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Davide Bolchini · Paolo Paolini

Goal-driven requirements analysis for hypermedia-intensive Web applications

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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, bridging the gap between requirements and Web design, and reusing requirements for an effective usability evaluation. Techniques should be usable, informal, require little training effort, and show relative advantage to project managers. On the basis of the *i* * framework, this paper presents a proposal for defining hypermedia requirements (concerning aspects such as content, interaction, 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 Goal-based analysis · Hypermedia design · Hypermedia requirements · Usability evaluation · Web applications

D. Bolchini (✉)
Tec Lab, Faculty of Communication Sciences,
University of Lugano, Via G. Buffi,
13 6900 Lugano TI, Switzerland
E-mail: davide.bolchini@lu.unisi.ch
Fax: +41-91-9124647

P. Paolini
Hypermedia Open Centre,
Department of Electronics and Informatics,
Politecnico di Milano, Via Ponzio,
64/A 20120 Milano, Italy

1 Introduction and motivation

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. Whereas the debate around Web site design stimulated both researchers and practitioners to develop design methods, patterns, and guidelines to support the work of Web designers, the activity of requirements analysis for Web sites seems still to be entirely left to the intuition of the Web analysts, who might benefit of proper conceptual tools to elicit, analyze, and document requirements in a systematic and effective fashion.

For small homemade Web sites (such as, for example, most personal homepages) a systematic requirements method or a systematic design method may not be worth using. Given the size and the resources of the project, adopting a structured model for the requirements and design activity would probably be less efficient than using an agile "sketch, code, and review" approach. However, as the size of the application and the number of stakeholders involved increases, it becomes more important to devote project resources to understand, elicit, and analyze Web site objectives and requirements, as well as to keep the complexity of the design under control.

It is clear that there are several families of Web applications, which may be classified according to different criteria such as their domain (e-commerce, healthcare, educational, corporate, etc.) or their goals (trading goods, community building, informing, entertaining, etc.). However, to better understand the approach to Web application requirements, it may also be useful to investigate the typology of the expected user experience on the site, so as it is reflected in the interaction paradigm established by the application.

Modern Web applications are basically merging two interactive paradigms [1]:

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 catalogues, 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 [1].

Over the last few years, advanced requirements methodologies (such as TROPOS [2]) applied to Web-based applications have considered mainly the transactional and operational aspects. However, hypermedia-intensive Web applications (those favoring the hypermedia style rather than the transactional style) are not systematically covered in requirements analysis concerns.

Large 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 some 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 [3, 4], i.e. they wish to use the site to get across structured messages and content to a variety of users. Requirements should take informed decisions about the design of the user experience by considering potential users who have goals with respect to the site and who expect to find a usable information architecture with which to learn, to be engaged, and to retrieve information.

This paper focusses on requirements analysis for hypermedia-intensive Web applications, also called information-intensive or communication-intensive. Moving from key achievements in goal-oriented requirements analysis and assessed hypermedia design techniques, AWARE—a model for the Analysis of Web Application Requirements—is introduced.

AWARE pushes for introducing a communication-oriented perspective in Web site development, where high-level communication goals and user requirements have to be taken carefully into account during requirements analysis. Moreover, requirements should be tied up coherently with conceptual design of hypermedia specifications, possibly capitalizing on current Web design practices. Requirements techniques for Web sites should also be extremely lightweight, intuitive, and usable by Web analysts and project stakeholders, who often have little or no technical background. Finally, 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 [5] found that fine-grained iterative development is mainly adopted in current practice by Web project teams. In this context, design artefacts 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 paperwork for Web project teams, but rather a support for communicating, negotiating, and reasoning about the strategic decisions during incremental development. In this context, AWARE may serve as a conceptual tool for effectively supporting these activities.

The paper is an extended and revised version of [6]. Section 2 discusses some relevant works related the requirements analysis for information systems and Web applications. Section 3 presents the key constructs of the AWARE model, describing how it extends and complements goal-oriented analysis based on *i* *. A real case study is discussed in Sect. 4. The case study shows concrete examples of the basic features of AWARE, defining hypermedia functional and non-functional requirements on the basis of the goals of the stakeholders. Section 5 illustrated the relationship between requirements and hypermedia Web conceptual design using a proven Web design methodology (W2000). Excerpts of the design are shown and commented upon. Section 6 indicates how to reuse the requirements knowledge for a systematic usability evaluation, an aspect often considered as standing apart in the Web development process. Section 7 presents the method and the results of an initial empirical evaluation of the model carried out with real Web analysts in the context of the UWA EU-funded project.[1] Section 8draws some concluding remarks. Section 9 outlines future work, which

[1]Ubiquitous Web Applications (UWA) IST-2000-2531 (http://www.uwaproject.org) is a two-year EU-funded project aiming at developing a set of design methodologies and tools for supporting the development of multi-channel Web applications. Part of the AWARE model was conceived and validated as an integral part of the project.

is dedicated to the further validation of the model, to its enhancement, and to the technology transfer.

2 Related works

Conceptual tools for analyzing goals and reasoning about actor–goal dependencies for e-commerce Web-based information systems were provided in the TROPOS project [2]. In this context, the *i* * framework [7] is adopted to model actor intentional relationships and analyze high-level goals together with non-functional requirements. In particular, one of the results of TROPOS is the definition of a bridge between organizational stakeholders and goals and candidate software architectures supporting the requirements. Passing from early requirements (organizational goals) to late requirements (system properties and service capabilities), much emphasis is on the functionality of the system, which is an important but not exhaustive aspect of a Web application. Late requirements should also give proper indications about the hypermedia aspects (concerning information architecture, interaction, and navigation), which directly affect the user experience. The 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 [8]. Here, techniques for goal decomposition allow for the formal definition and analysis of system goals, as well as for the exploration of alternatives. The operationalization of goals enables the specification of a detailed requirements set, where responsibilities for their fulfillment are assigned to agents.

Semi-formal goal analysis defined in GBRAM [9] 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 [10] as well as in usability evaluation [11], describe envisioned possible uses of the applications, highlighting in turn the motivation, the context, and the goals of the intended users [12]. Scenarios are powerful to exemplify goals and point out requirements vividly and are often used to complement goal analysis approaches. In Web site development, scenarios are often claimed by practitioners to drive the definition of requirements. However, whereas user scenarios may cover the analysis of user requirements, the requirements deriving from stakeholders who are not users (such as the client, client representatives, organizations, and other institutional entities involved in the project) are better covered by goal-based methods.

Over the last decade, the hypermedia community has elaborated user-centered Web design models. These design techniques (such as WebML [13], HDM [14], OOHDM [15], W2000 [16], WSDM [17], OO-Method [18], and UWE [19]) enable users to model the essential hypertext and hypermedia features of complex Web sites at a proper conceptual level. The motivation for the development of structured methodologies for Web site design is the recognition that complex Web sites cannot be designed "page-by-page," simply because the design of the information and navigation architecture quickly becomes unmanageable without using proper abstraction mechanisms. To this end, notations and models to describe the navigation, the information architecture, and interface structure of Web sites at a conceptual level (i.e. independently from implementation details) were defined together with proper tool support.

As many companies were motivated to develop a Web presence by the growth of the Internet economy, a large part of the basic principles underlying these systematic design approaches were borrowed by practitioners [20]. As a consequence, an explosion of literature about practical guidelines, lightweight methods, and "successful" processes for effective user-centered Web design occurred.

After so much attention was paid to the design process, the requirements activities for Web site development began to receive some consideration, because it was realized that a well-designed Web site is such only if it fulfills the expectations of the users, as well as the business and communication goals of the main stakeholders.

Initial research efforts to bridge the gap between requirements analysis and hypermedia conceptual design using scenarios can be found in [15]. In this case, scenarios drive the elicitation of the desired features of the Web site. Although scenarios may be useful for requirements exploration, they may be also deceiving if used in isolation. In fact, since they describe concrete uses of the Web site, they may introduce design decisions that are premature to commit on. Scenarios should be carefully used to suggest possible site uses and as a source for defining high-level and general user goals. Goals have to be extracted and abstracted from scenarios and then refined in the requirements analysis.

This paper illustrates how to use goal-oriented requirements analysis to define hypermedia specific-requirements that may be effectively used in Web conceptual design and usability evaluation. In this light, the AWARE model is introduced to provide project teams with proper modelling constructs and notations.

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 users to document and specify goal-oriented hypermedia requirements, as well as to keep 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. Whereas *i* * provides constructs to model actors and their dependencies with respect to their goals and tasks, 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 to help organize the design activity accordingly. As shown in the metamodel in Fig. 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, decision makers 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 goals or to 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 satisfaction of such goals (delegated goals).

Stakeholder (i actor) priority*. Project teams 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 properly weigh the goals and the needs expressed by each stakeholder, and consequently plan effort and resources for the analysis in a more efficient way [21].

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' goals and main stakeholders' goals. Goals can be decomposed by *i* * decomposition and means–ends relationships. As acknowledged by *i* * and other goal-driven methods [9, 2], goals may need to be expressed informally (or semi-formally) to enhance communication among stakeholders but as unambiguously as possible to avoid misunderstanding.

Task. Refining users' goals, user tasks may be defined. While a goal is a 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.

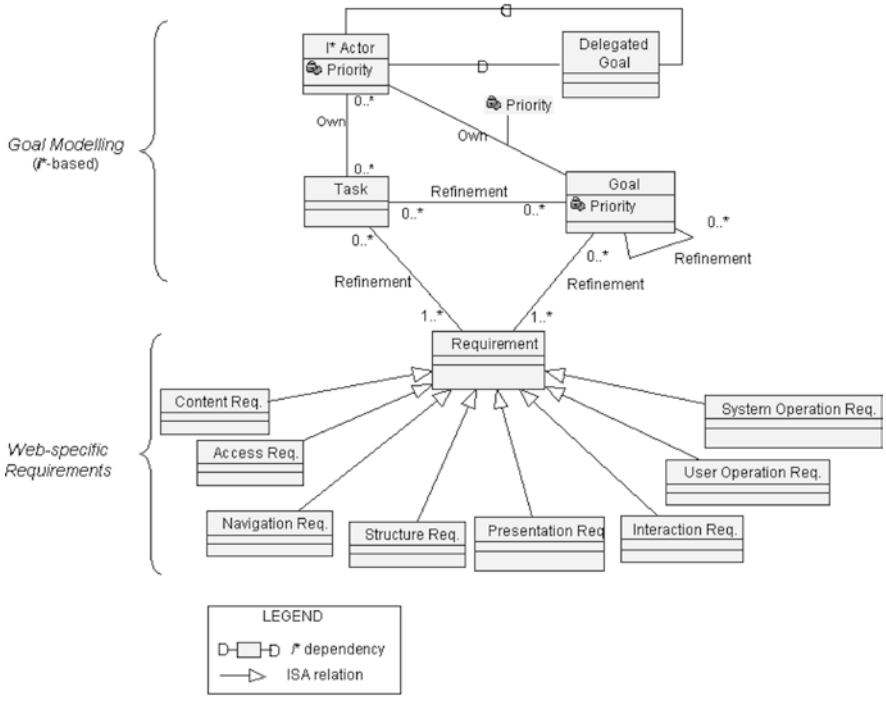


Fig. 1 The AWARE metamodel for Web application requirements

Stake priority. A stakeholder may consider a goal more important than another. In case of large number of goals, it would be recommendable to 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 others, or more crucial to support rather than others. Therefore, in the metamodel shown in Fig. 1, the stake priority represents the degree of interest for a goal as expressed by a stakeholder. It is therefore a property of the relationship between a stakeholder and one of his/her goals. This relevance may be expressed by quantitative (e.g. 0,...,1) or qualitative (e.g. +, -, ++, –, ...) values.

Goal priority. Since a goal may be owned by more stakeholders, the priority of a goal should be calculated properly, combining all the stakeholder priorities and stake priorities involving that goal. For example, analysts may multiply the stakeholder priority for the stake priority for each stakeholder owing that goal, and then summing all these values to obtain the absolute priority of the goal. Obviously, priority values are of use only when many high-level goals are at stake, and analysts have to make important decisions about pruning goals.

Requirement. Goals are refined, elaborated into subgoals, 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. Note that the requirement construct models both functional requirements and non-functional requirements.

The concept of ''requirement'' is not modelled explicitly by *i* * because it addresses mainly goals–actor relationships in the early stages of analysis. AWARE instead uses the concept of requirement as operationalization of goals as in [8].

3.1 A hypermedia requirements 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 [22] (see Fig. 1):

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 terms 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'', and ''communicate opening and visiting hour''.
2. *Structure of content*. Requirements can also give coarse-grained insights about how the content pieces identified might be structured. By ''structure'' we mean 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'', or ''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 to 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 artefacts 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'', and ''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 artefacts exploited by the user to navigate, once accessed a given information object, from that object to one or more others that are 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 or 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 and 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 not directly 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 [24]) 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). Note that interaction requirements cannot be reduced to the presentation aspects. Whereas presentation concerns aesthetic/cognitive aspects of the Web pages, interaction requirements may entail the motivational element of the user experience, the creation of expectation in the user, and his or her engagement in the Web site content.

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 environment) and may suggest new dimensions to be considered.

Dimensions can help organize the design activity. In fact, designers can then adopt any Web design method (e.g. WebML, OOHDM, HDM, WSDM, or 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 designers to focus 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 Web site. 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 example

During the requirements analysis of the Web site of an Italian supplier of silver-made artefacts (from now on called B-Silver), we adopted the AWARE model, employing an intuitive and 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 artefacts defined during the requirements analysis is 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 metamodel. Priorities at the top-level goals, for example, are not exploited due to the very limited number of stakeholders and high-level goals involved.[2] 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. As to the actor interdependencies, it is clear that the key dependency to be considered is that the accomplishment of the communication goals of the main stakeholder depends on the success of the user experience on the site.

Therefore, even if simple, the case study presented is suitable to exemplify the derivation of hypermedia requirements, since the site at issue was mainly hyper-

[2] In case of a very limited number of top-level goals and stakeholders, it may be more useful to assign priorities directly to requirements, and then employing prioritization techniques such as QFD [25]. A method for using prioritization in goal models is also shown in [26].

media-intensive and did not have particular operations or transactions involved. Moreover, the case study shows in practice how to use goal-oriented analysis in a Web project, how to manage the transition between requirements and hypermedia design by means of the requirements taxonomy, and how to reuse requirements knowledge for usability evaluation.

4.1 Goals of the firm

The crucial high-level objectives that B-Silver needs to address by means of the Web site are (Fig. 2):

1. *Attract new clients*. B-Silver is one of the leaders in the regions near 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.

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. Let us consider the analysis of the most important goal, namely *attract new clients* (Fig. 2). 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 subgoals identified should be analyzed and further decomposed. Decomposition here is not intended as a necessary derivation, but rather as the doc-

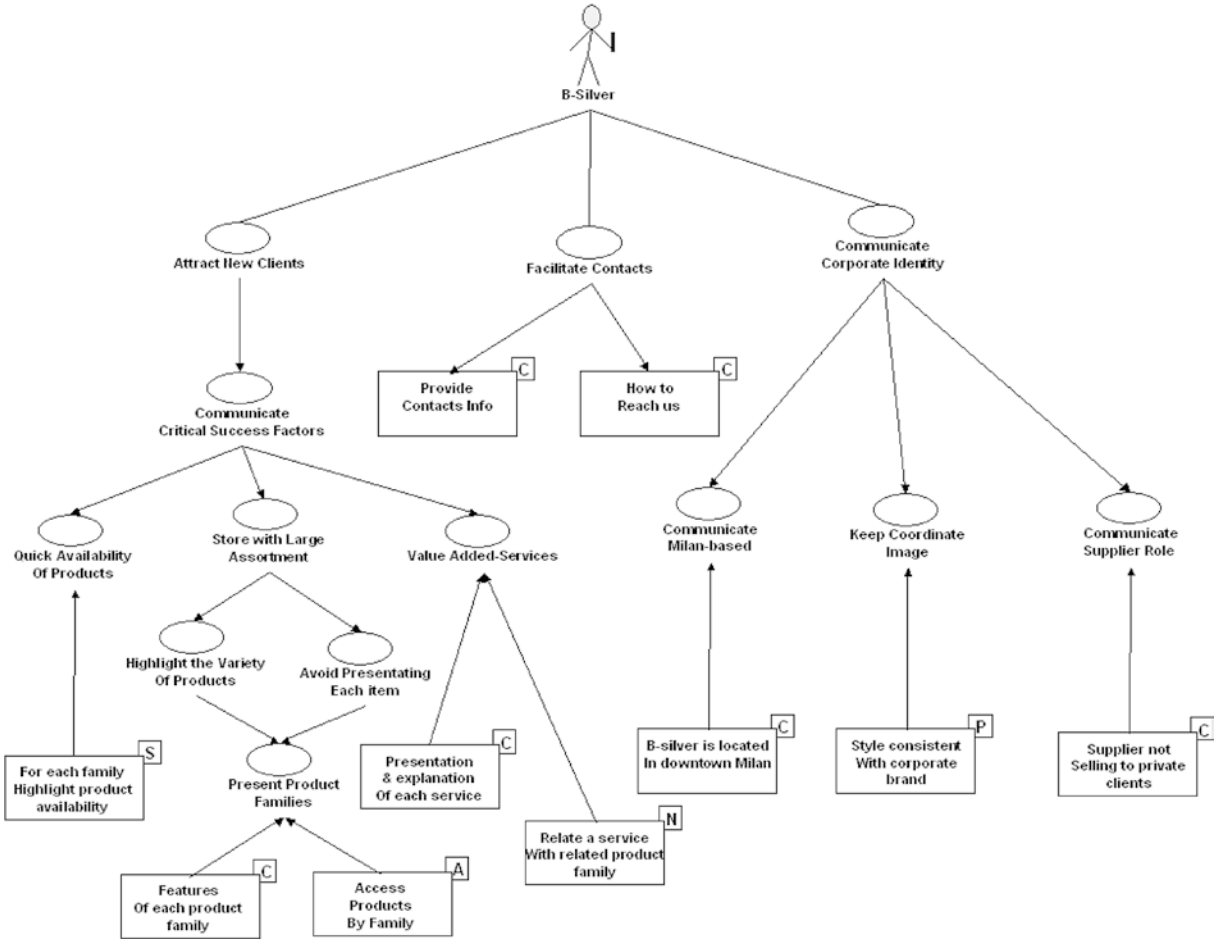


Fig. 2 From goals to hypermedia requirements for B-Silver main stakeholder

umentation of the outcome of a decision-making process. Moreover, the refinement decisions are strongly dependent to the resources available for the project, that is, a time to market of two months and a budget limited to 10,000 euros.

Elaborating on the *store with large assortment* subgoal, two goals were identified (Fig. 2): *highlight the variety of products* on one hand, and *avoid presentation of the single items* on the other. The latter subgoal is a case of negative goal (also called ''Avoid'' goal). Indeed, the discussion with the staff of the president gave rise 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 hundreds thousands of 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 a 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.

In order to solve the tension between *highlight the variety of products* and *avoid presentation of the single items*, a possible strategy identified is to *present main product families*. With such a strategy, the communication of the range of different products is ensured without dramatically affecting the budget available. Two requirements are defined to fulfill the *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 (the *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 also shown in Fig. 2. 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 type of content needed, and not yet how it will be integrated in the overall site architecture.

The communication of B-Silver corporate identity is achieved through three basic requirements (Fig. 2): the site will clearly explain that B-Silver will not sell artefacts to private clients (refining the *communicate supplier role* goal); moreover, it should be communicated that the store is located in the center of the city of Milan (refining the *communicate Milan-based* goal). As a third requirement, concerning the presentation aspect (labeled with P), the site should have a presentation style (in term of graphics and layout) consistent with the B-Silver corporate brand image.

Through this analysis, the analysts gathered a first set of essential hypermedia requirements and the basic rationale behind them. As a 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 a 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 the B-Silver president, one emerged as the most important (and the only) to be taken into account in this case (Fig. 3): a 40–50 year 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. Not all the characteristics of the profile will be easily mapped to requirements and design decisions. However, keeping in mind the target audience of the Web site in terms of a person (with a given average age, skills, and knowledge) maintains an important point of reference for the subsequent choices about the requirements (both functional and non-functional), as well for the selection of the user sample for the planning of the usability evaluation.

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, it also represents a first-time visitor or an experienced user of the site. These different aspects of the user are all taken into account in *user profile 1* in order to enable the consideration of more comprehensive set of requirements.

As shown in Fig. 3, the envisioned high-level goals for *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,

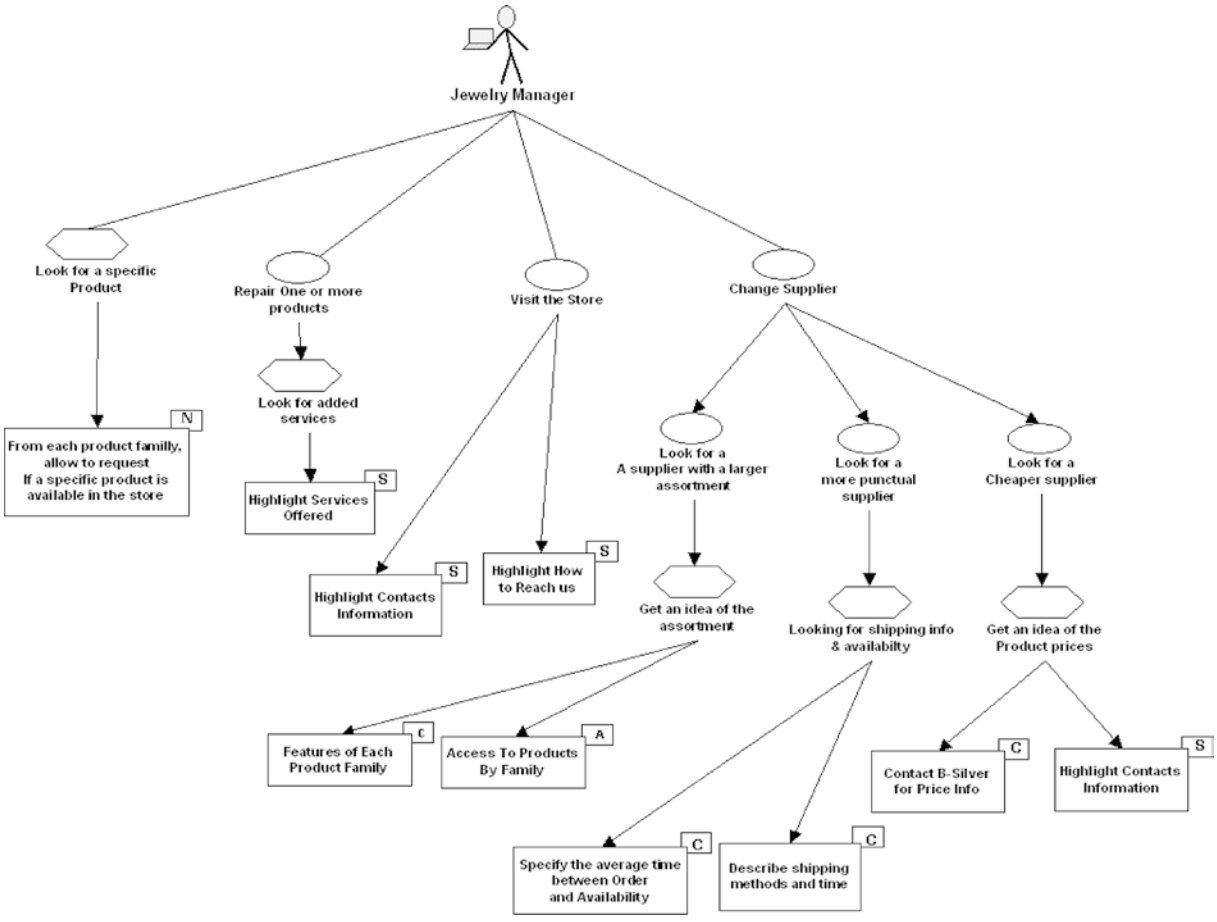


Fig. 3 From goals to hypermedia requirements for *user profile 1*

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. In fact, narrative scenarios were discussed with the main stakeholders, then the goals and tasks exemplified in the scenarios were generalized and abstracted in the goal graph. 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. 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 Fig. 3, 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* (Fig. 3).

The requirements defined to fulfill the *visit the store* goal (Fig. 3) 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 the elaboration of three further salient scenarios (Fig. 3) 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.

The user's goals analysis allowed for the partial definition of new requirements and partial matching of existing 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 [27], and on lessons learned from previous Web project experiences, relevant non-functional requirements were defined and classified in this case.

As shown in Fig. 4, relevant soft goals salient for the qualitative aspects of the Web site were elicited and consequently refined into hypermedia non-functional requirements. Non-functional requirements are classified according to the hypermedia taxonomy to facilitate the work of designers.

The top-level soft goal is to achieve *usability*, meant as the fundamental aspect of a satisfactory user experience. This high-level goal is relevant for the potential user of the B-Silver Web site, but also for the main stakeholder. In fact, delivering a usable Web site is an important concern for B-silver too, who does not want to disappoint their clients. Being too high-level and generic, usability has been decomposed into different aspects concerning the quality of the information architecture and its impact on user navigation. Since the hypermedia requirements defined do not assure in absolute terms the achievement of an optimal level of usability, each refinement link is to be intended as contribution to fulfillment (as the *i* * link " *Some*+" [2]) rather than a complete satisfaction of a goal. They may contribute to enhance usability, and may be considered "good-enough" to deliver a usable navigation experience.

To keep the user from losing orientation within the site (see *orientation* soft goal), maintaining the *status visibility* is an important navigational requirement to take into account. Status visibility refers to the capability of the site to show the user the current position within (a portion of) the information architecture. Advanced status visibility features also concern the highlighting of the path the user did to get to the current state, and the marking of the visited nodes.

Orientation is also facilitated by *consistency*, which may concern both structural, navigational, and presentation aspects. The content structure of the information

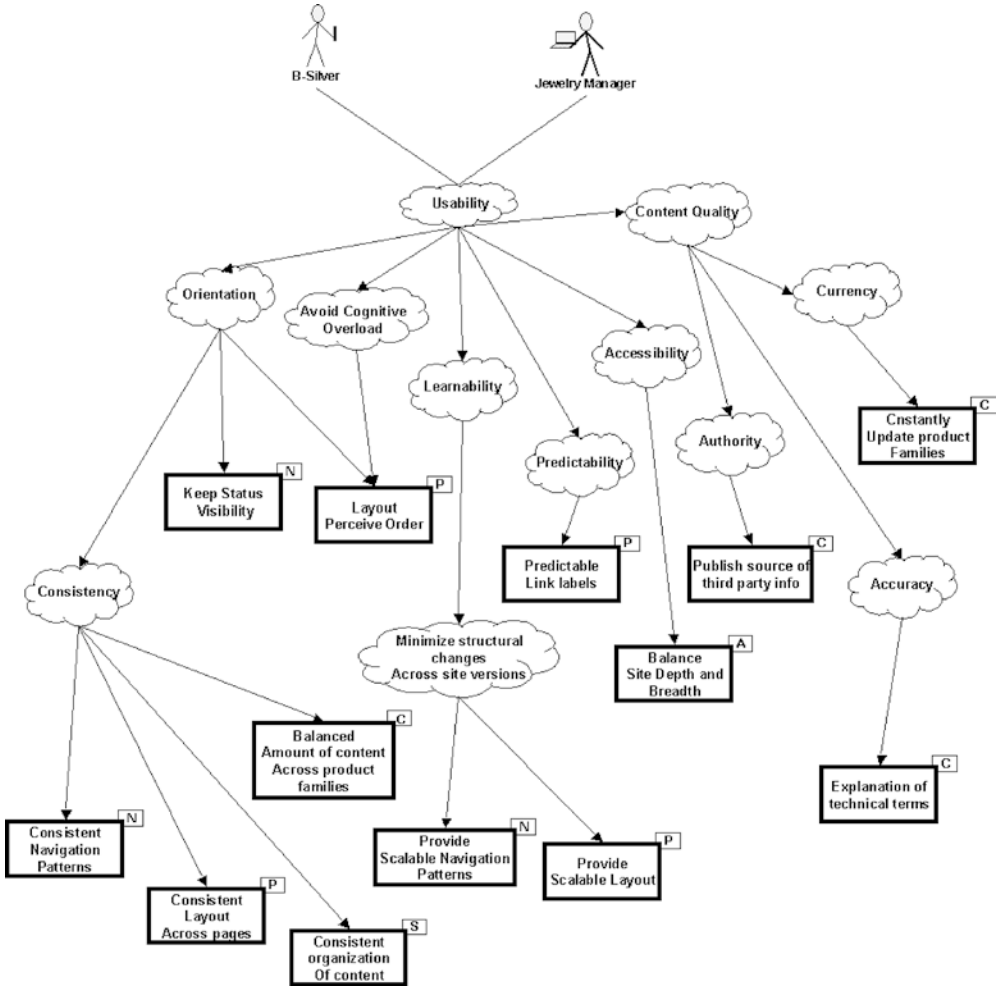


Fig. 4 Analyzing soft goals for deriving hypermedia non-functional requirements

objects should be as consistent as possible. Consistent navigation patterns are also a great support to enhanced orientation during navigation. The layout of the different information objects, indexes, and access structures should also be consistent across the nodes.

Designing a layout within a node that may be perceived as *ordered* by the user is a presentation requirement helping avoid cognitive overload for the user. Especially in information-intensive Web sites, this requirement is often neglected in favor of condensing information on the nodes, which is claimed to save the user navigational steps. However, the result is often a site with navigational nodes full of disorganized information that is cognitively difficult for the user to process.

To enhance the *learnability* of the site, that is, the property of having site structure and behavior easily recognizable for returning users, a possible strategy identified is to minimize structural changes across the different site versions over time. A site should evolve as its requirements evolve. However, the changes in features should not compromise the possibility for a returning user to recognize the site and to find his/her way within it as usual. To this end, two specific requirements are defined. Providing scalable navigation patterns (navigation requirement) means designing linking structures across nodes that do not change drastically as new information objects and links need to be added. At the presentation level, the layout should be scalable as well, to avoid redesigning the entire page scheme as content and site sections need to be added or removed.

Balancing the number of the site sections (or subsites) with their depth (navigation levels) is a requirement that may support the achievement of good *accessibility*. *Predictability*, that is, the property of an interface sign to transparently convey its meaning, may be satisfied by designing link labels, which may indicate clearly the content they point to.

Important content quality attributes [28] should also be carefully taken into account during requirements analysis. The *authority* of the content, that is, the extent by which the author of the information is easily recognized as having knowledge of the subject area [28], may be achieved by publishing on the site the source of any third-party information that is reported. *Accuracy* may be partly addressed by publishing proper explanation of the technical terms (about silver products and services) used on the site. Finally, currency is concerned with keeping the main content of the site (the family of products available) up-to-date.

5 From requirements to Web design

In the real case described, the level of detail of requirements may serve both as input for a systematic Web and hypermedia design [1, 13] and for more informal approaches to Web design [20].

We used a systematic Web design technique (called W2000 [1, 16], an evolution of HDM [14]) for elaborating design solutions on the basis of the requirements. W2000 is a schema-based conceptual design model for Web applications that—similarly to a variety of other design models—offers conceptual constructs to define the information design, the navigation design, the publishing design, and the operation design. We will not go into the details of W2000, which is a proven design method described in [16]; however, as examples we report some excerpts from the hypermedia design carried out for B-Silver.

5.1 Excerpts from information design

According to W2000, the task of information design is to shape, on the basis of the content, navigation, and structure requirements, the information architecture of the Web application. A basic artefact of information design is the hyperbase schema in-the-large (Fig. 5),

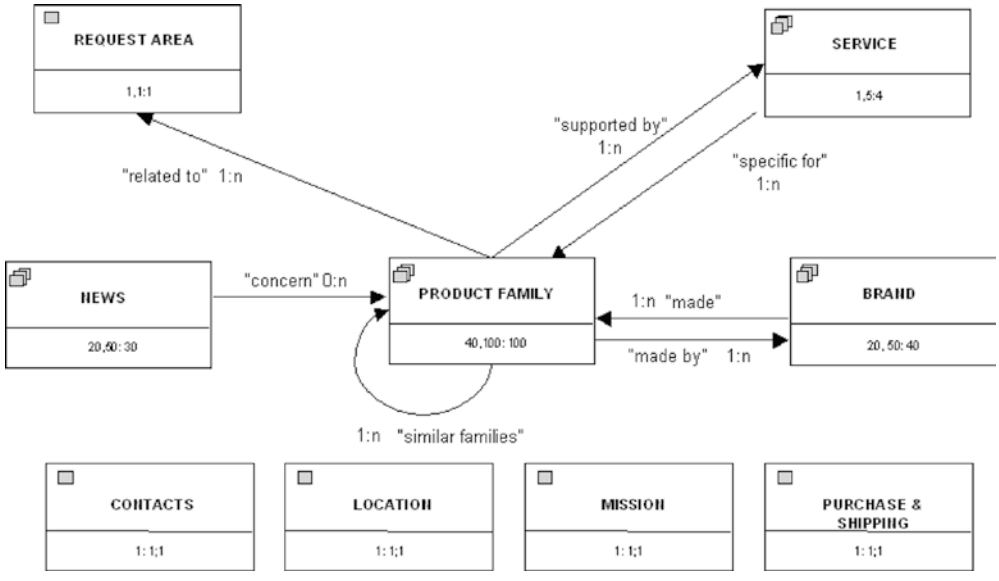


Fig. 5 Hyperbase schema in-the-large for B-Silver Web site

which defines the main information objects available to the users (entity types and single entities), and the semantic associations that may be exploited for navigating from one object to another. Each entity is marked with the expected number of instances for that entity.

The hyperbase was basically defined on the basis of the content and navigation requirements. However, at this stage only, new navigation capabilities emerged as relevant to offer to the user, which had not been envisioned at the requirements stage. For examples, the possibility of navigating from a family to similar product families, or to the description of the brands of the product family were defined and discussed with the stakeholders at design time. From this experience, we learnt once again that having a high-level design allows quick and inexpensive iteration between requirements and design documentation.

Information design comprises also the definition of the access structures available to the user to locate and reach the content of interest, as well as to be led to unexpected content. In the W2000 framework, entity types are grouped in *collections* for the purpose of access (Fig. 6).

As we consider the detailed content of the site, we have to define the information components of each entity type. Figure 7 shows the information components and the detailed information slots for the entity type Product Family.

Note that the information components do not describe any predefined user interaction or navigation structure. They just state the needed content for the information object. In fact, given the same information structure, different navigation paths may be designed on top of it. To this end, navigation design enables to define the Web site in terms of nodes and links derived from the conceptual objects of the information design.

5.2 Excerpts from navigation design

Navigation design aims at defining the detailed navigation contexts (called *clusters*) for the user to interact with the nodes and links composing the Web site. Clusters have to be defined for each type of navigation context to be supported: the semantic navigation *between* entity types (association clusters), the navigation *within* an entity type (structural clusters), and the navigation within a *collection* (collection clusters).

Let us consider two simple examples of navigation clusters: a structural and a collection one. Figure 8 shows the navigation cluster designed for the entity type Product Family. The components of the information design have been reorganized in nodes for the user to navigate, and navigation patterns have been defined between nodes. In simple cases, it may happen that components and nodes have a one-to-one correspondence. In this case, to avoid cognitive information overload, the content of the component *prices and availability* (Fig. 7) was divided into two navigational nodes, namely *availability info* and *prices and discount* (Fig. 8). Another important navigation design decision that was taken concerns the creation of one node for each *highlight product* information, and the definition of a suitable navigation pattern for allowing both guided tour access to this content (for example, for first time users) and direct indexing (preferred by frequent users) [23].

In W2000 terms, a cluster of an entity is called a structural cluster, because it defines the navigation paths enabling the exploration of the structure of an information object. Note that navigation design defines clusters as navigational context *types*, which will be instantiated according to the instances of its elements. In this example, each instance (100 overall) of the entity type Product Family will be organized according to this navigation dynamics.

Figure 9 shows the detailed navigation for the collection cluster of the collection Product Genres. In this context, designers define paths for the user to explore the different product genres. Links and navigation patterns from the entry point node of the collection to the collection members are designed.

5.3 Excerpts from publishing design

Once all the navigation clusters have been defined in terms of nodes and detailed linking, it is possible to decide how nodes and links will define the actual Web site pages. Pages are designed in terms of *page types* and *page sections*. A page type is composed by page sections. A page section may include links and one or more

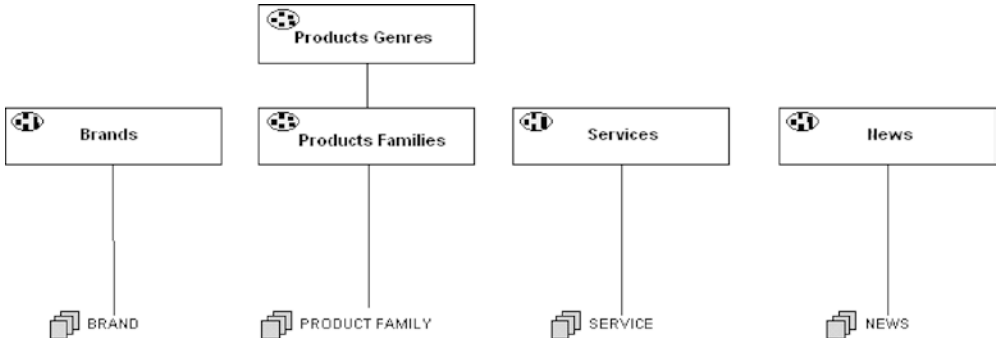


Fig. 6 Collection schema in-the-large for B-Silver Web site

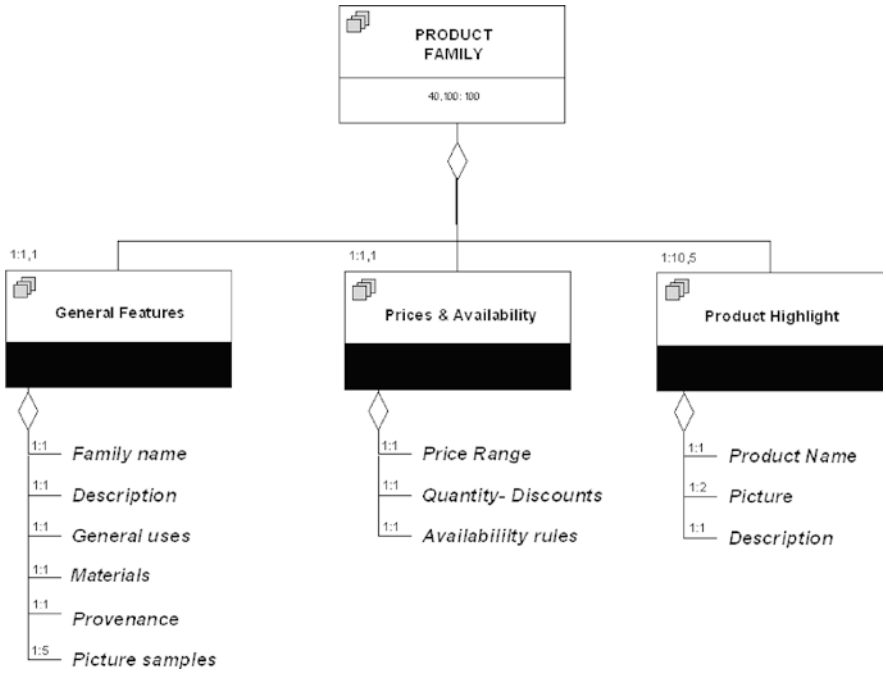


Fig. 7 Information components for the entity type product family

content nodes. Figure 10 shows the logical structure of the page type for the node *general features* of the entity type Product Family.

This page type is made of five sections, each one providing outcoming navigation links from the page, in compliance with the navigation design. Layout mock-ups and graphics proposals may then be made on the basis of this tentative page design.

Non-functional requirements were also very helpful in the design process. First, they support the decision of choosing a systematic design methodology over a non-structured design approach. In particular, the requirements deriving from two soft goals (''consistency'' and ''minimize structural changes across site versions'') brought designers to pick a design approach (W2000) that would easily facilitate consistency across navigation patterns and page layout for large Web sites. As showed in the information and navigation design, the design modelling abstractions used by W2000 helped take information and navigation decisions keeping consistency across artefacts, thus fulfilling important non-functional requirements (Fig. 4). Content non-functional requirements mainly supported the information design. Finally, a large part of the presentation and navigation non-functional requirements informed the publishing design and the subsequent graphic design of the detail page layout.

5.4 Operation design

With regard to user operations and system operation requirements, designers may employ standard languages (such as UML diagrams) to precisely define the trans-

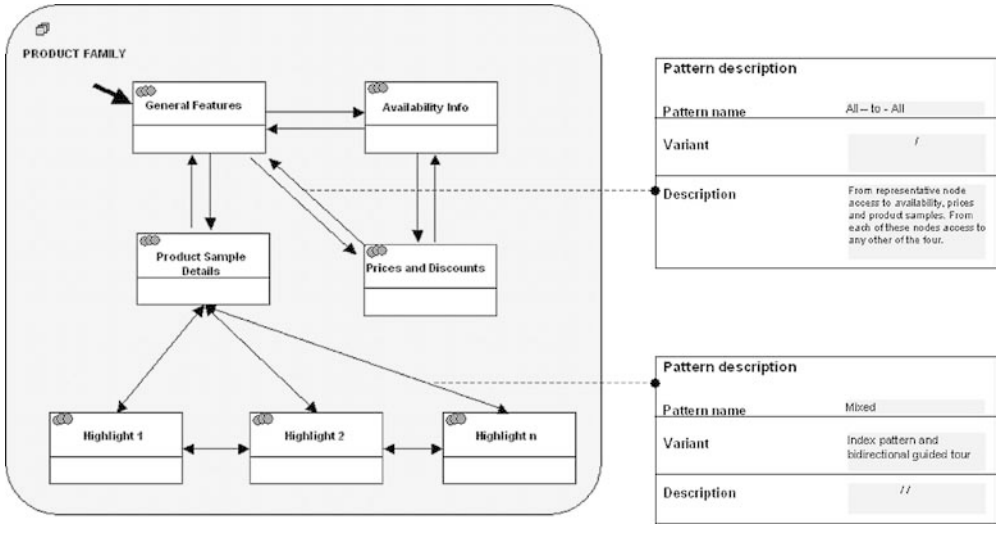


Fig. 8 Structural navigation cluster for the entity type product family

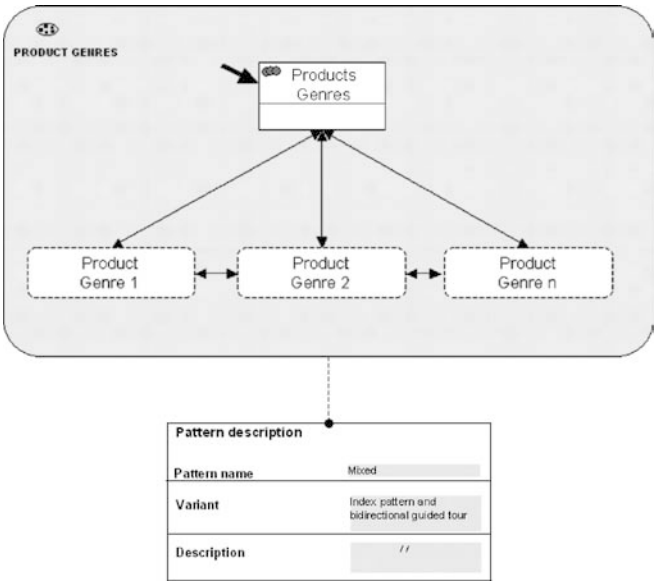


Fig. 9 Collection navigation cluster for the collection "product genres"

actions 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 design model provides also a UML-based framework for integrating hypermedia design with operations [16] and transactions [24] in a coherent fashion. WebML [13] defines design primitives for integrating information modelling with operations and functionality. In the real case example illustrated, the Web site did not require specific operation and transaction design. However, 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 [29] and [30].

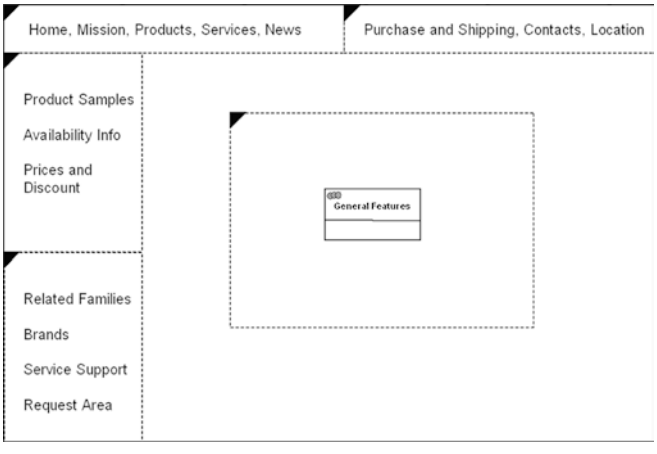


Fig. 10 Page type for the node general features of the entity type product family

6 Requirements-driven usability evaluation

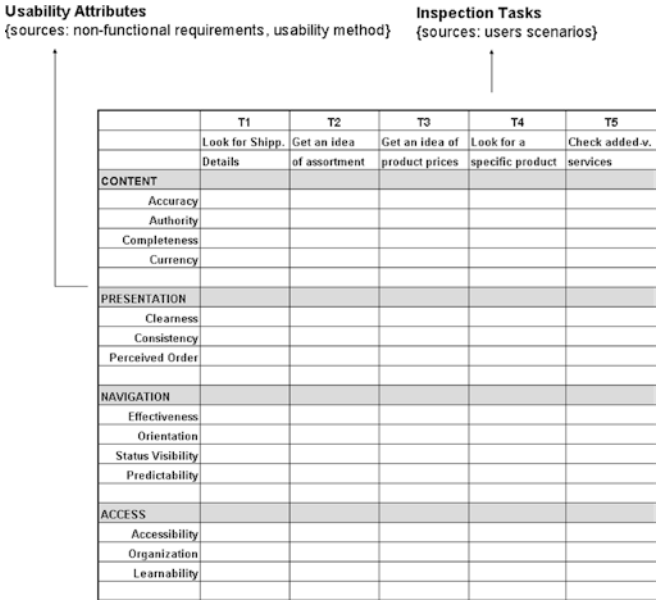
Usability evaluation aims at enhancing the quality of the user experience. Usability evaluation methods for Web applications usually blend different variants of two basic approaches: expert review (usually referred to as usability inspection [11]) and user testing. During expert review, one or more usability 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 [31, 32], planning a Web usability inspection means: (a) define 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. Figure 11reports the inspection matrix prepared for the B-Silver case.

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.
b. Usability attributes tend to correspond to the non-functional requirements. Examples of usability attributes considered for the inspection are in Fig. 11. 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, 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.



	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					

Fig. 11 Usability inspection matrix prepared for B-silver project

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]. This approach to usability analysis is part of a requirements-driven usability evaluation method for the Web called MiLE [32].[3]

7 Validating the AWARE model

AWARE was applied in industrial, research, and educational projects.[4] It is also being applied at the Webatelier (http://www.webatelier.net) of the University of Lugano on Web communication projects designed for public and private companies in Switzerland and in Italy. In some of 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 requirement set for the design.

A first empirical validation of the AWARE model was recently developed within the UWA European Project (IST-2000–2513) [34] 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 [35], which examines the rate and the motivations of adoption of a technological innovation by a group of potential users. Such an approach may also be fruitful 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 [36].

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 limited basis before adoption. *Observability*refers to the observable results deriving from the use of the new product. *Relative advantage* is the perception of how much better the innovation is 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.

Besides these attributes provided by the diffusion theory, we add two aspects that we consider important for a requirements model: completeness and expressiveness. Completeness measures the domain coverage provided by the approach; expressiveness measures whether the conceptual tools proposed are enough to cope with the complexity of the domain (Web application development in this case).

The quality of the document presenting AWARE was also assessed by means of three other attributes: consistency, effectiveness of the examples, and structure clarity.

On the basis of these ten attributes, a process-oriented evaluation was conducted: it focussed on the quality of AWARE and not on the products designed with the model. Eleven Web analysts all over Europe were recruited (nine from the industry and two academics) 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[5] presenting an in-depth explanation of AWARE (in terms of modelling concepts, notation, suggested process, and examples).

On the basis of the quality criteria, an online questionnaire with eleven questions was designed (see [34] for the detailed questionnaire rationale). The analysts were asked to answer the questionnaire by the fourth week after the assignment of the documentation. The questionnaire was divided in two parts: model evaluation and document evaluation.

[3]MiLE is in turn an evolution of SUE (Systematic Usability Inspection) [31], mainly used for hypermedia usability analysis.

[4]Web projects includes Banca121 credit card catalogue and Punto commercial e-business marketplace. Requirements specifications of these pilot applications are available at http://www.uwaproject.org.

[5]The document assigned for the evaluation is the Deliverable D6 [33] of the UWA EU-funded project.

The model evaluation part asks the following questions:

- **Question 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?
  - **Quality attribute**: Triability.
- **Question 2**: Do you see preliminary observable results from the application of the proposed model to the design of Web applications?
  - **Quality attribute**: Observability.
- **Question 3**: Do you consider the adoption of the model useful for your understanding of the relevant requirements issues for Web applications?
  - **Quality attribute**: Relative advantage.
- **Question 4**: Do you think that the adoption of the model can help you improve the quality of the requirements analysis for Web applications?
  - **Quality attribute**: Relative advantage.
- **Question 5**: Do you think that the model is overly complex to be understood and used?
  - **Quality attribute**: Complexity.
- **Question 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?
  - **Quality attribute**: Compatibility.
- **Question 7**: Is the method described comprehensive of the different aspects concerning practical requirements issues for Web application?
  - **Quality attribute**: Completeness.
- **Question 8**: Are the AWARE modelling concepts explained in the document adequate to the complexity of the topic?
  - **Quality attribute**: Complexity adequateness.

The document evaluation part asks the following questions:

- **Question 9**: Do you find the terminology used in the document clear and consistent with your past experiences in the field?
  - **Quality attribute**: Consistency.
- **Question 10**: Do you find the presented examples useful for your insight in the issues?
  - **Quality attribute**: Effectiveness of the examples.
- **Question 11**: Do you consider the structure and format of the document reasonably clear, effective, and consistent?
  - **Quality attribute**: Structure clarity.

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 1.25 on a ± 2 scale (Fig. 12), with a standard deviation of 0.29.[6]

A detailed report about the techniques and results of the empirical survey is publicly available [34]. Besides a general positive appreciation of the approach, Web analysts also made suggestions for improvements: (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. The legend for the AWARE model is given in Fig. 13.

8 Conclusions

Starting from the *i* * framework, this paper introduces a novel proposal to analyze, organize, and document requirements for content-intensive Web applications, extending traditional goal-oriented approaches (mainly *i* *) by adding the analysis of hypermedia requirements. A hypermedia requirements taxonomy—useful both for functional and non-functional requirements—is introduced to classify the requirements set and pave the way for a systematic conceptual design.

The results of the requirements analysis may also be reused for the inspection-based usability evaluation of the Web site, taking into account user goals and quality requirements. During an initial survey of AWARE, the approach gathered positive feedback from the analysts who participated in the evaluation. However, the model still need to be further improved across more Web projects and validated on a larger sample of practitioners.

The main expected benefit of the AWARE approach is the ability of keeping the big picture of the requirements (stakeholders and their goals) under control without losing trace of the design decisions impacting

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

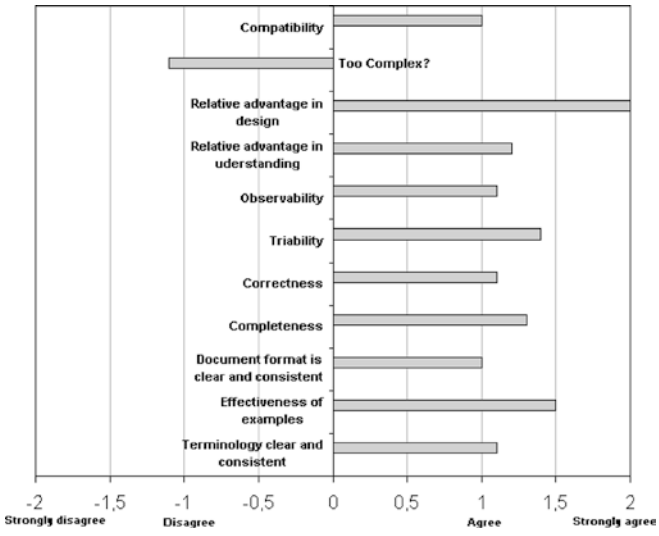


Fig. 12 Synopsis of the responses of the analysts

the hypermedia-specific artefacts. Moreover, an important contribution is the introduction of a taxonomy for hypermedia requirements, which bridges the gap between the specification of the goals and the design primitives currently offered by existing Web design models.

AWARE has also some current limitations that are worth noticing. First, it provides a conceptual model for deriving hypermedia requirements from goal-oriented analysis but it does not offer ready-to-use strategies to satisfy recurrent goals in a given domain with a suitable set of hypermedia requirements. For example, suppose that one of the goals of the main stakeholder of an e-commerce Web site is ''attract existing customers to the products on sale''. What is the proven requirements set that may lead design decisions to satisfy that goal? In other words, AWARE currently provides a set of concepts to represent requirements (requirements model) but does not offer requirements specifications to be directly applied to a domain-dependent problem (requirements patterns).

The evaluation of the AWARE approach still needs to be further extended, involving more Web analysts, Web site projects, and application domains. These and other aspects, which make room for further enhancement of AWARE, will pave the way for future work.

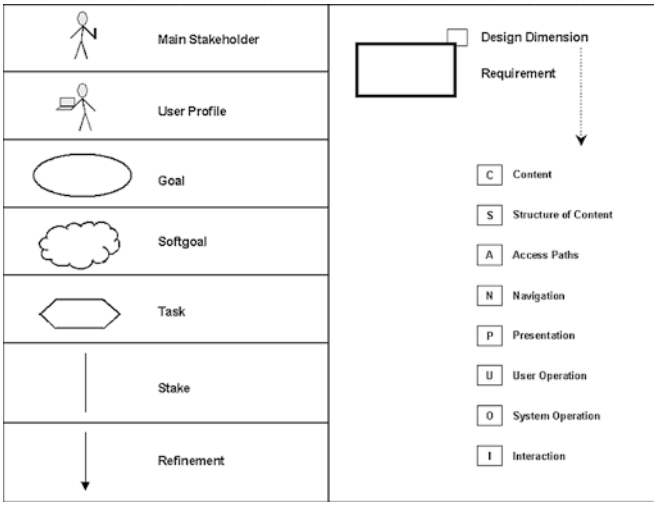


Fig. 13 Legends of the AWARE model

9 Future work

AWARE is an initial proposal to cope with the requirements analysis for Web applications. As such, the research done so far needs improvements and further evaluation, being just a first step in a promising research field. On the basis of the key results presented, current and future work is focussing on three main aspects of the AWARE model: validation, technology transfer, and enhancement.

9.1 Validation

AWARE is an evolving model. As we acquire project experience, we will enhance the model according to emerging needs. We are evaluating the effectiveness of AWARE by applying it to Web projects of various size and in different domains. Future work will be devoted to analyzing how AWARE is usable and useful to Web analysts and designers, gathering feedback from analysts with different level of expertise: novice, experienced, and advanced.

For example, an environment with high potential for the evaluation of the model is the Webatelier course of the University of Lugano, where more than ten Web projects a year are delivered for private and public companies in Italy and in Switzerland. The groups of designers may be monitored during their requirements and design activities while applying AWARE. Results of the analysis and feedback may then be gathered.

Another important dimension of the evaluation concerns the scalability of the model. We want to gain more evidence as to whether AWARE scales up in the context of large Web applications (e.g. banking Web sites, cultural heritage Web applications, e-commerce environments, and tourism Web sites), both in regard to the constructs and to the notation provided by the model.

9.2 Technology transfer

AWARE is meant to be a support for real analysts on real Web projects. However, the path from having a model to seeing it actually used and adopted by some practitioners is a long and hard one.

Current actions comprise the exploitation and the creation of all the opportunities to introduce Web practitioners to the model, and to train them on how

they could use it effectively. Considering the feedback gathered by these experience (some already carried out, some of them ongoing, and some to be done), AWARE is being refined, and under proper "packaging", to make it usable and correspond to the needs of the potential adopters in the field.

Target industries are Web agencies of middle and large dimensions, as well as consultancy, communication, and technology companies involved in Web application developments. In addition, exporting AWARE to professional training courses for designers and analysts is already giving insightful feedback.

Foreseen obstacles to technology transfer for requirements engineering techniques are the complexity of the method and the training time needed to make the method productive. Considering these factors, the experiences gained by training practitioners will be monitored, so to provide as much input as possible for making AWARE more usable, lightweight, and helpful.

9.3 Enhancement

The model may be enhanced and improved under several respects. 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 [21] and practices of requirements triage [37] will be explored to address the specific needs of Web site projects.

Usable techniques should be defined for managing more effectively the documentation of the post-traceability, that is, the traceability between the requirements specification and subsequent artefacts in the development (e.g. hypermedia design). Connecting manually and graphically all hypermedia artefacts to the requirements may turn out to be infeasible for the large number of objects and connections involved. AWARE provides initial support for pre-traceability, as far as the stakeholders, goals, and requirements are cast in goal graphs. However, even goal graphs may not scale very well. Solutions to make goal graphs more controllable as the number of objects grows will be explored.

Support for integrating customization techniques into the requirements framework should be defined. In the UWA project, customizing the application has been intended as applying customization rules to design artefacts so to generate multi-channel Web applications (available on PDAs, cell phones, smart phones, pocket-PCs, kiosks). However, at the requirements level, the relationship and the reciprocal influence between the customization requirements and the other requirements remains an open issue to be further explored.

Guidelines, golden rules and patterns for the entire analysis process would be recommendable. Having AWARE modules specialized on given domains may provide analysts with libraries of prototypical goals, recurrent user profiles, main stakeholders, and potential requirements to consider. Heuristics for defining requirements at the proper conceptual level, for identifying, adding, deleting, and modifying design dimensions for requirements would be helpful. Finally, a larger library of application examples on the different domain might also improve the model overall.

Tool support for AWARE may be improved. Within the UWA project, basic editor functionality for the AWARE primitives has been encoded in Rational Rose. Extending Rational Rose has turned out to be a good opportunity for facilitating the adoption of the model. However, adding mechanisms to assist traceability and requirements priority computation may enhance tool support.

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References

1. Baresi L, Garzotto F, Paolini P (2000) From Web sites to Web applications: new issues for conceptual modeling. In: Proc of international conference on conceptual modeling ER'00, Salt Lake City, USA, 2000
2. Castro J, Kolp M, Mylopoulos J (2002) Towards requirements-driven information systems engineering: the TROPOS project. Inform Syst 27:365–389
3. Van Der Geest T (2001) Web site design is communication design. Benjamins, Amsterdam
4. Cantoni L, Paolini P (2001) Hypermedia analysis. Some insights from semiotics and ancient rhetoric. Stud Commun Sci 1:33–53
5. Lowe DB, Eklund J (2002) Client needs and the design process in Web projects. J Web Eng 1:23–36
6. Bolchini D, Randazzo G, Paolini P (2003) Adding hypermedia requirements to goal-driven analysis. In: Proc 11th IEEE international conference on requirements engineering RE03, Monterey, USA, 2003
7. Yu E (1993) Modeling organizations for information systems requirements engineering. In: Proc 1st international symposium on requirements engineering, RE'93, San Jose, USA, 1993
8. Dardenne A, van Lamsweerde A, Fickas S (1993) Goal-directed requirements acquisition. Sci Comput Program 20:3–50
9. Antón A (1997) Goal identification and refinement in the specification of software-based information systems. Dissertation, Georgia Institute of Technology, Atlanta, USA
10. Carroll JM (2002) Making use. Scenario-based design of human-computer interactions. MIT Press, Cambridge, USA
11. Nielsen J, Mack RL (eds) (1994) Usability inspection methods. Wiley, New York
12. Jarke M, Bui TX, Carroll JM (1998) Scenario management: an interdisciplinary approach. Req Eng 3:155–173

13. Ceri S, Fraternali P, Bangio A, et al. (2002) Designing data-intensive Web applications. Morgan Kaufmann, San Francisco
14. Garzotto F, Mainetti L, Paolini P (1996) Navigation in hypermedia applications: modeling and semantics. J Organ Comput 6:74–86
15. Güell N, Schwabe D, Vilain P (2000) Modeling interactions and navigation in Web applications. In: Proc of international conference on conceptual modeling ER'00, Salt Lake City, USA, 2000
16. UWA Consortium (2001) Hypermedia and operation design: model, notation, and tool architecture. UWA project IST-2000-25131, deliverable D7 (public),http://www.uwaproject.org/downloads.html. Cited December 2001
17. De Troyer O, Leune C (1997) WSDM: a user-centered design method for Web sites. In: Proc 7th International World Wide Web conference, Brisbane, 1997
18. Gomez J, Cachero C, Pastor O (2001) On conceptual modeling of device-independent Web applications: towards a Web engineering approach. IEEE Multimedia 2(8):26–40
19. Koch N, Kraus A, Canchero C, et al. (2003) Modeling Web business processes with OO-H and UWE. In: Proc 3rd int workshop on Web-oriented software technology (IWWOST'03), Oviedo, Spain, July 2003
20. Garrett JJ (2002) The elements of the user experience. New Riders, Indianapolis, USA
21. Moisiadis F (2002) The fundamentals of prioritising requirements. In: Proc system engineering, test & evaluation conference, Sidney, Australia, October 2002
22. Bolchini D, Paolini P (2002) Capturing Web application requirements through goal-oriented analysis. In: Proc of 5th workshop on requirements engineering, Valencia, 2002
23. Paolini P, Garzotto F, Bolchini D, Valenti S (1999) Modelling by pattern of Web applications. In: Proc international conference on conceptual modeling ER'99 workshops, Paris, 1999
24. UWA Consortium (2001) Transaction Design: Model, Notation, and Tool Architecture. UWA project IST-2000-25131, deliverable D8 (public),http://www.uwaproject.org/downloads.html. Cited December 2001
25. Akao Y (ed) (1990) Quality function deployment: integrating customer requirements into product design. Productivity, Cambridge, USA
26. Maiden NAM, Pavan P, Gizikis A, Clause O, Kim H, Zhu X (2002) Integrating decision-making techniques into requirements engineering. In: Proc. of 8th international workshop on requirements engineering: foundation for software quality (REFSQ'02), Essen, Germany, 9–10 September 2002
27. Chung L, Nixon B, Yu E et al. (2000) Non-functional requirements in software engineering. Kluwer Academic, Dordrecht
28. Alexander JE, Tate MA (1999) Web wisdom: how to evaluate and create information quality on the Web. Lawrence Erlbaum, Mahwah, USA
29. UWA Consortium (2002) Requirements and design specification for Banca121 pilot application (produced with UWA tools). UWA project IST-2000-25131, deliverable D22 (public),http://www.uwaproject.org/downloads.html. Cited September 2002
30. UWA Consortium (2002) Requirements and design specification for Punto Commercial pilot application (produced with UWA tools). UWA project IST-2000-25131, deliverable D23 (public),http://www.uwaproject.org/downloads.html. Cited December 2002
31. Matera M, Costabile F, Garzotto F, Paolini P (2002) SUE inspection: an effective method for systematic usability evaluation of hypermedia. IEEE T Syst Man Cy A 32:93–103
32. Bolchini D, Triacca L, Speroni M (2003) MiLE: a reuse-oriented usability evaluation method for the Web. Proc HCII 2003 international conference on human–computer interaction, Crete, Greece, 2003
33. UWA Consortium (2002) Methods and tools for requirements elicitation. UWA project IST-2000-25131, deliverable D6 (public),http://www.uwaproject.org/downloads.html. Cited January 2002
34. UWA Consortium (2002) Evaluation of UWA design methods. UWA project IST-2000-25131, deliverable D13 (public),http://www.uwaproject.org/downloads.html. Cited October 2002
35. Rogers EM (1995) Diffusion of innovations, 4th edn. Free Press, New York
36. Kaindl H, Brinkkemper S, Bubenko JA et al. (2002) Requirements engineering and technology transfer: obstacles, incentives and improvement agenda. Req Eng 7:113–123
37. Davis A (2003) The art of requirements triage. IEEE Comput 36:42–49