Design Science Applications for Evolvable Accounting Information Systems

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Abstract. Companies need to report financial information to different stakeholders, using multiple generally accepted accounting principles (GAAP). Their Accounting Information System (AIS) needs to be able to comply with these GAAP. Since GAAP change frequently, the AIS needs to be evolvable. We use Normalized Systems Theory (NST) to adhere to the evolvability criterion. Our contribution to the problem of designing an evolvable AIS that supports multiple GAAP consists of three design processes in which we use a mixed method approach of design science and case studies. First, we identify combinatorial effects (violations of NST) in existing AIS (from case studies). To prevent these combinatorial effects, guidelines are designed in the second process. In the third process we build a prototype that serves as proof-of-concept for the developed guidelines. This study addresses the lack of domain specific guidelines to design an AIS and is the first evolvability study in AIS literature.

Key words: multiple GAAP, Normalized Systems Theory, design science, mixed methods

1 Introduction

Companies need to report financial information to different stakeholders like the regulating and supervisory (government) bodies (for example, filing agencies like the SEC or the IRS), investors/shareholders, customers and suppliers. However, the different regulators use different GAAP (generally accepted accounting principles) that prescribe how companies need to register and process financial facts, which financial information they need to report, how this information needs to be presented and so on [1]. A company might be obliged to simultaneously register and process financial facts in reports using different GAAP.

GAAP are not a static given, they change frequently. Recent events like the credit crisis and corporate fraud scandals have for example, increased the demand for transparency (and an increased quality and relevance) of financial information. Other changes might include more guidance on specific issues that were not addressed before.

To support the registration and processing of financial facts, companies use accounting information systems (AIS). Therefore the system design needs to
support multiple GAAP (subject to change) reporting. However, research shows the difficulty in customizing existing software packages or changing custom-built systems [2]. The Normalized Systems Theory (NST) [3] prescribes principles and design patterns to design an evolvable information system, i.e. a set of anticipated changes can be applied easily. This theory is generally applicable and hence does not formulate specific guidelines for the design of AIS that are able to report in multiple GAAP.

In this dissertation we try to contribute to the solution of the problem of designing an evolvable AIS that supports multiple GAAP reporting in a changing regulatory environment. Compliance with regulation is a primary concern for every company and they prefer to comply in an efficient, but effective way. We elaborate on this problem in Section 2. In Section 3, we elaborate on our used approach: a mixed method approach using design science and case studies. Our contribution to the solution of the problem will consist of three processes.

In the first process, the research question is: which violations of the evolvability criterion (combinatorial effects) are present in existing multiple GAAP AIS? In Section 4, we discuss the existing AIS designs. To adhere to the evolvability criterion, we use the NST, which we describe in Section 5. The result of the first process is a list of combinatorial effects, i.e. violations of the NST principles. We describe these combinatorial effects in Section 6.

The second process addresses the following research question: which guidelines can be used to design an evolvable AIS that supports multiple GAAP reporting? In this process, we design guidelines that prevent the combinatorial effects identified in the first process. These guidelines are the subject of Section 7.

In the third process the research question concerns the development of a prototype that serves as a proof-of-concept for the guidelines of the second process: what do we learn from implementing the guidelines in a proof-of-concept AIS? We discuss the development in Section 8.

In Section 9 we will summarize the most important results and limitations of this dissertation, as well as possibilities for future research.

2 Problem Statement

As shown in the introduction, a number of companies are obliged to report in multiple GAAP. As an example we consider a Belgian insurance company with a parent company in another EU country, listed on a Euronext stock exchange. This company needs to report according to the following GAAP: Belgian GAAP (accounting legislation) for the filing of the statutory annual report at the National Bank of Belgium, the Belgian tax legislation for filing their tax return, International Financial Reporting Standards (IFRS) to report to the parent company (the use of IFRS is mandatory for filing consolidated annual reports of listed companies in the European Union) and Solvency II, imposed by the EU for insurance companies, as from January 1st, 2016.
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Processing and reporting financial information according to multiple GAAP, requires knowledge of the differences between them. GAAP can differ in five different ways [4]:

- **The definition of concepts.** The basic concepts such as the definition of assets, equity, liabilities, income and expenses can differ. But also the definitions used by specific standards can be different. For example, the definition of capital grants. Belgian GAAP considers these as equity. In IFRS they can either be deducted from the asset they relate to or be posted as a liability, where they are periodically transferred to income following the depreciation pace of the asset to which they relate.

- **Recognition criteria:** determine if, when and how an item that answers to the definition, is recorded in the annual report. For example, revenue recognition when the goods are delivered versus when the invoice is drafted.

- **Measurement methods:** determine the amount included in the financial statements, based on a different measurement method or model. For example, derivative financial instruments are measured at historical cost in Belgian GAAP and at fair value in IFRS.

- **Presentation:** there are differences in the way financial statements should be presented regarding terminology, classification, which sections to use and the type of accounts to use. For example, Belgian GAAP imposes a minimum grouping in the chart of accounts, whereas IFRS does not impose a fixed structure.

- **Disclosure:** differences in the additional information to be included in the notes to the financial statements and the format/depth of these disclosures. For example, the requirement in IFRS to disclose the value of the different categories of financial liabilities (at fair value or at amortized cost).

Moreover when reporting in multiple GAAP, two additional issues should be taken into account [4]:

- **Alternatives:** GAAP allow alternative recognition and measurement rules. For example, IFRS allows both the weighted average and the FIFO method for inventory measurement.

- **Lack of requirements or guidance:** when one GAAP alternative does not address an issue that is specifically addressed in another GAAP. For example, IFRS 13 Fair Value Measurement specifies how to perform fair value estimation, whereas in Belgian GAAP such guidelines do not exist.

We have to take all of these possible differences into account when we design AIS that support multiple GAAP. AIS are usually not built/designed with the purpose of supporting multiple GAAP, although compliance with additional GAAP is not a new issue. This results in difficulties when the AIS needs to be changed/maintained when compliance with an additional GAAP is required or when regulation changes within one GAAP [5].
3 Methodology

3.1 Design science

The use of design science is mainly motivated by the perceived lack of professional relevance of IS research [6, 7]. We address this by electing a real-world problem and designing an artifact that solves the problem or improves upon existing solutions. The problem we study is the design of an evolvable AIS that supports multiple GAAP reporting. We solve the problem by identifying combinatorial effects in existing AIS structures first, then design guidelines to prevent the combinatorial effects and thirdly proving their utility in a prototype solution. The existing AIS structures, these guidelines and the prototype are the considered artifacts.

In a design science project, three (main) phases can be distinguished: problem statement, design and evaluation. Different authors like [8, 9, 10, 11], elaborate on one or more of these phases and provide guidance on how to conduct design science research.

In this dissertation we distinguish three consecutive processes of these three phases. In the problem statement phase the problem, the motivation and a justification for the value of the solution is described. The actual artifacts are built in the design phase. These artifacts are evaluated with respect to a set of predefined criteria. We illustrate these processes in Table 1.

<table>
<thead>
<tr>
<th>Design process</th>
<th>Problem statement (PS)</th>
<th>Design</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Multiple GAAP Reporting, propose evolvable solution (see Section 2)</td>
<td>Cases: existing AIS structures (see Section 4)</td>
<td>NST: combinatorial effects (see Section 6)</td>
</tr>
<tr>
<td>2</td>
<td>PS process 1 + CE of process 1</td>
<td>Guidelines (see Section 7)</td>
<td>Relate to cases and literature e.g. NST (see Section 7)</td>
</tr>
<tr>
<td>3</td>
<td>PS process 2 + guidelines of process 2</td>
<td>Prototype proof-of-concept (see Section 8)</td>
<td>Evolvability, using NST (see Section 8)</td>
</tr>
</tbody>
</table>

In this dissertation we use multiple methods, as described in [12]: in some phases of our processes, we use case studies. Therefore, we elaborate on their description and methodological approach in the following Section 3.2.

3.2 Case studies

To gain a deeper insight into the problem of multiple GAAP reporting (a contemporary phenomenon) in practice (its natural setting) we use case studies
and expert interviews [13, 14]. Applying NST is new, so exploratory case studies are appropriate [15, 16]. We choose a collective case study approach and a heterogeneous sample, because we want to be able to generalize our results: we want to identify combinatorial effects that are inherent in multiple GAAP AIS [17, 16]. Hence we include companies from different sectors: an insurance company, a manufacturer in the graphical and medical sector, a pharmaceutical manufacturer and two transportation firms.

The population from which we draw our cases are companies that report in multiple GAAP. We are dependent on the willingness of the companies to participate in our study and we did not make any conscious choices to exclude or include companies from certain sectors. The number of case studies is limited to five, since we need a high level of detail to be able to do the appropriate analysis [18, 19, 16]. This number falls within the range of four to ten cases, which is considered sufficient [20].

We conduct interviews with employees in the financial accounting department and in two cases also key informants from the IT department who are involved in the AIS design. During the interviews notes are taken, which are electronically archived. We mainly use open questions and adapt the questions after each interview. This is customary in exploratory research [20] and enables us to gain a profound insight into the existing design of the AIS of our cases. Since most of our contacts are financial accounting experts, we investigate the functional aspects of the system.

Next to our case studies, we interview two practitioners: someone from SAP Belgium who is responsible for localization (localization concerns country specific pre-configuration of SAP to comply with local regulation) of SAP and someone who works as a business intelligence consultant (for a software company) but permanently works with a client in the banking sector. These interviews help us to gain a deeper insight into the problems of multiple GAAP reporting, which allows us to analyze our case studies more thoroughly.

We analyze gathered data in two steps: within-case analysis and cross-case analysis. After each interview we analyze our notes to identify the structure of the AIS design of the case. Then we theoretically propose changes to the design and evaluate the impact of the change on the existing structure, identifying combinatorial effects. We use a flexible and opportunistic data analysis [13, 21, 20, 14]: when revealing a combinatorial effect in a certain case, we evaluate whether it also exists in previously analyzed cases. This is the first step in our cross-case analysis. Subsequently we structure our findings by comparing analysis and conducting necessary additional analysis. This results in the description of the different structures used to set up multiple GAAP AIS and the combinatorial effects resulting from different changes imposed on these structures. Lastly, we use insights from our expert interviews and online documentation of SAP to review and extend our analysis.
4 The different designs

Before we describe the existing AIS designs from our case studies, we first discuss some general observations from our case studies:

– Companies try to limit the differences between GAAP. For example, using the FIFO measurement method for inventory because it is allowed by both Belgian GAAP and IFRS, whereas LIFO is only allowed by Belgian GAAP.
– Companies choose one GAAP as their primary GAAP according to which they post all daily, operational journal entries and report internally. Two companies choose Belgian GAAP as primary GAAP, the other three choose IFRS. The secondary GAAP used is either IFRS, Belgian GAAP or another European GAAP. Fiscal legislation is not considered as a separate GAAP, rather spreadsheets are used to convert the Belgian GAAP report into a report that complies with fiscal legislation.

To describe designs of AIS that report in multiple GAAP, we base ourselves on our case studies, our expert interviews and the SAP website [22]. An AIS consists of different accounting components: ledgers, accounts, charts of accounts, entry processing modules, journal entries. Together these components form the modular structure we study. We graphically represent this modular structure in Figure 1.

![Fig. 1: modular structure](image)

When a financial fact occurs, it needs to be evaluated to determine how it should be processed according to the used GAAP. The tasks that need to be carried out to process financial facts according to accounting standards, are contained within the entry processing module. More specifically, the entry processing module analyzes a (financial) fact: it determines which definitions of concepts, recognition criteria, measurement methods, presentation requirements and disclosure requirements are applicable according to a certain GAAP. We use the term “entry processing tasks” to denominate these five tasks. The result of the entry processing tasks is a journal entry, consisting of the accounts that increase and/or decrease and the respective amounts.
Journal entries are posted to a ledger. A ledger is the collection of information about the financial facts of a company [22]. The accounts used by the journal entries and collected in the ledger, are hierarchically structured according to a chart of accounts (with an account name and account number). Each chart of accounts has a logical categorization of accounts (for example, assets, equity, liabilities, expenses and income).

In an AIS where the books of multiple juridical separated entities are kept, a company code is used to separate the financial information of the different entities. This implies that financial facts are always registered in a certain company code, where they are processed accounting wise. Therefore, a ledger (the collection of information about financial facts) belongs to one company code. A chart of accounts can be used by ledgers from multiple company codes, an entry processing module too. In SAP consolidation is required to report financial information from multiple company codes together [22].

The modular structure described above is generic when reporting is only required according to one GAAP. To support multiple GAAP, the modular structure needs to be expanded. However this can be done in multiple ways and thus requires making two design choices: the account design and the posting design. In the following sections, we will discuss these design choices and their implementation in our case studies.

4.1 Account designs

Different GAAP can require a different processing of the same financial fact, resulting in different journal entries. Therefore a design choice needs to be made to post the journal entries to separate accounts (within the same or a different ledger, using the same or a different chart of accounts), which we will denominate the account design. We identify three ways to separate accounts: parallel accounts (account design 1), parallel ledgers (account design 2) and separate company codes (account design 3). For the purpose of this paper, we will only discuss the parallel ledgers account design.

![Fig. 2: Account design 2: parallel ledgers](image-url)
The SAP website describes the design of parallel ledgers as follows [22]: every GAAP has a separate ledger and all ledgers use the same chart of accounts. We graphically represent this design in Figure 2: every account occurs once in the chart of accounts and is used by both ledgers. In two of our case studies we find a similar design: they use custom-build software and separate ledgers by the use of separate company codes, otherwise the design is the same as account design 2.

4.2 Posting designs

The second design choice to set up a multiple GAAP AIS, is the posting design. We discuss four different ways to post journal entries. Difference posting (posting design 1) means that all journal entries are posted to the accounts of the primary GAAP and only the difference between the primary and secondary GAAP is posted to the accounts of the secondary GAAP. The use of complete posting (posting design 2) means that separate journal entries are posted to the accounts of the different GAAP, also when the journal entries are identical. For example, depreciation of a machine (acquisition cost €100,000) with a different percentage (linear): 20% in the primary (€20,000 yearly) and 25% in the secondary GAAP (€25,000 yearly). This results in the journal entries in Table 2:

<table>
<thead>
<tr>
<th></th>
<th>For posting design 1</th>
<th></th>
<th>For posting design 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To the primary ledger</td>
<td>To the secondary ledger</td>
<td>To the primary ledger</td>
</tr>
<tr>
<td>3630200</td>
<td>20,000</td>
<td>3630200 5,000</td>
<td>3630200 20,000</td>
</tr>
<tr>
<td>@1241209</td>
<td>20,000</td>
<td>@1241209 5,000</td>
<td>@1241209 20,000</td>
</tr>
</tbody>
</table>

Table 2: Illustration of posting design 1 and 2. Account number 3630200 is used for “Depreciation of non-current fixed assets” and account number 1241209 for “Machines - accumulated depreciation”

In our cases we identified two additional posting designs (3 and 4). Both are a mixture of posting design 1 and 2, so we do not discuss them into detail here.

5 Theoretical Framework: the Normalized Systems Theory

We evaluate the designs described in Section 4 with regard to their evolvability by using the Normalized Systems Theory (NST). NST is originally applied in software design [3, 23], but has shown its relevance in business process design [24] and enterprise architectures [16]. [25] generalizes the theory so it becomes applicable for the design of modular structures. For accounting, we identified the primitives (building blocks) from the modular structure in Figure 1.

We use the NST theorems (separation of concerns, separation of states, version transparency and instance traceability) [3, 26, 25] in this dissertation to
adhere to the evolvability criterion we put forward. A modular structure that adheres to the theorems can change over time (with respect to a set of anticipated changes) without causing combinatorial effects. Combinatorial effects occur when a change to a system has an impact that is not only dependent on the change itself, but is also dependent on the size of the system to which the change is proposed [3, 23]. For example, we consider the modular structure consisting of a multinational company with a considerable number of subsidiaries which each have their own AIS. We assume that all subsidiaries report to the parent using US GAAP. Now the parent wants to change the internal reporting standard from US GAAP to IFRS. The impact of the change is proportional to the number of subsidiaries: every subsidiary need to change their AIS. Since the change is dependent on the size of the modular structure, it causes a combinatorial effect.

In Section 6 we will search for combinatorial effects in the existing designs (described in Section 4) of AIS that support multiple GAAP reporting. These combinatorial effects represent violations of the NST theorems. We use the NST theorems to evaluate our guidelines with regard to evolvability in Section 7. We also relate the guidelines to uncertainty effects from the entropy point of view of the NST. Next to the NST theorems, the guidelines of [24] are also relevant in the accounting domain, since they are generally applicable. Therefore, we relate our guidelines to the ones of [24].

6 The Combinatorial Effects

In this Section we search for combinatorial effects in the designs described in Section 4. We do this by proposing changes to the designs and evaluating their impact on the different designs by illustrating different contexts. If the impact is not only proportional to the change, but also proportional to the size of the system, we report a combinatorial effect. In the contexts we assume that reporting is required in two GAAP, which we will distinguish by referring to them as the primary and the secondary GAAP. We evaluate the impact of the following changes:

1. Creating a new account;
2. New version of an entry processing task for one GAAP (effect on journal entries);
3. New version of an entry processing task for one GAAP (effect on entry processing module);
4. New version of an entry processing task for all GAAP.

For the purpose of this paper, we will only discuss change 2. More precisely we will discuss the impact of new measurement criteria for assets on the journal entries. We use the depreciation of assets example mentioned before in Section 4.2. When we discuss this change, we need to take into account different possible situations. First, the impact is different when the measurement criteria change for the primary GAAP than when they change for the secondary GAAP. Second, there is a difference whether the measurement criteria were the same
in the past for both GAAP or the journal entry between the primary and the secondary GAAP was already different. We label these four possible situations A, B, C and D and represent them in Table 3.

<table>
<thead>
<tr>
<th>Journal entry in the past was:</th>
<th>Of which GAAP do the measurement criteria change?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The same</td>
<td><strong>Primary</strong></td>
</tr>
<tr>
<td>Different</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
</tbody>
</table>

Next to the differences between the previously mentioned situations, the impact of the change is also different, depending on the posting design.

**Context 1: impact on difference posting (posting design 1)** Here we discuss the impact of new asset measurement criteria on difference posting. In situations A and B the criteria before the change are the same for both GAAP: a depreciation percentage of 20%. Whereas in situations C and D the depreciation percentage for the primary GAAP is 20% and 25% for the secondary GAAP. When the depreciation percentage changes to 15%, it has a different impact in the different situations. In situation B and D the change applies to the secondary GAAP and only the entries to the secondary ledger need to be changed. Since the impact of the change does not have an impact that depends on the number of GAAP used (size of the system), the change does not cause a combinatorial effect in situations B and D. In situations A and C the change applies to the primary GAAP, so the entries to the primary GAAP need to be adjusted. But since the entries to the secondary GAAP are dependent on the entries to the primary GAAP (because of the use of difference posting), the entries to the secondary GAAP also need to be adjusted. Hence, in situations A and C the impact of the changing measurement criteria is dependent on the number of GAAP used (if all GAAP post by difference with regard to the primary GAAP). Since the impact of this change is not only dependent on the change itself, but also on the number of GAAP used, the change causes a combinatorial effect in situations A and C. The impact of the change is illustrated in Table 4.

**Context 2: impact on complete posting (posting design 2)** Changing the asset measurement criteria does not cause a combinatorial effect when complete posting (posting design 2) is used. The journal entries to the different ledgers are posted independently: when the measurement criteria change for one GAAP, only the journal entries for that GAAP need to be adjusted. No combinatorial effect arises, since the impact of the change only depends on the change itself and not on the size of the system (number of GAAP used). We illustrate this in Table 5 by the use of the situations (Table 3) and the example also used in context 1.
<table>
<thead>
<tr>
<th>Situation</th>
<th>Posting before the change</th>
<th>Posting after the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3630200 20,000</td>
<td>no entry</td>
</tr>
<tr>
<td></td>
<td>@1241209 20,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3630200 15,000</td>
<td>no entry</td>
</tr>
<tr>
<td></td>
<td>@1241209 15,000</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>3630200 20,000</td>
<td>no entry</td>
</tr>
<tr>
<td></td>
<td>@1241209 20,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3630200 20,000</td>
<td>1241209 5,000</td>
</tr>
<tr>
<td></td>
<td>@1241209 20,000</td>
<td>@3630200 5,000</td>
</tr>
<tr>
<td>C</td>
<td>3630200 20,000</td>
<td>3630200 5,000</td>
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<td>@1241209 20,000</td>
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<td>3630200 20,000</td>
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<td>@1241209 20,000</td>
<td>@1241209 10,000</td>
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<tr>
<td>D</td>
<td>3630200 20,000</td>
<td>3630200 5,000</td>
</tr>
<tr>
<td></td>
<td>@1241209 20,000</td>
<td>@1241209 5,000</td>
</tr>
</tbody>
</table>

Table 4: Impact of changing measurement criteria on posting design 1. Account number 3630200 is used for “Depreciation of non-current fixed assets” and account number 1241209 for “Machines - accumulated depreciation”

<table>
<thead>
<tr>
<th>Situation</th>
<th>Posting before the change</th>
<th>Posting after the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3630200 20,000</td>
<td>3630200 20,000</td>
</tr>
<tr>
<td></td>
<td>@1241209 20,000</td>
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<tr>
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<td>3630200 15,000</td>
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<td></td>
<td>@1241209 15,000</td>
<td>@1241209 20,000</td>
</tr>
<tr>
<td>B</td>
<td>3630200 20,000</td>
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<td>3630200 20,000</td>
<td>3630200 25,000</td>
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<td>@1241209 20,000</td>
<td>@1241209 25,000</td>
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<tr>
<td>D</td>
<td>3630200 20,000</td>
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<td></td>
<td>@1241209 20,000</td>
<td>@1241209 5,000</td>
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</table>

Table 5: Impact of changing measurement criteria on posting design 2. Account number 3630200 is used for “Depreciation of non-current fixed assets” and account number 1241209 for “Machines - accumulated depreciation”

7 The Guidelines

In Section 6 the combinatorial effects in the designs of Section 4 are described. This allows us to compare designs, to see which designs cause combinatorial effects and how they manifest themselves. After this analysis, we formulate generally applicable design guidelines that prevent the combinatorial effects. When a new guidelines is introduced, we first reevaluate previous guidelines to see whether they do not conflict with the new guideline or whether they need to be defined more strictly. This iterative method of design allows us to adjust and/or refine guidelines as we gain more insight into the problem of reporting in multiple GAAP. Subsequently, we relate the guidelines to our findings from the case studies and NST literature.

We derive the following guidelines:

1. Journal entries for different GAAP should be posted in separate ledgers.
2. All GAAP should use the same chart of accounts.
3. Journal entries to different GAAP should be posted independently of each other.
4. Every fact that can cause an accounting impact should be processed by at least five separate tasks (versions of the entry processing tasks: concepts, recognition criteria, measurement methods, presentation, disclosure) before a journal entry can be posted.
5. Every entry processing task that has a separate change driver should be separated in a distinct task, independent of the GAAP.

We illustrate the design process by discussing the third guideline. When measurement criteria change, the posting design has an influence on the occurrence of combinatorial effects. Difference posting (posting design 1) causes a combinatorial effect in situations A en C (Table 3), which is not the case when complete posting (posting design 2) is used. The difference is that in posting design 2, regardless of the nature or size of the differences or similarities between the GAAP, the journal entries are posted independently for the different GAAP. Because posting designs 3 and 4 are mixtures of posting design 1 en 2, they cause a combinatorial effect in certain situations. It becomes clear that combinatorial effects resulting from changing entry processing tasks can only be avoided by using complete postings. Hence we deduct the following guideline:

**Third guideline:** journal entries to different GAAP should be posted independently of each other.

This guideline is not applied in any of our case studies, they do use the mixed designs (posting designs 3 and 4). This indicates that in the current designs, they prefer to use complete postings in certain situations. In the insurance company, posting design 3 is used for journal entries regarding financial instruments, since the differences for the GAAP are large. The use of posting design 4 in one of our case studies, also implies that when the differences in measurement of for example fixed assets are large, it is preferred to use independent posting for that category of financial facts.

This guideline is an application of the first NST theorem “separation of concerns”. Journal entries to the ledgers of the different GAAP are based on another GAAP that can change independently, this implies that they have different change drivers. “Separation of concerns” requires separating change drivers, hence posting journal entries independently is an application of the theorem.

8 Prototype

The third design process has not yet been conducted. It will concern building a prototype of an AIS that supports multiple GAAP reporting. The problem statement of the third process consists of the multiple GAAP reporting, the evolvability criterion, the combinatorial effects from the first process and the guidelines from the second process. In the design phase the prototype is developed, which serves as a proof-of-concept for the guidelines of the second process. We evaluate the prototype by using NST.
The purpose of building this prototype is threefold. We use the guidelines of the second process to design the prototype. In this way we can first evaluate whether the guidelines provide enough guidance or whether they need more detailed specification. This also shows the guidelines’ limitations regarding scope. Then we have the possibility to provide additional guidelines to extend the scope.

Secondly, we want to evaluate whether following the guidelines results in an AIS design that is more evolvable. To do this we propose a set of (anticipated) changes that we apply to the prototype. This list is based on the theoretical changes of the first process that we use to derive the combinatorial effects. After implementing these changes, we evaluate for each change whether it causes (a) combinatorial effect(s) or whether following the guidelines prevented the occurrence of combinatorial effects. In this way we add a proof-of-concept on top of the theoretical proof for our guidelines (described in Section 7). Moreover, this way of working might reveal additional issues and/or combinatorial effects.

Thirdly the prototype is developed iteratively. If we find possible ways to improve the guidelines or additional combinatorial effects, we adjust or extend our guidelines and integrate the solution in the prototype. In this way, the final prototype will be evolvable (anticipated changes can be applied without causing combinatorial effects), although its scope might be limited.

9 Conclusion

9.1 Discussion/conclusion

In literature there is a lack of specific guidelines for registering and processing financial facts in an AIS that can report in multiple GAAP. In this study we provide a first start to solving this problem by the use of design science and case studies. We conduct three design processes. The first process consists of an evaluation of existing AIS from case studies regarding evolvability, using NST. The result is the identification of combinatorial effects (violations of evolvability). In the second process, we propose five guidelines to prevent the combinatorial effects from the first process. We relate these guidelines to existing case studies and NST literature. The five guidelines for the design of evolvable AIS that support multiple GAAP reporting are mentioned in Section 7. The third process consists of the design of a prototype that provides a proof-of-concept for the guidelines proposed in the second process.

This study is the first study that evaluates AIS with respect to its evolvability. In the past, NST has already shown its relevance to the design of software [3], business processes [24] and enterprise architectures [16], but in this study NST is applied in a specific economic domain for the first time. We contribute to NST literature by showing its relevance to the design of multiple GAAP AIS.

9.2 Limitations

We need to conclude that although the guidelines provide a first guidance to the design of evolvable AIS, they are not sufficient to prevent all possible combina-
torial effects in those AIS. Firstly, the list of combinatorial effects in Section 6 is not exhaustive. Secondly, our evaluation up until now is merely theoretical, by building the prototype we will provide practical evidence.

9.3 Further research

This study can be elaborated by conducting more (detailed) case studies: additional revealed combinatorial effects can be used to propose additional guidelines. Further research can also focus on other AIS design issues like XBRL reporting or cash flow calculation using the direct method. Next, there are research opportunities in other business domains like logistics, production. Moreover, additional research efforts will be made to develop additional general principles at the business (like [24]) and the enterprise level (like [16, 25]).

Disclaimer and Acknowledgments

Process one and two are (partly) published in conference proceedings [27, 28]. I thank Prof. Dr. W. Aerts (my promotor), Prof. Dr. J. Verelst, Dr. P. Huysmans and Dr. P. De Bruyn for their guidance and contribution to my work.

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