DOCTORAL SCHOOL OF
BUSINESS INFORMATICS

THESIS SUMMARY

DÓRA ŐRI

ON EXPOSING STRATEGIC AND STRUCTURAL MISMATCHES BETWEEN BUSINESS AND INFORMATION SYSTEMS:

MISALIGNMENT SYMPTOM DETECTION BASED ON ENTERPRISE ARCHITECTURE MODEL ANALYSIS

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associate professor

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DEPARTMENT OF INFORMATION SYSTEMS

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TABLE OF CONTENTS

1 RESEARCH FOUNDATION

1.1 Motivation

One of the most important issues on information systems (IS) research is the need to align business with information systems and information technology (IT). Since information systems facilitate the success of business strategies, the importance of business-IT (or strategic) alignment is unquestionable. While organisations address alignment achievement, they are continually suffering from misalignments. These difficulties (the misalignments) encumber the achievement of alignment and lead us to the phenomenon of misalignment.

Misalignment analysis (detecting, correcting and preventing misalignment) is an important step in achieving alignment since it helps to understand the nature and the barriers of alignment. Understanding the underlying cause of misalignments, as well as trying to correct the existing misalignments are one of the possible ways to achieve alignment (Carvalho and Sousa, 2008). Most traditional alignment studies deal with achieving alignment. On the contrary, misalignment issues (detecting, analysing and correcting misalignment) are considerably underemphasised in the literature. The state of (mis)alignment can be examined with several methods. Most of the methodologies approach (mis)alignment from management, organisational culture, and communication perspectives. In contrast to popular approaches, one of the main research methods for (mis)alignment evaluation is enterprise architecture-based assessment.

This Ph.D. dissertation deals with the concept of misalignment, with special attention to enterprise architecture (EA)-based analytical potential. In the following study, the problem of business-IT alignment will be translated into the aspects and concepts of enterprise architecture. The main purpose of the proposed research is to analyse strategic misalignment between the business dimension and the information systems dimension. In the Ph.D. dissertation, an analytical solution will be built to approach the topic of strategic alignment from an EA-based perspective. The study aims to accomplish an EA-based, systematic analysis of mismatches between business and information systems.

1.2 Problem Statement

The proposed research relates to the concept of strategic alignment. This research aims to approach strategic alignment from the perspective of misalignment. In this research, the problem of revealing the typical symptoms of misalignment will be addressed in order to assess the state of alignment in an organisation. The research aims to provide suitable tools and instruments to detect the symptoms of misalignment. Misalignment assessment will be based on the analysis of the underlying enterprise architecture models.

For general context setting, the proposed research works with the concepts of strategic alignment, misalignment and enterprise architecture. From the alignment perspective, the research builds on the traditional Strategic Alignment Model (SAM) by Henderson and Venkatraman (1993). Alignment assessment will be performed from the perspective of misalignment. The state of misalignment will be revealed by its symptoms. Symptom detection will be performed via an EA-based approach, i.e. the underlying EA models will be analysed in order to reveal the symptoms. EA-based analysis uses the TOGAF enterprise architecture framework (TOG, 2015), and is based on rule generation and testing. Based on the constituent parts, the research aims to build a framework for EA-based misalignment symptom detection.

1.3 Purpose of the Study

The study discusses the strategic misalignment between the business dimension and the information systems dimension. The aim of the study is to contribute to the above-mentioned concerns and gaps by introducing a framework that addresses these issues. The study conducts misalignment analysis by proposing an enterprise architecture-based framework to detect the typical signs of misalignment in an organisation. The proposed framework performs misalignment analysis by taking a symptom-based approach.

Expected outcomes from the proposed research include:

EO1:	CLASSIFICATION OF DIFFERENT MISALIGNMENT SYMPTOMS: EA INDICATORS ON MISALIGNMENT, EA DETECTION TECHNIQUES
EO2:	A FRAMEWORK WHICH CAN SUPPORT EA-BASED (MIS)ALIGNMENT ASSESSMENT
EO3:	CASE STUDIES ON THE OPERATION, CORRECTNESS, RELEVANCE, ACCURACY AND RESULTS OF THE FRAMEWORK

1.4 Research Objectives

The research addresses misalignment symptom analysis by proposing an EA-based framework to detect the typical indicators of misalignment in an organisation. The main research objective lies in identifying general ways for detecting the symptoms of misalignment in the underlying EA models. The sub-objectives of the above-introduced research objective consist in the breakdown of the main research objective into smaller, logically connected parts, viz.:

RO1:	WHAT ARE THE TYPICAL SYMPTOMS OF MISALIGNMENT ACCORDING TO THE OPERATION OF THE SAM MODEL?
RO2:	HOW TO TRANSFORM MISALIGNMENT SYMPTOMS INTO FORMALLY ANALYSABLE STATEMENTS?
RO3:	WHAT ARE THE FORMAL ANALYSIS METHODS OF DETECTING MISALIGNMENT SYMPTOMS IN ENTERPRISE ARCHITECTURE MODELS?

1.5 Research Questions

Based on expected outcomes and research objectives, the proposed research focuses on the following research questions:

RQ1: WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?

RQ2: WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?

RQ3: HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?

RQ4: WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

1.6 Research Model

The proposed research aims to address the above-introduced research objectives and research questions by building a framework for EA-based misalignment symptom analysis. *Figure 1* introduces the conceptual research model of the study. The proposed research framework introduces an approach for EA-based alignment assessment, i.e. a solution for assessing alignment phenomenon in EA models.

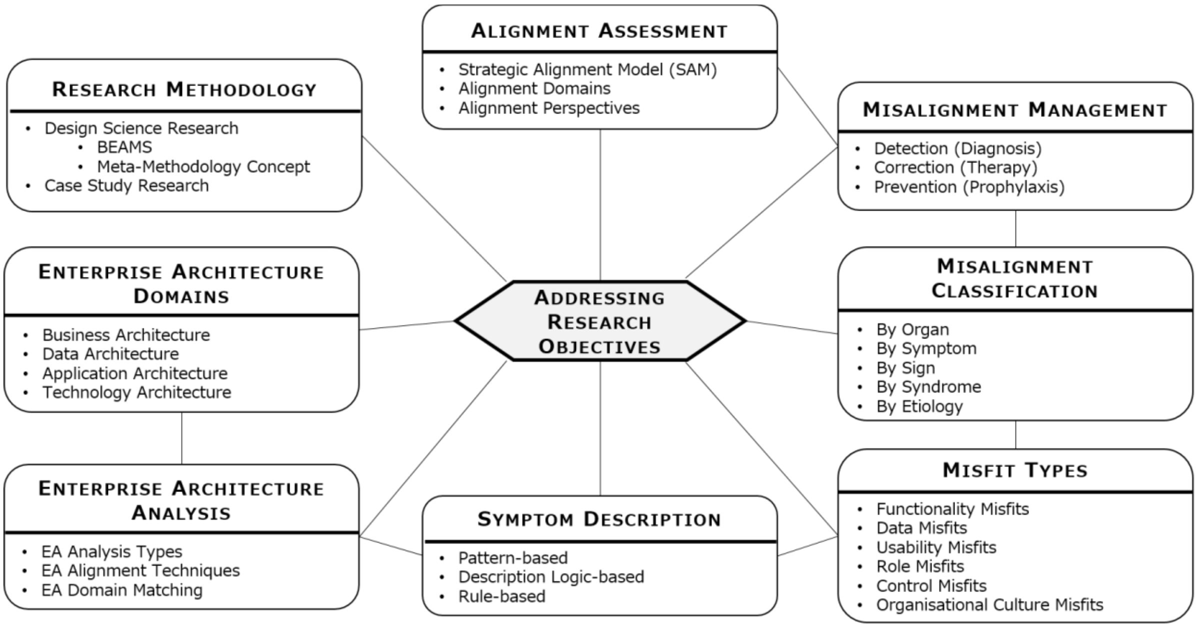

Figure 1. Conceptual Research Model

2 SUMMARY OF RESEARCH METHODOLOGY

The research aims to analyse the symptoms of misalignment via enterprise architecture assessment. The goal of the research is to create a framework that reveals the state and symptoms of misalignment in EA models. This section proposes an overview of the research methodology used in the Ph.D. dissertation.

2.1 Research Design

The research methodology section contains the overall strategy to choose and integrate the constituent parts of the study. In constructing the research approach, the interactive model of research design will be used (Maxwell, 1996). The structure of the proposed research model will reflect the recommendations of the model. *Figure 2* shows the structure of the interactive model.

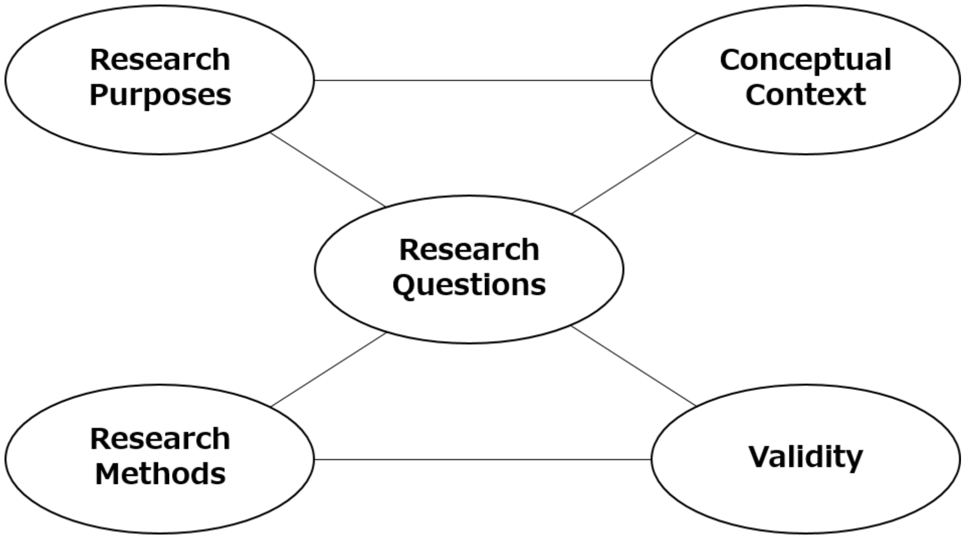

Figure 2. Interactive Model of Research Design (Maxwell, 1996)

2.2 Methodological Choices in Research

Choosing appropriate IS research methodologies is a key point in constructing the research approach. As an initial phase, a decision has to be made on the nature of the proposed research. The research will be based on the *inductive approach* since my research has an exploratory manner: it aims to explore a less grounded research area and proposes new ways of analysing the subject. The second influential choice on the research approach lies in the decision on quantitative or qualitative research. This research uses the *qualitative approach* since the main goal of the proposed research is to explore new theories by developing new approaches for (mis)alignment assessment. Justifications for these choices are given in the Ph.D. dissertation.

The proposed research combines methods from both social sciences and information systems studies. In addition, the research uses a *mixed approach* for framework building and validation. Mixed methods research (Creswell and Clark, 2007) is frequently used both in social sciences and in IS research. In this research, the Design Science Research and the Case Study Research methodologies will be mixed: Framework building will be supported by the Design Science Research methodology, while empirical validation will be conducted by using the Case Study Research method.

2.2.1 Design Science Research for Framework Building

In the proposed research, the Design Science Research (DSR) methodology will be used to support framework building. This systematic research method will be used in the dissertation for building research artefacts. *Figure 3* introduces the general process of DSR. In the proposed research, the DSR process will be used to define research artefacts.

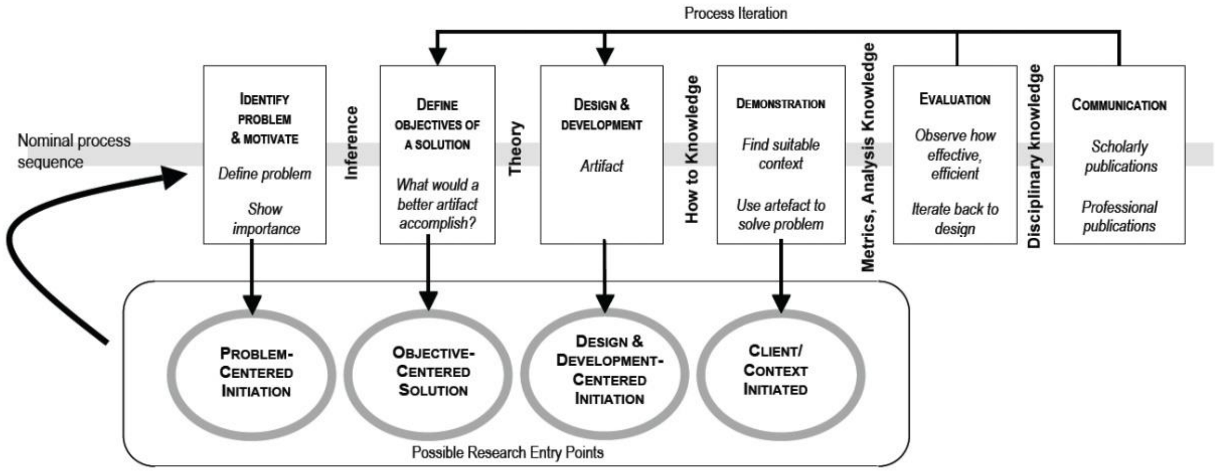

Figure 3. Design Science Research Methodology: Process Map (Peffers et al., 2007)

2.2.2 Case Study Approach for Empirical Validation

For empirical validation, the Case Study Research method will be used in the research. After developing the research model with the DSR approach, the model will be empirically tested with the Case Study Research method. The method allows an in-depth analysis of a research problem. It helps to narrow the field of study by focusing on some typical empirical examples. In addition, it provides ways to test whether a proposed theory or model applies to real-world phenomena. Yin (2013) summarises the process of case study method as follows (*Figure 4*):

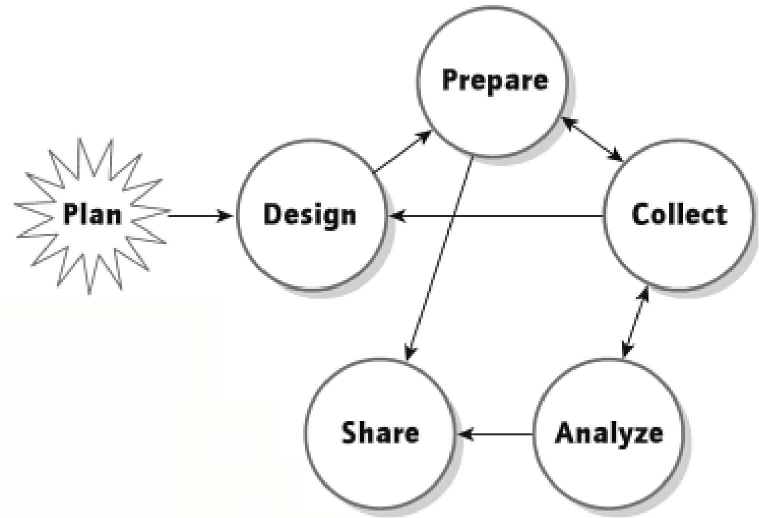

Figure 4. The Process of Case Study Method (Yin, 2013)

2.3 Concept Categorisation for EA-based Misalignment Assessment

In this section, an overview is given on potential concepts for EA-based misalignment assessment. Related concepts and solutions include means of both theory and implementation. This section of the Ph.D. dissertation aims to exhibit the setting and background of EA-based misalignment assessment, i.e. all possible means of approaching misalignment assessment from an EA-based perspective. *Figure 5* presents the concepts under review in the dissertation.

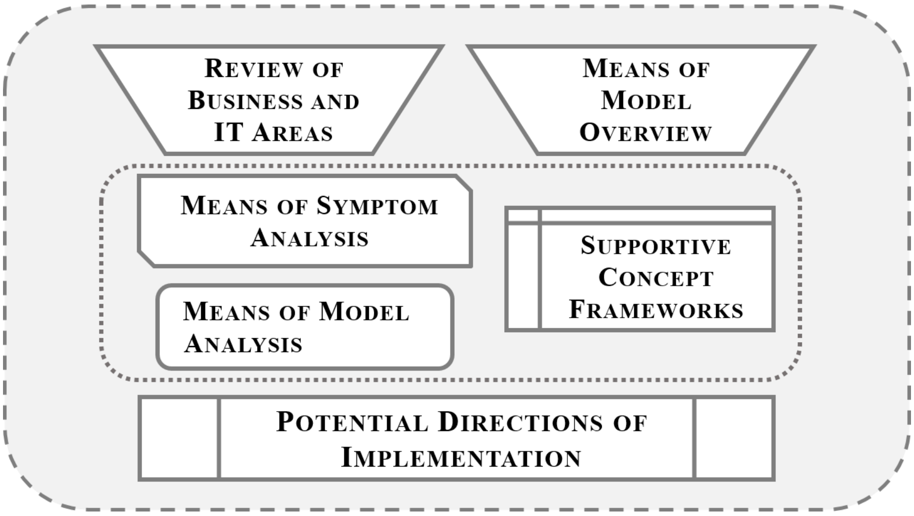

Figure 5. Areas of Concept Categorisation

2.4 Proposed Solution

This subsection summarises the proposed solution. In this part, an analytical solution will be built to approach the topic of strategic alignment from an EA-based perspective. The proposed solution reflects the research questions and maintains the coherence of research design. Research steps ensure the achievement of research objectives. The achievement of the research objectives is guaranteed by the use of the Interactive research model.

2.4.1 Conceptual Design

The research takes a rule-based approach to reveal the symptoms of malfunctioning alignment areas. The research steps are aggregated into three layers: 1) Misalignment Layer, 2) Enterprise Architecture Model Layer and 3) Analysis Layer.

Misalignment Layer is concerned with the construction and formal description of misalignment symptoms. Misalignment symptom construction is based on the matching of the SAM alignment domains. A formal description of misalignment symptoms consists of pattern generation.

EA Model Layer aims at preparing the underlying enterprise architecture models for the misalignment symptom detection. The phase consists of model transformation, artefact decomposition, and export file generation.

Analysis Layer is concerned with the implementation details of the proposed research. EA-based misalignment symptom detection will be performed by means of formal rule testing, i.e. the analytical potential of rule generation and rule testing will be exploited. Misalignment symptoms will be defined as formal rules. After rule construction, rule-testing approaches will be introduced.

2.4.2 Proposed Research Methodology

This section provides an overview of the components and the construction of the proposed research methodology. The framework described in the Ph.D. dissertation is a well-structured, easy-to-use tool to support misalignment symptom detection. The proposed research methodology builds on the previously introduced conceptual design and uses the three-layer approach. The framework has four main parts, which are connected to the corresponding conceptual design layers:

1) *Alignment perspectives* are used to structure the approach of misalignment symptom detection. Alignment perspectives are decomposed into constituent SAM domain matches.
   - This part of the framework refers to *1) Misalignment Layer*.
2) A *misalignment symptom catalogue* is composed of symptom collections found in the recent literature on misalignment.
   - This part of the framework also refers to *1) Misalignment Layer*.
3) An *artefact catalogue* is introduced, which summarises potential containing EA models.
   - This part of the framework refers to *2) EA Model Layer*.
4) *EA analysis catalogue* describes potential EA analysis types that are suitable for revealing misalignment symptoms in containing EA models.
   - This part of the framework refers to *3) Analysis Layer*.

The proposed research methodology uses an alignment perspective-driven approach. In the first step, traditional alignment perspectives are provided with typical misalignment symptoms. In the second step, relevant artefacts are connected to the misalignment symptoms, which may contain the symptom in question. In the third step, suitable EA analysis types are recommended to the misalignment symptoms. These EA analysis types are able to detect the symptoms in the recommended containing artefacts. *Figure 6* introduces the constituent parts and the structure of the proposed framework.

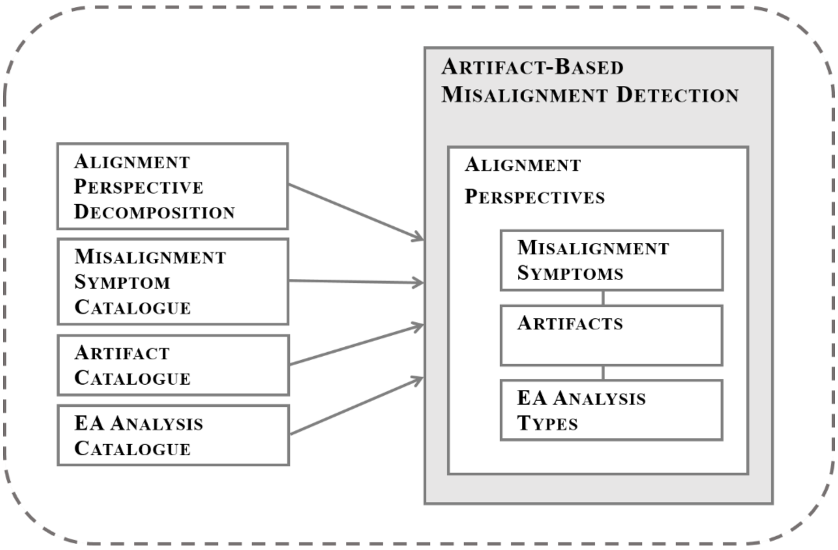

Figure 6. The Construction of Artefact-Based Misalignment Detection Framework

Implementation details of operating the proposed framework include the following: Queries for EA-based misalignment symptom detection will be written by using the XPath language and the Schematron language. Schematron language will be used for making assertions about patterns (i.e. misalignment symptoms) found in the XML exports of the EA models. XPath language serves as a supportive language for defining the context of the queries. Schematron-based queries will be written and validated in an XML validation tool. The tool includes an editor for writing Schematron queries as well as an inbuilt validator engine for validating XML documents against Schematron rules. Assertions reported by the validation engine will also be displayed by the editor.

After introducing the proposed analytical framework for EA-based misalignment assessment, the section concludes with some details on data collection, data analysis, and result interpretation.

Data collection: Data will be collected according to the recommendations of the Design Science Research and the Case Study Research methods. Suitable test organisations will be identified to be the subjects of the proposed analysis. The organisational models (process models, organisational charts, process maps, balanced scorecards, value chain diagrams, etc.) of the chosen test organisations will serve as input data. Besides the collection of organisational models, semi-structured interviews will be performed in order to collect further information about the organisational context of the models.

Data analysis: By means of case generation, the data collected in the previous phase will be analysed. Proposed steps of data analysis include research steps introduced in the previous subsections. The symptoms of misalignment will be detected in the structured XML exports of EA models by rule construction and rule testing techniques.

Plan for Interpreting Results: Data analysis phase will provide a certain amounts of structured data on identified misalignment symptoms. In the result interpretation phase, these data will be construed and processed. Based on the rule construction phase, rule-testing approaches will be used to identify formally described misalignment symptoms in the EA models. Based on the rule-testing phase, results will be interpreted in terms of the alignment-misalignment continuum.

3 Summary of Research Results

The Ph.D. dissertation dealt with the concept of enterprise architecture-based misalignment analysis. It presented a research approach for EA-based misalignment assessment. The main purpose of the proposed research was to analyse strategic misalignment between the business dimension and the information systems dimension. The research addressed misalignment symptom analysis by introducing an enterprise architecture-based framework to detect the typical signs of misalignment in an organisation.

3.1 Operating the Proposed Research Framework

To demonstrate the applicability of the proposed framework as well as to better understand how it works in practice, a case study has been conducted. The case study clarified the operation of the framework by applying it in the context of a real EA model structure. This section summarises the research results from the case analysis by introducing the symptom detection results of an exemplary misalignment symptom.

Preliminary reviews on the case consisted of the list of influential areas to review and the analysis of assumed malfunctioning areas. Malfunctioning areas were translated into the corresponding records in the misalignment symptom catalogue. It was followed by the categorisation of perceived misalignment symptoms. Non-analysable (S.C.03) symptoms were excluded from further analysis. The remaining S.C.01 and S.C.02-type symptoms were analysed according to the corresponding analytical tools from the proposed research framework (Ph.D. dissertation: *Table 27* and *Table 28*).

Results from operating the proposed framework for misalignment symptom analysis will be summarised by the analysis of an exemplary symptom: S.52 Not all data entity attributes are read at least by one process. Firstly, the symptom will be subject to the analysis of EA-scope applicability in *Table 1*. The S.C.01-type misalignment symptom belongs to the Strategy Execution alignment perspective. Containing EA models are AF.11 Process Flow Diagram, AF.12 Data Entity/Data Component Catalogue, and AF.13 Data Entity/Business Function Matrix. There are no other necessary sources for investigating this symptom.

Table 1. Analysis of EA-Scope Applicability for Misalignment Symptom S.52

ASPECT	MISALIGNMENT SYMPTOM
CODE	S.52
SYMPTOM CATEGORY	S.C.01
ALIGNMENT PERSPECTIVE	P.01 Strategy Execution perspective
ALIGNMENT TYPE	C.02 Matching of Business Structure and IT Structure domains
SYMPTOM DEFINITION	*Not all data entity attributes are read at least by one process*
LITERATURE REFERENCE	Pereira and Sousa, 2005
SIGN, PRESENCE	There are data entities that are not used by any business process
OCCURRENCE, PRESENCE IN EA MODEL	By scanning data usage in business process models, there are data entities that are not used by any business process tasks
CONTAINING EA MODEL	AF.11 Process Flow Diagram AF.12 Data Entity/Data Component Catalogue AF.13 Data Entity/Business Function Matrix
OCCURRENCE ON MODEL ENTITY LEVEL	There are data entities from the data entity catalogue that are not present on any business process model
OTHER NECESSARY SOURCES FOR INVESTIGATION	None

Secondly, *Table 2* contains the analysis results for detecting misalignment symptom S.52 in EA scope. Suitable EA analyses to detect the symptom are A.01 Dependency analysis and A.03 Coverage analysis. In detecting misalignment symptom S.52, the presence of data entities from the data entity catalogue is examined in a process flow model.

Table 2. Detection of Misalignment Symptom S.52 in EA Scope

Aspect	Misalignment Symptom
Code	S.52
Symptom Definition	*Not all data entities attributes are read at least by one process*
Suitable EA Analysis to detect the symptom	A.01 Dependency analysis A.03 Coverage analysis
Occurrence, Presence in EA Model	By scanning data usage in business process models, there are data entities that are not used by any business process task
Containing EA Model	AF.11 Process Flow Diagram AF.12 Data Entity/Data Component Catalogue AF.13 Data Entity/Business Function Matrix
Occurrence on Model Entity Level	There are data entities from the data entity catalogue that are not present on any business process model
Containing EA Model in Road Control Model Structure	Data Entity/Data Component Catalogue Process Flow Diagram
Occurrence, Presence in EA Model of the Road Control Model Structure	By scanning data usage in business process models, there are data entities that are not used by any business process task
Occurrence on Model Entity Level in Road Control Model Structure	There are data entities from the data entity catalogue that are not present on any business process model
Occurrence in XML-based EA Model Export	Comparison of business process models and data entity catalogue in terms of data entities
Occurrence on Model Entity Level in XML Export	Comparison of elements between Node type: data entity in the business process model and Node type: data entity in the data entity catalogue
XML-based Query	For every node where node type = data entity: - Compare the attribute names with the data entity attribute names from process flow diagram - Alert data entity nodes if they are not present in the process flow
Query in Schematron Language	<pattern name="S.52 Not all data entities attributes are read at least by one process"> <rule context="Object Definition[@Node Type='{*data entity*}']"> <assert test="Attribute Definition[@AttributeDefinition.Type= '{*attribute name*}']//PlainText[@TextValue=document ('process flow diagram.xml')//Object Definition[@Node Type='{*data entity*}'] //Attribute Definition[@AttributeDefinition.Type='{*attribute name*}'] //PlainText//@TextValue]"> Alert: S.52 </assert> </rule> </pattern>

Subsequently, relevant EA models are presented with both graphical and XML views. *Figure 7* and *Figure 8* present related model representations for misalignment symptom S.52. *Figure 9* shows an excerpt from Road Control Process 1.0 XML export for the detection of misalignment symptom S.52. The excerpt contains an object definition node from the type of data entity (TypeNum = “OT_CLST”) with an attribute definition element for the name of data entities (AttrDef.Type = ”AT_NAME”).

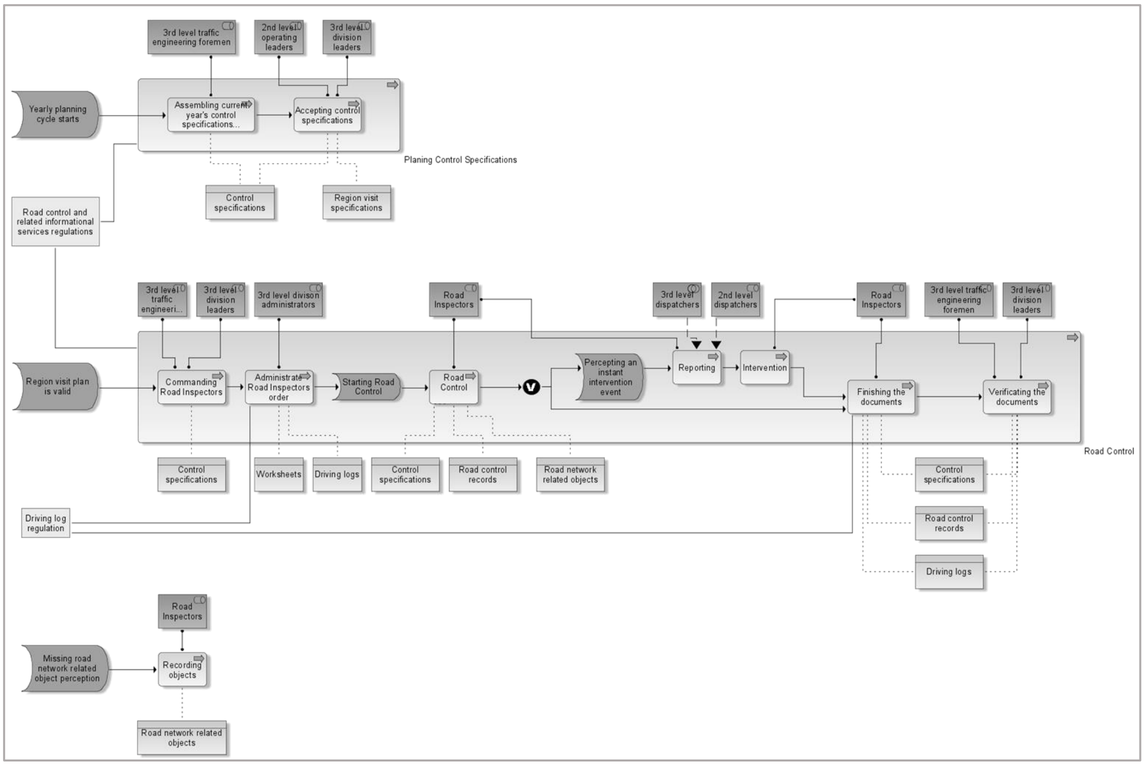

Figure 7. Road Control Process 1.0 Model Representation for Misalignment Symptoms S.52

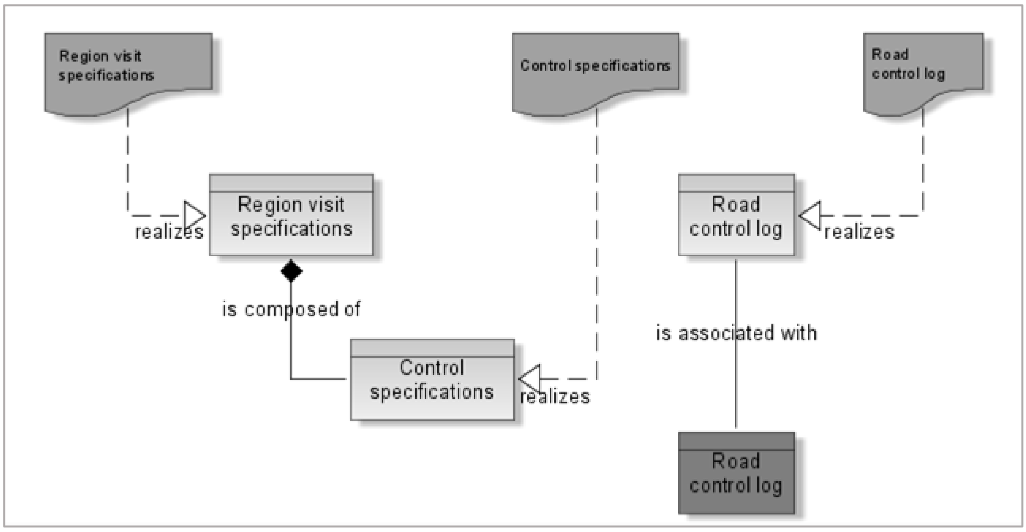

Figure 8. Excerpt from Road Control Data Model Representation for Misalignment Symptoms S.52

```xml
<ObjDef ObjDef.ID="ObjDef.5V9fxba5k_H-p-L"
    TypeNum="OT_CLST"
    ToCxnDefs.IdRefs="   CxnDef.-6GlqpAHySru-q-L  "
    SymbolNum="ST_CLST"
>
    <AttrDef AttrDef.Type="AT_PERS_RESP">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                <StyledElement>
                    <PlainText TextValue="Road Inspectors"/>
                </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
    <AttrDef AttrDef.Type="AT_NAME">
        <AttrValue>
            <StyledElement>
                <Paragraph Alignment="UNDEFINED" Indent="0"/>
                <StyledElement>
                    <PlainText TextValue="Road Control Records"/>
                </StyledElement>
            </StyledElement>
        </AttrValue>
    </AttrDef>
</ObjDef>
```

Figure 9. Excerpt from Road Control Process 1.0 XML Export for Misalignment Symptom S.52

Table 3 contains the customised query for misalignment symptom detection S.52. As for procession results, *Figure 10* illustrates the query of Q.07 in an XML Editor before XML validation. The query Q.07 was validated against the XML export of Road Control Data Model 1.0. *Figure 11* contains operation results for running the query of misalignment symptom S.52.

Table 3. Excerpt from the List of Customised Schematron Queries for Misalignment Symptom Detection

Query Code	Symptom Code	EA Model under Review	Query Description
Q.07	S.52	▪ Road Control Process 1.0 ▪ Road Control Process 2.0 ▪ Road Control Data Model 1.0 ▪ Road Control Data Model 2.0	<pattern name="*S.52 Not all data entities are read at least by one process*"> <rule context="ObjDef[@TypeNum='OT_CLST']"> <assert test="AttrDef[@AttrDef.Type='AT_NAME']//PlainText [@TextValue=document('Road Control Process 1.0.xml')// ObjDef[@TypeNum='OT_CLST']//AttrDef[@AttrDef.Type= 'AT_NAME']//PlainText//@TextValue]"> *Alert: S.52 Not all data entities are read at least by one process* </assert> </rule> </pattern>

schema pattern rule assert

```
<schema xmlns="http://www.ascc.net/xml/schematron" >
    <pattern name="S.52 Not all data entities are read at least by one process">
        <rule context="ObjDef[@TypeNum='OT_CLST']">
            <assert test="AttrDef[@AttrDef.Type='AT_NAME']//PlainText[@TextValue=document('Road Control Process 1.0.xml')
                //ObjDef[@TypeNum='OT_CLST']//AttrDef[@AttrDef.Type='AT_NAME']//PlainText//@TextValue]">
                Alert: S.52 Not all data entities are read at least by one process
            </assert>
        </rule>
    </pattern>
</schema>
```

Figure 10. Schematron Query Q.07 for Misalignment Symptom S.52

Figure 11. Query Q.07 Output/A for Misalignment Symptom S.52 Processed on Road Control Data Model 1.0

In the Ph.D. dissertation, seven misalignment symptoms were detected according to the proposed research framework. At the end of the symptom analysis, results were interpreted and discussions were drawn about the detection of the selected misalignment symptoms. Discussion on symptom detection results included the evaluation of the proposed framework as well.

3.2 Evaluation of the Proposed Research Framework

Misalignment symptom analysis and detection provided insights about query types. Evidence from the case study suggested that there are distinct types of misalignment symptoms that can be detected by the proposed research framework. The case study demonstrated that the proposed research framework is applicable for detecting the following types of misalignment symptoms:

- Symptoms in which the presence or lack of the certain types of attributes has to be investigated (e.g. S.02, S.32).
- Symptoms in which the cardinality of certain connection types has to be analysed. This type is applicable to three cases: Firstly, one particular model is analysed in terms of connection cardinality (e.g. S.05). Secondly, sole model variants are analysed in terms of connection cardinality and the query is processed for every available model variant (e.g. S.07). Thirdly, model variants under review are analysed with another type of static or

dynamic EA model in terms of connection cardinality. The expressiveness of the query language provides this kind of analysis. However, the case study did not provide any example of this kind of analysis.

- Symptoms in which more models have to be compared (e.g. S.16, S.18, S.52). This type is applicable to two cases: Firstly, model variants have to be compared with another group of model variants according to the project phases (e.g. S.52). Secondly, model variants have to be compared with a static catalogue (e.g. S.16, S.18).
- Symptoms in which more model variants have to be analysed and compared during the progression of the project (e.g. S.18).

Apart from the previous categorisation, the case study also demonstrated that particular symptoms have to be detected in more than one step, viz. by more than one rule. Misalignment symptom S.05 was a spectacular example of this kind of analysis. As part of future work, other misalignment symptoms can be broken down into more than one rule.

The case study provided considerable insight into the applicability of the proposed research framework. In addition, it has demonstrated the utility and usability of the proposed framework as well. The detection results confirmed the usefulness of the proposed research framework as a misalignment assessment framework Further analyses – which will be presented in the future work section – will show additional results for misalignment symptom detection.

3.3 Summary of Evidence

Table 4 gives a conclusion on how research objectives (RO1-RO3) have been addressed in the Ph.D. dissertation. Research objectives are contrasted with the accomplishments of the Ph.D. dissertation in order to show evidence for addressing research objectives in the dissertation. In the following summary, positions of the research results and accomplishments are pointed out to support traceability of evidence.

Table 4. Addressed Research Objectives

RESEARCH OBJECTIVE	ISSUE COVERED BY
RO1 What are the typical symptoms of misalignment according to the operation of the SAM model?	The framework included misalignment symptom categorisation according to traditional alignment perspectives and alignment types in Section 3.5.2.
RO2 How to transform misalignment symptoms into formally analysable statements?	Misalignment symptoms were managed as formal rules. The proposed framework in Section 3.5 processed rules via XML validation techniques.
RO3 What are the formal analysis methods of detecting misalignment symptoms in enterprise architecture models?	In Section 3.4 a concept categorisation was given on competing methods for EA-based misalignment symptom detection. In addition, the proposed framework in Section 3.5 served as a formal analysis method for the research topic.

In the subsequent categorisation, research questions validated against 1) corresponding concepts from the concept categorisation and against 2) the 3-layer research concept are summarised in order to show how research questions are addressed in the Ph.D. dissertation. In addition, research questions are contrasted with the specific solutions of the Ph.D. dissertation, which are provided throughout the dissertation for answering research questions.

RQ1: WHICH MISALIGNMENT SYMPTOMS CAN BE DETECTED VIA ENTERPRISE ARCHITECTURE ASSESSMENT?

CORRESPONDING CONCEPTS:
3.4.2 Means of Symptom Analysis

CORRESPONDING RESEARCH LAYER:
3.5.1.1 Misalignment Layer

SOLUTION PROVIDED:
The proposed framework consisted of an assessment tool (Section 3.5.2, *Table 27*) for architecture-scope misalignment symptoms. Architecture-scope misalignment symptoms were further examined in Section 3.5.2 for providing EA-based queries.

RQ2: WHICH DIMENSIONS AND DOMAINS ARE NEEDED TO EXAMINE IN AN EA MODEL TO DETECT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:
3.4.1 Review of Business and IT Areas
3.4.3 Overview of Organisational Models

CORRESPONDING RESEARCH LAYER:
3.5.1.1 Misalignment Layer

SOLUTION PROVIDED:
The proposed framework consisted of an assessment tool (Section 3.5.2, *Table 28*) for EA models and specific model elements to be investigated for misalignment symptom detection.

RQ3: HOW DO EA MODELS MANIFEST DIFFERENT MISALIGNMENT SYMPTOMS?

CORRESPONDING CONCEPTS:
3.4.3 Overview of Organisational Models
3.4.5 Directions for Implementation

CORRESPONDING RESEARCH LAYER:
3.5.1.2 EA Model Layer

SOLUTION PROVIDED:
Listing specific model elements and pattern queries in Section 3.5.2, *Table 28* provided tracking for misalignment symptom manifestation.

RQ4: WITH WHICH METHODS CAN WE EXPLORE THE DIFFERENT MISALIGNMENT SYMPTOMS IN EA MODELS?

CORRESPONDING CONCEPTS:
3.4.2 Means of Symptom Analysis
3.4.4 Means of Model Analysis
3.4.5 Directions for Implementation

CORRESPONDING RESEARCH LAYER:
3.5.1.3 Analysis Layer

SOLUTION PROVIDED:
A concept categorisation was given on competing methods for EA-based misalignment symptom detection in Section 3.4. In addition, the proposed framework in Section 3.5 served as a formal analysis method for the research topic.

Table 5 gives a conclusion on the comparison of expected outcomes and research outcomes, i.e. on how expected outcomes (EO1-EO3) have been addressed by the research outcomes of the Ph.D. dissertation.

Table 5. Expected Results and Research Outcomes

RESEARCH OUTCOME	EXPECTED OUTCOME
A classification scheme was proposed in Section 3.4 1) for EA-based indicators on misalignment and 2) for EA-based misalignment symptom detection methods.	EO1 Classification of different misalignment symptoms: EA indicators on misalignment, EA detection techniques
An EA-based misalignment assessment framework was proposed in Section 3, which is able to reveal the mismatches between the different alignment domains in the underlying EA models.	EO2 A framework which can support EA-based alignment assessment
Results were produced in the form of a case study in Section 4. Case analysis demonstrated the operation, correctness, relevance and accuracy of the framework.	EO3 Case studies on the operation, correctness, relevance, accuracy and results of the framework

3.4 Summary of Research Contributions

The Ph.D. dissertation dealt with the concept of enterprise architecture-based misalignment analysis. It presented a research approach for EA-based misalignment assessment. The main purpose of the proposed research was to analyse strategic misalignment between the business dimension and the information systems dimension. The research addressed misalignment symptom analysis by introducing an enterprise architecture-based framework to detect the typical signs of misalignment in an organisation.

The main contribution of the proposed study lies in connecting typical misalignment symptoms to relevant EA analysis types along traditional alignment perspectives. The specific contributions of the research are: 1) to assess the state of alignment from the perspective of misalignment, 2) to transform misalignment symptoms into formally analysable patterns and statements, 3) to detect the symptoms of misalignment in a structured and formal manner, 4) to perform misalignment assessment by using EA analysis techniques and 5) to provide formal analysis tools for EA model assessment. For general contributions, the construction and operation of the research framework resulted in contributions to the applicability of enterprise architecture management from a business perspective. The proposed framework provided new attitudes, analytical tools and methods to support EA planning and control. In addition, the proposed research framework extended available theoretical frameworks on misalignment symptom analysis.

The significance of the proposed research is the clear and accurate compound of research methods and implementation instruments to approach EA-based misalignment symptom detection. The results of the proposed research will contribute to alignment assessment by expanding the ways of addressing alignment problems. The proposed research framework has the potential to extend our understanding on assessing the state of misalignment in a complex EA model structure.

The novelty of the study lied in: 1) approaching the phenomenon of alignment from misalignment perspective, 2) using a symptom-based approach to detect the state of misalignment in an organisation, 3) using the concept of EAM to perform misalignment symptom detection and 4) applying rule testing and XML validation techniques in EA environment.

With the proposed research framework and the case study, considerable progress has been made with regard to the theoretical construction and practical application of EA-based misalignment assessment. Based on the experience gathered during framework and empirical validation, the proposed research framework has some limitations that were discussed in the Ph.D. dissertation. The proposed research also encounters some challenges and questions in need of further investigation. Topics reserved for further examination include among others: 1) the automatization of EA analysis types and 2) decoupling the framework from built-in EA tool features. Directions for future work are presented in detail in the Ph.D. dissertation.

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Journal Article

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