MASTER'S THESIS

Providing traceability in business rules to customers of a commercial organisation

Making business rules used in a commercial organisation traceable by applying a reference architecture for traceability

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Abstract

This research examines in which way business rules used by commercial organisations, can be made traceable by using a proposed reference architecture for traceability, called RA4T. Traceability of such rules and effects on the customers of these organisations is beneficial to provide more transparency to customers. The resulting system has functionalities to explain to these customers how and why conclusions are made. Controlled Natural Language (CNL) is used in this architecture to define and clarify business rules. A CNL is used because it is a controlled and standardised language for business rules; which makes it generic to apply to all sorts of companies. Semantics of Vocabulary and Business Rules (SBVR) is chosen to use as CNL, because of the commercial context: SBVR is especially in place in commercial organisations. In this research, the business context of, and applied rules within, EU-Rent is used to build a case study. EU-Rent is used as an example of an organisation, because it is fictional and multiple studies are based on this organisation – therefore a large variety of sources is accessible. Multiple scenarios are written out to examine in which way RA4T is applicable to a commercial organisation.

Key terms

Business rules, commercial organisations, Controlled Natural Language, transparency

Summary

This research focuses on business rule traceability for customers of a commercial organisation. The goal of this research is to determine in which way RA4T is fitted to develop such a system, so that the customer can see where conclusions come from, based on documents and source texts in the system. An organisation as such is best defined as an organisation that needs profit in money to exist, and therefore customers need to be bound by these organisations. Traceability of the conclusions drawn by the automated system is a way to keep or boost that bonding and let customers return to the organisation and give customers clarification about why a decision is made.

In this research, three scenarios – all within the company EU-Rent – are examined to provide insights on how, when, and how well the proposed reference architecture can be used. EU-Rent is chosen as the company to conduct research on because it has numerous sources of explained business rules. Because it is a fictitious, commercial organisation, no trade secrets can be exposed (by accident) in this research. The provided business rules are written in Semantics of Vocabulary and Business Rules (SBVR), accompanied by the vocabulary of the company and further explanations of the business rules and the context of the business rules. These sources are all useful to provide insights into which way EU-Rent operates and makes decisions, based on the business rules within the organisation.

The provided information is translated from the language of SBVR to a so-called OWL: Web Ontology Language. OWL is used to provide a structured language for explaining and visualising the constraints and relationships between entities in the SBVR language. This structured language is uploaded to Protégé, a tool that makes these constraints visual and structured even more. This helps to determine the different entities within a complex environment of business logic, business rules, and vocabulary. An example: a specific car is placed in a car group. To determine in which car group a specific car is placed, specifics or conditions are beheld, such as the capacity of passengers or luggage. Cars that have these specifics are merged into a car group. In the preceding example, some constraints are given on which basis a car is assigned to a car group. However, the basis on which a car group itself is determined is part of the business. The choice to enclose different conditions for a specific car group is a decision a company can make itself; this is not given in by any regulations. Therefore, these decisions are business rules without any regulations as basis.

Three scenarios are described, all by the same method. There is a desk clerk who has three different occasions with its customers. All three scenarios give a negative outcome for the customer and in the scenarios, the desk clerk can explain why the business rules did not rule in their favour. This is the user interface of the reference architecture for traceability (RA4T), which is the latest step in the architecture, but at the same time the first step in the explanation for end users – in this case both the desk clerk and the customer.

As the reference architecture further describes, there should be a traceback to the logic, on which basis the rule was triggered. In all three scenarios, there is a logical explanation of why the rule gave the outcome. This logic comes from any specific Controlled Natural Language (CNL); this is provided in the three scenarios as well. The CNL is the vocabulary on which basis a – for example – car group is determined. These steps are all provided in the scenarios; therefore the reference architecture fits well in the purpose of providing traceability to the end users. Although the last step – where the Documents for CNL come in place – in the reference architecture is not fully provided, because there is a reason not all documentation is provided by the organisation. In this way, a commercial organisation differs from non-commercial organisations. Companies have an existence because they have a unique selling point. These unique selling points – or actually trade secrets – may be kept a secret from the customers; there is no regulation that obliges a business to give away its trade secrets.

Conclusively can be stated that the reference architecture for traceability is applicable to the scenarios and situations of a commercial organisation. However, the full package is not in place: the last step in full traceability is not fully provided. To which extent the latter is inferior, can be a subject for further research.

Although the reference architecture is not completely applicable, most of it is. The main question of this research is how, when, and how well does the reference architecture for traceable business rules apply in a commercial context? This question can be answered in three steps. How the reference architecture is applicable: it is applicable for making it step-by-step traceable for end users why business rules give a specific outcome. The when is answered by the scenarios, there is always some trigger at hand: request a rental car. The outcomes of the scenarios are all different: someone who asks for a specific type of car that cannot be provided, a driving licence is invalid, or the customer is barred. How well the architecture is applied, is explained earlier, and can be said that most of the reference architecture is applicable. The architecture itself is not that rigid and therefore there is no necessity to adjust the reference architecture, one can pick different aspects of the architecture and apply that to their organisation.

The problem this research tries to solve is to make it traceable for customers of a commercial organisation what the origins of conclusions are and how they are made by a system. Because the business rules, on which basis decisions are made, are provided to the end user, the problem can be solved.

Contents

1. Introduction

1.1. Background

When making a decision in a business context, it is mostly based on processes written out in these businesses. For employees, these processes are common sense and logical. However, for customers of that particular organisation, these processes may not be as common as they are for the employees. To improve this gap of information for customers, traceability of the sources can come in hand. How well source documents can be found by customers is researched in this thesis.

1.2. Problem statement

The problem with untraceable business rules is that it is not traceable in which way these rules apply and how they apply to a specific situation. A rule is untraceable when the source documents of the rule itself, and where it is based, is undefined or unknown. These business rules are integrated into an automated system, and sources of these rules should be available for end-users. Therefore, the following problem must be solved:

> Making traceable to customers of a commercial organisation what the origins of conclusions are and how they are made by a system.

This research derives from other studies – such as the study of Berghuis (2022) and Soerokromo (2022) – in this area of interest because the present study is focused on commercial organisations. This means that there is a different motivation for why a commercial organisation should provide traceability, which can be brought down to let customers return to the organisation and acquire their service again. As a customer there is plenty of choice which organisation you choose to acquire services, therefore a commercial organisation does need to build a relationship with the customer. When the customer is rejected because it cannot acquire the wanted goods or services, the customer will leave. More on this is explained in §1.4. In this research, a reference architecture (§1.4) is used to aid developers of systems of business rules as such, to clarify to customers what conclusions are drawn by the business rules and why they are.

1.3. Research objective and question

In this research, the focus lays on the customer of a commercial organisation. This research contributes to the traceability on which basis an end user is shown the outcome. The main research question – within the given context – is:

> How, when, and how well does the reference architecture for traceable business rules apply in a commercial context between customers and front-office employees?

1.4. Motivation/relevance

As an example: imagine planning a vacation abroad and a rental car is necessary for the trip. By planning the trip, you apply online for a car. While filling in the necessary information, your companion does the same – to compare if there is a difference between car groups that are provided. The conclusion is that the companion gets a different group of cars than you. You, as a customer, want to know why you get a specific range of cars, and why your companion is shown a different group. Perhaps it is because your companion uses five passengers; you planned on four passengers. This research provides answers to the question of why a customer is shown that specific car group.

No end-user wants to be misinformed – or even rejected – due to a business rule that is ambiguous or misleading. In the previous scenario, it may be the right output, but an end-user wants to understand why the output is given. Mostly, a business rule cannot be easily read by the end-user, due to programming code in these rules. A commercial organisation provides the basics of a business rule, while a programmer starts coding this rule, mostly translated by a designer or system architect. The business rule is therefore understandable for (some of the employees in) the organisation, while the end-user does not have that insight. But, when you are a customer and use these services provided, you would want to know why you have the result you got. To get insights into the provided rules, traceability to the origin of these rules is accessible. In other words: traceability is a possibility for end users to follow on which grounds rules are based. Tracing means following a trail; in this case following it back to the origin (Stein, 2001).

This research aims to answer the topic of traceability in business rules of commercial organisations to automate decisions, based on data. As applications of business rules can be conclusive and can have a great impact on customers, the basis on which these rules decide must be transparent and clear. In this research, the traceability of business rules is explored. Where a governmental organisation provides services for society, a commercial organisation mostly provides services for a specific target: customers. In exchange for these services, a commission is paid by these customers – that is the profit of a company. To earn profit for the organisation, business rules are applied within the organisation: it defines why an organisation does, what it does.

This research is relevant, due to the impact it may have on customers, who are willing to use the services provided. Furthermore, the impact on a company can be severe as well: when it is in a business context, business rules must not just be clear and understandable, but competitive as well. The latter is different from other kinds of organisations, such as non-profit organisations. When being a commercial organisation, the impact of a rule not resulting in commercial activities can be strict. That is because the main part of a commercial organisation is to have commercial activities: it is the core business. Therefore, business rules need to be specified and carried out carefully. A business rule needs to be competitive compared to competitors; a business rule needs to exclude the risk for an organisation as much as possible, but in the meantime, it needs to draw in customers to continue the commercial activities. Besides the commercial part of an organisation as such, binding customer to the organisation is vital: a customer is amenable to return to a company when it delivered a fair or good service. When customers return to you, they would not search for another. This is especially important because customers know that a commercial organisation does have a conflict of interest, for the reason of making a profit.

Within the broad field of rule-based business information system development, this research focusses on traceability of business rules. In this area of interest, traceability means that the conclusion from a business rule has to be linked to the (part of a) policy document where the rules are defined. It continues specifically on the work of Rutledge and Italiaander (2021), as well as on other studies more based on the principle of business rules management. The study of Rutledge and Italiaander (2021) describes RA4T in multiple scenarios and how the architecture is established. Other studies are more focused on the practical side of implementing and tracing business rules. As an example, Graham (2007) provides a so-called 'pattern language'. In the mentioned study, a guide on how to add this language to your business rules is provided. Both the study of Graham (2007) and Zoet (2014) call this field of interest business rules management (BRM). As a starting point, the study of Rutledge and Italiaander (2021) will be used.

1.5. Main lines of approach

This research consists of five chapters. The first chapter clarifies the background of the research and the research objectives. In the second chapter, the theoretical framework is elaborated and relevant literature is analysed. The third chapter analyses and describes the methodologies that are used. Both theories and methodologies are applied in chapter four; the case study of EU-Rent, where three scenarios are used to test the proposed reference architecture for traceability, is used to apply. EU-Rent is further explained in §3.2. With these scenarios, a real-life, and relatable situation of customers of the EU-Rent company is staged. One scenario is describing a rental with a different pick-up and return point. Another scenario describes a young driver and the last scenario describes differences in pricing for the same car category. These scenarios are chosen because the applied business rules in the scenarios are described in the documentation. Therefore, traceability can be possible. The outcomes of the tests of these scenarios are analysed. Lastly, in chapter five, the analysis is discussed, so that the outcome can give input to an improvement of the reference architecture as well as how well the reference architecture for traceability provides traceability for the customers. The outcomes of this three-stage plan will provide an answer to the earlier mentioned main research question, as well as how the reference architecture for traceability applies to other commercial organisations.

2. Theoretical framework

2.1. Research approach

The basis of this research is the paper of Rutledge and Italiaander (2021): *Towards a reference architecture for Traceability in SBVR-based systems*. In this paper, a reference architecture is established for traceability on rule-based systems. In Figure 1 the reference architecture is visualised. From this starting point, the literature that is used within the paper is examined.

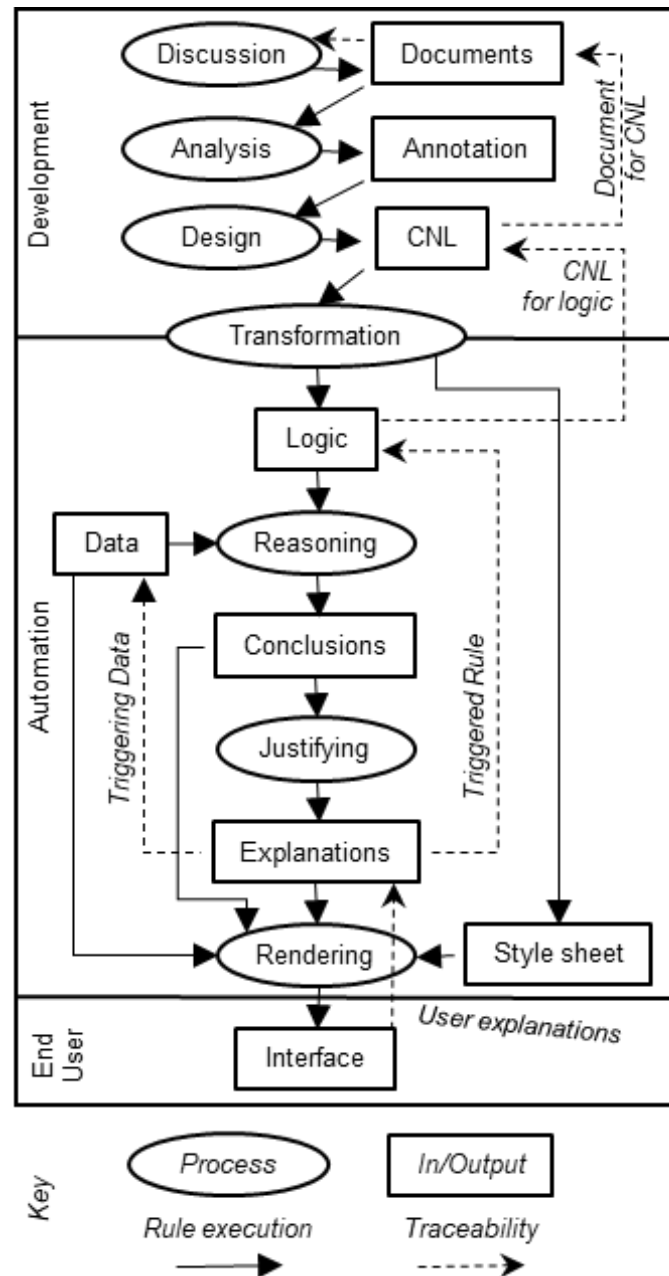*Figure 1: Proposed Reference Architecture for Traceability, by Rutledge and Italiaander (2021)*

The objective of this research is to examine in which way business rules can be more traceable for end-users – in this research the focus is on customers. The proposed reference architecture is used as a guideline for making the business rules in any organisation traceable for specific audiences. For this

research, the focus lies on commercial organisations and why they derive from other organisations. The search for this study focuses both on what a business is and on the business rules that can be used in these types of organisations.

To search for literature on the terms – or fields of interest – as stated before, there are common search strategies useful to conduct this, such as Snowballing and Berry Picking. Snowballing is the theory of starting with one entry – in this case, the paper of Rutledge and Italiaander (2021) – and moving from that one to the sources on which this particular research is based. In this specific case, the aforementioned source is used as an entry for more information about Semantics of Vocabulary and Business Rules (SBVR). This will only be the case when the relevant sources are provided – sources outside the research area shall not be examined (Wohlin, 2014). Berry Picking may also be known as reversed engineering. Mainly, it is the approach of having an endpoint – something which is related to the research – and parsing that particular endpoint into the sources on which that endpoint is based (Bates, 1989). Once again, the reference architecture in the paper of Rutledge and Italiaander (2021) is the starting point – or in the context of berry picking: the endpoint.

This research focuses – besides the reference architecture – on a commercial context, also described as a business (organisation). According to Needle and Burns (2010), a business is an organised entity, with organised activity or effort to produce and provide services and goods. These goods and services benefit the needs of society. In return, the business will be receiving profits from these activities. This means that the business context is as related to this research as traceability is.

Furthermore, businesses are special due to their unique selling point – whatever that may be for a particular organisation. A business can only exist, when there is a need for the services or goods that are provided (Harari, 2014; Needle & Burns, 2010). When managing these needs, business rules – or logic – are applied within these organisations. Due to the last matter, both queries which can be related to traceability and business are applied in the search for relevant literature.

Derived from the research question, and the context above, the key elements of this research are based on the terms: business rules and business rule management (BRM), rule traceability, SBVR, Controlled Natural Language (CNL), and reference architecture. All these terms are common to find in (online) libraries. One of these libraries is the library of the Open Universiteit (OU). Another library that is used often – and as well in this research – is Google Scholar. The terms, as stated above, are the words used in the search. Besides these terms, additional terms may occur in the research and will be examined when necessary. Due to the development of the field of research (Computer science, red.), sources from two decades ago may not be current and relevant anymore. Therefore, the year 2000 and before is mostly excluded from the results. There is an exception: when a source is relevant to point out the history of the field of interest, it can be included.

However, business rules are not 'new'. As business rules are inherently connected to the unique and specific aspects of businesses, business rules have been present from ancient times onwards (Harari, 2014; Zoet, 2014). Although the sorting of the results will be descending – which means that the most recent results will be the first records – a test on older citations is mandatory. This will be established by adding the citation in a separate query and testing that; when an additional, newer citation is provided, that citation will be the leading one.

Besides the year of results, there are other filters applied in the search query. Starting, the language of a result must be in Dutch or English – preferably the latter, because more literature is provided in English. Moreover, the results are sorted by relevance; this is mostly based on the number of cites a source has, this is also important due to the validity of the results.

2.2. Results

2.2.1. Business rules

GUIDE, which is a user group oriented on IBM[1] and their industry, is quoted by Morgan (2002) and states that a business rule is: "a statement that defines or constrains some aspect of the business. It is intended to assert business structure or to control or influence the behaviour of the business" (p.6). In other words: a business rule does not make a business, but it is seen as a building block on which systems within a business can be constructed. Within a business, the rules can be numerous: no business has just one rule on which processes are applied. The individual rules are mostly not that complex, because there is a simple statement involved – and it is logical as well. Logical due to their presence: if this, then case a, else case b. In certain scenarios, case a is not followed by case b. In that case, complex business rules are mostly in place – or at least an 'escape route' is provided. Complex rules are nonetheless not the best practice. As such, complexity in rules is mainly the outcome of complex business processes or a complex environment the rule takes place (Perkins, 2000).

The study of Steinke and Nickolette (2003) states that business rules define how a business is run. A business rule is used to guide behaviour of information through Information Systems (IS) and/or Information Technology (IT). The business context should always be the leading in developing and applying business rules to that same business. In fact, IT is always following the business needs – and therefore the business rules should always be understood by the business. In other words: limitations of IT should never lead to an inconvenience in the business rules and business needs (Ross, 2003).

On the contrary, the study of Knolmayer, Endl, and Pfahrer (2000) states that a process can also be modelled by the use of business rules. In other words: first, there are business rules, then there will be processes. On the one hand, this approach can be beneficial as there is a good scope of work within the processes – no unnecessary steps are taken. On the other hand, this approach risks that cases that are on the edge of the scope may fall behind and may not fit completely into these rules. Moreover, most organisations are not centred around business rules, since many of them have a large history and grew organically (Knolmayer et al., 2000; Lindsay, 2004). The latter ensures that it is difficult for existing organisations to gather all rules that are used in a business, within one overview. Although it can be seen as a different approach of Knolmayer et al. (2000), the basis is still the same: to aid business processes with business rules.

There are requirements on specifics of a business rule. The success factor in this is whether the business understands these rules, or not. The other way around: when a business rule – or the outcome – is not understood by the ones who are using it, it is not a proper rule (Steinke & Nickolette, 2003). One isolated rule can be understood, but a network of rules can be difficult to parse (Morgan, 2002). For understanding business rules, traceability is a vital part of it (Ross, 2003; Steinke & Nickolette, 2003). To summarise: business processes lead to business rules.

2.2.1. Business Rules Management

When a business grows, that organisation shall naturally include more business rules. Therefore, when many business rules are applied in the organisation, BRM comes into place. According to Zoet, Versendaal, Ravesteyn, and Welke (2011), BRM cannot be seen separately from Business Process Management (BPM). As stated in the aforementioned study, BRM should be aligned with the business

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[1] Formally: International Business Machines Corporation

processes within the organisation. Business rules are used to support the business as a whole and should be beneficial to the processes within these organisations.

The paper of Weigand, van den Heuvel, and Hiel (2008) states that most organisations are block-based. That means, that every department, section, or branch of a company has its own way of working and decision-making. Therefore, complete oversight of business rules is usually not common. The study pleads for an approach that manages these rules over the business. To accomplish that, a dynamic, central model is introduced for organisations. Central models can prescribe what the main core is when it comes to services, which are provided in every block of the organisation. In other terms: the centralised processes and business rules are prescribed throughout the business, while the departments can add their business rules and processes onto that central model. The central model is managed centrally, while the other blocks of an organisation can manage their own rules. This diverted model is an example of BRM (Weigand et al., 2008).

The studies of Zoet et al. (2011) and Weigand et al. (2008) seem to be contradictory. Where the latter mostly prescribes a top-down approach, the first study recommends a bottom-up approach. However, when reading both studies more carefully they, in fact, plea for the same thing: to manage business rules on an organisational scale, so that they can be beneficial to the organisation. Specific requirements for separate blocks of the company can be added, both studies agree on.

2.2.2. Traceability of business rules

When there is a large and wide structure in an organisation, it can be unclear on what basis a business rule acts. Furthermore: does a business rule – implemented in a system – do the same thing as a human would do? To accommodate those needs, multiple tools are developed through the years. These tools contain a graphical representation of business rules so that a human being would understand why a certain decision, based on these rules, is made (Armonas & Nemuraite, 2007).

These tools only come into place when previous work is done. This is included in the study of Rutledge and Italiaander (2021), where a reference architecture to develop traceability in business rules, is examined. This reference architecture is based on CNL-based systems: a system that narrows the gap between semantics in business and IT. Simply put: SBVR can create a semantic that can be used both in natural business language, as well in IT systems. As stated before, these tools only come into place when there is a basis on which they can be fed to generate output. Traceability, therefore, is only possible when there is a clear approach to how businesses apply processes to their daily routine. On that basis, business rules can come into place and be automated (Armonas & Nemuraite, 2007).

Although it may seem easy, traceability can be difficult to master when multiple systems are used within the organisation, or even within a process – interoperability it is called. When multiple systems are linked – or even integrated – the traceability can be compromised. Within one system, mostly a trace back to the initial start is possible – however, this may still not be easy to do. But with multiple systems adding additional information, traceability is even harder. When that is the case, a tool for visualising the rules that are applied can become a helpful instrument for clarifying (Armonas & Nemuraite, 2007; Terzi, Cassina, & Panetto, 2006). In this study, the focus is more on making business rules traceable than on visualising, concerning the reference architecture of Rutledge and Italiaander (2021) as a basis (§2.1).

2.2.3. Reference architecture

Reference architecture is used to build the integrated organisation. It spans most parts of an organisation: from the products it sells; to the systems, it uses to accommodate these sales. There is

a wide variety of architectures, but it defines all the aspects of an enterprise – some are, however, more important than others, Bernus and Nemes (1996) stated. A reference architecture captures the core of systems – and the essence of a collection of systems – and is especially used to update or extend the system (Muller, 2008).

Besides the reference architecture from the study of Rutledge and Italiaander (2021), there are more types of reference architecture. The field of research for reference architecture is not a new area of interest – in the nineties of the previous century, this was already acknowledged – as may be seen by the citations previously. Since then, the systems and IT within an organisation extended massively. Therefore, reference architecture – and its approach on how to accommodate this architecture – has changed and developed over the years. At first, reference architecture was developed for computer-based manufacturing. Later on, any sort of enterprise could benefit from it as Williams (1994) stated in his study. In the study, customer services are implemented within the architecture. Due to that matter, the study of Williams (1994) is relevant to this research.

2.2.4. Business rules in a commercial context

The involvement of customers is the main component that differentiates this research from the others within the circle of interest. This research focuses on business rules and how these apply in a commercial context. To be able to explain and understand how business rules function in a commercial context, a fictional case study is introduced. In short, this case study focuses on EU-Rent which is a fictional car rental company within the European Union. This company has branches in multiple countries within the EU and provides car rentals to customers from every origin (Frias, Queralt Calafat, & Olivé Ramon, 2003). The study of Frias et al. (2003) provides the possibility to conduct an in-depth analysis of the business rules applied in this specific organisation. The present research will focus on traceability when business rules are effectuated and applied for a rental period, made by a customer. In this research, multiple scenarios (§3.2) will be examined, based on the descriptions of Frias et al. (2003) of the EU-Rent organisation and the explanations in the paper of Rutledge, Corbijn, Wondaal, and Cuijpers (2022). Frias et al. (2003) have examined and described the EU-Rent organisation as a whole, and the business rules, semantic vocabulary, and source documents in particular – therefore the source is vital for this research. Although Frias et al. (2003) did examine EU-Rent, the study itself is based on KDMAnalytics (2016). In the latter source, the vocabulary, semantics, and rules are written out. The paper of Rutledge et al. (2022) is uniquely useful because that one describes the reference architecture (RA4T, red.) applied to scenarios from EU-Rent customers.

Within the case study of this research, service is a main part of the business strategy. Therefore, a service-oriented architecture is common. The service-oriented architecture provides flexibility to the business itself, its processes, and its IT systems. This is beneficial for that specific type of commercial organisations because dynamics between customers and commercial organisations change over time and therefore the architecture needs to provide this kind of flexibility. However, there is a challenging downside as well: a service-oriented architecture is very difficult to implement and maintain. Organisations built around multiple systems will experience this downside specifically. The services provided by these organisations are processed by their different systems, creating interoperability, making it onerous to implement and maintain as it constructs an extensive architectural framework. This intricate framework does not solely obstruct the implementation but also the maintenance (Arsanjani, Zhang, Ellis, Allam, & Channabasavaiah, 2007).

2.3. Objective of the follow-up research

This research aims for traceability of business rules in a commercial context – the context of customers is therefore relevant. When having an organisation as such, customers should be willing to possess your goods or use your service. This research is beneficiary to this motivation, as it describes an approach to how business rules on particular cases apply. Due to the nature of this research, a case study is the most common (Saunders, Lewis, & Thornhill, 2019). This will be explained in chapter 3.

3. Methodology

3.1. Conceptual design

This study examines multiple business rules within one commercial organisation. Firstly, the relevant literature is studied and the methodology is explained. The second part is to apply the theories and methodology in the case study, based on three scenarios (§3.2). The last part is to analyse and discuss the results. As the customer holds a central part in this research, the view of the external stakeholder is more provided than the internal view. Therefore, business rules related to external users are examined rather than business rules related to an internal user. The latter has, actually, already been done by the study of Frias et al. (2003). Thus, by focusing on the external users, this research becomes distinctive from other, earlier, research, while at the same time, it contributes to the broader circle of academic research within this field.

Furthermore, testing the outcomes of business rules – and how satisfactory these outcomes might be – is part of the research as well. Testing will be done in a case study, in which three scenarios are accommodated. This type of research is also known as illustrative scenarios. Within that method, illustrative scenarios are applied to situations to demonstrate the working of it, which can be in a synthetic situation, as well as in a real-world situation (Peffers, Rothenberger, Tuunanen, & Vaezi, 2012). These fictional scenarios contain fictional customers who apply for services, provided by the organisation of interest. The outcomes of these tests should be traceable within the business rules. Because this research contains one case study, with three different scenarios. Considering the constraints of space and time, three is defendable: one scenario is too narrow for a severe approach and can cause a false positive by luck or accident. Two scenarios can cause a tie; an effect every even number must deal with. The scenarios all differ, but all three are formed from the perspective of the customer. The variety is in the different scenarios themselves where multiple different rules apply.

3.2. Technical design

As stated before, there will be three scenarios included in this research. In this paragraph, the fictitious scenarios will be explained. The reference architecture is implemented in these scenarios. Furthermore, how the research is conducted is explained in this paragraph.

3.2.1. Conduct of the research

The business rules are selected, based on the scenarios that are written out. The source of the original business rules, written in SBVR, is KDMAnalytics (2016). With these in hand, the business rules are translated into OWL2 by a translator (Karpovic, Algirdas, & Nemuraire, 2020), called s2o: SBVR '2' OWL. In Figure 2 the translation schema is provided. With the translation to OWL, the provided OWL can be inserted in different tools for structuring OWL2 in human interpretable designs. In this research, Protégé is used to structure, reason, and explain the business rules as provided by the translation. Traceability to the source documents can be provided with those in place. The outcome of this research is that the source documents are directly linked to the outcome of the rules.
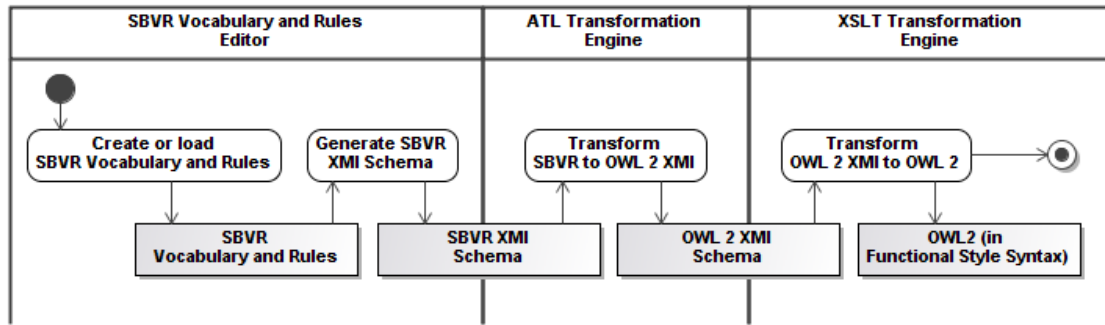
Figure 2: Schema of the s2o translator, derived Karpovic et al. (2020)

3.2.2.　　Scenarios

To give some context beforehand: EU-Rent is a car rental company, operating in the European Union and North America, and is owned by EU-Corporation. It has a total of thousand branches in several countries and multiple cities per country. Cars can be rented in various groups (Group A to F), where Group A is the cheapest group of cars, while Group F is the most expensive group. There is the possibility to return the car to a different branch than the branch where a car is picked up (Frias et al., 2003).

This particular organisation is chosen due to its fictional character of it. It is a non-existing company, but with process data free of use. When it comes to ethical aspects of the research, this organisation provides a severe base for the case study. Furthermore, the rental of a car is something many readers can imagine, which makes the scenarios more realistic, interpretable, and understandable. In these cases, the system is a booking system of the organisation: a computer system used by both desk clerks and customers at home. Although the back end is the same and works mostly on the same business rules, desk clerks have a different user interface and extended possibilities, compared to customers. One of these extended possibilities is that the desk clerk can see the stock of cars in different branches. That is a way to trace why a car rental proposal may be rejected: the stock of cars is inadequate. The latter example can be seen as a form of traceability of business rules; however, it is not the best practice to do so.

The three scenarios – as described hereunder – are all from the perspective of the customer and the interaction with a desk clerk. The scenarios differ from each other in such a way that in these scenarios different rules apply in the specific scenarios. In the scenarios, human interaction between the desk clerk and the customer is in place. This makes that the outcomes from a system are first 'socially' translated – which means that the desk clerk is the final decision maker if the customer may rent a car.

Scenario: Invalid driving licence

The following scenario is at hand:

> A customer wants to rent a Group A car, for two weeks. The customer is above the age of 25, books the car one week in advance via the website, and confirms the booking by credit card. The car will be picked up at London Heathrow Airport (LHR) but will be returned at the airport of Manchester Airport (MAN).

Upon pick up, the car is denied, because the driving licence of the person who is renting the car, is expired. The attendee of the customer has a valid licence, but the car cannot be rented on that driving licence.

Scenario: Lack of capacity

The following scenario is at hand:

> A customer requests an Economy car for four passengers and three large suitcases. The rental will last for two weeks. The customer will pick up the car and return it to the same branch.

Although the offered cars may be large enough, it is not shown to the customer, because the specifications of the wanted cars do not match the requirements. A solution may be to ask for a larger car, or to look for a car with different specifications – although that may match the requirements as well.

Scenario: Speeding tickets

The following scenario is at hand:

> A customer wants to rent a car at EU-Rent, the company the customer has previously used to rent a car. The customer books the car in advance and pays by credit card. At pickup, the rental is denied by the desk clerk, because the customer has three unpaid speeding tickets.

The system does not reject its requests, because there is no rule that the driver is automatically barred. However, the desk clerk can decide otherwise and bar the driver, unless the customer pays their speeding tickets and then pick up the rental car.

The scenarios all differ. In the first scenario, the focus is on a very basic fact: the permission to drive. In that case, the company is bound by the regulations of the country of residence. The second scenario focuses more on the computer-based decisions and the provided information from the manufacturer, while in the third scenario, the focus is on bad experiences with a specific driver, and the decision to bar a driver is based on internal rules. As seen in the three scenarios, the desk clerk is the filter between the customer and the system. This makes it untraceable for the customer itself; the desk clerk needs to explain specifically why a request is denied. When this is the case, a translation error can arise.

3.3.   Data analysis

Due to the created scenarios, a backward approach has been opted for. This means that all provided data leads to the outcome – or a result – of the business rule. Consequently, every step of the business rule is looked at closely and analysed, due to the result it provides. The main question is: "why is the outcome, the outcome?" That question will be answered by the end of this research.

3.4.   Reflection on the methodology

In this paragraph, a reflection on reproducibility and validity is provided; validity covers three themes: internal, external, and construct. Each of these themes will be explained in a sub-paragraph. These subjects are introduced by Yin (2009) as important when it comes to case study research. Furthermore, a reflection on ethical aspects is provided.

3.4.1.   Reproducibility

Reproducibility is the aspect in which way the results of this research can be reproduced. This means when in exact same circumstances, the result should be equal – if not, the research is not reproducible. To accommodate this, the scenarios and all accompanied provided data will be handed over to the research institute. Both of these sets can be used to reproduce this research; by new researchers, or

by open-source collectives. Another way of testing reproducibility is to repeat the research several times. Due to the lack of time, this cannot be achieved.

3.4.2. Internal validity

Construct, internal and external validity is part of this theme. Due to the qualitative aspect of this research, internal validity is essential (Plochg & Van Zwieten, 2007). To achieve great internal validity, the theoretical framework is the basis for the scenarios. Every aspect of the research is based on this theoretical framework and therefore the research is based on academic grounds. To test if the internal validity is severe, multiple times feedback from the supervisor is asked. All with the same question: 'are we still going in the right direction?' (Yin, 2009).

Although this opinion still can be biased, the supervisor is acknowledged in this field of research and therefore the directions of the supervisor are valuable. Furthermore, feedback and statements made by the supervisor will be tested on the theoretical framework.

3.4.3. External validity

If the research is only applicable to this particular case, depends on the external validity. The other way around: this research should be applicable in other branches, on different situations or cases (Yin, 2009). Although this is qualitative research, external validity is still a necessity – especially when it comes to the theoretical framework. Due to the variety of the theoretical framework, external validity is as much as possible arranged. Nonetheless, the results of this research are specified on a commercial organisation. Within the chapter conclusions, a broader aspect of the results is explained; in that particular section, the external validity will be summarised.

3.4.4. Construct validity

When it comes to the research, opinions, and statements can be misinterpreted. To prevent such acts, only factual descriptions will be used. That means that there is never asked for an opinion on any respondent, attendee in the case study, or whomever. The bias of a respondent has to be taken into account, which makes it hard to derive facts from opinions. Moreover, only experts on this topic will be considered valuable sources.

3.4.5. Ethical aspects

For ethical aspects, this research might scrape the edges. It may raise the stigma of 'big brother is watching you', especially in scenario 3. Therefore, all data used in the case study is anonymised. Within the scenarios, there is no perception of sexes, names, or nationality. However, particular situations can be seen as biased or prejudiced. With that in mind, the results of this research will be tested on these particular aspects. Any recommendations will be done on the ethical aspect as well, in the conclusion section.

4. Results

To answer the main question of this research (§1.3), there are three scenarios written out (§3.2). The proposed reference architecture for traceability will be evaluated by these scenarios and how applicable the architecture is for traceability. This research is conducted with the software Protégé.

4.1. Purpose

Based on these scenarios, various business rules within the organisation of the case study will be evaluated. These rules are mainly based on business policies and documentation. Business rules will be derived from the preceding sources and translated into SBVR; further translated into a Semantic Web language: OWL2 is a standardised type of language on which rules and logic can be programmed – and this can be applied on data too (W3C, 2022).

As stated before, there are translations in place. The translation to SBVR means that the incomprehensible business rules are structured in the semantics of SBVR. This is done by – or under supervision of – process owners or managers. SBVR is a structured and standardised language. The first translation is processed in the organisation unit(s) itself, not in the IT department. The result of that, which are structured business rules, will furthermore be translated into OWL2. The second translation is necessary because webpages cannot handle the semantics of SBVR, but they can handle a Semantic Web language. The second translation is executed by the IT department. The rules – which are twice translated – are evaluated in Protégé. Protégé is a tool that provides insights into the way a business rule is specified and whether that rule does what it should be doing. Protégé structures the business rules and provides structured insights, on which basis an evaluation by the business can be done: does the rule do, what it should do? Protégé translates business rules to a syntax like the example below:

Figure 3: Syntaxis of a business rule, derived from O'Connor (2009)

An instance is an object itself, such as a person. A person has (whereas 'has' is a property) a sibling – where the latter is a class. From there on it is possible to extend the rules further: from a class, you can add a new property which leads to another class, and so on (O'Connor, 2009).

The specifics of the scenarios will be added to the model in Protégé. The scenarios will evaluate the proposed reference architecture for traceability: it tests if the architecture fits the purpose of providing traceability to customers. Protégé will provide insights on this subject, as it tests the outcomes of the scenario and how well that fits into the reference architecture. One particular property results in traceability: rdfs:isDefinedBy (Berghuis, 2022). This property points to the source of the instance. When the latter is projected on the proposed reference architecture for traceability, a similarity is shown – especially on the link between Interface and Explanation, which is defined as the User Explanation. This is shown in Figure 1.

4.2. The case organisation

As stated before, the case organisation is EU-Rent (§3.2). This organisation is a fictional company, which has multiple branches across Europe to provide rental cars for customers. To clarify the business context in which EU-Rent operates, Figure 4 provides a visual insight.
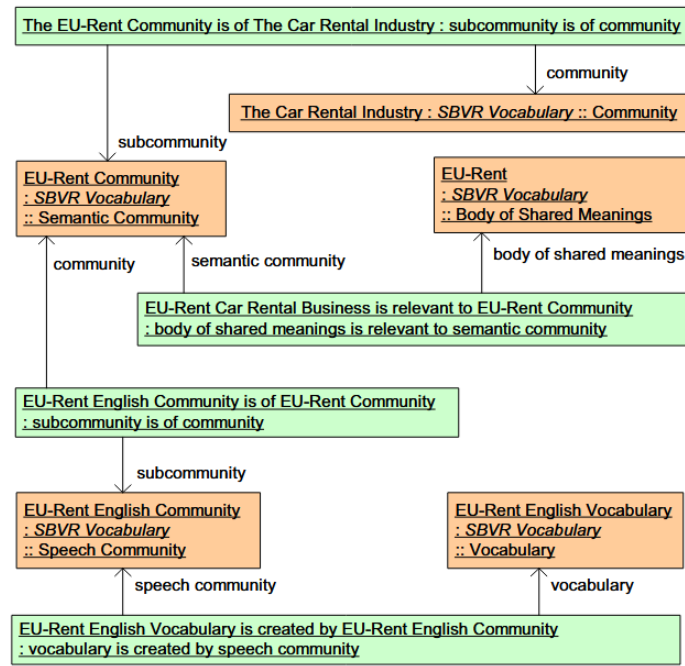
Figure 4: Instance diagram of concepts and facts expressing EU-Rent's vocabulary business context. Extracted from KDMAnalytics (2016)

In the next paragraph, the scenarios from §3.2 are evaluated. The results per scenario are structured in a table. After that, the source of the explanation is given. There is a translation made between the SBVR language and OWL. This is done via the tool s2o, which is an online tool that translates SBVR to OWL. The results of the scenarios are all structured in the same way, all based on – and derived from – the research of Rutledge et al. (2022). This means that there is a table provided with some subsections in it:

- SBVR from EU-Rent specification: Following the specifications provided by KDMAnalytics (2016), where the specific rule is written out.
- SBVR in s2o Vocabulary: The structure of s2o (§3.2.1) for the vocabulary section, where there are stated all the different subjects within a business rule.
- SBVR in s2o Rules: Where the constraints are provided, such as where one subject is a constraint to another subject.
- Test SBVR in s2o Vocabulary: The section where the business rules are tested with test data.

With the described structure, it is possible to determine in which way a business rule applies to the specific scenario.

4.3. Scenario: Invalid driving licence

In this scenario, fictitious names and driving licence numbers are used. However, this is comparable to the scenario itself: the names can be switched one-on-one to the customer – and the second attendee.

Invalid driving licence
SBVR from EU-Rent specification
Each driver license is for exactly one driver
SBVR in s2o: Vocabulary
drivinglicence driver drivinglicence is_attached_to driver
SBVR in s2o: Rules
It is necessary that drivinglicence is_attached_to exactly 1 driver
Test SBVR in s2o: Vocabulary

John
      General_concept: driver
William
      General_concept: driver
Mary
      General_concept: driver
 	
DV_247612
      General_concept: drivinglicence
DV_151231
      General_concept: drivinglicence
DV_161323
      General_concept: drivinglicence
 	
DV_247612 is_attached_to John
DV_161323 is_attached_to William
DV_151231 is_attached_to Mary

Derived from Rutledge et al. (2022)

Looking at the table above, there is no conclusion drawn based on the rules stated in it. A conclusion that can be drawn, is that it is impossible that John is Mary – but that is not the case here. However, the customer does have a driving licence that is not from the customer itself. In the example above, it is acceptable that John is the customer, but he holds the licence of Mary. As said: John can never be Mary – and the other way around.

For this specific scenario, no natural language source document is provided by the company. For this specific scenario, no natural language source document is provided by the company. That is, because it is common law in the country where the rental car is picked up: you must have a valid driving licence., according to regulations – in particular "The Motor Vehicles (Driving Licences) Regulations".

Besides the regulations of a country, EU-rent has its determination for a valid driving licence as well. As provided in Figure 5, there is the box of driver – a driver has to have exactly one driving licence. In Figure 5, there is an outcome of a driver as well: barred or qualified. This is a binary value: yes or no. A driver is qualified if that driver is "over 21 years old and has a valid driving licence and is not under any pending legal action that could adversely affect his driver's licence or insurability" (p.322); in this case, the driver does not have a valid driving licence and therefore the driver is not qualified (KDMAnalytics, 2016).
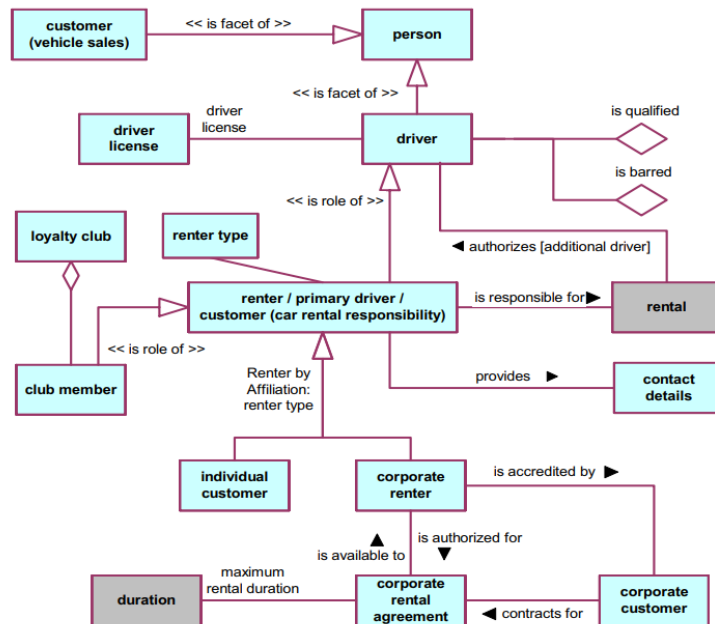
Figure 5: Customer specifications, derived from KDMAnalytics (2016)

As foreseen in this scenario, there is no question about the fact that the primary driver cannot rent a car. The attendee can provide a driving licence, but the attendee will then become the primary driver – which is not possible because the attendee is under 21 years old. The customer cannot authorise – via the rental (grey box on the right of Figure 5, red.) – an additional driver, because the customer is not the primary driver, nor the additional driver. Because the primary driver lacks, there is no possibility to assign an additional driver.

Applying this scenario on RA4T, there is a traceback necessary to the source documents. Therefore, a traceability environment can be made, based on the input the scenario provides. In this case, an explanation page can be looking like the page in the mock-up hereunder; the page is provided in-store on a screen at the desk.
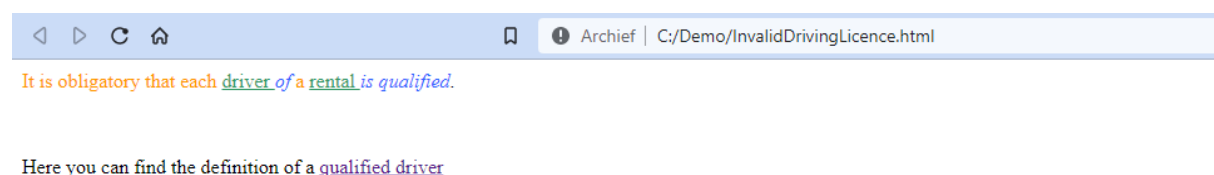

Figure 6: The business rule statement of unqualified drivers, and a link to the definition of a qualified driver

When clicking on the link for the definition of a qualified driver, the page as displayed in Figure 7 is shown. This is derived from the vocabulary of EU-rent, as provided by KDMAnalytics (2016).
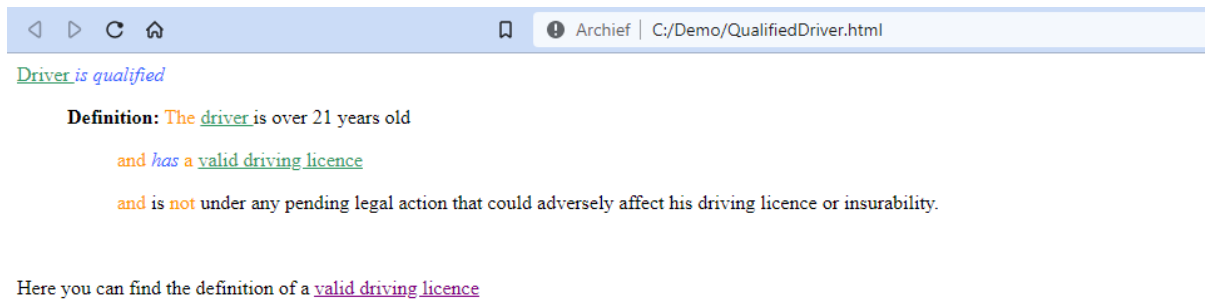
Figure 7: Business vocabulary with the statement of a qualified driver

The definition as stated in Figure 7 is not the definition provided by the government of the state the branch originates. The government of the United Kingdom does have its ruling when it comes to valid driving licences ("The Motor Vehicles (Driving Licences) Regulations," 1999). However, in this case, a commercial organisation as such can decide if they oblige to the rules as provided by the government, or create their own rules. One criterium: the ruling of the government is a minimum requirement – therefore a company can only decide if they will 'increase' their own rules. Furthermore, a valid driving licence is asked upon – which is a definition on its own and has in the case of EU-Rent the following meaning (Figure 8). This meaning is provided when clicking on the link as presented in Figure 7.
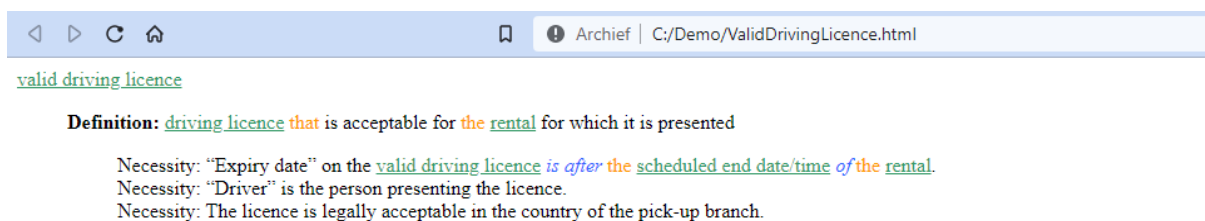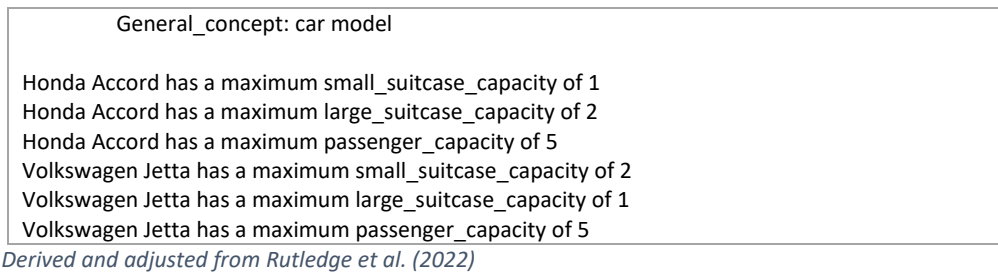

Figure 8: Business vocabulary with the definition of a valid driving licence

4.4.   Scenario: Lack of capacity

In this scenario, the lack of capacity is played with. That means that the customer has asked for a specific type of car (Economy, red.), but the car lacks capacity compared to the needs of the customer.

Table 2: SBVR in s2o for the scenario Lack of capacity

Lack of capacity
SBVR from EU-Rent specification
Economy has passenger capacity '4' and large suitcase capacity '1' and small suitcase capacity '1'
SBVR in s2o: Vocabulary

car_group
passenger_capacity
     General_concept: nonnegative_integer
car_group has passenger_capacity
     Concept_type: property_association
economy
     Definition: car_group that has passenger_capacity less_than_or_equal_to 4 and has
     passenger_capacity greater_than_or_equal_to 4
     General_concept: car_group

SBVR in s2o: Rules
It is necessary that Economy has_passenger_capacity 4 and large_suitcase_capacity 1 and small_suitcase_capacity 1.
Test SBVR in s2o: Vocabulary
Honda Accord   General_concept: car model Volkswagen Jetta

```
General_concept: car model

Honda Accord has a maximum small_suitcase_capacity of 1
Honda Accord has a maximum large_suitcase_capacity of 2
Honda Accord has a maximum passenger_capacity of 5
Volkswagen Jetta has a maximum small_suitcase_capacity of 2
Volkswagen Jetta has a maximum large_suitcase_capacity of 1
Volkswagen Jetta has a maximum passenger_capacity of 5
```
Derived and adjusted from Rutledge et al. (2022)

Both car models are of the car group Economy because they fit in the description of an Economy car. However, the cars do not match the requirements specified in the scenario. Therefore, an Economy car is not provided. Within the organisation of EU-Rent, there is no document that describes in which car group a specific car is scaled. However, when looking at existing organisations, there is a more or less standardised way of categorising cars into groups. The car groups in this research are based on Orbit (2022).

When taking a closer look at the Business Vocabulary provided by KDMAnalytics (2016) a car group has a number of passengers, as seen in the figure below. That means that this is an attribute of a car group. For example, a car group has a maximum capacity of five passengers.
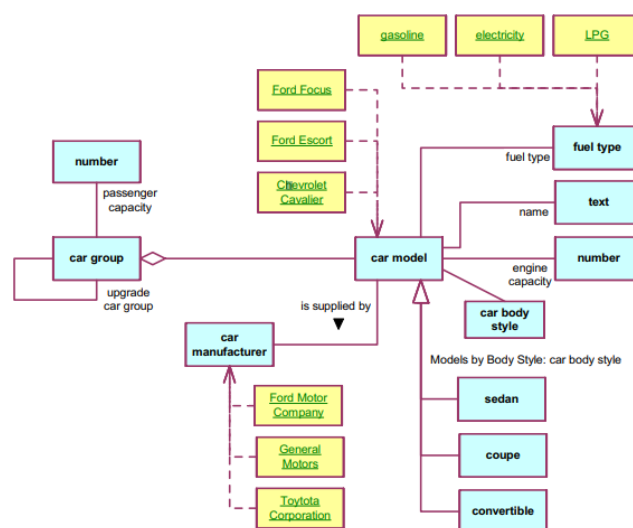

Figure 9: Car specifications, derived from KDMAnalytics (2016)

As stated in the outcome of this scenario, there is an alternative: the upgraded car group. Every car group has its upgrade car group when the requested car is not available. This is shown in the loop on the bottom and left side of the box car group, in the figure above.

There is an interesting thing that can cause miscommunication on which car belongs to which car group. Looking at the car specifications in Figure 9, the car group is defined by the car model; the car model is determined by car manufacturers and therefore a car model may be specified as another type of car group, based on the specifics provided by these car manufacturers. The main criterium in which car group a car model is placed remains the number of passengers. To provide insights on what car can be chosen, the rules as shown below can clarify.
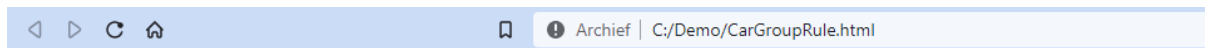
It is necessary that each rental *has* exactly one requested car group.

Description: The renter may request a change of car group up to pick-up time, but a car group must always be specified.

Here you can find the definition of a requested car group

Figure 10: The business rule statement of a requested car group, and a link to the definition of a requested car group

When clicking on the link provided in the figure above, the tab as shown in Figure 11 comes up. In this tab, the definition of a requested car group is provided. The desk clerk can click on this definition to provide more insights for the customer.
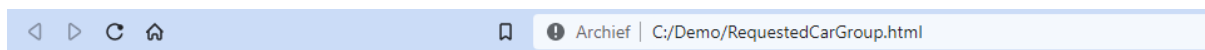
Requested car group

Definition: car group that is requested for a rental.

Here you can find the definition of a car group

Figure 11: Business vocabulary with the definition of a requested car group

The definition of a car group is provided when clicking the link. The definition of a car group is shown below. This definition provides a necessity in which the determination of a specific car, in a car group, can be found. This is provided when clicking the link below.
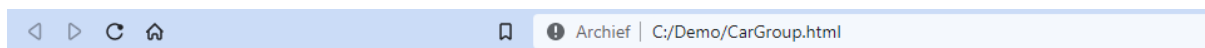
Car group

Definition: Different models of a car are offered for rental, organised into groups which establish a price point.

Necessity: Each car model that *is included in* a car group is charged at the rental rates of the car group.

Here you can find the definition of a car model

Figure 12: Business vocabulary with the definition of a car group

The link leads to the next page, where there is shown in which way a car model is assigned to a car group. This assignment is based on a few parameters, as shown in Figure 13.
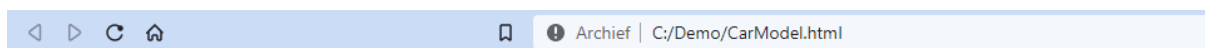
car model

Note: Cars of a given model are all built to the same specification, e.g., body style, engine size, fuel type.

Note: EU-Rent bases its model names on those assigned by the car manufacturers.

Furthermore, a car model...:

- ... *has* engine capacity
- ... *has* fuel type
- ... *has* name
- ... *has* luggage capacity

Figure 13: Business vocabulary with the definition of a car model

Especially the latter fact that it is based on luggage capacity as well, makes that the requested car group is not provided to the customer.

4.5.   Scenario: Speeding tickets

In this scenario, the customer wants to rent a car, but the customer still has unpaid speeding tickets – which is seen as an infringement. When the customer pays the speeding tickets, they can rent a car.

Table 3: SBVR in s2o for the scenario Speeding tickets

Speeding tickets
SBVR from EU-Rent specification
none
SBVR in s2o: Vocabulary

Driver
Infringement
      Driver features Infringement
Assessed_Driver
      Definition: Person that features at_least 3 Infringements
      Concept_type: verb_concept_role
      General_concept: Driver

SBVR in s2o: Rules
It is necessary that Driver features less_than 3 Infringements
Test SBVR in s2o: Vocabulary

John
      General_concept: Driver
Mary
      General_concept: Driver
Infringement1
      General_concept: Infringement
Infringement2
      General_concept: Infringement
Infringement3
      General_concept: Infringement
 	
John features Infringement1
John features Infringement2
John features Infringement3

Derived, adjusted and translated from Rutledge et al. (2022)

For this scenario, an infringement is determined based on what the company itself thinks is an infringement. When having multiple infringements, the driver is barred. When taking a closer look at the natural language source documents of EU-Rent, one of the terms states that "A barred driver is a person known to EU-Rent as a driver (either a renter or an additional driver), who has at least three bad experiences" (SBVR, 2008). These bad experiences are translated as infringements – therefore three is exceeded and John is a barred driver.

The aforementioned facts are hereunder conceptually visualised. As seen, the driver – in this case John – has infringements impending and therefore he is barred (also visualised in Figure 5). Furthermore, a bad experience is defined as an "undesirable occurrence during a rental that is the fault of one of the drivers" (p.313), and examples given as speeding offences, unpaid parking fines, or damage to the car (KDMAnalytics, 2016). In all cases, it is the fault of the driver – which is a prerequisite to be barred; this can be derived from the figure below.
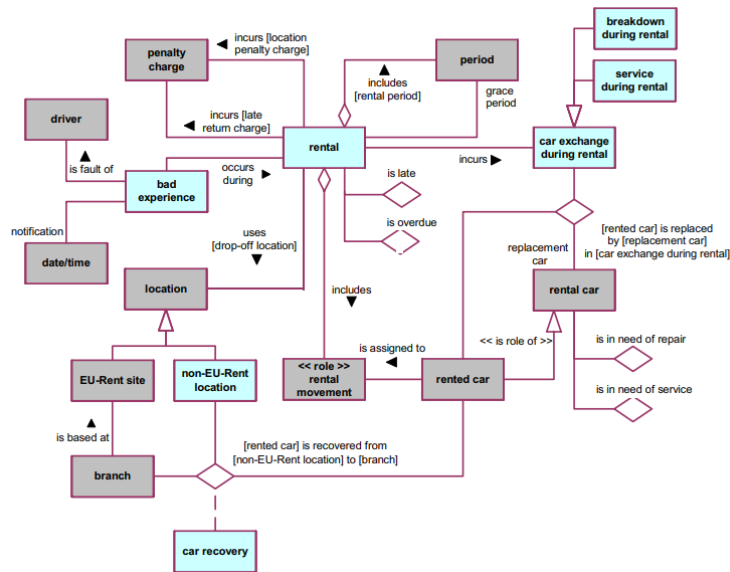
Figure 14: Rental problems, derived from KDMAnalytics (2016)

The accompanying rule, based on the description above, is stated in Figure 15. The rule itself is both positive and negative – both business rules are shown.

It is permitted that a rental *is* open only if each driver *of* the rental *is* not a barred driver.

    Synonymous Statement: It is prohibited that a rental *is* open if a driver *of* the rental *is* a barred driver.

Here you can find the definition of a barred driver

Figure 15: The business rule statement of a barred driver, with a link to the definition of a barred driver

As explained in Figure 15, a driver cannot be barred and acquire a rental car. When clicking on the link – in this scenario as done by the desk clerk – the definition of a barred driver is shown. In this case, a barred driver is someone who has three bad experiences; this is shown in Figure 16.

driver *is barred*

    Definition: driver *being prohibited from renting a car from EU-Rent*

    Note: A barred driver is a person known to EU-Rent as a driver (either a renter or an additional driver), who has at least 3 bad experiences.

Here you can find the definition of bad experiences

Figure 16: Business vocabulary with the definition of a barred driver

Following the proceeding explanations, a barred driver is a driver who has at least three bad experiences; but a bad experience is not defined yet. Therefore, the desk clerk can click on the next tab, as shown in Figure 17.

bad experience

  Definition: undesirable occurrence during a rental that is the fault of one of the drivers

  Example: Speeding offence, unpaid parking fine, damage to car caused by careless driving.

Furthermore, a bad experience...:

- ... *has* notification date/time
- ... *is fault of* driver
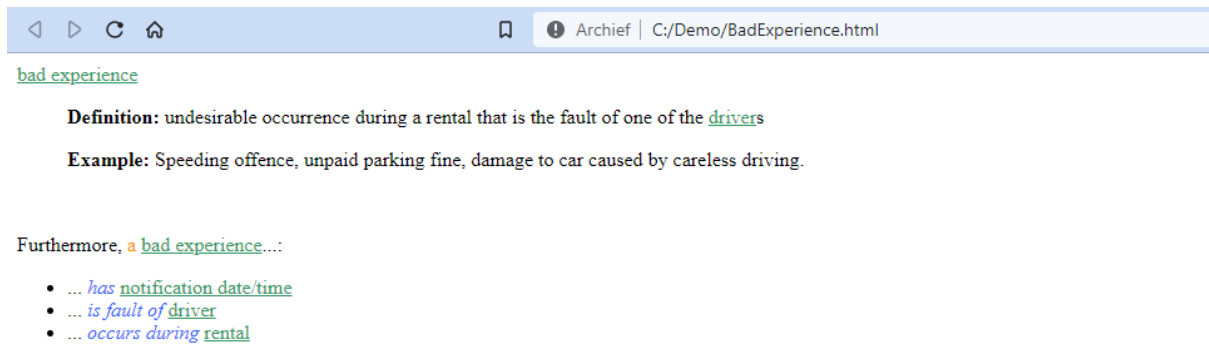- ... *occurs during* rental

Figure 17: Business vocabulary with the definition of a bad experience

Because of the explanation as shown in the previous figures, the driver with the speeding tickets is barred. The driver can be *unbarred* when the payment of the speeding tickets has proceeded. This is a decision by the desk clerk nonetheless; there is no rule a driver can be *unbarred*.

5. Discussion, conclusions and recommendations

In this chapter, a discussion, conclusions, and recommendations are provided. This is based on the results as explained in chapter 4.

5.1. Discussion

It is debatable in which way the explanation provided by the desk clerk in the scenarios is satisfying for the customer on the other side of the desk. It is just an explanation of why a customer does not get the requested services or goods. Nonetheless, the desk clerk does have a business rule based decision why a customer is not granted the services of a company – this can cause more understanding on both sides. As stated, the real use and purpose of traceability is debatable, since a customer still has its interpretation of a situation.

As an example, the barred driver can have its own interpretation of the situation. It is a possibility that the barred driver does have paid the speeding tickets, but did not have any evidence. Or, the customer is in believe that the speeding tickets are unlawful – and therefore the driver objects to it in court. When taking all these possibilities into account, the level of satisfaction of the explanation, as provided by the desk clerk, may not be as high as wished for. How a more satisfying explanation is given, can be subject to further research (§5.4).

5.2. Conclusions

The problem statement for this research was to make it traceable for customers or a commercial organisation what the origins of conclusions are and how they are made by a system. The setup of explanation pages to provide insights for customers can be seen as a type of traceability. This traceability is provided on a user interface, which is related to the RA4T by Rutledge and Italiaander (2021). This is shown in Figure 1 and contains several steps in traceability.

Keeping Figure 1 in mind, the traceback to the source is shown, following four steps, from the bottom of the bottom of the figure to the top. From the interface, the first step is back to explanations, which is called the User Explanations. In the scenarios, an explanation is provided to the desk clerk and customer, by writing out the rule on which basis a decision is made. The logic behind it is traceable: when a customer has an invalid driving licence, the rule is triggered – this is the second dotted line from explanations to logic and is called the Triggered Rule. To make logic traceable for the customer and desk clerk, CNL is provided: this standardised natural language for business rules is useful to make it as simple as possible for customers to understand the rules. This is in line with the approach of Armonas and Nemuraite (2007), as well as the study of Terzi et al. (2006): the rules are more or less visualised for the customer. That step of the reference architecture is called CNL for Logic.

The last step, from the CNL backwards to the original document, is the step called Documents for CNL. The definitions, provided in the mock-ups, can be seen as parts of the original documents. However, these definitions are parts of the completely original documents; no complete sources are provided; this can be a choice made by the organisation because in the documents trade secrets can be unveiled. This is the core of an organisation as such and therefore vital to the organisation. In this research, the 'cut' is made between these steps in providing traceability to the customer.

Comparing this to other studies in this area of interest – such as the studies of Berghuis (2022) and Soerokromo (2022) – the commercial context is especially different. The last step in the traceback of traceability is not (completely) provided in this case, but from a commercial perspective not unique. The trade secrets of an organisation are vital for that organisation; this differs from governmental institutes which are not allowed to make any profit, and therefore shall not have any trade secrets.

Back again to the scenario of the barred driver, there can be a separation in traceability as well. For the desk clerk, there is only visible that the driver who is applying for a rental car, is barred – the reason why the driver is barred, is given as well. However, the exact data from the speeding tickets are not provided; as well as that a back-office employee inserted the data about the speeding tickets. This data cannot be provided, but can be required internally for traceability. In this particular case, full traceability – or even better to say transparency – is not provided and will not be provided. This differs from the studies of Berghuis (2022) and (Soerokromo, 2022), where there should be as much traceability provided as possible.

This research should provide answers to the main question:

> How, when, and how well does the reference architecture for traceable business rules apply in a commercial context?

As stated in the previous paragraphs, how the reference architecture is fitted to provide traceability for customers and front-office employees, is explained. For the *when* part of the question, a closer look at the scenarios is necessary: particularly in these scenarios when a customer is approaching the desk clerk and requests are denied. In these scenarios, there is a social filter in place, in the form of the desk clerk. When an online booking made there is no such filter is in place; therefore the organisation must provide as much information about the decisions made as possible – this increases traceability to the customer who requests a car without the help of a desk clerk. The system provided to the desk clerk is an example of the explanations that can be provided to the online customer. Coming back to the question when the reference architecture for traceable business rules applies: the reference architecture and the implementation of the explanation, are beneficial to both types of customers.

The last part of the main question is the *how well* part of it. As stated already in the discussion (§5.1) and the first part of this paragraph, the architecture fits quite well. However, the last part of the traceback is not provided as this may not be in favour of the company itself, because the organisation has its way of 'doing business'. The trust a customer has in a commercial organisation is vital to the existence of that company, according to the book of Harari (2014) and the study of Needle and Burns (2010). Because of this, an organisation can choose to give no such insights into their businesses or their business rules. Therefore, the reference architecture is mostly followed and applicable, but the last part of the traceback may not be provided by the company – as per choice of the company itself. This mainly solves the problem that this research wants to solve: to make it traceable to customers of a commercial organisation what the origin of conclusions are and how they are made by the system.

5.3.   Recommendations for practice

The reference architecture provided by the study of Rutledge and Italiaander (2021) is especially well suited for governmental institutions, but for commercial organisations a little less. The reason to say, this is that the reference architecture is a traceback all the way to the root source of an organisation. When being a commercial organisation, you may not want to be traced back to the original documents – or some parts of it. This is, when having a commercial organisation, a choice and not an obligation; the latter differs from governmental organisations and therefore the reference architecture is especially suited.

However, the reference architecture is not a rigid model where no cherry-picking can be done. Therefore, when it comes to traceability in a commercial organisation, the reference architecture is a useful instrument to provide the insights asked for. It is recommendable that commercial organisations provide insight into how they make decisions for their business, in an operational

context. The companies can provide insights as explained in the scenarios in this research, which gives the customers more explanation about the modus operandi of an organisation. Therefore, it is recommended that commercial organisations bring such explanations to customers in place – where the last step is optional.

5.4. Recommendations for further research

This study provides insights into a car rental company – a company which is specialised in providing some service to the customer. However, there is a multitude of companies – all with their unique selling point. And in nearly every company, business rules are at hand: if this, then case a, else case b. Therefore, further research is necessary to determine in which way the reference architecture for traceability is suitable for other types of commercial organisations, such as industrial organisations.

Another recommendation for further research is the target audience: in the scenarios in this study, the target audience was the customer, especially the contact between an employee (the desk clerk, red.) and the customer. Further research can be done to determine in which way the reference architecture can provide insights for other employees within an organisation. Further research can be conducted in the field of customer satisfaction and in which way traceability as provided by an organisation is satisfying for the customer. This area is especially interesting when it comes to more delicate matters, such as a barred driver or an invalid driving licence.

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