Adding Hypermedia Requirements to Goal-Driven Analysis

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Abstract

Requirements analysis for web applications still needs to employ effective RE practices to accommodate some distinctive aspects: capturing high-level communication goals, considering several user profiles, defining hypermedia-specific requirements, and reusing requirements for an effective usability evaluation. Techniques should be usable, informal, require little training effort, and show relative advantage to project managers. Starting from the i framework, this paper presents a proposal for defining hypermedia requirements (concerning aspects such as content, navigation and presentation) for web applications. The model adopts a goal-driven approach coupled with scenario-based techniques, introduces a hypermedia requirement taxonomy to facilitate web conceptual design, and paves the way for systematic usability evaluation. Particular attention is paid to the empirical validation of the model based on the perceived quality attributes theory. A case study developed with industrial partners is discussed.*

Keywords: web applications, hypermedia requirements, hypermedia design, goal-based analysis, usability evaluation.

1. Introduction

Unlike traditional information systems, web applications have still not received enough attention by RE research. Conversely, the hypermedia and hypertext communities developed a large variety of techniques for systematic web application design.

Modern web applications are basically merging two interactive paradigms [2].

1) *The hypermedia-style* of interaction is derived from hypertext and multimedia applications. In the hypermedia paradigm, users basically navigate in the applications, select a variety of possibilities, traverse links, explore content, and access and learn information. Key modelling concerns are user-centered design, ill-defined user tasks, content and navigation architecture.

2) The *transactional-style* of interaction is typical of traditional information systems. Users activate operations, modify the application status, input data, receive system notifications, follow strictly predefined paths and perform transactions. Key modelling concerns are low-granularity user tasks, user-systems data exchange, and sequential interaction modelling.

E-commerce web sites are typical examples of this combination of interactive styles. Navigation-based user experiences such as accessing product catalogue, locating needed content, freely exploring product information, navigating to related products, and changing site department are blended with operation-oriented tasks such as putting a product in the shopping bag, starting a purchase process, providing authentication info, setting a payment method, setting shipping and billing address, and confirming the order. It has been acknowledged that the blending of these paradigms poses new challenges for the design of the user experience [2].

Over the last few years, requirements methodologies applied to web-based applications have considered mainly the transactional and operational aspects [1] [6]. However, hypermedia-intensive web applications (those favoring the hypermedia-style rather than the transactional-style) are not systematically covered in requirements analysis concerns. Cultural-heritage web sites, educational web sites, institutional web sites, promotional and corporate web applications, and even a large part of e-commerce web sites are just a few examples of domains in which sites are designed first and foremost as means to communicate content and *also* as a tool for accomplishing operations and transactional tasks. In such domains, stakeholders need to address communication goals [4], i.e. they wish to use the site to get across structured messages and content to a variety of users. In turn, potential users have their own goals with respect to the application; they expect to find a usable site architecture with which to learn, to be engaged and to retrieve information.

This paper focuses on requirements analysis for hypermedia-intensive web applications. Moving from key achievements in requirements analysis and assessed hypermedia design techniques, the paper presents

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AWARE, a model for the Analysis of Web Application Requirements. In particular, the following issues are addressed: a) high-level communication goals and user requirements have to be taken carefully into account in the requirements analysis; b) requirements should be tied up coherently with conceptual design of hypermedia specifications; c) requirements engineering techniques should be extremely lightweight, intuitive and usable by web analysts; d) the model proposed must show a relative advantage to project managers, requiring little training effort to be adopted and effectively integrated into current practices.

Recent empirical studies [15] found that fine-grained iterative development is mainly adopted in current practice by web project teams. In this context, design artifacts play a major role in clarifying clients' needs and system requirements. In the exploration phase of the iterative process an initial (not definitive) set of goals of the stakeholders and final users may be negotiated. Once sufficient understanding is achieved, the iterative process can commence. As such, analyzing and documenting requirements should not be additional paper work for web project teams, but rather a support for communicating, negotiating and reasoning about requirements during incremental development.

The paper is organized as follows. After the review of the relevant background (section 2), the key constructs of the AWARE model are presented (section 3) and a real case study is discussed (section 4). The relationship between the requirements and the hypermedia specifications is presented (section 5), as well as the reuse of the requirements knowledge for usability evaluation (section 6). Finally, the results of an empirical evaluation of the model (section 7) are followed by conclusions and future work (section 8).

2. Related Works

Conceptual tools for analysing goals and reasoning about actor-goal dependencies for e-commerce web-based information systems have been provided in the TROPOS project [6]. In this context, *i** framework [6] [27] is adopted to model actor intentional relationships and analyse high-level goals together with non-functional requirements. AWARE model specializes *i** in the sense that it allows deriving hypermedia requirements from a further analysis of *i** actors' goals.

The ability of moving from high-level goals to detailed requirements is already provided by KAOS [9]. Here, goal decomposition allows defining, analysing system goals and then exploring alternatives. The operationalization of goals enables to specify a detailed requirements set, where responsibilities for their fulfillment are assigned to agents.

Semi-formal goal-analysis defined in GBRAM [1] provides effective support for the elaboration and pruning of goals for web-based information systems by coupling goal-oriented analysis with scenario-based techniques. Scenarios, as used in HCI analysis and design [5], as well as in usability evaluation [18], describe envisioned possible uses of the applications, highlighting in turn the motivation, the context and the goals of the intended users [14].

Over the last decade, the hypermedia community has elaborated user-centered web design models. These techniques [7][11][12][25] enable to model the essential hypertext and hypermedia features of complex web sites at a proper conceptual level. Notations and constructs to describe – on the basis of the requirements - the navigation, information and page structure of web sites were defined together with proper tool support. Large part of the basic principles informing these approaches has also been borrowed by practitioners [20]. Initial research effort to bridge the gap between requirements analysis and hypermedia conceptual design can be found in [21] and [12].

3. AWARE: Analysis of Web Application REquirements

In order to support the requirements analysis activity of web analysts and designers, the AWARE model offers simple primitives enabling to document and specify hypermedia requirements, as well as keeping traces of the requirements and design rationale. Rather than prescribing a process or a method, AWARE offers a set of conceptual tools that web analysts might find useful for describing and reasoning with web site requirements.

AWARE recognizes the central role of the stakeholders and their goals, as in traditional goal-based approaches. In particular, *i** provides constructs to model actors and their dependencies with respect to their goals and tasks. Starting from high-level goals, AWARE extends the analysis of *i** to the elaboration and definition of hypermedia-specific requirements. To this end, AWARE introduces a requirement taxonomy to bind requirements to hypermedia conceptual design and help organize the design activity accordingly.

As showed in the metamodel expressed in *i** notation (Figure 1), the main constructs offered by AWARE are the following.

Stakeholder (i actor)*. This construct models every user profile to be considered for the web application to build and all the relevant clients and main stakeholders to be involved (the company representatives, marketing managers, sponsors, and opinion makers). Stakeholders correspond to the notion of actor in *i**. *i** actors own goals and may depend on other actors to fulfill their goal or

perform tasks. In many web applications, a basic dependency between actors is between the stakeholders who run the site and the users. The former depend on the latter to satisfy the objectives of the web site. For example, the marketing manager (actor *a*) of an online shop may have the goal to sell the products of the site sponsor. At the end of the day, the fulfillment of this goal depends on the actual purchases made by the site users (actor *b*). Thus, an actor may either have his own goals or may depend on other actors for the fulfillment of such goals (*delegated* goals).

Stakeholder (i actor) priority*. Project team may need to decide internally which stakeholders are more important than others, because of organizational reasons, or because of business or communicative purposes. A *priority* may thus be associated to each stakeholder in order to help analysts weigh properly the goals and the needs expressed by each stakeholder, and consequently plan effort and resources for the analysis in a more efficient way [17].

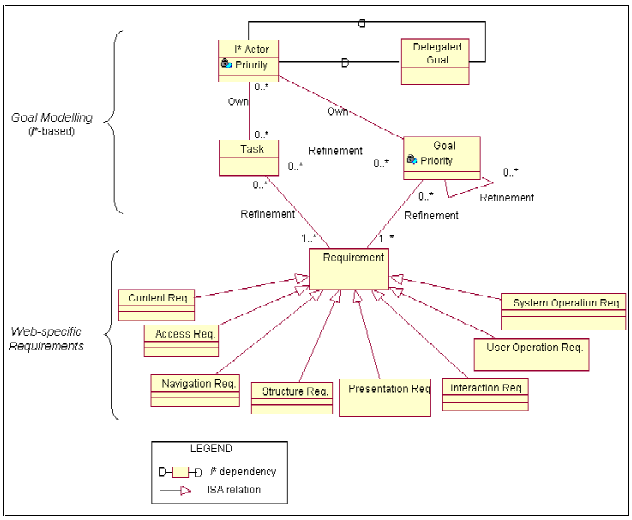


Figure 1. *i extended metamodel for hypermedia web applications.**

The priority value can also be used to capture the importance that stakeholders (e.g. the marketing strategists) assign to each user profile. Indeed, a good web requirements analysis should identify and prioritize the target audience of the application in order to focus the communication effort and spend the design resources towards specific user profiles rather than others. Priority may be expressed by quantitative (e.g. 0...1) or qualitative (e.g. +, -, ++, --, ...) values.

Goal. A goal models a high-level objective of one or more stakeholders. Goals may represent users' goal and main stakeholders' goals. Goals can be decomposed by *i** decomposition and means-ends relationships. As acknowledged by *i** and other goal-driven methods [1] [6], goals may need to be expressed informally (or semi-formally) to enhance communication among stakeholders.

Task. Refining users' goals, user *tasks* may be defined. While a goal is wished state of affairs, a user task (*i** task) is a high-level user activity on the site. User tasks in web requirements analysis should be higher level than the ones defined in task analysis for interface design. In traditional HCI design, user tasks can be easily mapped on screen mock-ups. In case of complex web applications, user tasks have to be further elaborated to envision a proper hypermedia structure (e.g. a navigation schema, a set of information objects, several access paths) that might support them.

Goal Relevance. A stakeholder may consider a goal more important than another. As suggested by traditional elicitation techniques, analysts may gently "force" stakeholders to prioritize their goals, so to make the project converge to crucial application objectives. Stakeholders and the project team may also agree on considering some users' goals more improbable to happen rather than other, or more crucial to support rather than other. Relevance may be expressed by quantitative (e.g. 0...1) or qualitative (e.g. +, -, ++, --, ...) values.

Requirement. Goals are refined, elaborated into sub-goals, tasks and eventually into requirements. Hypermedia requirements are informally expressed in natural language and their level of detail is negotiated between analysts and design team. Requirements are not aimed at capturing all the functionality of the web application but only those crucial features needed by designers to shape the user experience and by stakeholders to agree on initial specifications. The requirement construct models both functional requirements and non-functional requirements. *i** does not model explicitly the concept of requirement because it addresses mainly goals-actor relationships. AWARE uses the concept of requirement as operationalization of goals and tasks as in [9].

Requirement Taxonomy. In order to organize the hypermedia requirements set and facilitate the design activity, requirements are classified according to the design aspect on which they have an implication. The hypermedia requirement taxonomy comprises so far the following dimensions [3]:

1. *Content*: Content - the core value of a hypermedia-intensive web application - refers to that set of ideas and messages that the site communicates to its users. Ideas and messages are mainly specified in term of information chunks provided. In the case of a museum web site, content requirements might be: "present details for each painting", provide bibliography for each painter", "present museum collection history", "provide director's welcome", "communicate opening and visiting hour".

2. *Structure of Content*: Requirements can also give coarse-grain insights about how the content pieces identified might be structured. By "structure" is meant the

organization of the content. Providing initial requirements about the structure of content means expressing the need of highlighting particular pieces of content or messages within an information object. In the museum example, such requirements might be: "in the museum presentation, highlight the historical value of the building", "presenting the painting, detail the techniques used".

3. *Access Paths to Content*: This dimension refers to the navigational paths available to the user in order to reach the needed content. The user should be allowed to access the needed information or be guided in the exploration of the offered content following the navigational access paths best corresponding to his expectations and goals. This dimension captures the strategy behind the hypermedia artifacts exploited by the user to start the navigation, to locate and reach the interested content. Examples of requirements pointing to this design aspect are: "allow accessing paintings by author", "provide thematic guided tours", "allow accessing authors by period and by name", "provide access to recommended work of arts", "guide through the paintings of the weeks", "allow planning a visit by date and preferences".

4. *Navigation*: Requirements can suggest connections between different information pieces allowing the user to navigate from one piece of content to another. Semantic relationships among information pieces can be relevant for navigation, i.e. can be exploited by the user to traverse the path connecting one object to one or more others in order to complete his cognitive or operational task. This design dimension captures the hypermedia artifacts exploited by the user to navigate, once accessed a given information object, from that object to one or more others semantically related. Examples of navigation requirements are: "relate each painter to its author", "relate visits information to restaurant and hotel services available", "relate history collection to most precious work of arts", "and relate information about an artistic movement with its representative authors".

5. *Presentation*: Requirements can also give guidelines and design input for conceiving the visual communication strategies for presenting content, navigational capabilities and operations to the user. Presentation design concerns two main aspects: graphics and interface layout. Graphics concerns the visual element composing the user interface (buttons, icons, images, font proportions, titles); layout concerns the physical positioning of these objects on the page. Examples of presentation requirements might be: "present a young style for teenagers in the Kids section", or "present a professional but artistically rich style in the collection layout".

6. *User Operation*: User operations are those operations that are visible to users to complete some tasks. These operations are all operations that users can trigger by interacting with the application. In the museum web site, examples are: "subscribe to a mailing list", "create personal collection", or "post personal comment to a painting".

7. *System Operation*: System operations are directly not visible to users, but become mandatory to "build" user operations. Possible system operation requirements include: "force user authentication for building personal collection", "track user navigation and build preference profiles", or "update recommendations every five user sessions". Operations are expressed informally at the requirements level. Formal specification of web operations and web transactions are delegated to the design level (see details in [25]) and are not treated in this paper.

8. *Interaction*: Interaction requirements describe envisioned styles of interaction for the user. In a museum of modern art, an interaction requirement could be to "provide the user with an interactive 3D model of a representative work of art" to raise her interest in understanding the modern art. Such requirements are obviously related to content and presentation aspects; however, they capture application aspects that may need a specific design elaboration (in terms of design skills and resources needed).

Although a requirement may concern more than one dimension, our project experience suggests that it is better to refine a requirement to the point where exactly one dimension can be assigned to it. If a requirement cannot be easily and clearly assigned to exactly one dimension, then it is still too general to serve as input for design and should be further refined. This separation of concerns facilitates the achievement of an agreed granularity level.

The AWARE requirements taxonomy is obviously open and always revisable. Emerging web applications may call for ad-hoc types of requirements that need to be captured early in the analysis (e.g. multi-channel applications, web-based collaborative 3D environment) and may suggest new dimensions to be considered.

Dimensions can help organize design activity. In fact, designers can then adopt any web design method (e.g. WebML, WSDM, EORN, HDM, UML for the web) to shape design solutions in term of detailed specifications solving the requirements.

Given the initial set of requirements, designers can read requirements "by dimension", "by stakeholder" or "by goal". Considering requirements by dimension allows designers to assign requirements to the proper conceptual design toolset and to specific design competences. Reading requirements by stakeholders or by goal allows focusing on design solutions required to fulfill some "high-priority" stakeholder (such as the Museum Director) or indispensable goal.

In order to facilitate the elicitation and refinement process user scenarios may complement goal analysis. Scenarios are commonly recognized as powerful drivers

for goal-based approaches. They are task-oriented vivid descriptions of envisioned use of the website. They can help analysts discover new requirements, exemplify goals, surface new goals and better define stakeholders. A scenario may be synthesized as a pair user profile + goal(s) or user profile + task(s), in order to be integrated with the goals model in a coherent fashion.

4. Application Examples

During the requirements analysis of the web site of an Italian supplier of silver-made artifacts (from now on called B-silver), we adopted the AWARE model employing a more informal, stakeholder-oriented graphical representation. It is structured (to communicate with designers) but simple and semi-formal (to communicate with clients). In this simplified format, requirements are visually "labeled" according to the hypermedia taxonomy and goals are mainly considered in "and" relation. In this section, an excerpt of the artifacts defined during the requirements analysis will be discussed.

This case study has the advantage of representing the outcome of a *real* requirements analysis; however (as it often happens), it has the drawback of not illustrating *all* the features of the model. Priorities, for example, are not exploited much, due to the limited number of stakeholders involved. In fact, two main stakeholders for the web site were identified: the firm itself (represented by the president) and one user profile corresponding to the typical B-silver client.

4.1. Goals of the Firm

The crucial high-level objectives that B-Silver needs to address by means of the web site are (see Figure 2):

1. *Attract New Clients*. B-Silver is one of the leaders in the regions near to its location. However, the company planned to acquire new silver resellers in other Italian regions. The site could be a useful communication tool to contribute to this strategy.
2. *Facilitate Contacts*. The site should serve as an easy-to-reach resource for potential and current clients to get in touch with B-silver.
3. *Communicate Corporate Identity*. B-Silver has a corporate identity based on a long tradition of style and quality in the Italian panorama of silver suppliers.

On the solicitation of the analyst, the B–silver president prioritized the goals in a discrete range from 0 to 1 as shown in Figure 2. Such priorities values justify that one of the main reasons by which B-Silver wants to have a web site is to attract new clients to its business. The president decided that the goal "Attract New Clients" is more important than the others because the firm is investing for gaining market share in other regions. The base of customers has to be enlarged and the web site is seen as a powerful tool to contribute to this end.

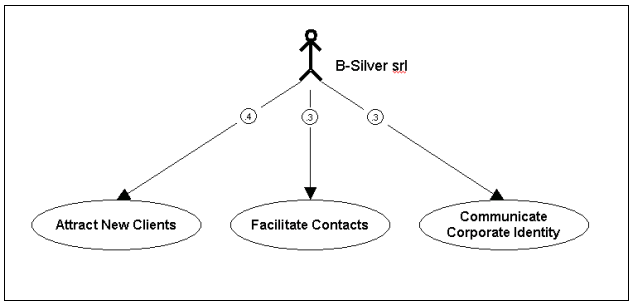


Figure 2. The highest-level goals of B-Silver.

Goals are in "and" relation in the sense that the web site should be a tool to allow B-Silver to satisfy all these three goals. In this simple case, since there is just one stakeholder on the B-Silver side, a priority 1 (not marked) has been assigned to the president.

Let us consider the analysis of the most important goal, namely *Attract New Clients* (Figure 3). During the meetings with the president and his staff, it emerged that the most reasonable strategy for B-Silver to convince potential web site visitors to become clients is to communicate the critical success factors of B-Silver in the silver supplier market. Furthermore, these were identified in having a store with very large assortment of products, making product available in a short time and offering repairing and restyling services.

It is clear that the fulfillment of the *Attract New Clients* goal relies also on the promotional strategy (online and offline) of the web site (registration and keyword-buying on search engines, merchandising, and newsletters). This aspect, which is not strictly related to the design of the web application but to its promotion, is intentionally not documented in the requirements analysis directed to designers.

All three sub-goals identified should be analysed and further decomposed. Decomposition here is not intended as a necessary derivation, but rather as the documentation of the outcome of a decision-making process.

Elaborating on *Store with Large Assortment* sub-goal, two goals were identified (Figure 3): *Highlight the Variety of Products* on one hand and *Avoid Presentation of the Single Item* on the other. The latter sub-goal is a case of negative goal (also called "Avoid" goal). Indeed, the discussion with the staff of the president gave raise to the belief that B-Silver does not intend to present on the web site the details of each single product available in the store. It is not reasonable to manage the presentation of more than hundreds thousands products on the B-Silver web site, mainly for prohibitively expensive costs of

content production, maintenance and updating. It is interesting to notice that such negative goal is not properly a negation of a final state of affairs in the real world, but rather the declaration of the intention of not following a given communication and design strategy.

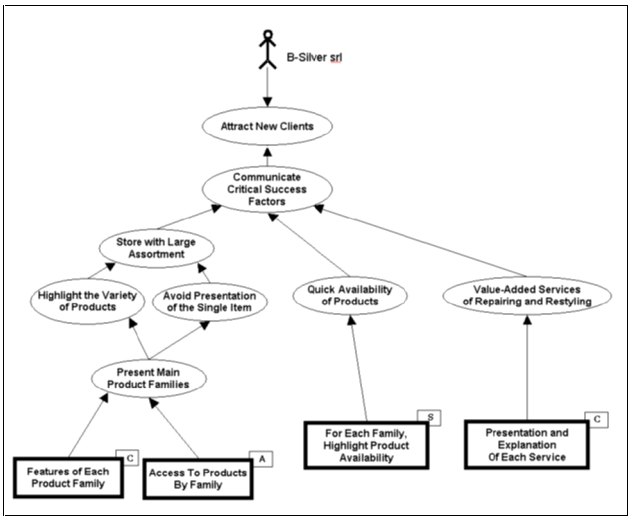


Figure 3. Analysis of the "Attract New Clients".

In order to solve the tension between *Highlight the Variety of Products* and *Avoid Presentation of the Single Item*, a possible strategy identified is to *Present Main Product Families*. With such strategy, the communication of the range of different products is ensured without affecting dramatically the budget available. Two requirements are defined to fulfill *Present Main Product Families* goal: a content requirement (labeled with C) stating that descriptions of the features of each product family has to be provided; and a requirement saying that the user might be able to access the products "by family". The latter requirement concerns the "Access" aspect of the web site design and is then labeled with A. In order to communicate that B-Silver makes products available in a short time (*Quick Availability of Product* goal), the requirement defined is to highlight the average time of product availability for each product family. This is a requirement concerning the structure of content (labeled with S) because it states that, in the context of the description of the product family, the information about availability should be particularly visible.

Analysis for the other two high-level goals is shown in Figure 4 and Figure 5. Two content requirements capture the information needed to *Facilitate Contacts* with B-Silver. It is important to note that such requirements do not anticipate design solutions because they just identify the content needed.

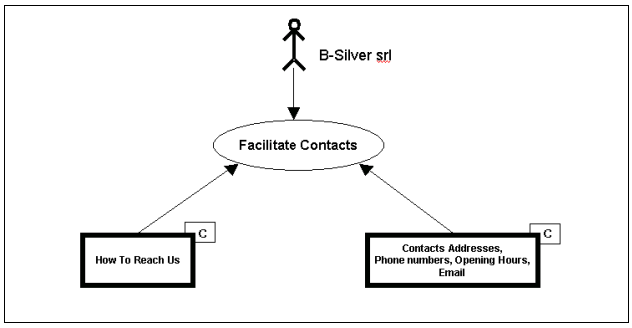


Figure 4. Analysis of "Facilitate Contacts" goal.

The communication of B-Silver corporate identity is achieved through three basic requirements (Figure 5): the site will clearly explain that B-Silver will not sell artifacts to private clients (refining "Communicate Supplier Role" goal); moreover, it should be communicated that the store is located in the center of the city of Milan (refining "Communicate Milan-based" goal). As third requirement, concerning the presentation aspect (labeled with P), the site should have a presentation style (in term of graphics and layout) consistent with B-Silver corporate brand image.

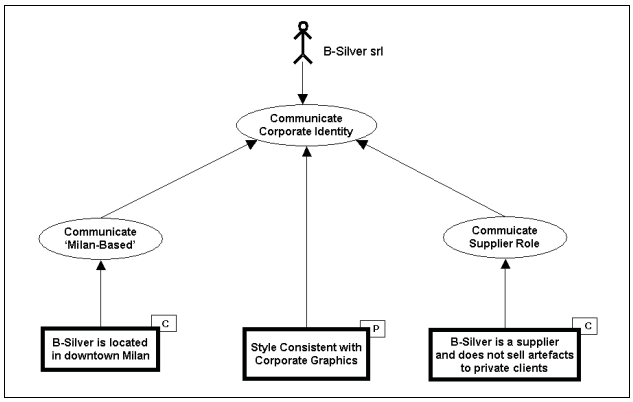


Figure 5. Analyzing "Communicate Corp. Identity".

Through this analysis, the analysts gathered a first set of essential hypermedia requirements and the basic rationale behind them. As crucial complement to the analysis, the next paragraph will discuss the definition and the elaboration of users' goals, which will dictate new requirements for the web site.

4.2. Users' Goals

Obviously, the public area of the web site is potentially accessible by any web user. However, any communication act presupposes an intended target audience [4]. The more the characteristics and the expectations of the addressee are known, the more the communication act has chance to succeed. User

requirements analysis should define the specific desired users to address and anticipate their goals, in order to deliver a satisfactory user experience and achieve the communication objectives. Among the different user profiles envisioned by B-silver president, one emerged as the most important (and the only) to be taken into account in this case (see Figure 6): a 40-50 years old manager of a small or medium Italian jeweler with a discrete familiarity with Internet sites. This user profile models that community of users that represents the main target audience of the communication strategies envisioned in the previous analysis. In fact, it also represents the profile of the typical B-Silver client.

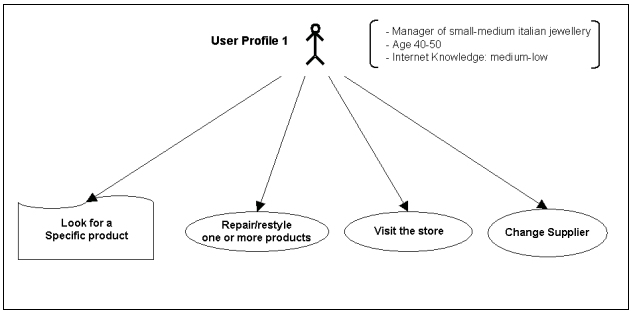


Figure 6. High-level view on user's goals.

Given these basic features, User Profile 1 models a variety of user types. This profile may represent either a potential client of B-Silver or someone who is *already* a B-Silver client. Moreover, both users should be taken into account as *first time visitors* or *experienced users* of the site. Whatever combination of user types is considered, the analysis focused on User Profile 1 as representative of those user types sharing a set of goals or tasks.

As shown in Figure 6, envisioned high-level goals for the User Profile 1 are: repairing or restyling one or more silver products, visiting the B-Silver store, and being persuaded to change the current silver supplier. Moreover, User Profile 1 might also want to look for a specific product on the web site. This is considered a *task* rather than a *goal*, because it does not express a wished state of affairs for the user but rather a user activity on the site.

Any given combination of User Profile 1 and goal (or task) is the essence of a *user scenario*. During analysis, scenarios have been envisioned in more narrative form, specifying further the user type considered, detailing the context of use and adding details about the goal to be accomplished. Then, to document the salient scenarios and smoothly represent the results of the scenarios analysis similarly to the previous goal analysis, a more synthetic and schematic notation has been chosen. This choice also facilitated the discussion with the stakeholder. Tasks and users' goals are in "and" relation in the sense that the site must support all the goals and tasks defined.

The task *Look for a Specific Product* cannot be supported in this case by access structures typically employed for comprehensive product catalogues (e.g. lists of all product instances or search engines) because just the families of products (and not the single product info) are presented (see Figure 3). Therefore, from each product family, it is possible for the user to navigate to a related area to request if the desired product of that specific family is available in the store. A shown in Figure 7, this is a navigation requirement (labeled with N).

The goal *Repair/Restyle one or more products* is refined into the user task *Look if repairing services are offered*. The requirement defined to support this task concerns a structural aspect of the site content: *Highlight Added-Value Service Offered*. This requirement means that the user should be easily guided to locate the repairing services description within the site. This requirement actually adds structural information to a requirement already defined in the stakeholder analysis: *Presentation of Each Service Offered* (see Figure 3).

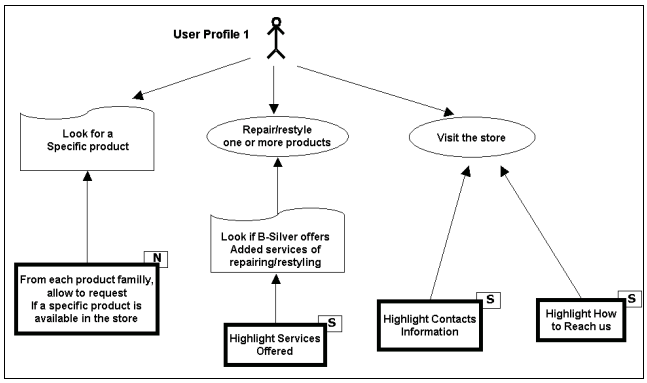


Figure 7. Analysing user's goals.

The requirements defined to fulfill the *Visit the Store* goal (see Figure 7) partly match with the ones discovered in the stakeholder goal-analysis but, in addition, they state that these pieces of content should be particularly highlighted for the user. The design activity will then decide *how* this "highlight" will be solved, according to the economy of the overall site structure and design style.

The goal *Change Supplier* enabled to elaborate three further salient scenarios (see Figure 8) discussed with the stakeholders. User Profile 1, in order to change supplier, might want to look for a more punctual partner, or one might be looking for a larger assortment because the current supplier does not satisfy the diversified needs of his/her clients. In a third scenario, the potential client might be interested in finding a supplier with a better quality/price ratio. These three scenarios have been refined consequently in tasks and then into hypermedia requirements.

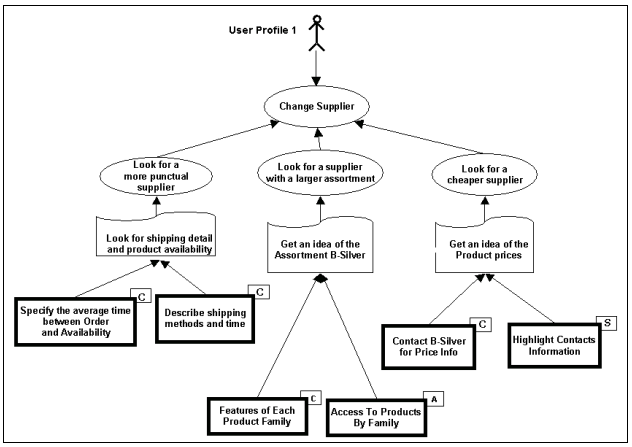


Figure 8. Defining requirements for "Change Supplier" user's goal.

The user's goals analysis allowed partly to define new requirements and partly to match already stated requirements with user needs.

4.3 Defining Non-Functional Requirements

The hypermedia taxonomy may also help define and organize non-functional requirements in a coherent fashion. On the basis of a comprehensive classification of quality attributes for user interface design presented in [8], and on lessons-learnt from previous web project experiences, relevant non-functional requirements were defined and classified in this case. *Effectiveness*, *orientation*, *status visibility*, *predictability* are salient for the navigational aspect (N) of the web site. Requirements such as *completeness*, *authority*, *currency* and *accuracy* are taken into account for the content aspect (C). *Clearness*, *Consistency* and *Perceived Order* have been instead considered for the presentation aspect (P). *Accessibility*, *Organization of Information* and *Learnability* are classified under the access dimension (A).

5. From Requirements to Hypermedia Design

In the real case described, the level of detail of requirements may serve both as input for a systematic hypermedia design and for totally informal and non-structured approaches to web design (which most practitioners adopt).

We used a systematic web design technique (an evolution of HDM [11]) for elaborating design solutions on the basis of the requirements. HDM is a schema-based hypermedia design model that - similarly to a variety of other design models, such as WebML [7], W2000 [25] or OOHDM [12] - offers conceptual constructs to define:

a) the information model of the web site. Given the content and structure requirements, this model enables to design the overall information architecture and the detailed the structure of the types of information objects;
b) the navigation model: given the navigation requirements and the information model, this model enables to design the structure of node types and links and the detailed navigation patterns;
c) the publishing model: given the presentation and interaction requirements, and the navigation model, this model enables to design the structure of the page types (in term of layout sections and labelling);
d) the operation model: given the user operations and system operation requirements, designers may employ standard languages to precisely define the transactions and the operations that the site will support and integrate them in the overall site structure. This design aspect accounts for the transactional-style typical of traditional information system architecture. The W2000 [2] design model provides a UML-based framework for integrating hypermedia design primitives with operations [25] and transactions in a coherent fashion.

Concrete results of a successful integration of goal-driven analysis based on AWARE and hypermedia design (based on W2000) on larger projects are fully described in [22] and [26].

AWARE lends itself particularly well for a systematic design approach, because it organizes requirements in hypermedia taxonomy. In the example, designers read the requirements set of B-silver by dimension, and were facilitated in planning the design activity. AWARE specifications allowed designers to take decisions based on the high-level goals of the application.

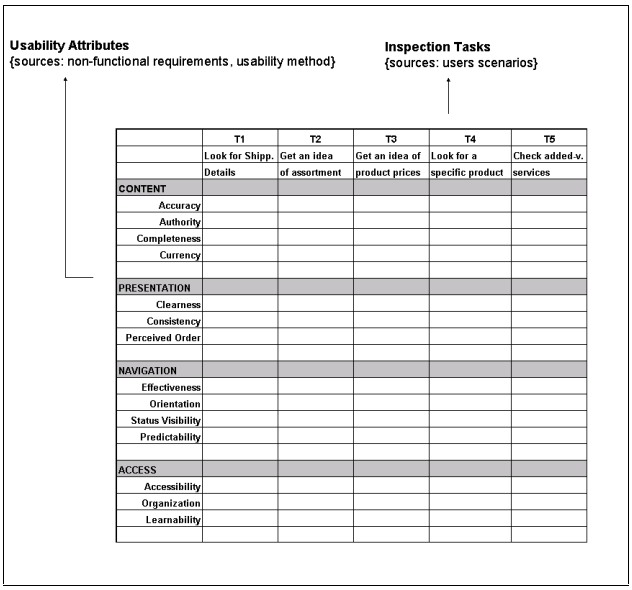
In our project experience, due to the partiality of scenarios, hypermedia design schemas offered by HDM allowed designers to capture (at design time) more interactive capabilities than the ones envisioned by scenario analysis (at requirement time) [11].

6. Reusing Requirements for Usability

Usability evaluation aims at augmenting the quality of the user experience. Usability evaluation methods for the web usually blend different variants of two basic approaches: expert review (usually referred to as *usability inspection* [18]) and user testing. During expert review, one or more usability experts perform critical tasks on the web site to detect if and how they are feasible. They highlight possible usability breakdowns and provide suggestions for improvement. Inspection may be done at low cost after the deployment of the web site, after a prototype is available, or even early in design. Indeed,

usability evaluation should be an attitude to keep throughout the development process.

As systematic approaches to hypermedia and web site usability suggest [16], planning a web usability inspection means: a) defining the areas of the application to evaluate and the *design aspects* to consider (e.g. performance, content, or layout); b) prepare the set of *tasks* that the inspector will perform to assess the aspects at issue; c) define the *usability attributes* (also called *usability issues*) to be considered for each task. Table 1 reports the inspection matrix prepared for the B-silver case.



	T1	T2	T3	T4	T5
	Look for Shipp. Details	Get an idea of assortment	Get an idea of product prices	Look for a specific product	Check added-v. services
CONTENT					
Accuracy					
Authority					
Completeness					
Currency					
PRESENTATION					
Clearness					
Consistency					
Perceived Order					
NAVIGATION					
Effectiveness					
Orientation					
Status Visibility					
Predictability					
ACCESS					
Accessibility					
Organization					
Learnability					

Figure 9. Usability Inspection Matrix.

AWARE helps in planning the inspection because the usability experts can easily draw large part of the material needed for the evaluation right in the requirements specification:

a) The *tasks* that the inspector will perform could be easily taken out from the user scenario analysis. The inspector can also elaborate further on the tasks, detail them, find exception cases or different alternatives (see Figure 9).
b) *Usability attributes* tend to correspond to the non-functional requirements. Examples of usability attributes considered for the inspection are in Figure 9. Inspectors select appropriate usability attributes that are relevant for a given task. The same usability attribute can be employed for different tasks.
c) Usability attributes are organized through the requirement taxonomy. In this way, the inspection can focus on relevant *design aspects*. In fact, some usability attributes measure content aspects, others are more suitable for measuring navigation aspects, and others assess presentation features and so on.

To perform the inspection, usability experts systematically try to accomplish each single task. They evaluate not only whether each task is feasible but also assess each task by means of the usability attributes. For example, while trying to perform the task *Get an idea of the assortment* the inspector wonders: How is the product family information accurate? How is the presentation consistent among pages traversed? How is the navigation architecture of the visited section self-evident? How are the link labels predictable? And so on for each task. In this way, inspector assigns a value to each task for each relevant usability attribute. This first analytic evaluation could then serve to usability experts as input for future elaboration. The user testing is then prepared on the basis of the results of the inspection [16].

7. Validating the AWARE Model

AWARE was applied in industrial, research and educational projects[1]. It is also being applied at the Webatelier[2] of the University of Lugano on web projects designed for public and private companies in Switzerland and in Italy. In these experiences, AWARE was used effectively by analysts to define a clear picture of the goals of all the relevant stakeholders involved, to negotiate the requirements with the stakeholders, and to derive an accurate requirements set for the design.

A first empirical validation of the AWARE model was recently developed within the UWA European Project (IST-2000-2513) [23] and is summarized in the next paragraphs.

7.1. Evaluation Method

The evaluation method for assessing the effectiveness of the methodology was defined on the basis of the Diffusion Theory [19], which examines the rate and the motivations of adoption of a technological innovation by a group of potential users. Such an approach may be fruitful also for the evaluation of a novel conceptual tool (such as a design or requirements method), by assessing whether it is appreciated by a community of users [13].

The Diffusion Theory defines five *perceived quality attributes* of an innovative product. *Triability* is the degree by which the product can be tried on a limit basis before adoption. *Observability* refers to the observable results deriving from the use of the new product. *Relative*

[1] Web projects includes the Museum of Israel Shrine Educational Web Environment (http://hoc.elet.polimi.it/pages/progetto.php?lang=en&id=20), the Opendrama project prototype (www.opendrama.com), Banca121 credit card catalogue and Punto commercial e-business marketplace. Requirements specifications of these pilot applications are available at www.uwaproject.org.
[2] www.webatelier.net

Advantage is the perception of how better is the innovation than the competing solutions currently adopted. *Complexity* refers to the fact that the innovative product should not be overly complex to understand and to use. *Compatibility* measures how the innovation is perceived as compatible and consistent with existing practices shared among the community of users. On the basis of these attributes, a process-oriented evaluation was conducted: it focused on the quality of AWARE, and not on the products designed with the model.

Eleven web analysts all over Europe were recruited (both from the industry and the research arena) to let them know in detail the AWARE model. Obviously, the number of sample users is not representative of the community of web designers and analysts. However, it gives an initial interesting feedback on how such a systematic approach to requirements is considered by web professionals. To avoid the premature emotional involvement of a workshop *in presentia* and consequent evaluation biases, the potential users of the model were provided with a document presenting an in-depth explanation of AWARE with examples and were then asked to apply it to a case study at their choice. On the basis of the perceived quality criteria, an online questionnaire with eleven questions was designed (see [23] for the detailed questionnaire rationale). The analysts were asked to answer the questionnaire by the fourth week after the assignment. The questionnaire was divided in two parts: model evaluation and document evaluation.

The model evaluation part asks the following questions:

1. According to your experience, do you think that the model provides sufficient elements to be tested on a limited basis before adoption and definitive release?
2. Do you see preliminary observable results from the application of the proposed model to the design of web applications?
3. Do you consider the adoption of the model useful for your understanding of the relevant requirements issues for web applications?
4. Do you think that the adoption of the model can help you improving the quality and the efficiency of the requirements analysis and usability of web applications?
5. Do you think that the model is overly complex to be understood and used?
6. Do you perceive the described approach to be compatible and consistent with the existing practices, design culture, values, standards and technologies shared in your organization/institution?

The document evaluation part asks the following questions:

7. Do you find the terminology used in the document clear and consistent with your past experiences in the field?
8. Do you find the presented examples useful for your insight in the issues?
9. Do you consider the structure and format of the document reasonably clear, effective and consistent?
10. Is the method described comprehensive of the different aspects concerning practical requirements issues?
11. Are the concepts explained adequate to the complexity of the topic?

For each question the evaluators could choose among the following options to express their level of agreement: Strongly Agree / Agree / Disagree / Strongly Disagree. A 'neutral' field was intentionally not defined to solicit the evaluator to express a judgment on the requested aspect.

7.2 Evaluation Results

In general, evaluators consider AWARE as a good-quality proposal for modelling requirements of web applications. The overall mean value obtained after the evaluation on every quality dimension is between 1 and 1.5 on a ± 2 scale (See Figure 10).

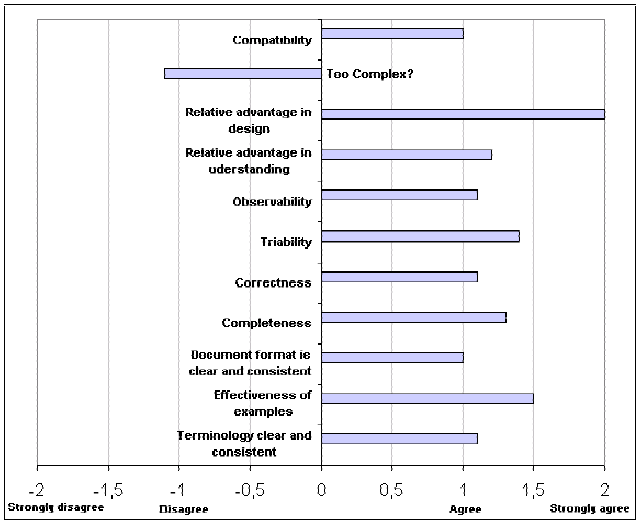


Figure 10. Responses of the analysts[3].

A detailed report about the techniques and results of the empirical survey is publicly available [23].

Besides a general positive appreciation of the approach, web analysts made also suggestions for improvements [23]: a) detailing a process guide that might lead step-by-step through the requirements analysis; b) highlighting more clearly the link between requirements and interface customization; c) providing heuristic principles, golden-rules and patterns supporting the model.

8. Conclusions and Future Work

Starting from the *i** framework, this paper introduces a novel proposal to analyse, organize and document requirements for hypermedia-intensive web applications, making use of goal and scenario-based techniques. Future

[3] The complexity value may appear a negative judgment. Reviewers disagreed when asked whether the method is too complex. Thus, the value is to be read as a positive appreciation.

research will consider the suggestions for improvement gathered during the empirical evaluation. Moreover, guidelines and heuristics to identify, add, delete, and modify new dimensions to the requirements taxonomy may be developed.

Notations and techniques to support traceability from hypermedia requirements to conceptual design artifacts are being defined, because iterative development risks to loose traces of quickly evolving requirements and designs.

Stakeholder and goal priorities have to be further investigated. As the size of goals, stakeholders and requirements grows, the impact and propagation of priorities from goals to requirements have to be more carefully studied. Requirements priority techniques [17] and practices of requirements triage [10] will be explored to address the specific needs of web site projects.

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