Structural Requirements Language Definition

Defining the ReDSeeDS Languages

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Summary

Existing approaches to object-oriented software development mostly focus on *software objects*, i.e., something *within* the software. Referring to such objects in a Requirements Specification would blur the distinction between Requirements Specification and SoftwareDesign, however.

The structural part of our requirements specification language deals with models and descriptions of objects existing in the domain (environment) of the software system to be built — *domain objects*. These objects are part of a Domain Model (to-be) and/or described in a defined vocabulary. This facilitates a better understanding of the requirements.

This deliverable contains the structural part of the requirements specification language, i.e., all the parts of the meta-model and other descriptions dealing with abstractions of important objects existing in the environment of the software system to be built, as well as their attributes and relations, including their relationships to the software system. Note, that this is a structural requirements language definition, but it is *not* about "structural requirements". This deliverable first gives a conceptual overview of this structural requirements specification language. In the second part, it provides a comprehensive language reference including concrete syntax.

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Chapter 1

Scope, conventions and guidelines

1.1 Document scope

This document provides a conceptual overview, and defines syntax and semantics for the ReDSeeDS Structural Requirements Language (SRL). This definition is required to aid the construction of accurate requirements specifications in the form of descriptive or model-based representations.

The conceptual overview of the SRL explains the approach taken to allow for describing structural requirements meant as vocabularies and thesauruses or ontologies containing domain elements, including terms used in the domain and their descriptions. This document then presents the SRL Reference which covers definitions for Domain elements. This reference explains the syntax of the language in its abstract form (using a meta-model) and in its concrete form (using concrete examples of language usage). The semantics of all the language constructs is also defined.

The definitions for Domain elements describe language constructs that allow for depicting elements of the domain vocabulary. This explains how to structure domain elements into full vocabularies. It also defines possible relationships between domain elements, including the system under development and actors. The reference for Domain elements defines top-level, general representations for all the constructs of the language, including its behavioural and UI part (see deliverables D2.1, D2.3). It also defines how to express phrases and terms that can be used for representing Domain elements. Within its definition, the SRL uses hyperlinks as basic facilitators of coherence. This allows for building a requirements specification where behavioural and quality requirements are based on the domain vocabulary, thus greatly enhancing the possibility to reuse it in the future.

1.2 Approach to language definition and notation conventions

1.2.1 Defining languages using meta-modelling

The Structural Requirements Language (SRL) is defined using a meta-model. A meta-model can be treated as a definition of a language in which models can be expressed properly. A meta-model sets well-formedness rules for models. A model has to comply with the meta-model of the language it uses. In defining the whole Requirements Specification Language (RSL) we use MOF [Obj03] as a meta-modelling language. More details on the meta-modelling approach and notation conventions are given in D2.1, section 1.2.

1.2.2 Structure of the language reference

Part II of this document contains the SRL definition. It has been divided into sections according to logical structure of packages of the BRL.

SRL is contained in a single main package “Domain elements” which starts with an overview of division into subpackages. Every subpackage is presented in an overview explaining general ideas behind a package, a meta-model diagram for this package and two sections which describe the abstract syntax with the semantics of language constructs and their concrete syntax.

1.3 Related work and relation to other documents

External research work conducted in compliance with formulating a good understanding of the Structural Requirements Language included researching and reasoning about such areas as software case representations, query procedure pragmatics, Domain representation, Domain mapping with or without hyperlinking, Domain access methods via taxonomies and similarity measures concerning domain constructs (vocabulary items) and requirement dependencies/interdependencies leading to possible upgrades of the domain or industry specific dictionary of terms.

In Chapters 3, 4 and 6 means for modelling domain entities are introduced, such as domain entity types, vocabulary, phrases, and terms. Terms are organized in a thesaurus. Domain entities are used for representing requirements of *each* new software development project forming a requirement model of the developed software case. For performing case retrieval on the basis of similarity measures, this requirement model is mapped and included in a so-called *software knowledge model*. This software knowledge model contains the knowledge known for *all* software cases of an organisation i.e. the software vendor that implements the different software cases.

For reuse purposes, we strive in this project for finding software cases based on similarity measures. In principle, this can be done by text-based approaches, where our thesaurus as defined in the language will be very useful. For including more semantics into similarity measures, an *ontology* of the given application domain should be available. While our requirements language does not yet include any means for knowledge representation and reasoning, the user may still use it to represent a domain model using object-oriented means (in the form of a domain element diagram, as derived from a UML class diagram). Such models can be used as a simple form of ontology. These issues will be worked out in Workpackages 3 and 4 of ReDSeeDS and discussed in the related deliverables.

One form of representing requirements in ReDSeeDS is to write them down in constrained language. This constrained language uses the so-called *SVO(O)-Grammar*, recently researched at WUT [SBNS05b, SBNS05a]. Other significant work concerning some kind of restriction to natural language was and is still done in the *Attempto* research project conducted by the Department of Informatics and the Institute of Computational Linguistics at the University of Zurich [FHK+05].

The *Attempto Controlled English (ACE)* language developed in the course of the *Attempto* project is currently available in its fifth version. Although ACE closely resembles natural English, the syntax of a text written in ACE is based on a defined abstract grammar which avoids ambiguity in language constructs [Hoe04][1]. Furthermore, ACE can be automatically translated into first-order logic and consequently be read by humans as well as by machines.

[1]The cited article contains abstract grammar for ACE 4.0. The grammar for version 5.0 has not been published yet.

1.4 Structure of this document

Part I of this document, covering chapters 2 to 4, gives a conceptual overview of the Structural Requirements Language. While chapter 2 serves as an introduction, the following chapters 3 and 4 describe different types of entities existing in a domain and the conceptual model of the domain's vocabulary, respectively.

Part II, after discussing the benefits and consequences of using a domain vocabulary in its first chapter 5, defines six major packages of the language meta-model in its second chapter 6. The first four of these packages are related to the basic domain entities, the actors in the system's environment and the representations of the system and the entities. The fourth package contains phrases and other, more fine-grained elements which compose phrases. Phrases constitute the names of the entities as well as the parts of a sentence in constrained language. The last package comprises the individual terms which can occur in a phrase. Each section concerning one of the packages has an overview, defines abstract syntax and semantics, and then gives a short explanation of the concrete syntax using the Fitness Club case study as a running example.

The final Chapter ,7, sums up the document and draws conclusions from the previous parts.

1.5 Usage guidelines

ReDSeeDS Structural Requirements Language (SRL) definition should be used as a book that guides the reader through the structure, syntax and semantics of the SRL, as part of the complete ReDSeeDS Requirements Specification Language. It should be used mainly by creators of appropriate CASE tools that would allow handling of the language by end users (analysts, etc.) to express descriptions of static elements (domain elements) of the system under development. It can be used by advanced end users of the language as a reference to the language's syntax and semantics. Examples of SRL elements' concrete syntax have illustrative character and should be treated only as support in understanding of each element's occurrence.

Users of the SRL Specification are expected to know the basics of metamodelling and MOF (Meta Object Facility) specification [Obj06]. Knowledge of UML ([Obj05b] and [Obj05a]) could be helpful as some elements of SRL are extensions, constraints or redefinitions of UML elements.

Part I

Conceptual Overview of the Structural Requirements Language

Chapter 2

Introduction

The Structural Requirements Language Definition is primarily concerned with the specification of entities or concepts in an application domain. Referring explicitly to entities of an application domain from requirements was proposed in [Kai97].

Traditionally, we use object-oriented analysis and design methods to discover these entities in a domain and then use them for design purposes. However, several misunderstandings existed about which entities are to be represented in the course of object-oriented analysis. For a discussion and clarification see [Kai99]. A clear separation between analysis and design artefacts in a meta-model can be found in [EK02].

In this chapter we describe a common approach to OOAD, i.e., how the domain entities are discovered and used, and in the next chapter we discuss what is typically captured using these types of methods and how our language documents it.

2.1 Typical OOAD method

This section describes the parts of a typical object-oriented analysis and design (OOAD) method. Full details about OOAD methods can be found in many OOAD books and articles (e.g. [Lar01, Gom01, Dou99, Kai99]).

2.1.1 Requirements modelling

Input: Business tasks, use cases, and other business engineering artifacts.

Goal: Break down business-level artifacts in order to capture and define the scope and responsibilities of a system to be built that meets the requirements embodied in the input.

Activities: The main requirements modelling activities are:

- Identify main *business goals*, *processes*, *resources*, and *features*.
- Write use case descriptions with a clear identification of the *actors* and the *data* exchanged between the system and the environment, and the *context* expressed through pre-conditions, post-conditions and invariants.
- Draw a use case diagram with all the use cases in order to depict the relationships among use cases.

2.1.2 OOA

Input: All Requirements Modelling artifacts.

Goal: Decompose requirements artifacts and build a domain model.

Activities: The main OOA activities are:

- Relate use cases to each other with respect to their main concerns. This produces the first level of the domain's decomposition into related functionality domains, that is, the domain subsystems. Show the decomposition of the use case diagrams using the UML package notation. Repeat this step for any identified domain subsystem.
- For each domain subsystem, from its task and use case descriptions, extract its classes, attributes, and the relationships among them. Show the decomposition using UML-like class notation in what is known as a domain model (DM). This step is present in most OOA methods. Our opinion is that use case conceptual analysis is not an effective way for developing the DM. Analysts should have good prior domain knowledge, which should be the main source for domain concepts. Of course, in the absence of knowledge of the domain, use case conceptual analysis at least represents a good starting point.
- Extract common concepts from different domain subsystems and allocate them to common domain subsystems.

- Emphasise relationships among data concepts in the DM. Data concepts represent external data with a high probability of having to be used and preserved within the system. These data concepts and their relationships constitute the traditional relational part of the DM.
- With use cases, develop the domain-level interaction diagram. The main goal of this step is to define the domain's external interface.
- With use cases, DMs, and the domain-level interaction diagram, for each domain subsystem, develop the domain subsystem interaction diagrams. The main goal of this step is to define the domain subsystems' interfaces. Use higher-level domain subsystem interaction diagrams to develop the lower-level domain subsystem interaction diagrams. This activity is recursive.
- With use cases, DMs, and the domain subsystem interaction diagrams, develop the low-level object interaction diagrams. The main goal of this step is to capture:
  - how objects collaborate to accomplish the functionality described in use cases — note, these objects are the objects from the domain and not the software objects,
  - definitions of object interfaces,
  - object associations and interactions, and
  - the sequence of the objects' interactions.
- With all interaction diagrams, build a unified collaboration diagram (UCD) without message numbering, multiple objects of the same type, or object names. Indicate:
  - *Controller* and *coordinator objects* — the main sources for the definitions of *active objects* in the design phase.
  - *Entity* and *service objects* — the main sources for the definitions of *passive objects* in the design phase.
  - *External objects* — the main sources for the definitions of *interfaces* in the design phase. These objects include devices and business resources.
- With the UCD, record each message as a method in the DM.
- For each controller and coordinator object in the UCD, develop a state diagram. The messages from the UCD are the main sources of events; the mapping is not necessarily one to one.
- Develop state diagrams for any additional objects that have non-trivial state transitions. The messages from the UCD are the main sources of events; the mapping is not necessarily one to one due to the possible presence of internal events.

Additional Notes: It is usually recommended that one should capture invariants, pre-conditions, and post-conditions for each entity in the OOA artifacts. Each entity or artifact has to be taken into account and to be related by its constraints, business goals, business rules, non-functional requirements, to other artifacts captured during the requirements modeling phase.

2.1.3 OOD

Input: All requirements and domain model artifacts, with special emphasis on the DM, the UCD, and the state diagrams.

Goal: Map the domain model into an OOD model [Kai99] taking into account internal system requirements and development resources.

Activities: The main OOD activities are:

- Using the domain subsystem information from the DM and internal architectural requirements, design the initial high-level non-run-time architecture of the system. Define the interfaces of the system and its subsystem.
- Using the DM and the UCD, in addition to internal system requirements, map domain concepts into software classes. This mapping should be performed taking into account reusability, maintainability and other design goals. Take into account the internal system requirements such as persistence, security, performance, and so on. Augment and refine the class interfaces.
- Define the run-time architecture of the system. Define run-time components, processes, and processing node allocations.
- Define the run-time communication channels, interfaces, and protocols.
- For each run-time entity, i.e., component, process, or communication channel:
  - make its decomposition explicit, i.e., define out of which objects it is constructed, and
  - make a clear distinction between active objects, i.e., controllers and coordinators, and passive objects, i.e., data concepts, computation and logic providers.
- Refine all class interfaces.
- For each class, design its internals, i.e., its algorithms, additional classes, data types, internal attributes, and so on.

There are many different OOAD methods, but common to all of them is an early conceptualisation of the domain into concepts. These concepts drive specification and have an impact on all the produced OOAD artifacts and, in some cases, propagate all the way to the code. This propagation of the concepts and the concepts' influence on the other produced artifacts might have both positive and negative effects.

2.2 Our Language

A typical approach to OOAD is described above. Our language can be useful for the early stages of such an approach. Nevertheless, our language introduces a number of changes and enhancements. Namely, we do not use UML class diagrams with attributes and methods. We use "domain entity diagrams", where domain elements have Phrases. Our language describes these domain entities. Our language also allows for linking the vocabulary precisely with the behavioural and quality requirements. However, we are also not limited to use cases only.

Chapter 3

Domain entities

The main purpose of a domain model (DM) is to capture the entities that exist in a system's domain. The domain can be seen as consisting of:

- business entities, and
- computer entities, including hardware and software.

In the sections below we discuss these two main groups.

3.1 Business entities

A software system is part of a larger business system, and serves as a resource to accomplish business goals. To build a useful DM, we need to study and discover different business entities of the domain. The possible sources of business entities are presented below:

1. *Business Resources* — All entities, both physical and abstract, that exist inside the environment of the business are business resources. They include people, information, different systems, and business supplies and products. They participate in the business processes. A subset of these resources is a source of modelling entities for the system to be built. The value of tracking and preserving knowledge about these entities is that these entities are used to perform analysis of the system's architecture, to track changes to the

domain and the system from the beginning, and to evaluate how well the system reflects current business needs. For an elevator system, an example business resource is the *cable* used to pull up the elevator cab.

2. *Business Processes* — A system to be built may participate later in several business processes in order to help achieve several business goals. Use cases (UCs) describe subprocesses of larger business processes that are automated by the software system. It is important to understand a business process as it relates its UCs, which in turn relate software requirements that the system has to satisfy. For an elevator system, an example business process is *a passenger's riding of an elevator cab*.

3. *Business Rules* — Business rules are a major source of constraints on a software system. Many constraints directly influence the system's architecture. Therefore, it is important to understand these constraints and to keep track of them, for example, to be able to remove architectural limitations imposed by constraints that do not hold any more. For an elevator system, an example business rule is *the elevator will not change its direction until it services all previously received calls that lie in the current travelling direction*.

The main source of business domain objects are Business Resources, but they are very tightly interlinked with Business Processes and Business Rules. In some cases, they cannot exist separately. Therefore, we need to seek for domain objects inside business process or business rule descriptions. These are not intended to be described using our Structural Requirements Language (SRL), but can be sources to elements expressed in the SRL.

3.2 System entities

It is often a case that we are building a new system for which domain consists of an already existing computer-based system that includes both software and hardware. For such a system, domain entities are not some "natural" objects but rather software and hardware components and other building blocks. For such domains, the main aspects of a system that should be modelled are:

- *System*,
- *subsystems*,
- *modules*,

- *connectors*,
- *processes*, and
- *hardware devices*.

The *System*[1] entity defines the outermost boundary of the system under consideration. The *System* serves as a container for all other entities, and defines the system as a resource in the business system.

A *subsystem* is a part of a *System* or a *subsystem*, being an abstraction of actual physical modules, connectors, and processes. It serves as a container and a building block.

A *module* is a basic architectural building block. For example, in the logical view, it represents a entity that occurs in a domain, and in the implementation view, it represents a code unit. *Modules* are abstractions of basic building blocks of the domain, depending on the development technology used.

A *connector* is an abstraction of a communication mechanism or a channel that exists in a system. Its size and complexity vary from a simple procedure call to a connection on the Internet.

A *process* is an executable piece of software. *Processes* are basic building blocks of a run-time architectural view.

A *hardware device* is an entity that occurs in the run-time architectural view, and it represents a physical device that is a part of the system.

The above types of system entities have their place in the domain model created at the requirements level, using the SRL. The System entity is used throughout the descriptions of functional requirements in general, and in use case descriptions (scenarios) specifically. Other system entities can be used in requirements that specify technical constraints on the prospective system. Refer to document D2.1 for more details.

[1]Note that this “system” is spelled out with initial uppercase letter to distinguish it from the generic “system” used elsewhere.

Chapter 4

Domain vocabulary representation

4.1 Overview

This Chapter introduces the concept of domain vocabulary. In Section 4.2 the need to separate the vocabulary from a requirements representation is explained. This section also describes the structure of domain vocabularies. Section 4.3 shows the idea of the vocabulary in the context of the whole ReDSeeDS Requirements Specification Language (RSL).

4.2 Domain vocabulary concept

The main purpose of a requirements specification in software engineering is to reflect the real needs of the clients. This specification should be the basis on which developers build a software system of a good quality – i.e. a system that meets clients' expectations to high extent. Unfortunately, a commonly encountered problem with requirements specifications is that they are imprecise and have many inconsistences. Specifications are often written using wordy style or, on the contrary, they are too general. In both cases, the intentions of the writer are hard to understand and interpret causing ambiguity. The majority of requirements specification writers tend to mix descriptions of the system's behaviour, quality or appearance with descriptions of notions from the application (problem) domain. Definitions of notions are buried in many different places inside scenarios, stories or simply free text. What is more harmful, the same notions often have conflicting definitions and, on the other hand, a number of different synonyms are used to describe identically (or close to identically) defined notions. Having the requirements specification of such a poor quality, it is a very hard task to build a system that fully fulfills the *real* clients' needs. It is hard to reflect these requirements in the architecture and in the design of the prospective system as well as to apply changes in the system when requirements change. Finally, imprecise requirements make it close to impossible to apply the concept of software reuse at the level of problem definition.

To overcome all problems mentioned above, we need a special language for creating precise and consistent requirements specifications. With this language we should be able to describe all functional and non-functional requirements on the prospective system with the simplest possible sentences in well defined grammar. For example, to describe interactions between a customer of a fitness club and the fitness club system in a scenario, sentences in SVO(O) grammar (see deliverable D2.1) could be used:

- Customer wants to sign up for exercises.
- System shows time schedule.
- Customer chooses time from time schedule.

With these simple sentences we can precisely describe actions performed by an actor or by the system. However, they are not appropriate for defining the notions used therein. For example, we lack explanation of what 'exercises' or 'time schedule' is and how they relate to each other. In order to avoid inconsistencies, as mentioned above, we should not insert definitions of notions into the sentences. Thus, the requirements specification language should provide means to describe the environment of the system. We need to have a *domain vocabulary* – a repository that keeps all necessary notions from the system's domain along with their definitions and relationships between them. For the above example, the domain vocabulary would contain definitions for nouns:

Exercises – Form of physical activity performed in fitness club. Exercises may be [cyclic exercises] or [sporadic exercises].

Time schedule – A program of [exercises] offered to [customers] by the [fitness club] in a given period of time: day, week or month.

Square brackets in notion definitions denote relationships with other notions. Every notion in the domain vocabulary can have different forms (i.e. singular and plural) and synonyms. In addition to nouns, the domain vocabulary can also contain verbs. However, verbs do not have their own autonomous definitions – they are related to nouns as their meaning depends on the

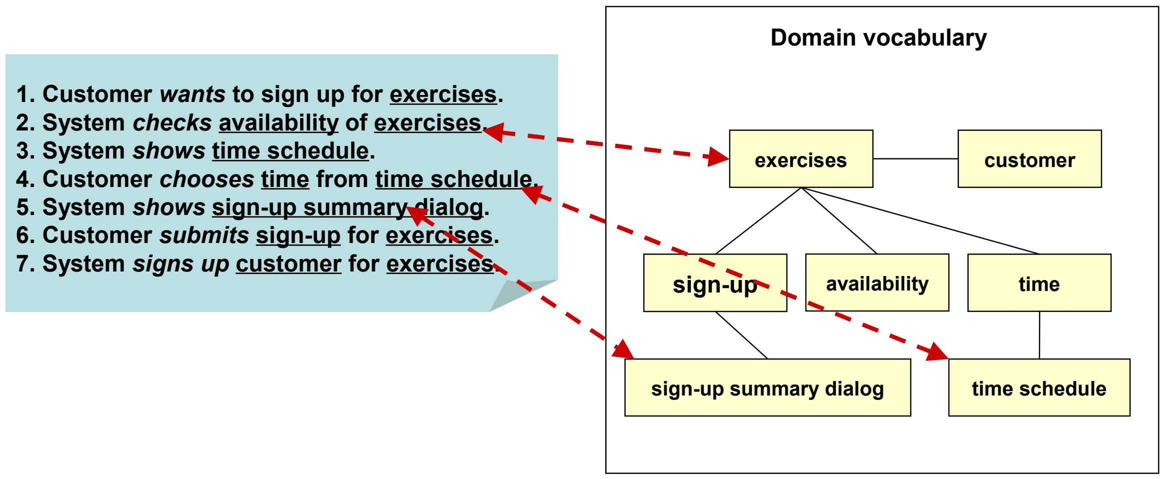

1. Customer wants to sign up for exercises.
2. System checks availability of exercises.
3. System shows time schedule.
4. Customer chooses time from time schedule.
5. System shows sign-up summary dialog.
6. Customer submits sign-up for exercises.
7. System signs up customer for exercises.
Domain vocabulary
exercises
customer
sign-up
availability
time
sign-up summary dialog
time schedule

Figure 4.1: Scenario with separated domain vocabulary

context of a concrete noun. Verbs are treated as behavioural features of related nouns. For example, “choose exercise” has a different meaning than “choose time from time schedule”, although both contain the verb “choose”.

The domain vocabulary should be partially created by interviews with the future users of the prospective system as well as with specialists from the problem domain. While writing requirements in an appropriate grammar (see deliverable D2.1), the writer has constant access to the vocabulary and can easily insert notions directly into sentences. He/she can also extend the vocabulary at any time by introducing new notions and their definitions. Figure 4.1 illustrates the concept of separation of the domain vocabulary from requirements descriptions. In the example, scenario sentences have links (depicted as dashed arrow lines) to notions defined in the domain vocabulary (depicted as boxes). The lines connecting the notions in the domain vocabulary denotes relationships between them.

4.3 Domain vocabulary in the RSL

Domain vocabulary should hold all the notions used in a requirements specification. Notions are usually nouns from the problem domain that the requirement specification describes. In RSL, such a notion is represented by DomainElement.

Such a DomainElement should include a description (definition) and relations to other DomainElements and phrases containing this DomainElements. For this reason, the RSL’s domain vocabulary is based on the phrase concept. Every DomainElement is described by its wiki-like description (text with hyperlinks relating to other notions or phrases). Its name is a phrase, composed from noun terms (and optionally some modifiers and/or quantifiers). DomainElement also contains a set of phrases referring to this notion. A phrase, in a similar way to a notion, contains its definition in the wiki-like description form.

Every phrase is based on terms existing in a general thesaurus. A thesaurus stores terms with their inflections, classified by their types of speech. These terms are the building blocks for phrases. Terms in a thesaurus are related to their homonyms and synonyms. Such information allows for measuring similarity between phrases composed of such terms. This mechanism makes it possible to use not only identical, but also similar phrases when trying to reuse requirements.

In RSL we need a set of grammars that would allow us to express precise, coherent and well-formulated user requirements. If these grammars are based on a properly structured vocabulary, they ensure separation of concerns (behaviour from the environment description) and guarantee consistency of requirements expressed.

The proposal to use a domain vocabulary structure facilitates creation of other parts of the RSL (behavioural, UI, quiality) through the use of phrases as atomic "lexemes". Any phrase can be perceived as a complex domain vocabulary element. Using phrases as lexemes we can easily define grammars based on such complex elements. For example we can define an SVO(O) sentence (see deliverable D2.1) using just two phrases: a subject phrase and a predicate phrase. Subject can include any noun from a domain vocabulary grouped with its quantifier and modifier (which together form a noun phrase, e.g. *every registered customer*, *authorized user*). Predicate is a more complex phrase, containing a verb and possibly referring to some other notion (it is a noun phrase). Such a VerbPhrase forms the VO (simple verb phrase) or VOO (complex verb phrase pointing also to another notion) part of the sentence. Let's now consider the following example sentences that use the SVO(O) grammar:

- *User submits form.*
- *System adds user to the user list.*
- *Registered customer cancels reservation.*

The first sentence consists of the *user* phrase (a noun with no quantifier or modifier) in the role of a subject and the *submits form* simple verb phrase in the role of a predicate (VO part of the sentence). The second sentence consists of the *system* phrase in the role of a subject and the *adds user to the user list* complex verb phrase (pointing to the *user list* notion) in the role of predicate (VOO part of the sentence). In the third sentence we have an example of a more complex noun phrase *registered customer* (containing a modifier). For more details and examples please refer to Chapter 6

Chapter 5

Discussion

Requirements can be compared to novels in literature. Good novels communicate stories treated as sequences of events, and place these stories in a well described environment. Unfortunately, writing “stories” that describe requirements for software systems seems to be equally as hard as (or harder) than as writing good novels. However, unlike writing novels, lack of coherence and ambiguities may cause disaster when developing a system based on such requirements.

Finding inconsistencies in a set of several tens or hundreds of requirements is quite a hard task, especially, when these requirements are written by different people and at different times. It seems that keeping the vocabulary separate from the rest of the requirements specification can significantly facilitate keeping sparse requirements documents consistent by keeping the vocabulary controlled. This is because most inconsistencies in requirements are caused by contradictory definitions of terms. To eliminate the source of such inconsistencies we introduce a single repository of notions (a vocabulary) that can be used in various requirements. This means that for instance, the behavioural requirements could use definitions already found in the repository and just concentrate on the actual sequence of events.

In addition to the above, having a clearly defined vocabulary makes it possible to introduce certain query mechanisms that would allow for easy retrieval and reuse of requirements. For such mechanisms it is very important to be able to compare requirements. This comparison should be based on a thesaurus where terms with similar meaning are related. It has to be stressed that the language to define vocabularies has to be used in conjunction with a tool. This is necessary as using notions stored in a vocabulary within requirements and keeping it constantly coherent would be very laborious and error-prone if done manually. Thus such a tool would need allow for providing consistency between different requirements using the same notions (notion has the same definition wherever it is used).

Part II

Language Reference

Chapter 6

Domain entities

6.1 Overview

The DomainEntities part defines the domain description aspects of a requirements specification. All terms that are domain related, for instance actors and components of the system under development as well as special actions of actors or the system will be stored in the domain vocabulary.

While this part of the language has a focus on structured language, it also allows basic object-oriented representation of structured domain knowledge in the spirit of UML class diagrams. So, even a simple form of ontology can be represented in this language. Further work on the query mechanism in WP4 and the experiences from industrial applications during ReDSeeDS will show whether extensions of the requirements language would be desirable for supporting a knowledge representation and reasoning approach, which would support the representation of ontologies even better.

The specification in this part of the Requirements Specification Language contains six packages as shown in Figure 6.1.

- The Terms package contains constructs that allow for building a thesaurus of words (terms) that can be used in various requirements specifications. Out of these terms, more complex constructs, like phrases can be built. This is done through the use of hyperlinks to appropriate terms in the thesaurus.

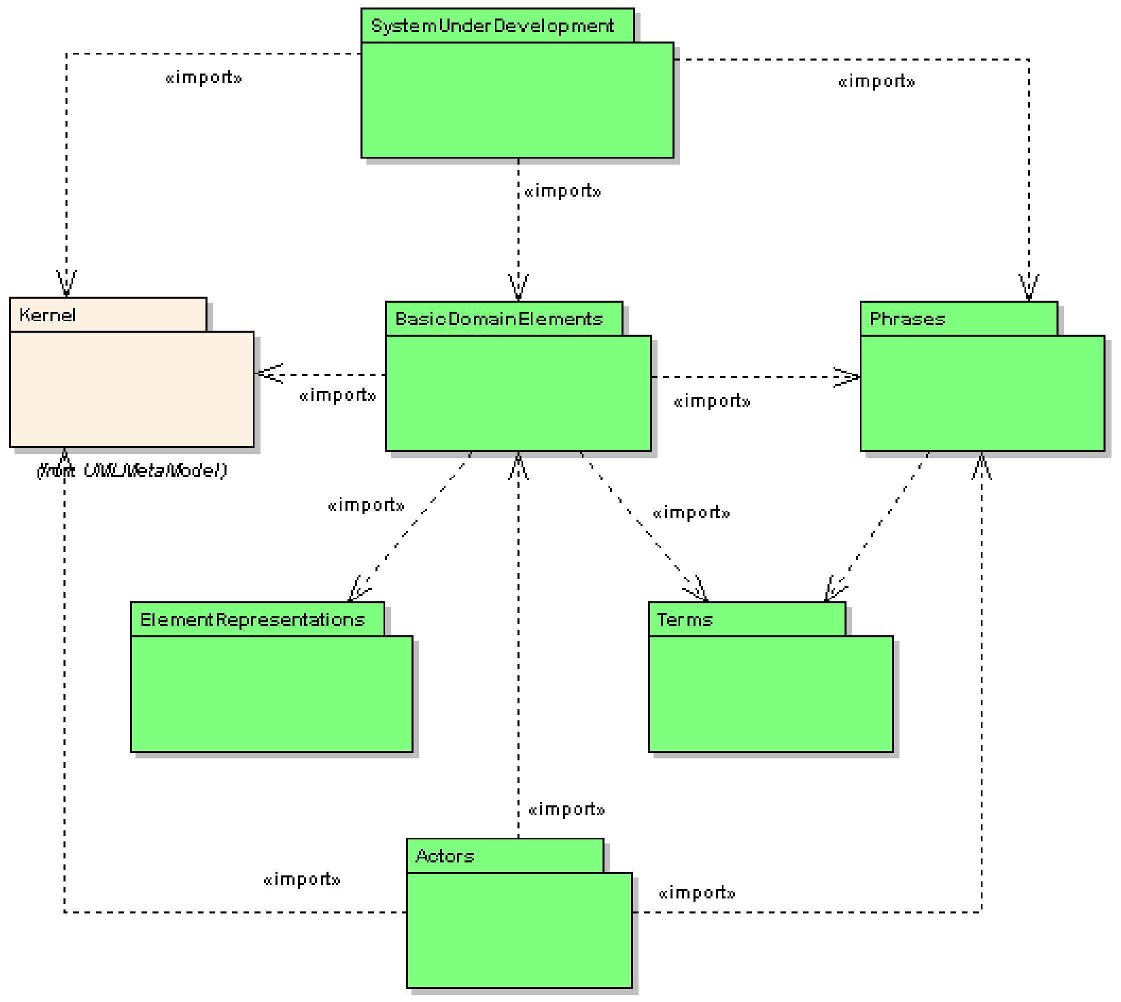


Figure 6.1: Overview of packages inside the DomainEntities part of RSL

- The Phrases package adds to the language important constructs that allow for building parts of sentences in a structured language. Phases of various type are constructed as sets of hyperlinks to appropriate words in the thesaurus.
- The ElementRepresentations package supplies the language with abstract, high level constructs for elements with their representations separated. These elements have names, and their representations contain sets of sentences. Both the names and sentences can contain hyperlinks to terms or phrases.
- The BasicDomainElements package is the basis for the construction of a domain vocabulary. Such vocabularies contain sets of domain elements which define notions existing in the problem domain. These notions have appropriate statements attached which allow for expressing various phrases associated with a given notion. All the vocabulary elements are representable through hyperlinked text. Domain elements can have relationships.

- The Actors package allows for defining actors as part of the domain vocabulary. There can be shown relationships between actors. Actors are representable, and can have descriptions in hyperlinked text.
- The SytemUnderDevelopment package adds to the vocabulary the possibility to express the system and its general components. This does not allow for designing the system but allows for showing those elements of the system that might be used inside requirements specifications.

Generally, the vocabularies defined through our language consist of RepresentableElements which have names and HyperlinkedSentences as descriptions. Since these HyperlinkedSentences may contain Hyperlinks, RerpesentableElements resp. their descriptions that are related to each other are logically connected.

RepresentableElements can be actors, system components, special actions or entities that are domain-related, but not part of the system under development. Hence, the class RepresentableElement is a base class for some more special classes such as Actor, SystemComponent, and DomainElement. Everyone of these classes derived from RepresentableElement may have special associations to other RepresentableElements, for instance the DomainElement called wristband in the fitness-club is associated with the Actor customer as every customer wears a wristband. These associations are modelled with the class DomainElementAssociation and derived ones.

6.2 Basic domain elements

6.2.1 Overview

This package describes the general structure of domain elements as part of RequirementsSpecifications :: RequirementsSpecification. This structure is typical three level package structure. We have the DomainVocabulary class that defines the top level element holding a whole collection of DomainElements (second level) for a specific system. Every DomainElement has to have at least one DomainStatement (third level). DomainStatement is a description of an element of the domain of the system to be developed with its context.
DomainVocabulary can be presented in Package Diagrams that have their syntax derived from UML Package Diagrams. DomainElements are presented in DomainElements Diagrams as simple rectangle icons with their 'name' or rectangle with 'name' and names of DomainStatements included in concrete DomainElement. DomainStatements are presented in a form of source or preview of wiki-like hyperlinked sentence. All these elements can be placed in the Project Tree.

6.2.2 Abstract syntax and semantics

Abstract syntax for the BasicDomainElements package is described in Figure 6.2.

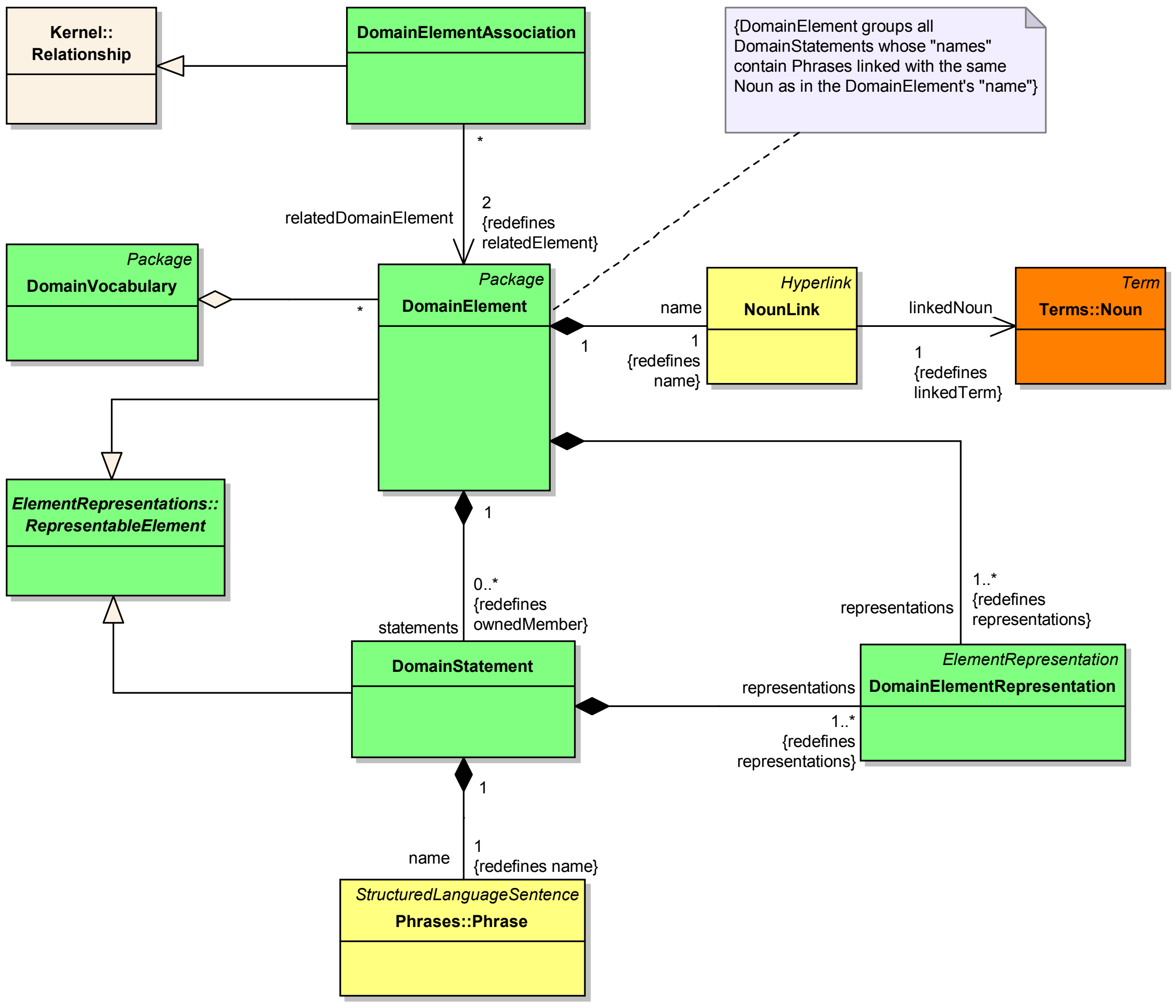


Figure 6.2: Basic domain elements

DomainVocabulary

Semantics. DomainVocabulary is a type of UML Package, i.e. a structure that groups elements and constitutes a container for these elements. It can contain only DomainElements and Actors :: Actors. DomainVocabulary is specific for only one RequirementsSpecification.

Abstract syntax. DomainVocabulary is a specialisation of UML :: Kernel :: Package ([Obj05b]). It can contain many DomainElements.

DomainElement

Semantics. This is a type of a UML Package, i.e. a structure that groups elements and constitutes a container for these elements. DomainElement contains all DomainStatements whose 'name's contain Phrases linked with the same Terms :: Noun as in the DomainElement's 'name'. DomainElements can be related.
Abstract syntax. DomainElement is a specialisation of UML :: Kernel :: Package ([Obj05b]) and ElementRepresentations :: RepresentableElement. It redefines ownedMember. Owned members for the DomainElement must be DomainStatements. It also redefines 'name' with NounLink and representations with DomainElementRepresentation. DomainElements can be related only by DomainElementAssociation.

DomainElementRepresentation

Semantics. This is a representation for elements from package BasicDomainElements (DomainStatement and DomainElement) in form of wiki-like description. It contains set of hyperlinked sentences derived from RepresentableElements :: ElementRepresentation.
Abstract syntax. DomainElementRepresentation is concrete specialisation of RepresentableElements :: ElementRepresentation. It overrides representations for classes from package BasicDomainElements.

DomainElementAssociation

Semantics. DomainElementAssociation denotes relationships between two DomainElements.
Abstract syntax. DomainElementAssociation is a kind of Kernel :: Relationship [Obj05b]. It connects two DomainElements by redefining relatedElement with relatedDomainElement. This relationship is not directed.

NounLink

Semantics. NounLink is a hyperlink that points to the Terms :: Noun used for naming DomainElements.
Abstract syntax. A NounLink is a kind of a BasicRepresentations :: Hyperlink. It is associated with Terms :: Noun and DomainElement.

DomainStatement

Semantics. DomainStatement is a wiki-like description of an element of the domain of the system to be developed with its context - noun with modifiers, verbs and other nouns. DomainStatements are grouped in DomainElement.

Abstract syntax. DomainStatement is a specialization of ElementRepresentations :: RepresentableElement. It redefines 'name' with Phrases :: Phrase. DomainStatements are contained in DomainElement.

6.2.3 Concrete syntax and examples

DomainVocabulary. The concrete syntax is similar to Kernel :: Package, described in the UML Superstructure (in [Obj05b], paragraph 7.3.37, page 104): "A package is shown as a large rectangle with a small rectangle (a 'tab') attached to the left side of the top of the large rectangle. (...) Members may also be shown by branching lines to member elements, drawn outside the package. A plus sign (+) within a circle is drawn at the end attached to the namespace (package). (...)" In addition to the above Kernel :: Package description, name of DomainVocabulary package is inside rectangle situated in the center of the large rectangle. It can also be presented in a tree structure with a minimized icon. See Figure 6.3 for examples of concrete syntax in a Package Diagram and in a Project Tree structure with a minimized icon, respectively.

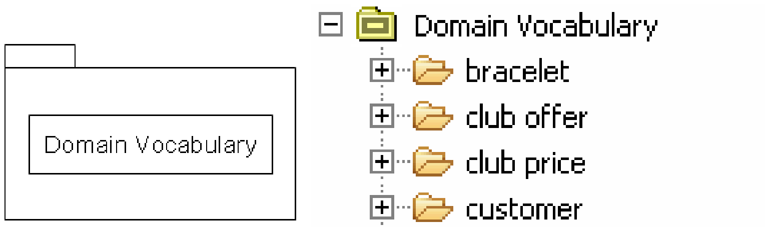


Figure 6.3: DomainVocabulary example, normal and tree view

DomainElement. The basic representation of DomainElement is denotated by a rectangle with its name inside it (see Figure 6.5). Another form of representation is a rectangle divided into two parts by a horizontal line. The name of DomainElement is placed in the upper part. The bottom part includes hyperlinked names of DomainStatements, each in its own rectangle (see Figure 6.6). DomainElements can be presented in s diagram as both of their forms of representation. DomainElement can also be presented as a tree structure with a minimized icon. An example of concrete syntax for the tree view of DomainElement can be found in Figure 6.4.

DomainElementRepresentation. is a description of DomainElement. Its concrete syntax depends on the context in which DomainElementRepresentation is presented to the user. It can

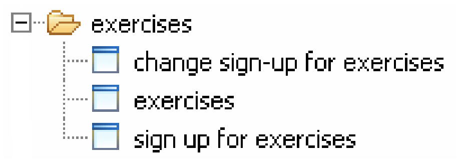


Figure 6.4: DomainElement tree view example

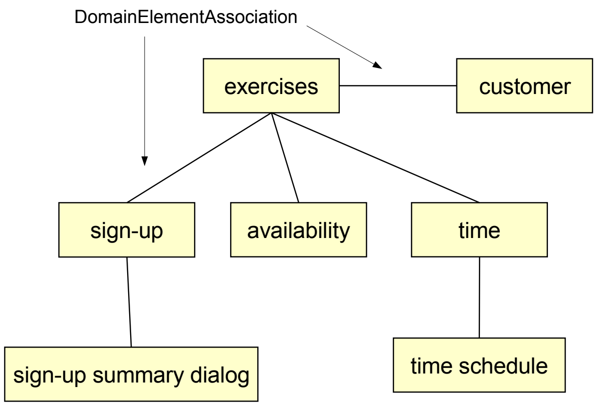


Figure 6.5: DomainElement's diagram example

be represented in the form of a purely textual "source", or in a "preview" form of sentences with underlined wiki-like links. In source, DomainElementRepresentation consists of text with a double pair of square brackets ("[[]]") surrounding text to be hyperlinked in preview mode. In preview, contained BasicRepresentations :: Hyperlinks are represented as coloured and underlined text (see Figure 6.7).

DomainElementAssociation. is presented as a line connecting two ordered SVOScenarioSentence. See Figures 6.5, 6.6 for examples of concrete syntax in a Domain Element Diagram.

NounLink. Concrete syntax is inherited from the BasicRepresentations :: Hyperlink meta-class.

DomainStatement. Concrete syntax includes the name of DomainStatement as a hyperlink to Phrases :: Phrase or one of its subclasses and description as NaturalLanguageHypertext. It can be represented in the form of a source or preview of wiki-like hyperlinked sentence. Example of concrete syntax of DomainStatement can be found in Figure 6.8.

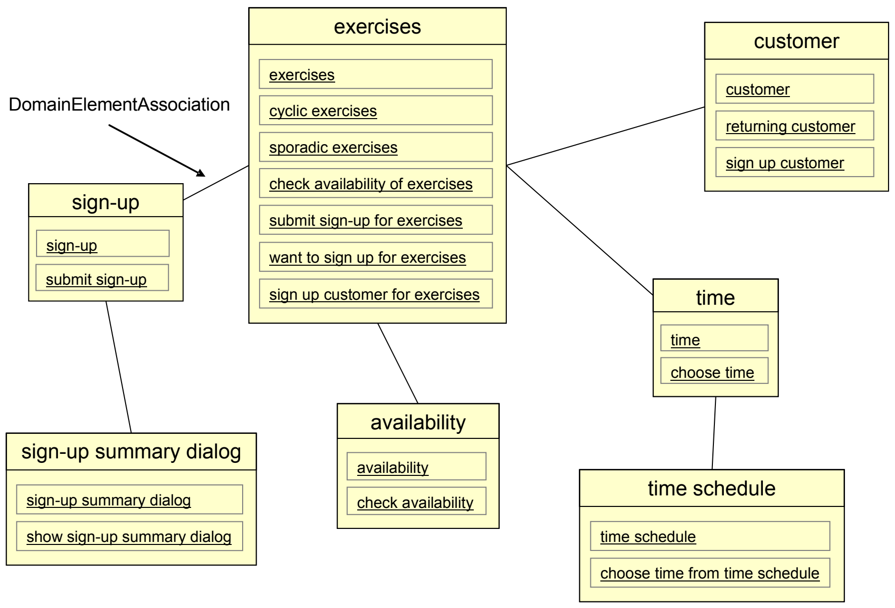
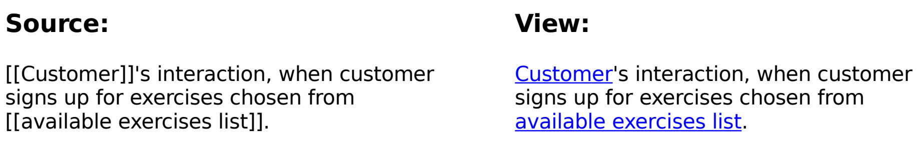


Figure 6.6: DomainElement's diagram example


Source:

[[Customer]]'s interaction, when customer signs up for exercises chosen from [[available exercises list]].

View:

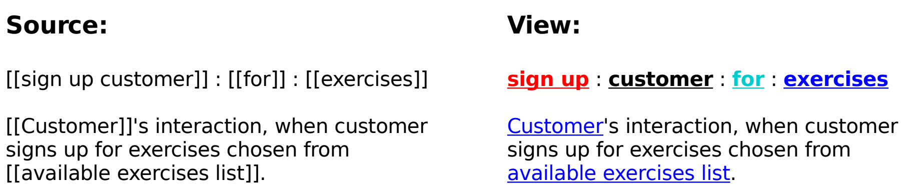
Customer's interaction, when customer signs up for exercises chosen from available exercises list.

Figure 6.7: DomainElementRepresentation's concrete syntax example

6.3 Actors

6.3.1 Overview

This package contains that part of the RSL metamodel that deals with the representation of actors in the requirements specification. Actors are for instance "customer" or "fitness club employee", they can be refered in every type of requirement representation.


Source:

[[sign up customer]] : [[for]] : [[exercises]]

[[Customer]]'s interaction, when customer signs up for exercises chosen from [[available exercises list]].

View:

sign up : **customer** : **for** : **exercises**

Customer's interaction, when customer signs up for exercises chosen from available exercises list.

Figure 6.8: DomainStatement example

6.3.2 Abstract syntax and semantics

The diagram in Figure 6.9 describes the RSL part that is related to actor. The two classes Actor and ElementActorAssociation which are introduced in this Figure are described in the following sections.

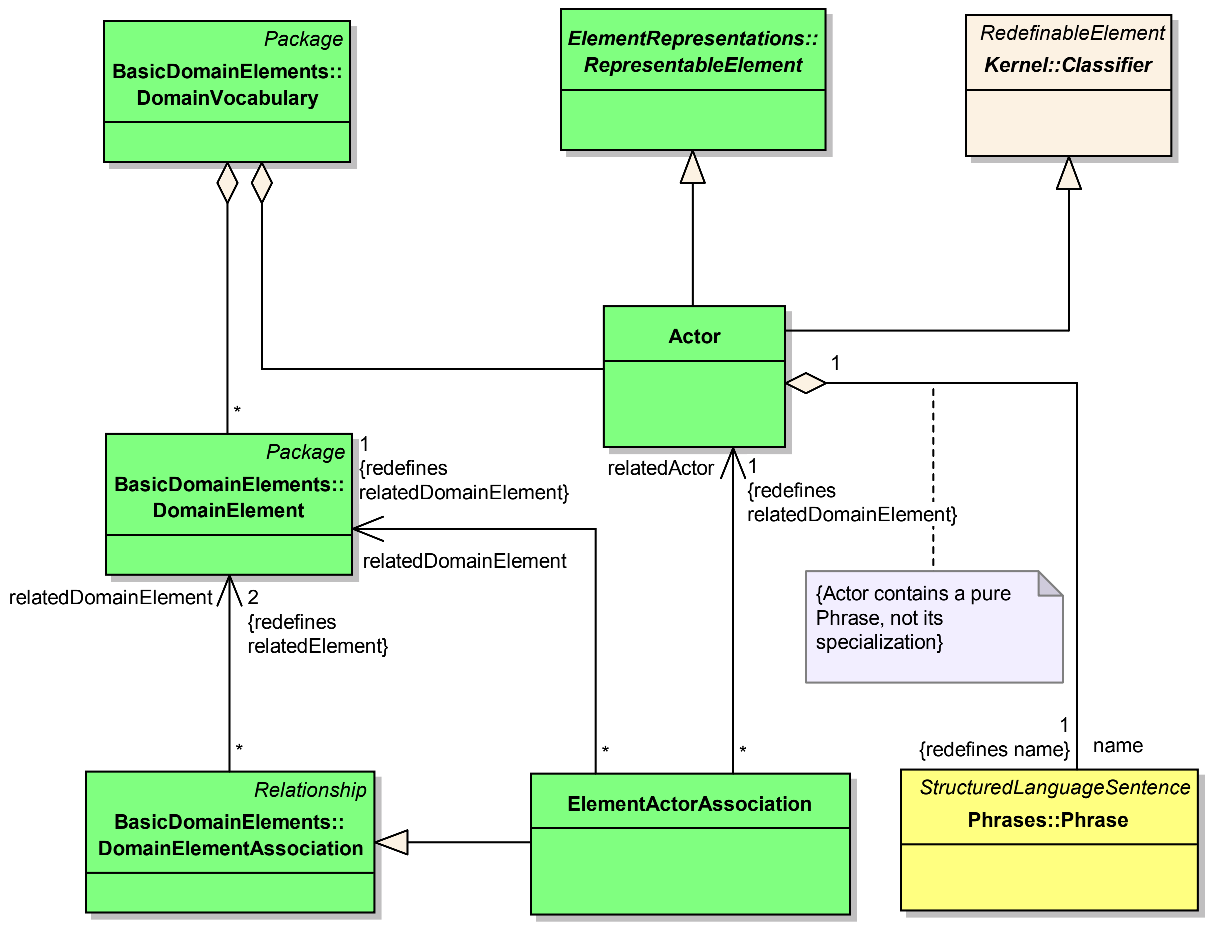


Figure 6.9: Actor metamodel part

Actor

Semantics. This class is the most important class in this package. Every actor that is referred to in the requirements specification is modelled as an instance of Actor. If requirements for a fitness club system are specified, actors may for instance be “customer”, “system administrator”, or “staff member”. Actors participate in scenarios and use cases on the one hand, but they may also be referred to in other functional and even non-functional requirements.
Abstract syntax. The class Actor is derived from the classes Classifier from the UML 2.0 Superstructure and ElementRepresentations :: RepresentableElement. The aggregation to BasicRepresentations :: HyperlinkedSentence, which specifies the name of a ElementRepresentations ::

RepresentableElement is redefined, thus the name of an Actor may only be a Phrases :: Phrase. The constraint is added to this redefined aggregation because an actor's name should be for example "a customer" but not a Phrases :: VerbPhrase like "take". Actors can be associated with other elements through ElementActorAssociations, as described below Since Actors are domain specific, they are part of the BasicDomainElements :: DomainVocabulary.

ElementActorAssociation

Semantics. An ElementActorAssociation models the relationship between an Actor and other domain specific entities in the BasicDomainElements :: DomainVocabulary.
Abstract syntax. ElementActorAssociations base-class is BasicDomainElements :: DomainElementAssociation, which models the relationship between any two BasicDomainElements :: DomainElements. Since the ElementActorAssociation should only be used to model the relationship between one Actor and one BasicDomainElements :: DomainElement, the inherited association to BasicDomainElements :: DomainElement is redefined as two associations, one to Actor and one to BasicDomainElements :: DomainElement, each of them needing exactly one instance of Actor perBasicDomainElements :: DomainElement to participate.

6.3.3 Concrete syntax

Actor. An Actor occurring in an interaction or a use case representation is depicted as a stylised stick figure (see Figure 6.10), though not only a person can be an actor, but also external software systems interacting with the system in development. The actor's 'name' is written below the stick figure.

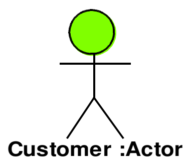


Figure 6.10: The concrete syntax of an actor.

ElementActorAssociation. This class models a relationship between an Actor and some other BasicDomainElements :: DomainElements. This element can for instance be a noun like "wristband" if a fitness club software system gets specified. In schematic requirement representations, the ElementActorAssociation is modelled as a solid line from the stick figure representing the Actor to the BasicDomainElements :: DomainElement the Actor is associated with. In textual representations, the ElementActorAssociation are not explicitly modelled.

6.4 System representations

6.4.1 Overview

This package contains the part of the RSL meta-model that deals with the representation of the system under development and its components in the requirements specification. If the system under development is the fitness club software system, its components are for instance "terminal" or "database".

6.4.2 Abstract syntax and semantics

The diagram in Figure 6.11 describes the part of RSL that is related to system representation. The three classes SystemUnderDevelopment, SystemComponent, and ElementSystemAssociation introduced in this Figure are described in the following sections.

SystemComponent

Semantics. This class is the most important class in this package. Every part of the system that is referred to in the requirements specification is modelled as an instance of SystemComponent. If requirements for a fitness club system are specified, system components may for instance be "terminal", "database", or "reception computer". System components can be referred in functional and non-functional requirements.
Abstract syntax. The class SystemComponent is derived from the classes Classifier from the UML 2.0 Superstructure and the class ElementRepresentations :: RepresentableElement. SystemComponent is the base class for SystemUnderDevelopment. The aggregation to BasicRepresentations :: HyperlinkedSentence, which specifies the name of a ElementRepresentations :: RepresentableElement, is redefined, thus the name of a SystemComponent may only be a Phrases :: Phrase. The constraint is added to this redefined aggregation because a system's name should be for example "terminal" but not a Phrases :: VerbPhrase like "take". SystemComponents can be associated with other elements through ElementSystemAssociations, as described below. Since SystemComponents are domain specific, they are part of the DomainVocabulary.

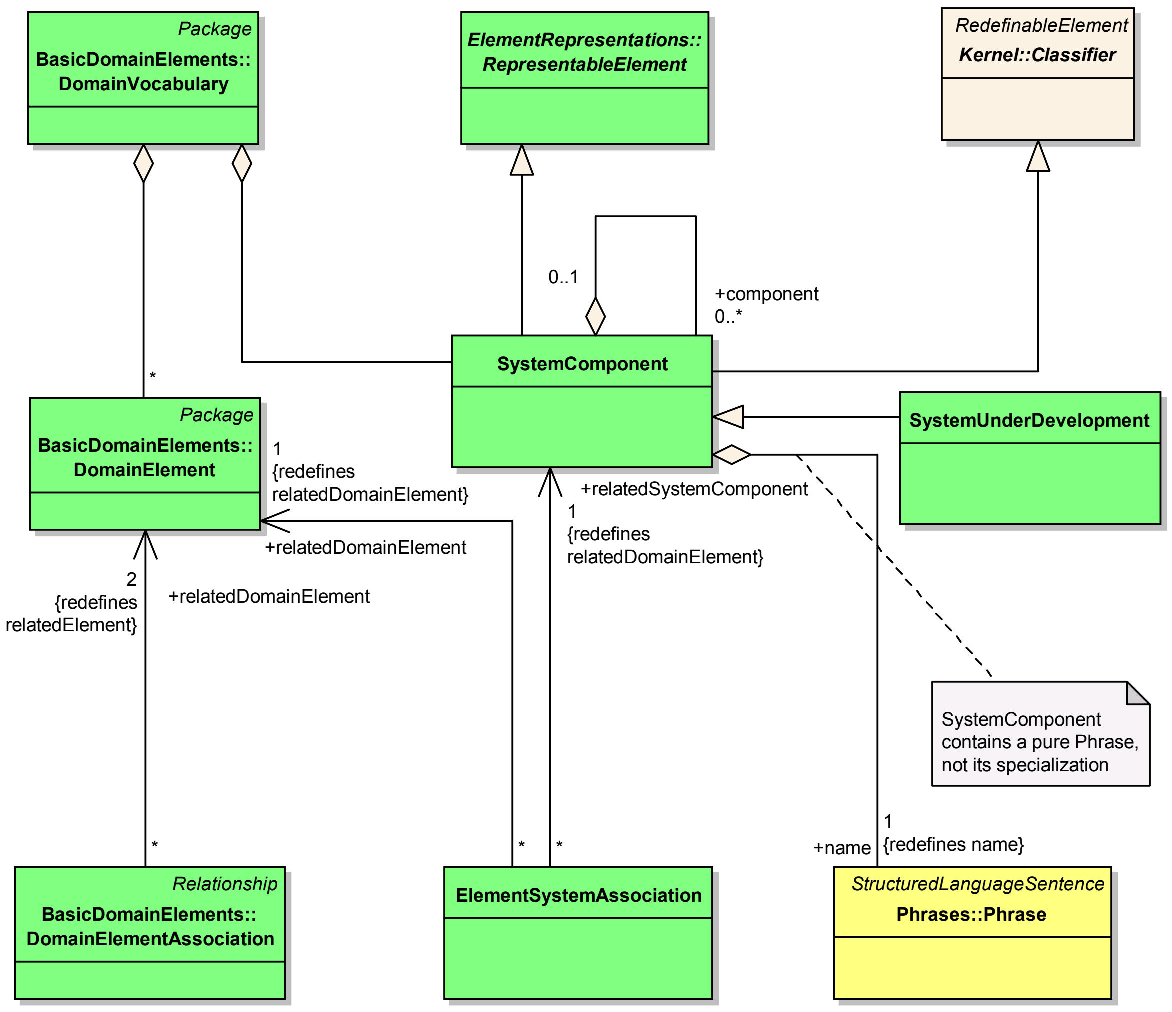


Figure 6.11: System representations

SystemUnderDevelopment

Semantics. The class SystemUnderDevelopment represents the whole system under development as a black box. It can be used in all kinds of requirement representations, especially if requirements on all parts of the system are modelled or if modelling is on a coarse granularity.
Abstract syntax. SystemUnderDevelopment is derived from SystemComponent, so it inherits all associations from SystemComponent. Since SystemUnderDevelopment depicts the whole system under development, it may not be part of another SystemComponent, as the constraint in the diagram indicates. Another restriction is the cardinality at the aggregation to DomainVocabulary, since there is exactly one SystemUnderDevelopment during the requirements specification process, it must be exactly one SystemUnderDevelopment in the DomainVocabulary.

ElementSystemAssociation

Semantics. An ElementSystemAssociation models the relationship between a SystemComponent and other domain specific entities in the DomainVocabulary.
Abstract syntax. The base class of ElementSystemAssociation is the class DomainElementAssociation, which models the relationship between any two DomainElements. Since the ElementSystemAssociation should only be used to model the relationship between one System and one DomainElement, the inherited association to DomainElement is redefined as two associations, one to System and one to DomainElement, each of them needing exactly one instance of System per DomainElement to participate.

6.4.3 Concrete syntax

SystemComponent. A SystemComponent occuring in an interaction or a use case representation is depicted as a rectanglular UML object (see Figure 6.12). The Phrases :: Phrase that defines the name of the SystemComponent is written in the rectangle. If a SystemComponent is refered to in a textual description, it is represented only by the Phrases :: Phrase that defines its name.

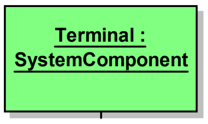


Figure 6.12: The concrete syntax of an system component.

SystemUnderDevelopment. As SystemUnderDevelopment is the SystemComponent at a very coarse granularity, its concrete syntax is exactly the same as for SystemComponent.

ElementActorAssociation. This class models a relationship between a SystemComponent and some other DomainElements. This element can for instance be a noun like “wristband” if a fitness club software system gets specified. In a schematic representation, the ElementSystemAssociation is modelled as a solid line from the rectangle representing the SystemComponent to the DomainElement the System is associated to. In textual descriptions, this association is not explicitly modelled.

6.5 Element representations

6.5.1 Overview

The package ElementRepresentations contains the classes RepresentableElement and Element-Representation that model the basic representation of domain-specific elements. These domain specific elements are for instance actors, components of the system under development or other terms from the problem domain that the requirement specification is describing. This section describes only that part which all those element representations have in common; the specific parts are described in the other sections of this chapter.

6.5.2 Abstract syntax and semantics

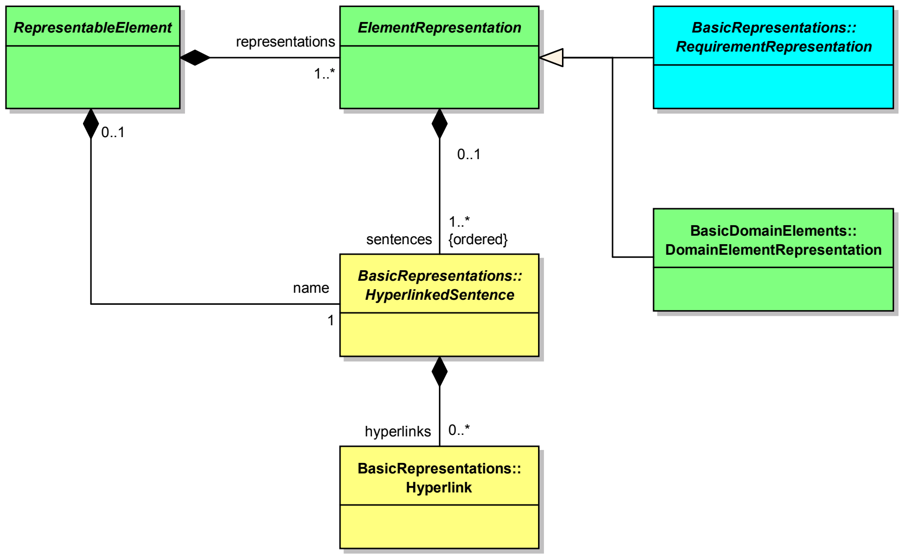


Figure 6.13: Entity representations

The diagram in Figure 6.13 shows the abstract syntax of the classes in the package ElementRep-resentations. The following sections explain semantics and abstract syntax for the two recently introduced classes RepresentableElement and ElementRepresentation.

RepresentableElement

Semantics. Every entity that is related to the system under development is represented by a RepresentableElement and has a name. Since such elements can be represented in different ways, every element has at least one representation.

Abstract syntax. RepresentableElement is the abstract base class for all elements related to the system under development that are represented in the requirements specification, such as RequirementSpecification :: Requirement, DomainElements :: DomainElement or Actors :: Actor. Every RepresentableElement has a name, which is a BasicRepresentations :: HyperlinkedSentence, so it may contain BasicRepresentations :: Hyperlinks that refer to Phrases :: Phrases and Terms::Terms in the thesaurus. In addition to the name, the RepresentableElement is represented by at least one ElementRepresentation, as the aggregation between these two classes indicates.

ElementRepresentation

Semantics. Every ElementRepresentation is one possible representation of a RepresentableElement. Due to this, a RepresentableElement may contain one or more representations. All those representations in the requirement specification, for instance InteractionRepresentations :: ActorLifeline, which is introduced in section 7.7 “ScenarioRepresentation” of D2.1 “Behavioural Requirements Language Definition”, are derived from ElementRepresentation.

Abstract syntax. The class ElementRepresentation is the base class for all representations such as e.g. BasicRepresentations :: RequirementsRepresentation or InteractionRepresentations :: ActorLifeline. The aggregation to BasicRepresentations :: HyperlinkedSentence shows that a ElementRepresentation contains BasicRepresentations :: HyperlinkedSentences, but as the way these aggregation is realized differes from representation to representation, it is redefined in most of them. These sentences are typically ordered and may be used to build up the textual description of the element the ElementRepresentation describes, but there are also other types of containment relations between ElementRepresentation and BasicRepresentations :: HyperlinkedSentence, for instance in the InteractionRepresentations :: InteractionScenario described in D2.1 “Behavioural Requirements Language Definition”, chapter 7.

6.5.3 Concrete syntax

RepresentableElement. ElementRepresentation. These classes are abstract, and they do not introduce any concrete syntax.

6.6 Phrases

6.6.1 Overview

The Phrases package contains language entities that allow for formulating phrases in a structured language. These Phrases represent Terms :: Nouns associated with other Terms (Terms :: Verbs, Terms :: Adjectives). A generic Phrase is always put in the context of a Terms :: Noun (is part of a BasicDomainElements :: DomainElement) and is (possibly) associated with a Quantifier and/or Modifier. Another kind of Phrase is VerbPhrase which describes the context of Verb.

6.6.2 Abstract syntax and semantics

Abstract syntax in this package is presented in Figure 6.14.

Phrase

Semantics. Phrase describes an expression involving a given Terms :: Noun.
Abstract syntax. Phrase is a kind of RepresentationSentences :: StructuredLanguageSentence. Phrase consists of an Object (a BasicRepresentations :: Hyperlink to a Terms :: Noun) and optionally a Terms :: Modifier and a Terms :: Quantifier (BasicRepresentations :: Hyperlinks to special types of Terms :: Term). It represents the “name” of a BasicDomainElements :: DomainElement by pointing to a Terms :: Noun and is associated with other Terms (Terms :: Modifier, Terms :: Quantifier) through BasicRepresentations :: Hyperlinks. Phrase contains a hyperlinked description. It is used for referencing the vocabulary of different requirement representations (controlled grammars, wiki-like descriptions).

VerbPhrase

Semantics. This expression describes an operation that can be performed in association with the Object described by a Terms :: Noun.
Abstract syntax. VerbPhrase is an abstract kind of Phrase. It exists in two concrete classes: SimpleVerbPhrase and ComplexVerbPhrase.

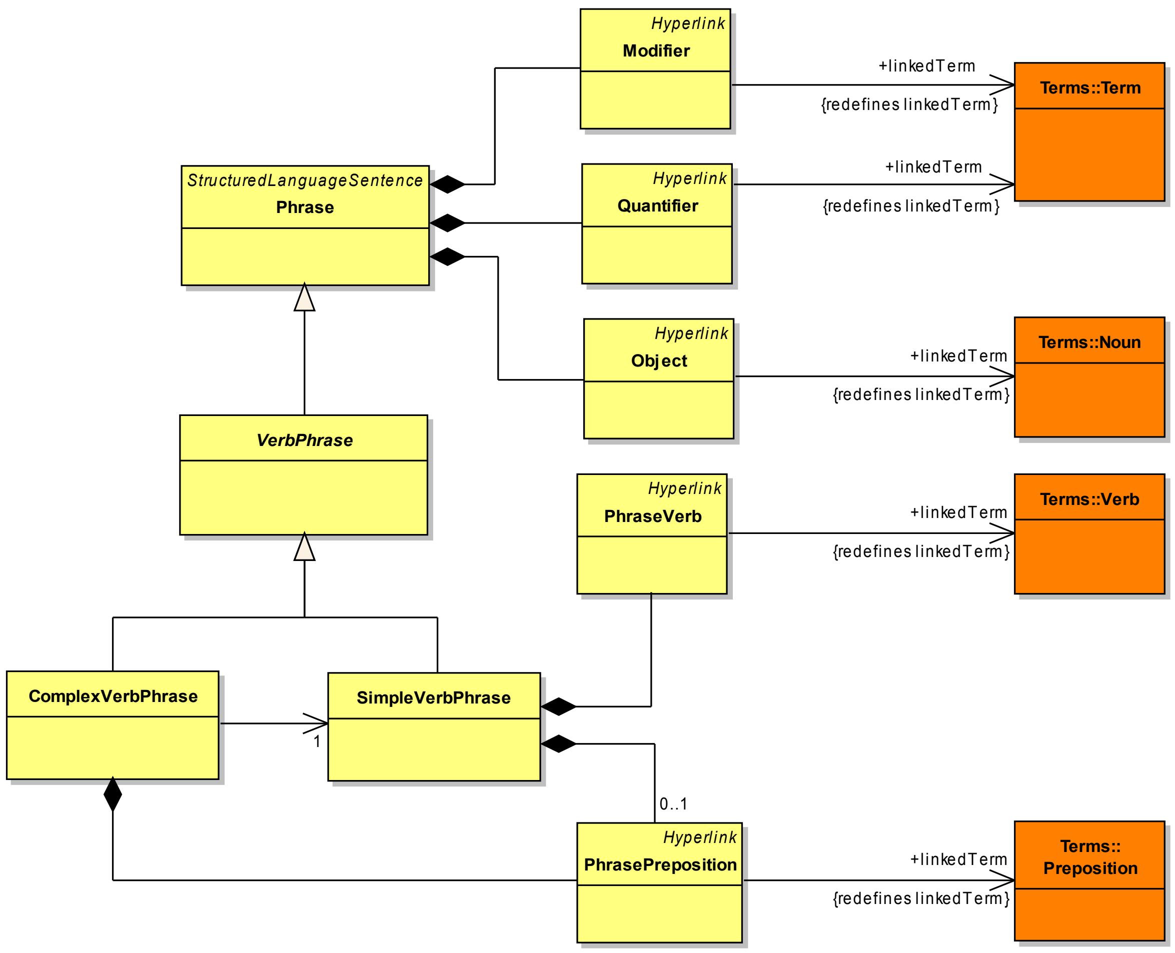


Figure 6.14: Phrases

SimpleVerbPhrase

Semantics. SimpleVerbPhrase has the semantics of VerbPhrase and can be used as the **VO** part in an SVOSentences :: SVOSentence.
Abstract syntax. SimpleVerbPhrase, in addition to a Phrase, includes a PhraseVerb (BasicRepresentations :: Hyperlink to a Terms :: Verb). SimpleVerbPhrase is a concrete subclass of VerbPhrase.

ComplexVerbPhrase

Semantics. ComplexVerbPhrase can be used as **VOO** (SVOSentences :: SVOSentence with direct and indirect object) part in an SVOSentences :: SVOSentence. ComplexVerbPhrase

describes a behavioural relation between a direct and an indirect object.
Abstract syntax. ComplexVerbPhrase extends SimpleVerbPhrase with an additional Terms :: Noun (indirect object). It is a kind of VerbPhrase pointing to the other BasicDomainElements :: DomainElements's SimpleVerbPhrase. It includes also a PhrasePreposition. ComplexVerbPhrase is a concrete subclass of VerbPhrase.

Modifier

Semantics. A Modifier combines with Object and indicates how it should be interpreted in the surrounding context. In this way it creates a Phrase that distinguishes this Object's meaning from its main vocabulary entry.
Abstract syntax. Modifier is a kind of a BasicRepresentations :: Hyperlink. It points to the Terms :: Term used as a Modifier in a given Phrase.

Quantifier

Semantics. A Quantifier combines with Object and indicates how they should be interpreted in the surrounding context in terms of quantity and variability, that is the extent to which Noun holds over a range of things. In this way it creates a Phrase that distinguishes this Object's meaning from it's main vocabulary entry.
Abstract syntax. Quantifier is a kind of a BasicRepresentations :: Hyperlink. It points to the Term :: Term used as a Quantifier in a given Phrase.

Object

Semantics. An Object is a type of a BasicRepresentations :: Hyperlink that points to the Terms :: Noun specific for this Object's Phrase.
Abstract syntax. Object is a kind of a BasicRepresentations :: Hyperlink.

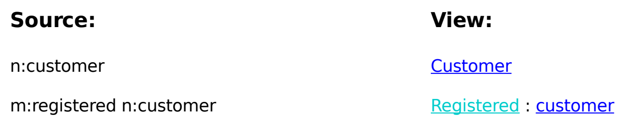
PhraseVerb

Semantics. A PhraseVerb is a type of a BasicRepresentations :: Hyperlink that points to the Terms :: Verb specific for this Phrase.
Abstract syntax. PhraseVerb is a kind of a BasicRepresentations :: Hyperlink.

PhrasePreposition

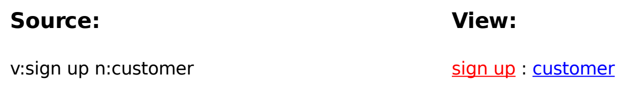
Semantics. A PhrasePreposition is a type of a BasicRepresentations :: Hyperlink that points to the Terms :: Preposition used to connect SimpleVerbPhrases with ComplexVerbPhrases.
Abstract syntax. PhrasePreposition is a kind of a BasicRepresentations :: Hyperlink.

6.6.3 Concrete syntax and examples



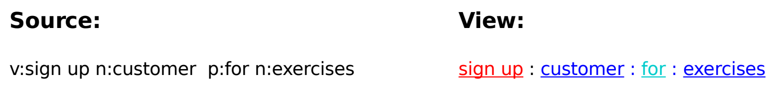
Source:	**View:**
n:customer	Customer
m:registered n:customer	Registered : customer

Figure 6.15: Phrase concrete syntax examples



Source:	**View:**
v:sign up n:customer	sign up : customer

Figure 6.16: SimpleVerbPhrase concrete syntax examples



Source:	**View:**
v:sign up n:customer p:for n:exercises	sign up : customer : for : exercises

Figure 6.17: ComplexVerbPhrase concrete syntax examples

Object. PhraseVerb. PhrasePreposition. Their concrete syntax is inherited from the BasicRepresentations :: Hyperlink meta-class.

Phrase. SimpleVerbPhrase. ComplexVerbPhrase. Their concrete syntax depends on the context in which phrases are presented to the user. They can be represented in a form of source or preview of wiki-like hyperlinked sentence. In the source form, they consist of element's names preceded by a letter with a colon (":") indicating this element type ("n:" for noun (Object), "m:" for Modifier, "q:" for Quatifier, "v:" for PhraseVerb, "p:" for PhrasePreposition). In preview form, they are represented as coloured hyperlinks to appropriate elements separated with colons (see Figures 6.15, 6.16, 6.17).

6.7 Terms

6.7.1 Overview

This package describes Term and its relationship to Thesaurus. Thesaurus is a kind of highly structured conceptual dictionary, common for all vocabularies. It contains morphological information of terms, with their forms (cases, inflections, etc.) and semantic information. Currently the TermSpecialisationRelation as well as HasSynonym and HasHomonym relations are seen as the main semantic information.

The TermSpecialisationRelation structures the terms in a taxonomical hierarchy. This semantic definition is organisation-specific and is specified by extending the term structure (see Figures 6.20 and 6.21 for an example).

Every term is a distinguished part of speech. Note that "term" is not necessarily a single word (eg. some modal verbs – see note on the Diagram 6.18). We also treat phrasal verbs as Verb class objects. Terms from Thesaurus are used for building Phrases.

6.7.2 Abstract syntax and semantics

Figure 6.18 shows the specialisation hierarchy of the different types of Terms, which are ConditionalConjunction, ModalVerb, Verb, Noun, Modifier, Quantifier and Preposition. Additionally, this figure introduces two bi-directional relations that can be defined between two Terms, namely HasHomonym and HasSynonym.

Figure 6.19 also contains all the above mentioned specialisations of Term. This figure focuses on the relationships that can be defined between two terms of the same type (only in between two Nouns, between two Verbs, etc.). All relations are specialisations of TermSpecialisationRelation and thus define a directed taxonomic relation.

Figures 6.20 and 6.21 show the abstract syntax of a thesaurus with domain-specific extensions (for ProDV related terms in this case). Figure 6.20 depicts the noun related part of the thesaurus, while Figure 6.21 shows the verb related part respectively.

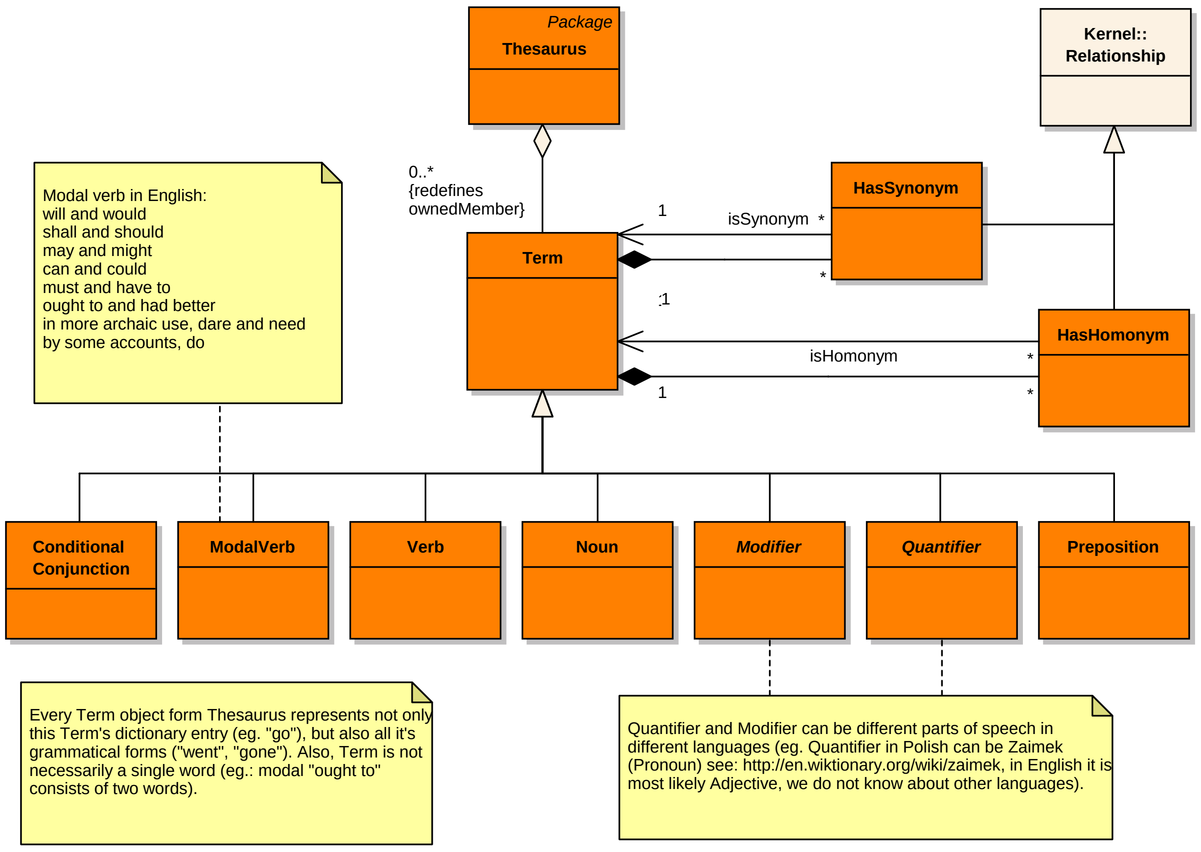

Package
Thesaurus
Kernel::
Relationship
Modal verb in English:
will and would
shall and should
may and might
can and could
must and have to
ought to and had better
in more archaic use, dare and need
by some accounts, do
0..*
{redefines
ownedMember}
1
isSynonym *
HasSynonym
*
Term
1
isHomonym
*
HasHomonym
*
1
Conditional Conjunction
ModalVerb
Verb
Noun
Modifier
Quantifier
Preposition
Every Term object form Thesaurus represents not only this Term's dictionary entry (eg. "go"), but also all it's grammatical forms ("went", "gone"). Also, Term is not necessarily a single word (eg.: modal "ought to" consists of two words).
Quantifier and Modifier can be different parts of speech in different languages (eg. Quantifier in Polish can be Zaimek (Pronoun) see: http://en.wiktionary.org/wiki/zaimek, in English it is most likely Adjective, we do not know about other languages).

Figure 6.18: Thesaurus, Term and its specialisations.

Term

Semantics. Term is a unit of language that native speakers can identify as a meaning-coherent notion. It is a block from which a phrase is made. A Term usually has different grammar forms.
Abstract syntax. Term has a 'name' attribute. Terms are grouped in a Thesaurus.

Thesaurus

Semantics. Thesaurus is a structure containing all the Terms, with their forms, inflexions, cases etc. as well as their relations between each other. These relations define the semantics of the Terms.
Abstract syntax. Thesaurus is a kind of Package. It contains Terms.

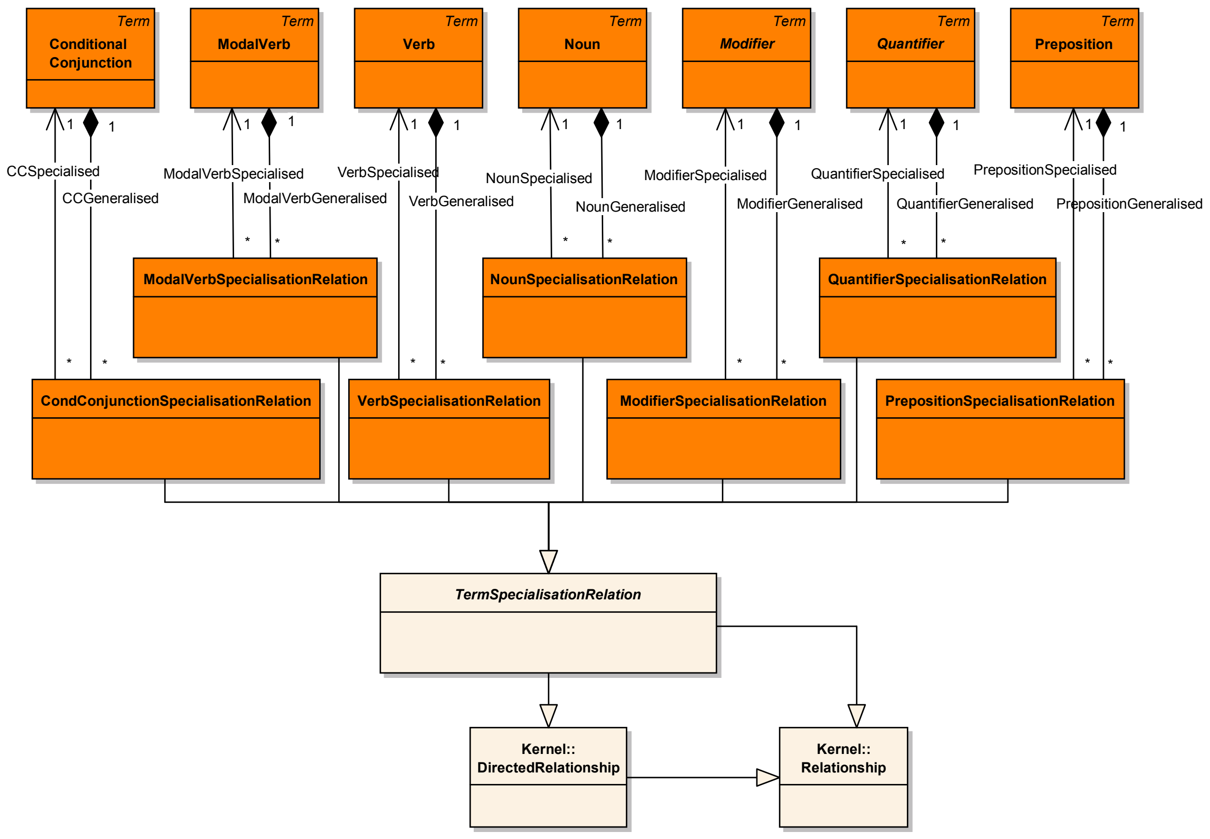


Figure 6.19: Specialisation Relations of terms from the same type.

Conditional Conjunction

Semantics. A Conditional Conjunction is a Thesaurus element used for combining two sentences into a conditional or state descriptive structure.
Abstract syntax. Conditional Conjunction is a kind of a Term.

ModalVerb

Semantics. A Modal Verb (also modal, modal auxiliary verb, modal auxiliary) is a type of auxiliary verb that is used to indicate a provision of syntax that expresses the predication of an action, attitude, condition, or state other than that of a simple declaration of fact.
Abstract syntax. ModalVerb is a kind of Term.

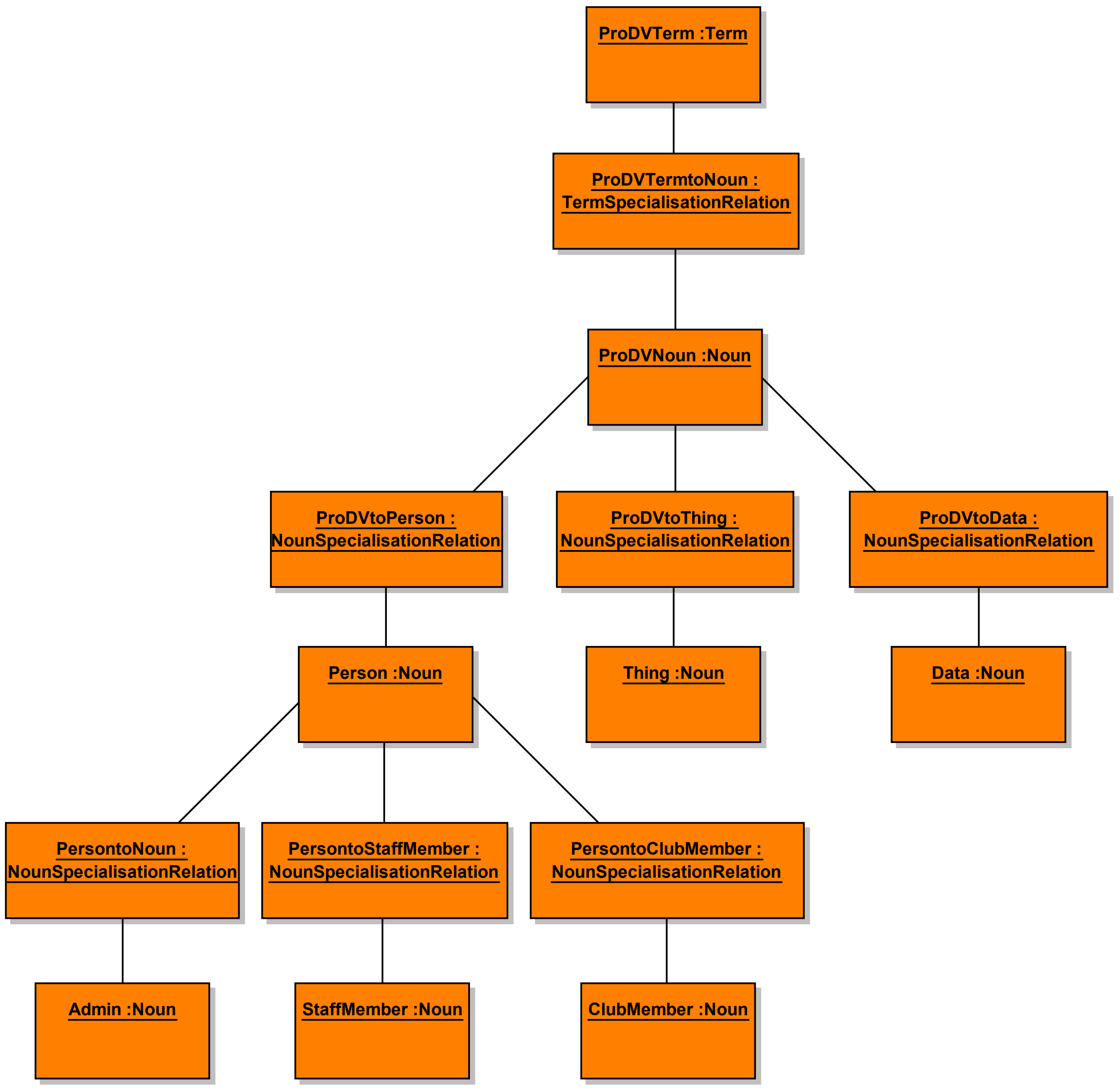

ProDVTerm :Term
ProDVTermtoNoun : TermSpecialisationRelation
ProDVNoun :Noun
ProDVtoPerson : NounSpecialisationRelation
ProDVtoThing : NounSpecialisationRelation
ProDVtoData : NounSpecialisationRelation
Person :Noun
Thing :Noun
Data :Noun
PersontoNoun : NounSpecialisationRelation
PersontoStaffMember : NounSpecialisationRelation
PersontoClubMember : NounSpecialisationRelation
Admin :Noun
StaffMember :Noun
ClubMember :Noun

Figure 6.20: Part of a Thesaurus in abstract syntax with organisation-specific extension (only Nouns are presented in this figure.)

Modifier

Semantics. A Modifier is a type of Term that combines with Noun and indicates how it should be interpreted in the surrounding context. Modifier can be different parts of speech in different languages (eg. Modifier in Lithuanian can be adjective, pronoun, pronoun+adjective, participle, pronoun+participle, in Polish it is an Adjective sourcing from a Noun).

Abstract syntax. Modifier is a kind of a Term. It is an abstract class.

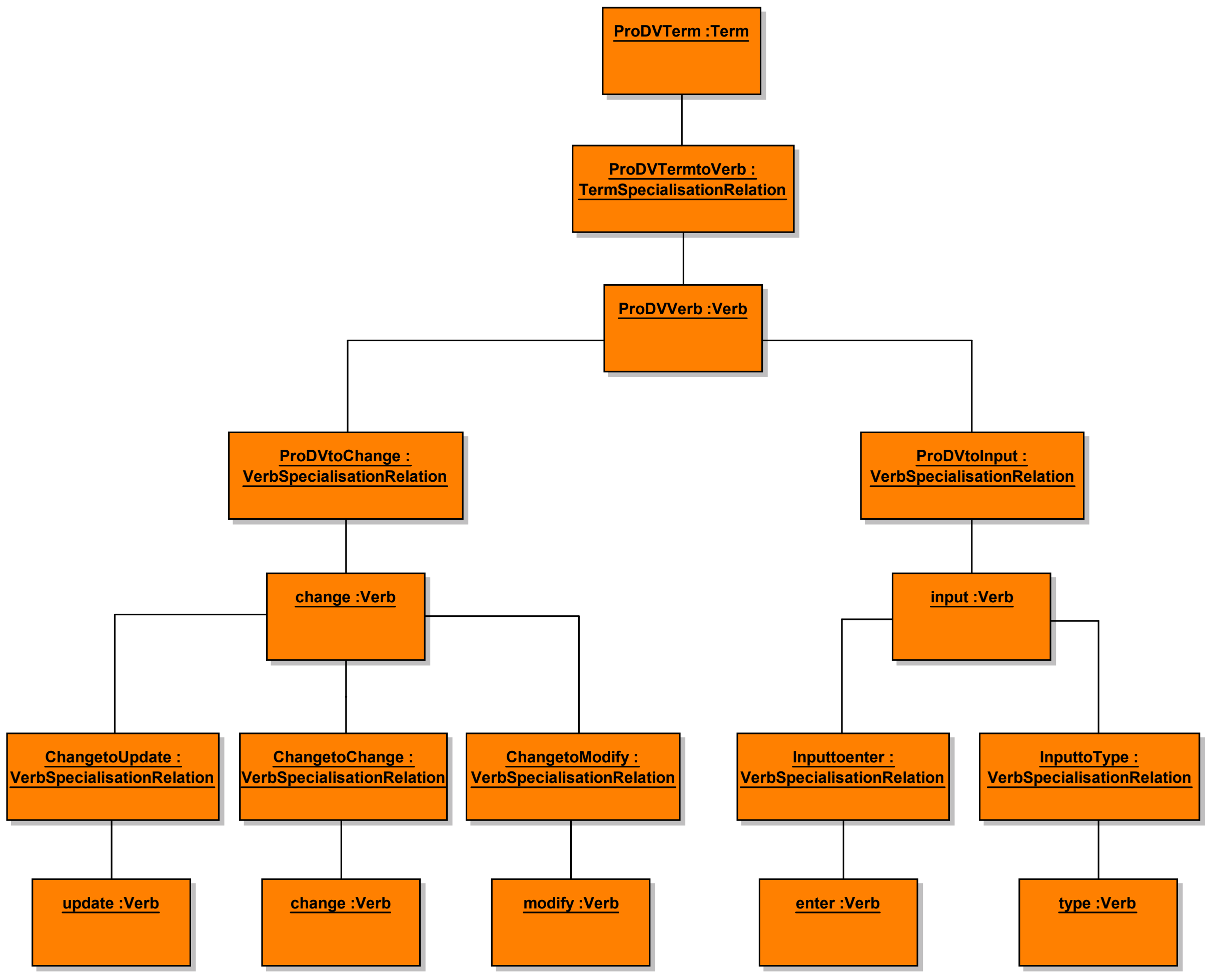

ProDVTerm :Term
ProDVTermtoVerb : TermSpecialisationRelation
ProDVVerb :Verb
ProDVtoChange : VerbSpecialisationRelation
ProDVtoInput : VerbSpecialisationRelation
change :Verb
input :Verb
ChangetoUpdate : VerbSpecialisationRelation
ChangetoChange : VerbSpecialisationRelation
ChangetoModify : VerbSpecialisationRelation
Inputtoenter : VerbSpecialisationRelation
InputtoType : VerbSpecialisationRelation
update :Verb
change :Verb
modify :Verb
enter :Verb
type :Verb

Figure 6.21: Part of a Thesaurus in abstract syntax with organisation-specific extension (only Verbs are presented in this figure.)

Quantifier

Semantics. A Quantifier is a type of Term that combines with Noun and indicates how they should be interpreted in the surrounding context in terms of quantity and variability, that is the extent to which Noun holds over a range of things. Quantifier can be different parts of speech in different languages (eg. Quantifier in Polish can be Zaimek (Pronoun), in English it is most likely an Adjective).
Abstract syntax. Quantifier is a kind of Term. It is an abstract class.

Noun

Semantics. A Noun is a type of Term that names objects (a person, place, thing, quality, action or data).
Abstract syntax. Noun is a kind of Term.

Preposition

Semantics. A Preposition is a type of Term that combines with Phrases :: Phrases and indicates how they should be interpreted in the surrounding context.
Abstract syntax. Preposition is a kind of Term.

Verb

Semantics. A Verb is a type of a Term that expresses action or state of being.
Abstract syntax. Verb is a kind of a Term.

TermSpecialisationRelation

Semantics. TermSpecialisationRelation is an abstract class that defines semantics for all other relation classes in this package other than HasHomonym and HasSynonym. TermSpecialisationRelation inherits concrete syntax form DirectRelationship. The subclasses of TermSpecialisationRelation are: CondConjunctionSpecialisationRelation, ModalVerbSpecialisationRelation, NounSpecialisationRelation, ModifierSpecialisationRelation, QuantifierSpecialisationRelation, PrepositionSpecialisationRelation. These relations define specific specialisation relations for the diverse types of terms. Those subclasses ensure that the source and the target of the relationship are of the same kind of Term. The source of each such relationship should be different from its target - Term cannot be associated with itself.
Abstract syntax. TermSpecialisationRelation is a kind of DirectRelationship from the UML :: Kernel package [Obj05b].

CondConjunctionSpecialisationRelation

Semantics. A CondConjunctionSpecialisationRelation relates one ConditionalConjunction (as the source of the relationship) to another ConditionalConjunction (the target of the relationship).
Abstract syntax. CondConjunctionSpecialisationRelation is a kind of TermSpecialisationRelation.

ModalVerbSpecialisationRelation

Semantics. A ModalVerbSpecialisationRelation relates one ModalVerb (as the source of the relationship) to another ModalVerb (the target of the relationship).
Abstract syntax. ModalVerbSpecialisationRelation is a kind of TermSpecialisationRelation.

NounSpecialisationRelation

Semantics. A NounSpecialisationRelation relates one Noun (as the source of the relationship) to another Noun (the target of the relationship).
Abstract syntax. NounSpecialisationRelation is a kind of TermSpecialisationRelation.

ModifierSpecialisationRelation

Semantics. A ModifierSpecialisationRelation relates one Modifier (as the source of the relationship) to another Modifier (the target of the relationship).
Abstract syntax. ModifierSpecialisationRelation is a kind of TermSpecialisationRelation.

QuantifierSpecialisationRelation

Semantics. A QuantifierSpecialisationRelation relates one Quantifier (as the source of the relationship) to another Quantifier (the target of the relationship).
Abstract syntax. QuantifierSpecialisationRelation is a kind of TermSpecialisationRelation.

PrepositionSpecialisationRelation

Semantics. A PrepositionSpecialisationRelation relates one Preposition (as the source of the relationship) to another Preposition (the target of the relationship).
Abstract syntax. PrepositionSpecialisationRelation is a kind of TermSpecialisationRelation.

HasHomonym

Semantics. A HasHomonym relates two Terms that have the same character string as "name" attribute but that have different meanings.
Abstract syntax. HasHomonym is a kind of Relationship from UML :: Kernel package [Obj05b]. HasHomonym inherits concrete syntax form Relationship.

HasSynonym

Semantics. A HasSynonym relates two Terms that have the same meaning but a different character string as "name" attribute.
Abstract syntax. HasSynonym is a kind of Relationship from UML :: Kernel package [Obj05b]. HasSynonym inherits concrete syntax form Relationship.

6.7.3 Concrete syntax and examples

Term. It is a string of letters and white spaces having a logical meaning in a specific natural language. *Examples (for English):* "car", "buy", "look for", "buy ticket button", "at", "must", "every".

Thesaurus. It is a semantic structure that holds Terms. This structure should allow for semantic-based reuse of organisation-specific Terms as well as browsing the Thesaurus contents by Phrases :: Phrase names and Verbs associated with Phrases :: Phrases. The concrete syntax is equivalent to the concrete syntax of the DomainVocabulary (compare Figure 6.22 and Figure 6.3) which is based on Kernel :: Package. More important is the tree view presentation of the Thesaurus as depicted in Figure 6.23. Please note that the tree view depicts only the specialisation relations. Therefore the thesaurus itself is not shown.

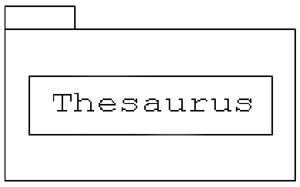


Figure 6.22: Package view: thesaurus's concrete syntax.

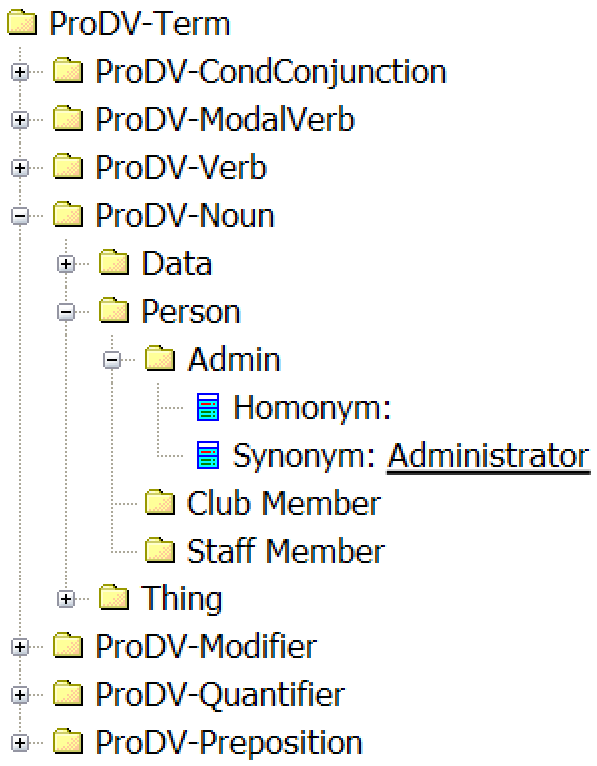


Figure 6.23: Thesaurus tree view example

Conditional Conjunction. It is a string of letters and white spaces used in formulating conditional or state descriptive clauses. *Examples (for English):* "if", "when", "upon", "after", "during".

ModalVerb. It is a string of letters and white spaces used in formulating a modal form. *Examples (for English):* "will"/"would", "shall", "should", "may"/"might", "can"/"could", "must", "have to", "ought to".

Modifier. As an abstract meta-class, it has no concrete syntax. It can be formulated in any of those representations of the meta-classes that derive from it. The derivatives of Modifier should have their concrete syntax as a string of letters and white spaces used in formulating a Noun's context. *Examples (for English):* "**registered** user", "**selected** window"

Quantifier. As an abstract meta-class, it has no concrete syntax. It can be formulated in any of those representations of meta-classes that derive from it. The derivatives of Quantifier should have their concrete syntax as a string of letters and white spaces used in formulating a Noun's context. *Examples (for English):* "every", "all", "no", "none of"

Noun. It is a string of letters and white spaces used in formulating an objects' description. *Examples (for English):* "user", "system", "buy ticket button", "accessibility", "saving"

Preposition. It is a string of letters and white spaces used in formulating Phrases :: Phrases' context. *Examples (for English):* "on", "of", "to", "for", "inside", "next to", "in accordance with"

Verb is a string of letters and white spaces used in formulating an action description. *Examples (for English):* "add", "show", "save", "start", "provide", "look for", "choose between"

TermSpecialisationRelation. This relationship between two Terms is depicted as a package with a subpackage in the tree view of the thesaurus (see Figure 6.23). Homonyms and Synonyms are presented for each term (see Figure 6.23).

Chapter 7

Conclusion

This deliverable presents a novel requirements specification language, more precisely its structural part. This language is special because of its explicit inclusion of objects existing in the domain (environment) of the software system to be built — *domain objects*. While the representation of a Domain Model (to-be) makes use of standard UML, which is still allowed, additional descriptions are possible in a newly defined representation of vocabulary. This facilitates a better understanding of the requirements per se. Our language is the first requirements specification language intimately integrated with UML and defined using the same meta-modelling approach as used for UML itself (using MOF). This deliverable also presents and explains the structural part of this language definition, from abstract down to concrete syntax.

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