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Abstraction Guides: Interrelating Conceptual Models with Real World Scenes

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Abstract. The role of the requirements engineer is to establish a complete consistent and unambiguous requirements specification which defines the requirements at a conceptual level. Many traditional modelling approaches from Structured Analysis [6], [14] to UML-based methods [7] supporting him in this task neglect the use of concrete examples about current or future system usage.

In this paper, we present so called Abstraction Guides which assist the requirements engineer in establishing and applying an interrelating structure between conceptual models and persistent recorded usages of existing systems called Real World Scenes (RWS). This structure is used to improve traceability, understandability and negotiation of conceptual models. We show how Abstraction Guides define support for eliciting requirements from RWS, validating requirements against RWS, explanation of conceptual models, and comparing scenes and models.

1 Introduction

In 1984 McMenamin and Palmer [11] argued that one has to consider the history and functionality of the existing system when building a new one (see also Gause and Weinberg [8]). There are two main reasons for this: a) the new system has to provide to a large degree the functionality of the old system; b) one can learn a lot from the success stories and pitfalls of the existing system; thereby to make failures twice could be avoided. The quality of the current state model obviously depends on the knowledge elicited from stakeholders; i.e. it heavily depends on the successful stakeholder involvement in the requirements engineering process. To achieve better involvement of different stakeholders the use of rich media (e.g. video, pictures, screen dumps, speech etc.) to record and discuss current system usage is proposed, e.g. by participatory design techniques ([10], [3], [12], [9], [2]). Rich media like video provide intuitive means for capturing observation about the usage of the current system. Among others, advantages of using video are a better understanding of the usage domain, focused observation of (temporal and/or spatial) distributed aspects, avoidance of presumptuous abstractions, repeatability of results, better understanding, and the possibility for late reflections (see e.g. [3] or [9]).

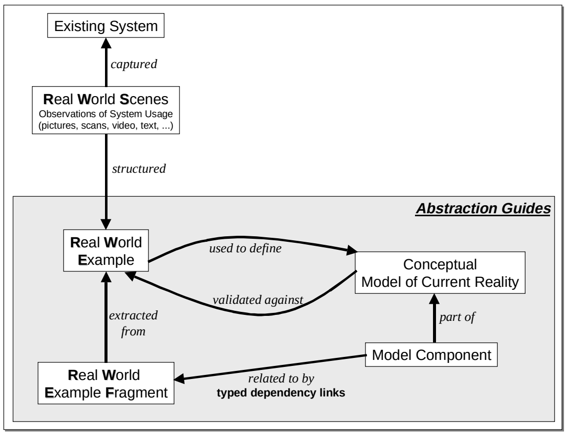

Fig. 1: Abstraction Guide: Supporting the Interrelation of Real World Example Fragments with Model Components

In this paper, we present so called *Abstraction Guides*, which support the requirements-engineer in the definition of a current state model based on real world scenes. A *real world scene (RWS)* is the captured observation material of a current system usage. Because RWS gathered during an observation can contain information about many system usages, we propose to pre-structure this material into what we call *real world examples (RWE)* that represents exactly **one** system usage. The material belonging to a real world example should be arranged in a suitable manner, e.g. if the observation was recorded using video, the video should be cut in a way where it shows the temporal sequence of a sample system usage.

Real world examples are used for two main purposes: On the one hand, existing current state models can be validated against the real world examples. On the other hand, new concepts can be elicited from the real world examples. In both cases, we propose to interrelate the corresponding fragments of the real world examples with the concepts of the current state model. The requirements engineer has therefore to select the corresponding fragment of the real world scene and to indicate the dependency type, which should be created between this part and the component of the current state model. Establishing the *real world example fragments (RWEF)* and the typed dependency links during the requirements engineering process successively establishes a formal structure for the real world examples. This structure can be used for

- *explanation of the current state model components with the real world examples* which caused their creation respectively have been used for their validation to people which are not trained in formal modelling, to ease the training of people joining the project, but also to assure a better model understanding during the whole system development lifecycle;
- *comparison of different real world examples*, because given tasks can be performed by different stakeholders in a large variety of ways, or the implementation of a given objective differs. We aim in comparing different real world examples using the current state model, i.e. using the goal model which describes the objectives to be achieved by the system;

- *reviewing of conceptual models by other stakeholders* in a structured way helping the reviewer in justifying and commenting on the abstractions made by the model builder; in addition we support comparison of multiple viewpoints created during reviewing and further refinement by different stakeholders.

A prerequisite for achieving this is the fine-grained interrelation of the components of the current state model to the fragment of the real world scene that caused their definition.

We argue to define a goal model of the various observations first. In contrast to the data, behaviour, and functional description, a goal model is more abstract and thus better suited for a first comparison of different observations. Goal models focus on *why* systems were constructed rather than with *what features* [1], [15]. Concentrating on the goals facilitates the detection of commonalities between different real world examples that would otherwise be obscured by the conceptualisation of totally different incarnations. Thus, an agreement about the observed phenomena is easier to gain when focusing on goals. If detailed knowledge about the achievement of a particular goal is required, a more detailed conceptual model can be created. Such re-modelling or detailing can be supported if the goals are related to the corresponding parts of the captured observations. Moreover, establishing a goal structure in the first place and defining a more detailed conceptual current state model whenever required, reduces effort and time to be spent and is thus more cost effective.

In contrast to approaches of participatory design (SEP [10], Xerox Parc [3], [12], and Contextual Inquiry [9], [2]) mentioned earlier, which are often parts of ethnographic and user-centred design approaches providing detailed method descriptions for preparing and performing real world observations and how to interpret the results captured on video and other recording means, we concentrate our efforts on providing support for relating real world examples with conceptual models, especially goal models, once the observation and recording is performed. Here, we will show how fine-grained interrelationships are used in applications that have been neglected and not supported by the ethnographic approaches, as well as other multimedia-based approaches like AMORE [5], [13] or Raison d'Etre [4]. Further, approaches in literature neglect the fact that the abstractions performed for analysing real world examples are always personal interpretations of the analyst. Different stakeholders may have different interpretations. Therefore, it is necessary to support several stakeholders in eliciting and validating conceptual models as well as reviewing the others interpretations against the examples and then to be able to display differences between them. These problems are not recognised and featured by any of the approaches cited, because they only consider one interpretation of real world observations.

The rest of this paper is structured as follows. At first Sect. 2 introduces the types of relationships defined for Abstraction Guides. Then three facets of Abstraction Guides are presented in Sect. 3–5. Finally, we draw the conclusions and give a brief outlook to future work in Sect. 6.

2 Relationships between Goals and Real-World Examples

The objective of an Abstraction Guide is to provide a set of method chunks[1] for creating an interrelating structure between real world example fragments (RWEF) and conceptual models in the form of sets of typed dependency links. This imposes on the one hand, access paths upon the real world examples; i.e. a set of real world example fragments typed by the incident links is gained from initially totally unstructured multimedia material. On the other hand, the goal model is annotated by a set of real world evidences, which are close to the perception of the involved stakeholders. For goal model components and RWEFs we provide the following dependency types:

- `Attains`: An RWEF is interpreted by an analyst as an example of how the current system attains a goal.
- `Fails`: An RWEF is interpreted by the analyst as an example that shows a bad, unwanted or a to be avoided attempt of attaining a goal which results in its failure.
- `Positive`: distinguishes the subset of RWEFs that show the most preferred way of attaining a goal (strengthening of `Attains`, see Sect. 3.3).
- `Negative`: Similarly, we may want to state that a set of RWEFs shows the most illustrative ways of failing to achieve a goal (strengthening of `Fails`).

Due to the small amount of link types defined between the goal model and the real world examples, we are able to distinguish differences between relations set-up by different stakeholders during review and refinement as described below. Note that the visualisation of overlaps and differences of the real world scenes and the stakeholders' viewpoints described below would not be possible if there would be a larger set of interrelations.

3 Intertwined Elicitation and Validation

During the interrelation of goals with real world examples, *validation* and *elicitation* can be distinguished as two conceptually different objectives. The objective of validation is to collect real world evidences for the individual goals of an initial goal model. The focus of elicitation lies on extending the goal model according to the additional knowledge gained by analysing the observations. In a typical analysis session however, validation and elicitation are often heavily intertwined. Whenever the analyst encounters problems in validating a goal model against the RWEs it leads to the elicitation of new goals that either have to be attained in addition to existing goals, or may represent alternative goals for achieving a super-goal. In the following, we elaborate on the principle relationships that can exist between a real world example fragment and the components of a goal model. Then we describe a set of method chunks that establish these relationships.

Based on the assumption that the observation material belonging to one RWE has been arranged according to some logical criteria, e.g. to the temporal sequence of events, we recommend to analyse each RWE video from the beginning to the end. Fragments are cut out by marking temporal beginning and ending points and then displayed as individual objects. Fig. 2 displays an example using our modelling envi-

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[1] Method Chunk: Description of a modular and reusable set of requirements engineering process activities.

ronment from which we will use example screen dumps for clarification purposes, but which is not explained in detail in this paper. Here on can see the two different types of videos: On the left a video representing the complete RWE and on the right the cut-out fragment recognisable by the black bar displaying the length and position of the scene in respect to the source video.

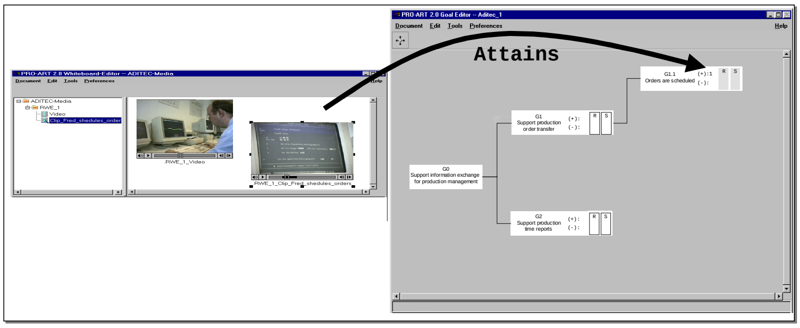

Fig. 2: Interrelation between a real world example fragment and a goal concept.

3.1 Primitive Steps for Validation of Goal Concepts

If the requirements engineer identifies a goal to be achieved in a fragment of a RWE and the goal is defined in the current goal tree, he extracts the RWEF as shown above and interrelates it with the goal using as link type either

1. `Attains`, if the RWEF shows how the goal is achieved or
2. `Fails`, if the RWEF shows an example of how the goal can fail.

The relationships mentioned above only make sense when the analyst can be sure that the goal is actually being tackled in an RWEF. When the goal is not tackled in the fragment at all or the attainment respectively failure of the goal is not observable, then there is no statement on the relationship between the two possible. In this case, they remain unrelated.

3.2 Primitive Steps for Elicitation of Goal Concepts

The analysis of a real world example may also lead to the elicitation of a new goal. Whenever the requirements engineer interprets a part of a real world example as an attempt to achieve a goal which is not yet present in the goal model, four situations can be distinguished:

1. The requirements engineer interprets the new goal as necessary for the attainment of a super-goal in addition to currently defined goals. In this case, the new goal is introduced as a sub-goal of the super-goal and related to the existing goal as an and-refinement.
2. The requirements engineer interprets the goal observed in the RWEF as a further alternative to achieve a certain super-goal which is not yet expressed by the existing alternatives. Then the new goal is added as a sub-goal of and related to the existing goal as an or-refinement.
3. The requirements engineer cannot determine the relationship of the new goal to other goals within the current goal hierarchy. Then the new goal is added to the existing goal hierarchy but without a relationship to other goals.

4. The requirements engineer is uncertain to which goal a RWEF contributes. Then he introduces a “to be determined”-goal (TBD-goal).

In all cases, the corresponding part of the real world example is extracted as real world example fragments and linked to the new goal either via an `Attains` link, if the goal was in fact attained, or via a `Fails` link otherwise. An example for the elicitation of an attaining goal for a newly created fragment is displayed in Fig. 2. Here a part of the RWE video has been extracted to the fragment on the right and linked to a newly created goal displayed in the goal editor shown on the right.

3.3 Distinguishing Positive and Negative Examples

Once a larger set of real world examples has been matched against a goal model (possibly by different stakeholders), there may exist several real world attainment evidences for a certain goal. These different attainment evidences may show different ways of attaining the goal. However, by saying that an RWEF is an attainment evidence for a goal we do not make any statement on the way how the goal was achieved in the real world, i.e. whether it matches the expectations of the analyst or not. We use `Positive` and `Negative` links to distinguish the appropriate subset of real world fragments and therefore mark certain evidences as *reference examples* of how to attain or fail a goal. This greatly improves the understanding of individual goals in the goal model when for instance new team members have to be introduced into the domain and trained.

4 Navigational Explanation Support

This section presents method chunks using the interrelating structures between real world example fragments and goals in a navigational manner. Links are used to navigate from examples to related goals and vice versa for driving to support explanation of the models. Queries on the dependency links provide access paths on both the goal model and the real world examples.

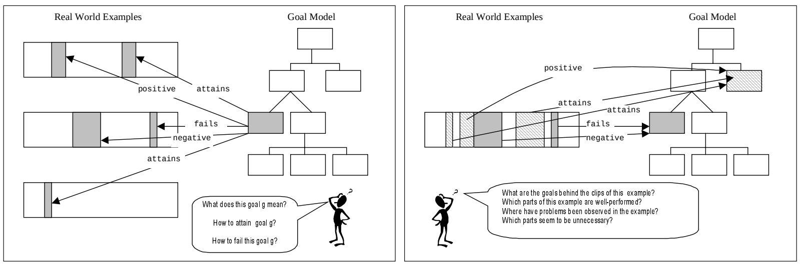

Fig. 3: Goal Explanation with related RWEF and Explanation of Goals behind RWE

Goals are mostly formulated in an abstract way, which makes it difficult for different stakeholders to share a common understanding of its meaning. By using the established traceability links, real world example fragments of attaining and failing a given goal can be retrieved. In particular, the use of `Positive` and `Negative` links allows illustrating *reference* examples of goal attainment and failure, respectively. Thereby, new team members and stakeholders, who are not familiar with the goal-modelling notation, can be easily and rapidly drawn into the project. Fig. 3 (left) illustrates the use of the traceability for goal explanation.

Conversely, one could take a real world example as starting point and ask for the "Why" and "What", i.e. the goals, behind certain real world example fragments. More precisely, as illustrated in Fig. 3 (right) one could ask for the those RWEFs of the given RWE

- which are well-performed, i.e. which fragments are related to some goals via an `Attains` or even `Positive` link, and to which goals;
- where problems have been revealed, i.e. which fragments are related to some goals via a `Fails` or even `Negative` link; and to which goals;
- which seem to be unnecessary since there is no obvious correspondence to a goal, i.e. for which fragments does not exist a link to any goal.

Another application of traceability information seeks for retrieving alternatives for a given RWEF through their relation to common goals. Fig. 4 (left) exemplifies a situation where we start with a RWEF r_1 showing a failure of goal g_1. In case (1) we use the traceability information to retrieve a fragment of a different example r_2 showing the attainment of g_1. In case (2) we go a more indirect way and access a fragment of example r_3 linked to an alternative goal g_2 of g_1.

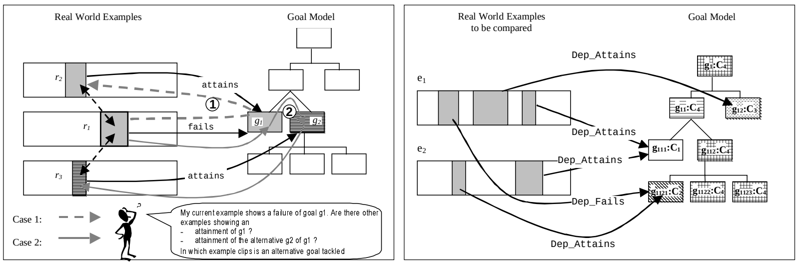

Fig. 4: Finding Different Ways to Tackle a Goal and Visualisation of Differences in RWEs

5 Support for Comparison of RWS and Models

In the following, we present method chunks that use the traceability information not in a navigational manner, but more in declarative way. Dependency links are queried for differences to compare different scenes (Sect. 5.1) and models (Sect. 5.2).

5.1 Comparing Real World Scenes

Consider the situation that an analyst wants to compare two real world examples in order to detect similarities or differences. In general, it is very difficult to compare the real world examples directly at the instance level since correspondences are often blurred by completely different incarnations. In this situation, the established relationships to the goal model provide an excellent means to visualise the overlaps between both examples with respect to the goals that they treat. This is done by representing goals that are, for instance, tackled in both examples in a different way than those which are only tackled by one example. Since a goal can have one of three different relationships (attained, failed, unrelated[2]) to each real world example independently, altogether nine different combinations are possible in principle. Since some combinations fall into the same category, it is sufficient to use different colours $C_1 – C_4$ for the four combination types for a goal *g*:

C_1 the goal is related to both examples by the same link
C_2 the goal is related to both examples by different links
C_3 the goal is only related to one example, but not to the other
C_4 the goal is related to none of the both examples

Fig. 4 (right) shows a possible visualisation of the goal tree where the four combination types are assigned to different goal node representations. It now becomes apparent that e.g. for goal g_{1121} the examples completely differ. By retrieving the corresponding RWE fragments of both real world examples, the attainment of this goal in e_2 and the failure in e_1 can be directly compared and studied.

5.2 Different Viewpoints of Stakeholders

The development of a goal model (and any conceptual model in general) always depends on the requirements engineer's *subjective* interpretation of the real world which he wants to capture in the goal model. For balancing and negotiating the goal model with the perceptions and opinions of other stakeholders, a review of the goal model is crucial. The established relationships to the real world examples provide an excellent means for illustrating the decisions and considerations underlying the development of the goal model during the reviewing process, i.e. the reviewer is enabled to understand the original model builder's interpretations e.g. the attainment of certain goals.

The interpretations and considerations of the original model builder must not necessarily be shared by the reviewer. This possibly leads to a different view, i.e. the existence of a goal as well as its relationship to a certain RWEF may be questioned by the reviewer. For expressing a match or a mismatch, we allow marking a goal or relationship as either *agreed* (expressed by green colour) or *disagreed* (red coloured) by the reviewer. In addition, the reviewer may enrich the goal model with *new* relationships (blue colour) between goals and RWEFs or even elicits new goals.

Fig. 5 shows an example goal tree visualising of the results of the review activities of a stakeholder in our tool environment. Note that each goal node contains two coloured bars: the left (labelled G) bar for indicating the differences concerning the goal itself and the right bar (labelled D) for indicating differences in the relationships from this goal to the RWEFs. By the colours one can see that during the reviewer disagreed with the refinement of goal G3.1 by the goals G3.1.1 and G3.1.2, because both goals and the dependencies leading to RWEFs have been marked red; as well as the dependencies of goal G3.1 saying that the reviewer doesn't accept the real world example fragments as evidences for these goals. Furthermore, it is visible that evidences for goals G1.1 to G1.3 as well as the goal itself have been confirmed by the reviewer. In the case of goal G2.1 the reviewer has found additional evidence, which also led to the introduction of further refining goals[3].

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[2] For the sake of simplicity, we do not differentiate between attains and positive, and fails and negative, respectively.

[3] Angular refinement edges mean and-refinement whereas direct edges are defined as or-refinement

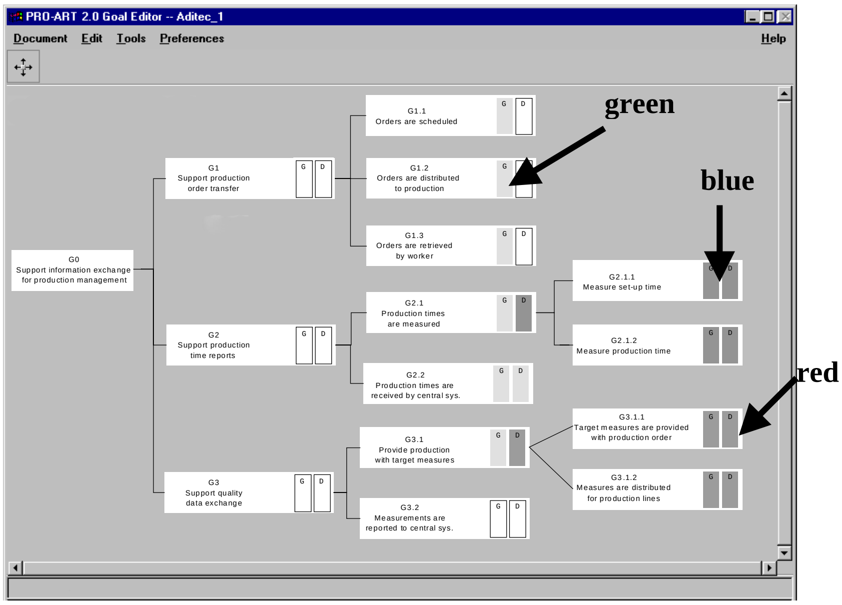

Fig. 5: Goal Tree Visualising the Differences between Stakeholder Views

The coloured goal tree provides an excellent basis for detecting conflicts in the perceptions of the different stakeholders. Using the traceability links, the corresponding real world examples fragments can be retrieved for negotiation and resolution of this conflict.

6 Conclusions

Capturing current system usage using representations which are as close as possible to the current reality serves as an ideal starting point for analysing the goals behind the existing system. We have presented an approach for eliciting current state models from real world scenes and validating them against real world scenes. The elicitation and validation is supported through Abstraction Guides. An Abstraction Guide supports the interrelation of real world examples fragments with components of a current state model. We have presented an Abstraction Guide for defining a goal model of the current system. According to our experience goal models are very well suited for representing the essence of the current system independent of the incarnation captured in the real world scenes. Concentrating on the essence is a prerequisite to be able to compare different observed incarnations, and different goal models defined for the same observations by different stakeholders. In principle, Abstraction Guides can be defined for any conceptual target model.

We presented the basic method chunks for establishing the traceability relations between the captured real world examples and the goal models. In addition, we described method chunks for using the fine-grained interrelations to visualise the evidence of the defined goals, to compare different stakeholders viewpoints and to compare different real world examples. The annotated goal trees provide excellent means for comparing different real world examples and for comparing goal models defined by different stakeholders for the same real world scene. Moreover, the fine-grained interrelations support the review process of the conceptual model and the visualisation of defects detected during the review with an annotated goal tree helped in resolving the detected conflicts.

The definition of Abstraction Guides for further target models and the development of advanced negotiation support based on the interrelated current state models and the real world examples will be the focus of our future work.

Based on Abstraction Guides we developed a process-integrated modelling environment CREWS-PROART which is not described in this paper, but which provided the screen dumps for Fig. 2 and Fig. 5. CREWS-PROART offers tool support for multimedia management, goal modelling, and the method chunks described in this paper for establishing and using the fine-grained interrelations. The modelling environment has been successfully tested on a small case study analysing information flow in a machine manufacturing company, which will be described in future publications.

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