordance with the DS research cycles defined by Hevner [66], we are communicating an analysis of the *Relevance Cycle* in Section 3.3.1, the *Rigor Cycle* in Section 3.3.2 and the *Design Cycle* in Section 3.3.3.

3.3.1 Relevance Cycle

The *Relevance Cycle* concerns the identification of opportunities/problems in the application domain. In our context, we identified the problem referring to the lack of a framework being able to adopt strategic opportunities in short time frames through the evaluation of the value they offer on a strategic, tactical and operational level. The problem has been identified in practice within a partner organization (that had already been in collaboration for the build-up of [176]). The former had been implementing an IT governance framework that was in a state of disruption with traditional (IT governance) frameworks for allowing the evaluation of larger technological developments and their added value on multiple levels; however, the framework was not agile enough to deal with changing business contexts. Even though agility was a major area of concern, together with the quest for integration with operational agility approaches, their existing framework offered analysis abilities through the use of conceptual modeling. The latter also contributed to the creation of an archetype for the evaluation of the strategic opportunities while maintaining uninterrupted the daily mode of operations within the organization. The recognition of the aforementioned problem along with the creation of the artifact occurred iteratively. The final release of the artifact had to satisfy each sub-sect of this problem.

3.3.2 Rigor Cycle

The *Rigor Cycle* refers to the theories/methods that are used to ground the construction and evaluation of our artifact. Our framework is built upon an existing framework for IT governance validated in previous research. In order

to support the contribution of this chapter, we created a so-called 'pseudo-ontology[1]' [164, 131] (i.e., not a fully-fledged ontological construction but the creation of an informal user friendly ontology). Indeed, we use a restricted and structured form of natural language to state and clarify the definition of its concepts. A Unified Modeling Language (UML) class diagram [118] is used to formalize the concepts of our ontology as well as the links between these concepts. The ontology and its application, through the use of existing models, constitute a contribution to the knowledge base of agility. More precisely:

- For the **strategic layer** we started from the MoDrIGo framework which was applied for the IT governance of the partner organization. More precisely, the strategic-layer concepts started from the ontology of MoDrIGo. The latter is aimed at defining key concepts for a governance situation where development/adoption decisions need to be taken for IT services. We were interested in linking the strategic layer with the overall organizational (business and/or IT strategy) so we used MoDrIGo for the representation of the business (and IT) strategies because of its specific purpose of evaluating business and IT alignment out of conceptual models for service-based systems. The business situation we aim to represent here is nevertheless slightly different than in the traditional MoDrIGo framework. We have reviewed a series of papers for the identification of relevant concepts for strategic agility. Unfortunately, and as explained before in this chapter, we mostly found sources negotiating it in a very abstract manner through qualities or practices to align to but never in the form of a framework that can be instantiated. Therefore, the concepts had to be refined from the domain of strategic agility but also driven by traditional agility (thus focusing on value). The framework indeed focuses on any technological adoption driven by a moving business context (which could also be an IT service); we have thus included the ones of *business context* and *strategic opportunity*. Finally, with respect to MoDrIGo, the concept of *Business IT Service* (by nature also very abstract thus represented at strategic-level, see [176, 184]) has been removed; the *strategic opportunity* can nevertheless be a *Business IT Service* even if the former is broader so can be a broader range of technological means;

- For the **tactical layer**, the concepts are driven by stakeholder analysis so we tried to incorporate/represent the impact on stakeholders and the value provided to them by the adoption of the *strategic opportunity*;

- Finally, for the **operational layer**, we link the tactical concepts to the notions of *Epic User Story* and *User Story* (these concepts are defined in [29, 181, 182]) to point to the agile (operational) development of the strategic opportunity; this nevertheless remains an optional part and is left for future work.

[1]We use here the term *ontology* because we depict a representation of the relevant concepts to deal with an agile situation at strategic and management levels. The pseudo-ontology is then supported by two existing models for graphical representation. Thereby, it is not a meta-model as such because it is instantiated using two different models.

3.3.3 Design Cycle

The *Design Cycle* refers to the construction and the evaluation of the artifact. Our framework (which we refer to as the artifact developed in this research from a DS perspective) has been constructed as an evolution of existing approaches that have been adapted to support agility on multiple levels due to the underlying focus on value. The evaluation is done through a case study onto an organization where the impending problem has been identified.

The framework focuses on value through the triptych: *strategic*, *stakeholder* and *user*. The visual representation of the levels and the respective value brought is made using existing models and following the principle of *separation of concerns*. This means that although the ontology is presented here as a unified set of concepts, instantiations are done through the use of different models to illustrate/treat the different aspects of the problem separately. This allows to keep the problem manageable; we can also deal better with scalability when evaluating strategic opportunities having a large impact on the organizational setting or the representation of situations with the adoption of multiple strategic opportunities. More specifically:

- At **strategic level**, an Non-Functional Requirements (NFR)-like diagram [28] is used to represent the benefits of the strategic opportunity(-ies) on the business objectives to identify strategic value. Such diagrams were originally used to represent non-functional requirements but have later evolved to represent high level (very abstract) strategic objectives and trace the impact of functional developments (called operationalizations) on these kinds of developments (see for example [86, 176]). This level thus allows to isolate the strategic objectives and the strategic opportunities as coarse grained elements to study instantly the impact of the later on the former without tactical-level details (i.e., details on the impact of the deployment of the opportunity on the organizational setting);

- At **tactical and operational levels**, a Strategic Rationale Diagram (SRD) [201] is used to represent the stakeholders and identify stakeholder value. Although it is called *strategic*, the SRD allows to represent a tactical-level situation where the goals of individual actors (i.e., stakeholders) and the means for their realization can be documented. It allows to study the organizational impact of the adoption of a strategic opportunity and, consequently, the induced value for these stakeholders (so stakeholder value, at tactical-level). Finally, end users of the technology constituting the strategic opportunity can be represented in the SRD along with their goals and tasks to identify the value, provided by this technology, for them (so user value, at operational-level).

To show how the ontology can be dynamically used/applied in practice and supported with existing models, we also depict a process fragment, i.e. a set of process elements out of which concrete process instances can be composed when executed. The latter illustrates how to apply the framework as a method or within an existing (software) development method. It has been built generically

to highlight the roles and activities that are performed in the context of a strategic opportunity evaluation for adoption decision. The constituting activities are customizable in function of the project and the process fragment should only be taken as a guidance for application; it is not meant to be used as a turnkey process but as a plug-in to technology development/adoption methods and/or agile methods; it has been formalized using the process fragment concepts of [137] and represented graphically in i* [201] in the same fashion as in [180, 176]. We chose the formalization of i* because it highlights the social dependencies between the actors/roles without it being sequential. Indeed, we did not aim to document a sequence of activities in the process fragment because of the high variability existing in the sequence and/or parallelism from business situation to business situation. This also shows implicitly the flexibility in the adoption of the process fragment by an organization. Indeed, multiple activities can be performed simultaneously, some can be omitted while others can be added and the sequence can be chosen in function of the field requirements/constraints. Workflow-based notations – that are more directive in terms of sequence – do not highlight social dependencies and are less tailorable/customizable, thus less relevant. Conversely, the i* notation accounts for the variability in the activities' execution and selection.

The validation of the framework has been made through a case study in a Belgian hospital already studied in previous work (see [186, 176]) but with the new context of the Covid-19 crisis as the cause of a changing business environment. The same organization had already applied the MoDrIGo approach (see [176]) but needed a more flexible approach to deal with crisis situations like for example the Covid-19 pandemic. More specifically, new technological developments helping to deal with the Covid-19 situation are evaluated through conceptual modeling to identify the value provided at various levels. For illustration purposes, we take the examples of *a videoconferencing system* and *a Covid-19 self assessment app* considered here as the *strategic opportunities*. This is fully detailed in Section 3.7. An expert opinion on the framework and its application has also been gathered for a better appraisal of the contributions.

3.4 Ontology

Figure 3.1 depicts our reference ontology documenting the concepts required for dealing with strategic agility.

For the description of the ontology, we will first start with the strategic-level; strategy is one of the most important aspects of corporate governance [45]. Strategic agility essentially delivers its full potential in a dynamic business environment where the context changes without notice and unexpectedly. We refer to this as the *Business_Context* which is represented as a class in the ontology. An example of an instance could be the Covid-19 pandemic, the 2008 financial crisis, the 2015/2016 terrorist attacks in Paris and Brussels, or other kinds of game changing events like a merger, new trends in customer habits, new behavior in employees' work, etc. The core strategy may be impacted by the business context; we represent this by the *drives* relationship link between the *Business_Context* and the *Strategic_Objective* class (the latter

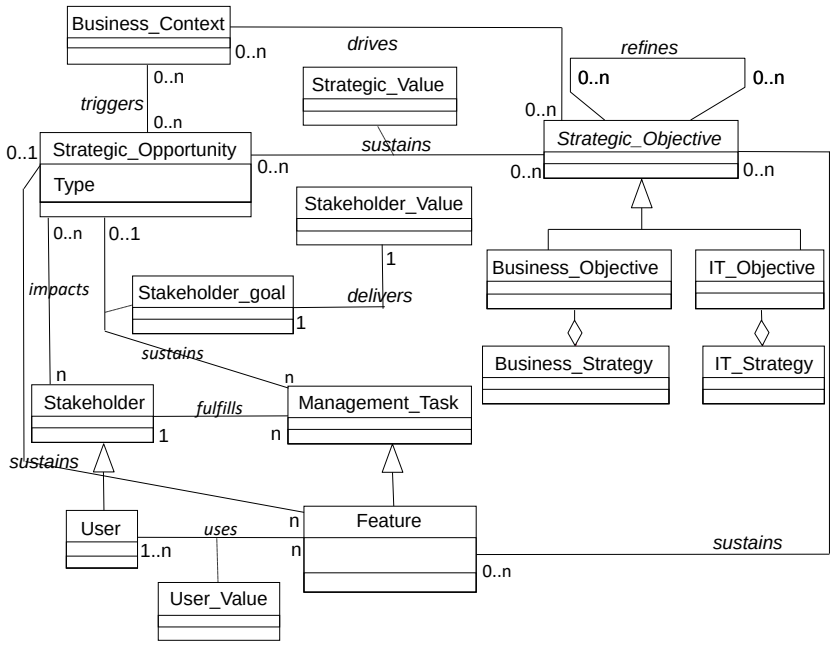


Fig. 3.1 Strategic Opportunities Driving the Strategic Objectives: An Ontology.

can be in nature a *Business_Objective* then part of the *Business_Strategy* or an *IT_Objective* then part of the *IT_Strategy*). In parallel, a changing *Business_Context* can drive one or more *Strategic_Opportunities*; these have a *Type* attribute that identifies the form it takes, e.g. an IT Service (see for example [56, 184] for a characterization), an entire software system, a single mobile application or any technological device. These are represented by the *Strategic_Opportunity* class in the ontology; what matters is that the development/adoption of the *Strategic_Opportunity* requires an amount of effort/resources having a significant impact on the organization's performance jeopardizing its competitive position in the long run. The adoption of the *Strategic_Opportunity* can thus sustain pre-existing *Strategic_Objectives* and/or new ones driven by the *Business_Context*. When a *Strategic_Opportunity* sustains a *Strategic_Objective* it delivers *Strategic_Value* to the organization.

The management-level further supports the governance one through the implementation of solutions supporting the strategic decisions/objectives. We aim here to bring value through the adoption of the *Strategic_Opportunity* to all of the stakeholders (represented through the *Stakeholder* class). The latter entails all the actors that have an interest in the organization and can either affect it or be affected by it. The approach presented here is, by nature, aimed to be stakeholder-driven and, to such an end, it explicitly identifies *Stakeholder_Goals* so, as a consequence, *Stakeholder_Value* resulting of the adoption of a *Strategic_Opportunity*. *Stakeholders fulfill Management_Tasks* some being required by the *Strategic_Opportunity* to be successfully adopted/deployed in the busi-

ness environment. Also, they achieve their individual *Stakeholder_Goals* by the fulfillment of *Management_Tasks*. In turn, the users (represented through the *User* class) are a subgroup of *Stakeholders* that are directly using the *Strategic_Opportunity* in one way or another. Consequently, *Stakeholder_Value* is a concept that is broader than the *User_Value*, the latter being value given by the immediate use of the *Strategic_Opportunity*. More specifically, a *User* uses a *Feature* which is a special kind of *Management_Task* that possibly sustains, through technology, the realization of *Strategic_Objectives*. Stakeholders get direct (if they are *Users*) or indirect (if they are not *Users*) value from the adoption of the *Strategic_Opportunity* (through the use of its *Features*) in the specific *Business_Context*.

The evaluation of a strategic opportunity (in the aforementioned manner) suggests implicitly that the application of the framework is not made to be fully top-down but rather a round-trip between the levels to identify and exploit the relevant identified sources of value at any level. Further explanation on the followed application process will be given in section 3.6.

3.5 Model-Based Value Representation

While the previous section concentrated on defining the relevant concepts for strategic agility and the sources of value, this section proposes an instantiation of the concepts using existing modeling notations to visualize the sources of value brought by the adoption of a strategic opportunity at strategic (governance) and management levels.

3.5.1 Strategic Value Driven by Strategic Opportunities: NFR Approach

In accordance with MoDrIGo and, as explained earlier, to represent the strategic level (where the strategic value brought by the adoption of a strategic opportunity can be identified), we use an NFR tree [28]. Indeed, the latter is used first to build a strategic-level representation offering a decomposition of the *Strategic_Objectives* in a refinement fashion. Note that the same modeling approach can be followed for the organization's *Business_Strategy* and for the *IT_Strategy*. In both cases, *Strategic_Objectives* are refined from top-level parent elements to more concrete leaf-level elements. In the NFR tree, *Strategic_Opportunities* are linked to leaf *Strategic_Objectives* through contribution links; this is both valid for the *Business_Strategy* and the *IT_Strategy*. Positive and negative contributions are inferred from the i* *Strategic Rationale Diagram* (*SRD*) – i.e., the management level – as task elements fulfilling a solution contributing to the realization of the *Strategic_Objectives* (see Section 3.5.3). A canonical form of an NFR tree customized for our purpose is given in Figure 3.2.

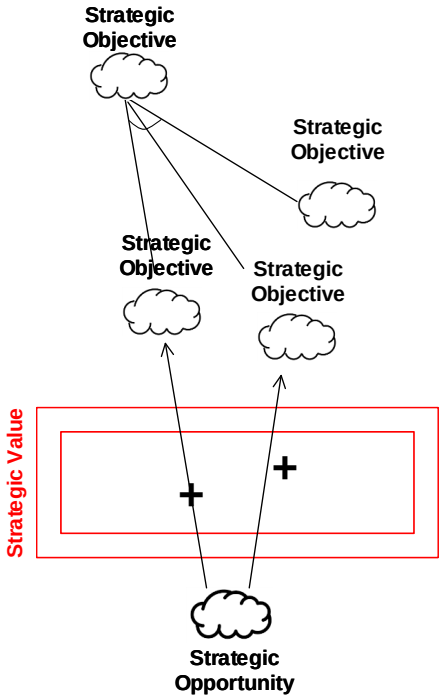


Fig. 3.2 Model-Driven Representation of Strategic Value: Canonical Form.

3.5.2 Stakeholder and User Value Driven by Strategic Opportunities: i* Approach

In accordance with MoDrIGo, to represent the management-level (where the stakeholder and the user value are identified), we use the i* *SRD* [201]. Nevertheless, the latter is slightly adapted/customized for our specific purpose. Figure 3.3 depicts a canonical form of the i* SRD instantiated to outline the *Stakeholders*' intentions with respect to the *Strategic Opportunities* (so the impact of the latter on the former) within the organizational setting.

The i* framework is a goal-oriented graphical requirement modeling notation [201]. It allows an early requirement engineering analysis in environments where social actors depend on each other for goals to be achieved, tasks to be performed, and resources to be furnished [201]. Previous researches proved the relevance and utility of i* to model organizational requirements of a "multi-agent system" [184] facilitating stakeholder's interactions by depicting their dependencies and hence providing a mean for coordination. i* was previously used to model several organizational settings [172] like online stores [87], hospital beds management and health care [176, 186], supply chains and more specifically outbound logistics [175], production support in the steel industry [187] and also for the development of higher education platforms like collaborative learning software [86] and Massive Open Online Courses (MOOCs) [183]. The i* framework is divided in two parts, each providing a different level of abstraction: the Strategic

Dependency (SD) model (used for the representation of actor-interdependencies) and the Strategic Rationale (SR) model (used for the representation of the actors' internal intents) [201]. Figure 3.3 provides the core elements of the i* framework as well as their graphical representations.

The first element that needs to be highlighted is that *Strategic Opportunities* are explicitly represented, in the diagram, as i* actors stereotyped as i* agents (because a *Strategic Opportunity* is, in our framework, by nature technological). The most concrete *Strategic_Objectives*, identified during the strategic evaluation, are cascaded in the i* SRD representation at management level as goals in the scope of the agent(s) representing the strategic opportunity(-ies). A *Strategic_Objective* found as a leaf in the NFR Business (or IT) strategy decomposition is found in the i* SRD representing the management-level organization *if and only if* the adoption of the *strategic opportunity* supports, by the use of a specific *Feature*, the realization of the *Strategic_Objective*. The *Feature* is represented as a mean to achieve the *Strategic Objective* it supports as an end (so means-end decomposition). The *Feature* is being pictured as an i* Task and the *Strategic Objective* as an i* goal. This allows to trace the concrete functional realization of the *Strategic Objective* through a *Feature*.

Similarly, the *Feature* requires the intervention of a user that gets direct operational value from its use but also has an impact on a broader range of stakeholders that, even if they are not direct users, need to be somehow involved for a successful adoption. Stakeholders typically need the strategic opportunity (through its *Features*) to help towards the fulfillment of some of their goals; these goals are represented as dependencies between the actors. So, all in all they get value from the adoption of the *Strategic Opportunity*. Note that, in the canonical form of Figure 3.3, one of the goals is represented as a dependency required by the Stakeholder (depender) but needs support from the Strategic Opportunity (dependee); in that case the latter finishes a service like automation, computing, etc. to fulfill the former's referenced goal (the stakeholder is not necessarily a direct user of the technology but is benefiting for its deployment). The strategic opportunity then furnishes stakeholder-value (as can be seen in the Figure). A *User* represents a *Stakeholder* that has a direct interaction with the technology implemented through the *Strategic Opportunity* (e.g. an application end-user). In the canonical form of Figure 3.3, the first goal dependency represents the *User* as depender and the *Strategic Opportunity* as a dependee so that the User needs a direct interfacing with the *Strategic Opportunity* to get (user) value. In the case of the second goal dependency, it is the *Strategic Opportunity* (depender) that needs the *User* (dependee) to fulfill it. In that case the technology might need direct input from the stakeholder for its processing.

3.5.3 Traceability Between the Strategic and Management Levels

Figure 3.4 merges the strategic- and management-level views to show that the Strategic Objectives found in the business strategy, depicted in the NFR graph, can be found within the scope of the actor representing the Strategic Opportunity at management-level. The Features there furnish a solution to

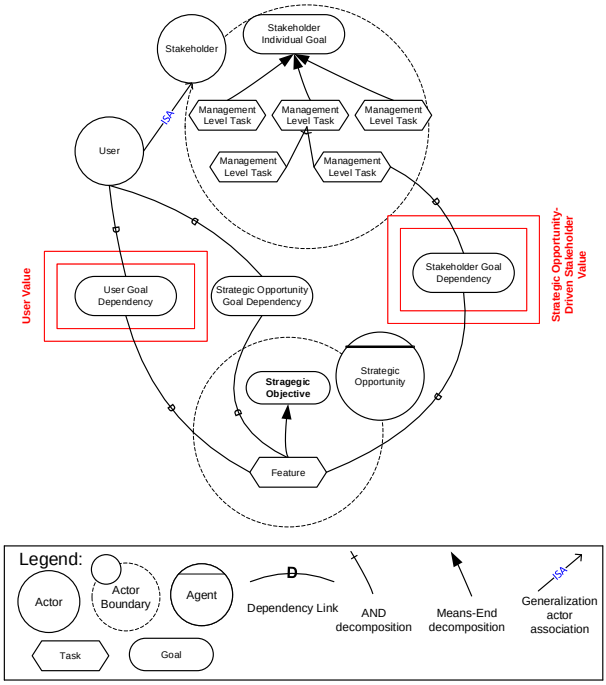


Fig. 3.3 Model-Driven Representation of Stakeholder and User Value: Canonical Form.

a Strategic Objective. Similarly, the Strategic Opportunity is represented at management-level as an actor whose internal intentions can be depicted, and, at strategic-level, we only see an aggregation of it summarizing its overall impact of the Strategic Objectives (so on the business strategy).

The aim is not to build the strategic representation before the management-level one since one needs the latter to infer the overall contribution of the strategic opportunity on the strategic objectives. The goal is rather to do the two representations together and to have a round trip where different configurations can be tested. As an example of how a development team can get along with the different diagrams and collect the required knowledge, we depict in the next section a process fragment illustrating the possibilities when applying the framework. We would rather say that we are in a middle-out approach than in an top-down or a bottom-up one.

3.6 Process Fragment

As already said, to highlight the ***Roles*** involved in the process fragment, their ***Work Product*** dependencies and their ***Activities***, we use a pictorial

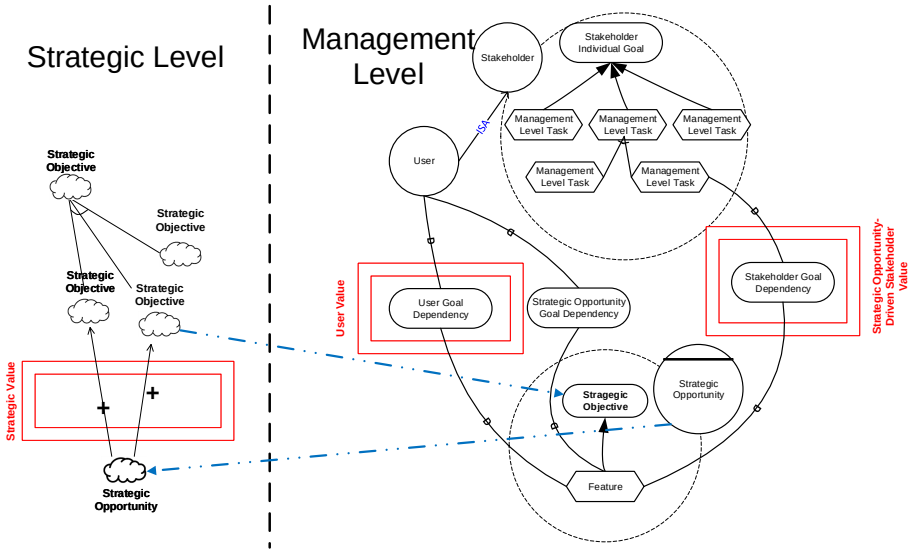


Fig. 3.4 Traceability Between the Strategic-Level (NFR graph) and the Management-Level (i* Strategic Rationale Diagram).

Description using the i* framework[2]. Each ***Role*** can be played by several individuals; similarly, an individual can play different ***Roles***.

Table 3.1 documents all of the process fragment elements defined in Seidita et al. [137] that are instantiated onto our contribution using i*; this mapping is taken from previous work and is further justified in [180].

Table 3.1 Instantiation of a Process Fragment as an i* SRD.

Element	Definition (from [137])	i* Representation
Phase	*A specification of the fragment position in the design workflow. Usually referring to a taxonomy.*	Goal
Activity	*A portion of work assignable to to a performer (role).*	Task
Work Product	*The resulting product of the work done in the fragment; it can be realized in different ways also depending on the specific adopted notation.*	Resource

[2]We use i* in this section to depict how the framework can be used by a consulting or professional team. i* is also used **in** the framework to depict a management-level organization of stakeholders (as seen in Section 3.5.3). So, i* is used in 2 very different contexts in this chapter and these should not be mixed to understand the research.

Role	*The stakeholder performing the work in the process and responsible of producing a work product (or part of it).*	Actor
Description	*It is the textual and pictorial description of the fragment; it provides a panorama on the whole process the fragments come from and the fragment overview in terms of tasks to be performed, roles and work product kind to be delivered.*	A Strategic Rationale Diagram

Figure 3.5 depicts our process fragment using an i* SRD; the following description systematically refers to it. We distinguish several types of stakeholders, all having various objectives and expectations, i.e.:

- The *Board of Directors* (*BoD*) ***Role*** represents the top management of the organization regrouped in advice and/or decision boards [191]. The BoD is required to *Set-up the Strategy* and to be *Dealing with a Changing Business Context* which are process *Phases* so represented as *Goals* in the i* SRD. These ***Phases*** basically involve the same ***Activities*** as can be viewed in the graphical representation, so we point out that the former ***Phase*** is about defining the strategy in normal times while the latter represents evaluating the strategy shift when a new business context (as defined in Section 3.4) takes place. The main *Activity* (represented as an i* Task) required to perform these *Phases* is *Determine Strategic Objectives*. The *Strategic Objectives* are then a *Work Product* required by the *Strategy Manager* to perform its *Activities*;

- The *Strategy Manager* ***Role*** thus depends on the *BoD* ***Role*** for obtaining the *Strategic Objectives* ***Work Product***; that is why it is represented as a Resource dependency in the i* diagram of Figure 3.5. The *Strategy Manager* is responsible of the *Determine Strategic Value* ***Phase***. This is done through the realization of the *Evaluate Impact of Strategic Opportunities on Strategic Objectives* ***Activity***. For this, the *Strategy Manager* requires the *Strategic Objectives* but also the *i-star Strategic Rationale Diagram* produced by the *Analyst* ***Role*** in order to examine the impact of the *Strategic Opportunities' Features* on the *Strategic Objectives*;

- The *Chief Information Officer* (*CIO*) ***Role*** is in charge of the *Evaluate Strategic Opportunities* ***Phase***. To such an end the ***Role*** performs the ***Activity*** *Determine/Overview Features*. The latter examines in detail the main ***Features*** brought by the *Strategic Opportunity*. The *Analyst* ***Role*** is depending on the *CIO* ***Role*** for the *Strategic Opportunity's Features* ***Work Product***;

- The *Analyst* ***Role*** is in charge of understanding the intentions of stakeholders with respect to the *Strategic Opportunity*. To this end, this ***Role*** is

in charge of the *Determine Stakeholder Value* ***Phase*** which is represented as an i* Goal in Figure 3.5. A means-end decomposition then allows to refine the i* Goal representing this ***Phase***. To fulfill it, the *Software Analyst* ***Role*** performs the ***Activity*** *Represent stakeholder's goals and management tasks*. The purpose of this ***Activity*** is to build an i* SRD representation (see Section 3.5.3). More domain knowledge is usually needed to fully perform this ***Activity*** so that the *Analyst* ***Role*** needs to discuss elements with all of the possible stakeholders (including *Users*) to understand their *Intentions*. The (*Strategic Opportunity's Adoption Stakeholders*) *Intentions* are then a ***Work Product*** represented as a resource dependency: the *Analyst* depends of the *Strategic Opportunity's Adoption Stakeholders* for furnishing it;

- The *Stakeholder* ***Role*** is in charge of performing the *Furnish Knowledge* ***Activity***. The result of this ***Activity*** is the ***Work Product*** *Intentions* furnished to the *Analyst*;
- The *Product Owner* ***Role*** is in charge of the *Determine User Value* ***Phase***. To such an end, it performs the *Define Epic User Stories* ***Activity***. Epic User Stories are essentially mapped to the *Strategic Opportunity*'s *Features*. The *Product Owner* ***Role*** is also in charge of collecting the *Feature's User Stories* from the *User* ***Role*** for an Agile development of the *Feature*;
- The (end) *User* ***Role*** is in charge of performing the *Furnish Feature Requirements* ***Activity***. The result of this ***Activity*** is the ***Work Product*** *Feature's User Stories* furnished to the *Product Owner*.

3.7 Framework Application, Evaluation, and Validation

This section summarizes the application of the framework on the case of the hospital. The presentation of the subsections follows a logical order. Subsection 3.7.1 depicts the context of the study. Subsection 3.7.2 depicts the data collection process, the evaluation of the representations, and the gathered expert opinion. Subsection 3.7.3 depicts the evolution of the strategy in the changing business context of the Covid-19 pandemic. New business objectives are indeed identified and exposed in the latter subsection; these new objectives, along with the existing ones, represent the elements that need to be sustained by strategic opportunities. The follow-up order explains that we need the information provided by the management-level illustrating the tactical and operational support of the strategic opportunity's features (depicted in subsection 3.7.4) to be able to aggregate the overall support of the strategic opportunity on the business objectives constituting the business strategy. Finally, subsection 3.7.5 overviews the impact of the strategic opportunities' adoption on the evolved business strategy as an aggregation. This is the reason justifying the placement of subsection 3.7.5 as last; the presentation in subsection 3.7.5 can indeed be seen as a roll-up of the representations of subsection 3.7.4.

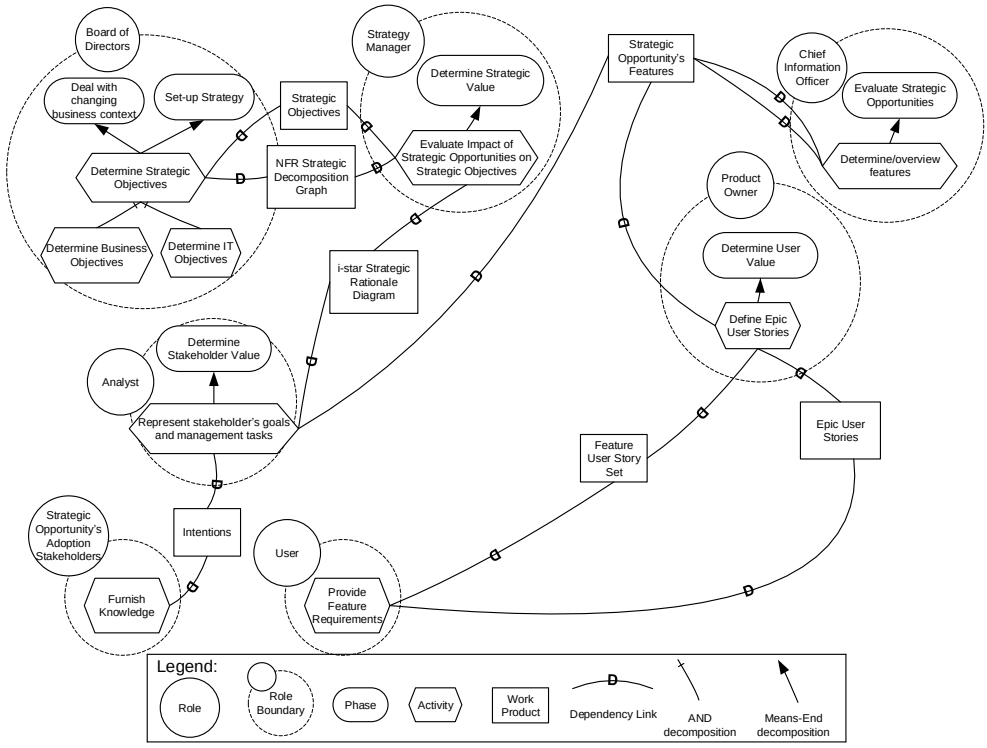


Fig. 3.5 Process Fragment for Strategic Agility.

3.7.1 Case Study Background

The case study described in this section further develops the case of a Belgian hospital already used for validation purposes in [176] and whose strategy has been described extensively in [186]. The example is adapted in some parts to deal with confidentiality issues but taken from a real case. Even though the application is only partial, it is meant to be realistic and relevant. Saint-Romain[3] is a Belgian hospital whose activities have grown exponentially in the last few years; available IT budgets have nevertheless grown only in a linear way.

The hospital has been dealing recently with a drastic change in the business context. To be specific, the Covid-19 crisis has drastically impacted Belgium causing the need for an immediate response from the authorities. This context is particularly interesting to study the impact of a few initiatives seen as strategic opportunities on their produced value at strategic, stakeholder and governance level. The examples provided here refer to a *videoconferencing system* and a *Covid-19 self-assessment app* developed as part of the measures taken to control the pandemic.

[3]For confidentiality reasons the name of the hospital has been changed.

3.7.2 Data Collection, Representations Evaluation, and Expert Opinion

The collaboration with the hospital started a few years ago with the development of a new information system for the hospital (more information about the implemented software system can be found in [186]). Back then the university team did not participate in the implementation (coding) of the new software system but it was involved in the organizational modeling and design of the new system. Organizational representations using i* were realized then and validated as a continuous process with the staff members in a back and forth fashion.

The business strategy representation is an evolution of the one presented in [176] and has also been built on the basis of interviews. With respect to previous developments, the current research implied collecting new information about the impact of the pandemic on the hospital's strategy as well as the IT developments that have (or have been envisaged) to be set-up in response to it. We consulted sources internal to the hospital to identify the impact of the pandemic on the strategy. Nevertheless, the data collection was not done in a systematic way but rather as a recollection of the impact on the basis of the documentation at disposal. External sources, including more technical documentation, were also consulted to evaluate the functions supported by strategic opportunities and to be taken as example when realizing the i* representations.

The researchers' experience with the strategic representations and with i*, the pre-knowledge on the organization as well as the available technical documentation assisted in the rapid realization of the modeling within two business days. The models were not further validated with the members of the hospital. Nonetheless, they were audited (together with the entire approach) by an external expert in digital transformation having extensive (10+) professional experience in conducting digitalization projects along with a deep understanding of academic approaches (the expert holds a PhD in business strategy). The latter confirmed the interest and value of the approach while he never made use of a structured (meaning non-textual) approach to depict a business (or IT) strategy. Similarly the structure and impact given by the management-level was pointed out as a strength of the approach; the expert pointed out such a structure is traditionally given/perceived in an ad-hoc manner (or with the use of a generic digital roadmap that is not adapted to moving contexts and very waterfall in its spirit) without any reasoning ability. He notably emphasizes *It is not really about immediately identifying structural changes, it is more about bringing the necessary, the required bricks in order to identify required changes and be able to adapt.* The interviewee pointed out that the application and adoption of such a framework in times of business variability changes the mindset of people seeking for digital innovations *...by reviewing the involved stakeholders, resources and capabilities and thinking about potentially integrating strategic opportunities on-the-fly changes your way of working.* In turn, the interviewee explains that before being agile at all organizational levels, especially at a higher one, a *digital maturity* needs to be reached in the organization where knowledge and mastering of key components like the current IT infrastructure, the strategy, knowledge about stakeholders, etc needs to be reached. According

to the expert, StratAMoDrIGo is an innovative way of reaching towards a higher level of digital maturity by becoming more efficient in IT adoption decisions. The interviewee also identified the importance of working top-down and bottom-up at the same time (so implicitly working in a middle-out fashion). By that, the expert referred to the capability of identifying the structural impact (i.e., the organization of stakeholders) of technological adoption, the end-user experience and, at the same time, identifying the strategic impact. The representations of StratAMoDrIGo can be updated and reconfigured at will and this allows to support the framework's round-trip way of working while reasoning on business situations. Business reasoning is an important point of consideration for the interviewee pointing out the necessity to include new business models and streams of revenue which, in changing times, they can be partially studied through considering strategic opportunities as new actors impacting the organizational setting. Finally, the expert recognized the lack of a global reasoning mechanism within the framework which would act as a way to quantify value ex ante and measure value ex-post for a full governance life cycle support. The expert would also like to see a measure of risk and a cost of adoption of different configurations (i.e. scenarios) represented through the framework. These elements will be studied later even if the heaviness of quantification in hazardous times could act against the simplicity/speed required by agility at all levels.

3.7.3 Evolution of the Business Strategy due to the Business Context

As said previously, the *Business Context* in our case study is the Covid-19 pandemic; the *Strategic Opportunities* that pop-up in this context are the development of a *videoconferencing system* and a *Covid-19 self-assessment app*. As can be seen in Figure 3.6, because of the pandemic, new *Strategic Objectives* have been defined by the BoD; more precisely, we distinguish 4 new ones brought by the *Business Context* and 2 existing ones triggered by the *Business Context*. As an example, we can take the new *Business Objective* called *Establish a synchronous and asynchronous communication channel between the citizen and the health care professional* which has risen because of the pandemic and needs to be further supported by new IT solutions.

3.7.4 Stakeholder and User Value: Graphical Representation

Figure 3.7 shows a management-level representation of the impact of the *Strategic Opportunities* onto the *Stakeholders* in general and the *Users* in particular. As discussed in Section 3.5.3, the *Strategic Opportunities* are represented as actors in the SRD (they are particularly stereotyped as agents). All of the other actors (except for the *Integrated Videoconferencing for Primary and Specialized Care* and *Mobile App for Covid-19 Self Assessment*) represent stakeholders. We see explicitly what are the intentions of each stakeholder with respect to the *Strategic Opportunities* and from the *Strategic Opportunities* to the *Stakeholders* through the dependency elements (i.e., goals and softgoals in this Figure). Following Yu et al. [201], a softgoal is *... a condition in the world which the actor would like to achieve, but unlike in the concept of (hard-) goal, the criteria for the condition*

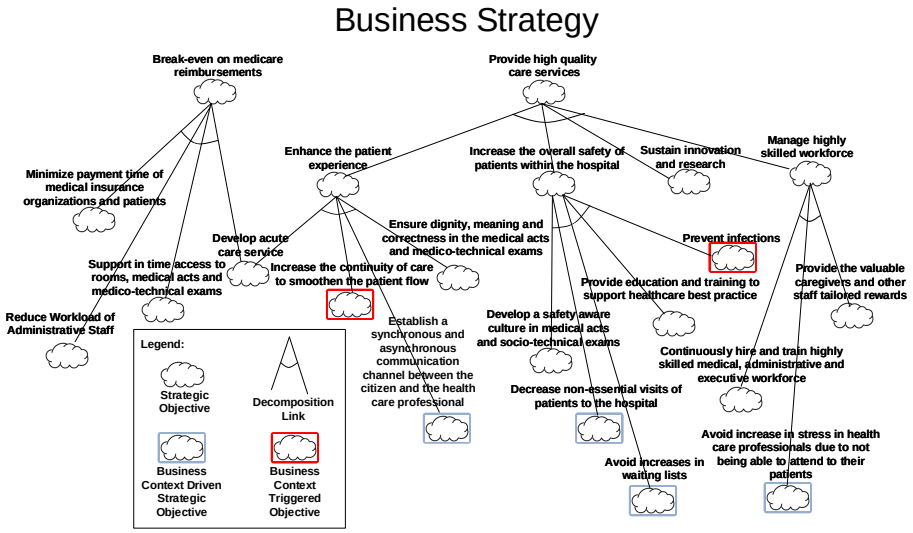


Fig. 3.6 Business Strategy Impacted by the Covid-19 Crisis.

being achieved is not sharply defined a priori, and is subject to interpretation. Within the scope of each actor, the internal goals and tasks that need to be achieved for a proper integration of the *Strategic Opportunities* are specified. Also, the *Strategic Objectives* supported by the *Strategic Opportunities* are cascaded into the agent's (representing the *Strategic Opportunity*) scope. We can take the example of *Establish a synchronous and asynchronous communication channel between the citizen and the health care professional* which is a *Strategic Objective* cascaded under the scope of *Integrated Videoconferencing for Primary and Specialized Care* which is a *Strategic Opportunity* represented as an i* *Agent*. The *Features* are the elements of the *Strategic Opportunity* that support each of the relevant *Strategic Objectives*. *Features* should be seen as coarse-grained pieces of functionality requiring IT capabilities to be executed. We can for example point the *Quickly furnish a meeting with the relevant healthcare professional* as a *Feature* furnishing a (partial) solution to the *Establish a synchronous and asynchronous communication channel between the citizen and the health care professional* through *Integrated Videoconferencing for Primary and Specialized Care* which is the *Strategic Opportunity*. The *Users* are the *Stakeholders* that are directly using the *Features*. The *Citizen* is an example of a *Stakeholder* that is also a *User* of the *Integrated Videoconferencing for Primary and Specialized Care* app and that depends on it for the fulfillment of its *Reduction of face to face visits* goal. *Features* can be further developed in an agile fashion on the basis of bottom-up approach. *Users* are then expected to specify their desiderata with respect to the implementation content of the *Features*.

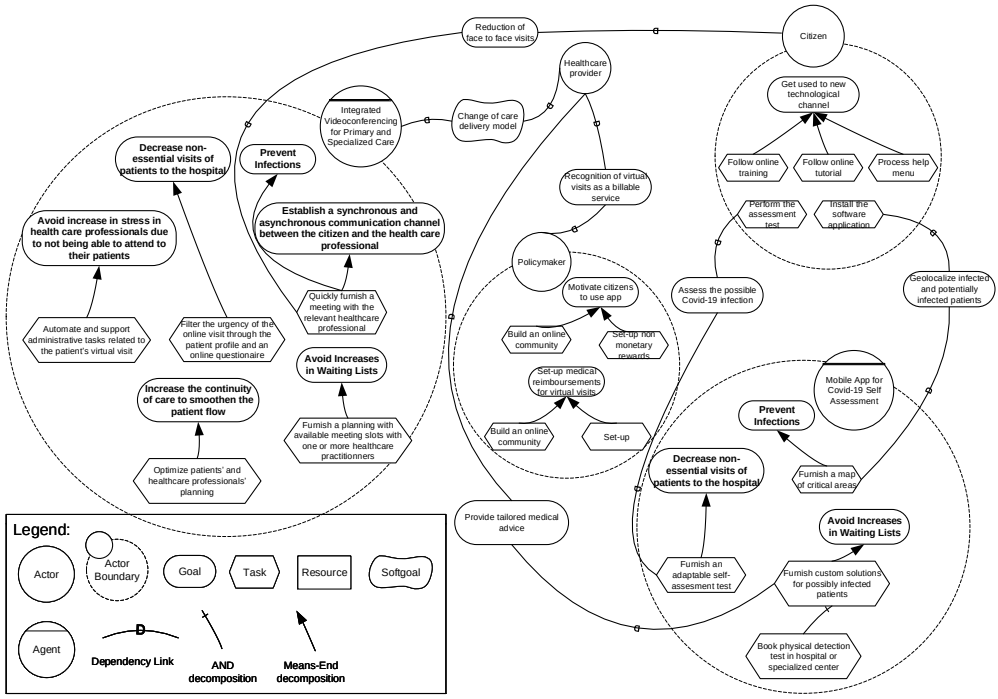


Fig. 3.7 Strategic Rationale Diagram Showing Stakeholder and User Value for the *Integrated Videoconferencing for Primary and Specialized Care* and *Mobile App for Covid-19 Self Assessment* Strategic Opportunities.

3.7.5 Strategic Value: Graphical Representation

The knowledge extracted from the i* SRD allows us to determine the positive impact of the *Features*' implementation/deployment onto the *Strategic Objectives* so as to evaluate the *Strategic Value* of the *Strategic Opportunity*. We can take the example of the *Integrated Videoconferencing for Primary and Specialized Care*; as we have seen in detail at the management-level (so in the i* SRD), this *Strategic Opportunity*'s *Features* partially implement the realization of the following *Strategic Objectives* (i) *Increase the continuity of care to smoothen the patient flow*; (ii) *Establish a synchronous and asynchronous communication channel between the citizen and the health care professional*; (iii) *Decrease non-essential visits of patients to the hospital*; (iv) *Prevent infections*; (v) *Avoid increases in waiting lists*; (vi) *Avoid stress increases in health care professionals due to not being able to attend to their patients*. Within the NFR graph of Figure 3.8 we can thus witness that a positive contribution link has been put between the *Strategic Opportunity* and the *Strategic Objective*. This gives a rolled-up representation useful to immediately identify the *Strategic Value* provided by the *Strategic Opportunity*.

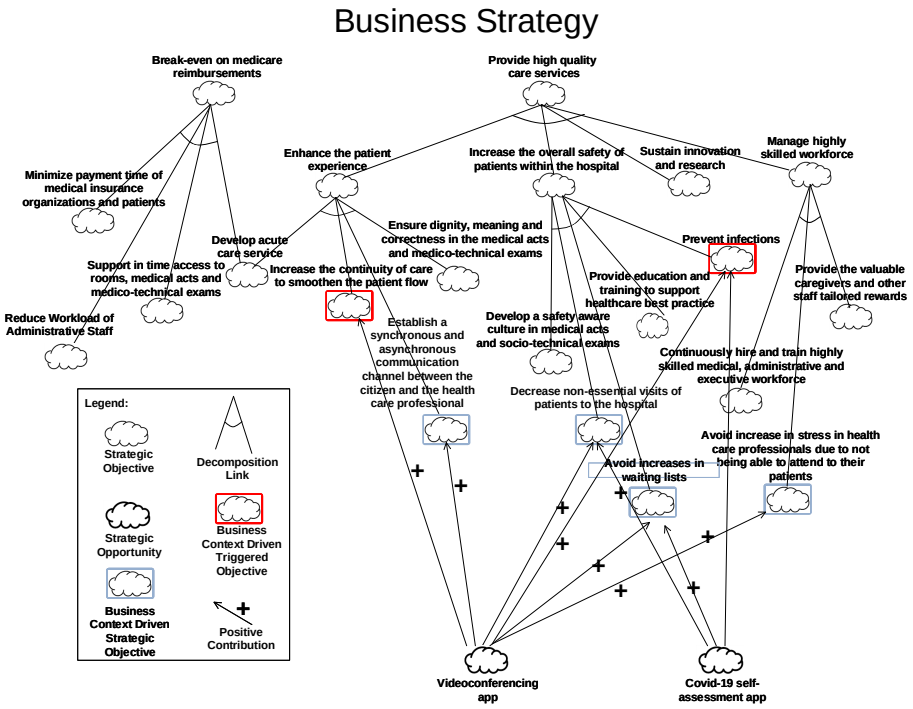


Fig. 3.8 Impact of Strategic Opportunities on the Business Strategy.

3.8 Discussion

This section further discusses different aspects of the framework. More precisely, Section 3.8.1 compares the framework with other approaches in terms of their contribution to strategic agility. Section 3.8.2 describes the lessons learned, the limitations, and the applicability of the framework. Finally, Section 3.8.3 describes the threats to validity.

3.8.1 Framework Comparison with other Approaches Using Strategic Agility as the Evaluation Dimension

As already discussed earlier, the ability to render an organization in a state of strategic agility is construed concerning an organization's capacity to **sense** opportunities in the event of changing business contexts, its capacity to **seize** opportunities when such events occur, and its capacity to **shift** (reconfigure) its assets to take advantage of strategic opportunities [49]. These 3 criteria are used as the constituents of our main evaluation dimension; in fact, we determine how the previously identified (and industry accredited) frameworks contribute to the attainment of these criteria (Table 3.2). The aim is to identify gaps and misconceptions compared to our current solution; regardless of the elements

included in the table, a few more considerations are given in the rest of this Section for the SAFe framework and e3value.

To begin with, SAFe signifies organizational agility as the optimization of operational agile development. SAFe considers an organization to be in a state of enterprise-wide agility when front-to-back supply-chain streams (they are called operational value streams within the framework) have been aligned with the agile development of a product to maximize its delivered value. To do so, SAFe prompts a continuous engagement of all the business actors in order to identify bottlenecks that would disrupt this value creation process. Nevertheless, SAFe does not seem to support a simultaneous top-down/bottom-up ideation process that would make it susceptible to external and/or internal business stimuli. On the contrary, the optimization of the operational value streams has to be reconcilable with the company's 'strategic themes' [4]. This limited capability in *sensing* changes in the business context admonishes the introduction of mechanisms for the evaluation of such changes (i.e., non-existent *seizing* capabilities). Overall, this asynchronous coping mechanism between the strategic and operational levels within the organizational ladder facilitates the erection of silos between development teams and the actual strategic directives 'indoctrinated' in a top-down manner. In this sense, the actual organizational leaders (i.e., roles in a position of influence) appear to be the agile coaches (or external consultants as mediators) acting as the 'conductors' of the agile release trains. Consequentially, one of the immediate actions that may come as a priority when implementing the SAFe framework is the harmonization of large scale agile development rather than the ability of the organization to reconfigure *(shifting)* its strategic assets to leverage drastic changes in the business context.

Contrastingly, e3value, aims to project the necessary organizational configurations that need to take place in order to make the release of a new product/service/technology viable economically. This is done via the evaluation of 3 distinct value-driven 'viewpoints' (i.e., value viewpoint for the business layer, the process viewpoint for the operational layer, and the system architecture viewpoint for the infrastructural layer); similarly to the purposiveness of Archimate, such an approach is focused on the successful governance of the endeavor that is under examination. However, e3value's consideration of value merely on its economic constituents (and its immediate byproducts) creates various strategic blind-spots (i.e., inadequacy to organize a faster response to changing business requirements/faster time to market to beat the competition etc.,) which impedes the exploration (*sensing)* of a dynamic business setting. In actuality, e3value supports tools/techniques (i.e., BPMN or UML activity diagrams) to bring the organization in a state of betterment when it comes to *seizing* opportunities and going through organizational configurations *(shifting)* to achieve such opportunities. Nonetheless, the latter can hardly be considered as strategic since they negotiate a better allocation of resources to economize on internal cost-saving procedures rather than bringing the organization in a state of readiness to exploit strategic opportunities.

[4]SAFe 5.1 describes these as the company's long-term values and a compliance evaluation process, reactive to new governmental regulations.

Table 3.2 Various Frameworks Facing Strategic Agility Criteria.

	Strategic Sensitivity (sensing)	Strategic Response (seizing)	Shifting
StratA-MoDrIGo	Its application and use pushes towards a culture of opportunities adoption and value seeking (also emphasized by the interviewee).	Quickly overviews the impact of the deployment of a strategic opportunity in terms of strategic, stakeholder and user value. Several configurations can also be studied through i*.	Through the representation of the information related to the adoption of a strategic opportunity with the identification of value, it supports communication of *what to implement* to the tactical/operational levels.
MoDrIGo	No support, Business IT Services are driven by need for IT support from IT clients (internal or external) and seldom driven by the business environment.	Overviews the impact of the deployment of a Business IT Service in terms of strategic value. Poor flexibility for configuration since Services are very constrained.	Through the representation of the information related to the adoption of a service, it supports communication to the tactical/operational levels.
SAFe	SAFe pushes towards a culture of taking advantage of external value streams. However, SAFe is more focused on feeding the operational Agile development.	No framework for ex-ante solution impact evaluation.	Development of software following the classical SAFe canvas, benefits are the one of large scale agile development.
e3value	Limited support in sensing new strategic opportunities/threats. e3value allows top-down ideation for the exploration of IT-enabled value propositions; however, the latter are analyzed profoundly on their economic viability.	With the use of BPMN or UML activity diagrams, e3value facilitates the provision of resource planning, resource allocation and release management cycles. Therefore, e3value offers the possibility of strategic response.	Limited support in shifting (reconfiguring) organizational capabilities towards the achievement of strategic concerns.

3.8.2 Practical Aspects and Applicability

In the case study, we only considered the alignment with the business strategy. Traditional corporate governance focuses on the completion of the business strategy while IT governance focuses on the IT one. The alignment with the IT strategy could be considered in the same way. Two reasons are given here to justify our focus on the first one: (i) in a moving business context, a quick adaptation is critical to get new revenue streams or keep the current ones flowing; this is the focus of the business strategy; (ii) the hospital is considered as being in *strategy execution* mode following the *Strategic Alignment Model* of Henderson et al. [62] so, in accordance with the BoD, we considered that the business strategy primes especially in the context of a changing business environment.

StratAMoDrIGo offers an interface ensuring continuity in the evaluation of value from the strategic to the management level. Strategic, stakeholder and user value is indeed evaluated through 2 traceable diagrams. Features – that can be aligned with epic user stories which constitute a functional level supported by methods like Scrum – can then be used to ensure concrete development by a traditional agile team. More precisely, features are the finest-grained level covered by our framework and the central pivot elements between strategic and operational agility. In other words, the framework allows to integrate IT governance mechanisms for adoption/implementation decisions with feature-oriented development (which are supported scope elements in user story-based development). Other types of information technologies (hardware, devices, off the shelf apps etc.,) being strategic opportunities can of course be adopted on the fly without a sprint-based implementation cycle but when strategic opportunities are based partly or exclusively on software, the latter cycle (or even a DevOps approach [12]) delivers an interesting way of implementing the feature(s). More specifically, we prescribe the use of (operational) agile development (e.g. through Scrum) for user-intensive applications where innovation plays a critical role. We also point (when possible) to independent feature development and deployment; this to effectively get all the sorts of value as early as possible as well as early field feedback that can later be used for adjustments and/or relevant knowledge for other feature(s) development. The strategic opportunity is thus not necessarily an unbreakable whole but since it is composed of features all delivering value, those can be implemented and deployed in an asynchronous manner (if these are of course sufficiently independent).

The StratAMoDrIGo framework is intended to be applied to organizations being in dynamic businesses by people providing support to the C-level executives. The latter are the ones that can use the framework to understand the implications of strategic decisions taken in a short time frame. Internal employees or external consultancy companies can apply the framework to furnish support and advice to a BoD (so composed of C-level executives). The process fragment for the application of StratAMoDrIGo provided in Section 3.6 gives an illustration of how internal employees or an external consultancy team can structure themselves for the application of the framework. The framework can be used on a regular basis to identify when the business context changes and new strategic opportunities can be identified. The results do not furnish

a binary true/false answer but rather a general guidance supporting C-level executives in the adoption or development decision they might have to take.

One may raise the question of the willingness of strategy consultants and agile teams to deal with a modeling approach, something they could be reluctant to. We cannot avoid making a strategic representation in the form of a diagram to ensure a proper alignment study; this is an exercise relevant for helping C-level executives to define their strategy and is independent of a software development practice (where mostly conceptual modeling is applied). In our experience from the case study of the chapter but also other cases, the representations can be done rather quickly with some knowledge of conceptual modeling. Moreover strategic representations need to be done once from scratch but then it is more an exercise of updating the information to keep it consistent. In a strategic agile perspective, the important but challenging aspect is to update the strategy with the impact of a new business context. Management-level representations are more time consuming but, in any case, if a new technology needs to be adopted in a short time frame, studying the impact of its adoption/deployment needs to be done to some extend as a premise to its design. Of course, it requires more time to study the complete stakeholder impact than only the operational requirements of users; this will eventually pay off with the provision of important information/insights on the IT investment(s) that needs to be made.

3.8.3 Threats to Validity

We discuss here the threats to the construct, internal and external validity of the StratAMoDrIGo framework and of its use.

3.8.3.1 Construct Validity

The design of StratAMoDrIGo had to be checked in terms of its construct validity. In the scope of a model-driven framework, within the information systems' domain, this means that the relevant concepts defined in this framework have been operationalized adequately into observable/workable elements [195]. A threat to the construct validity is that the modeling constructs are incorrectly interpreted by the modelers or any other practitioner aiming to put StratAMoDrIGo into use. This entails the risk of using the framework (and its corresponding concepts) in another way than intended. In our case, the modeling work has here been realized by the two authors of the paper and the operationalization of the modeling constructs, within the setting of the hospital-case, was discussed systematically. In consequence, every concurrent/conflicting interpretation was discussed and resolved beforehand. Overall, the threat of not being able to encapsulate exactly (via the modeling process) what is being claimed to be encapsulated can be mitigated through the use of meetings or workshops were every modeling choice is discussed by the practitioners and specialized consultants.

3.8.3.2 Internal Validity

Through the use of StratAMoDrIGo, the internal validity concerns the objectivity of the views gathered by the subjects within the knowledge acquisition procedure. Subjects can, during interviews, report on their personal view (as opposed to a collective consensus) when giving information on strategic or management-level aspects. This would lead to inconsistent representations. Since the specialty of each corresponding interviewee can create a partial or bounded view where some aspects of the modeled realization are (under)overemphasized, this threat to validity can be dealt with through multiple interviews and systematic comparison of the views of these actors for knowledge validation. In our case, the representations of the strategic-/management-level configurations in the hospital-case were determined based on a rigorous interview process (it is discussed in [176]) and an overall cross-reference of the subjects' individual opinions.

3.8.3.3 External Validity

External validity can be formally defined as the degree of support for the generalization of an 'architectural explanation' to a theoretical population [193]. In our case, the architectural explanation refers to the modeling constructs of StratAMoDrIGo, their in-between interactions, and the purpose they are supposed to fulfill (i.e., quick assessment of strategic opportunities in an organizational context according to the value they expose). A threat to the external validity is the misappropriation of StratAMoDrIGo when applied to different organizational settings by various supporting or consulting groups. This jeopardizes the generalized use of the framework by the corresponding information systems' community (i.e., our population). Until now, the framework has solely been applied by the authors of this paper, by members of the research group being familiar with conceptual modeling, goal-based requirements engineering and i* (so up to 5 people) and a few consultants familiar with conceptual modeling through UML. Such experience and pre-knowledge certainly has an impact on the ability to apply such a framework correctly and successfully so not many valuable insights could be drawn in terms of its generalization. For this reason, the ability of novice modelers to apply goal-based conceptual modeling has been tested in [188, 156] with other kind of formalisms. The latter showed that consistently applying goal-based frameworks with some guidance on real life problems can be done rather easily and it allows practitioners to understand requirements. Lack of experience with such frameworks can thus be compensated by proper guidance and it leads to an increase in understandability.

3.9 Conclusion

The need for an IT development approach structured around strategic opportunities yet allowing agility at all levels has risen progressively due to fast moving business contexts. The concept of value is, in StratAMoDrIGo tailored to (i) the strategic-level for the long-term competitive position of the organization, (ii) the tactical-level to ensure taking into account the broad impact of adopted

solutions on stakeholders and (iii) the operational-level to practically support the end-user requirements.

At this stage, we can get back to the RQ stated in the introduction (i.e., *How could conceptual modeling be applied to highlight strategic, stakeholder and user value within technological adoptions in a fast moving business context?*). To answer this question, we have developed a framework called StratAMoDrIGo which is to be conceived as an evolution of MoDrIGo. It has been formalized through an ontology and its instantiation has been based on the NFR and i* frameworks. On the one side, NFR allows to model the strategic layer and to roll-up the impact of the tactical and operational layers onto the (business or IT) strategy. On the other side, i* allows drilling down to detail how specific strategic objectives are supported by the (functional) features of strategic opportunities. StratAMoDrIGo has been applied on a case in the medical sector. It has also been compared to existing approaches to highlight its focus and support to strategic agility. The latter has been depicted within the (strategic management) literature as a concept describing the capacity of an organization to *sense*, *seize*, and *shift* opportunities. All in all, the application of StratAMoDrIGo (i) pushes towards a culture of persistently adopting opportunities and seeking value (sensing); (ii) allows to overview the impact of the deployment of a strategic opportunity in terms of strategic, stakeholder and user value but also to possibly test several configurations with the use of i* (seizing); and (iii) allows the representation of information related to the deployment of a strategic opportunity with the identification of value, supporting thusly the communication of *what to implement* to the tactical/operational levels (shifting).

Even if the framework has been fabricated to be the most expressive possible by using existing modeling notations, it can be seen as requiring some technical knowledge to be adopted. Even if the expressiveness and details may suffer in the process, we aim to provide something as simple as possible to organizations to ease the adoption on the largest possible scale.

Chapter 4

Strategic Agility In Practice: Experts' Opinions On The Applicability of StratAMoDrIGo

4.1 Introduction

The notion of strategic agility is to be considered as inherently paradoxical [38, 94, 76]. On the one hand, it dictates organizations to develop (and commit to) a comprehensive and well-articulated strategy that sets them apart from the competition. At the same time, organizations are required to allow for a certain level of flexibility to (i) accommodate the flow of new ideas, (ii) incorporate new technologies, and (iii) be able to maneuver efficiently in the face of external (or internal) changes in the business context. Consequently, there seems to be a need for comprehensive frameworks, clear processes, or any kind of exhaustive method that would make organizations refrain from having to rely on unintegrated (ad-hoc) processes in their effort to reach a state of strategic agility.

In this setting, the previous chapter purports the anatomization of a novel framework (StratAMoDrIGo) purposed to offer a practical roadmap on how diverse organizations can achieve a state of strategic agility. The model-driven approach of StratAMoDrIGo emphasizes primarily on the interdependence that has to be sustained between any top-down delineation of strategic objectives and the changes that occur externally (and/or internally) at the level of the organization. Simultaneously, StratAMoDrIGo aspires to promulgate the intentions of any stakeholder having an implicit interest in the adaptation of strategic opportunities; the latter could be schematically described as any novel technology intended to augment (i) employee productivity, (ii) customer satisfaction, (iii) competitive advantage, and (iv) overall capital gains, for the entirety of any organization. As explained in the previous chapter, StratAMoDrIGo aims to counteract the command-and-control design of various strategic agility frameworks (e.g., SAFe 5.1 [84]); such designs mostly favor the top-down indoctrination of a series of complicated operationalization procedures that end up impeding the bottom-up dissemination of agile core principles.

The present chapter can be construed as a more empiricist approach towards

the strategic agility research strand. More specifically, we offer the stand to professionals (experts) implicated in strategic agility implementation projects within contemporary organizations. We want to comprehend how these experts perceive the notion of strategic agility and how they implement it into the matrices of their organizational structures. Most importantly, we present these experts with the structure and internal workings of StratAMoDrIGo to receive some lessons about the latter's applicability and ease of use into the setting of a modern-day enterprise.

This chapter has been prepared in cooperation with L. Truyers, Y. Din, and Y. Wautelet; it is organized as follows: Section 4.2 describes the adopted research approach. Section 4.3 elucidates the sampling techniques for the retrieval of our strategic agility experts; it also illustrates the data collection technique speciated to gathering, cleaning, and compiling the pieces of information brought by these experts. Section 4.4 describes the data analysis and presentation of our results. Section 4.5 presents our derived insights, some possible limitations based on the design of our survey, and some concluding remarks.

4.2 Research Approach

Overall, there is a plethora of academic studies addressing the topic of strategic agility from a strategic management or human resources' perspective (see [128, 38, 39, 94, 2]). However, to this day, the theoretical attribution of such studies rather impedes organizations from exporting practical insights and developing comprehensive awareness on how to reach a higher level of strategic agility. Additionally, to the best of our knowledge, there seems to be a dearth in bibliographic references that perform empirical observations on the actual activators or inhibitors of strategic agility within the complex and ever-changing structure of modern-day enterprises. Thusly, we chose to perform an exploratory study [14, 134, 19] targeted at gathering, investigating, comprehending, and performing in-between comparisons of various strategic agility definitions attributed to a specific pool of experts. Instead of setting up initial testable hypotheses, we chose to be truly exploratory and rely on the collection of empirical data to identify, gather, and iteratively refine some of the strategic agility characteristics that seem to predominate the perception of these professionals; their competences were also used to perform a practical evaluation of the StratAMoDrIGo framework. In this context, an abductive research approach [134] i.e., a combination of deduction and induction was adopted due to its iterative exploration of the inference that best explains empirical data [135]. Indeed, the setting of our research exercise began with the identification of key strategic-agility project coordinators within several technology-oriented organizations, and the collection of data exploring these organizations' in-situ (or planned) strategic agility capabilities. We wanted to capture rich in-content, non-quantitative data in a bottom-up manner by these professionals' opinions, experiences, and expertise so a qualitative research methodology [79, 113] was adopted via the conduct of semi-structured interviews. Another objective that was placed adjacently to our research exercise referred to the iterative creation of an appropriate interview protocol. The creation of the latter had to be dealt

in a way rendering it capable of (i) collecting data for the factual exploration encompassing the nature of strategic agility, and (ii) properly exposing the StratAMoDrIGo to the acuity of these experts so they can consider its potentiality as a strategic agility facilitator. Our iterative process for the creation of the interview protocol followed the logic of the 'Interview Protocol Refinement Framework' described in the study of Castillo-Montoya [22]. Practically, this means that we did not use the same set of questions for all the interviewees; rather, following the premise of Evers & Wu [43] and Yin [200], we treated each instance of our sample as a transmitter of a cohesive amount of empirical knowledge capable of releasing information that can be used for the reevaluation, readjustment, and evolution of the interview protocol. The detailed analysis of both the data sampling technique and the iterative creation of the interview protocol can be found successively in the below section.

4.3 Data Sampling Technique and Data Collection

The nature of our research dictated the use of a purposive sampling technique [42] in order to determine a pool of respondents that possess a specific set of traits. To be specific, our target sample should primarily consist of individuals that are academically oriented and professionally competent in functions related to business information management, business and IT alignment, and/or software development. These individuals should have a broad (technical or managerial) view on subjects related to the implementation of agile frameworks and methodologies; executives and/or consultants that would be well-versed in matters closely associated to the optimization of business and IT processes could be particularly felicitous in terms of providing subjective definitions for the notion of strategic agility. There was no limitation in terms to the specifics of an expert's industry since we were aiming to capture multiple viewpoints from people in different sectors. An initial number of cases (3 candidates) was selected primarily from the professional network[1] of one of the members of the research team with the consent of the remaining members. A snowball sampling technique [134] was then followed from those initial cases in order to retrieve additional survey candidates whose profiles could adhere to the selection criteria as set by the research team. At the end, a total number of 13 candidates expressed interest in participating in the survey but 5 candidates were eliminated from the process as their roles were related to the formulation of business strategies and not so much involved with the implementation of agile solutions; this brought the final number of participants to 8 which was close to what Hennink & Kaiser [65] and Guest et al. [53] describe as the point of data saturation[2]. All the survey participants were in possession of advanced degrees; many of them had acquired several certifications related to the domain of agility (i.e., certified SAFe agilest, Lean Six Sigma [141] practitioner, etc.,) and they have had on-the-job training by being implicated in the

[1] Using a well-known professional networking social media platform.

[2] Hennink & Kaiser [65] estimate the point of data saturation for qualitative studies to be reached in between 9 and 17 interview cases. Guest et al. [53] estimate the point of data saturation to be reached in between 7 to 12 interview cases.

implementation of software-development projects. Some candidates, on account of their long-standing experience, were directly involved in projects related to upscaling agility at a strategic level. Due to privacy reasons, the names of these respondents will not be revealed. Table 4.1 provides an overview of their background, responsibilities, and characteristics.

Respondent	**Highest Degree**	**Current Role**	**Industry**	**Experience (years)**
Respondent 1	Master in Business Administration	Senior Consultant in Strategy and Digital Transformation for the Public Sector	Consulting	4
Respondent 2	Bachelor in Engineering	Director of Processes, Data Quality, and Innovation	Healthcare	12
Respondent 3	Master in Business and Information Systems Engineering	General Manager	Information Technology Services and Consulting	16
Respondent 4	Master in Innovation and Entrepreneurship	Digital Transformation Manager	Consulting	6
Respondent 5	Master in Digital Product Management	Information Technology Agile Delivery Manager	Automotive	6
Respondent 6	Master in Information Systems Management	Information Technology Strategy Manager	Consulting	6.5
Respondent 7	Master in Business Information Management	Business Intelligence Engineer	Consulting	3
Respondent 8	Master in International Business	Information Technology Strategy Manager	Consulting	5

Table 4.1 Participating Respondents and Their Characteristics.

At a later stage, these 8 professionals received a formal email invitation to participate in our survey along with detailed information about the interview process which would take the form of a 60-minute, individual conversation taking place online[3]. For the purposes of our study, we used a semi-structured interview format. This form of data gathering allowed us to be in contact with the interviewees and perform an in-depth dialogue guided by a set of questions; these were meant to allow the interviewees to express their understanding of the notions of strategic and operational agility in order to identify themes, patterns, and challenges in the implementation of strategic agility. As such, these questions were meant to serve as the preamble for the examination of the StratAMoDrIGo framework by these experts. In practice, after having conducted our first interview, we went into a process of adjusting our interview protocol (i.e., some questions had to be rearranged, the focus of some questions had to be more narrow, some questions had to be dropped altogether, etc.) as the interviewees were spending too much time focusing on the thematic related to the definition and implementation of strategic agility and did not have the time to get to the part related to the examination of the StratAMoDrIGo. The interview protocol was iteratively reevaluated and readjusted three times by the research team before reaching a stable form. This fixed form was then administered to the five remaining survey participants and can be described as such: for each interviewee, a combination of open and closed questions was used; these questions were clustered around 3 major thematic areas. Each thematic successively addressed (i) the definition and distinction between operational and strategic agility, (ii) the explanation of some of the practical issues regarding the implementation of strategic agility, and (iii) the evaluation and potential applicability of the StratAMoDrIGo framework. The specifics of the interview protocol are given below.

To reiterate, the interview protocol was split into three major thematic areas (parts). The first thematic was meant to collect background information about the experts' educational accreditations, their professional engagement, as well as explicating their responsibilities under the tenure of their current role within their respective companies. However, the centerpiece of this thematic area was dedicated to inquiring how the respondents realize the notion of strategic agility (e.g., *How would you define strategic agility?., In what specific ways does strategic agility contribute to change and innovation?., According to you, what traits does an organization need to exhibit in order to achieve a state of strategic agility?., Does it have an added value in each company?* etc.,). The questions that were addressed in this cluster were also meant to capture whether the respondents are able to distinguish between the preconceptions of strategic and operational agility.

The second thematic was meant to inquire the respondents about some of the methods/steps that they would take to implement strategic agility under the tenure of their current role. This part was also purposed to reveal some challenges that would impede this implementation. At the same time, the respondents were asked to report what they would consider as best practice in terms of overcoming these challenges (e.g., *What do you think are the most*

[3]We made use of an online-conference platform for the realization of the interviews.

effective methods of implementing strategic agility in a company?., Is there a standard method that you would apply in every company regardless the sector or size?., What do you consider as the biggest challenge to implement strategic agility in a company?., How do you go about in solving some of these challenges?., According to you, is there a method that offers effective tools in solving some or all of these challenges? etc..,).

The third thematic was dedicated to the evaluation of the StratAMoDrIGo. The purpose was to provide the interviewees with a general understanding of the framework. Accordingly, the interviewer was commencing this thematic by swiftly describing (i) the general structure of the framework, and (ii) the nature of strategic opportunities and how their value-driven impact can be evaluated at a strategic-, stakeholder-, and a user-level. A set of questions were then asked to appraise whether each expert found comprehensible, valuable, functional, and practicable the attempted linkage between strategic opportunities and the pursued value-driven vistas which the framework was creating (e.g., *In what ways, if any, you think that defining strategic opportunities is important for an organization?., In what ways, if any, the definition and periodic assessment of strategic opportunities affects the achievement of strategic agility for an organization?., In what ways, if any, would the top-down governance executives/stakeholders of an organization be impacted from connecting these strategic opportunities with strategic objectives?* etc.,). The correspondence between the strategic-, and the management-layer was also being explained along with a brief illustration of the modeling approaches that were used for each layer in order to appraise (and represent) the stakeholder-, and user-level value determinants. Following, a set of questions were asked to test the respondents' understanding of the interconnection between these layers (e.g., *Do you find important to be able to produce a modeling representation between a strategic opportunity and the roles, goals, and tasks which have to be activated for the realization of this strategic opportunity?., Are there any other -or more practical- ways, methods, and/or modeling representations that you have successfully used to achieve such a level of traceability between the strategic and management level for the assessment of strategic opportunities?* etc.,). A final set of questions were meant to allow the experts freely their opinions regarding the structure of the framework, its corresponding parts, understandability, and ease of use.

4.4 Data Analysis and Results

The discussions that took place during the interview sessions were recorded in video format after having acquired the consent of the interviewees. Upon completion of the interviews, the subjects' recordings/answers were subsequently transcribed into text, analyzed, and codified which means that parts of the text were given a code representing a certain theme/construct, etc. Overall we approached the analysis of the data gathered during the interviews under the scope of thematic content analysis [6, 165]. More specifically, we revisited the recorded material several times to identify a convergence cluster within the respondents' answers which could take the form of similar phrases in different parts of the material, patterns in the data, reoccurring differences

between sub-groups of subjects, etc. Data was tabulated so as to offer an overview of all main insights and themes. The results of this process are illustrated in the below figures aggregating and categorizing the responses of the interviewees in four major themes; these are correspondingly related to the interviewees' attributed strategic agility (i) definitions and characteristics (see Figure 4.1) , (ii) differentiators with operational agility (see Figure 4.2), (iii) mode of organizational proliferation (see Figure 4.3), and iv) corresponding implementation patterns (see Figure 4.4). Each one of these figures was created according to the decrees of Miles et al. [111] and Hassanzadeh et al. [60] in terms of representing qualitative interview data. Pragmatically, the first column of each figure represents the transcribed verbal statements of the interviewees; these instantiate the original verbal statements as prescribed in the interviews after being minorly processed for the sake of coherency; the meaning and general spirit of the verbal statements was not altered in any way during this process. The second column represents a codified extraction of these statements while the third column presents a theme-attribution to these codes; the codification and theme-attribution was performed jointly (and in agreement) by all the members of the research team. The final column presents the identification numbers of the interviewees (as presented in Table 4.1) that were attributed to the statements of the original sentences.

StratAMoDrIGo has also been audited by respondents 4 to 8 (see Table 4.1) in terms of its overall structure, understandability, applicability, ease of use. These experts were encouraged to consider the fit-for-use of the StratAMoDrIGo meta-model (as presented in Figure 3.1 in Chapter 3) within their daily organizational activities and tasks in order to offer comments, recommendations, concerns, or vulnerabilities about its characteristics.

Regarding the framework's overall structure, all the experts seem to appreciate the trichotomy into strategic-, management-, and user-oriented layers in terms of reviewing the conceptualization of new strategic opportunities. The respondents acknowledge that StratAMoDrIGo is novel in the way it realizes the simultaneous representation of various bases of concerns; they recognized that the standard way of working usually considers one of those layers as the starting point of analysis. In particular, the *fourth respondent* mentions that, in the world of consultancy, it is always welcoming to be able to furnish to the clients any sort of representation of their strategic and operational level as well as being able to utilize a tool to study the interdependence between these two layers; in that way the leaders can easily create a mosaic where all the teams are represented and everyone can work in the same direction.

Moreover, all the respondents note that they were not aware of a conceptual modeling approach that could guide/aid them throughout their strategic agility implementation efforts. In that context, StratAMoDrIGo was perceived as a novel approach that could be used to define, model, and represent specific strategic objectives before the start of a particular IT development project; these strategic objectives could be then communicated more easily with other stakeholders and create a sense of unity within the organization. The *fifth respondent* observes specifically that the use of models offers visibility in the attainment of organizational goals and a sense of 'story-telling' that can be

Transcribed Verbal Statements	Codified extraction of verbal statements	Theme	Interviewees
…a company being in a state of strategic agility must be in a position to be aware of what it wants to achieve in the future in view of the opportunities that arise. …Strategic agility should offer the business the opportunity to constantly revise its strategy to see if it is still relevant. …Strategic agility should allow the incorporation and configuration of processes and/or systems in such a way that the business can quickly adapt to a changing context or environment. …Strategic agility is about leaders imbuing a certain time of mindset to the rest of the team. It is about having the vision to manage the company from a high-level and strategic point of view, starting from a proper value creation. …Strategic agility is about being able to offer the tools so that the company can adapt to clients' constantly changing needs.	Ability to create opportunities' awareness. Propensity for periodic revaluation of strategy. Capacity to Incorporate processes and specific systems. Enabling thought leadership and value creation. Ability to create situational awareness for client's needs.	Defining Strategic Agility.	[2], [3], [4], [6], [7]
…Strategic agility allows for greater flexibility and encourages innovation and creativity. …Strategic agility offers a company-wide approach of being flexible, adaptive and geared towards change. …Strategic agility has a wider view and a longer time horizon in terms of reevaluating the core business for the achievement of objectives.	Flexibility. Innovation-driven. Adaptability. Change-oriented mentality. Extensive time-horizon.	Strategic Agility characteristics.	[1], [4], [6], [8]

Fig. 4.1 Codified Interview Data on Defining Strategic Agility and its Characteristics.

imbued into the work of different agile teams when performing their development cycles. However, some reservations were expressed regarding the framework's ease-of-use and instant applicability; according to the respondent, the successful adoption of a strategic agility framework depends highly on its ability to be perceived as 'plug-and-play'. In that aspect, the fifth respondent juxtaposed StratAMoDrIGo with the SAFe framework and the latter's perceived advantage of having in its disposal a number of certified practitioners promising a quick (and standardized) deployment with an immediate return-on-investment. Therefore, the respondent believes that the StratAMoDrIGo would benefit from a customized and user-friendly interface that would convince the management

Transcribed Verbal Statements	Codified extraction of verbal statements	Theme	Interviewees
…Even though strategic agility should not be confused with operational agility within the layers of an organization, it is almost impossible to implement the former without a universal acceptance of the importance of the latter.	Interdependence between Strategic and Operational Agility.	Strategic versus Operational Agility.	[1], [2], [8], [3]
…Nowadays, it is not enough to focus only on operational agility. To survive companies must embrace an agile way of working at the strategic level.	Upscaling Operational Agility at the strategic level.		
…Operational agility is about simplification of structures and finding efficiency in the way teams are working together. …Operational agility is about being more efficient at what you do while strategic agility is about recognizing opportunities outside the core of your business.	Operational agility for efficiency, strategic agility to recognize novel opportunities.		

Fig. 4.2 Codified Interview Data on Differentiators Between Strategic and Operational Agility.

level of its added value and would influence its adoption; the respondent realizes though that such an endeavor would require the framework to be applied in multiple organizations (of varying sizes and sectors) and that the industry today is quite competitive (and in multiple occasions fragmented) making the exploration of new ideas quite difficult.

The *sixth* and *eighth respondents* emphasized on the framework's utilization of value streams. They reported that incorporating different value streams plays a major role in their line of business as it would allow them to create instant client satisfaction, especially during the delivery of the first minimum viable product. Nonetheless, the sixth respondent noted that the use of certain modeling notations within the framework may seem counter-intuitive and might make harder the representation of the management-level tasks and value streams; the respondent noted that it is not always easy to get professionals initiated to new modeling notations; that initiation might even backfire if it is 'forced-fed' from the top. But the respondent recognizes that teams are often unwilling to adopt a new element/technique in their way of working so StratAMoDrIGo should be reinforced with some basic change management guidelines. The eighth respondent was also skeptic about some modeling techniques at the level of the user. The respondent was explained that StratAMoDrIGo is flexible enough to allow the implementing team to have their own choosing of the method or technique for the specification of the features (at the user level) that new technologies should portray.

On the other hand, the *seventh respondent* recognized immediately the

Transcribed Verbal Statements	Codified extraction of verbal statements	Theme	Interviewees
…Achieving strategic agility from all levels is better than a top-down indoctrination or an attempt for a bottom-up upscale of any operational efficiencies. …Strategic agility should be implemented across the levels of the organization, and should not be limited to the strategic level.	Round-trip adoption of strategic agility.	Choosing a top-down or a bottom-up proliferation of Strategic agility.	[4], [6], [7], [5], [8]
…A constant emphasis on communication on all layers can facilitate the imbue of a strategic agility mentality and can give a better overview of the projects' progress and scope.	Emphasis on communication to facilitate adoption.		
…however, the characteristics of a company should drive the choice between a top-down or a bottom up approach (depending on the scope, the size, and the availability of resources for an organization). For example a technical-oriented company could work faster/more efficiently by upscaling their agile ways of working.	Companies to choose an adoption plan that fits them best.		

Fig. 4.3 Codified Interview Data on Strategic Agility's Mode of Organizational Proliferation.

added value of utilizing intentionality to model the task-to-goal dependencies at the management level and the specification of the roles that are entailed within this layer. The respondent added that, on many occasions, the middle-layer is not given enough attention as the entire focus goes either on the C-level (and the determination of strategy) or on the operational layer (and the endeavor to upscale their agile way of working into the wider organizational spectrum). The respondent also assessed positively the framework's round-trip (top-down and bottom-up) assessment of potential strategic opportunities from all organizational levels. The abstractive logic that the StratAMoDrIGo propagates for a fast assessment of strategic opportunities was viewed positively; however, the respondent would have also liked to see a link between the StratAMoDrIGo's meta-model and the materialization of a detailed script (perhaps in the logic of a balanced scorecard) that would provide some sort of accountability for the C-level and middle-level management in terms of appropriating, in the maximum level, the strategic opportunities that arise.

4.5 Discussion and Conclusion

The data, as presented in Section 4.4, can yield some primary remarks: overall, the majority of the interviewees seems to be describing the notion of strategic

Transcribed Verbal Statements	Codified extraction of verbal statements	Theme	Interviewees
...The means and methods to implement strategic agility depends highly on the industry and sector of each company. ...Companies should start by looking at their assets and decide which ones they want to keep and which ones need further development. On top of that, they must look at where they want to go and in which markets they want to be active.	No universal approach for implementing strategic agility. Define priorities and opportunities before implementation.	Implementing Strategic Agility.	[1], [2], [3], [4], [5], [6], [7], [8].
...It is important that the whole company understands the importance of the strategic agility implementation and stimulates the dialogue about it. Incorporating it in the annual policy and objectives ensures a uneventful implementation. ...Avoiding contradictory decisions during the implementation process is crucial. ...Establish a cross-functional and complementary team ensuring that the right people support the implementation process, and allow the team to access resources for the fulfillment of their mission,	Embrace strategic agility at the C-level, and allocate resources.		[2], [1], [3]
...A regular, periodic, two-way communication between the implementation team, the C-levels and the rest of the stakeholders is crucial for the success of the implementation. ...Change management and communication is key when implementing strategic agility. ...The strategic vision for the implementation should be shared throughout all the organizational layers.	Establish change management processes and communicate effectively.		[4], [6], [1]
...Creativity and innovation can be stimulated when companies eliminate internal bureaucracy and downtime can be minimized. ...an ideation process having to go through many validation layers/steps does not guarantee neither an effective nor an efficient implementation.	Eradicate bureaucratic procedures and hierarchical impermeability.		[1], [3]
...Big companies and organizations are much more keen to adapt the latest agile frameworks; smaller companies and start-ups try to implement strategy agility using ad-hoc techniques based on practical experience since they are on a resource-saving mode. ...Established companies also face the danger of stop looking for opportunities once they have found a successful product or service; hence, the implementation of strategic agility may seem obsolete. ...Established companies are in a more comfortable position with a more predictable income, while start-ups really need to operate in the right market and offer the right products in order to survive. Therefore, start-ups seem to be more urged to implement strategic agility.	Established companies versus SMEs and start-ups.		[7], [3], [2]

Fig. 4.4 Codified Interview Data on Implementation Patterns for Strategic Agility.

agility by using similar (marginally distinguishable) characteristics. Indeed, our survey suggests that, in practical terms, strategic agility is more than often associated with the ability of an organization to be in a state of openness, adaptiveness, and flexibility in order to discover opportunities outside its main business scope. This seems to be in agreement with the classic bibliographic attribution to strategic agility; for example the highly-cited studies of Weber & Tara [189] and Lewis et al. [94] essentially describe strategic agility as the ability of a company to sense opportunities, to successfully respond to them and to be aware of any reoccurring business-impacting changes. Nonetheless, a closer examination of our data relinquishes some new significations within the already established strategic agility connotations:

First, our survey suggests the coupling of strategic agility with the enablement of thought leadership at the top and the inculcation of a value-creation mentality to all the actors residing within the boundaries of the organizational spectrum. By no means does this observation suggest any sort of top-down tutelage or an attempt to catechize the employees in accepting the complexities of a strategic agility implementation process; rather, the interviewees seem to attribute the success of such a process to the C-level management ensuring (i) the effective incorporation of multi-channeled communication for the timely funneling and dissemination of information, (ii) the definitive prescription and propagation of strategic objectives and (iii) the set-up of an efficient

resource-allocation mechanism. The aforementioned factors are perceived by the interviewees as the epitome of every proper stakeholder-management regiment that should be supporting every strategic agility implementation framework. Starting from the last point, StratAMoDrIGo does not prescribe specifically the elaboration of a definitive resource allocation mechanism by the C-level; the framework's purpose is not fixed on the detailed specification of the duties of each role within an organization as this would transgress axiomatically the notion of agility. It does, however, provide a core stakeholder-driven analysis where multiple viewpoints are being taken into consideration for the evaluation of the impact of a new (strategic) opportunity. Additionally, the majority of the interviewees seem to accede to the framework's use of visualizations as the medium of an effective communication regarding the substance of strategic objectives. There was also positive support on the framework's provided impact analysis of user-driven concerns within the shaping process of these strategic objectives. During the evaluation of StratAMoDrIGo, there were concerns expressed by some interviewees about the use of specific (and task-oriented) modeling techniques within the framework itself. However, StratAMoDrIGo is not restrictive in the use of these techniques; it does allow the use of customization in order to be compatible with the modeling formations that different teams are accustomed to.

Second, all the interviewees are able to produce a definitory distinction between operational agility and strategic agility; however, the majority of the interviewees acknowledge that most organizations are not likely to achieve the latter unless they have first established a shared culture as well as a precedent in the ways-of-working of the former. The interviewees suggest that the aptness to efficiency, the liberation from sluggish hierarchical evaluation procedures, and the empowerment of the personnel that seem to be at the forefront of many operational agility frameworks (e.g., Scrum, Kanban, etc.,) should be imbued in every strategic agility implementation mechanism. In that sense, StratAMoDrIGo's feature-driven exploration in terms of swiftly evaluating novel strategic opportunities encapsulates the essential competences as exhibited within various agile methodologies (the previous chapter mentions Scrum specifically but other methodologies can be utilized and incorporated in StratAMoDrIGo's core). Some interviewees seemed to express some concern whether a periodic alignment evaluation between (operational) user-driven features and top-down defined strategic objectives would signify a dampening of the agility effect within the entire development process. However, this need not be the case; indeed, the alignment evaluation process can be incorporated within the sprint retrospective discussions as long as there is a specific role allocated to perform a methodical exploration of how most stakeholders are affected by the development of each feature; the next chapter describes a way to the conduct of such a process (see Agile-MoDrIGo).

Third, our data suggest that strategic agility seems to be associated with the structured incorporation (and/or configuration) of processes (and/or systems) that would (i) strive for a constant improvement of internal procedures, and (ii) allow the detection of even minor changes within the business habitat. The interviewees did not seem to favor the use of a specific technique, method, or modeling

language for the set-up of such processes; they did, however, seem to prefer the utilization of 'plug-and-play' techniques that could provide instant insights in terms of evaluating (and optimizing) the state of organizational-wide agility. The interviewees expressed the consideration that conceptual modeling-based methods (such as StratAMoDrIGo) are deemed to require some acclimation to those with no prior experience in practicing them. In regards to that, the seventh chapter within this dissertation delineates an experiment designed to measure whether inexperienced and uninitiated modelers can effectively understand (and practically apply) conceptual modeling-driven techniques in comparison to simpler industry-adopted agile requirement specification techniques.

At this point, we need to be critical regarding the limitations that might have influenced our results in some manner. We acknowledge that our sampling technique, which relied mostly on a combination of convenience and snowball sampling, may have been suboptimal in terms of (i) using a specified sampling frame to monitor the representability of our population and (ii) making strong statistical inferences on that population based on the retrieved sample. Nonetheless, we used these particular sampling methods because we wanted to retrieve candidates whose roles/functions adhered to a very specific set of attributes (as the ones described in section 4.3). Given the potentially small size of the population permeating individuals with such exact characteristics, the use of non-probability sampling techniques can be justified as long as there is some caution regarding the generalization of the sample findings [167] while being attentive in curving the sampling bias. In terms of the latter, the recognition of the attributes of our population was the result of an active deliberation process amongst the members of the research team. Specifically, each team member was asked individually to create a list containing the potential characteristics of the population; following, a discussion took place based on these individual lists where the exact characteristics were determined upon unanimity amongst the team members. Furthermore, the compliance to a population with such particular characteristics accounts for the deliverance of a non-extended number for the final survey-participants. This creates an extra consideration whether the number of the interviewees could have been higher in order to reach a fuller information backlog. However, given the set time-frame of the survey process, the addition of more interviewees that would not precisely satisfy the criteria established by the research team would only harm the quality of the retrieved information. Finally, we need to note that not all interviewees got the opportunity to evaluate StratAMoDrIGo; as explained in the sections before, the information extracted by the first three interviewees was used as input in the process of the iterative build-up of our interview protocol. Therefore, although not every survey participant was given the chance to perform the framework evaluation, the information provided by the first three interviewees gave us the chance to construct an interview protocol that could frame the questions about the definition of strategic agility and the framework evaluation rather well for the remaining sample instances.

Chapter 5

From Service-Orientation to Agile Development by Conceptually Linking Business IT Services and User Stories: A Meta-Model and a Process Fragment

IT services are being built by IT departments and other service providers to address the core technological requirements of organizations. Even if these services solve operational issues, their adoption – because of their internal behavior – has a sustaining or non-sustaining impact on the (long term) strategy of the organization. This impact is called the Business and IT Alignment (BITA); as such, it is problematic to estimate before the development of the service without a view on its design. To be properly done, BITA evaluation indeed needs details about the service run-time behavior. Conversely, the agile wave refrains from a detailed upfront software design; functions providing high operational value to users are indeed selected and built for one sprint at a time. The mismatch between a traditional service approach and an agile way of development is therefore quite obvious. The present chapter proposes a method (it is called Agile-MoDrIGo) to reconcile these two approaches. For this purpose, this method (i) decomposes services into epic user stories under the scope of which (user-level built) user stories can be mapped (i.e. functional alignment) and (ii) links services as (coarse-grained) conceptual elements along with the strategic objectives they sustain to fine-grained user story functional elements for value-driven prioritization (i.e. strategic alignment).

The research presented in this chapter has been realized in collaboration with Y. Wautelet. Results have been published in [158, 159]. The rest of the chapter is structured as follows: Section 5.1 provides a short outline of the merits found within the two distinguishable approaches (i.e., top-down IT governance in the form of service-orientation, and bottom-up agile software paradigm via the use of user stories). Section 5.2 gives the context of the research, more specifically the application of design science through the relevance, rigor and design cycles. Section 5.3 presents the elaboration of the ontology upon which the Agile-MoDrIGo framework is based; this section goes also into detail pertaining the individual approaches (i.e., top-down, bottom-up, and middle-

out) constituting the entirety of the framework, and presents a process fragment that demonstrates a possible way of instantiating it. Section 5.4 depicts a particular case that is used for the framework's application, evaluation, and validation. Section 5.5 addresses some questions related to the framework's capacity in fully embracing agility. Section 5.6 compares the framework with other state-of-the-art approaches, while Section 5.7 concludes the chapter.

5.1 Introduction

Global economic perturbations have been compelling organizations to impose tighter IT budget restrictions and to reconsider the cost-centered character of their IT departments in the effort to transform them from centerpieces of technical support to autonomous providers of low-cost/high-quality IT services to other departments/organizations [125]. Consequently, IT services have been evolving in order to better align with organizational requirements and have become more abstract to favor reusability and componentization [27]. For example, Business Process-as-a-Service (BPaaS) furnishes services supporting or automating entire (or parts of) the business processes of the organizations. In their present form, IT services necessitate further analysis to evaluate their alignment with the organizational (strategic) orientation. In this perspective, Wautelet [176] proposes the Model Driven IT Governance (MoDrIGo) framework, which is, as its name indicates, a model-driven corporate and IT governance process allowing to evaluate the alignment of so-called business IT services (i.e. custom services developed to support business processes and can be deployed on premise or in the cloud [184]) with strategic (business and IT) objectives. MoDrIGo furnishes a compact integration of the governance level as a (graphical) (business and IT) strategic layer made of long-term objectives that organizational services potentially contribute or hamper to attain.

At the same time, the agile initiative is becoming all the more important in the software development industry due to its focus on producing core functional elements offering the highest value to end-users/stakeholders, its ability to cope better with changing requirements, and its independence from rigid governance conventions [3]. Agile software development is often driven by user stories [29, 181], which are structured natural language artifacts recording user desiderata and immediate operational improvements to be implemented without appraising long-term expectations. However, service-oriented development cannot be driven by operational aspects only like the agile initiative implicitly prescribes and needs at least partial alignment with long-term business and IT objectives. We thus face a mismatch between agile practices allowing high uncertainty at the level of system behavior and traditional IT governance requiring an evaluation of BITA leading to two incompatible development frameworks.

This chapter studies the alignment between a top-down service-driven framework and a bottom-up agile approach based on user stories. More specifically, both are combined through a middle-out approach where a functional and strategic (value-driven) alignment is ensured via the use of conceptual models; we call our framework *Agile-MoDrIGo*. The latter is made of a meta-model to be instantiated on a case in the form of a graph as well as a process fragment

to support the meta-model's application. At earliest stages of development, the strategic alignment allows to validate (or reject) a service development/adoption decision whereas in later development stages, the fine-grained functions depicted in user stories are prioritized for implementation in function of the strategic value they provide. This approach is meant to be flexible so that new strategic-value evaluations can be made on the fly when requirements change, new requirements appear or even when process flows are dynamically changed.

5.2 Research Paradigm, Method, and Approach

The research presented here takes roots in the Design Science (DS) paradigm [67]; the latter aims to deliver generic solutions for known (or not yet considered) problems. The result of a DS research problem can be a solution in the form an artifact, terminology, methodology, engineering tool, and so forth. In the present research, an attempt has been made to build artifacts to improve the business strategic performance while being able to deal with agility at development level. These artifacts aim to solve an unresolved issue or a problem considered being in a precarious state. In particular, envisaging the strategic value of agile releases based on user stories has, to the best of the authors' knowledge, not been addressed yet.

We explicitly formulate the following research question: *How can the MoDrIGo framework be used in an agile service-driven development context?* The main contribution of this chapter is the enhanced Agile-MoDrIGo framework, its theoretical description, and application on a particular case. In accordance with the cycles for design science research defined by Hevner [66], we point our contribution to cover the following:

- The *Relevance Cycle* concerns the identification of opportunities and/or problems in the application domain. In the present context, we identified the problem referring to the lack of a framework being able to not only decide on the adoption of services top-down but also take into account the operational feedback/user desiderata (thus bottom-up) meeting-up in a middle-out fashion. The problem has been identified in practice within a partner organization. The former had been implementing an IT governance framework independent from agile practices (see [176]);

- The *Rigor Cycle* refers to the theories/methods used to ground the construction and evaluation of our framework. The latter is built upon an existing framework for IT governance validated in previous research. To support the contribution of this chapter, we have created a so-called pseudo-ontology, the establishment and elaboration of which follows the logic presented in Section 3.3.2 of Chapter 3.

- The *Design Cycle* refers to the construction and the evaluation of the artifact. It has been constructed from existing approaches that have evolved to become more agile on multiple levels because focused on value. The evaluation is done on a case study from the organization where the problem to solve has been identified.

In order to reconcile the service-based development with the requirements engineering of agile methods, based on user stories, we proceeded through the mapping and merging of previously developed and (independently) validated meta-models. To this end we have built a meta-model depicting the key concepts to represent/model a business situation where service-orientation and user story driven development are combined. On the one hand, the MoDrIGo approach of [176] was considered because of its specific purpose of evaluating BITA out of conceptual models for service-based systems; on the other hand, the rationale tree approach [181, 182, 180] was used for its ability to build a conceptual diagram out of a user story set. Given that these two approaches cover different abstraction levels, the concepts of each meta-model are conceptually linked to study the approaches' complementarity. This is detailed in Section 5.3.

To show how the meta-model can be used/applied in practice we also depict a process fragment. The latter has been built generically out of the case that inspired Agile-MoDrIGo to highlight the roles and activities that are performed in the context of such a development. The constituting activities are customizable in function of the project and the process fragment should only be taken as a guidance for application; it is not meant to be used as a turn key process but as a plug-in to service-development methods and/or agile methods; it has been formalized using the process fragment concepts of [137] and represented graphically in i* [201] in the same fashion as in [180]. We chose the formalization of i* because it highlights the social dependencies between the actors/roles without it being sequential. Indeed, we did not aim to document a sequence of activities in the process fragment because of the high variability existing in the sequence and/or parallelism from project to project. This also shows implicitly the flexibility in the adoption of the process fragment by a new development team. Indeed, multiple activities can be performed simultaneously, some can be omitted while others can be added and the sequence can be chosen in function of the field requirements/constraints. Workflow-based notations that are more directive in terms of sequence, do not highlight social dependencies and are less tailorable/customizable, thus less relevant. Conversely, the i* notation accounts for the variability in the activities' execution and selection.

The validation of Agile-MoDrIGo has been made through a case in a Belgian hospital. The latter had already applied the classical MoDrIGo approach (see [176]) but is now facing the adoption of agile methods for software development. More specifically, new services are evaluated for business and IT alignment but constituting software is now developed using Scrum. For illustration purposes, we take the example of a new user-intensive service to be developed in an agile fashion. This is detailed in Section 5.4.

5.3 Merging Service-based IT Governance and Agile Development

This section describes the Agile-MoDrIGo meta-model (visualized in Figure 5.1) obtained through the merging of the meta-models of [176] and [181, 182]; it further depicts the dynamics of the approach using a process fragment

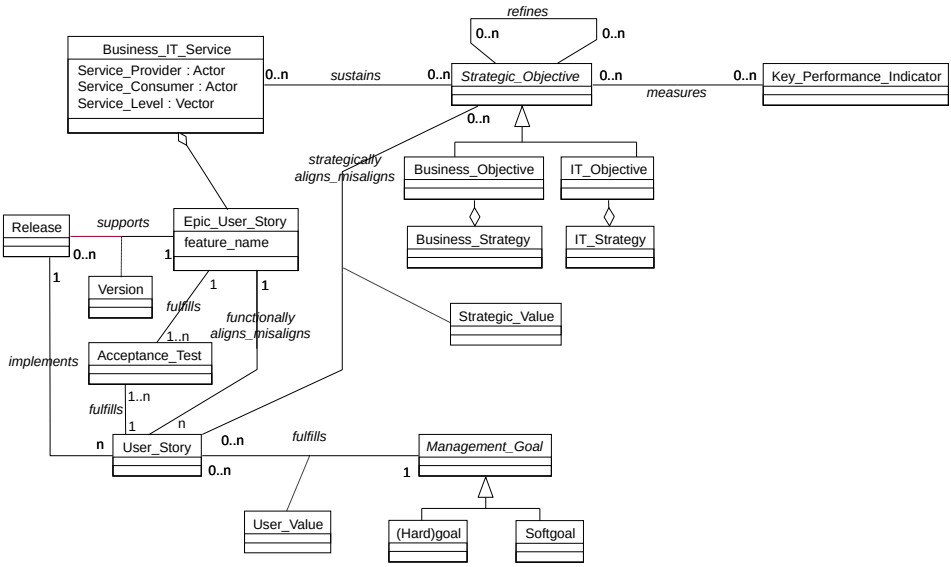


Fig. 5.1 Merging Service-based IT Governance and Agile Development: A Meta-Model.

(represented in Figure 5.2[1]. We split the meta-model in three sub-models (approaches) and engage in "'structural walkthroughs"' [133] by justifying each individual approach to the overall model correctness. We start by describing the *top-down* approach, then the *bottom-up* one and finally the *middle-out*.

5.3.1 Top-Down Approach: Defining the Strategic Objectives and Linking the Business IT Services with Epics

The decision on which services to acquire or implement is reached at the governance level [108] and has an immediate impact on the entire organization in terms of structures, processes and people. From a technical point of view, services are presented as encapsulated and loosely coupled software entities [89, 56] of which the design and implementation is ensured at the IT management level. As they play an important role in how an IT provider structures itself, services can be used as scope elements for BITA. Accordingly, services can be used as elements to evaluate whether the adequate IT assets and capabilities are put in practice to support the business and IT strategies [176]. Thereby, the service as a whole and its constituting behavior provide or hamper value delivery at the strategic level.

Three types of elements are commonly defined top-down in Agile-MoDrIGo:

- The **strategic objectives**. They are defined as the objectives that an organization aims to achieve over a defined period to fulfill the strategic

[1]We immediately put the name of the process fragment concepts mapped from [137] in the legend.

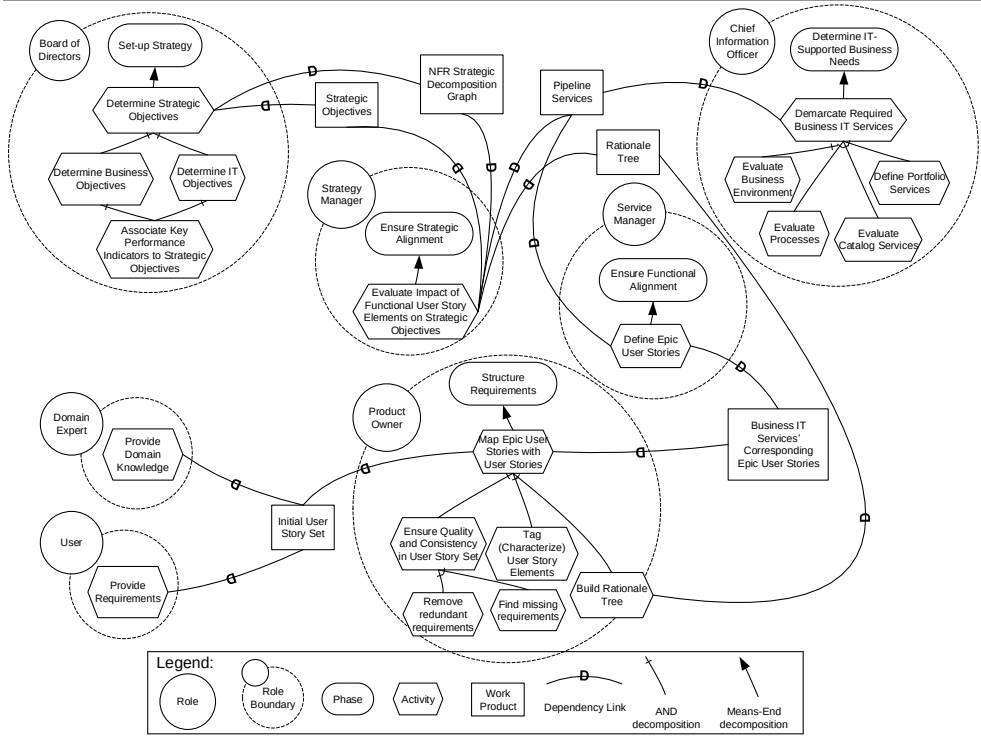


Fig. 5.2 Merging Service-based IT Governance and Agile Development: Process Fragment.

plan [176]. They express long-term (up to 5 years) strategic aspirations and, by hypothesis in our framework, they are established in a top-down fashion, i.e., by the board of directors, C-level executives and/or a representative committee of stakeholders. A strategic objective is represented as the class *Strategic_Objective* in the meta-model; it is an abstract class meaning that it should be necessarily instantiated as a *Business_Objective* or an *IT_Objective* which are "traditional" classes. Typically, the realization of these two types of *Strategic_Objectives* can be measured by *Key_Performance_Indicators*; this is why these two classes are linked. Also, *Strategic_Objectives* can be further refined into other *Strategic_Objectives* so that a decomposition hierarchy can be set-up. The entirety of the business objectives are pursued through the set-up of the *Business_Strategy*; therefore there is a composition relationship between the *Business_Strategy* and the *Business_Objective* classes. The same goes for the classes of *IT_Objective* and *IT_Strategy*. From the perspective of the process fragment, we can see that the *Set Up Strategy* ***Phase*** is represented as an i* Goal, in Figure 5.2. A means-end decomposition then allows to refine the i* Goal representing this ***Phase***. Indeed, to

fulfill this i* Goal, the *Board Of Directors* ***Role*** performs the ***Activity*** *Determine Strategic Objectives*. In itself, the latter ***Activity*** requires a set of other ***Activities*** to be achieved (as shown through the decompositions in Figure 5.2). These are *Determine Business Objectives*, and *Determine IT Objectives*; themselves decomposed into the (optional) *Associate Key Performance Indicators to Strategic Objectives* ***Activity***;

- The **business IT services**. Within the traditional MoDrIGo framework described in [176], services are further characterized as *business IT services*. The latter aim to fulfill, notably through the use of IT capabilities, the business needs of a specific organization; they are used to structure the global IT problem into the organizational modeling stage. They are designed and built to support specific business processes but also developed in a customer-centric way meaning that they are aimed to support user desiderata. We thus describe services as entities encapsulating relevant business behavior that needs to be supported and on which their alignment with the business and IT strategies can be evaluated. Business IT services are different than classical IT services in the sense that they are designed to fulfill a specific business process support problem through IT and are thus more abstract than a classical generic IT service like printing for example. Within the meta-model of Figure 1, the business IT service concept is represented as the *Business_IT_Service* class itself linked to the *Strategic_Objective* class to represent the ability of the former to impact the latter. Therefore, the behavior of particular services can be constantly reevaluated with respect to the business and IT strategies. Illustratively, business and IT strategies impact the organizational behavior of pipeline services while for catalog services the strategies serve for the evaluation of the current situation leading to a continuous modification whenever deemed necessary; even small modifications in terms of infrastructure (hardware, software) or processes can be dynamically made in order to better align (or realign) particular business IT services with the business or IT strategies. Business IT Services are represented as top-level elements on the decomposition graph (see Section 5.4). From the perspective of the process fragment, we can see that the *Determine IT supported business needs* ***Phase*** is represented as an i* Goal, in Figure 5.2. A means-end decomposition then allows to refine the i* Goal representing the ***Phase***. Indeed, to fulfill this i* Goal, the *Chief Information Officer* ***Role*** performs the ***Activity*** *Demarcate Required Business IT Services*. In itself, the latter ***Activity*** requires a set of other ***Activities*** to be achieved (as shown through the decompositions in Fig. 5.2): for space reasons we do not further depict them;

- The **epic user story**. Epic user stories (represented as the class *Epic User_Story* in the meta-model) describe large functions of the system to be estimated, implemented and tested at once. Typically, one or more epic user stories are defined for the successful development of a *Business_IT_Service*. An epic user story is too large to be developed in a single iteration so it takes several iterations to build a *Release*. A release is

a deployable software package built over several iterations to fulfill an Epic User Story which, as shown in the meta-model, can be validated through an *Acceptance_Test*. The latter indeed defines the minimum system behavior that needs to be fulfilled to validate the epic user story. The evolution in releases is supported through different versions (class *Version* in the meta-model). Epic user stories are represented as decomposition elements from the business IT services in the decomposition graph (see Section 5.4). From the perspective of the process fragment, we can see that the *Ensure Functional Alignment* ***Phase*** is represented as an i* Goal, in Figure 5.2. A means-end decomposition then allows to refine the i* Goal representing the ***Phase***. Indeed, to fulfill this i* Goal, the *Service Manager* ***Role*** performs the ***Activity*** *Define Epic User Stories*.

5.3.2 Bottom-Up Approach: Building-Up User Stories and Mapping them to an Epic

User stories are typically defined by the to-be system's end-users/stakeholders under the responsibility of the Product Owner. In this sense, user stories express elements defined in a bottom-up fashion. They are represented by the class *User_Story* in the meta-model of Figure 1. User stories are generally structured around three dimensions, i.e., the *WHO*, the *WHAT* and (possibly) the *WHY* and are usually expressed in the format: *As a <type of user >, I want <some goal> so that <some reason>* [29]. The *WHAT* dimension specifies a functional or non-functional element desirable by the end-user/stakeholder. The *WHY* dimension illustrates short or middle-term user-level (i.e., operator to middle manager) objectives incorporated in the class *Management_Goal* in the meta-model. The latter represents an abstract class to be further instantiated as the traditional classes of *(Hard)Goal* and *SoftGoal*. The i* notation differentiates between the two as *(hard)goal* defines a state that is sought to be achieved whereas *softgoal* represents a goal whose satisfaction is subject of interpretation [47]. The i* notation is adopted here because we use the meta-model and graphical notation of user story elements developed in [181, 182, 180]. Typically, a *Management_Goal* can be fulfilled by zero or many user stories. From the process fragment perspective, the *User* ***Role*** is also involved through the *Provide Requirements* ***Activity*** and the *Domain Expert* ***Role*** is involved through the *Provide Domain Knowledge* ***Activity***; information is furnished in the form of the *Initial User Story Set* ***Artifact***.

5.3.3 Middle-Out Approach: Merging the Top-Down Governance Approach and the Bottom-Up Agile Development

Agile-MoDrIGo incorporates a top-down service-based governance approach based on business IT services split in epic user stories, and the bottom-up agile one based on traditional user stories. These two are reconciled in a middle layer. All in all, two important alignment activities need to be taken:

- Each user story expressing a functional element in its *WHAT* dimension and defined in a bottom-up-fashion needs to be mapped to an epic user

story defined top-down. Roughly speaking, the most important element is that the set of user stories relating to a specific epic user story allows to meet the acceptance test, as defined by the governance-level, for validation and inclusion as a release. This is the first type of alignment of the middle-out approach (between bottom-up defined user stories and top-down defined epic user stories) that we call the **functional alignment**. Ultimately, the process is similar to the user story mapping approach [121] i.e., linking a low level function to a more aggregate one, contributing to its fulfillment. However, we opt here for a graphical notation and, in line with [182, 180], we represent an epic user story - and all of the user stories related to it - in the form of a task decomposition (see Section 5.4). From the perspective of the process fragment, we can see that the *Structure Requirements* ***Phase*** is represented as an i* Goal, in Figure 5.2. A means-end decomposition then allows to refine the i* Goal representing the ***Phase***. Indeed, to fulfill this i* Goal, the *Product Owner* ***Role*** performs the ***Activity*** *Map Epic User Stories with User Stories*. In itself, the latter ***Activity*** requires a set of other ***Activities*** to be achieved that are concerned with building the rationale tree (for space reasons we do not further document it and point to [180] for more information about the building process). The Rationale Tree approach of [182, 180] uses parts of the constructs and visual notation of i* to build various trees of relating US elements in a single project. The benefits of sculpturing such a rationale diagram is to identify depending US, identifying epic ones and group them around common user story themes. User stories are represented as decomposition elements from the epic user stories in the decomposition graph (see Section 5.4);

- Each function depicted in an individual user story needs to be aligned with the strategic objectives in order to evaluate if the implementation of the former contributes to (or hampers) the realization of the latter. This evaluation can be the responsibility of the *Strategy Manager* where during each sprint he/she can evaluate and discuss with relevant stakeholders the contribution of user stories to business and IT objectives. This allows evaluating whether the user story development is aligned with the long-term aspirations of the organization. This is the second type of alignment of the middle-out approach (between bottom-up defined user stories and top-down defined strategic objectives) that we call the **strategic alignment**. Support links between the user stories depending on a specific epic and the strategic objectives can be used, in a diagram, to highlight the contribution of the (to-be) business IT service in terms of BITA. More formally we define that a user story has a *positive impact* on a strategic objective if the functionality expressed in that user story, and implemented within the context of an epic user story relating to a business IT service, has a positive impact on the quantitative evaluation of *Key Performance Indicators* (KPI) associated to that strategic objective. From the perspective of the process fragment, we can see that the *Ensure Strategic Alignment* ***Phase*** is represented as an i* Goal, in Figure 5.2. A means-end decomposition then allows to refine the i* Goal representing

the ***Phase***. Indeed, to fulfill this i* Goal, the *Strategy Manager* ***Role*** performs the ***Activity*** *Evaluate Impact of Functional User Story Elements on Strategic Objectives*. An NFR-like decomposition graph [28] is used to depict this hierarchy (see [176] and Section 5.4); it is a *Workproduct* represented in Figure 5.2 as a *Resource*.

Ultimately, these two types of alignment allow (i) at evaluation stage to validate the development/deployment of a business IT service through information about the potential strategic value and (ii) at implementation stage to maximize the strategic value through the inclusion/identification of most relevant functions.

5.4 Validation: Applying Agile-MoDrIGo's Meta-Model for Service Development in a Hospital.

5.4.1 Case Study Background

The case study described in this section develops further the case of a Belgian hospital already used in [176] and whose strategy has been described extensively in [186]. The example is adapted in some parts to deal with confidentiality issues but taken from a real case. Even though the application is only partial, it is meant to be realistic and relevant. Saint-Romain[2] is a Belgian hospital whose activities have grown exponentially in the last few years; available IT budgets have nevertheless grown only in a linear way. After the successful commissioning of an emergency unit a few years ago and the construction of new spaces devoted to care, Saint-Romain rapidly tripled its patient base while rendering its administrative activities all the more complex. This expansion generated revenues leading to a major reconsideration of the entire organization which resulted in the technical exercise of the IT development project built in a service-driven way and published in [186, 176]. Recently, Scrum has been adopted as a development life cycle for new software developments. The agile management approach required compatibility not only with the existing IT infrastructure, but also with the governance mechanisms. The Agile-MoDrIGo approach has thus been developed and adopted to fill the need of the hospital to fit their service governance with the use of Scrum; it accounts thereby for an adequate continuity mechanism with the existing IT infrastructure but also the existing service governance.

5.4.2 Application of the Meta-Model and Instantiation as a Multi-Layer Graph

Top-Down Approach. The strategic objectives have been determined by interviewing C-level executives; they can be visualized in Figure 5.3 and the entire process is documented in [186]. The strategy has evolved since the publication of [186] but for confidentiality reasons we use the earlier version as reference in the present chapter; this does not affect in any way the validity

[2]For confidentiality reasons the name of the hospital has been changed.

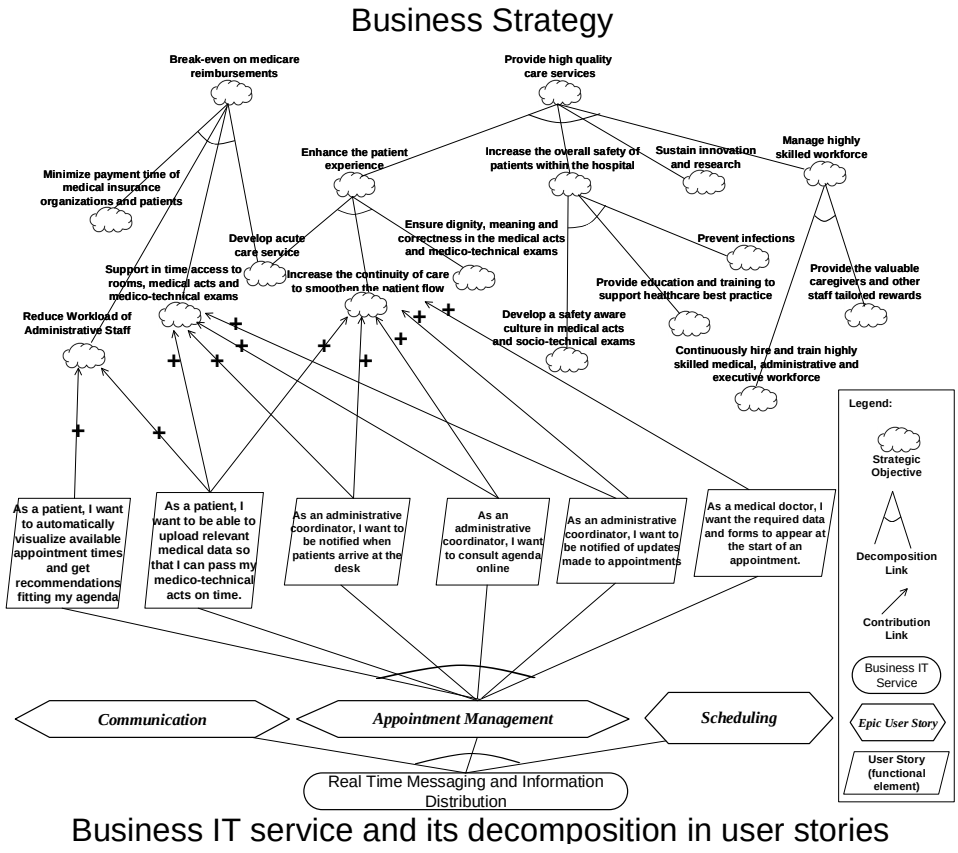


Fig. 5.3 User Story Support of Business Objectives in a Belgian Hospital.

of the application. A new business IT service, called *Real-time messaging and information distribution*, has been validated for development at the governance level. The aim is to furnish a new software (actualized though a traditional web portal and a mobile app) for each of the stakeholders involved in making appointments and medical exams processes notably the *Patients*, the *Administrative Coordinators* and the *Medical Doctors*. This new service involves lots of possibilities for innovation and a great amount of co-creation with stakeholders which is primary for its successful adoption and use; thereby, an agile approach has been followed for its implementation.

As a top-down governance approach, three epic user stories are set-up for the *Real-time messaging and information distribution* service: *EUS1: Communication*, *EUS2: Appointment management* and *EUS3: Scheduling*.

Bottom-Up Approach. To save space, an illustrative subset of the user stories has been placed online[3]; these have been defined by groups of users coordinated by the *Product Owner*.

[3]They can be accessed at: https://bit.ly/3Lng3WG

Middle-Out Approach. Figure 5.3 shows the entire alignment process through a multi-level graph and summarizes the middle-out approach. More specifically we emphasize:

- The **functional alignment** is the mapping process of the user stories with the epic user stories. The assignment of the former to the latter has been done by the Product Owner as a conventional structuring process in line with user story mapping. It can be visualized in Figure 5.3: the business IT service *Real-time messaging and information distribution* decomposes into the 3 epic user stories, themselves decomposing into user stories; an *AND_decomposition* is used to illustrate this. The following user stories have been assigned to the epic user story *Appointment Management*:
  - US1: As a *Patient*, I want to *automatically visualize available appointment times and get recommendations fitting my agenda.*
  - US2: As a *Patient*, I want to *be able to upload relevant medical data* so that *I can pass my medico-technical acts on time.*
  - US3: As an *Administrative Coordinator*, I want to *be notified when patients arrive at the desk.*
  - US4: As an *Administrative Coordinator*, I want to *consult agenda online.*
  - US5: As an *Administrative Coordinator*, I want to *be notified of updates made to appointments.*
  - US6: As a *Medical Doctor*, I want *the required data and forms to appear at the start of an appointment.*
- The **strategic alignment** is the alignment between functional elements of user stories and the strategic objectives. Such an assignment has been done here by the research team in collaboration with the Product Owner and led to *traces* (positive contributions in the instantiated example of Figure 5.3) starting from user stories to the business objectives (we only show here the business strategy and not the IT one). These traces show the contribution of each user story to the business strategy in terms of strategic value. We can take the example of US2 *As a patient, I want to be able to upload relevant medical data so that I can pass my medico-technical acts on time.* In this particular US, the function is *upload relevant medical data* which, as we can see in the user story, satisfies the management goal *pass medico-technical acts on time.* The function also has an impact at the strategic level. More specifically, it contributes positively to the strategic (business) objectives (i) *Reduce Workload of Administrative Staff*, (ii) *Support in time access to rooms, medical acts and medico-technical exams* and (iii) *Increase the continuity of care to smoothen the patient flow.* As an example for evaluating the strategic value, the first of these three business objectives can be evaluated through the *workload/staff ratio* KPI. The latter is an indicator of the overall performance of the current staff; by adopting the function depicted in US2, that KPI is thus expected to improve.

5.4.3 Implications of the Meta-Model's Instantiation

Within the planning game, the elements delivering highest strategic value can be prioritized as of higher importance. In the present case, for the epic user story *Appointment management*, it is the user story *As a patient, I want to be able to upload relevant medical data so that I can pass my medico-technical acts on time* that receives highest priority. Strategic value evaluation can be done on the basis of the graph on an empirical basis or, more complex, by following the projected improvement rate of the KPIs associated to each strategic objective. The level of complexity for this operation remains an issue determined by the team using Agile-MoDrIGo. In the Saint-Romain case, prioritization was made on the basis of an informal evaluation to align with agile principles. The functions that do not deliver strategic value can also be further evaluated. If the latter are commodity functions (e.g. furnish access to the system) they may be indispensable; otherwise they can simply be left out of any developments.

5.5 Discussion

The main advantage of the Agile-MoDrIGo approach within the hospital case is that it offers a unique interface ensuring continuity in the governance of services and their management (i.e., the development) with epic user stories as central pivot elements. In other words, it allows to integrate IT governance mechanisms (thus the strategic-level) with user story-driven development (which are the traditional scope elements in user stories). Benefits are found for each practice: the strategic representation in the form of objectives helps to define clearly the direction to follow which is useful to determine the long-term relevance of functions and features demanded by end users. It acts thusly as a general structuring approach for flexible content-adaptation yet fulfilling an implementation contract within a particular service development.

From a software engineering perspective, the approach allows to align a service's development with the Scrum approach (that uses by nature very short cycles) by breaking it down into different epic user stories. Services supporting well known and standard business processes where innovation does not play any role can of course still be implemented in a waterfall fashion without a study of the strategic impact of user stories.

Another question that needs to be addressed is *whether the application of the framework hampers the agility of the entire development process.* For the functional alignment it is a natural process in agile development since it is very similar to the industry-adopted user story mapping approach; it could nevertheless induce, from the Product Owner's side, to build-up new user stories in order to fulfill the complete specification (i.e., acceptance test) of the epic user story. This work is by nature not fully bottom-up because some user stories are then not immediately driven by users but by their representative. Determining the strategic value and prioritizing the development of user stories from that value also leads to giving a higher privilege to the long-term perspective than to immediate user value. Nonetheless, this makes sense in the context of service-driven development. Finally, one may raise the question of the willingness

of agile teams to deal with models, something they are often reluctant to do. We cannot avoid making a strategic representation in the form of a diagram to ensure a proper alignment study; this is an exercise relevant for helping C-level executives to define their strategy and is independent of a software development practice. We will nevertheless enhance further the DesCartes Architect CASE Tool [85] to be able to link a specific user story (in the user story list) immediately to a defined strategic objective without going through a visual representation. Then, from the links set up by practitioners, the CASE-tool will automatically suggest a "strategic value-driven" user story hierarchy. This alternative approach is less constraining (but also less formal) than the entire approach as proposed in this chapter but can lead to a more practical way when developing with agile yet willing to consider strategic value. This will be tested with the help of a major consultancy company, partner of our research lab. Lastly, some threats to validity for this study can be managed with the same logic as outlined in Section 3.8.3 of Chapter 3.

5.6 Related Work

A number of prior studies have been assessed as the theoretical groundwork in search of aligning service-orientation with agile development. In particular, Souza & do Prado Leite [144] focus on bridging the representational disassociations across strategic, tactical, and operational layers by proposing a model-driven methodology which merges i* and BPMN [117]. The authors claim that integrating fit-for-purpose modeling constructs for each organizational level is bound to improve their in-between alignment, at least in a vertical (functional) perceptive. However, their solution entails a meticulous up-front design effort for all organizational tiers. This is seemingly at odds with the paradigm of utilizing services (mostly as 'black boxes' of abstraction) to spur flexibility and reusability thus allowing businesses to react rapidly to internal or external change. Contrastingly, Agile-MoDrIGo uses services to support the business processes and organizational needs through the use of IT and as such, they are the basis upon which the alignment between the business and IT strategies can be represented and evaluated. In this aspect, Agile-MoDrIGo presents similarities to the service-development governance framework portrayed by Wautelet in [177]; the latter ties strategic/tactical organizational decision-making with the establishment, maintenance, and management of a 'business IT service' portfolio corresponding to major software-investment decisions under review. Nevertheless, Agile-MoDrIGo manages also to combine the governance approach on business IT services with agile development at implementation stage. To such an end, the internal behavior of the business IT service is conceptually linked with user story elements.

Estrada et al. [41] adopt a modeling approach intended to design software systems better aligned to the business needs of an organization. The centerpiece of their approach is the concept of *business service* representing building blocks of information for encapsulating organizational behaviors. Their three-tier modeling process starts by defining a high-level view of the services (functionalities) offered and used between the enterprise and external actors (customers,

suppliers etc.). Secondly, each business service can be refined into more concrete process models. The latter can be further delineated into business interactions using i* constructs. In essence, business services act as the interfaces between internal and external business actors and they can be represented as abstract or as detailed according to the demands of the modeler. As a result, services are no longer considered as black boxes; in fact, their internal behavior can be tied to the long-term strategic objectives of the enterprise. However, the authors' process-centered service representation detailing the involved tasks, activities, requirements, and roles does not account for agile development methodologies focusing on short-term, stakeholder-oriented outcomes emerging during each single sprint. The latter is considered explicitly within Agile-MoDrIGo with the concession of user-oriented features (i.e., realized in an agile manner) based on the value they diffuse on organizational strategic aspirations.

Hachani et al. [55] furnish a model-driven framework that depicts how agile service-orchestrations can address dynamic changes within the design processes in Product Life-cycle Management (PLM). Their solution portrays a layered architectural structure starting from a high-level characterization of the product design processes that comprise the routine activities of the enterprise. One level lower, there is a more detailed overview of the functional PLM services independent to any PLM platform while the last level presents a set of technical PLM services allowing the platform-specific implementation of the previously defined functional PLM services. Within their approach, the notion of agility is considered as an implicit internal attribute of their service-oriented architecture. The latter is being embraced as 'agile by nature' just by allowing fixed business processes to be decomposed to specific on-demand services. While service-orientation assists in building strategic information systems compatible with the needs of dynamic and flexible organizations [59], the notion of service-reusability might in fact decrease operational agility as it increases the number of dependencies that have to be considered in case services need to change [23]. In this perspective, Agile-MoDrIGo makes use of its middle-out tier to determine the alignment between service-based elements (i.e., epic user stories as defined for the successful development of business IT services) and bottom-up agile ones (i.e., operational user stories).

5.7 Conclusion

Aside from reusability, the value proposition of service-oriented development comes from eliminating the need for a client (personified as an end-user and/or an entire organization) to invest heavily in IT assets before accessing them. In this sense, services do not only aid in structuring the IT solution around consistent business processes supported and automated as a package; as coarse-grained entities, they can also support C-level governance mechanisms as they are easy to use as scope elements to evaluate both BITA and development/acquisition decisions. At the same time, agility prescribes to focus on the ground-level requirements of users; its iterative nature and short delivery cycles aim to bring value at the earliest stages of the development process.

This chapter has introduced a framework merging the two aforementioned

approaches. Agile-MoDrIGo asserts that software development should not be driven by enforcing a choice between considering either strategic or operational aspects; it reconciles both venues counterbalancing possible vulnerabilities when only one of them is considered. The framework uses a parallel top-down and bottom-up approach based on conceptual modeling where integration is ensured middle-out by the use of goal-driven models. Specifically, Agile-MoDrIGo allows:

- a top-down delineation of custom Business/IT strategies and their representation as strategic organizational objectives. Also, business IT services defined the coarse-grained functional aspects that need to be fulfilled. Following their definition, business IT services can be then decomposed in a few epic user stories;
- a bottom-up collection of user requirements through user stories by nature following the approach of agile methods;
- a middle-level reconciliation between the top-down and bottom-up approach where: (i) (operational-level) user stories are mapped to (tactical-level) epic user stories refining a business IT service (i.e., *functional alignment*), and (ii) the contribution of user stories to business and IT objectives can be evaluated during each sprint in order to determine how user driven functions align with strategic aspects (i.e., *strategic alignment*).

We thus answered the present chapter's research question by furnishing a new version of the MoDrIGo approach that offers more flexibility and broadens its application scope.

Chapter 6

An Action Research Investigation into the Applicability of Agile-MoDrIGo Within A Medical Device Manufacturer

6.1 Introduction

Contemporary IT governance structures need not only to periodically study the alignment between business and IT organizational objectives. These set structures also need to incorporate mechanisms (or account for the provision of tools) for the perpetual evaluation of pipeline or catalog IT services in terms of their value attribution to end-users, customers, and other stakeholders implicated within the entire organizational network (i.e., suppliers). In that sense, the Covid-19 pandemic has certainly solidified the fact that organizations should not be making use of IT governance as a unidirectional (i.e., solely top-down) custodian of business-IT alignment practices. Indeed, in order to survive a rising tide of extended lock-down regimes and the switch to remote-working norms, many organizations were in dire need of methods and tools that could help them swiftly (i) reimagine their IT service-offerings, (ii) ensure the alignment of these services to their business and IT strategies, and (iii) materialize such services into full-fledged technological solutions offering instant value to users and customers [136, 97, 169, 202, 72].

The previous chapter described the application of design science research for the elaboration of the Agile-MoDrIGo framework leading to the aforementioned contributions. Indeed, Agile-MoDrIGo incorporates a tripartite model-driven approach attempting a linkage between the conception of abstract business-driven IT services (acting as IT governance emulators) and the specification of user-oriented functionalities for the materialization of these services into complete IT solutions. More specifically, Agile-MoDrIGo's **top-down approach** is used for the specification of *Business IT Services*[1] and their upcoming decomposition into coarse-grained functional elements (Epic user stories) of a pending IT development. The **bottom-down** approach marks the agile approach where fine-grained user-driven functionalities (i.e., user stories) are

[1]These *Business IT Services* are top-down defined, abstract in nature elements aiming to fulfill the strategic business needs of an organization through the use of IT capabilities.

specified for this IT development. The **middle-out approach** allows for the examination of the alignment between Epics and fine-grained user stories (i.e., functional alignment); concurrently, this approach offers a close inspection of the impending technology's operational user-driven specifications, rendering them as another basis of analysis for the retrieval (or not) of the organization's business and IT objectives (i.e., strategic alignment).

The present chapter focuses on the exploration of a real-world problem that a private medical device manufacturer has been facing; the latter has been in the process of assessing and deploying a new version of their Enterprise Resource Planning (ERP) system. This would signify that the C-level management of the company would have to go into a process of deliberation for the (re)evaluation, and perhaps recreation, of new services that would have to be aligned to their strategic (business and IT) objectives. At the same time, new software modules for the incorporation of these services would have to be developed for the ERP system. Part of the company's desideratum is the bequest for a method that could help them investigate whether they can manage a switch to an agile way of working for the development of these software modules. This whole process of deliberation was violently interrupted by the outbreak of the Covid-19 pandemic; thereby, the company was in need of a method, a tool, or framework to help them continue (and perhaps facilitate) the entire strategic reorientation process. In that context, the purpose of the present study is to determine the capacity to apply the Agile-MoDrIGo within the premises of this particular organization. We wanted to investigate whether Agile-MoDrIGo can assist this medical device manufacturer in determining crucial business IT services while leading them into an agile method of working for the software materialization of those services. At the same time, we wanted to study the actual implementation process in order to receive some practical insights regarding the framework's easiness to use. In this regard, the main research question of the present chapter can be stated as: *What lessons can be received from the empirical application of the Agile-MoDrIGo framework during the investigation of a real-life problem for an organization?*.

This chapter has been prepared in cooperation with D. Tupili and Y. Wautelet and it is organized as follows: Section 6.2 describes the adopted research methodology which corresponds to the conduct of an action research within the premises of the aforementioned organization. Section 6.2 is organized in several parts; each one describes a different phase contributing to a typical action research design. Section 6.3 describes the details of the way the Agile-MoDrIGo framework is being instantiated within the company; it also presents the results of this instantiation. Section 6.4 elaborates on our derived insights based on the framework's implementation; it also provides a reflection on some possible limitations based on the design of our survey and some conclusions.

6.2 Research Methodology

This section provides a description of the methodology that is used in order to respond to the research question as previously posed. Overall, our methodology is based on the design of an action research implementation [146]; the latter

is considered to be a qualitative research method stipulating a combination of both research and practice for the determination of a problem within a real-life context; the ultimate goal is to conceive a thorough process of understanding attributed to this particular problem in order to deliver change and reflection [7, 126]. The materialization of an action research design is most often associated with the undertake of a series of knowledge-gathering/change-implementing cycles; each one of these cycles is known to be encompassing the iterative manifestation of five action research phases. These can be summarized into the (i) diagnosis-, (ii) action planning-, (iii) action taking-, (iv) evaluation-, and (v) specifying learning-phase [11, 7, 78]. In what follows, we will be providing a short description of each one of these phases as well as the steps that we have taken in the process of their implementation in the context of the present study.

6.2.1 Diagnosis of the Problem Domain

The ***diagnosis*** phase is meant to elaborate on (i) the description of the organization being in the process of investigating a particular problem (or area of concern) within their field of operations, and (ii) the specification of the problem itself [78]. The present research has been conducted in the premises of a private medical device manufacturer operating in Europe, for the duration of one year (September 2020 to September 2021). To offer some specifics, MedicalDev Europe[2] acts as the European subsidiary of the MedicalDev Group headquartered in Asia. MedicalDev Europe has implemented SAP[3] as its ERP system in 2015, however, a next-level upgrade was proposed in 2019. The project has been planned in two phases; *Phase 1* describes the *Move* stage, where the infrastructure is to be moved towards S/4HANA, an upgrade to the existing system. *Phase 2* concerns the *Transformation* stage, where new services are to be embedded within the organization's existing processes. Overall, the upgrade of the existing ERP system was meant to increase compliance and enable some integration capabilities for several processes within the service areas of finance, logistics, and manufacturing. The upgrade decision was documented at the senior-management level of MedicalDev Europe and it was to be approached as an efficiency improvement project to better align with the current business context and user needs, rather than a full-scale development project. Since the upgrade was planned to go further than a mere technical update and was aimed at leveraging on high added-value streams, the use of agile methods has been proposed for its development, utilizing user stories for requirements elicitation. MedicalDev Europe's IT department was already in the process of evaluating a switch towards the execution of software development projects in an agile fashion; however, the ERP implementation started in 2015 in a non-agile way. As soon as the planification procedures started for the 2019 upgrade, the Covid-19 pandemic occurred; on the one hand, this radical switch in the way of doing business gave the C-level the opportunity to start an internal discussion about a more aggressive redefinition of their business processes and offered business services. Indeed, the new business context led governance members to

[2]The names have been changed for confidentiality reasons.
[3]More information can be found at: https://www.sap.com/index.html.

profoundly rethink the financial processes in collaboration with end-users and focus on automation, integration and the delivery of performance indicators. In reality, the organization wanted to become more agile-driven not only in its IT developments but also in the way it conducts its business. On the other hand, the outbreak of the pandemic and the switch to remote ways of working made it clear to the C-level representatives that they were in need of a method or approach that could guide them in the conceptualization of their new business and IT objectives and the inception of their offered services in the context of their ERP-upgrade project. Furthermore, such a method would have to provide for a link between these services and the (agile) development of the software modules for the upgraded ERP system.

In order to proceed to the state of diagnosis for the aforementioned problem, the research team engaged in *participant observation* [126] for 3 months. Pragmatically, this means that in order to gain knowledge about the internal proceedings of the organization, a specific member of the research team (which was a former employee of the MedicalDev Europe) participated[4] in the majority of the online meetings that were concerned with the redefinition of the company's business processes in relation to the upcoming ERP upgrade; the purpose was to be able to crystallize the outcomes and the specificities of these meetings into mature business and IT objectives.

6.2.2 Action Planning

The diagnosis phase was followed by the realization of the ***action planning***; the latter essentially entailed the cooperation between the research team and members of the C-level management of MedicalDev Europe for the formulation of a practical roadmap aimed at delivering a detailed proposition of the way, approach, and time-line in order to tackle the identified problem. The end-goals of this intervention were also discussed between the two parties. Pragmatically, during this phase (it lasted an entire month) the members of the research team organized a number of online meetings with various stakeholders from the MedicalDev Europe to discuss the possible implementation of the Agile-MoDrIGo framework. During these meetings, the research team made an detailed presentation of the framework and its distinctive parts. The research team defined as an end-goal the creation of a conceptual model what would primarily support the documentation of MedicalDev Europe's business and IT strategies in the form of pragmatic (long-term) objectives. Second, the concept of Business IT Service was described to these stakeholders; the implementation of the framework was supposed to assist C-level representatives with the deliberation of such Business IT Services that should act as (i) an alignment evaluator towards the previously-formed Business and IT objectives, and (ii) a supportive concept for the automation of the financial business processes within the company. Third, the implementation of Agile-MoDrIGo was meant to assist in provision of a visual pathway that would assist the company's IT

[4]Due to the ongoing Covid-19 lock-down enforcements at that time, the majority of the meetings for the ERP upgrade were taking place online via a popular online conference platform.

department to create a list of user-driven priorities (i.e., operational user stories) that would guide the agile transition for the software development of the distinctive modules of the upgraded ERP system and might lead to a better product ownership. The purpose was to help the end-users frame this list of prioritized functionalities in correlation to their attainment of the strategic objectives as set by the governance layer. The practicalities of the implementation roadmap (e.g., set dates for the conduct of interviews on behalf of the research team, the identification of the possible interviewees, set dates for the deliverance of some work products, major milestones etc.) were also discussed and agreed upon during these meetings.

6.2.3 Action Taking

The ***action taking*** phase is meant to prescribe the steps taken during the actual implementation of the Agile-MoDrIGo framework within the premises of MedicalDev Europe. The entire implementation process lasted about five months. Section 6.3 provides a complete specification of the work-deliverables resulting from this implementation. The action taking phase started with the planification for the conduct of semi-structured interviews (our main data-collection method) with key representatives of MedicalDev Europe. Our objective was to find suitable candidates occupying different roles within the company; such candidates would be in a position to assist us in the visualization of the company's Business and IT strategies in association with the desired redefinition of their business processes (and services) resulting from the upgrade of the new ERP system. Ideally, we also needed to tap into a pool of candidates that would have the necessary professional experience in order to help us stipulate a series of Business IT Services and decompose them into Epic User stories; lastly, we needed to gain access to roles that would be implicated with the retrieval of user-driven functional requirements for the technical deliberation of the ERP's software modules.

After framing our interview objectives, we presented them to the C-level representatives of MedicalDev Europe where they provided a sampling frame (a full list with the characteristics and contact details) of all the members that were directly implicated with the redefinition of the corporate and IT strategy in terms of the upgrade of the ERP system. We made use of this sampling frame by sending an email to these employees to make them aware of the research objectives of our study and inviting them to participate. A total number of 11 candidates expressed interest in participating in the survey. Table 6.1 provides an overview of their background, responsibilities, and characteristics.

At a later stage, these 11 professionals received a formal email invitation to participate in our survey along with detailed information about the interview process which would take the form of a 60-minute, individual conversation taking place online. To reiterate, we used a semi-structured interview format; this form of data gathering allowed us to be in contact with the interviewees and perform an in-depth dialogue guided by a set of questions. The format and allocation of these questions were meant to guide us in terms of instantiating the top-down, bottom-up, and middle-out approach of the Agile-MoDrIGo

framework. Before proceeding to the actual interviewing process, the research team clustered these respondents according to the characteristics of their roles and responsibilities; overall, four major clusters (they will be called domains onwards) were recognized for the survey participants (see Table 6.1). All domains received a set of generic (common) questions that were meant to frame the company's intentions towards its forthcoming digital transformation and reevaluation of its internal business processes. A set of targeted questions were also asked to gain particular knowledge from the representatives of each domain. For example, the interview questions for the survey participants belonging to the *Business Strategy* domain were meant to produce particular information capable of guiding us in the representation of the business objectives that the company sets in association with the upgrade of the new ERP system and its sought-after agile transformation (e.g., *What do you consider as a priority in terms of defining the business objectives associated with the upgrade of the new ERP system?., Would you consider this 'X' business objective as a self-sustaining one or could it be further analyzed in other sub-objectives? How do you determine that a business objective is a self-sustaining primary objective?.,* etc.,). Accordingly, the interview protocol for the survey participants belonging to the *Project Management* domain was meant to produce information capable of guiding us to the further characterization and decomposition of the identified Business IT Services to their Epics (e.g., *What services in IT could support best the materialization of the business objectives?., How would you ensure that these IT services developed in your organization are aligned with your Business objectives?., What would be the main actors participating in the creation of these Business IT Services?., What would be the main tasks of these actors?., What key functionalities are those Business IT Services are expected to fulfill?.,* etc.).

The discussions that took place during the interview sessions were recorded in video format after having acquired the consent of the interviewees. Upon completion of the interviews, the subjects' recordings (answers) were subsequently transcribed into text and analyzed. Our goal was to organize and codify all the necessary information from the interview data so we can efficiently use it for the instantiation of the three approaches of the Agile-MoDrIGo framework (see Section 6.3). Overall, we approached this task under the scope of template analysis [173]. The latter offers a deep structural analysis of qualitative data while allowing for flexibility in the creation of themes for the individual purposes of a particular study [82]. Once more, our interview protocol was comprised of a generic question set (i.e., common questions for all the survey participants) along with a set of specialized questions meant to disinter specific knowledge from each domain. Therefore, the implementation of template analysis allowed us to perform a two-stage pattern recognition of the transcribed textual artifacts from these two question sets in order to create a cumulative thematic representation of the interviewees' answers. To be specific, the research team performed an initial analysis on the contextual convergence of the respondents' *answers to the generic questions*; this process allowed us to classify the textual data according to 7 distinguishable codes (see Figure 6.1). These codes were then used as the basis for the performance of a second-stage thematic attribution

on the transcriptions of the respondents' *answers to the specialized questions*. The end-result of this process is presented in Figure 6.1. The conduct of the interviews along with the data analysis process and the actual instantiation of the framework concluded the action taking phase.

Initial Codes and description	Themes	Description	Contributing Domain
Code 1:Digitalization Code 2: Agility Code 3: Business Value	Theme 1: used for the top-down instantiation of Agile-MoDrIGo	Determination of Business and IT objectives	Business Strategy, IT strategy, Project Management, Process Management and Alignment
Code 4: Business IT Alignment Assurance Code 5:Business Services	Theme 2: used for the top-down instantiation of Agile-MoDrIGo	Identification of Business IT Service Portfolio and Decomposition (Epics)	Business Strategy, IT strategy, Project Management
Code 6: Requirements Engineering Process Code 7: Feature Identification	Theme 3: used for the bottom-up instantiation of Agile-MoDrIGo	Specification of User-Driven Functionalities	Process Management and Alignment

Fig. 6.1 Thematic Analysis for the Classification of the Interview Data.

6.2.4 Evaluation and Specifying Learning

The ***evaluation*** phase refers to the appraisal of the outcomes as derived from the implementation of the action taking phase. In our case, the evaluation was performed on the work-deliverables of the Agile-MoDrIGo framework as to be presented in Section 6.3 (see Figures 6.2 & 6.4). These were documented by the research team and presented to the C-level representatives of the organization after the implementation of the framework. The meeting took the form of an informal discussion. The evaluative feedback received by the members of the C-level representatives of MedicalDev Europe was used as input for the commencement of the ***specifying learning*** phase; the latter refers to the research teams' collection of lessons received from the implementation of Agile-MoDrIGo at MedicalDev Europe. Such lessons can be considered as the reflective basis upon which another potential cycle of the action research exercise may begin. In our case, the specifying learning was the last phase of our action research exercise. The collective findings from the evaluation and the specifying learning phases are located in Section 6.4.

6.3 Results

This section presents a synopsis of the results of the actual implementation of the Agile-MoDrIGo in MedicalDev Europe; this implementation is making use of the information derived from the interview sessions and the data analysis process as previously described. To accommodate the reader's comprehension,

we will follow the trinitarian approach of Agile-MoDrIGo to present these results. We begin with the top-down approach incorporating the representation of the strategic objectives, the identification of Business IT Services and their decomposition into their Epics. Next, the bottom-up approach is described; this approach explicates the specification process for the retrieval of (operational) user stories that are considered significant for the upgraded ERP system. Last, the middle-out approach is presented; this describes the details for the materialization of the functional alignment and the strategic alignment evaluation processes in the context of the research exercise.

6.3.1 Top-Down Approach

6.3.1.1 Model-Based Representation of the Business Strategy

Our first concern, as part of the Agile-MoDrIGo implementation process, was to model MedicalDev Europe's business and IT strategies as a set of (long-term) business and IT objectives in close association to the upgrade of the ERP system. The business strategy was mostly elicited from the specialized questions asked to the business strategy domain representatives (see 'Theme 1' in Figure 6.1). Likewise, the IT strategy was documented by the IT strategy domain representatives. We were mostly interested in the illustration of the company's business strategy and how the recognition of Business IT services aligns with it. For this reason, and to conserve some space, the IT strategy will not be depicted in this chapter. However, a similar modeling representation between the IT strategy and the creation of the corresponding IT objectives can be assumed following the paradigm of the business strategy. Overall, we make use of a Non-Functional Requirements (NFR) Decomposition tree [28] to represent and summarize these business objectives (see Figure 6.2). The data gathered during the interviews led to the identification of four primary objectives closely associated with the change that the company is trying to relinquish prompted by the ERP-system upgrade. These are: (i) *Promote digitalization and business model transformation*, (ii) *Reinvent core technologies that constitute strengths*, (iii) *Strengthen and optimize global organization and operational capabilities,* and (iv) *Demonstrate comprehensive strength and brand power.*

As suggested in the first objective *'Promote digitalization and business model transformation'*, an acute digitalization process along with its accompanying changes in terms of retrieving a sustainable way of doing business is of primary importance. This is further decomposed in the two sub-objectives *'Think and act in a sustainable way'* and *'become agile'*. These two sub-objectives are documented within the interview transcriptions. More specifically, the first respondent mentions that *'... embracing agility is clearly the solution for the company to be able to survive the complexities of the business environment. Agility means not only being able to respond quickly to urgent situations, such as the Covid-19 outbreak, but to be able to build a sustainable strategy in order to anticipate and properly respond to external challenges in the future.'*. In terms of becoming agile, the third respondent mentions *'... the organization needs to become more conscious of customer needs. Customers crave for a swift, iterative and incremental, value-based delivery mechanism that is significantly*

different than the heavy project-based mechanism we have been using thus far and is quickly becoming redundant'.

The second objective *'Reinvent core technologies that constitute strengths'* emphasizes on the aspiration of the company to be in state of strategic agility; the latter can bring the company in a state of organizational preparedness (and awareness) for the swift identification of new opportunities that can be swiftly materialized in full-fledged client-centric solutions. Additionally, the process of upgrading the ERP system is supposed to help in the identification of new internal services that are meant to bring a sense of unification between the headquarters in Asia and its corresponding subsidiaries; this is expected to increase customer satisfaction even further via the use of a single interface for all the customers. This objective is further decomposed in the following sub-objectives: *'Increase efficiencies with new customer-centric solutions'* and *'Communicate and share the knowledge, continue to build one organization'*. In terms of these two sub-objectives, the second respondent mentions *'... the company is operating in an international and incredibly dynamic environment with multiple markets, cultures, laws, and jurisdictions. In that sense, the only way for the company to move forward is to become more agile and to be able to pinpoint fast the details that might bring it face-to-face with a risky situation. This means that we have to adopt an efficiency-oriented business model looking with particular emphasis on digitalization as a strategic goal'*.

The third objective *'Strengthen and optimize global organization and operational capabilities'* refers to the organization's determination to leverage its IT systems and capabilities to bring balance between an optimized way of managing its global entities and the challenge of reaching a financial bottom-line. At the same time, the organization prioritizes on the infusion and promotion of a commonly-shared culture of collaboration within cross-functional teams and amongst departmental entities. This objective is decomposed in the following sub-objectives: *'Maintain operating profit'* and *'Break down silos and build cross-functional team collaboration'*. In function of the aforementioned, the second respondent mentions *'... the business should be in a very close collaboration with the IT function in order to develop the right system. A complex system that is not of use to the business will not only cause redundancy but it will also jeopardize financially the entire enterprise. But how do you find the right system? Through collaboration, engagement, and employee participation'*.

The fourth objective *'Demonstrate comprehensive strength and brand power'* refers to the company's aspiration to leverage its strong global presence and cumulative experience in the MedTech market to further promote its brand as a value-based/highest-quality offering. In that way, the company wishes to be considered as a partner in improving the quality of life of patients rather than a seller of medical products. This top-level objective can be decomposed in the following three leaf-level objectives: *'Meet customer requirements'*, *'Focus on outcome and value while maintaining the highest quality'*, and *'Supply and service our customers and their patients, in any circumstance'*. In terms of these sub-objectives, the first and third respondent agree that it is not sufficient (nor desirable) for the organization just to seek profit. In order to leverage the company's best asset, which are the people that compose it, the company has to

focus on value and take the extra mile in terms of listening and comprehending the patients' agony while attending the production teams' needs when building a health-ameliorating product. These top-level business objectives with their sub-objectives are represented in Figure 6.2.

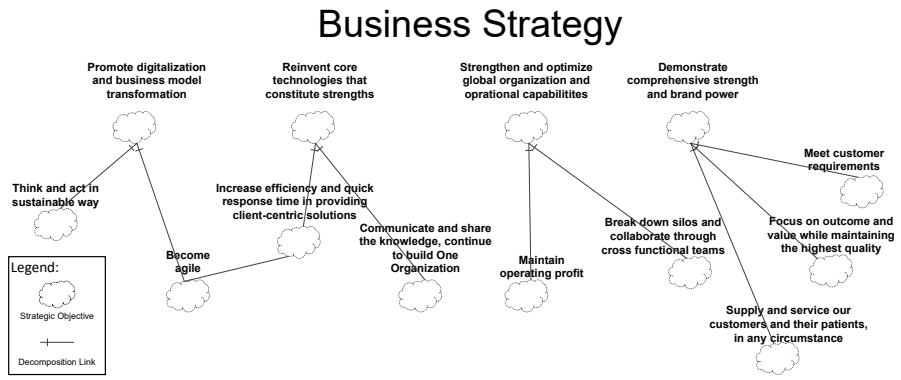


Fig. 6.2 Business Strategy NFR Decomposition Model.

6.3.1.2 Conceptualizing Business IT Services and Decomposing them into Epic User Stories

The data gathered during the interviews (see 'Theme 2' in Figure 6.1) identified specific finance and controlling activities linked to Record to Report (RTR) processes (SAP Credit Management FINFSCM-CR - SAP Help Portal, n.d.) as the most significant *Business IT Service* for the upgrade of the new version of the ERP. The importance of adequate credit and cash management in terms of integrating (and centralizing) the company's financial management processes for different departments, units/regions was listed as one of the top priorities at the executive board level. At this point, we need to mention that other services (i.e., Tax Management, Multicurrency Contract Management, Insurance Mediation Service etc.,) were also identified during the interview sessions with the *Business Strategy, IT Strategy*, and *Project Management* domains. However, these services were still early in the entire tendering process for the upgrade of the ERP and their evaluation and incorporation within the new system was pending the approval of the headquarter company; for this reason, these services were not considered for our study. Thereby, we applied the Agile-MoDrIGo framework to the *Credit Management* Business IT Service. Since we intended to focus mainly on the evaluation of operational user-oriented functionalities (i.e., user stories) of the upcoming ERP system to the attainment of top-down strategic objectives, we do not document the entire Business IT Service's top-down evaluation that would be realized using i* [201] and NFR diagrams [28]; the evaluation of this particular Business IT Service and its alignment to the strategic objectives were already documented during the interview sessions. Instead, we focus immediately on the decomposition of the *Credit Management*

Business IT Service into the coarse-grained functional elements provided in a top-down manner by the Agile MoDrIGo framework, i.e., the Epic User stories. Overall, three Epic User Stories related to the *Credit Management* Business IT Service have been recognized in a top-down fashion mainly by the members of the *Project Management* domain. These are: **Epic User Story 1**: *As a customer I need to have consistent delivery from my suppliers.* This epic is to describe customers' accessibility to consistent and reliable product delivery; **Epic User Story 2:** *As a Tax and treasury user I need to reduce delays in payments, non-payments and process costs.* The second epic describes coarse grained credit management functionalities; **Epic User Story 3:** *As a manager I need to make sure the cash status is up-to-date.* This epic is linked to the record-setting functionality within the cash management process; a constantly up-to-date cash management record is valuable for strategic managers planning for future investments.

The rest of this chapter will be exclusively devoted on the retrieval, exploration, and study of the impact of the fine-grained user stories falling under the scope of **Epic User Story 2** (so we will focus on the operational/user-level attribution of this particular coarse-grained functionality). This particular Epic User Story was found to be of primary strategic importance during our interviews; for example all the *Business Strategy* domain representatives have recognized the strategic value attributed by the ability of the new system to provide instantaneous cash & credit settlements and cut down on processing delays. The exemplary importance of such a coarse-grained functionality of the upgraded system has also been noted by the members *Process Management and Alignment* domain; these members mentioned that the capacity of the forthcoming system to accommodate the automation of cash & credit transactions is of tantamount importance for the efficient consolidation of the daily activities of its end-users (i.e., financial administrators, account managers, accountants etc.).

6.3.2 Bottom-Up Approach

For the bottom-up identification of the user-driven desiderata, we turned respectively to the representatives of the *Process Management and Alignment* domain (see 'Theme 3' in Figure 6.1). It is important to note that the specification of fined-grained user stories did not occur with the direct involvement of the potential end-users (and other user-level stakeholders) of the forthcoming ERP system. In fact, due to an augmented workload amount (mainly because of the switch to remote-working schemes) the research team was not allowed to be in direct contact with these employees; therefore the respondents belonging to the *Process Management and Alignment* domain acted as the user-level representatives given their daily interaction with financial administrators, account managers etc. A series of user-driven specifications were provided by these roles during our interview sessions. Figure 6.3 illustrates these user stories; the first column presents the user story in the format *As a <role>, I want <goal> so that <benefit>* [29]. The second column characterizes the feature associated with each individual user story while the third column represents the priority

that the interviewees place on the materialization of this particular user story within the ERP software. This priority can be considered as a user-driven (and perhaps subjective) measure of urgency since it is the middle-out approach of the Agile-MoDrIGo (see section 6.3.3) that is supposed to prioritize these user stories according to their contribution (or not) to the attainment of the business objectives. A user story that meets both the user's level of urgency as well as providing a positive contribution to the acquirement of the strategic objectives should be placed high in the backlog for the next development sprint.

6.3.3 Middle-Out Approach

This section represents the culmination of the Agile-MoDrIGo implementation process within the premises of MedicalDev Europe. The implementation of the middle-out approach commenced with the evaluation of the **functional alignment;** the latter describes the process of associating bottom-up defined user stories to their corresponding Epics (defined in a top-down manner). The framework suggests the use of a *Product Owner* role to be in charge of this process; such a role is indeed defined in many agile methodologies as the overseer handling the configuration of the user stories' backlog. However, since MedicalDev Europe was not yet fully immersed in an agile way of working, no straightforward Product Owner role was identified for the completion of this task. Therefore the research team in conjunction with the ninth[5] respondent occupying the role of the *Business Process Expert in the domain of Finance* took over the task of interrelating fine-grained user stories to a suitable Epic. This particular respondent was deemed the most appropriate for the realization of this task due to him being responsible for conceptualizing and aligning the financial processes (and their retrieved services) offered through the corresponding IT systems. The mapping process occurred with the use of the Rationale Tree [182]; the latter refers to a conceptual modeling-driven method to represent graphically sets of user stories in order to identify their interrelated elements and aggregate them into Epic user stories. The research team was responsible for the creation of the Rationale Tree while the respondent was responsible for its final validation. Overall, the mapping game led to five main user stories under the scope of the second Epic User Story. This is visualized in Figure 6.4; the *Credit Management* Business IT Service is decomposed into three Epic User Stories, themselves decomposing fine-grained user stories; an *'AND'* decomposition is used to illustrate this. The following user stories have been assigned to the **Epic User Story 2:** *As a Tax and Treasure User I need to reduce delays in payments, non-payments and process costs:*

- **User Story 1:** *As an account manager I want to apply credit segmentation between client transactions so that effective risk management practices can be followed;*
- **User Story 2:** *As an accountant I want to see the history of credit exposure in accounts receivable so that overexposure can be avoided;*

[5]See the respondent's characteristics in Table 6.1

User Story	Feature Characterization	Priority
As an account manager I want to apply credit segmentation between client transactions so that effective risk management practices can be followed	Credit Segmentation of customers	High
As a financial administrator I want to apply credit drilldowns within the account receivables so that manual workload can be reduced	Credit Drilldowns within account receivables	High
As a financial administrator I want to be able to access financial data per Business Unit so that customary financial reporting can be produced	Reporting based on pre-defined attributes	Middle
As a financial administrator I want easier navigation between various transaction tabs so that efficiency can be ensured during account reconciliation	Easier navigation	Middle
As a compliance manager I want automated integration of credit data so that quality credit checks can be executed	Automated Integration of credit data	High
As an account manager I want automated alerts on credit limit changes in order to execute efficient credit checks	Automated alerts for credit limit changes	High
As an account manager I want to be able to block customers for credit, legal, or compliance purposes so that to avoid any new sales being registered for a particular account	Blocking customers	High
As an account manager I want the system to validate automatically any newly inserted account information so that account transparency can be optimized	Auto validation rules in the system	Middle
As a supply chain officer I want to detect immediately which business partners are to be contacted in Collections Management so that an overview can be projected during the client payment process and follow-up	Instant detection of business partners' list	Low
As a supply chain officer I want to apply priority filters on the business partners to be contacted in the work-list so that an efficient client payment follow-up can be performed	Application of priority filters for business partners	Low
As a financial administrator I want to be able to apply currency conversions in the worklist amounts so that an accurate multi-currency client payment process can be performed	Entering currency in the work-lists amounts	High
As an account manager I want to be able to view the time-intervals for the maturity date of the receivables so that efficient client- payment follow-up can be performed	Visibility of time-intervals for maturity dates	High
As an accountant I want to see the history of credit exposure in accounts receivable so that overexposure can be avoided	Credit exposure status of customers	High
As an account manager I want to determine the influence of the payment conditions on the collection process so that proper discount conditions can be discussed with the client	Influence of payment conditions	Middle

Fig. 6.3 Bottom-up User Stories' Specification from the Interview Process.

- **User Story 3:** *As an account manager I want the system to validate automatically any newly inserted account information so that account transparency can be optimized;*
- **User Story 4:** *As a financial administrator I want to be able to access financial data per Business Unit so that customary financial reporting can be produced;*

- **User Story 5:** *As a financial administrator I want easier navigation between various transaction tabs so that efficiency can be ensured during account reconciliation.*

The **strategic alignment** refers to the evaluation of (operational-level) user stories based on their contribution to the attainment of the company's strategic objectives. This process was conducted by the respondents belonging to the *Business Strategy* and *IT Strategy* domains[6]. Within our pool of respondents, the aforementioned were considered as the overseers for the conception of the business and IT strategies in relation to the ERP-system upgrade. The research team occupied the role of the coordinator for this process but was not directly involved in the evaluation of any of the fine-grained user stories according to their individual value to the attribution of the strategic objectives; this task was completely undertaken by our aforementioned respondents. More specifically, each respondent was asked to evaluate the level of contribution of each individual user story (out of the five that were associated to the second Epic) to the attainment of each strategic objective in an informal manner according to their judgment and expertise; however, their replies had to be justified. At the end, their answers were aggregated and the user stories characterized as the most contributing ones to the attainment of the strategic objectives were added in Figure 6.4. Overall, this multi-level graph summarizes the middle-out approach by showing the support of these individual user-delivered sources of value on the business strategy and by visualizing the entire alignment process.

6.4 Discussion and Conclusion

This section provides a consolidation of the insights drawn during the last two phases of our action research conducted in the premises of the particular medical device manufacturer. The first subsection is comprised of the evaluation of the Agile-MoDrIGo as performed by the representatives of the company. The second subsection represents a codification of the specifying learning as received during the conduct of the entire action research exercise.

6.4.1 Evaluation of Agile-MoDrIGo

To reiterate, the evaluation of the Agile-MoDrIGo was mainly focused on the model-driven representation of the business objectives (Figure 6.2) as well as the final graph representing the user stories' support towards the attainment of these objectives (Figure 6.4). This evaluation took the form of an informal discussion after the presentation (and signification) of the main figures by the research team. The majority of the C-level representatives expressed the opinion that the rendition of the company's strategic objectives in the form of a NFR-decomposition tree provides a simple and comprehensive blueprint of the company's should-be strategic vision in times of global economic restlessness. The representatives appreciated the outcomes of the performed interviews as they were able to capture quite accurately the need for advanced digitalization

[6]These correspond to respondents 1 to 6 in Table 6.1.

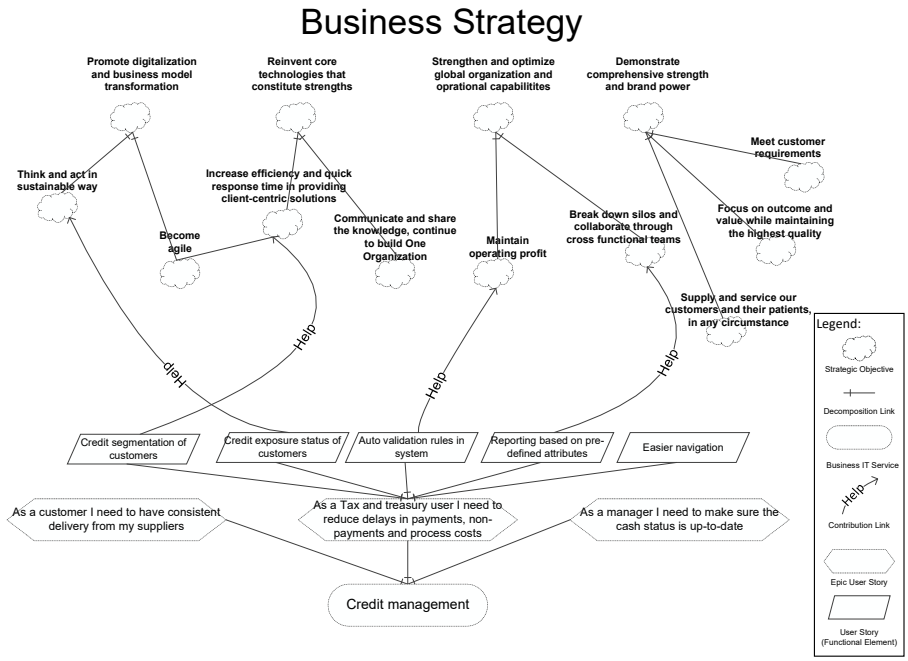


Fig. 6.4 User Story Support of Business Objectives in MedicalDev Europe.

and agility; these objectives were able to apprehend the need for a different service proposition as a result of the Covid-19 workplace disruptions as well as the need for an internal recalibration of the organizational credit management processes in factor of the ERP-system upgrade.

Some representatives mentioned that the parent company has already set-up diverse steering committees and a number of governance bodies entrusted with the amalgamation of business and IT processes within the corresponding organizational entities running under the MedicalDev umbrella corporation. In that aspect, they expressed some reservations about the lack of details within the model-driven representation of the strategic objectives; they were rather expecting a diagram that could provide inputs for the production of an architectural roadmap ensuring the (profitable) amortization of IT investments on behalf of the business. However, it was explained to them that the purpose of Agile-MoDrIGo is not to go into such a level of analysis. As a matter of fact, Agile-MoDrIGo sees to the swift production of a snapshot of the corporate and IT strategies at a particular moment in time. This snapshot can become the basis for the evaluation of new (or existing) services that can lead to an amelioration of a number of business indicators (e.g., greater customer engagement, shorter value-chains cycles, etc.,) via the use of specific technologies.

In general, the representatives were satisfied with the framework being able to bring to the forefront some of the parallel processes that were running under the auspices of corporate governance and IT governance; they acknowledged

that a proper instantiation of the Agile-MoDrIGo could provide with a practical sequence of activities for the convergence and validation of the alignment of these separate views (Business and IT) via the conceptualization of Business IT Services. More specifically, they mentioned that the gestation of the *Credit Management* Business IT Service has helped the C-level realize that the business layer is being preeminent in orchestrating the project for the ERP-system upgrade; this realization can help the IT function to (re)adjust its service-offerings accordingly to better support the organization. In terms of the upgrade of the ERP system specifically, the IT function can make more cognizant decisions in terms of choosing between committing to a new IT investment or collaborating with external vendors when there is a lack of IT capabilities (and knowledge) within the organization.

However, the C-level representatives acknowledged a discrepancy in the easiness, understandability, and capacity to apply the framework depending on the type of the activity performed each time. This was also observed by the research team during the time of the actual implementation (i.e., action taking phase). For example, during the implementation of the top-down approach, the survey participants were comfortable in specifying the business and IT strategies in correspondence to the company's reevaluation of its internal business processes prior to the upgrade of the ERP-system. Additionally, the interviewees had no difficulty in comprehending the notion of Business IT Service and in investigating the existence of such elements in connection with this particular project. Nonetheless, the decomposition of these Business IT Services in their Epic User Stories was not a self-evident task. Indeed, the research team had to explain persistently the format (and purpose) of an Epic User Story in order to complete the task at hand. At the end, the survey participants were able to recreate simpler statements explicating the coarse-grained functionalities of the Business IT Service; the research team had to transfigure these sentences into the format of an epic user story; these epic user stories were then validated by the survey participants. The same problem was also identified during the bottom-up specification of operational-level user stories. Difficulties were also encountered during the evaluation process for the establishment of the functional alignment; more specifically, the lapse of a Product Owner role within the company added another level of complication to the entire the process of corresponding operational-level user stories to their epics. Nevertheless, both parties at the evaluation meeting agreed that these particular bottlenecks during the implementation of the framework were useful as they provided insights about the present state of agility within the company.

Finally, the research team noticed some ambivalence amongst the C-level representatives in terms of the potency and efficacy of the strategic alignment process. On the one hand, the majority of the representatives found quite appealing the idea of coupling user-level expectations with the attainment of strategic-level objectives. They mentioned that such an act creates the preconditions to start building an empowering culture where the operational layer is no longer considered segregated from the strategic one. They also noticed that such a strategic alignment process can also be used bidirectionally where the persistent non-fulfillment of a specific strategic objective by a multitude

of operational-level user stories could signal the incongruous predisposition of that objective; this could be leveraged to create a de-facto 'strategic participation policy' where the operational layer makes an actual contribution in the shaping of the strategic objectives. On the other hand, some representatives expressed reservations about the nature of the approach that is being used for the evaluation of the strategic alignment. In our case, the interviewees had to explicate each user story's contribution to the strategic objectives according to their experience and personal judgment. The representatives questioned whether the followed approach can be considered as an 'objective' and 'robust' way of performing such delicate evaluations. The research team explained that the framework is not restrictive in terms of dictating a specific approach for the aforementioned evaluation. In fact, the framework is intentionally unrestrained offering the implementing team the choice to go for a quick evaluation (for the swift provision of user stories' insights before the start of a corresponding sprint cycle) or opting for a thorough evaluation of the user-level desiderata (for example before deciding whether to commit or not to a resolute IT development investment).

6.4.2 Specifying Learning

One of the most important determinants for the successfulness of this particular action research exercise is related to the participants' willingness to introduce any sort of change in their corporate ideocracy after the research team's specific intervention. In our case, the implementation of the Agile-MoDrIGo framework was meant to elicit specific organizational desiderata that could assist the company to reevaluate their internal business processes in furtherance of their agile transformation. Our intervention reveals a strong C-level support in terms of aligning the state of the corporate objectives towards an integrated treatment of specific credit management procedures; to achieve this alignment, senior managers are willing to investigate mechanisms, assign roles, and planify for the release of corresponding resources. Nevertheless, this top-down level of support receives occasionally some form of resistance from the lower-levels of the organizational spectrum towards the generic objectives of the entire agile transformation endeavor. Even though the respondents seemed to acknowledge the need for a recalibration of their internal business processes in correlation to the upgrade of their ERP system, some were unsure whether the embrace of an agile approach for the development of the corresponding software modules would lead to concrete results. Since the goal was to integrate primarily the treatment of financial (i.e., credit & cash management) processes with other organizational entities, the use of agility seemed to purvey some cause for concern given its scalability difficulties and the challenge in concurrently coordinating multiple development teams. In that aspect, our intervention could be considered of added-value since the survey participants (and some key-level senior managers) were able to get a more complete picture about the company's state of agile readiness. In fact, our intervention revealed that, besides the recalibration of business processes, MedicalDev Europe needs to engage in a state of apperception of the strengths (and vulnerabilities) of its internal IT

function. This entails the performance of a thorough stocktaking in terms of the IT talent capable of handling the agile transition. In addition, the activation of solid change-management mechanisms targeting a maximum level of employee engagement was suggested on account of our intervention. In that aspect, the implementation of the Agile-MoDrIGo gave the survey participants the opportunity to become better affiliated with some cornerstone-notions espoused with the agile mentality. For example, during the functional alignment process, the research team tried to convey the importance of establishing a distinct role for the set-up and management of the user-driven functionalities' backlog. Before the intervention, such duties were assigned to the project managers handling the entire ERP upgrade project.

At this point, we need to critically reflect some of the limitations that were encountered during the implementation of the Agile-MoDrIGo within the premises of the particular company. For example we need to examine whether the choice and number of our sample instances were sufficient in terms of gathering the required amount of information in order to produce a representative visualization of the company's business and IT objectives. First, we need to mention that the assemblage of our survey participants was mainly consisted of a purposive (judgment) sampling technique [88] based on an sample frame offered by the C-level representatives of MedicalDev Europe. Each member of the research team performed an individual examination of this frame to retrieve roles that would be directly implicated in the devising of the strategic trajectory of the company relating to the ERP project. Next the research team convened and discussed all their individual choices. The end-result of this process was the establishment of a final list including particular roles that were chosen after consistent deliberation and unanimity among the members of the research team. The people occupying these roles received an invitation to participate in our survey. Those who did accept our invitation possessed an extensive amount of experience within the corporate and IT structures. Of course, a more enriched sample would have perhaps contributed to the release of more information regarding the intended strategic direction of the company. In any case, our modeling representations were evaluated by the C-level representatives during one of the phases of our action research exercise. We also need to mention that, in terms of sample representability, our (operational) user-stories were not gathered directly by the end-users. As mentioned in one of the previous sections, the research team was not granted direct access to these users due to their increased amount of workload. Instead, we used the respondents belonging to the *Process Management and Alignment* domain (respondents 9 to 11 in Table 6.1) as their representatives. These roles seemed to possessed credible experience since their duties enforced them to act as the gatekeepers for the gathering of user-driven specifications; still, we acknowledge that not involving directly end-level users (i.e., financial administrators, account managers etc.) in the entire implementation process of the Agile-MoDrIGo can be perceived as a limitation and it does not represent the intended way of approaching the framework's bottom-up approach.

Similarly, we can raise the question whether the provision of the internal composition of the Credit Management Business IT Service in the form of an

i* Strategic Rationale Diagram (SDR) [201] would have been of added value to the company representatives. We need to transmit that the Agile-MoDrIGo is to be considered as an evolution of the classic MoDrIGo [176] approach; the latter suggests the visualization of the internal composition of Business IT Services (in the form of an i* SDR) in the effort to map their contribution (help or hurt) towards the attainment of the organizational strategic objectives. Within Agile-MoDrIGo, the basis of analysis for the attainment of strategic objectives is shifted towards the user-driven specificities of the IT developments that materialize these Business IT Services. In that aspect, a complete sequence of analysis should have first introduced the classic MoDrIGo approach (i.e., the mapping of all the interdependencies between Business IT Services and strategic objectives) and then proceed to the implementation of the Agile-MoDrIGo (i.e., creating the link between Business IT Services, user stories, and the attainment of the strategic objectives). In our case, the performance of the classic MoDrIGo could be omitted since the company had already initiated with the process of reevaluating their internal business processes and services which would be aligned with the company's strategies. The research team's task was to be able to help the company recognize these elements and shape them in the form of Business IT Services so they can facilitate their future development of appropriate software modules for the upgrade ERP system. In actuality, the possibility of ascertaining the internal workings of any of the Business IT Services that would be discovered during the process of our research exercise was discussed with the C-level representatives during the action planning meetings. Eventually, this course of action was finally abandoned due to time restrictions. However, the possibility of creating a model-based representation for the entire Business IT Service portfolio for the entire MedicalDev group (under the scope of the merger of their financial processes via the ERP system upgrade) was discussed during the final evaluation meeting. This endeavor is out of the scope of the present study and can be left for future work.

At this point, we can concretely return to the recurring research question in terms of the lessons received from the implementation of the Agile-MoDrIGo in the context of our action research exercise. A precept that cannot be admonished refers to the occasional communication lapses between the research team and the company representatives in terms of the expectations (and deliverables) of this exercise. On the one hand, the research team aspired that the implementation of the Agile-MoDrIGo would lead to the provision of an integrated conceptual model-driven method offering the C-level managers a way of quickly evaluating the technology-development processes of their organization via the identification of Business IT Services. Indeed, the latter offer an innocuous way of conceptualizing some crucial IT government elements that stipulate to the fulfillment of business-IT alignment practices. Additionally, they offer support in finding the adequate alignment between which functions to adopt for the delivered technology and the overall Business and IT strategies that IT acquisitions need to comply with. The feedback that was received during the evaluation phase stipulates to the fulfillment of that goal. Nevertheless, the company-representatives were sometimes quick in dismissing the value of using software-modeling practices mainly due to the lack of familiarity with

them. In that aspect, the participation of a member of the research team in the meetings regarding the ERP-upgrade discussions has been indispensable for the uneventful execution of the entire action research as well as making the representatives realize the role, use, and ultimate value of our model-oriented artifacts.

Respondent	**Highest Degree**	**Current Role**	**Domain Representation**	**Experience (years)**
Respondent 1	Master in Finance	Chief Finance Officer and Vice-President in the EMEA region for Finance	Business Strategy	20
Respondent 2	Master in Law	General Counsel, Vice-President for Legal and Compliance	Business Strategy	25
Respondent 3	Bachelor in Literature	Strategic Planning Manager	Business Strategy	20
Respondent 4	Master in Business Administration	IT Applications, Enterprise Architecture and Analytics Director in the EMEA region	IT Strategy	23
Respondent 5	Master in Science	IT Director	IT Strategy	23
Respondent 6	Master in Information Technology	IT Infrastructure, Operations and Security Director in the EMEA region	IT Strategy	20
Respondent 7	Master in International Business	Validation and Compliance Manager in the EMEA region	Project Management	13
Respondent 8	Bachelor in Science	Project Manager and ERP Upgrade Coordinator	Project Management	13
Respondent 9	Master in Economics	Business Process Expert in the domain of Finance	Process Representation and Alignment	7
Respondent 10	Master in Industrial Management	Manager of Record to Report and Enterprise Performance	Process Representation and Alignment	20
Respondent 11	Master in Law	Tax and Treasury Manager	Process Representation and Alignment	20

Table 6.1 Participating Respondents and Their Characteristics.

Chapter 7

Further Discussions on the Developed Frameworks

7.1 Discussing the Developed Frameworks Using a Range of Specific Determinants

The classic MoDrIGo, and the enhancing StratAMoDrIGo and Agile-MoDrIGo approaches are being discussed in this chapter to provide a clear positioning of the different trajectories that these frameworks follow. This discussion is based on a range of specific determinants that are supposed to reveal each framework's intended purpose. These determinants are revolving around the frameworks' (i) abilities to represent strategic concerns, (ii) the type of conceptual models they support, (iii) their employed scope elements, (iv) the type of value-based modeling they support, and (v) the type of agility they negotiate. StratAMoDrIGo and Agile-MoDrIGo are also compared to an industry accredited framework dealing with agile development while encompassing a strategic analysis (SAFe) and a widely researched value-based modeling framework (e3value). The results of such an analysis can be seen in Table 7.1, and are elaborated in Sections 7.1.1 and 7.1.2. In addition, Section 7.2 is negotiating a possible extension of the StratAMoDrIGo framework in order to regard agility not only from a strategic (and tactical) level, but to also include aspects adhering to operational agility (i.e., the determination of fine-grained functions in the form of user stories which are highly valuable to end-users). Section 7.3 touches upon the complementarity between the StratAMoDrIGo and Agile-MoDrIGo approaches, while Section 7.4 discusses aspects related to the scalability of the aforementioned approaches and their expected domains of applicability. The work presented in this chapter has been conducted in collaboration with Yves Wautelet.

7.1.1 Discussing Elements of the MoDrIGo, StratAMoDrIGo, and Agile-MoDrIGo Frameworks

The MoDrIGo, StratAMoDrIGo, and Agile-MoDrIGo approaches are all meant to support the C-level by using strategic objectives to depict the strategy. However, each framework uses different scope elements to pursue such a goal. MoDrIGo uses Business IT Services as functional high-level scope elements;

Table 7.1 Comparison of Key Aspects of the MoDrIGo, StratAMoDrIGo, Agile-MoDrIGo, SAFe, and e3Value Methods.

	Strategic level support	Types of conceptual models supported	Type of scope elements	Type of value-based modeling	Type of Agility
MoDrIGo	Yes.	Uses NFR for strategic-level roll-up and i*, SSD for Service Consumer and Provider identification and i* for service tactical/operational visualization (drill-down).	Business IT Services.	Service Strategic value only.	None.
Strat-AMoDrIGo	Yes.	Uses NFR for strategic-level roll-up and i* for the edition of tactical/operational stakeholders and technology configurations (drill-down).	Strategic opportunities.	Strategic, Stakeholder and User value of Strategic opportunities.	Strategic.
Agile-MoDrIGo	Yes.	Uses NFR for strategic-level; supports the use of i* for the retrieval of interrelated user-oriented elements (operational level) and their mapping to coarse-grained functionalities defined at the strategic level.	Business IT Services on strategic level; User Stories for user and strategic value.	Service Strategic value and User value.	Operational.
SAFe	Partial	None.	Value Streams.	None.	Scaled Operational.
e3value	Partial	Use Case Maps for top-level evaluation of economic value streams among actors; UML or BPMN models for middle-level plot of business processes.	Value Exchange Flows.	Stakeholder value. Value conceived in a monetary perspective.	None.

the use of service-orientation is primary in major frameworks that negotiate a synchronization between the IT governance and management levels in an organization (see COBIT[1] and ITIL[2]). Agile-MoDrIGo is also capable of providing evaluations on the state of BITA with the use of Business IT Services for governance-level adoption decisions. Nevertheless, Agile-MoDrIGo uses a different route for the provision of such evaluations; the latter utilizes support links between operationally-defined user stories and organizational strategic objectives to highlight the BITA contribution of the (to-be) Business IT Service. Contrastingly, StratAMoDrIGo uses strategic opportunities as the means of ex-ante evaluating (and optimizing) IT governance processes within organizations along with their software development cycles before committing to the release of indispensable resources.

In terms of their implicated conceptual models, MoDrIGo, StratAMoDrIGo, and Agile-MoDrIGo represent the organizational strategy in a similar manner (with the use of NFR representations). Business IT Services are ultimately the ones for which an adoption or development decision needs to be taken in MoDrIGo, and their tactical and operational behavior is represented with i*. On the other hand, StratAMoDrIGo utilizes i* to represent the impact of strategic opportunities on the organizational setting. Once again, strategic opportunities, contrarily to Services, are considered very innovative so specifically developed to furnish strategic, stakeholder and user value in moving business contexts. As a result, in MoDrIGo, strategic objectives are perceived at managerial-level into the i* representation as soft goals that elements within Business IT Services help or hamper to fulfill. In StratAMoDrIGo, strategic objectives are cascaded, in the management-level into the i* representation, as (hard) goals that are immediately fulfilled by functions of the strategic opportunity. Dissimilarly, user stories (using their corresponding Epics as the linkage point with Business IT Services) are the ones for which an adoption or development decision needs to be taken in Agile-MoDrIGo, according to their value attribution at the strategic level. Agile-MoDrIGo supports the utilization of i*-based techniques (i.e., the Rational Tree [182]) to map such bottom-up defined user stories to their corresponding Epics, demarcated at the governance level. Nevertheless, other techniques which do not necessarily constitute conceptual models (i.e., the User Story Mapping [121]) but offer nonetheless an internal analysis of the interrelated elements within user stories, can be used as a plug-in at the heart of the framework.

As far as value is concerned, StratAMoDrIGo can also be seen as broader than MoDrIGo. Indeed, value is considered at multiple levels in the former. One of the most differentiating elements between the two is their value presuppositions with the former considering that not all value can be determined beforehand so that new sources of value (especially for the stakeholder and the user) will be determined and supported at the time of implementation. On the other hand, Agile-MoDrIGo offers value attributions at the user level (via the provision of bottom-up defined user stories), and the strategic level (via their strategic alignment assessment either before the start of a sprint cycle or in the context

[1]The current version is 'COBIT 2019': Retrieved from: http://www.isaca.org
[2]The current version is 'ITIL version 4': Retrieved from: https://www.axelos.com

of the sprint retrospection). However, the 'user' connotation is perceived here mostly in its operational aspect. Contrastingly, the class of stakeholders introduced in StratAMoDrIGo can go beyond the role of an end-user; indeed, they can they be either instantiated in the form of specific roles that directly affect the strategic direction of the organization or in the form of crucial roles outside the direct boundary of the organization (i.e., suppliers).

7.1.2 Discussing Elements of the StratAMoDrIGo, Agile-MoDrIGo, SAFe, and e3value Frameworks

The purpose of the SAFe [84] framework is to furnish an approach for using the agile development approach on large development projects (i.e., to scale agility). This is not the case with either StratAMoDrIGo (it aims to support agility at a strategic level) or Agile-MoDrIGo (it aims to attribute strategic value to operational-level desiderata). SAFe partially supports the strategic level; it uses value streams to determine which high-level trends need to be supported, and Epics as functional high-level scope elements. The notion of an Epic in SAFe is considered more abstract/coarse grained than in traditional methods like Scrum, and is used to represent functions that are sufficiently large to be developed in a stand-alone fashion. SAFe has a strategic alignment vision based on portfolio management rather than focusing on individual projects.

As far as value is concerned, SAFe prescribes to be value stream driven at strategic-level and in that sense it partially overlaps with StratAMoDrIGo and Agile-MoDrIGo. Strategic value is driven by a value stream involving 4 (time) horizons, while Epics are defined from the portfolio in alignment with the value stream. Epics are then connected to their Program Increment (PI) planning in a top-down fashion. In fact a PI is a sequence of four different sprints where, for each individual sprint, different teams are working independently on different system parts (in parallel) by defining the Minimum Viable Product (MVP) of features that first need to be validated before further building the product. Therefore, the vision of SAFe is essentially top-down and waterfall (thus poorly agile), fuzzy in its application and very complex to trace at operational level since no unique form of conceptual modeling is suggested to support the alignment between the strategic goals and all the decision-level structures within an organization. There is partial congruence between StratAMoDrIGo, Agile-MoDrIGo, and SAFe in their exploration of the ways in which governance decisions (i.e., evaluation of pending heavy IT investments) can be reconciled with the agile management of their development. StratAMoDrIGo is similar to SAFe in terms of not aiming to fund projects but strategic opportunities encompassing new major functions that need to be supplied by the IT ecosystem. SAFe's *Epic* notion can also be compared to Agile-MoDrIGo's *Service* notion in terms of granularity. However, SAFe's strategic approach is portfolio-based while StratAMoDrIGo's is strategic opportunity-based, and Agile-MoDrIGo's is service portfolio management-based.

Contrastingly, the purpose of the e3value framework is to represent organizational business models while integrating business and IT modeling approaches by focusing on how economic value is created and exchanged within a network

of actors. e3value partially supports the strategic level. The use of the term 'partially' refers to the framework's limitation in considering economic value exchanges as the sole decision-making factor during the set-up, extension or modification of a business model.

Conceptual modeling wise, e3value was created primarily to support the requirements' analysis stage for the creation of business information systems by defining an ontology to compromise business-oriented concepts with the required formality of information systems development modalities [50]. Right from the get-go, we experience a contrast between e3value and StratAMoDrIGo as the latter aims not only to facilitate the adoption of technological solutions that fulfill business (long-term strategic) objectives, but it does so by considering the elimination of any lag between the decision and the incorporation of these technologies within the organizational gears.

The value concept is central within e3value. Indeed, amongst its primary concepts, the e3value ontology describes the participating – in a value-exchange setting – actors; these are to be considered elementary or composite in nature, but they are strictly economically independent from each other; this independence seems to be the guarantor of any gain that might occur during the entire value-exchanging process. A composite actor is perceived as a group actor that uses value interfaces with all its internally participating elementary actors. These value interfaces group value ports that provide (or request) value objects to or from other actors. Value flows are mapped using 'AND' or 'OR' operators which attribute a sequential character within the positioning of value activities [145]. Finally, e3value modeling allocations allow actors' compositions but no actor specializations [119]. Contrastingly, the StratAMoDrIGo approach allows for the vertical decomposition of actors according to their strategic, tactical and operational facets, which in turn attributes to them a different 'value portfolio'. Each actor's value portfolio is not considered in isolation and no value portfolio is considered more important than the rest. The point is to utilize parts of the i* modeling notations to map the intentionality among these different actors and determine how their overall social interactions affect these value-portfolios in response to the accumulative well-being of the entire enterprise. In this context, the value-flow from the upcoming technological adoption/development, as derived from the strategic opportunity, is being trichotomized in order to gratify the needs of all the enterprise actors by simultaneously (i) sustaining their strategic needs, (ii) accommodating their stakeholder goals, and (iii) allowing for feature implementations that will contribute towards the achievement of their strategic objectives. The plausibility of analyzing these value-interdependencies is not present in the e3value where its sequential value-flows focus on a quid-pro-quo economic exchange (i.e., product for a service, product for a monetary exchange etc.) within bilateral actor-to-actor relationships.

7.2 Linking Strategic with Operational Agility in StratAMoDrIGo

To reiterate, the StratAMoDrIGo framework essentially addresses the problem of locating an effective method to approach the state of strategic agility in an

organizational-based environment. In this framework, solutions depicted as strategic opportunities have been considered in their broader sense than software-based only. Nevertheless, software is an important part of IT development and strategic opportunities can be based partly or exclusively on software. In that case "traditional" agile development (or even a DevOps approach [12]) delivers the most interesting way of developing the said software. Indeed, in a moving business context, we are seeking for short development cycles, value-based sprint prioritization as well as a maximum of user input. The StratAMoDrIGo framework, as depicted thus far in this dissertation, makes a round trip between the top and the middle-level where the value is discussed and evaluated but does not cover the pure operational level where user desiderata are discussed. In other words, the lowest functional level of the framework is the *Feature* concept.

The *Feature* concept can be aligned with the one of an *Epic User Story*. Several definitions and understandings of the *Epic User Story* notion can be found in literature and in practice (see for example [29, 140, 84]). Presently, we regard the *Epic User Story* as a coarse-grained functionality under the scope of which fine-grained elements (functional or non-functional) can be placed. In that way, the notion of an *Epic User Story* is to be considered in the standard way adopted in agile methodologies (i.e., Scrum) and tools (i.e., Jira) [163]. In other words, the *Epic User Story* contains one *Feature* (the 2 concepts are perfectly aligned) and under one *Epic User Story* a collection of *User Stories* collected in a bottom-up fashion can be placed. This way, the StratAMoDrIGo framework can conciliate a high-level strategic approach founded on strategic agility and stakeholder-based governance with a pure operational-level agile development of the (functionally) identified sources of value. Figure 7.1 refines the meta-model presented in Chapter 3 (see Figure 3.1) and expresses this refinement in the general ontology of the StratAMoDrIGo framework. In that way, Figure 7.1 reports that *User Stories* are expressed by Users, and these elements are to be considered under the scope of a specific *Feature* itself being an *Epic User Story*; a backlog of *User Stories* is thus created and can be managed using an agile method like Scrum. The reader can find a detailed analysis of this type of Feature-to-Epic relationship in the study of Tsilionis et al. [163].

The implementation as well as the management of the implementation of *User Stories* can be done in a custom fashion, i.e., using any agile development method based on user stories. This is generally the responsibility of the *Product Owner*. For illustrative purposes, the process fragment depicted in Figure 3.5 has been further enriched in Figure 7.2 to cover the edition of *User Stories*. The *Product Owner* Role has been included and represented as an i* *Actor* being responsible of the *Structure Requirements* Phase realized by the *Map Epic User Stories with User Stories* Activity, depicted as an i* Task. Further refinements depend of the agile process used. In Figure 7.2, for descriptive purposes, the refining process activities are being performed with the use of the Rationale Tree technique depicted in [182] for this special context. However, StratAMoDrIGo is flexible enough to support other methods that incorporate ways of investigating commonalities among multiple user stories' sets and attempt to bind user stories to their corresponding Epics.

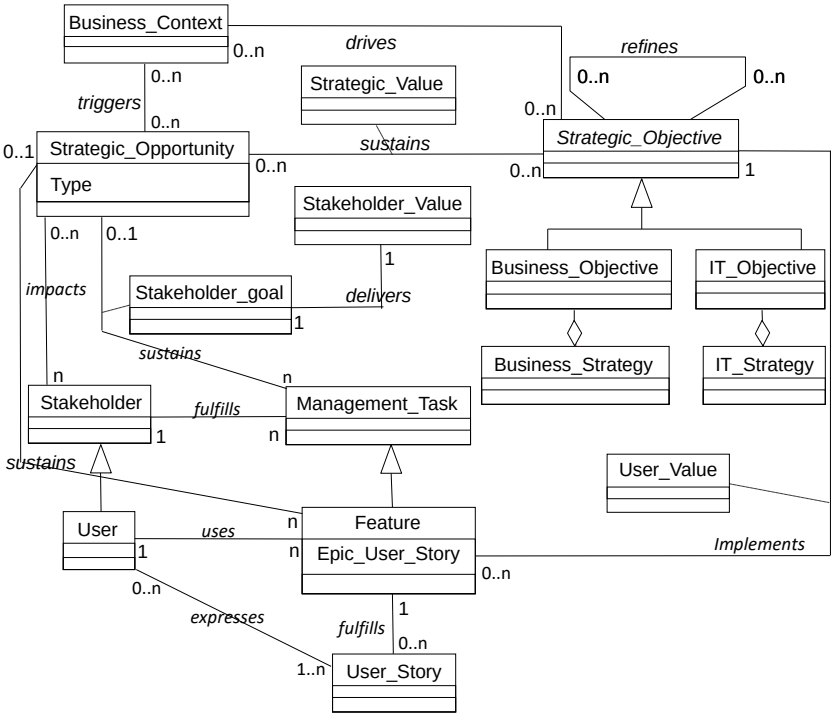


Fig. 7.1 From Strategic to Operational Agility via the Linkage of Conceptual Elements: An Ontology.

7.3 Discussing the Complementarity of the StratAMoDrIGo and Agile-MoDrIGo Methods

The present section articulates on the link and complementarity of the StratA-MoDrIGo and Agile-MoDrIGo frameworks. In that way, it attempts to present a merger of their ontologies in the effort to furnish a unified architecture for these two distinct methods.

To reiterate, StratAMoDrIGo and Agile-MoDrIGo are two frameworks born out of the same source (the classic MoDrIGo approach), but are meant to furnish distinct solutions on different problem domains. While StratAMoDrIGo is focused on providing a model-driven approach to guide the adoption of strategic agility in organizations, Agile-MoDrIGo rather focuses on aligning agile development fragments with the business (or IT) organizational strategy. Since they address problem outlets that can be considered complementary, a legitimate question can be asked concerning the capacity (and the way) to integrate these two approaches and treat them as unified; the latter can be considered as the point of origin which can be, at a later stage, moderated and compartmentalized accordingly depending on the exact organizational conditions asking for a precise solution. While the establishment of a process to fully answer the aforementioned question would require the conduct of an

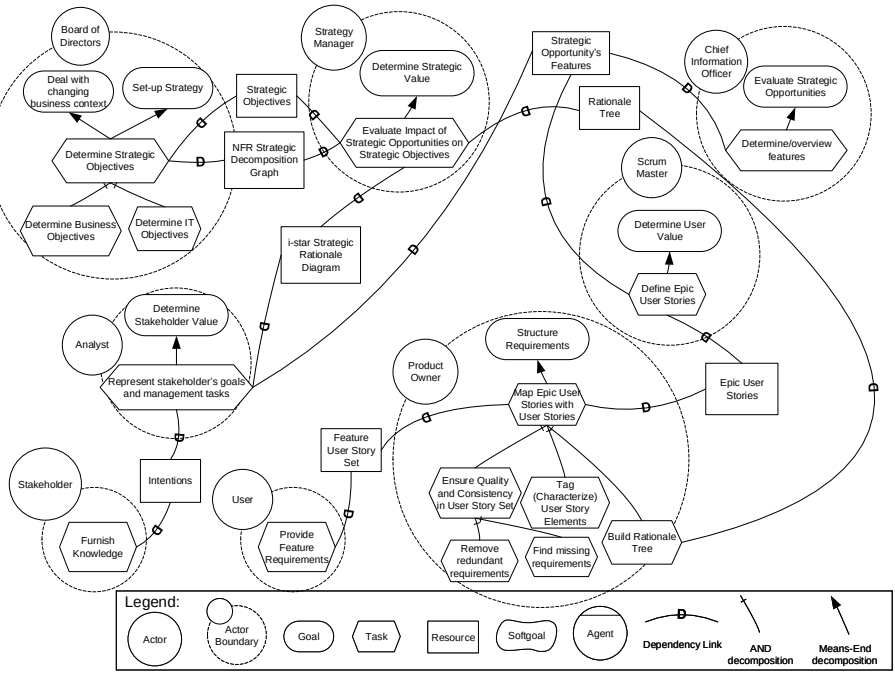


Fig. 7.2 Refining the StratAMoDrIGo Process Fragment.

elaborate and self-sustained research, we provide, in this section, some hints in the form of a preliminary study on the integration of the two ontologies.

To begin with, StratAMoDrIGo is to be considered the more generic framework of the two because its ontology entails in its core the *Strategic Opportunities* elements. The notion of *Business IT Services*, integrated within Agile-MoDrIGo, can be one element of those strategic opportunities; the latter focus also on a broader scope of values (i.e., strategic, stakeholder, and user) so in a preliminary fashion, we decide to use the meta-model of StratAMoDrIGo as the core architecture and evaluate how it can be further enriched with the required concepts described within Agile-MoDrIGo.

At the top-level, the elements to model the business and IT strategies are common to both frameworks so there is no work to be performed on an ontological level. Nevertheless, these frameworks do not project the same high-level scope elements as the point of evaluation for the release of value on a strategic level (once again, strategic opportunities are the main elements for StratAMoDrIGo, while business IT services take their place in Agile-MoDrIGo). The *Strategic_Opportunity* class subsumes the *Business_IT_Service* one, since, as mentioned explicitly in StratAMoDrIGo, a strategic opportunity can be a business IT service; thereby, for the integrated framework we adopt the *Strategic_Opportunity* class without further refinement. Similarly, the *Feature* class subsumes the *Epic_User_Story* one because, axiomatically, an epic user story is a feature (see the explanation provided in the previous section). Therefore, once

again, we consider here the *Feature* class to encompass the *Epic_User_Story* one and do not further refine it in the merged ontology. The other elements can be simply linked to the existing or more general elements (*Strategic_Opportunity* and *Feature* classes) proposed by StratAMoDrIGo. A visual representation of the integrated ontology is shown in Figure 7.3.

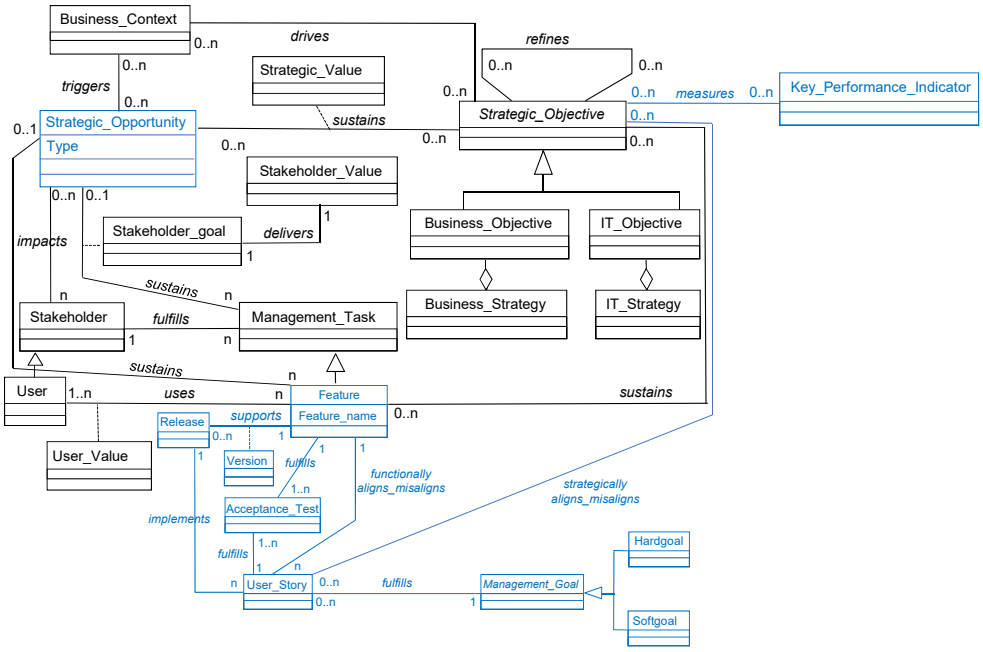


Fig. 7.3 Integrating the StratAMoDrIGo and Agile-MoDrIGo Ontologies.

7.4 Discussing the Frameworks' Scalability, Cost-Benefit Ratio, and Domains of Applicability

The scalability of the StratAMoDrIGo and Agile-MoDrIGo frameworks should also be discussed. However, it is necessary at this point to make a clear distinction between the layers tackled by these frameworks when considering the issue of scalability. In that sense, the latter becomes more paramount when operational elements are represented in comparison to tactical or strategic ones (which are inherently more abstract).

Basically, one could argue that the StratAMoDrIGo framework scales up better than the Agile-MoDrIGo one. Inherently, having *strategic opportunities* as the pivot elements when working on different layers facilitates the purpose of allowing to easily drill-down for more details, for example after having conducted a primary and swift investigation of the added-value of impending solutions relied on digital technologies. The use of such pivot elements also facilitates the roll-up again for the impact overview when (i) new technologies are needed

to improve internal performance indicators for the organization (i.e., employee productivity), and/or (ii) the external business context has been drastically altered. As far as scalability is concerned, strategic-level representations are not meant to deal with a lot of details and different elements, whatever the size of the concerned organization. In the cases on which the StratAMoDrIGo framework was applied, strategic objectives were present in a manageable visual perspective bearing a certain amount of abstraction, and their purpose was to offer a primary hierarchical foundation of the organizational strategy so the latter can be more easily consolidated/communicated to the lower levels. Indeed, in the context of our case studies, we have never really noticed a multitude of strategic objectives defined by the strategic boards. In addition, strategic opportunities are, by nature, very aggregated elements and if there is a certain amount of these elements that must be simultaneously evaluated, they can easily be studied (and compared) by using separate diagrams so as not to overload individual representations.

At managerial level, the scalability constraints of StratAMoDrIGo are typically the ones that are encountered when making use of the i* [201] modeling framework. For example, Franch [46] argues that a common issue related to the use of the i* has to do with the framework's perceived difficulty in turning its models in other types of models and notations (e.g., UML [118]). Comparably, Gralha et al. [51] name the inherent complexity of i* and similar goal-driven modeling approaches as the main reason hindering their widespread usability in terms of modeling real-life problems (which are by nature also very complicated). Moody et al. [112] go as far as denoting that there might be some conceptual flaws within the original notations of the i* framework that might be jeopardizing its effective use on behalf of modelers. Some approaches have been proposed to counteract such issues and, at a large part, these entail the modularity configuration of large goal models into smaller chunks of comprehensive visual models that deal clearly (by renouncing the use of aggregate complex visualizations) with a specific aspect of the problem domain (see the study of Lima et al. [98] for a broader elaboration on issues related to the scalability of i* and some proposed solutions). In contrast, within Agile-MoDrIGo, the scalability issue is subsequently more perplexed since there might be a potentially large number of user stories, explicating several features and functionalities for a complete IT solution, that can be evaluated. The existence of an overextended set of such stories can have a heavy impact on the visual representations offered by the framework. To tackle the scalability issue in the case of a large and complex set of user stories, one possible way to go is via the implementation of a user story structuring technique in order to (i) identify dependencies among the user stories, (ii) identify and remove redundancies, (iii) organize user stories around their identified commonalities, and (iv) and prioritize the strategic evaluation of features that provide instant user value. The next chapter actually describes a controlled experiment that studies the performance of two such user story structuring techniques when novice modelers are asked to utilize them in order to better structure a specific requirements specification problem in an agile setting.

The effective cost-to-benefit ratio of applying these two methods can also be

further discussed. StratAMoDrIGo can be applied with the use of a relatively small consultancy team (specialized in providing model-driven representations of organizational settings for the optimization of business and IT processes) having access to key personnel members. Such a team can be hired for a specific mission when strategic opportunities need to be evaluated in a particular enterprise. The representations should be stored and maintained so people can be trained internally in order to minimize the lead time for the method's actual application. On the other hand, Agile-MoDrIGo requires a genuine involvement of the software development team in order to be applied correctly. It requires the presence and involvement of appropriate roles understanding the strategic aspects of the organization and the possible influence these can exert within the development cycles of any related IT solution. We could go as far as equalizing this approach with the need to build a *Strategic Developers* (StratDev) team comprised of strategists and developers during the entire software development process, in the same was as a DevOps team mixes developers and operators. The exact cost-benefit ratio of such an endeavor in the effort to build such a team remains an open issue.

In terms of the domains for their applicability, globally, both frameworks should be able to reach their full potential in heavily governed, large, and possibly complex cross-functional organizations that tend to need more flexibility and speed in their decision-making processes, than in small organizations (being in practice business and IT aligned) and start-ups (being by nature innovation-driven). Indeed, these two frameworks intend to bring some insights in order to align any development (and/or adoption) decision at tactical/operational level, before or during the actual development, by utilizing their methods' offered flexibility to envisage strategic aspects ex-ante (or making changes incrementally within the software releases at development time) without having to get back to a heavy validation scheme. There are some tools that can also be used for a strategic-level evaluation of user-centric functionalities by workers situated in the operational apex of organizations (for example, roles implicated in a StratDev team), rather than having to consistently get back to the C-level for the strategic evaluation of individual features. Indeed, in order to be able to use these methods in a more extensive manner on large projects (so implicitly to better deal with the scalability of these methods), and by people that are not necessarily experts in conceptual modeling, the use of an advanced Computer-Aided Software Engineering (CASE) tool seems rather designated. There are several possibilities for this, either by defining a new and minimal tool or refining an existing one. In the present context, it is deemed much more efficient to proceed with the refinement of an existing tool. DesCartes Architect [85] is a CASE tool that was first developed in the context of supporting the methodology I-Tropos [174, 178], and is already supporting a large amount of the representations that are incorporated in the StratAMoDrIGo and Agile-MoDrIGo frameworks. Indeed, the tool supports the MoDrIGo and Rationale Tree models. A few extensions for the integration of the all elements in the models need to be performed for a full support of the methods developed in this thesis. Such extensions concern the integration of notations to ensure that a same logical construct/element is traceable in multiple views (e.g., a strategic

opportunity can be drilled down to/or rolled up from an i* diagram, etc.), rather than creating the repair for new models entirely.

Finally, within most of the cases that have been viewed and presented in this thesis, the contributions of functional elements onto strategic goals have been positive (meaning that they are deemed to attribute a certain level of added-value for the achievement of these organizational goals). Once more, this is inherent to the nature of the approached case studies. Within future work and the possible investigation of more diverse case studies, a negative impact evaluation will be studied in depth.

Part IV

Optimizing Agile Requirements Engineering Processes as a Means to Align Strategic Intents

Chapter 8

Conceptual Modeling Versus User Story Mapping: Which Is the Best Approach to Agile Requirements Engineering?

User stories are primary requirements artifacts within agile methods. They are comprised of short sentences written in natural language expressing units of functionality for the to-be system. Despite their simple format, when modelers are faced with a set of user stories they might be having difficulty in sorting them, evaluating their redundancy, and assessing their relevancy in the effort to prioritize them. The present chapter tests the ability of modelers to understand the requirements' formulation problem through a visual representation (named the Rationale Tree [182]) which is a conceptual model and is built out of a user stories' set. The chapter is built upon and extends previous work relating to the feasibility of generating such a representation out of a user stories' set by comparing the performance of the Rationale Tree with the User Story Mapping approach [121]. This is achieved by performing a two-group quantitative comparative study. The identified comparative variables for each method are understandability, recognition of missing requirements/epics/themes, and adaptability. Overall, the controlled experiment to be presented in this chapter is purposed to evaluate whether a conceptual model could be a consistent solution towards the holistic comprehension of a software development problem within an agile setting, compared to more 'conventional' techniques used so far.

The research presented in this chapter has been realized in collaboration with J. Maene, S. Heng, Y. Wautelet, and S. Poelmans. Results have been published in [156, 157]. The rest of the chapter is organized as follows: Section 8.1 yields some introductory information relating to the nature and utility of the user stories' notation; it also explicates the User Story Mapping technique and encapsulates the ways in which the latter differs from a conceptual model-driven method (the Rationale Tree) in terms of organizing a complex set of user stories. Section 8.2 presents a state-of-the-art of the sources and experiments that have been dealing with the implementation of conceptual modeling methods in terms of organizing a software representation problem (mostly via the utilization of user stories). Section 8.3 describes the present chapter's followed research approach encompassing the sampling technique, the design of the entire experiment, and

the stated hypotheses. Section 8.4 explains the performed analyses for the validation of these hypotheses. Section 8.5 discusses some of the results of the experiment and the observed differences in terms of the comprehension between the User Story Mapping Technique and the Rationale Tree method. Section 8.6 discusses some threats to validity while Section 8.7 concludes the chapter.

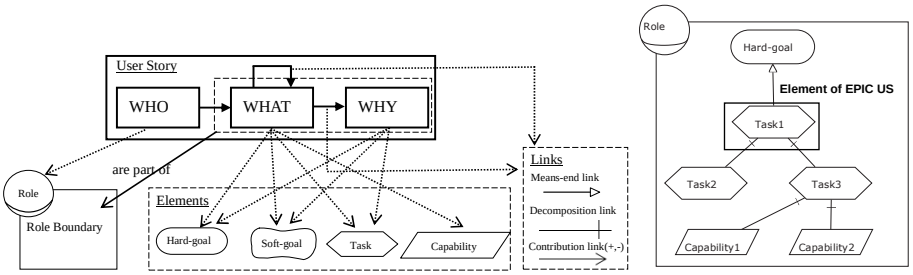
8.1 Introduction

User stories are artifacts often used in agile methods to describe requirements in a simple manner, demonstrating thusly the advantage of being easily understandable especially when read individually or in small sets. Nevertheless, user stories can face various levels of quality and this is why Lucassen et al. [100, 101] propose the Quality User Story (QUS) framework, i.e., a linguistic approach to evaluate and improve their quality individually and collectively. To unify their format, Wautelet et al. [181] collect and unify the templates mostly used by academics and agile practitioners. However, even when they are written with high quality, structured correctly and respecting defined semantics in their instances, understanding the *entire* software problem from a list of user stories remains challenging.

User Story Mapping (USM) [121] is used to address this challenge. This approach refers to a structuring method based on listing, under the scope of *Activities* (epic user stories), all of the related lower-level functions described in ordinary user stories. Meanwhile, conceptual modeling represents another approach to structuring desired system functionalities under certain criteria. Even though the latter is independent of a specific design method or technique, various notations, diagrams, and/or their corresponding instantiations are often adopted in view of a modeling exercise aiming to represent and group certain functions/elements of the to-be system. In this regard, the Rationale Tree (RT) [182] offers, as a conceptual model, a visual representation of a user story structuring method, strongly inspired by i* [201]. The RT uses parts of the i* strategic rationale diagram constructs and visual notation to build various trees of relating user story elements in a single project (Figure 8.1.a) with the purpose of identifying depending user stories, identifying Epic ones and group them around common Themes (Figure 8.1.b).

Both of these techniques can be used for structuring sets of user stories but have different complexities in their application and different abilities to represent dependencies and decompositions. Intuitively, one could ask if the RT allows, as a conceptual model, for a better comprehension of the software problem or a simpler representation artifact derived from the implementation of the USM would already be sufficient. To provide more insights to this question we relay, in this chapter, the results of a controlled experiment. Indeed, a first group of students has been required to employ the RT and build artifacts out of a given user stories' set; a second group has been asked to do the same with the USM approach. This study is based on the comparison of the results for these two groups. As so, the main contributions of this chapter are based on:

- The evaluation of the applicability of the RT and USM by non-experienced



(a) Icons used for representing user story's elements (b) Canonical model

Fig. 8.1 Using the Rationale Tree to Structure User Stories' Sets.

modelers. The former has been evaluated preliminary in earlier studies. Nevertheless, the understandability and applicability of the latter has not been tested extensively, to the best of the authors' knowledge, despite its popularity in agile environments;

- The exploration of the applicability of conceptual modeling in agile requirements engineering. Indeed, we aim to evaluate whether the RT, based on a comprehensive feature decomposition, can perform efficiently compared to the USM technique which is, strictly speaking, not a conceptual model but a simple user story structuring approach. Such a comparison between two diverse techniques can impact the Computer-Aided Software Engineering (CASE) tools used to support requirements engineering in agile methods;
- An investigation into the pedagogical orientation of software engineering. Conceptual modeling has been traditionally associated with object-oriented development (i.e., taught through the use of Unified Modeling Language/UML [118]) and/or database modeling (i.e., the Entity-Relationship Model [25] etc.). However, we want to evaluate the impact of teaching and using conceptual models in the requirements engineering stage of agile developments. Thereby, the design of the present experiment aims to test the use of conceptual modeling out of its customary-taught modalities and study the possible pedagogical impact on students.

8.2 Related Work

Dimitrijević et al. [36] evaluate different software tools, each one offering diversified features in identifying functional requirements from user stories' sets. The study assesses the operational aspects of these tools based on a number of criteria, but the context of the entire exercise is the determination of a linkage between these functionalities and the array of different (cognitive) needs that modelers express during the exploration of a software problem. These diversified needs are essentially the drivers for establishing multiple user story management/structuring approaches. However, the study does not incorporate a method for evaluating the latter.

Tenso & Taveter [153] suggest the use of a simple goal-oriented approach to address the user stories' limitation in visualizing their proposed development trajectories. This approach negotiates the analysis of the sequence of activities and resource requirements within user stories and assigns them into functional/non-functional goals. However, it does not seem to proceed into a refined decomposition of these goals into simpler tasks that can be mapped directly to the user stories; nor does it analyze visually the inter-dependencies among the aforementioned elements to track redundant tasks and resource waste during the conceptualization of the requirements gathering process. Tenso et al. [152] interview experts so as to evaluate the previous method; its understandability is impacted without the use of implementation guidelines. Moreover, the authors seem to acknowledge that such an evaluation is limited without the use of a control group using another agile requirements method in comparison.

Dalpiaz et al. [31, 32] perform an experiment to test the adequacy of two widely used natural language notations for expressing requirements (namely *use cases* and *user stories*) in delivering top-quality conceptual models. Their findings supported clearly the user stories' optimality, measured by the correctness and completeness of a manually derived UML class diagram by novice modelers. Nonetheless, Lucassen et al. [102] argue for a certain level of semantic ambiguity within the utilized words during the formation of user stories, ultimately jeopardizing the entire meaning of the story. To surpass this vulnerability, the authors suggest the utilization of an automated approach based on natural language processing, in order to produce representative (graphical) models from user story requirements.

Wautelet et al. [179] conduct an experiment to identify whether improving the user story quality by using the QUS framework [101] would lead to a better identification of different concepts of a user stories' set and a better development of the 'RT diagram'; this is the artifact produced when employing the RT method as described in [182, 180]. Overall, the experiment was performed on novice modelers composed of two groups, one using a raw user stories set while the other using an abstract user stories set reshaped to be QUS-compliant. Overall, quality improvements in the formulation of user stories engaged the modelers' abilities to identify elements like tasks and capabilities.

Lastly, Tsilionis et al. [157] explore the performance of novice modelers when they apply the RT and USM in terms of providing artifacts that encapsulate efficiently the entire software problem as described in a specific case description. However, the study does not test the impact of understandability of these two approaches in correspondence to the modelers' performance; nor does it check the ease of use of these methods in the identification of missing requirements/epics/themes. These issues, including the search for which method can be considered more adaptable, are addressed in the present study.

8.3 Research Approach and Background

8.3.1 Research Goals

This chapter aims to evaluate the RT as a user stories' structuring method. To this end, it was compared to one out of many industry-adopted approaches, namely USM. While the focus of the present experiment is the investigation of the context in which the RT is used, our current research focuses more on the comprehension of the RT as a conceptual modeling technique, rather than the case being fed to it. Therefore, the case studies and variables used in the experiment are sourced from [157, 179] and they have been maintained to allow for their longitudinal comparison. As such, this research represents an extension of [157, 179, 188]; it attempts to evaluate and explain the problems faced in these earlier research iterations regarding the exploration and exploitation of the RT.

8.3.2 Sampling Method and Experimental Design

For the purposes of this controlled experiment, we chose students attending the Master program of Business Administration with a specialization track in Business Information Management (BIM) from the 'Katholieke Universiteit Leuven (KULeuven)' (Brussels Campus) as our sample source to perform a quantitative comparative study [134]. The BIM specialization is addressed to students having a limited real-life working experience in software engineering. For this reason, it offers several courses aimed at developing multiple complementary views of software problems and their corresponding solutions. Even though the target population for the use of the RT is comprised of students, academics, and business users, the only group effectively performing the experiment was comprised of students. This can be considered as a limitation [44]. However, since no comprehensive sampling frame was available (especially for the academics and business users), we decided to use non-stochastic purposive sampling [134] in the form of typical cases [122] representing the students from the particular specialized curriculum. The participating BIM group counted originally 72 students; these were split up equally and randomly into two groups (i.e., 36 students per group). The first group was handed individual identical questionnaires dealing with the RT throughout the experiment; the questionnaires for the second group dealt with the USM.

The experiment was conducted as an extra activity during one teaching session of a compulsory spring-semester course included in the BIM curriculum and the time for completion was set to two hours. Overall, the experiment questionnaires consisted of three parts: **Part 1** was common for both groups and introduced a mix of open-ended and closed questions that explored the participants' prior software engineering knowledge and collected general background information (i.e., education level, occupation, etc.). Their domain knowledge was also assessed via a 'pre-test' evaluation asking participants to recognize the structure of a user story, recognize specific elements in an Activity diagram, and recognize the structure of a USM artifact. Due to size limitations, all the

information collected in *Part 1* is presented in Appendix 1[1]. At the time of the experiment all students had already received courses in software design & modeling. Thereby, they had a theoretical understanding of user stories and several software modeling techniques (UML, Entity-Relationship Model, etc.). However, extra theoretical explanation was provided during the experiment (in *Part 2*) when it comes to identifying missing requirements, epics, themes and the basics of the RT and USM approach.

Indeed, for **Part 2**, the questionnaires introduced a detailed theoretical explanation of the user story structuring approach assigned to each student group. Next, they presented a case description ('Company X' case, see Appendix 2.1) and a set of seven user stories derived from that case. Each student had to identify elements of the user stories' *WHO/WHAT/WHY*-dimension and correspond them to the modeling notations of his/her assigned approach. Next, each student had to design these modeling notations and their in-between links graphically on paper; in essence, the students had to draw a complete artifact based on information retrieved from the case description, the user stories and the theoretical instructions given in the beginning of *Part 2*. Basing themselves on their previously drawn artifacts, the students had to recognize missing requirements/epics/themes; they also had to respond to six closed Likert-scale questions regarding the ease of use of each technique in identifying the previous elements. Appendix 3 provides a detailed description of the modeling exercise. *Part 2* concluded by asking the students to suggest improvements for the usability of the RT/USM.

For **Part 3**, the students had to check a separate attachment that was distributed with the original questionnaires. This attachment was introducing: (i) a case description ('Film Finder' case, see Appendix 2.2), (ii) a complete and complex USM model (artifact) modeling the 'Film finder' case description to be used by the USM group, and (iii) a complete and complex RT diagram modeling the 'Film finder' case description to be used by the RT group. The first segment of the questionnaires asked the students to explain parts of these complex artifacts in order to test their understanding about the 'Film finder' case. The second segment tested the students' ability to adapt these artifacts by asking them to make changes and/or introduce new elements to them, on the premise of changing requirements.

8.3.3 Hypotheses

The hypotheses presented below are built upon existing literature that theorizes the advantages and drawbacks of the user story structuring methods proposed by Wautelet et al. [182] and Patton & Economy [121]. Conversely to the USM, the RT contains links and decompositions making it more difficult to be comprehended by novice modelers [188]. The latter incorporates also a broader choice of elements with semantics open to interpretation, adding thusly to its overall complexity [179]. Hence, we can formulate our first set of the null and alternative hypotheses:

- ***$H_0 1$****: The RT is as easy to understand as the USM.*

[1]All Appendices are available at: https://data.mendeley.com/datasets/fsphwk2sk4

- ***H_a1**: The RT is more difficult to understand than the USM.*

USM aims to create one-dimensional, purely hierarchical visual artifacts structuring the most basic user stories that satisfy intricate – to the software project – stakeholders [121]. Contrastingly, the RT is meant to relinquish artifacts with detailed feature decompositions assisting in the identification of missing requirements and higher-level epic user stories while grouping interrelated elements within sets of themes [182]. Therefore, the distinction between elements will probably be more difficult for the RT diagrams in the sense that a steeper learning curve may be required for a proper and qualitative representation of a software problem. This entails that more thought and especially **more time** should go into developing the RT diagram and the links among its elements. Nonetheless, the time given to complete the experiment was exactly the same for both groups (two hours). Hence, our next set of hypotheses:

- ***$H_0$2**: The resulting RT diagrams and USM artifacts are equally good in providing qualitative representations.*
- ***H_a2**: The resulting RT diagrams are worse than USM artifacts in providing qualitative representations.*
- ***$H_0$3**: The resulting RT diagrams and USM artifacts are equally good in identifying missing requirements, epics and themes.*
- ***H_a3**: The resulting RT diagrams are better than USM artifacts in identifying missing requirements, epics and themes.*

The complexity faced in recreating the RT diagram will eventually pay off due to its property of adaptability [182]. Once drawn, it is supposedly easier to adapt and better to maintain when requirements are changing due to its visual links. As such, we can formulate a fourth set of hypotheses:

- ***$H_0$4**: The resulting RT diagrams and USM artifacts are equally good in being adaptable.*
- ***H_a4**: The resulting RT diagrams are better than USM artifacts in being adaptable.*

8.3.4 Variables

This section identifies the variables testing the hypotheses. The answers and artifacts drawn by each student were nested together for (i) the RT respondents, and (ii) the USM respondents; this grouping between the two acted as our independent variable. The dependent variables evaluating the students' RT diagrams and USM artifacts are: (i) Existing knowledge; (ii) Pre-test evaluation; (iii) Understandability; (iv) Model (artifact) creation; (v) Identification of missing requirements, epics, and themes; (vi) Adaptability. 'Existing knowledge' and 'Pre-test evaluation' acted as our control variables since most of the experiment participants had a harmonized theoretical knowledge of user stories but a rather limited knowledge in the debated user story structuring approaches.

8.4 Data Analysis and Validation of the Hypotheses

After processing the data received from the students, we analyzed the understandability of each method (validation of our first hypothesis). Following, we checked whether the employment of either of the two methods facilitated the students' dimension identification capabilities for the user stories' set for the 'Company X' case. Next, we evaluated their drawn RT diagrams and USM artifacts and compared the quality of their representations (validation of our second hypothesis). Our analysis concluded with a comparison between the answers of the two groups pertaining the identification of missing requirements/epics/themes (third hypothesis), and the adaptability of each method when requirements are changing (fourth hypothesis). These steps are detailed below.

8.4.1 $H_0$1: The RT Is as Easy to Understand as the USM

The theoretical explanations for the RT and USM in the beginning of **Part 2** were purposed to educate the students about these techniques, optimize their comprehension of user stories/epics/themes, and describe the expectations of the upcoming modeling exercise. The theoretical explanations concluded by asking three Likert-scale questions to determine to what extent was: *Q1) the theory about the different elements and links – of each approach – understandable, Q2) the explanation of the upcoming modeling exercise understandable, and Q3) the expectation of the modeling exercise understandable.* The frequencies of the respondents' answers were mapped out based on the range of their understandability (i.e., the theory/explanation/expectation was 'Not at all', 'Slightly', 'Moderately', 'Very' or 'Extremely' understandable), where most of the students in both groups found the theory about different links and elements very understandable. Similarly, the modeling exercise explanation/expectation seemed also to be very understandable (see Appendix 4.1). However, when processing the answers to these three questions to recreate and compare the means of the students' responses by group and by question, we discovered that the understandability of the RT group seems to be lagging compared to the understandability of their counterparts in the USM group (Table 8.1). This discrepancy between the two groups takes its highest value when referring to Q1. The parametric independent-samples t-test represented in Table 8.2 measures whether the difference between the understandability means for the two groups relating to Q1, Q2, Q3 is significant. Due to the Central Limit Theorem (CLT), the variable used for recreating the means can be assumed normally distributed since our sample size per group is larger than 30. Equal variances were assumed after performing a Levene's test. The results show that the RT students had significant difficulty – compared to their counterparts – in understanding the theoretical concepts of the RT; the difference in the understandability between the two groups regarding the Q2 & Q3 was not significant. Hence, our *first null hypothesis can be rejected.* This difficulty in understanding the RT theory could be attributed to an insufficient theoretical explanation in the beginning of **Part 2** and not to the internal workings of the RT approach itself. However, this scenario does not seem to justify the answers provided by the RT group for

questions Q2 & Q3. Additionally, the provided RT theoretical explanation seems to be the basis for the students' qualitative representations of the 'Company X' case as it will be shown during the validation of the second hypothesis.

Table 8.1 Understandability Means by Group and by Question.

	USM Mean	RT Mean
Q1 Is the theory about the different elements and links understandable?	4.06	3.78
Q2 Is the modeling exercise explanation understandable?	3.69	3.49
Q3 Is the modeling exercise expectation understandable?	3.67	3.51

Table 8.2 Significance Testing for the Three Questions: Independent-Samples T-test.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Q1	2.061	70	.043	.273	.133	.009	.538
Q2	1.461	68	.148	.200	.137	-.073	.473
Q3	1.140	65.97	.258	.152	.134	-.114	.419

*The significance level is set at 5%.

8.4.2 $H_0$2: The Resulting RT Diagrams and USM Artifacts Are Equally Good in Providing Qualitative Representations

We started exploring the students' model-creation capabilities by checking whether each group could identify correctly the elements from the *WHO*, *WHAT*, and *WHY* dimensions (roles, functionalities, etc.) within the set of seven user stories provided for the 'Company X' case. Next, we checked whether the students could correspond each of these elements to the modeling notations of their assigned approach (i.e., *Role/Task/Capability/Hard-Goal/Soft-Goal* for the RT, and *User/Activity/Task/Detail* for the USM approach). Eventually, we compared the students' artifacts resulting from the modeling exercise, between the two groups. These steps are described below.

8.4.2.1 User Stories' Dimension Identification for the RT Group:

The *WHO*-dimension was identified correctly by 73% of the students assigned to the RT group. This was to be expected since the RT contains only one modeling construct (i.e., *'Role'*) corresponding to this dimension. However, the group had difficulty in identifying elements within the *WHAT*-, and *WHY*-dimension in the provided user stories' set.

Table 8.3 Dimension Analysis (*WHAT/WHY*) for the RT Group.

US Dimension	Task	Capability	Soft-Goal	Hard-Goal	Element Not Present
US2WHAT	45.9	**48.6**	5.4	0	0
US2WHY	2.7	5.4	**51.4**	40.5	0
US3WHAT	**94.6**	5.4	0	0	0
US3WHY	21.6	16.2	**56.8**	5.4	0
US4WHAT	29.7	**70.3**	0	0	0
US4WHY	0	0	0	0	100
US5WHAT	**59.5**	40.5	0	0	0
US5WHY	10.8	0	43.2	**45.9**	0
US6WHAT	16.2	**81.1**	2.7	0	0
US6WHY	0	0	13.5	**86.5**	0
US7WHAT	**62.2**	35.1	2.7	0	0
US7WHY	2.7	5.4	**54.1**	37.8	0

*__Elements in bold font__ indicate the most frequently identified elements within the group.

Table 8.3 validates our last statement. For instance, in the first row corresponding to the *WHAT*-dimension of the first user story, we notice a significant discrepancy in the percentage of the students' answers reporting a *Task* or a *Capability* element. In the second row for the *WHY*-dimension of the first user story, we also notice that the answers of the students are divided between the *Soft-Goal* and *Hard-Goal* element. These two examples encapsulate the students' challenge in distinguishing between the modeling constructs *Task*/*Capability* on the one hand, and *Soft-Goal*/*Hard-Goal* on the other. These results validate the ones found in the study of Wautelet et al. [188] stating the possibility of a limited semantic difference between such elements. Cells assigned with the number zero mean that no student reported that particular modeling element in his/her answer.

8.4.2.2 User Stories' Dimension Identification for the USM Group:

The *WHO*-dimension was identified correctly by 62.9% of the USM group. This percentage is smaller compared to the one retrieved for the RT group. This discrepancy could be explained by the difference in the used terminology between the two approaches in terms of the identification of the *WHO*-dimension. The RT contains the term *Role* (which is completely identifiable with the term provided in the theoretical explanation for the *WHO*-dimension of a user story) while the USM contains the term *User*. As for the *WHAT*-, and *WHY*-dimension, Table 8.4 reveals that the students tended to recognize the semantic difference between the *Activity* and *Task* element and assign them well to their proper dimensions. This is aided by the hierarchical structure of the USM where an *Activity* must be followed by a *Task* and finally a *Detail*. Nevertheless, the numbers reveal that the students experience ambiguity regarding the granularity-level associated with the elements belonging to the *WHAT*-dimension of the user stories. In particular, the students seem not to be able to differentiate well between the

semantics of *Task/Detail* as the reported numbers depict in rows one, five, and seven.

8.4.2.3 Comparison of the Drawn RT Diagrams and USM Artifacts for the 'Company X' Case:

This part describes the evaluation of the artifacts drawn by the students according to the tasks prescribed by the modeling exercise of **Part 2**. We evaluated the produced artifacts basing ourselves on methods elaborated in previous studies. For the drawn RT diagrams, we used the *Three Criteria* evaluation method namely completeness, conformity, and accuracy [188], and the *Golden Standard* method [179]. The latter was based on an 'ideal' artifact, created by the research team, whose every correct element and link was awarded with the maximum of points. The artifacts provided by the students approaching this 'ideal' solution the most gathered the most points. The artifacts drawn by the USM group were evaluated based on five identified criteria namely completeness, consistency, accuracy, correctness, and complexity. Appendix 4.2 provides a detailed description of each evaluation method.

Table 8.5 presents the descriptive elements related to the acquired points for each drawn artifact, based on their corresponded evaluation method. We observe that the means/medians of the gathered scores are similar for the two groups. Hence, despite the difficulty that RT students show in corresponding the *WHAT-/WHY*-dimension to the modeling constructs of the RT, they still manage to produce artifacts that gather similar points with the USM group (in terms of representing the requirements problem within the tasks of the modeling exercise). Thereby, our *second null hypothesis cannot be rejected.*

Table 8.4 Dimension Analysis (*WHAT/WHY*) for the USM Group.

US Dimension	Activity	Task	Detail	Element Not Present
US2WHAT	5.7	**57.1**	37.1	0
US2WHY	**51.4**	11.4	34.3	2.9
US3WHAT	20	**77.1**	2.9	0
US3WHY	**71.4**	25.7	0	2.9
US4WHAT	0	37.1	**62.9**	0
US4WHY	2.9	2.9	0	**94.3**
US5WHAT	2.9	**74.3**	22.9	0
US5WHY	**62.9**	8.6	25.7	2.9
US6WHAT	8.6	**74.3**	17.1	0
US6WHY	**71.4**	5.7	20	0
US7WHAT	5.7	**74.3**	17.1	2.9
US7WHY	**51.4**	14.3	25.7	8.6

*__Elements in bold font__ indicate the most frequently identified element within the group.

Table 8.5 Drawn Artifacts: Descriptive Statistics of Acquired Points Per Evaluation Method.

	% of points on USM artifact	% of points on RT diagram (Golden Standard evaluation)	% of points on RT diagram (Three Criteria evaluation)
N	36	36	36
Mean	.5281	.5536	.5522
Median	.5690	.5806	.5965
Std. Deviation	.13698	.20109	.17229
Minimum	.14	.03	.11
Maximum	.71	1.29	.83

8.4.3 $H_0$3: The Resulting RT Diagrams and USM Artifacts Are Equally Good in Identifying Missing Requirements, Epics, and Themes

The last steps of the modeling exercise in **Part 2** were meant to test whether the employment of either of the RT/USM is significantly better in helping modelers to produce artifacts that facilitate with the identification of missing requirements, epics and themes. Table 8.6 presents the means of the scores that the students' artifacts gathered, by group, when performing these 3 tasks. The numbers suggest that the USM group performed better in the identification of missing requirements. Conversely, the average of the achieved scores was higher for the RT group in respect to the identification of epics and themes. We wanted to test whether these performance variations, as measured by the differences in the score means for the two groups, are significant. Table 8.7 presents the confidence intervals corresponding to the differences in the score means for the two groups and reveals that while the USM group's performance is significantly better in identifying missing requirements, the difference in the performance between the two groups is not significant in terms of identifying epics and themes. This is a first –but not conclusive– indication that our *third null hypothesis cannot be rejected.*

Table 8.6 Descriptive Statistics on the Student-Scores for the Tasks of Identifying Missing Requirements/Epics/Themes.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score on the task of identifying MR	USM group	36	1.2286	.68966	.11657
	RT group	36	.7794	.97849	.16781
Score on the task of identifying Epic US	USM group	36	.4071	.33258	.05622
	RT group	36	.4559	.33411	.05730
Score on the task of identifying Themes	USM group	36	1.7929	1.20276	.20330
	RT group	36	2.2574	1.33922	.22967

To further support (or rebut) this indication, we checked the students' answers to six Likert-scale questions that were meant to establish the (possible)

Table 8.7 Mean Difference of the Student-Scores in Identifying Missing Requirements/Epics/Themes: Confident Intervals.

	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
MR Score	.44916	.20332	.04333	.85499
Epic Score	-.4874	.08027	-.20897	.11149
Theme Score	-.46450	.30673	-1.07694	.14795

*The significance level is set at 5%.

relationship between the *perceived* ease of use of each method in identifying missing requirements/epics/themes. These questions were: *Q1) How hard was it to find missing requirements in Part 2?, Q2) How hard was it to find epics in Part 2?, Q3) How hard was it to find themes in Part 2?, Q4) Did the RT/USM help you find missing requirements?, Q5) Did the RT/USM help you find epics?, Q6) Did the RT/USM help you find themes?.* We processed the answers to these questions to recreate and compare the means of the students' responses by group and by question. We used their descriptive elements in order to perform an independent-samples t-test to examine the significance in their perceived level of difficulty in identifying missing requirements/epics/themes between the two groups. Once again, the justification for using such a parametric test stems from the CLT; given the sample size of each group (larger than 30 participants) the variable used for recreating the means can be assumed normally distributed. A Levene's test was performed for each question ensuring the equality in the variances (see Appendix 4.3 for the detailed descriptive statistics for the comparison of the means, by group, for all six questions). Table 8.8 informs us that insofar the recognition of missing requirements/epics/themes, there are no significant differences between the perceived ease of use for either of the RT/USM. Thereby, our *third null hypothesis cannot be rejected.*

Table 8.8 Identification of Missing Requirements/Epics/Themes: T-test by Question and by Group.

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Q1	-1.818	68	.073	-.395	.218	-.829	.039
Q2	-.942	64.01	.350	-.225	.238	-.701	.251
Q3	-1.367	67.98	.176	-.371	.272	-.914	.171
Q4	-.077	66.52	.939	-.021	.273	-.565	.523
Q5	-1.185	65.19	.240	-.325	.274	-.873	.223
Q6	.573	67.19	.569	.152	.265	-.377	.681

*The significance level is set at 5%.

8.4.4 $H_0$4: The Resulting RT Diagrams and USM Artifacts Are Equally Good in Being Adaptable.

This section addresses the tasks that the students had to complete for **Part 3** of the experiment. Six questions were asked to determine the respondents' ability: (i) to understand the structure of a complex model (artifact) provided for the 'Film Finder' case, and (ii) to make adaptations to this model based on changing requirements. We followed the same process as the one used to test our third hypothesis. In particular, we collected and processed the participants' answers to all six questions to recreate the means of their responses by group and by question (see Appendix 4.4). Next, we used these descriptive elements in order to perform an independent-samples t-test to check whether the differences of the responses by group and by question were significant. Table 8.9 demonstrates that there were significant differences between the two groups concerning the time disposed to answer the first, second, and last question.

Table 8.9 Adaptability: Independent-Samples T-test by Question and by Group.

	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
						Lower	Upper
Q1	-2.763	69	.007	-.275	.099	-.538	-.011
Q2	-2.552	68	.013	-.286	.112	-.509	-.062
Q3	.802	67.452	.426	.19365	.24155	-.28842	.67572
Q4	-.457	68.854	.649	-.26984	.59069	-1.4483	.90859
Q5	-.196	68.996	.845	-.08532	.43450	-.95213	.78149
Q6	1.854	67.420	.068	.27500	.14835	.02759	.52241

***The significance level is set at 5%.**

Q1 & Q2 demanded the (partly) explanation of the 'Film Finder' case with the aid of the provided models and they were answered better by the USM group. Of course, the 'Film Finder' case description addressed to this group was comprised of two pages, while the one for the RT group was over four pages. This was done in order to increase the visibility/readability between the links and elements of the provided RT diagram for this case. So, as the provided 'Film Finder' USM model (artifact) was more compact the students could have gotten more information in a shorter amount of time which inevitably leads to a faster, better understanding of the case. Q6 asked specific description of the models themselves and was answered better by the RT students. The remaining questions asking the respondents to adapt the models were slightly better for the RT group but the difference, compared to the USM group, was not significant. Therefore, our *fourth null hypothesis cannot be rejected.*

8.5 Discussion

Our analysis suggested that the RT seemed more difficult to understand compared to the USM. Although this created the expectation that the RT group

would deliver artifacts which would not represent properly the software problem as described by the 'Company X' case (compared to the USM group), this was in fact not verified by our analysis. We will try to explain this contradiction by using the students' answers to an open question at the end of **Part 2** that gave them the opportunity to provide suggestions for improving further the RT and USM. Regarding the former, a recurring request from many students was the addition of extra elements complementing the existing set. For example, the students perceived that the addition of a decision point would facilitate its use. However, this would imply that the RT is process-oriented like a BPMN process diagram [117]. But its true purpose is to facilitate the decomposition of a feature and not to analyze a process. This observation suggests that participants 'anchored' on their previous trainings in UML and BPMN diagrams in order to conceive, comprehend and compare the RT. Since the latter is structurally different than the modeling elements the students were accustomed to, this can be the reason for their perceived difficulty in understanding the theory. However, the solved examples at the end of each step of the modeling exercise that were incorporated in **Part 2** guided the students during the conduct of their modeling exercise; at the end, the RT students provided qualitative artifacts (according to pre-set standards). Another recurring criticism referred to the difficulty in distinguishing between *Tasks/Capabilities* and *Hard-goals/Soft-goals*. This can be partially explained by the students' lack of experience with modeling frameworks such as i* [201] which incorporates such elements. Some participants even asked for stricter rules and guidelines to define the different RT elements and how to put them into practice each time. These 'criticisms' can reveal some of the bottlenecks that should be addressed when it comes to making non-experienced modelers exposed in the use of a conceptual model (i.e., the RT in our case). Vague semantics were also an issue for the use of USM, as the distinction between *Tasks/Details* was not clear for many participants.

8.6 Threats to Validity

Our presented results consider some threats to validity; these are presented according to the classification scheme provided in the study of Wohlin et al. [197].

Construct validity. Our selected cases may affect the results. The 'Company X' case was considered complex and slightly unstructured and this factor in combination with the subjects' working inexperience with user stories can jeopardize the quality of their provided artifacts. However, the students did not have to extrapolate the user stories' set themselves for the build-up of their artifacts; the former was already provided in the questionnaire. This gave the students a well-established outset especially since the user stories' set was reviewed and optimized using the QUS framework.

Internal validity. The questionnaire of the experiment was quite large amounting to fifteen pages for the RT group and fourteen pages for the USM group. A survey instrument of such size is prone to cause fatigue leading respondents ultimately to satisfice rather than optimize during their response effort. We tried to counter that effect by: (i) applying correctional penalties for

guessing; (ii) boosting the students' motivation through an additional bonus grade (corresponding to their performance) to be applied on top of their final grade for the compulsory semester course in the session of which the current experiment was organized.

External validity. The inclusion of students in the experiment may condition our results considering the participants' practical inexperience in software design & modeling. However, Kitchenham et al. [83] do not discourage the use of students as test subjects in software engineering experiments as long as the research questions match their level of experience. This has been the case in our experiment; the content of the questionnaires was the product of an iterative deliberation process among the members of the research team. In addition, the research questions and the ease of understanding of the theoretical explanations for the RT/USM were tested separately on three junior researchers (first-year PhD students). Their suggestions/proposed alterations were incorporated into the final version provided to the test subjects.

An additional concern is that the quality of the artifacts produced by the students (in the context of their modeling exercise) depends not only on their (in)experience but also on the cognitive complexity of each tested method. In principle, there seems to be some adversity between the two tested methods given that the USM represents essentially a structuring approach of user stories based on their level of granularity and that's relatively easier for the students to understand. Contrastingly, the subjects were not well versed in the i* framework whose elements/notations are used in the RT method. We acknowledge this confounding factor in the experimental design and this why we included a detailed theoretical explanation of each method – with one extra page for the RT – incorporating a complete set of solved examples at the beginning of each step of the modeling exercise in **Part 2**.

8.7 Conclusion

This chapter analyzed the ability of novice modelers to understand a software problem by using a conceptual modeling approach (RT) and a structuring method (USM) for the formation of user stories. Our *first hypothesis* indicated that the RT seems not as easy to understand as USM. To reinforce the RT's applicability, more focus should be placed into making the semantics of its modeling elements self-evident along with a proper illustration of their in-between links. This hypothesis was tested on the basis of theoretical explanations provided within the questionnaires. Nevertheless, when the students receive practical, step-by-step guidance on how to apply the RT, they manage to use it to produce qualitative representations of the software problem (*second hypothesis*). This observation can influence the way conceptual modeling is taught within IT curricula; first, our analysis highlights the possible transition from an ex-cathedra approach based on theory to a more empirical one where students practice modeling from the start. Second, the tutoring of conceptual modeling, to better understand the software problem, can be valuable in an agile setting as well; the RT itself – descending from an elaborate framework for socio-technical analyses (i*) – shows indeed promising results for agile requirements engineering. Con-

trastingly, our *third* and *fourth hypotheses* highlight a reoccurring discrepancy between the RT's intended purpose and actual performance. Theoretically, the RT's complexity is to be counterbalanced by delivering adaptable artifacts assisting modelers identify missing requirements/epics/themes more easily. However, our results showed neither a significant facilitation by the RT diagram in these tasks, nor by the USM (despite the latter's embedded simplicity). All in all, we believe that the teaching of the RT (i.e., a conceptual modeling-based approach for agile methods) next to the traditional USM method, furnishes an added value to IT students. It allows them to learn complementary ways of reasoning about a software problem, based on user stories, and they can experience on their own how it can be structured best. Learning the RT also reinforces their general skills on conceptual modeling and allows them to experience that the domain can be fruitfully used outside the scope of object-oriented modeling and database design.

Chapter 9

A Unified Ontology Supporting the Creation of BDD Scenarios

Behavior Driven Development (BDD) offers a way to express scenarios, written in structured natural language, on how the system should act to fulfill a requirement. Such a test scenario is written together with the requirement; this way these two can be conceived in unison, nested into each other. Lots of templates have been written to construct BDD scenarios and various practices were born out of usage. We mostly fail to find documentation on the used templates and understand empirical practices. A strict set of templates with a clear definition of the used keywords would provide guidance when building scenarios aligned with the intends of BDD (e.g. concrete scenarios truly user-driven). First, this chapter explores empirically the BDD templates used in practice by evaluating the keywords mostly associated to the *GIVEN*, *WHEN*, and *THEN* scenario dimensions. It then studies whether we can use these existing keywords to build a set of non-redundant concepts covering the representational needs and being usable as reference when constructing BDD scenarios. We consolidate these findings in an ontological structure; the latter is being evaluated onto a set of test scenario instances (see Chapter 9 for this evaluation process). At modeling time, by linking a BDD instance to strictly-documented keywords, we get meta-data allowing to (i) build a graphical notation where user stories and their BDD scenarios can be represented together for further analysis and (ii) suggest treatments to the BDD scenario for test automation (e.g. translating the scenario in an object-oriented script).

The research presented in this chapter has been realized in collaboration with Y. Wautelet, S. Heng, and C. Faut. Results have been published in [161, 162]. This chapter is structured as follows: Section 9.1 explicates shortly the purpose of BDD as an agile process and reports on literature works that have been done thus far in terms of optimizing the structure of acceptance tests in BDD. Section 9.2 describes the research approach and method. Section 9.3 depicts the details of the steps required to build the ontology. Section 9.4 describes fully the ontology used for building BDD test scenario templates; each element is defined and the ontology is presented. Section 9.5 depicts the threats to validity for this study. Finally, Section 9.6 concludes the chapter.

9.1 Introduction

Among the agile-related processes and techniques appearing over the last 20 years, BDD and its ability to define user-oriented scenarios for the validation of requirements have received poor attention in the scientific area. Nevertheless, BDD gives a way to *execute the requirement* depicted in a user story so that the scenario constitutes a valuable extension of the story. Ideally, scenarios are then written in conjunction with their corresponding user stories to have an agreement with the user on the requirement and its validation. BDD scenarios are thus supposed to be centered on the user with no supporting technical details [139].

In terms of optimizing the structure of acceptance tests in BDD, a Question-Based Checklist [116] and a set of criteria [15] have been proposed. Nevertheless, none of the consulted sources offers a clear definition of what should be in a test scenario; they only provide some related concepts. The Question-Based Checklist by Oliveira et al. [116], offers a structured way to check scenarios after having written them. Therefore, this approach misses the focus on the elaboration of a structure that can be used while writing these scenarios. Lazar et al. [91] provide a BDD test profile as a library structure containing concepts and their syntaxes, but the latter are not accompanied by any related semantics. In view of this, there is a necessity for a newly established structure that could provide clear semantics associated to the BDD scenarios' concepts.

In order to build an ontology for BDD scenarios, we have applied in this chapter, a method similar to the one proposed in Wautelet et al. [181] consisting of collecting, selecting, and associating semantics to the most frequent keywords linked to the *GIVEN*, *WHEN* and *THEN* dimensions found in such scenarios. The research approach presented in this chapter is driven by empiricism to lead to an ontology allowing to build BDD templates; these templates are useful for the requirements engineer when defining the scenarios. The latter can then also "tag" the BDD scenario elements when defining them to furnish the required meta-data.

9.2 Background and Research Approach

This section depicts the approach followed to build the ontology for BDD scenarios.

9.2.1 Descriptive Concepts in BDD Test Scenarios

The ontology has been built in an empirical way. The goal is to collect the keywords and thus the concepts that are effectively used in practice when building BDD scenarios and to bring more formality and consistency in their use. The research process first required to collect **primary data**; the latter was gathered online in order to list and evaluate the most commonly used BDD test scenario templates. Scenarios are typically structured around the *GIVEN*, *WHEN*, and *THEN* dimensions[1]; therefore, it is the only format

[1]These will be referred to as the BDD scenarios' *dimensions* for the purposes of this study.

considered here. We consider each keyword found in such BDD templates as a *Descriptive_Concept* (*D_C*) which is a class of concepts containing a dimension (*GIVEN*, *WHEN* or *THEN*), a syntax (i.e. the keyword itself) and a semantic (a definition). The *D_C*-based approach was defined and applied in Wautelet et al. [181]. *D_C* as well as their dimension and syntax attributes can immediately be instantiated when a template is found in a formal or informal source (so typically we have one instance per dimension). Further investigation is generally needed to fill out the *semantic* attribute; indeed, we seldom find a definition associated to a keyword so a definition needs to be associated with it in another way (this is documented in Section 9.3). This approach is mapped from [181] that applies it to user story templates for concept unification.

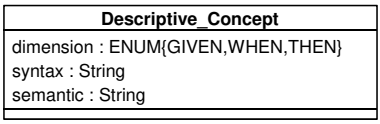


Fig. 9.1 The Descriptive_Concept Class (from [181]).

9.2.2 Building the Dataset

Primary data was collected through formal and informal sources to gather the most commonly used **test scenario templates**.

We distinguish *formal sources* as published scientific articles and books on BDD and specifically on acceptance test criteria. These sources came from searches on Google Scholar, Limo libis, IEEE Xplore and Springer Link using the keywords "scenario acceptance test", "bdd", "gherkin", "given when then", "behavior driven development", "bdd scenario". The first 10 pages of the returned results, per source, were consulted. We worked in this way to keep the results as relevant as possible to our research as after the tenth page the returned results started to become irrelevant. The templates extracted from these sources can be found in Appendix A[2].

We distinguish *informal sources* as blogs and forums. We found them using the same keywords as for formal sources but also including the following ones: "feature file", "bdd feature file", "feature file template", "bdd template", and "scenario template". Our preferred search media was primarily the Google search engine in the traditional textual format but we also analyzed the images using the Image field since it reported pictures of relevant BDD scenarios. The former facilitated a wide range of results coming from many different sources and the access to visual information provided for a swift first-level ruling regarding the relevance (or not) of the source material. As for formal sources, the first 10 pages of the returned results were consulted, for the reasons mentioned before. The templates extracted from these sources can be found in Appendix B.

[2]All Appendices are consolidated within the file Appendix_Consolidated_BBD_templates.docx., and they can be retrieved at: https://data.mendeley.com/datasets/svmcxt5z5f/1.

These primary data sources yielded 120 formal and informal test scenario templates (see Appendix E).

Secondary data, consisting of **test scenario examples/instances**, has also been collected. The goal with this secondary data set is to validate if each of these examples could be instantiated with one of the concepts depicted in the meta-model for BDD scenario templates built out of the primary data set. *Informal sources* indeed reported a lot of examples so that we performed Google searches using the following keywords: "scenario", "acceptance test", "bdd example", "gherkin example", "given when then", "behavior driven development scenario", "bdd scenario", "feature file", "bdd feature file", and "feature file example". In total, 48 test scenario examples were collected; these are gathered in Appendix C.

9.2.3 Building the Ontology

As already mentioned, the elaboration of our primary data sources (formal and informal) yielded 120 test scenario templates containing multiple keywords to describe each of the scenarios' dimensions. Each keyword has been considered separately and included in a list related to the dimension it supports. From that point onwards, a series of refinements were made to keep the most relevant keywords. Relevant means here precise, specific and complementary to the other keywords ensuring the coherence of all the scenarios' dimensions. More specifically, these refinements were necessary to (i) filter-out non-significant, vague, and/or overlapping terms allowing the remaining ones to serve as the candidate *D_C* for inclusion in a unified ontology, and (ii) associate a semantic to each of the candidate *D_C*. The refinement process consists of the following stages:

- We listed, on the basis of the primary dataset, all of the keywords in a table where each dimension is considered separately. The number of occurrences of the keyword in formal and informal sources was noted; In total, 21 different instances were recorded for the *GIVEN* dimension, 22 for the *WHEN* and 19 for the *THEN* dimension (see Appendix F). Next, informal non-significant and vague terms were removed; non-significant and vague were the terms that could not be directly/clearly associated with one of the *GIVEN*, *WHEN*, *THEN* dimensions, i.e.: 'Something', 'Scenario', 'It', 'Future', 'Past', 'Present'. Table 9.1 was the end-result of this stage.

- We then associated semantics to all of the potential *D_C* instances. Since no semantics were ever found with the collected templates, we had to find corresponding semantics in another way. A first overview was performed in BDD related books to evaluate if more information on templates was available. More specifically we searched in [140, 57, 24, 130, 127] but did not find any useful information. We thusly looked for definitions of the keywords, found in the previous stage, in a list of sources in the domain of agile processes, GORE frameworks, and software engineering in order to find a matching semantic. When a match was found between the syntax

found in a test scenario template dimension and a semantic given in the former sources, we proceeded to a preliminary adoption and did not go through the rest of the sources in the list. The keywords for which we could associate a semantic were allowed to proceed to the next stage. Otherwise, the syntax was being abandoned and considered irrelevant for the construction of the unified ontology. The list of sources from the most to the least preferred one are:

1. User Stories Applied: a publication elucidating the ways for improvements in agile processes in requirements engineering [29];
2. KAOS: a framework for requirements engineering based on goal modeling [33, 93];
3. Requirements Engineering Fundamentals: a study guide for the Certified Professional for Requirements Engineering Foundation Level exam as defined by the International Requirements Engineering Board (IREB) [124];
4. BABOK: a professional guide describing the terms and concepts related to the role of a business analyst [73];
5. SEVOCAB: a glossary of concepts and their definition in the field of Software and Systems Engineering [138].

- At stage 3 we compared the semantics associated to the keywords in the previous stage. This was done to highlight any similarities, overlaps, and/or mismatches between semantics into a same dimension. Explicitly, every initial semantic overlap between two (or more) keywords was further analyzed. In several occasions, a presumed semantic overlap was eventually being dismissed as one upon further investigation. Each D_C instance candidate was then allowed to pass to the next stage of evaluation. If the semantic overlap was persisting, we were checking whether the use of another source from the aforementioned list could attribute a different semantic definition to either of the two (or more) keywords. The D_C instance of which the semantic was the most alienated to the purpose of the scenario's dimension was taking a new semantic from another source. If no new semantic could be allocated to the keyword through another source, the most generic one was allowed to pass to the next stage of evaluation.

- Finally, the kept D_C were included to form our base unified ontology and the concepts were **evaluated on the basis of the secondary data**, i.e. the set of test scenario examples.

Few D_C remained at the end of this process; they were consolidated in an ontology. The latter was built by a member of our research team and it was evaluated by the remaining members of the team. Elements that led to debates were carefully evaluated and discussed until a consensus was found.

Table 9.1 Instances for Descriptive_Concept and Related Syntax (# of Formal Sources Relating the Keyword + # of Informal Sources Relating It).

GIVEN	**WHEN**	**THEN**
Context (15 + 52)	**Event (16 + 48)**	**Outcome (18 + 82)**
Precondition (8 + 42)	**Action (11 + 47)**	**Postcondition (8 + 27)**
State (4 + 21)	**Interaction (0 + 30)**	**Output (2 + 20)**
Input (0 + 24)	**Behavior (0 + 8)**	**Change (0 + 6)**
Setting (0 + 7)	Act (1 + 3)	Goal (0 + 5)
Arrange (1 + 2)	Condition (0 + 4)	Action (0 + 3)
Expectation (0 + 2)	Process (0 + 3)	Verification (0 + 3)
Business Intent (0 + 1)	Input (0 + 2)	Behavior (0 + 2)
Outset (0 + 1)	Change (0 + 1)	Reaction (0 + 2)
	Command (0 + 1)	Consequences (0 + 1)
	Context (0 + 1)	Response (0 + 1)
	Execution (0 + 2)	
	Exercise (0 + 1)	
	Launch (0 + 1)	

9.3 Descriptive Concepts' Selection for Inclusion in the Unified Ontology

Table 9.1 summarizes the relevant keywords from each BDD scenario template found in the primary data set (see Section 9.2.3). The keywords with a low number of occurrences have been dropped; the ones with a high number (outlined in bold in Table 9.1) were the ones kept to be associated with a semantic. For each dimension, we indeed kept the 4 keywords with the highest number of occurrences for further evaluation, the remaining ones were left out of the process of building the candidate ontology before any semantic was associated to them. Full rationale for the selection for each one of these dimensions is given in the remaining of this section.

9.3.1 The *GIVEN* Dimension

Syntax Included and Semantic Association: Using the method and the list of sources depicted in Section 9.2.3, the semantics associated to the kept syntaxes for this particular dimension were:

- Context: *The system context is the part of the system environment that is relevant for the definition as well as the understanding of the requirement of a system to be developed* [124].
- Precondition: *A required precondition captures a permission to perform the operation when the condition is true* [93].
- State: *A state defines a period of time in which a system shows a particular behavior and waits for a particular event to occur* [124].

- Input: *An input represents the information and precondition necessary for a task to begin; it may be: explicitly generated outside the scope of business analysis (e.g. construction of a software application) or generated by a business analyst task* [73].

Comparison of Associated Semantic: A complementarity was noted between the semantics associated to the keywords *Precondition* and *Input*. More detailed, the International Institute of Business Analysis (IIBA) [73] states that an input can be regarded as a precondition to start a task; all in all the *Precondition* encompasses the *Input* but is more general than it so we decided to keep the former as one of the *D_C* candidates to be integrated in the ontology. Additionally, *State* and *Context* are both described in [124] as behavior-communicating elements (on behalf of the system). However, the former seems to focus on the time-dimension of the system's expressed behavior in-between transitions while the latter focuses on the system's surrounding circumstances to better understand the behavior itself. Therefore, despite their slight initial convergence in their meaning, these two elements seem not to be overlapping each other. To be sure, we allowed the *D_C* class instantiated with both of these keywords to proceed to the next phase so they can be further evaluated semantically based on our assembled BDD scenario examples.

Semantic Evaluation on Examples: The semantics for *Context*, *Precondition*, and *State* were further evaluated on the basis of BDD scenario examples gathered from our secondary dataset. This revealed that the word *Precondition* was used in 59% of the scenarios' instances, compared to a corresponding 25% use of the word *Context* and 16% use of the word *State*. Despite the predominance of the word *Precondition* compared to the other two terms, their semantic interpretation could not be easily differentiated within the examples where it was suggested that *Context* was incorporating a set of necessary *Preconditions* required for the BDD testing phase landing the system in a specific *State*. The *State* was is the examples related to a set of *Preconditions* rather than behavior as suggested in its definition. We decided thus to keep the *State* element but to change its semantics to "a set of preconditions" rather than the original semantics that were associated to it in order to match the empirical use of the term. Hence, all three concepts were kept as candidates for the construction of the ontology.

9.3.2 The *WHEN* Dimension

Syntax Included and Semantic Association: Using the method and the list of sources depicted in Section 9.2.3, the semantics associated to the kept keywords for this particular dimension were:

- Event: *Actions and events are the plot of a scenario. They are the steps an actor can take to achieve his goal or a system's response* [29].
- Action: *Actions and events are the plot of a scenario. They are the steps an actor can take to achieve his goal or a system's response* [29].
- Interaction: *An interaction is an action that takes place with the participation of the environment of the object* [138].

- Behavior: *Observable activity of a system, measurable in terms of quantifiable effects on the environment whether arising from internal or external stimulus* [138].

Comparison of Associated Semantic: Sevocab [138] details that an *Interaction* can be uni-directionally regarded as an *Action* while the opposite does not seem to hold. Hence, out of the two, the latter being more generic, it seems like the better candidate for a possible integration in the ontology. Moving on, Cohn [29] yields an exact overlap between the semantic definition of *Event* and *Action* so we had to proceed to the next source to see whether the meaning of the two could be extended further. The IIBA [73] describes an *Event* as a *system trigger initiated by humans* whereas Darimont et al. [33] describe an *Action* as *an input-output relation over objects; action applications define state transitions; actions may be caused, stopped by events and they are characterized by pre-, post- and trigger-conditions.* So Darimont et al. [33] present actions to be initiated by events rendering the latter as a trigger of the former; with their semantic being aligned it is equal to take one or the other but one must be selected. So the *Event* was allowed to move on to the next phase of evaluation as a candidate *D_C*.

Semantic Evaluation on Examples: The words *Event* and *Behavior* were prevalent within our list of test scenario examples revealing a 76% use of the former compared to a 22% use of the latter word. We also noticed that 2% of the examples contained the word *Precondition*, however, since the last one was not part of our primary syntax selection for this particular dimension, it was not further considered. Given the clear predominance in the use of the word *Event* within the examples, corresponding also to the semantic definition as prescribed in the previous phase, we decided to keep this syntax as candidate for the *D_C* instance of the ontology for this particular dimension. The term *Behavior* was also kept because of the clear difference in its definition with respect to the other concepts.

9.3.3 The *THEN* Dimension

Syntax Included and Semantic Association: Using the method and the list of sources depicted in Section 9.2.3, the semantics associated to the kept syntaxes for this particular dimension were:

- Outcome: *The business benefits that will result from meeting the business needs and the end state desired by stakeholders* [73].
- Postcondition: *A required postcondition captures an additional condition that must hold after any application of the operation* [93].
- Output: *An output is a necessary result of the work described in the task. Outputs are created, transformed or change state as a result of the successful completion of a task* [73].
- Change: No semantic was found for this syntax hence it was considered as non-relevant for the construction of the ontology.

Comparison of Associated Semantic: A semantic complementarity was noted between *Outcome* and *Output* as the IIBA [73] portrays both as the *culminating effect* of a task/operation. This similarity can be problematic for the construction of the ontology as no clear differentiating factor can be found between these *D_C* instances so we proceeded to the next source seeking whether the meaning of the two can be extended. Sevocab [138] defines *Outcome* as *an artefact, a significant change of state or the meeting of specified constraints* and *Output* as a *a product, result or service generated by a process* or as an *input to a successor process*. The latter definition outlines the process-driven nature of an *Output* signaling a temporary result being in a transient state while waiting to contribute as input to the start of the next in-line activity; on the other hand, an *Outcome* is deemed as an enduring effect signifying the achievement of a specific purpose. Considering the culminating disposition of the *THEN* dimension in a BDD scenario, we considered the instance of the *D_C* class associated to the syntax *Outcome* as more relevant for the construction of the ontology.

Semantic Evaluation on Examples: Our consulting examples depicted a 57% use of the term *Postcondition* compared to a 29% use of the word *Outcome*. They also showed a 14% use of the word *Event* but as the last one was not part of the selection process for the *THEN* dimension, it was not considered further. Despite the predominance of the term *Postcondition*, we encountered difficulties dissociating it from a *State* in the sense that one or multiple postconditions were required to be satisfied for the achievement of an outcome within the examples. Hence, both *D_C* instances through their associated semantics were considered relevant for the construction of the ontology.

9.4 Ontology for BDD Test Scenarios

The remaining concepts, after the selection process, have been placed in an ontology. From the selection process and their definitions, we can hypothesize that two kind of concepts can be distinguished and should not be mixed: The first kind refers to *human-related concepts* i.e., the *Context*, the *Event*, and the *Outcome* that are used to describe *user-driven scenarios*; these are typically instantiated by depicting, within a business context, the behavior taken by the user to achieve the outcome and they are written from the point of view of the user. So, we hypothesize that these are expressed using a pronoun. The second kind refers to *software-related concepts*, i.e. the *Precondition*, the *Behavior* and the *Postcondition* that are used to describe *system-driven scenarios*; these are typically instantiated by describing successively the state of the system before, and after the occurrence of a specific event. We nevertheless point to the fact that, in the ontology, the keywords *Behavior* and *Event* are difficult to evaluate (and differentiate) in nature without their associated semantics. Moreover, the keyword *Behavior* is misleading since it refers to system behavior in the semantics but, by nature, it is matching to the topic of behavior driven development which is theoretically centered on the user. After several observations, the true element that assists in the discrimination of instances is the *WHEN* dimension so that particular attention needs to be dedicated to its characterization. We suggest

to change the keyword *Event* to *User_Behavior* and the keyword *Behavior* to *System_Behavior* while keeping their associated semantics. Finally, a *State* is seen as a set of preconditions; this is here also extended to the postconditions. The *State* is thus relevant only in a system-driven context. The finally adopted pairs syntax/semantic are:

1. **Context:** "*The system context is the part of the system environment that is relevant for the definition as well as the understanding of the requirement of a system to be developed*" [124];
2. **Precondition:** "*A required precondition captures a permission to perform the operation when the condition is true*" [93];
3. **State:** "*A set of preconditions or postconditions*" (custom definition);
4. **User_Behavior:** "*The steps an actor can take to achieve his goal or a system's response*" [29];
5. **System_Behavior:** "*Observable activity of a system, measurable in terms of quantifiable effects on the environment whether arising from internal or external stimulus*" [138];
6. **Outcome:** "*The business benefits that will result from meeting the business needs and the end state desired by stakeholders*" [73];
7. **Postcondition:** "*A required postcondition captures an additional condition that must hold after any application of the operation*" [93].

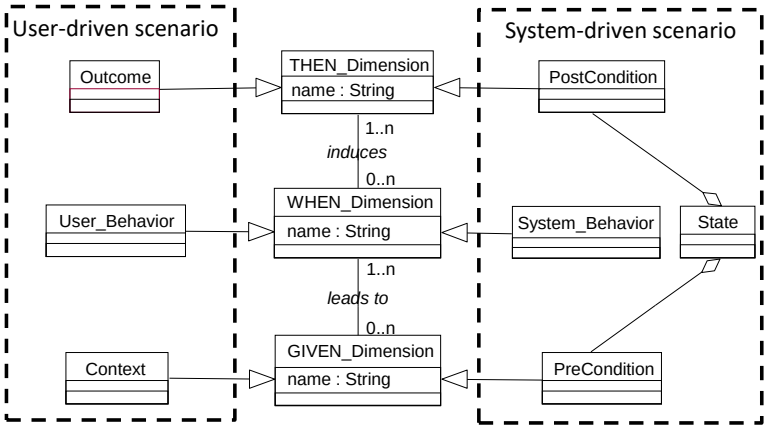


Fig. 9.2 Ontology for BDD Test Scenarios.

In order to treat the ontology elements in a generic manner, we build 3 super classes: respectively one for the *GIVEN*, *WHEN* and *THEN* dimensions. Specific elements inheriting from these classes are specified as children. Empirically we have seen that the *THEN* dimension is sometimes used without *WHEN* dimension and that the latter is sometimes used without the *GIVEN*

dimension. The link between the *GIVEN_Dimension* element class and the *WHEN_Dimension* one is thus 0..n at the side of the former and 1..n at the side of the later. Similarly, the link between the *WHEN_Dimension* element class and the *THEN_Dimension* one is thus 0..n at the side of the former and 1..n at the side of the later. A merger of this ontology with another one that is used to represent user story elements is presented in the next chapter (see Figure 10.4).

9.5 Threats to Validity

The relative importance of each retrieved element in the *D_C* class could have been biased by the fact that, during our primary data collection, we have come up with an unequal number of formal and informal test scenario templates. This discrepancy has been present in our methodology during the build-up of the ontology, especially during the retrieval and listing of the syntaxes for any of the *GIVEN*, *WHEN* and *THEN* dimension. Nonetheless, since BDD is an applied technique, the use of only formal templates could not be exhaustive; the work of BDD (and agile) practitioners contributes greatly in the evolution of the field and the amelioration in the use of these scenarios. This discrepancy has been addressed via the validation of the retrieved syntaxes through test scenario examples gathered from informal secondary sources and the validation of the ontology based on actual projects found in an online platform (see the *exogenous validation process* described in the next chapter).

The choice of the sources used during the phase of the semantic association can also be seen as arbitrary. As mentioned, we searched in [140, 57, 24, 130, 127] but did not find any useful information. A second search iteration was based on a comparison among multiple primary sources linked to KAOS [33, 93] and i* [201] frameworks as well as the Cucumber [61, 24, 198] software tool. This second iteration did not yield any important semantic information that could be attributed to specific keywords. We then decided to expand the search to other sources more closely related to quality improvements within agile processes. We acknowledge that the selection of the different sources might have led to variances in the concepts included in the ontology and their semantic association. Nonetheless, these sources were chosen after deliberation and unanimity among the members of the research team.

Finally, the process of comparing the semantic complementarity for some of the retained syntaxes/keywords has proven to be difficult as the semantics attributed to these syntaxes could be associated to a diversified set of domains derived from our list of sources. Therefore, a question of objectivity was risen when it comes to deciding whether a set of semantics could be perceived as overlapping or not. In order to address this issue, each member of the research team went through the process of semantic comparison individually while noting down the reasons contributing to his/her choice. Afterwords, the team reconvened discussing and assessing each member's choice where a final decision was made based on the individual choices that concurred the most.

9.6 Conclusion

Despite the existence of a multitude of BDD test scenario templates, there is a lack of clearly defined guidelines on how to write fit-for-purpose scenarios. This chapter aimed at creating a unified and well-defined ontology to better instantiate most BDD test scenario templates in conjunction with the user stories they are associated with. Such a structure that includes a set of concepts accompanied by their syntax and semantic, aspires to assist practitioners to engage in a common and more precise use of BDD test scenarios increasing their overall understandability within - and outside - the premises of a development team. The use of the ontology, accompanied by qualitative user stories and BDD test scenarios, could provide scenario instances enhanced with meta-data which can be used to serve as input for automated software tests. Further validation of the ontology is needed and will be performed in the next chapter using examples collected on the Github platform as well as expert opinions.

Chapter 10

Building User Stories and Behavior Driven Development Scenarios with a Strict Set of Concepts: Ontology, Benefits and Primary Validation

As already mentioned, lots of templates exist for the construction of Behavior Driven Development (BDD) test scenarios. However, the practice of building such templates is mostly driven by empiricism (thus offering mostly circumstantial assistance) rather than providing a comprehensive guide on how to effectively shape functional acceptance tests in the form of BDD test scenarios. A strict set of concepts with a clear definition of the used keywords aligned with the intends of BDD has been proposed in the previous chapter in the form of an ontology. The present chapter (i) evaluates the ontology on existing BDD test scenarios found in the GitHub repository (exogenous validation) and (ii) merges an ontology for user story elements' representation with the one expressing BDD test scenarios to evaluate its ability to guide the writing of BDD test scenarios (endogenous validation). By linking both ontologies, through strictly-identified concepts, we (i) provide guidance to the practitioner in the agile requirements engineering phase and (ii) with the adequate tagging of elements during the requirements engineering process we get meta-data allowing to suggest treatments to the BDD scenario (e.g. test automation or forward engineering into a software architecture or even code).

The research presented in this chapter has been realized in collaboration with S. Heng and Y. Wautelet. Results are to be published in [64]. This chapter is organized as follows: Section 10.1 summarizes some of the concepts elaborated on the previous chapter and utilizes them as the preamble for constructing the research questions that guide the theoretical development of the present chapter. Section 10.2 describes the background; it introduces the corresponding ontologies for user stories and BDD test scenarios. Section 10.3 depicts the validation of the BDD ontology on BDD test scenario sets found within the GitHub platform. Section 10.4 depicts the consolidation of the ontology for BDD test scenario templates with the ontology for User Story templates. Section 10.5 depicts the endogenous validation which was performed using experts' opinions.

Section 10.6 discusses the merged ontology's impact and perspectives. Section 10.7 discusses the related work and, finally, Section 10.8 concludes the chapter.

10.1 Introduction

BDD corresponds to an agile process that encourages collaboration among all the stakeholders in a software development project. For that purpose, requirements and acceptance tests, so the elements meant to determine the behavior of the software system, are written in a common non-technical language defined at the beginning of the project. So the determination of the behavior of the system is the central element in BDD, from the formation of the requirements (most commonly in the form of user stories) to the implementation of the software. In that context, BDD test scenarios are preferably written in conjunction with their corresponding user stories to be in agreement with the user on the requirement and its validation. BDD test scenarios are thus supposed to be centered on the user with no supporting technical details [139].

Tsilionis et al. [161] present an ontology depicting the keywords most usually found in BDD templates. By tagging (i.e., associating a defined concept to part of a user story or BDD instance) at modeling time, we invoke on meta-data giving us guidance on how to write the scenario; this practice also explicates (i) the point of view used to write the scenario (i.e., whether user-behavior or system-behavior was required), and (ii) the nature of the elements, so the way they can be used in the software design. The former source elaborated on the ontology and the way it was built; however, an illustrative application or a validation procedure were not proposed. The present chapter is purposed to fill this gap by addressing two distinct research questions. These are: *'What is the representation ability of the BDD ontology on large real-life test scenario sets?'* (RQ1), and *'How can we use the ontology for building BDD scenarios in conjunction with the one on user stories to furnish guidance in the building of the former along with the deliberation of potential synergies?'* (RQ2). We refer to the establishment of a procedure to answer the first research question as an *exogenous validation* since the real-life test scenario sets were built out of the context of the ontology; we refer to the procedure of the second research question as an *endogenous validation* since the aim is to build scenarios with the support of the ontology.

To answer the RQ1, we apply the ontology to evaluate the completeness and accuracy of the templates that can be built out of it through the application of a test set of 10 different projects found in GitHub. To answer the RQ2, we merge the BDD ontology with the one developed in Wautelet et al. [181] allowing to build a unified ontology that can serve as guidance to build user stories and BDD scenarios and see a formal link between the nature of the elements used in both of them. Three experts in agile methods and software testing have also been consulted for the evaluation of the strengths and weaknesses of the *consolidated ontology* (so the merged user stories' and BDD scenarios' ontology).

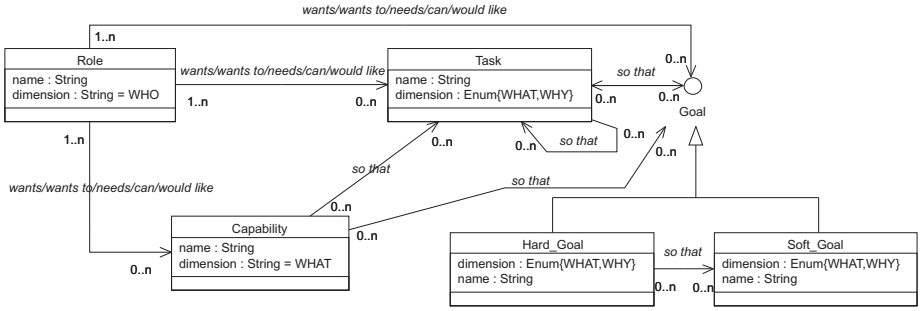


Fig. 10.1 Unified Ontology for User Story Descriptive Concepts (from [181]).

10.2 Background

The ontologies presented in Sections 10.2.1 and 10.2.2 have been built using a comparable approach. Indeed, by collecting the mostly used keywords in practice to build user stories and BDD scenarios, it has been possible to further conceptualize the elements constituting each of the dimensions and propose definitions for the used keywords. This way a set of non-redundant and non-overlapping concepts could be distinguished and formalized. This section summarizes the results for both ontologies.

10.2.1 Ontology for User Stories

Wautelet et al. [181] have built an ontology for designing and building User Stories (US) templates; this is represented in Figure 10.1. A US template can be designed taking an element from the *WHO*, *WHAT* and possibly *WHY* dimensions. The link between the classes conceptually represents the link from one dimension to the other. Concretely, the unidirectional association from the *Role* to one of the *Capability*, *Task* or *Goal* classes implies that the target class instantiates an element of the *WHAT* dimension (always tagged as *wants/wants to/needs/can/would like* in the ontology). Then, the unidirectional association from one of these classes instantiating the *WHAT* dimension to one of the classes instantiating the *WHY* dimension (always tagged as *so that* into the ontology) implies that the target class eventually (since 0 is the minimal cardinality) instantiates an element of the *WHY* dimension. A US template supported by this ontological structure is for instance: *As a <Role>, I would like <Task> so that <Hard-Goal>*.

Each concept is associated with a particular syntax (identical to the name of the class in Figure 10.1) and a semantic. The syntax and semantics of the ontology are summarized here. As a result of the research conducted in [181], the couples syntax/semantic are the following:

- *A **Role** is an abstract characterization of the behavior of a social actor within some specialized context or domain of endeavor*;
- *A **Task** specifies a particular way of attaining a goal*;

- *A **Capability** represents the ability of an actor to define, choose, and execute a plan for the fulfillment of a goal, given certain world conditions and in the presence of a specific event*;
- *A **Hard-Goal** is a condition or state of affairs in the world that the stakeholders would like to achieve*;
- *A **Soft-Goal** is a condition or state of affairs in the world that the actor would like to achieve. But unlike a hard-goal, there are no clear-cut criteria for whether the condition is achieved, and it is up to the developer to judge whether a particular state of affairs in fact achieves sufficiently the stated soft-goal.*

10.2.2 Ontology for BDD Test Scenarios

Tsilionis et al. [161] have built an ontology for defining BDD scenarios. As can be seen in Figure 10.2, two kind of concepts can be distinguished: *human-related* concepts that are used to describe *user-driven* scenarios, and *software-related* concepts that are used to describe *system-driven* scenarios.

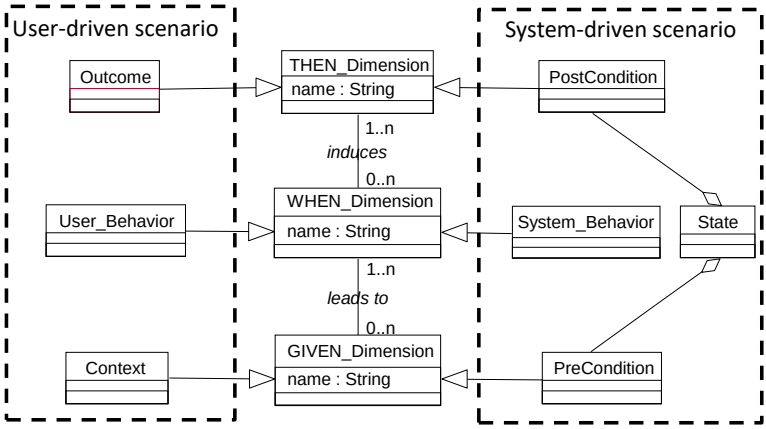


Fig. 10.2 Ontology for BDD Test Scenarios (from [161]).

Each concept is associated with a particular syntax (identical to the name of the class in Figure 10.2) and a semantic. The syntax and semantics of the ontology are summarized here. As a result of the research conducted in [161], the couples syntax/semantic are the following:

- **Context:** "*The system context is the part of the system environment that is relevant for the definition as well as the understanding of the requirement of a system to be developed*" [124];
- **Precondition:** "*A required precondition captures a permission to perform the operation when the condition is true*" [93];
- **State:** "*A set of preconditions or postconditions*" (custom definition);

- **User_Behavior:** "*The steps an actor can take to achieve his goal or a system's response*" [29];
- **System_Behavior:** "*Observable activity of a system, measurable in terms of quantifiable effects on the environment whether arising from internal or external stimulus*" [138];
- **Outcome:** "*The business benefits that will result from meeting the business needs and the end state desired by stakeholders*" [73];
- **Postcondition:** "*A required postcondition captures an additional condition that must hold after any application of the operation*" [93].

In order to treat the ontology elements in a generic manner, we build 3 super classes, each one corresponding respectively to one of the *GIVEN*, *WHEN* and *THEN* dimension.

10.3 RQ1: Ability of the BDD Ontology to Characterize Scenario Sets

The ontology for building BDD scenarios, as presented in Figure 10.2 is evaluated here on the basis of its **coverage** and **completeness**. The former evaluates whether all of the ontology's elements are required while the latter examines whether there are any missing elements (i.e., instances that cannot be assigned to an element present in the ontology because no matching semantic as defined in Section 10.2.2 could be fitted). Secondly, we checked whether the *hypothesis* stating that BDD scenarios can be classified in *user-driven* and *system-driven* types, stands true.

To perform the validation, 10 projects describing BDD test scenarios were selected randomly from the GitHub's repository; these accounted for **356 test scenarios** in total. The details of the evaluating process and the actual dataset are presented in the Appendix[1] due to the space limitations.

To perform the validation, we searched the GitHub's repository for projects where BDD test scenarios have been used. We used keywords 'BDD' and 'BDD Test' to search in the GitHub repository. A list of projects was provided as a result. We went through every single project to evaluate whether test scenarios are effectively used; then the project could be selected. We selected only the first 10 projects found from the repository. The evaluation was systematically conducted by one of the authors and double-checked by the rest. After a careful examination of each BDD scenario, each dimension's instance has been related to the best matching semantic (to tag it as an element of the ontology). Table 10.1 provides the result of the evaluation. It accounts for 355 test scenarios in total.

Our analysis shows that, considering the test scenarios provided by these 10 projects, we have full coverage; this means that, in regards to these projects, no ontology element is in excess. Additionally, we have found that not every

[1]The dataset as well as all the other appendices for the evaluation of the ontology can be found at: https://data.mendeley.com/datasets/svmcxt5z5f/1

Table 10.1 Result of the Evaluation of the Hypothesis of the Ontology.

	Context	User_Behavior	Outcome	PreCon.	System_Behavior	PostCon.	User_driven	System_driven	Number of tested Scenario
Project 1	0	72	0	141	0	136	72	69	141
Project 2	9	5	9	13	13	14	5	18	23
Project 3	0	52	51	67	15	16	52	15	67
Project 4	12	10	12	0	2	0	10	2	12
Project 5	0	24	0	24	0	24	24	0	24
Project 6	19	20	22	0	2	0	20	2	22
Project 7	8	8	8	0	0	0	8	0	8
Project 8	7	7	7	0	0	0	7	0	7
Project 9	0	16	0	16	0	16	16	0	16
Project 10	35	35	35	0	0	0	35	0	35

dimension corresponding to the *GIVEN*, *WHEN* and *THEN* canonical form is systematically present in each of these test scenarios. Nevertheless, each time a scenario contains all these dimensions, their instances can always be assigned to one of the defined concepts within the ontology corresponding to a matching semantic as derived from our approach. Furthermore, our aforementioned hypothesis is confirmed; our analysis suggests that every test scenario can always be classified as either a *user-driven* or a *system-driven* one. To be specific, within our test set, 250 test scenarios are user-driven scenarios while the remaining 106 are system-driven.

The test scenarios, as found within these 10 projects, suggest that once the *WHEN* dimension is absent, the BDD scenario is likely to be a *system-driven* one (because it depicts system outputs that we relate as post-conditions). Conversely, once the *WHEN* dimension is present, it constitutes the decisive element making a true segregation between a *user-driven* and a *system-driven* scenario. In other words, it was often hard to discriminate a *Context* from a *Precondition* and an *Outcome* from a *Postcondition*. However, it was easy to distinguish between a *User_Behavior* and a *System_Behavior* in the *WHEN* dimension. For this reason, we point to the discriminating elements as being the *User_Behavior* and the *System_Behavior*; the *Context* is a *Precondition* in a *user-driven scenario* and the *Precondition* is a *Context* in a *system-driven scenario*. Similarly, the *Outcome* is a *Postcondition* in a user-driven scenario and the *Postcondition* is an *Outcome* in a *system-driven scenario*.

We also noticed that an instance of *User_Behavior* is often written in the form of <*Role*> followed by an action verb. The <*Role*> is expressed by using a pronoun, e.g. 'I', or a noun phrase, e.g. 'the user'. Instead, an instance of *System_Behavior* is expressed in the form of a subject which refers to a component or an object of the system, e.g., *the default password*, *the login page*, etc. In general, it is written in a passive form. However, this finding requires

a more in depth investigation. We have to build a larger dataset and employ Natural Language Processing (NLP) techniques which is out of the scope of the present study.

In addition, we found that the percentage of the concepts' occurrences for PreCondition (73.88%) is higher than the one for Context (25.00%) for the *GIVEN* dimension. Similar observations can be made for the *WHEN* dimension (70.22% for User_Behaviour and 9.55% for System_Behaviour) and *THEN* dimension (58.15% for PostCondition and 40.45% for Outcome).

The result shows that all the concepts of the ontology are used (so the completeness element is validated). We found that not every dimension of the canonical form *GIVEN*, *WHEN*, *THEN* is systematically present in the test scenario. However, when it is present, its instance can always be assigned to one of the concepts of the ontology (so a matching semantic was found). In addition, every scenario can be assigned to one and only one type of scenario: i.e., either *user-driven scenario* or *system-driven scenario*. Therefore, we can conclude that our hypothesis is valid.

Finally, we have empirically observed that BDD scenarios are used with user stories in half of the selected projects of the dataset. A user story is tested at least by one scenario; as can be seen in Figure 10.3, the *WHAT* and *WHY* dimensions in the user story are linked, respectively, to the dimensions *WHEN* and *THEN* of the BDD test scenario. However, the dimension *GIVEN* has no link with any of the dimensions of a user story. We also witnessed occasionally that the BDD's *THEN* dimension had a link with the user story's *WHAT* dimension. This motivated us to consolidate concepts used in test scenarios with the concepts used in user stories as presented in the next section.

```
As an online customer, I want to start the game so that, I can start to play

Given the app has already loaded the question
When the customer requests to start the game
Then the app should allow the customer to insert
answers

Given the app has already loaded the question
When the customer requests to start the game
Then the counter should starts to count
```

Fig. 10.3 User Story and Corresponding BDD Scenarios: An Example.

10.4 Unifying User Story and BDD Scenario Elements: Consolidated Ontology

A scenario's purpose is to specify the desired system behavior upon the implementation of the expressed desideratum as described in the *WHAT* dimension of a user story. Therefore, a link can be made between the BDD ontology and the user story one presented in the study of Wautelet et al. [181]. Both were

built following a similar methodological approach. This section thus presents the merging of both ontologies.

To simplify the consolidation of the ontologies, we only took the elements of the *WHAT* and *WHY* dimensions of the user story ontology and aggregated them through superclasses (so one for the *WHAT* and the other for the *WHY* dimension). The *WHEN* dimension of the BDD scenarios has been linked with the *WHAT* dimension of the user story elements to show that a *Capability*, a *Task* and a *Goal* can be operationalized through *User_Behavior* or *System_Behavior*. Similarly the *THEN* dimension of the BDD scenarios has been linked to the *WHAT* and *WHY* dimensions of the user story elements to show that an *Outcome* or a *Postcondition* fulfills the elements instances of those classes.

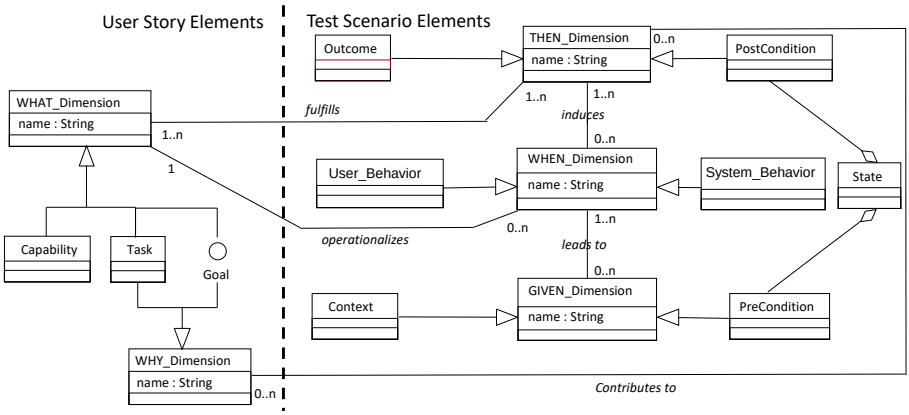


Fig. 10.4 User Stories and BDD Scenario Elements: Consolidated Ontology.

The cohesion between the user story and BDD artifacts is maximum. Both furnish a non-overlapping and complementary documentation to the software development team. User stories are driving agile software development by being the scope elements for sprint content planning and BDD scenarios furnish enough documentation to execute and validate the requirement depicted in the user story. Moreover the user story is not only the higher-level (or aggregated description) of the BDD scenario but it gives also the general context of the BDD scenario. The user story is thus also necessary for the development team to understand under what scope the execution takes place and documents relevant complementary system behavior.

10.5 RQ2: Expert Opinions on the Use of the Consolidated Ontology

The consolidated ontology (Figure 10.4) has been audited by 3 software development experts in terms of its structure, corresponding parts, understandability, applicability, and ease of use. Given that the BDD domain is being mostly driven by the use of empiricist practices, these experts have been selected not

only based on their academic qualifications; primarily, we were interested in engaging professionals with significant experience in testing practices especially when performed within the context of agile software development. Such profiles, ideally combined with a research-affiliated background, could evaluate the consolidated ontology based on its ability to solve bottlenecks encountered in the experts' everyday testing practices and, simultaneously, comprehend (and perhaps challenge) its methodological inception with the goal of providing feedback for its further refinement and/or customization. To be specific, the first expert holds a PhD in computer science and currently fulfills the role of a researcher and developer. The second expert occupies the role of a team coordinator in a software development team given his extensive experience (+15 years) in the field. The third expert holds a PhD in computer science and is currently occupying the role of an analyst-developer. All three experts were acclimatized to agile methods and test-driven software development processes (mainly via the use of test-driven development and secondly via the use of domain-driven development and BDD); they were encouraged to consider their business roles and the fit-for-use of the ontology to their daily organizational activities and tasks in order to offer comments, recommendations, concerns, or vulnerabilities about its characteristics.

Each expert participated in an individual interview-session lasting about 90 minutes. The interview protocol that was followed for the evaluation of the unified BDD test scenario ontology was the same for the three experts. In general, the first part was devoted to collecting some background information about the experts' knowledge/expertise and the nature of their interaction with BDD. For the second part, a specific software application was presented to each expert along with a set of 10 user stories describing the user/system requirements for this application. Next, each expert was asked to compose 5 BDD test scenarios corresponding to the subset of the first 5 user stories presented before. Following, a member of the research team proceeded in a full-scale description and explanation of the ontology of Figure 10.4 along with its corresponding concepts (i.e., keywords and their semantic allocation). Each expert was asked then to compose 5 BDD scenarios for the remaining 5 user stories of the application while using the ontology as a guiding aid. For the last part of the protocol, each expert could perform a thorough audit of the ontology when it comes to its structure, understandability, applicability, and ease of use.

All the experts found the ontology easy to understand and to be providing a benefit in offering a distinction between *human-related* concepts and *system-related* concepts within different BDD test scenarios; they all converged that the job of a tester can become easier with the introduction of some clear semantic definitions within the notions used in BDD scenario templates. In the **first expert's** own words "*...after the presentation of the ontology, I have a better grasp of the distinction between the user requirements, and what the state of the software system before/after a specific event needs to be, for the latter to be in a specific condition validating the user story*". The expert reported that the above-mentioned distinction made him realize that his current role falls under the determination of system-driven behaviors and the set-up of quality

criteria to better test the functionalities of these systems. Finally, the expert acknowledged that the ontology seems a bit generic and lacks some pivotal details that would make it more customized to the needs of his team (so he values it as a generic guidance that could be customized for a specific team). He also admitted that such a customization would require a lot of time investment on behalf of his team and they would probably be unwilling to put in that extra effort in order to bring a new element/technique in their way of working; the expert admitted that this very last remark is more related to people's natural resistance to change management than an actual drawback of the ontology itself.

The **second expert** expressed the opinion that the ontology can be targeted towards novice testers where a preliminary conceptual differentiation between *user-driven* and *system-driven* scenarios would be particularly beneficial for customers and developers. In the expert's words "*when an approach (a user-driven or a system-driven) is selected, the ontology can give some guidance on how to correspond the script of each scenario to its different dimensions and not to mix both approaches. I have personally seen how easy it is for customers and developers to mix both approaches*". So, overall, the second expert notes that the aforementioned distinction can be particularly beneficial in terms of getting clients, developers, and testers on the same page in terms of declaring the outcome of a testing process successful (or unsuccessful) when targeted at the validation of a user/system requirement.

The **third expert** found very interesting the use of different keywords that can be corresponded to *user-driven*, and *system-driven* scenarios according to the nature (technical or not) of the user story. The expert found the semantic definitions that accompany these keywords supportive of this primary scenario distinction. In his own words "*the ontology, and hence the two types of scenarios, can be used by different types of test teams or testing purposes. System-driven scenarios can be used by the development team, and user-driven scenarios can be used by the unit acceptance testing team or the quality assurance team*". In this regard, we notice a discrepancy between the second and third expert; the former sees the ontology more fitting to novice testers while the latter considers the ontology relevant to more experienced testers/developers since they may be more capable of realizing the nature of the scenario they want to produce; in such manner, the ontology's accentuation of the different keywords attributed to user-, and system-driven scenarios would be of help. In this regard, his opinion coincides to the one of the first expert when recognizing that the ontology can be used in a top-down fashion "*as a reference ontology that we can use for writing different tests for different teams. However, since each User Acceptance Testing (UAT) team has a different perspective of testing, different parts of the ontology can be used by different development teams according to the different testing prerequisites that they have*" thus allowing for a bottom-up use of the ontology.

Finally, all experts converged on the fact that the ontology benefits from a visible link between the *WHAT*-, *WHY*- user stories' dimensions and the *GIVEN*-, *WHEN*-, *THEN*- BDD scenarios' dimensions; they seemed to agree that pairing elements found within the user stories with elements found in the

BDD scenarios furnish extra context and information on the way things can be expressed in a coarse- and fine-grained manner. The consolidation of the user story and the BDD ontologies is justified.

10.6 Ontology Impact and Discussion

Even if the BDD ontology has been evaluated on 10 projects and we collected the opinion of 3 experts, a more extensive validation of it and the consolidated version (the one including the user story concepts) still needs to be achieved. This will be done on the basis of a larger test set combined with interviews from practitioners to study the rationale of their BDD scenario expressions and automated NLP techniques. We want to study particularly the pair user story/BDD scenario and develop guidelines to build them in a unified way and, with the use of a specifically developed CASE tool, we can trace the link between them and the validation of traditional user stories but also Epic user stories on the basis of multiple BDD scenarios. All in all, this will allow a global linkage between the requirements in terms of user goals and tasks and their operational realization. Also the use of the meta-data to automate the transformation process of the BDD scenario into code will be further studied.

The overall quality of BDD scenarios will also be further studied with the ontology as main guidance. The ultimate goal is to build a set of rules that can be used to evaluate and guide the writing of BDD scenarios as it has been done for the user stories' paradigm in the work of Lucassen et al. [101]. Also, we will study how we can build a graphical approach to link user stories decomposition (functional but also non-functional elements) with their realizing scenarios on the basis of the Rationale Tree approach [182].

Finally, we aim to study the forward engineering (transformation) process of BDD scenarios into an Agent-oriented software design in the same fashion as it has been done for user stories in the work of Wautelet et al. [180]. A preliminary study to bridge the user story/BDD concepts to behavior-oriented languages like agent-oriented ones is performed in Heng et al. [63]. The pair of information based on the ontology has been used to generate a software architecture for an agile declination of the MERODE process in Snoeck & Wautelet [142].

10.7 Related Work

As seen, Wautelet et al. [181] address the topic of quality improvements in agile requirements by materializing an objective standard in the use of user stories. We implicitly expand that work here in the field of BDD. This ontology becomes the basis for a visual representation of a user story structuring method called the Rationale Tree [182]. The latter uses parts of the i* framework and visual notation to group user stories around common Epics and Themes for recognizing and reducing even further any occurring modeling redundancies during the stages of requirements analysis and design.

To continue, we examined the work of Bjarnason et al. [16]; the authors perform a case study using data from 6 different software developing companies in order to depict the causes and aftermath of a weak traceability between the

stage of analysis of newly-introduced requirements and their testing. Before the actual case study, the author present the evaluation of many methods, automated or not, targeted at reducing the disaffiliation between these two stages. The lack of guidelines the number of traces between requirements and test are reduced by linking test cases to user scenarios abstracted from the formal requirements, thus tracing at a higher abstraction level.

Hotomski et al. [70, 71] specify an approach that uses a three-step intervention system to synchronize between changes in the requirements and changes in their corresponding acceptance tests, during the evolution of a software system. Their approach identifies firstly all relevant change patterns in requirements; second, it generates suggestions in natural language about the processing of these changes; third, it disseminates information about the changes and suggestions to the relevant parties. Overall, this particular approach uses a semantic evaluation of words/sentences to estimate a dissimilarity index which corresponds to the discrepancy between old and newly-introduced requirements. When this index transcends a certain threshold, the discrepancy is considered substantial which means that the acceptance tests nested within the old requirement will need to be modified also. Our study uses semantic evaluation but towards a different direction; it is targeted at creating a broader understanding of the used keywords that would guide requirements engineers in building scenarios that fully correspond to the intends of BDD.

Improvements in BDD test scenarios are tackled in Oliveira et al. [115] via a literature review on quality characteristics in agile requirements resulting in a list of prospective attributes that test scenarios should share. This primary list is further scrutinized via a student experiment and later evaluated by BDD practitioners in Oliveira et al. [116]. Based on their evaluation, a test scenario is graded as qualitative when it is *concise*, *testable*, *understandable*, *unambiguous* and *valuable*. Comparably, in Binamungu et al. [15], BDD practitioners are being surveyed on the minimum quality criteria that BDD test suites should fulfill. The study proposes ultimately four principles supporting the assessment of quality in test suites (i.e., *smaller scenario steps*, *use of the same domain terms*, *use of generic rather technical terms* and *use of a consistent level of abstraction everywhere in the test suite*). It is important to mention that these principles do not seem to surface from the practical experience of the practitioners; rather, the practitioners are provided with a well-scrutinized list of principles, as derived from the existing literature, and are asked to validate it. Overall, these last research strands, appraising whether a test scenario script matches a predetermined checklist of attributes/principles, provide useful insights in defining the objectives of test scenarios a priory; in practice, it can be difficult to recognize and fully instantiate these attributes/principles in the course of writing test scenarios.

Lastly, Li et al. [95] use visual diagrams as requirement interceptors for the creation of automated test scenarios in Cucumber [61, 24, 198]. Their approach involves the use of a software tool which receives UML state machine diagrams [118] as input and transforms them into abstract graphs with initial and final nodes. The number/format of these nodes leads, according to predetermined rules, to the evolution of Cucumber features. While the quality of the scenarios

is ensured by the internal configuration rules of the software itself, still it remains a plug-and-play technique that does not discuss any objective criteria for the correctness of these acceptance tests nor gives any guiding criteria on how the latter were perceived. Hence, the issue of analyzing the current format of BDD test scenarios in order to map-out inductively a generic and unified meta-model that could instantiate a test scenario according to BDD requirements has not, to the best of the authors' knowledge, been addressed yet.

10.8 Conclusion

BDD is a technique often used in agile methods aimed to deliver system functionalities best suited to the needs of the end-users while facilitating the cooperation between the roles involved in the entire development process. The focal point of BDD is situated on the definition of acceptance criteria written in a simple non-technical language to validate the user desiderata described, usually, in the form of user stories. These acceptance criteria take the form of test scenarios examining the alignment between the expected and actually performed user- or system-behavior upon the implementation of these functionalities. Despite the multitude of BDD test scenario templates, there is a lack of clearly defined guidelines on how to write fit-for-purpose scenarios. This chapter aimed at evaluating a unified and well-defined ontology to better instantiate most BDD scenario templates in conjunction with the user stories they are associated with. Such a structure that includes a set of concepts with syntax and semantic, aspires to assist practitioners to engage in a common and more precise use of BDD scenarios increasing their overall understandability within and outside a development team.

From the dataset applied on the BDD ontology we learned that the coverage and completeness of its constituting elements are optimal. We also found that not every dimension of the canonical form *GIVEN*, *WHEN*, *THEN* is systematically used in practice. In addition, every scenario can be assigned to one and only one type of scenario i.e., either *user-driven scenario* or *system-driven scenario*. The key elements discovered during the expert interviews can be summarized in the below:

- the ontology offers strong guidance in terms of writing user stories and their corresponding BDD scenarios;
- the opportunity of having in one's disposal a unique way of consulting how the pair user story/BDD scenario should be defined brings unification in a very fragmented domain of agility;
- the ontology would be of help for automated testing of system- and user-oriented scenarios. With the use of the ontology and adequate quality level user stories and BDD scenarios, scenario instances with the meta-data can be used as input for automated software tests.

Since the increase in quality of user stories and BDD scenarios written with the support of the ontology remains an open issue, a future research direction

would include the design of a controlled experiment examining the easy of use, consistency, completeness, accuracy, and adaptability of the unified test scenario ontology. Such a research design would dictate the separation of a prospective sample of novice modelers in several test groups. One group would be asked to draft test scenarios from a given user stories' set with the help of our ontology while the other group would be asked to perform the same task but without the assistance of our ontology. They would, however, be provided with examples concerning the use of test scenarios (or other treatments) in order to make a final comparison in the quality of the furnished BDD scenarios and the understandability of the software problem and solution for all test groups.

In terms of the forward engineering/transformation abilities from the ontology combining user stories with the BDD scenarios, some preliminary work has been done on the generation of code constructs. Finally, using meta-data on the type of elements, fragments can be used to generate not only design elements but also a graphical representation for analysis purposes. For this, we will, in future work, refine the proposal of Wautelet et al. [180] to integrate the BDD scenario in a tree depicting user stories' elements links and decompositions. A complete formalization and validation of a graphical representation and its use will be the subject of a future communication. Finally, two Computer Aided Software Engineering (CASE) tools using and supporting the ontology for writing user stories and BDD scenarios are under development: the DesCartes Architect tool for agent-based development and the Merlin-tool to support the Agile-MERODE process.

Part V

Conclusion

Chapter 11

Conclusion

11.1 Contributions

Service attribution is becoming increasingly important within the IT industry via the promotion of a novel 'Everything as a Service' (XaaS) [40] business-operating model. Indeed, companies already established within the technological domain (e.g., Microsoft) can no longer create value solely by selling software or blocks of software-intensive products, especially when the latter are perceived as non-modifiable black boxes by the end-user. Instead, such companies seem to be marketing nowadays the sale of customizable software or the use of computing power as a *service*. Therefore, the notion of service is all the more relevant for organizations consuming off-the shelf, customized, or custom produced services as well as for organizations offering such elements. Frameworks sustaining the integration of IT in an organization and favoring internal or external innovation adoption thus need to center on the notion of service not at a technical-level but in a more abstract one considering the service itself as a source of added value. The integration of such services within the socio-technological ecosystem must face the examination of their alignment with the long-term strategy of the organization; at the same time, the internal configuration of such services must be composed in such manner as to allow them to be the carriers of tactically and operationally-driven innovations. The present thesis has been focusing on the elaboration of mechanisms to alleviate any sort of tensions between the long-term commissioning of such services (i.e., satisfying the organizational strategy and ensuring the business and IT alignment at the strategic level) and their quick delivery of innovational value (at the managerial and operational level). This direction has been set by stating a main research question in the introduction, i.e., *how can we use conceptual models to evaluate through traceability the alignment of the governance and management levels in a business context where IT developments are driven by ad-hoc, disruptive or experimental concerns?*

The internal configuration of services, their operating environment, they way they are packaged, and the strategic context in which they need to be integrated are all elements whose representations can be significantly facilitated by the use of conceptual models. This has been shown in this dissertation; indeed, the different chapters made out of individual researches contributing

to the construction of this final thesis particularize all the addressed elements related to answering the aforementioned research question. Admittedly, the latter cannot be answered as a whole but through the collection of various elements which are purposed to study it through various lenses and are intended to focus on specific (and distinguishable) levels. We point out here that:

- StratAMoDrIGo allows to trace the impact of the deployment of a strategic opportunity in terms of strategic, stakeholder and user added-value. Explicit traceability is provided between the governance and management-levels. Implicitly, the framework serves as the basis upon which a quick decision can be taken by the C-level board in terms of adopting a new technology, when the organization operates within a highly disruptive business context. Value is evaluated at a strategic level without neglecting the stakeholder-, and user-level. The overall innovation approach is top-down but takes into account the bottom-up value streams coming from the innovation itself;

- Agile-MoDrIGo allows to trace the functional and strategic alignment between coarse-grained functions defined at governance level and fine-grained functions defined by the users in an agile fashion. It offers thusly a genuine (and strong) bottom-up approach coexisting with a top-down one. Implicitly, the rationale is to have two coexisting forces where genuine and clear innovative features can be defined by the user (and other field stakeholders) with a true evaluation of their alignment with the strategy conditioning their implementation/deployment;

- Within the application of agile development itself, techniques like user stories and BDD scenarios which are used to express requirements can, with a small increase in formality translated by adding some meta-data, provide elements directly traceable with the strategy defined at governance-level. In other words, by enhancing and enriching some techniques, more traceable evaluations can be offered to better understand the strategic alignment of tactical and operational-level defined features.

In terms of answering the main research question, both StratAMoDrIGo and Agile-MoDrIGo allow for a common rapprochement between the governance and management levels within an organization when the latter is in need of a swift, upfront evaluation for an impending technological evolution. However, their main difference resides in the type of approach as the leading venue to favor the use of agility (i.e. focus on immediate value and rapid deployment); StratAMoDrIGo focuses on the strategic level via a value-based cogitation of strategic opportunities while Agile-MoDrIGo focuses on the managerial level via the conceptualization (and perhaps internal characterization) of business IT services. Additionally, with the use of some enhancements, industry adopted techniques like user stories and BDD scenarios (used within multiple agile paradigms) can help in establishing traceability between the requirements formulation and validation stages.

11.2 Limitations

We need to mention that each of the presented chapters discusses some individual constraints that might be posing a specific threat or challenge to the unhinged development of a particular research approach. However, by adopting a broader view at this stage, we can point the following limitations that can serve as the basis for the betterment of the work presented in this thesis. To be specific:

- In terms of IT governance, the proposed frameworks mostly concentrate on the *Strategy* principle as defined by ISO/IEC 38500 [75]. These frameworks could be extended to include more principles, especially *Conformance*, since the alignment of Business IT Services (or Strategic Opportunities more broadly) with managerial-level laws and regulations could be traced using the same models;
- In terms of the development of a Computer-Aided Software Engineering (CASE) tool, not much work has been done thus far. A tool allowing the edition of the models and the support of the application of the methods in an integrated manner should capacitate the delivery all of the value of the proposed methods. Such a tool should also be able to imprint a way for their parallel/common use;
- All the frameworks have been validated on real-life cases and expert opinions but new case studies are always welcome. Applications always come with new findings and refinements or adaptations of the frameworks and their applicative process fragments;
- Significant experience in software modeling is required for the understanding and correct application of the frameworks. In that manner, support to inexperienced (in software modeling) roles is not always provided in an optimal manner. Additionally, the use of simplification could be studied to help deliver the benefits of the framework while lowering the modeling effort.

11.3 Future Research Directions

We hereafter detail the future work that can be prescribed as the natural progression of the research presented in this thesis. In particular:

- Chapter 7 has already discussed some of the commonalities of the StratA-MoDrIGo and Agile-MoDrIGo frameworks. Indeed, the aforementioned are kindred frameworks but they are based on a somewhat different hypothesis. A unification or integration of the frameworks could be further studied as well as the elucidation of some particular environmental elements stipulating the choice of one or the other framework;
- The frameworks can be presently perceived as ways of building IT services by offering a support to internal business processes of the organization; however, they could also be adapted in a way to support the transition from a product-based offer to a service-based offer for IT provider companies;

- More work could be done on the evaluation of the use by non-experienced (strategic or software modeling-affiliated) stakeholders. Such evaluations could serve as the basis for the provision of an integrated interface (either with the use of a CASE tool or the use of a paper-based guiding template) providing directions for the use of the frameworks according to specific environmental circumstances;

- Study of the integration of the DevOps principles in the cloud context can also deliver value. The use of a cloud-based platform allows for a swift integration of the new releases (in our case an IT service integration in SaaS environments) that have been developed taking technical deployment constraints into account;

- The frameworks are essentially organized on the basis of a traditional governance model where a central board or committee acts as the sole decision-making center in function of the issues that are deemed important. However, the frameworks also account for the fact that most of stakeholders are represented within these centers and taken into account for value delivery for the entire organization. The incorporation of a fully decentralized governance model where it is not one central authority that takes the decision but different local ones could also be studied as an add-on to these frameworks;

- The use of BDD scenarios has been studied, within the present thesis, at the operational level as the means of better calibrating the requirements specification to requirements validation process. However, their inclusion in the strategic alignment process has not really been considered. This would be the natural next step in the context of the studies that have been done in this thesis.

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