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A Classification of Modification Categories for Business Rules

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Abstract

Business rules play a critical role in an organization's daily activities. With the increased use of business rules (solutions) the interest in modelling guidelines that address the manageability of business rules has increased as well. However, current research on modelling guidelines is mainly based on a theoretical view of modifications that can occur to a business rule set. Research on actual modifications that occur in practice is limited. The goal of this study is to identify modifications that can occur to a business rule set and underlying business rules. To accomplish this goal we conducted a grounded theory study on 229 rules set, as applied from March 2006 till June 2014, by the National Health Service. In total 3495 modifications have been analysed from which we defined eleven modification categories that can occur to a business rule set. The classification provides a framework for the analysis and design of business rules management architectures.

Keywords: Business Rules Management, Business Rules Modifications, Business Rule Architectures, Change Management.

1 Introduction

Laws, regulation, protocols, standards, are each example of rules that organizations are forced to act in accordance with (Shao and Pound 1999; Bajec and Krisper 2005; Tarantino, 2008). Each of the previous mentioned form of rules is applied to guide/constrain entities, such as individuals, teams and organizations to act in accordance with internal or external provided criteria. Take, for example, a general practice. From a regulatory and legislative point of view, business rules are used to restrict access to patient information, force general practitioners to be more transparent in their decision- making and constrain the incentive system general practices can apply (Blomgren and Sunden, 2008; King and Green, 2012). In addition to externally provided criteria, organizations themselves also create additional rules, which they want teams and individuals to comply to. For example a general practitioner states rules on how a specific decision must be made.

To prevent individuals and teams in an organization deviating from desired behaviour, laws regulation, protocols and standards are translated to business rules. A business rule is (Morgan 2002): "*a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behaviour of the business.*" In addition to faster changing and increased amounts of laws, regulation, protocols and standards implemented, trends like higher demanding customers and, faster changing customer's demands give rise to an increase in the amount of business rules as well as an increased pace of modifications to these business rules. Thereby increasing the need to decompose and structure business rules to accommodate for expected or unexpected modifications and making it possible to rapidly modify them when necessary.

Scientific research with respect to business rules decomposition and structuring to address modifiability in terms of anomalies such as insertion, updates and deletion is scarce (Vanthienen and Snoeck 1993; Von Halle and Goldberg, 2010; Anonymous et al., 2012). Current research that is conducted mostly applies experimental research methods and applies theoretical modifications that can occur to a business rule set. This paper extends understanding of business rules modification by addressing the type of modifications that can occur to a business rule (set). Dissimilar to previous research we do not approach this from a theoretical point of view, but analyse eight years of actual modifications to a business rule set. Within this scope, the research question addressed is: *"Which modifications can impact a business rule set?"* Answering this question will help practitioners better manage business rules that support analytical activities in business processes.

The remainder of this paper proceeds as follows. The next section provides a context by describing business rules, separation of concerns, and theory on modification that can occur to business rules. The third section describes the data collection and data analysis. Section four presents the analysis and results of the grounded theory study. The final section summarizes the study's core findings, contributions as well as its limitations.

2 Literature

Evolution of information systems is characterized by functional or non-functional modifications that occur to the information system. Modifications are necessary because of changes in 1) the operating environment, 2) the implementation technology, and/or 3) in stakeholder needs. In this work, we adopt the concept of modifiability as defined by Bass et al, (2012): "*The ability to incorporate anomalies to an information system made possible by the minimal number of changes*." An information system cannot be engineered to adept to every possible modification. Qumer and Henderson (2006, p3) state that a system must be able to accommodate *"changes rapidly, following the shortest time span, using economical, simple and quality instruments in a dynamic environment and applying updated prior knowledge and experience to learn from the internal and external environment*." From a technical and economic perspective it is impossible to build a system that can cope with every modification possible.

To increase the number of modifications an information system can cope with, multiple design principles have been proposed and validated. One important principle in information systems and computer sciences which enables organizations to manage change is separation of concerns (Versendaal, 1991, Van der Aalst, 1996, Weske, 2007). The advantages of applying the separation of concerns principle are simplified development and simplified maintenance. Development and maintenance are simplified because concerns are separated and therefore can be modified independently of each other without having to know the other concern's details. Although several variants of separation of concerns have been proposed, various authors agree on a general evolution of information technology architecture which is depicted in Figure 1. This general evolution follows the decoupling of operating systems from applications, database from applications, the user interface from the application and in the 90's the workflow from the application. With each of the concerns separated, research streams started to focus on modifications within the individual concerns answering questions like: *"which modifications can occur to a database?"*, *"how to cope with change to databases?*", *"which modifications can occur to user interface?"*, and *"which modifications can occur to workflows?*" In the workflow (Business Process Management) community this research has led to the classification of different type of business processes, e.g. workflow processes, adaptive case management and, straight through processes. Based on the change behaviour of the process a different design paradigm is applied to design and execute the business process. For example a process which is highly structured applies workflow management while a process which is late-structured applies adaptive case management (Van der Aalst, 1996). This example illustrates that organizations need to make a decision on what set of anticipated modifications should be defined to cope with to be able to utilize a stable product and/or service (Mannaert and Verelst, 2009).

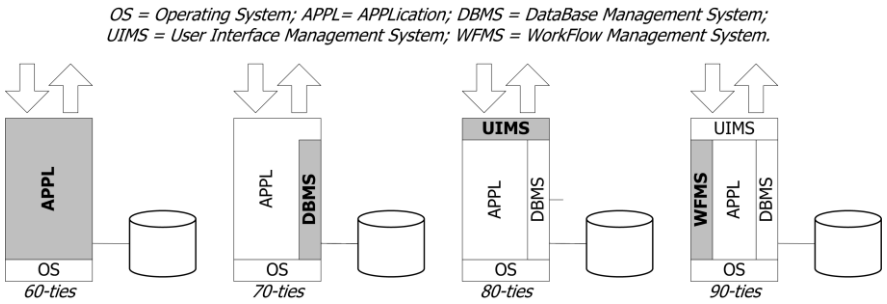

Figure 1: Evolution of Information Technology Architecture (Van der Aalst, 1996)

The next wave of separation followed around the 2000's where research and practice started to propose the separation of business rules from the application and create a separate layer (Chapin et al, 2001; Boyer and Mili, 2011, Graham, 2006). Chapin et al. (2001) states that among the other concerns (application, databases, user interface and workflow) business rule modifications are the most frequent and have the highest impact on software and business processes. Additionally, the authors identified that the other concerns rely extensively on the support of business rules and that modifications to business rules are commonly the most significant in terms of effort required, thereby indicating the need to properly manage modifications to business rules.

Scientific research with respect to business rules modeling guidelines that address manageability in terms of anomalies such as insertion, updates and deletion is scarce (Vanthienen and Snoeck 1993; Zoet et al. 2011). Some research regarding this subject can be identified in the knowledge management community (e.g. Vanthienen and Snoeck 1993), the business rules management community (e.g. Zoet et al, 2011) and the software engineering community (Chapin et al, 2001). Chapin et al. (2001) proposes that modifications to business rules are either 1) Reductive, 2) Corrective, or 3) Enhancive of nature. The first modification archetype, Reductive, comprises reducing the business logic implemented. The second modification archetype, Corrective, comprises refinement and making more specific of implemented business rules. The third modification archetype, Enhancive, comprises changing and adding upon the repertoire of software implemented business rules to enlarge or extend their scope. Although Chapin et al. (2001) proposes a theoretical set of modification archetypes they do not elaborate in detail how they affect business rules and how to manage / design business rules in such a way that one can cope with change. Vanthienen and Snoeck (1993) propose in their study, based on relational theory and database normalization, guidelines to factor knowledge thereby improving maintainability. VanThienen and Snoeck's (1993) research showed that normalization has a positive effect on the average number of business rules affected when anomalies occur. Thus, when anomalies such as updates, inserts and deletes occur, the number of business rules affected in third normal form is less than the number of rules affected in first normal form. However, their research is based on decision tables instead of business rules in general. Building on the work of VanThienen and Snoeck (1993), Zoet et al. (2011) developed a normalization procedure based on representational difference analysis of existing business rules

modelling languages, relational theory and database normalization. The procedure consists of three steps: 1) apply first normalization form, 2) apply second normalization form and 3) apply third normalization form. This research strengthens the conclusions drawn by VanThienen and Snoeck (1993) that normalization has a positive effect on the average number of business rules affected when anomalies occur. A contribution from practice which has the same focus is The Decision Model (Goldberg, 2010). Von Halle and Goldberg's (2010) normalization procedure also is based on the ideas proposed by VanThienen and Snoeck (1993), showing similarities with the solution proposed by Zoet et al. (2011). An important difference between the method proposed by Von Halle and Goldberg (2010) and Zoet et al. (2011) is that the latter supports multiple business rules formalism like decision tables, event condition action languages while Von Halle and Goldborg (2010) focus only on decision tables.

Previous research provides conceptual and theoretical understanding of modifications that can occur to business rules. However, these studies applied controlled experiments based on small case studies and/or theorized modifications that can occur to business rules. Thereby focusing on generalization from construct or theory to collected data and generalization from theory to theory (Lee and Baskerville, 2003). We feel that this represents a notable gap, and we argue that there is a need to generalize from collected data to constructs and theory. Differently stated, collecting modifications which occurred to business rule (sets) and generalize this to a theoretical framework. A research method to generalize from data to constructs and theory is grounded theory (Glaser, 1978), which therefore will be adapted for this research.

3 Data collection and analysis

The goal of this research is to identify and define the most common set of anticipated modifications (Manneart and Verelst, 2009) that impact the design of a business rule set. To accomplish this goal a research approach is needed that can: 1) identify modifications applied to the business rule and 2) identify similarities and dissimilarities between types of modifications. An additional criterion is that the set of anticipated modifications is grounded in practice. Each of these goals are realized when applying grounded theory. The purpose of grounded theory is to (Glaser, 1978): "*explain with the fewest possible concepts, and with the greatest possible scope, as much variation as possible in the behaviour and problem under study*."

Theory states that the first selection of respondents and documentation is based on the phenomenon studied at a group of individuals, organization, information technology, or community that best represents this phenomenon (Glaser, 1978). Our choice for a case was based on theoretical and pragmatic criteria. Our theoretical criterion was: "the case site should deal with business rules, regulation, laws or policies that change frequently." Our pragmatic criterion was: "the case site should have kept different versions of the business rules, regulation, laws or policies." Based on these criteria the British National Health Service (NHS) was selected.

3.1 Data Collection

The NHS is built up from four different health care systems, England, Northern Ireland, Scotland, and Wales. These regions combined provide healthcare services for over 64.1 million UK residents. The NHS employs more than 1.6 million people, which makes it one of the top five workforces in the world in terms of scale. Over one million patients every 36 hours make use of NHS services. A significant part of healthcare management in the UK by the NHS focuses on the management of chronic diseases. In April 2004 the NHS introduced the Quality and Outcomes Framework (QOF) as part of the new General Medical Services (GMS) contract. The QOF is a Pay-for-Performance-scheme covering a range of clinical, organizational, and patient areas in primary care. It is established to reward practices for the provision of high quality care and helps fund further improvements in the delivery of clinical care. The QOF includes the measurement of different domains, however, due to the scope of this study only the clinical and public health domains are considered. The NHS manages the QOF which is a Pay-for-Performance-scheme in that comprises to 25 clinical conditions. For each individual condition they create business rules to select when a clinic must be paid for the treatment of the patient (Gilliam and Siriwardena, 2011).

The business rule sets are updated twice a year to accommodate the introduction of new insights revealed by empirical research and/or changes in law and regulations. At the time of writing, the combination of these domains contain 25 clinical conditions, with a large amount of underlying indicators, which make up for 80 percent of the commonly encountered health issues in primary care (Gilliam and Siriwardena, 2011). Examples of clinical conditions as part of the QOF are: Heart Failure (HF), Diabetes Mellitus (DM), and Chronic Obstructive Pulmonary Disease (COPD).

Of the 25 clinical conditions, 16 have been analysed. The selection of the 16 clinical diseases has been done semi-randomly. First we selected the two clinical conditions with the largest set of business rules: Coronary heart disease and Diabetes Mellitus. After which fourteen additional diseases have been randomly selected: Chronic Obstructive Pulmonary Disease (COPD), Cancer, Asthma, Obesity, Atrial Fibrillation, Chronic Kidney Disease (CKD), Cardiovascular Disease (CVD), Blood Pressure, Contraception, Osteoporosis, Peripheral Arterial Disease (PAD), Cervical Screening, Cytology, and Dementia. For each disease the different versions of the business rules have been collected. At the time of writing the QOF is at version 29. However, version 1 till 8 and 20 cannot be retrieved, not even by the NHS itself. Therefore our analysis included versions 9 till 19 and 21 till 29. In total, the data collected comprises 229 versions (documents) of clinical conditions, from which the publication ranges from March 2006 until June 2014. In total, 16 out of 25 clinical conditions have been fully coded.

3.2 Data Analysis

The goal of the first phase of coding (open coding) was to establish a coding scheme. To develop the coding scheme, first, each individual researcher read and coded two consecutive versions of a randomly selected clinical condition. In open coding the unit

of analysis are business rule sets and individual business rules (Boyatizs, 1998). For examples of open coding in our study see Table 1. After both researchers finished, the coded parts were discussed and compared to understand the process and agree on the elements that had to be coded. The result of this first cycle was a coding scheme. The goal of the second cycle of coding was to refine the coding scheme. Therefore two researchers, one researcher from the first cycle and one new researcher, coded multiple consecutive versions of multiple clinical conditions. The clinical conditions were randomly selected from the pool of clinical conditions. After both researchers finished, the coded parts were discussed among the three researchers, including the researchers from the first round. In these sessions coding was compared to understand the process and agree on the elements that had to be coded. The result of this second cycle was an improved coding scheme. The goal of the third cycle was to code the remainder of the 229 versions of clinical conditions and identify the modifications. This cycle was performed by two researchers. The third researcher acted as reliability coder which randomly selected modifications and compared his coding to those of the other two researchers. An extract of the coding scheme is shown in first row of Figure 2. Open coding resulted in 3495 references classified to eleven modification categories: A) create decision, B) delete decision, C) update decision, D) create business rule, E) delete business rule, F) create condition, G) delete condition, H) update condition, I) create fact value, J) delete fact value, and K) update fact value. An overview of all modifications per modification category is provided in Figure 2.

Table 1: Examples of open coding: clinical condition COPD (Health and Social Care Information Centre, 2007)

Text Fragments Version A	Text Fragments Version B	Open Coding
Clinical indicator COPD8	Clinical indicator COPD13	**Update decision**
If COPDSPIR_DAT >= (COPD_DAT – 3 months) AND If COPDSPIR_DAT <= (COPD_DAT + 12 months)	If COPDSPIR_DAT >= (COPD_DAT – 3 months)	**Delete business rule**
Read codes v2: (8I2M., 8I3b., 8I6L.) **SNOMED-CT:** (415571003, 415572005, 415570002) **CTV3:** (XaJz4, XaK27, XaK2A)	**Read codes v2:** (8I2M., 8I3b., 8I6L., 8I6d.) **SNOMED-CT:** (415571003, 415572005, 415570002, 279261000000103) **CTV3:** (XaJz4, XaK27, XaK2A, XaMh9)	**Create fact value**

The second phase of coding is axial coding. To support this process Glasser (1978) formulated 18 coding families. Glaser (1992) stresses that researchers should not blindly apply each individual coding family to data at hand. The application for a specific coding family must emerge first from the research question and secondly from the data. The purpose of applying coding families in our research was to determine mutual exclusivity between and completeness of the modifications that can be applied to business rules (sets). To test for mutual exclusivity and completeness we therefore applied coding families that searched for end stages, clusters, conceptual ordering, conformity, and structural ordering: the ordering and elaboration family and means-goal family (Glaser, 1978). Applying the mentioned coding families served as a basis for the business rule modifiability framework, which is depicted in Table 2.

	A - Create decision	B - Delete decision	C - Update decision	D - Create business rule	E - Delete business rule	F - Create condition	G - Delete condition	H - Update condition	I - Create fact value	J - Delete fact value	K - Update fact value
Version 9				1		1	3		72	49	13
Version 10									15	12	10
Version 11									21	40	12
Version 12			8	3		2			9	8	14
Version 13									3		10
Version 14	12	4	1	7	4	2		9	16	4	10
Version 15									13	150	10
Version 16							157		39	310	10
Version 17									2		12
Version 18									19		10
Version 19	16	20	9	26	64	81		5	4	7	11
Version 21			1	4					106	16	12
Version 22	4	2	7	25	86	83	12	2	59	28	20
Version 23				1					99	12	12
Version 24									107	2	12
Version 25	33	32	52	19	28	10	21	18	29	33	93
Version 26				4					77	4	25
Version 27				8					113	7	44
Version 28	2	16	10	13	70	27	2	534	30	15	26
Version 29								8	16		14
Total	67	74	88	111	252	206	195	576	849	697	380
Grand total	3495										

Figure 2: Amount of modifications per modification category

Furthermore, it is interesting to report on what caused the large amount of modifications for some versions of the business rule sets. For example, we know that the large amount of modifications concerning the modification type Delete fact value in version 16 are caused by the phase out of a medical information system containing those fact values. However, it is beyond the scope of this study to fully elaborate on these causes. More research on the causes of the large amount of modifications for some versions can be found in the work of Gilliam and Siriwardena (2011).

4 Results

In this section the identified modification categories are presented elaborated upon. To ground the modification categories, our research includes an example of a business rule set within the context of the QOF which is provided in Figure 3 and Figure 4.

Table 2: Business rules modification framework

	Decision	Business Rule	Condition	Fact value
Create	CD	CBR	CC	CFV
Update	UD		UC	UFV
Delete	DD	DBR	DC	DFV

A. The first modification is identified as: "*create decision."* This modification adds an additional decision or sub-decision to the already existing set of business rules. This includes all underlying variables such as new business rules and new fact values. This particular modification category is observed 67 times out of 3495 observations.
B. The second modification is identified as "*delete decision.*" This modification deletes a decision that, for example became obsolete. This includes all underlying variables such as new business rules and new fact values. This particular modification category is observed 74 times out of 3495 observations.
C. The third modification is identified as "*Update decision.*" This modification solely updates the name (label) of a specific concept without changing underlying logic. An example regarding the QOF is a decision currently labelled as: *Amount of achievement points obtained*, which is modified into: *Amount of achievement percentage obtained*. This particular modification category is observed 88 times out of 3495 observations.
D. The fourth modification is identified as "*create business rule.*" This modification creates a new business rule within the business rule set of a given decision, including one or more conditions and one conclusion. This particular modification category is observed 111 times out of 3495 observations.
E. The fifth modification is identified as "*delete business rule.*" This modification deletes an existing business rule within the business rule set of a given decision, including one or more conditions and one conclusion. This particular modification category is observed 252 times out of 3495 observations.
F. The sixth modification is identified as "*create condition.*" This modification creates a new condition to be used by existing or new conclusions. An example regarding the QOF is the addition of a ratio to calculate the conclusion *final points achieved*. The condition *relative achievement ratio* is added in the calculation to balance inequalities of register list sizes of general practices. This particular modification category is observed 206 times out of 3495 observations.
G. The seventh modification is identified as "*delete condition.*" This modification deletes an existing condition from a given ruleset. An example regarding the QOF is the deletion of the condition *higher threshold*. In the new situation, GP's will or will not achieve the minimum threshold and will not be able to attain bonus achievement over a

certain achievement percentage anymore. This particular modification category is observed 195 times out of 3495 observations.

H. The eight modification is identified as "*Update condition.*" This modification solely updates the name (label) of a condition. An example regarding the QOF is a condition currently labelled as: *REF_DAT*, which is modified into: *ACHIEVEMENT DAT*. This particular modification category is observed 576 times out of 3495 observations.

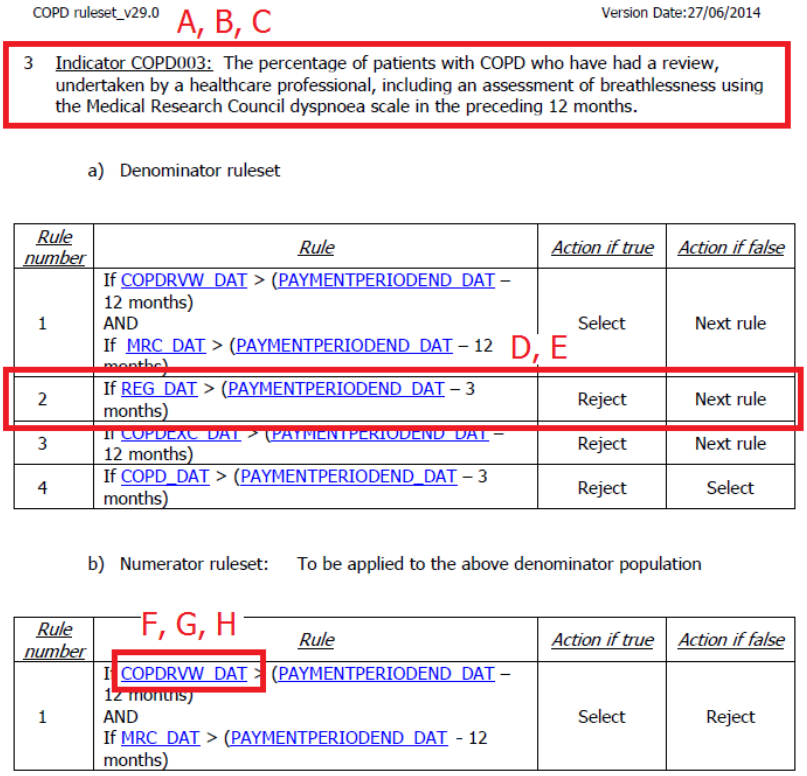

Figure 3: Example business rule document of the QOF 1/2 (Health and Social Care Information Centre, 2014)

I. The ninth modification is identified as "*create fact value.*" This modification creates a new fact value for its parent condition or conclusion. An example regarding the QOF is the addition of a fact value under a new condition labelled as *maximum raw points achieved*. The fact value added operates as an upper threshold and is set to *550*. This particular modification category is observed 849 times out of 3495 observations.

J. The tenth modification is identified as "*delete fact value.*" This modification deletes an existing fact value from its parent condition or conclusion. An example regarding the QOF is deleting a fact value from the conclusion *patient registration status*. From the four available conclusions this ruleset can generate, the fact value *previously registered* is deleted, leaving the possibility to generate three conclusions. This particular modification category is observed 697 times out of 3495 observations.

K. The eleventh modification is identified as "*Update fact value.*" A fact value is a possible value or fixed value of its parent condition. An example regarding the QOF is renaming the fact values of the condition *Upper threshold* from 70 achievement

percentage to 80 achievement percentage. This particular modification category is observed 380 times out of 3495 observations.

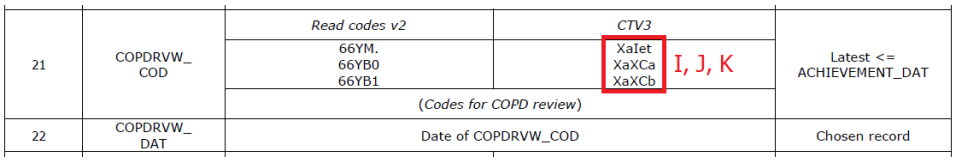

Figure 4: Example business rule document of the QOF 2/2 (Health and Social Care Information Centre, 2014)

The eleven identified modifications have a hierarchical structure. In this structure the highest level of is a decision followed by business rules, conditions and fact values. The existence of a hierarchy indicates a cause and effect relationship between the different elements. For example, when a new decision is created the possibility exist that also new business rules, conditions and fact values must be created. The data shows this is not always the case since underlying hierarchical elements are reused. Due to size constraints we decided to omit a full overview of this phenomenon.

5 Conclusion & discussion

Business rules are widely applied, standalone and embedded in smart objects. Therefore they have become a separate concern in information system design. As a result they also have to be managed separately. From a technical and economic perspective it is impossible to build an information system that can cope with every modification possible. Therefore a choice has to be made which defined set of anticipated modifications the system must be stable to cope with (Mannaert and Verelst, 2009). The purpose of this research is to define the set of anticipated modifications a business rule set must be able to cope with. To be able to this we addressed the following research question: "*Which modifications can impact a business rule set.*" In order to answer this question, we conducted a grounded theory study on modifications occurring in the business rules applied for payment to primary care organizations in the United Kingdom by the NHS, the QOF payment schemes. In total we analysed 3495 modifications that occurred during the last eight years resulting in a set of modification types that can occur to business rules (sets).

From the data, we identified eleven types of modifications: A) create decision, B) delete decision, C) update decision, D) create business rule, E) delete business rule, F) create condition, G) delete condition, H) update condition, I) create fact value, J), delete fact value, and K) update fact value. From a research perspective, our study provides a generalization from collected data to constructs and theory (Lee and Baskerville, 2003). Thereby it provides a fundament for further research which can focus on building business rule architectures that can optimally cope with the identified modifications. From a practical perspective, our study provides an overview of the modifications that can occur to business rules which can help organizations to construct test scenarios that help information systems to cope with future modifications.

Several limitations may affect our results. The first limitation is the related to sample size. While the sample size of business rules modifications (3495) is representative, the

modification types are all derived from one organization, which may limit generalization. The second limitation is related to the first, our sampling strategy. Our research was applied to business rule sets from the medical industry. And while the medical industry is known for the relatively high amount of utilization of business rules, several other industries are interesting to include as well; for example the financial or governmental industries. The omission of modifications to business rules from other industries may also limit generalization. Adding business rule sets from other industries will be a part of further research.

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