Utilizing Inheritance in Requirements Engineering

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INTRODUCTION
Specifying the requirements of a new system to be built is one of the most important parts of the life cycle of any project. In the field called requirements engineering many approaches have been proposed [1]. However, few methods and tools have been available for practical use. In fact, for the early phase of defining the requirements, nearly no support is available.

While from a theoretical point of view it would be desirable to have formal representations of requirements, in practice unstructured natural language is often used informally. Our approach attempts to bridge the gap between these extremes in providing semiformal hypertext representations. Therefore, our approach and the tool supporting it are named RETH (Requirements Engineering Through Hypertext). Actually, RETH uses a combination of various technologies, including object-oriented approaches and artificial intelligence (in particular frames). We do not attempt to exclude or replace formal representations, but try to complement and to provide means for gradually developing them.

The scope of this paper is the utilization of inheritance for requirements specification, i.e., the tasks of analyzing and modeling the domain, as well as forming and defining requirements.

Among others, RETH has been applied in the CERN (Conseil Européen pour la Recherche Nucléaire) Cortex project. While it would be impossible to explain this project in detail here, it should be sufficient to know that it deals with a generic distributed control system. Since this project is not finished yet, it is difficult to state its size precisely. In order to give an idea, its final goal is to substitute the many existing similar control systems at CERN by this generic approach. Currently, RETH is also tested using real-world requirements for the Pastel Mission Planning System at ESOC in Darmstadt.

First, we outline how hypertext is integrated into a frame system in our approach. Moreover, we demonstrate the usefulness of inheritance as performed by the tool RETH. We then summarize our experiences of utilizing inheritance in the Cortex project. Lastly, we relate RETH to existing work.

HYPERTEXT INTEGRATED INTO A FRAME SYSTEM
A hypertext node is represented as a frame in our approach. (The original notion of a frame was coined by Minsky [2], but the frame systems implemented the original ideas only partially. In the context of this paper, a frame can be viewed as a data structure that combines data stored in slots.) According to the differences between object-oriented languages and frame systems as discussed in [3, 4], we selected the frame system of PROKAPPA as the basis of our tool RETH.

Our approach of integrating hypertext into a frame system is similar to the one described and used by Kaindl and Snaprud [5, 6] for knowledge acquisition in the course of building knowledge-based (expert) systems. One distinctive feature lets the user define disjoint partitions of nodes that together cover the whole node. Such a partition of a hypertext node is comparable to a slot of a frame. The idea is to support the user in partitioning the textual content in a machine recognizable form, serving as an additional means of introducing more formality.

In order to make the example below understandable, we shortly sketch the hypertext user...
interface of RETH (see Fig. 1 showing a screen dump). The presentation level handles hypertext links as follows: if the underlined string representing the link is clicked with the mouse, the window of the target node is displayed by the tool. The arrows in the figure are drawn to indicate the effect of following links on the screen. The windows shown in the figure actually popped up one at a time.

In contrast, the display of partitions of hypertext nodes is implemented in our tool like expand buttons (cf. the hypertext system Guide [7]). When the name of a partition (inverted in the display) is clicked, the content is expanded or shrunk (implemented as a toggle). E.g., in the window at the top of Fig. 1 the partition DDE: Service Realization is currently shrunk, while Aggregation: Consists of Action(s) is expanded. In contrast to many hypertext systems, our approach lets users mix browsing and editing of nodes, though one node can either be edited or browsed at one point in time.

INHERITANCE IN REQUIREMENTS SPECIFICATION

Due to lack of space, we cannot describe here the details of using RETH for domain analysis and modeling, and for the formation and definition of requirements. The key ideas are to represent requirements as objects, and to organize these objects as well as the objects of the domain model in a taxonomy. Within this taxonomy, inheritance can be used in several ways (see below). Hypertext links are used to interlink the hypertext nodes representing the objects. For a detailed description, the interested reader is referred to [8].

Due to our tight integration of hypertext in a frame system, inheritance can be used already in the semiformal representation. There is a notable difference between frame systems and object-oriented languages relevant for our approach: in contrast to the latter, the former also support inheritance of values [3, 4]. Since classes (of the domain model as well as of requirements) are described in hypertext nodes, and since these are represented as frames, the text contained in them is inherited.

Together with the concept of partitions of nodes, inheritance supports templates, e.g., for requirements to be filled in. Whenever a node for a requirement is created as an instance of a class of requirements, the appropriate structure is already given initially through inheriting a template. Inherited partitions in the (requirements) instances provide for the representation of information on requirements such as their source, reason and priority.

Detailed information about requirements is especially important for large projects, but without sufficient tool support it is often omitted. Since all the instances inherit all the respective partitions, providing such information cannot be forgotten, and the user of the system just has to fill in the text.

When requirements are organized in classes, all the requirements of a specific class can have a special attribute in common — represented as a partition. Moreover, whole classes of requirements (defined by the user) can have the same value (text) of an attribute, and this value can be defined once in the description of the class. The subclasses and instances inherit this value, but inherited information can also be overridden.

An important point is that inheritance allows one to define special attributes (including a value
or not) once in the definition of the class, without
the necessity to copy. Even more important is the
possibility of re-inheriting changed values.

In contrast to most current OOA tools, RETH
implements OOA inheritance already in the semi-
formal hypertext representation (see also Fig. 1).

EXPERIENCE WITH RETH IN THE
CORTEX PROJECT

According to our experience in the real-world
project Cortex, all the features of our method and
its supporting tool were useful to some extent.
In fact, some of them were worked out in detail
in the course of this application. Due to lack of
space, we will only focus here on the utilization
of inheritance.

The templates of requirements depending on
their class helped to point out missing informa-
tion. Actually, much of it was known by the
people involved, but we found it important to get
it written down.

Moreover, we would like to point out specifi-
cally the usefulness of domain-specific require-
ments classes, and the use of inheritance within
the corresponding taxonomy. They allowed the
explicit ordering of the requirements according
to the classification principle. While this is of
course not a new principle for ordering require-
ments, our approach and the tool provide inheri-
tance. Therefore, it was possible and very useful
to specify information such as priorities once for
whole classes. When the priority of a class of re-
quirements changes, it is only necessary to specify
this once — in the corresponding partition of the
node representing this class. The nodes repre-
senting requirements subclasses and instances of
this class re-inherit this changed value.

Another interesting example of the use of inheri-
tance that we came across during the work
on Cortex is illustrated in Figs. 1 and 2 (in the
notation of [9]). An Action is part of a Ser-
vice_Realization. Since a Composite_Action, e.g.,
is an Action, it is also part of a Service_Realization.
This inference has to be drawn by the viewer of the
O-O diagram but is made automatically via inheri-
tance in RETH. In the bottom window of Fig. 1,
the inherited partition Aggregation: Part of Ser-
vice Realization (i) shows this. Moreover, inheri-
tance points to the fact that a Composite_Action
is (potentially) also part of a Composite_Action
(see the inherited partition Aggregation: Part of
Composite_Action (i) in the bottom window of
Fig. 1). Especially this kind of inference may
be difficult for people not so familiar with recur-
sive structures in O-O diagrams. Of course, the
diagram has its advantages, too. Therefore, both
forms of representation are complementary in our
view.

RELATED WORK

Due to lack of space we cannot give here a
comprehensive overview of all the proposed ap-
proaches to requirements engineering. Especially
for the traditional ones, the interested reader is
referred to [1]. Recent OOA approaches (for
an overview see [10]) challenge the traditional
ones. RETH heavily builds on object-oriented
ideas. However, most of today's OOA methods
still ignore early development phases where im-
portant clarifications have to be made. It may
even be argued that they are designed for a dif-
ferent phase. RETH specifically focuses on the
early phase, and we propose to combine RETH
with object-oriented analysis approaches.

The method by Jacobson et al. [11] and the
tool supporting it (Objectoly) bear some similar-
ity to our approach. However, it does not apply
object-oriented principles to the organization of
the requirements, and consequently inheritance
cannot be utilized (e.g., for templates).

Since RETH's internal representation is based
on frames, it may be interesting to compare it with
other approaches to requirements engineering using
artificial intelligence (AI) technology. GIST
[12] is an important early approach. RML [13]
emphasizes the use of knowledge representation
techniques of AI and domain modeling. Telos
[14] is a derivative of RML. RA [15] shares with
RETH the focus on a transition between infor-
mal and formal representations. The approach
of ARIES [16] is quite similar to RA in being
very knowledge-intensive. KBRA [17] utilizes
hypertext ideas internally. While RETH's user
interface for structuring text appears to be more
developed, some of KBRA's features of machine support could be very useful in RETH. However, KBRA lacks several important features of RETH.

CONCLUSION

In summary, our tool-supported method named RETH supports several activities in the course of requirements specification. Our approach of organizing the hypertext according to object-oriented principles has several advantages. Representing requirements as objects helps when structuring them via classification. Inheritance is provided by our tool already in the early phase of requirements specification, which helps to avoid redundant representation of information. In particular, it provides users automatically with templates of the internal structure of requirements, that depends on the kind of requirement. This way, the users are guided to fill in important information like the reason and priority of each requirement. While RETH is not intended to substitute useful existing techniques emphasizing more formal representations, it can be combined with them.

Since the advantages of such an approach to requirements engineering cannot be fully utilized without more elaborate traceability of the requirements, we also investigate how to best link requirements objects with design objects.

The usefulness of RETH to space projects is currently assessed using real-world requirements for the Pastel Mission Planning System at ESOC in Darmstadt. While it is too early for a final statement at the time of this writing, the preliminary results are encouraging. Since RETH is very general in terms of application areas, we could not find any reason why the application to space projects should be a problem.

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References


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