Quality Models for Web [2.0] Sites: a Methodological Approach and a Proposal

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Abstract. This paper discusses a methodological approach to define quality models (QM) for Web sites of any kind, including Web 2.0 sites. The approach stresses the practical use of a QM, in requirement definition and quality assessment, during design & development processes or during site operation. An important requirement for such QMs is *organization mapping*, which allows who is in charge of quality management to easily identify the actors in the organization responsible for implementing or improving each specific quality characteristic. A family of QMs is proposed and compared with ISO/IEC 9126 and ISO 25010 QMs for software products and software-intensive computer systems.

Keywords: quality, quality model, web, web engineering, web 2.0.

1 Introduction

According to ISO/IEC 25000:2005 [1], a *quality model* (QM) is a "defined set of characteristics, and of relationships between them, which provides a framework for specifying quality requirements and evaluating quality."

QMs are very important in Web engineering. Having a good QM at hand can be extremely useful in all phases of a Web site life cycle. In the requirement specification phase, a QM helps in elicitating and orderly describing all important facets of the site to be designed. Indeed, the table of contents of a good requirement specification document could strictly mirror the QM, by assigning to each model characteristic a specific section of the document [12]. During the development process, a QM helps the project team in keeping their eyes on all desired quality attributes of the system to be implemented. In assessing the quality of an existing site, or different sites for comparison or benchmarking, a QM provides a structured approach to the evaluators, helping them to stay focused on the important issues. In the operation phase, a QM provides the site management with a "compass" to keep its evolution on the right track. Indeed, all Web sites are very dynamic; their evolution is constant and substantial: it is therefore essential to continuously monitor their quality, to avoid that the frequent changes disrupt piecemeal an initially sound project. This is particularly important for Web 2.0 sites, whose evolution is determined not only by the site management, but also by the (possibly large and uncontrollable) user

community. A "suitable" QM is the necessary supporting tool for these monitoring actions.

But *how* do we choose it? The selection of a QM is a delicate task, because it may have a large impact on the site's success, and is not trivial at all, for two main difficulties: *orthogonality* and *measurability* of characteristics. Orthogonality is difficult to achieve because the quality attributes of a Web site interact in complex ways; measurability, because many of them are subjective.

The literature on Web quality is very large, and a number of QMs for Web sites have been proposed over the years, approaching the problem from different perspectives. QM characteristics may be chosen on the basis of their semantic orthogonality, their measurability, the feasibility of their automatic evaluation, their relationship with the Web site development process, or with the use of statistic or probabilistic models (among others: [2],[3],[4],[5],[6],[7],[8]). Some QMs address specific types of Web sites, such as e-commerce or information portals; others analyze specific attributes, like data quality or quality in use (e.g. [8], [9], [10], [11]). Most of them are in some way related with the ISO quality standards. However, there seem to be no general consensus on their definition and characteristics.

This paper will contribute to this debate, by proposing an approach specifically oriented to the needs of the people responsible for the *management* of a Web site, and by sketching a QM family which can be proficiently used by project managers and Web properties managers both in the development and operation phase. This is a revision and extension of a simple QM for Web 1.0 sites previously defined by the author [5], following its experimentation in the Web site development road-map described by the author in [12] and the Web evolution of recent years.

In Section 2 the ISO approach to QMs for software and computer systems is summarized. Section 3 will discuss the main peculiarities of Web sites with respect to traditional software systems, and lay down a few basic requirements for Web sites QMs, also considering the evolution of the role of users in Web 2.0 sites. Section 4 will describe the proposed QM family, and briefly compare it with the ISO standard. Finally, Section 6 will contain some conclusions and indications for future work.

2 The ISO Software Quality Model

In the software engineering literature, software QMs have been discussed for many years. The ISO/IEC 9126, issued as an International Standard (IS) in 1991 and revised in 2001, is the best known reference in this area. Part 1 of this multi-part document [13] provides a very general QM for software systems, based on a set of 6 *quality characteristics* (*Functionality*, *Reliability*, *Usability*, *Efficiency*, *Maintainability*, *Portability*) and 27 *sub-characteristics*. This IS has been recently canceled, and replaced by ISO/IEC 25010 [14], which updates the previous QM in various ways. It addresses "software products and software-intensive computer systems" of any kind, and defines two QMs. The *Product quality model* encompasses internal and external qualities of the system, and is composed of 8 characteristics and 31 sub-characteristics (Fig.1). The *Quality in use model* allows to define/assess "the impact that the product has on stakeholders" and is composed of 5 characteristics and 9 sub-characteristics.

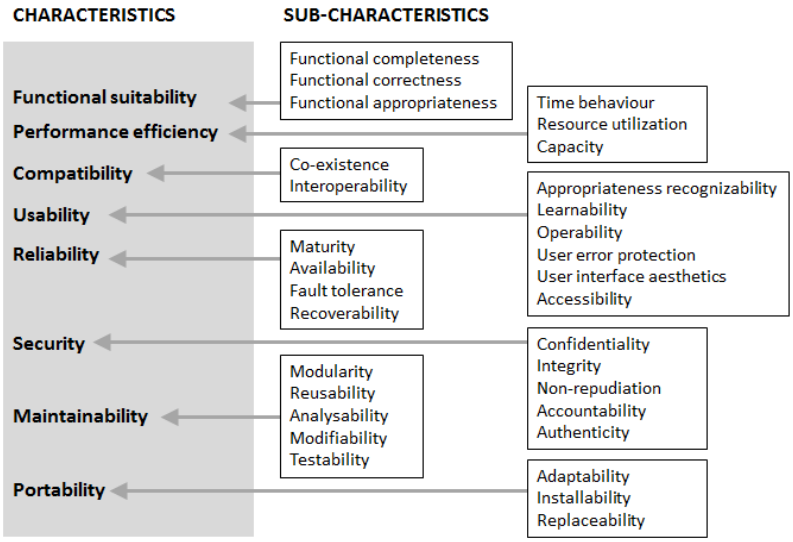

Fig. 1. Product quality model according to ISO/IEC 25010:2011

Each sub-characteristic may be further hierarchically decomposed. Quality characteristics and sub-characteristics at any level should be *measurable*, either directly or indirectly, through a set of associated *measurable properties*.

Fundamental in the ISO approach is the distinction between the *internal properties* of a product (which contribute to the *internal quality*), its *external properties* (which contribute to the *external quality*), and its *quality in use properties*, i.e. properties which influence quality and which can be measured when the product is actually in use in specific contexts. All these properties influence each other and the resulting quality in a complex way, as schematized in Fig.2.

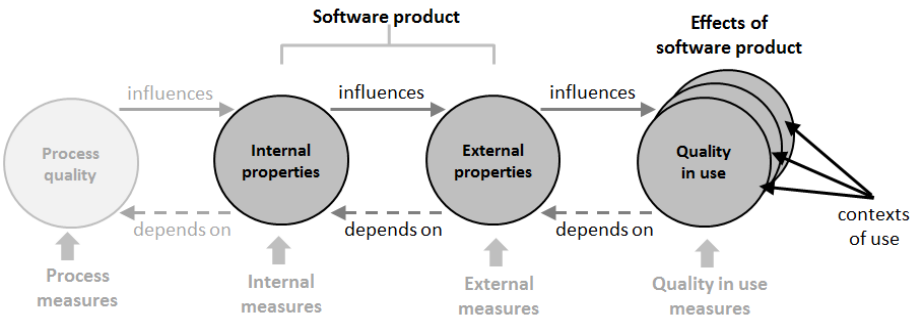

Fig. 2. Conceptual approach to quality, according to ISO/IEC 25010:2011

3 Quality Models for Web Sites: Why They Should be Different

3.1 Web Sites Peculiarities

The ISO standard provides a very general conceptual framework for defining QMs for complex systems with a substantial software component. The basic approach of defining a hierarchy of quality *characteristics*, and *measurable properties* which can be aggregated to obtain a quantitative measure of characteristics provides a sound foundation for defining *any* QM, in *any* domain. Moreover, the ISO model is the result of two decades of discussions about the basic quality dimensions of software-based systems. Its categorization and terminology can be discussed and - in a few cases - may also be considered somehow obscure, but certainly cannot be ignored in any approach to quality in software engineering.

On the other hand, it should be clearly understood that the ISO documents only provide a *conceptual framework*, and not a ready-to-use QM. To be of practical use, this framework must be tailored to the specific [class of] system[s] under consideration. This may not be a simple task, especially when these systems do not fit well with the systems considered in classical software engineering, such as ERP, command & control, embedded systems. This is the case of Web sites, which possess a number of peculiarities that greatly differentiate them from the above systems:

Information content. In the large majority of cases, unstructured information content prevails on structured data. Emphasis is on user navigation, not on data management and algorithmic computation. Therefore, a fundamental dimension of quality relates to *information architecture* [15]. Information architects are more and more involved in large Web sites, together with *content editors*, who create and manage its information content. Information-rich sites may employ large editing staffs, with an organization in some ways similar to that of traditional magazines.

Communication. In most cases, Web sites can be considered machines whose main purpose is communication, rather than computing and data management. This is also true for e-commerce or other sites offering online services. Web sites address a global audience, in a strongly competitive, "open" environment. There is no user lock-in: competition is only a few clicks away, so visitors' loyalty must be won on a day-by-day basis. User attention span can be extremely short, so his/her interest must be captured in brief time-intervals. So big efforts are required on communication and branding, and professionals typically not seen in traditional software projects are necessary (visual designers, art directors, communication experts).

Continuous evolution. Web sites are living organisms. Their contents are constantly updated, and even their information architecture changes frequently. This is true for *any* site, not only for information portals. Visitors of a site often expect the content to be updated practically in real time. Site managers must strive hard to comply with these expectations, just to keep their site reputation. Interactive services and the user interface are frequently modified and improved. According to the

perpetual-β concept, the software behind these services is continuously modified to better serve user needs. These – in turn – change as new possibilities are discovered, in a constant *co-evolution* of usage patterns and system functions. In a word, managing the evolution of a Web site sets pressing requirements to site administrators, and this should be taken into account seriously in any QM designed for these systems.

3.2 Web Site Quality Actors

By [*quality*] *actor* we mean any system stakeholder with an active role in creating/maintaining some quality attribute, such as Web designers, visual designers, content editors, software developers. Actors of a Web site are more numerous and more varied than in traditional software systems. Indeed, the development of any site is really a multi-disciplinary project, involving many different roles (Fig.3).[1]
In a typical Web 1.0 site, end users have a passive role, so they are not considered actors because they do not contribute to its quality: they only navigate the site and possibly interact with it in predefined transactions (as in e-commerce). In Web 2.0 sites the situation is completely different. The users can typically create and upload content, embed content from other sites, tag, comment or rate content created by other users and share it with their "friends", and interact with them in public. This is not only true for large social networks such as Facebook, Twitter, Youtube and Flickr, but also for an increasingly large number of small sites, due to the many available tools which allow to easily implement these functions, such as share buttons, plugins, html snippets. Therefore, in Web 2.0 sites, *the users themselves must be considered quality actors* and critical ones indeed, since they can have a big impact on the global functioning of the site. Even a perfectly designed and implemented site can fail as a consequence of "bad" (or unexpected) user behavior. So users must be continuously monitored and in some way controlled or stimulated, requiring the presence of new roles (denoted as *community management* in Fig.3), and in some cases the evolutionary modification of specific site functions, intended – so to speak – to improve the user-generated quality. A typical example is the evolution of the community content moderation mechanisms in Yahoo!Answer, where they had to oppose the unexpected volume of user spam and troll activity, that seriously risked crashing the site [16].

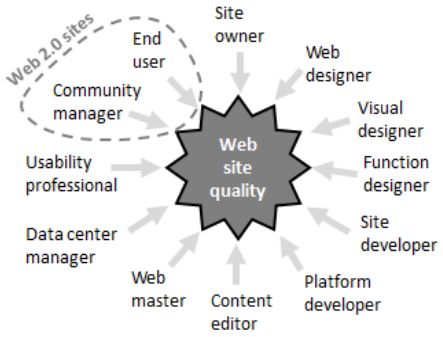

Fig.3. The main quality actors of a Web site

[1] Different roles may not necessarily be played by different people. For very small sites, all of the above roles may also be impersonated by the same person.

3.3 Organization Mapping

The ISO definition of a QM, quoted in Section 1, emphasizes the practical purposes of any QM, which is not viewed as a mere categorization of the quality attributes of a system, but rather as a *practical tool*, to steer design ("specifying requirements") and evaluation ("evaluating quality") processes. In our view, this should be constantly kept in mind when defining any QM. To this end, we require that there be as simple as possible relation between quality [sub-] characteristics and the roles responsible for implementing and improving them. In this way, responsibility for different quality characteristics can be easily allocated and tracked, being always clear who is responsible for what. We call this attribute of a QM *organization mapping*. In Fig. 4, mapping on the left can be considered better than the mapping on the right, because responsibilities are better isolated, and quality characteristics improvements are easier to manage.

A good mapping is a crucial requirement of a Web site QM because, as shown in Fig.3, the actors involved in Web projects are many, and the involved skills are extremely varied. In a multi-disciplinary team, different cultures, practices and value systems may sometimes create interaction difficulties, as anybody involved in medium to large Web site development or operations may have experienced. To avoid these problems, it is necessary that the teams be correctly organized, with a clear allocation of responsibilities on the different system components and associated quality characteristics.

Of course, the goodness of the mapping does not depend only on the QM, but also on the actual organization which develops and manages the site. A chaotic organization will nullify the practical utility of even the best QM. Nevertheless, after fifteen years of Web engineering experiences, the roles and functions of the different quality actors in e Web project are today sufficiently well understood. This allows to define good QMs which are reasonably applicable to most Web organizations.

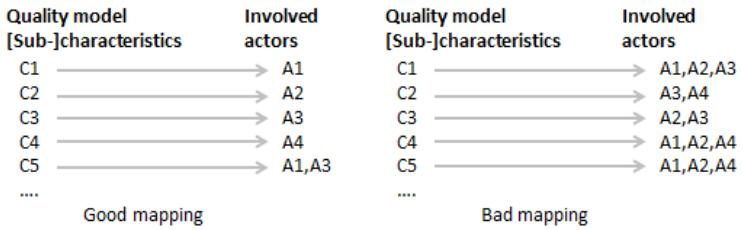

Fig. 4. Organization mapping of quality models

3.4 Requirements for Web Sites Quality Models

With the above premises, we can now lay down the main requirements for our QM.

Requirement 1. QM should have an organization mapping as simple as possible, as discussed in 3.3. We do not require that it be related to a *specific* project organization

schema, but simply that the quality [sub-] characteristics be associated in a simple way to the quality actors of Fig.3. It is rather evident that the ISO QM of Fig.1 does not satisfy at all this requirement.

Requirement 2. QM should be tailorable to the class of sites under consideration. Web sites are enormously diversified. They may differ in size, in technology, in purpose, in complexity, in relationship with the front users (from purely informative to interactive to social), in impact on their activities (from critical to non-critical). So there will be no universal QM. Tailoring the QM would mean dropping some sub-characteristics or specializing some of them with further levels of detail. Sometimes we would also assign *different weights* to the [sub-] characteristics, to express their importance in the particular context.

Requirement 3. QM should be subsettable according to its specific purpose. Some [sub-] characteristics should be droppable from the QM, when they are not needed in its actual context of use. E.g., when using a QM to compare a site with its competition, we usually do not have access to information on their internal structure. Thus, we would drop all [sub-] characteristics referring to internal quality from the QM.

Requirement 4. QM should be scalable according to site complexity. Any site (even the simplest) is really a very complicated system, as briefly discussed in 3.1. But it is totally unrealistic to pretend that small organizations (which own the large majority of sites) may (or want to) deal with all the subtleties of a conceptually sound and complete QM. Simple users need simple tools. Therefore, a scalable QM would be available in simplified versions to be used in simple contexts.

Requirement 5. QM should be universally usable and accessible. Last but not least, if we want to have a real impact on the quality of the present day Web, we should design QMs that, as much as possible, are *universally usable and accessible.* This would entail the use of broadly understood concepts described in a simple language, with easy and free accessibility. [2]

The stated requirements imply that we need a *family of closely related QMs*, and not a single QM, if possible with a common set of top-level characteristics. These are the "foundations" of the QM, and therefore should be easily recognizable by anybody as the basic dimensions of the quality of *any* Web site. They would constitute the main sections of the requirement specifications of *any* Web development project, and the main aspects to be considered in *any* assessment or evaluation. QM personalization should then be localized in the lower levels of the hierarchy, to cope with specific Web applications (Req.2), to QM purpose (Req.3), to site complexity (Req.4) and to the complexity of the organization (Req.5). This will be mostly done by adding/dropping sub-characteristics or defining lower levels in the characteristics tree.

[2] Lack of usability and accessibility are, in our opinion, the main problems with the ISO QM, which hinder their large scale adoption by the general community of Web practitioners. ISO documents are organized in a very complex structure, which is continuously evolving. To understand the status of the ISO document system and to identify the documents relevant to a particular activity, it is not easy and very costly, since documents are not freely available, and cost a lot of money. Regrettably, this is also true for quality related standards, which should be, in our opinion, as openly available as possible.

4 A Quality Model Family for Web Sites

4.1 Defining the Top-Level Characteristics

Rather than start from the ISO model and modify it piecemeal to comply with the stated requirements, it seems more reasonable to start anew, and see where this approach leads. Requirement 1 suggests to start by defining a general model of a Web site, showing its main "physical" components (the quality of which we wish to take under control), its main quality actors and the relationship between actors and components. This can be done a)- considering the Web site design & development process, or b)- considering the Web site in operation. The second approach seems more comprehensive because of the constantly evolving nature of Web sites (which are not "frozen" when they are published online after development) and because it allows to consider the role of end users as quality actors, which is fundamental in a Web 2.0 context. Thus this paper will use approach b).[3]

Therefore, a Web site will be modeled as a set of nested (physical) components, as shown in Fig.5: *Information architecture & navigation*, *Graphics & branding*, *Software functions*, and so on, which are self-explaining.

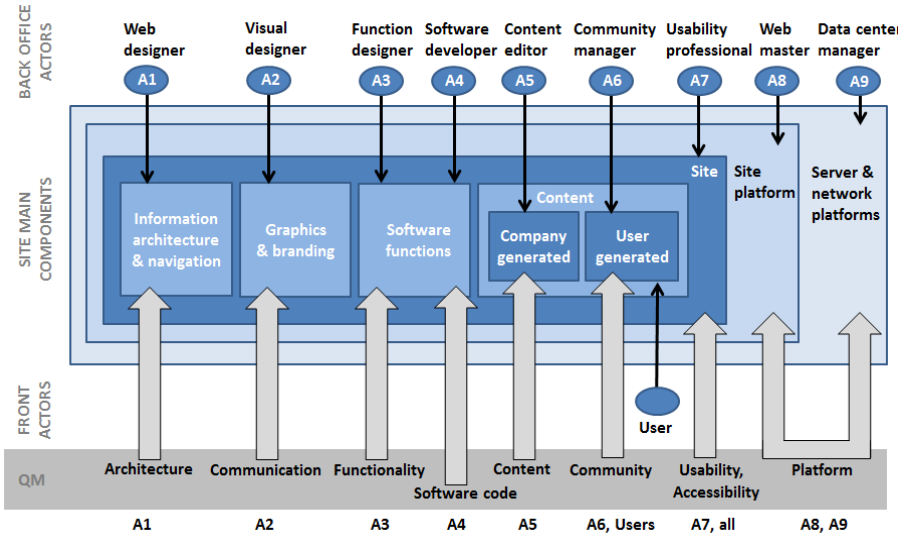

Fig. 5. A general model of Web site components and quality actors, and the resulting QM

[3] Approach a) has been used in the previous version of this QM, dealing only with Web 1.0 sites [5], using the design & development model described in [12]. Not unexpectedly, the results are the same, since the same actors and components are present in both approaches. Lack of space does not allow to further comment on this issue here.

Each component is associated to its (prevailing) quality actor. For example, the *Company generated content* component is under the responsibility of *Content editor(s)*. Actors are all members of the back-office organization, except in Web 2.0 sites, where the users are also considered actors. The bottom line in Fig.5 shows the 9 top-level characteristics of the proposed QM: *Architecture*, *Communication*, *Functionality*, *Content*, *Community*, *Platform*, *Accessibility*, *Usability* and *Coding*.

Here, the term *Architecture* refers exclusively to information architecture [15], including site navigation facilities, and not to internal software architecture. Its associated actor is therefore the Web designer (or information architect). *Communication* refers to all aspects of site communication, typically embodied in the site *Style Guide*, defining graphics, multimedia usage and style issues. The associated actors are the visual designers because in small/medium sites this responsibility is usually assigned to them. Note, however, that larger sites may have a more complex organization. Like the ISO Functional suitability [14], *Functionality* means "the degree to which the site provides functions that meet stated and implied needs when used under specified conditions". Note that this does not include navigation functions (menus, breadcrumbs, and so on), which are part of the *Architecture*. *Content* collects all the quality characteristics related to the company-generated information/data content of the site, under the responsibility of the content editors. *Community* is mostly used only for Web 2.0 sites, and considers user-generated content: associated actors are site users and site community managers. *Platform* considers the site platform (e.g., the used CMS), the hardware and software of the server hosting it, and the network infrastructure. Its quality characteristics are both static (i.e.: are they suitable for the context?) and dynamic (i.e.: are their operations well managed?). Quality actors may differ from case to case: when server and network management are outsourced to an external organization, the *Data center manager* is simply the person interfacing the service. *Usability* and *Accessibility* have the usual meaning of the ISO QM. Finally, *Software code* refers to the quality of the software specifically developed for the site (therefore excluding platform components acquired on the market).

Because the chosen names are very mundane, the site quality profile can be easily communicated to *all* site stake-holders, e.g. with a simple radar diagram, as in Fig.6.

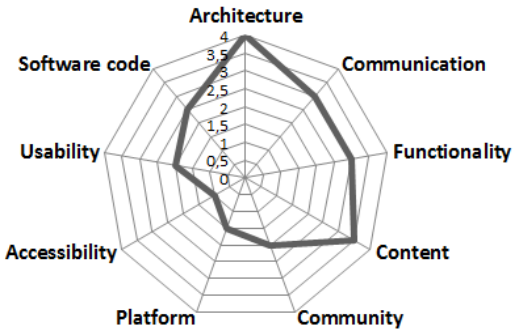

Fig.6. The quality profile of a Web site

Note that in most cases there is a one-to-one relationship between characteristics and actors, as shown in the bottom line of the schema, thus the QM has a good *organization mapping*, as required. The one-to-one criterion is not satisfied only for *Usability* and *Accessibility*, which are the results of the cooperation of all actors.

As is often said, usability is like a chain with many rings, and its strength is that of the weakest.

4.2 Defining the Sub-Characteristics

The definition of sub-characteristics is less critical. Once the top-level framework is stable and well understood, the lower levels can be tailored to specific contexts and improved over time, as experience in their use increase and Web applications evolve.[4] Our proposal is based on 30 sub-characteristics (Fig.7), including internal quality (*Compliance to standards*, *Maintainability*) and Web 2.0 sites (*Community Management*).[5] These should be dropped when assessing only external quality and quality in use of Web 1.0 sites, as in [5]. A number of sub-sub-characteristics should be further defined, tailored to specific classes of sites. This is the case, for example, of *Functional adequacy* and *Information quality*, which should be specialized on the particular functions and information (or data) supported by the site. Note that *Accessibility* does not only concern people with disabilities, but has a wider meaning. For *Usability*, we stay, for simplicity, with the ISO/IEC 9241-11 definition [17], which defines *Effectiveness*, *Efficiency* and user *Satisfaction*, as these logically include all other sub-characteristics considered in ISO/IEC 25010:2011.

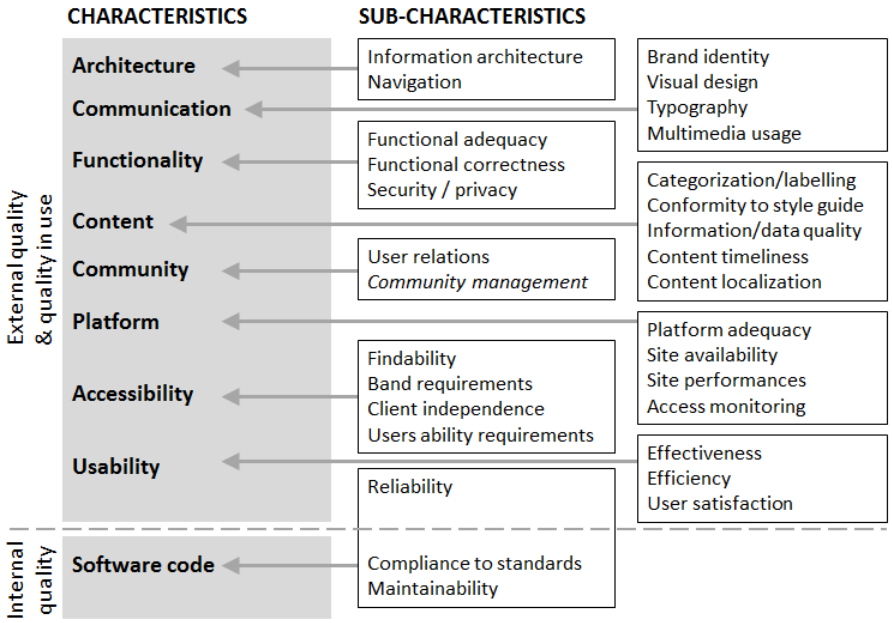

Fig. 7. The proposed QM. Sub-characteristics for Web 2.0 are in italics.

[4] The ISO standard itself explains that "the set of sub-characteristics associated with a characteristic have been selected to be representative of typical concerns without necessarily being exhaustive" [4, pag.2].

[5] *User relations* concerns the management of user requests, and applies also to Web 1.0 sites.

4.3 Relationships with the ISO Standard

Table 1 compares the proposed QM to ISO ones. While there is no mention in the ISO models for *Architecture*, *Communication*, *Content* and *Community*, which differentiate Web sites from traditional software systems, *Functionality* and *Usability* are included in all models. While *Accessibility* is considered a sub-characteristic in ISO, we put it at the top-level, given its importance in many Web sites. While *Maintainability*, *Portability* and *Compatibility* are given much emphasis in ISO, they do not need a front-line position in present day Web sites, more and more built on-top of widely used and compatible CMS platforms. We put *Maintainability* under *Software code*, and dropped *Compatibility* and *Portability*. Both may be considered a third level under *Platform adequacy*, for the evaluation of the selected CMS, and of *Client independence* (e.g., browser independence), under *Accessibility*.

Table 1. Comparison with ISO quality models.

PROPOSED QM	ISO/IEC 25010:201	ISO/IEC 9126:2001
Architecture		
Communication		
Functionality - Security	**Functional suitability**	**Functionality**
Content		
Community		
Platform - Site performances		
Accessibility		
Usability	**Usability** - Accessibility	**Usability**
Software code - Reliability - Maintainability		
	Reliability	**Reliability**
	Maintainability	**Maintainability**
	Portability	**Portability**
	Performance efficiency	**Efficiency**
	Security	
	Compatibility	

5 Conclusion and Future Work

This paper has proposed a methodological approach to define QMs for Web sites of any kind, including Web 2.0 sites. The approach stresses the practical use of a QM, in requirement definition and quality assessment, during design & development processes or during site operations. Therefore, the main driver for QM definition has been what we called *organization mapping*, as opposed to the conceptualization of abstract quality characteristics. Organization mapping allows who is in charge of quality management to easily identify the actors in the organization responsible for implementing or improving each specific quality characteristics. This is much more important for Web sites than in traditional software systems, given the high number and diversity of the actors involved, and the possibility of conflicts arising from their

diverse approaches. Accordingly, a simple QM family has been proposed, starting from a very general model of Web site, showing its main physical components, mapped to the actors responsible for their quality. This QM defines the characteristics down to the second level: it is general enough to be applicable to a very large class of sites and to be used as a viable table of contents for requirement definition documents. It should now be specialized and experimented for specific classes of Web sites. A comparison with the ISO QM for software and software intensive systems has shown important differences, due to the peculiar nature of Web systems.

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