Specifying Quality Requirements for the Web 2.0 Applications

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Abstract

To specify quality requirements for Web 2.0 applications we propose an integrated approach which considers features for contents, functionalities and services. In this work we discuss how to model internal quality, external quality and quality in use views taking into account not only the software characteristics – as those specified in the ISO 9126-1 quality models- but also the own features to Web applications (WebApps). Particularly, we thoroughly discuss the modeling of the content characteristic for evaluating the quality of information – so critical for the whole Web application eras. The resulting models contribute towards a multidimensional integrated approach to evaluate WebApps at different lifecycle stages, independently of Web eras.

1. Introduction

As the Web usage continues to grow, users expect WebApps to be more mature with regard to the functionalities and contents delivered for their intended tasks at hand. Moreover users expect these functions and contents be relevant, accurate, suitable, usable, secure, personalised, and ultimately with perceived quality. Despite the major breakthrough in Web methods and technologies there are some Web Engineering branches still in their infancy: Modelling of quality requirements at different lifecycle stages is one of them. In this paper we propose, based on related research literature and a bunch of ideas published in [9], an integrated approach to specify quality requirements for contents and functionalities to WebApps.

WebApps were conceived as content-oriented artefacts from the very beginning. Few years later, Websites started to provide not only contents but software-like functionalities and services as well. Since then, WebApps have at a fast pace emerged for many different sectors as e-commerce, e-learning, e-entertainment, and so forth. After that era named Web 1.0, a recent era that considers a set of strategies and technologies focusing on social networking, collaboration, integration, personalization, etc. is emerging – currently called Web 2.0. We argue that WebApps will continue being centered on functionalities, services and contents independently of the new technologies and collaboration strategies. However, as aforementioned a challenging issue still is how to specify and assess the quality and the quality in use of WebApps since their intrinsic nature will continue being both content and function oriented.

In the present work, by reusing and extending the ISO 9126-1 [4] quality representation, we discuss how to model internal, external quality, and quality in use views taking into account the previous concern. Particularly, we thoroughly discuss the modeling of the content characteristic for evaluating the quality of information – so critical for the whole WebApp eras.

The rest of this paper proceeds as follows. In Section 2, we give an overview of the Web eras as well as the unique intrinsic features of WebApps compared to traditional software applications. A review of the ISO software quality models follows in Section 3; we also discuss what is missing in these models for the Web features. Section 4 illustrates the proposed extension to ISO quality models in order to specify the quality of information. Then, we analyze our proposal in the light of related work, and, finally, we draw concluding remarks.

2. Particular Features of WebApps

First, the aim is to introduce the main features of the Web 2.0 highlighting some of its applications; second, to outline the distinctive features of WebApps compared to traditional software applications.

The first WebApps can be grouped in the Web 1.0 era, and they can be categorized into static and dynamic; most recent WebApps can be grouped in the so-called Web 2.0 era as per O'Reilly [12]. These allow people collaborate, share and edit information online in seemingly new ways of interaction. Other applications could be grouped in the mobile Web era, where applications could offer some

additional features such as personalization and context-aware capabilities and services; and the semantic Web era where applications offer the automatic processing of information meaningfully. We can feature Web 2.0 WebApps as follows:

- User generated content: if we check the rating of the most popular sites (http://www.alexa.com/site /ds/top_sites), we can figure out that currently, after 'google.com' and 'yahoo.com', one of the most visited is 'youtube.com'. Maybe the best example to explain how big has become the Web 2.0 phenomenon and what user generated content means.
- User active involvement: the active participation of users is one of the most important features, which has changed the way users have to interact with WebApps. Now users' role can be defined as 'prosumer' since s/he is content producer and consumer at the same time. WebApps like blogs are significant examples.
- Sharing information: in social network people share interests and activities. Examples of these applications are 'myspace.com', 'facebook.com' and 'orkut.com'.
- Endless beta condition: considering the above three features it is easy to understand that Web 2.0 apps are mostly dynamic and under ongoing changes. Wikipedia is for instance continually subject to editing by users so there is no a 'final version' of it.

In addition, Murugesan [8] says these new sites *"offer smart user interfaces and built-in facilities for users to generate and edit content presented on the Web and thereby enrich the content base. Besides leveraging the users' potential in generating content, these applications provide facilities to keep the content under the user's own categories (tagging feature) and access it easily (Web feed tool)"*. On the other hand, WebApps taken as product or product in use entities (without talking about distinctive features of Web development processes) have their own features distinct from traditional software, namely [9]:

- WebApps will be even more information-driven, content-oriented. Most WebApps, besides the increasing support to functionalities and services – seen since the dynamic Web 1.0 era – will continue aiming at showing and delivering multimedia information. This info orientation is a basic feature stemming from the early, static Web 1.0 era;
- WebApps are interactive, user-centered applications, where the user interface plays a central role; thus, they will continue to be highly focused on the look and feel. Web interfaces ought to be easy to use, understand, operate, and navigate because thousands of users with different profiles and capabilities interact with them daily; in addition, WebApps currently have to cope with a variety of display devices and screen sizes.
- The Web embodies a greater bond between art and science than that encountered in software applications. Aesthetic and visual features of Web development are not just a technical skill but also an artistic skill.
- Internationalization and accessibility of contents for users with various disabilities are real and challenging issues in WebApps, independently of eras.
- Searching and browsing are two basic functionalities used to find and explore information and services.
- Security is a central issue in data-transaction-oriented WebApps. Likewise, performance is also critical for many WebApps, although both are also critical features for traditional applications.
- The medium where WebApps are hosted and delivered is generally more unpredictable than the medium where traditional software applications run. For instance, unpredictability in bandwidth maintenance, or in server availability, can affect the perceived quality that users could have.
- Contents privacy and intellectual property rights of materials are current issues too. They involve ethic, cultural, and legal aspects as well.

Most of the above features make a WebApp a particular artifact. However, like any software application, it also involves source and executable code, persistent structured data, architectural design and so on. Ultimately, many of the above features will influence the way quality requirements are modeled. We need to deal not only with usability, functionality, efficiency, reliability and maintainability, as in traditional software products but also with info quality, i.e. with content accuracy, suitability, accessibility, and legal compliance.

3. ISO 9126-1 Quality Models

3.1 Overview

The concept of quality is not simple and atomic, but a multidimensional and relative one. Common practice assesses quality by means of the quantification of lower abstraction concepts, such as attributes of entities. The attribute can be briefly defined as a measurable property of an entity category. Therefore, quality – and its sub-dimensions, called characteristics and sub-characteristics in the ISO 9126-1 standard – is an abstract relationship between attributes of an entity and a specific information need, with regard to its purpose, context, and user's viewpoint [10]. On account of such multidimensionality [7], a quality model, which specifies the relationships between characteristics, sub-characteristics and associated attributes, is usually necessary. Further, an instantiated quality model can in the end be calculated and evaluated in order to determine the level of satisfaction achieved.

The ISO 9126-1 standard (and the ongoing SQuaRE project) distinguishes among three different approaches to

software product quality, viz. internal quality, external quality, and quality in use. These three views of quality in ISO 9126-1 can be summarized as follows [9]:

- *Internal Quality*, which is specified by a quality model (i.e. a set of six characteristics – functionality, usability, reliability, efficiency, maintainability and portability- and a set of sub-characteristics per each characteristic are prescribed), and can be measured and evaluated by static attributes of documents such as specification of requirements, architecture, or design; pieces of source code; and so forth.
- *External Quality*, which is specified by a quality model (equally to the previous model), and can be measured and evaluated by dynamic properties of the running code in a computer system, i.e. when the module or full application is executed in a computer or network simulating as closely as possible the actual environment.
- *Quality in Use*, which is specified by a quality model (i.e. a set of four characteristics – effectiveness, productivity, safety and satisfaction- is prescribed), and can be measured and evaluated by the extent to which a software or WebApp meets specific user needs in an actual, specific context of use.

The same quality model have been maintained both to internal and external views (see Fig. 1). For instance, functionality characteristic is defined as "*the capability of the software product to provide functions which meet stated and implied needs when the software is used under specified conditions"*. It has in turn five sub-characteristics, i.e. accuracy, suitability, security, interoperability and compliance. Functionality – from the nonfunctional requirement point of view – is concerned with what the software does to fulfill the user needs (software is defined as a set of programs with the associated data and documentation). Considering for example the accuracy and security definitions both function and data attributes can be associated in order to assess them. This is also valid for WebApps where programs and persistent, structured data (and its effects) are there as well. Note that in the information quality literature data and information quality are treated very often as synonymous terms but we make a clear difference as we discuss later on.

Besides, usability characteristic is defined as *"the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions"*. Usability is subdivided in turn into five sub-characteristics, i.e. understandability, learnability, operability, attractiveness, and compliance. Usability and its sub-characteristics apply also to specifying internal and external quality requirements for WebApps.

Lastly, the core aim in designing a WebApp is to provide users with degrees of excellence or quality in use by interacting with the application and by performing its tasks comfortably. Regarding the spirit of the ISO 9126-1 standard, quality in use is the end user's view of the quality of a running system containing software, and is measured and evaluated in terms of the result of using it rather than by properties of the software itself. Ultimately, taking into account meaningful software or WebApp attributes for internal quality are a prerequisite to achieve the required external behavior, and considering meaningful software attributes to external behavior are a prerequisite to achieve quality in use.

3.2 ISO Quality Models for WebApps: A Discussion

Consequently, we argue that the software quality models introduced above are also applicable to a great extent to intermediate and final lifecycle Web products. Note this discussion is an extension of that made in [9] reinforcing the same line of argumentation.

Like any software production line, the Web lifecycle involves different stages of its products, whether in early phases as inception and development, or in late phases as deployment, operation, and evolution. To assure the quality of products, we can plan to do it by evaluating and controlling the quality from intermediate products to final products. Thus, to the general question, if we can apply to WebApps the same ISO internal and external quality, and quality in use models, the natural answer is *yes*.

Nevertheless, to the more specific question whether we can use the same six prescribed quality characteristics (and their sub-characteristics) for internal and external quality requirements, and the four characteristics for quality in use requirements, our answer is *yes* for the latter, but some other considerations might be taken into account for the former. As highlighted in Section 2, the very nature of WebApps is a mixture of content, functions and services. Therefore we argue that the set of six characteristics, i.e. functionality, usability, reliability, efficiency, maintainability and portability, and their sub-characteristics respectively, are not well suited (or they were not intended) to specify requirements for information quality.

At this point, we would like to introduce the slight difference in meaning between data and information terms. A piece of data is raw material; even though it has some degree of information. Data come from attribute measurements, facts, formula calculations, etc. and basically they have categorical or numerical values, a scale type, and may also have an explicit procedure to produce or collect them. Structured data sets are often represented in databases. On the other hand, information has an added value over data. That is, information is the meaningful interpretation of data for a given context, purpose, and user viewpoint. Usually, in a traditional

software program there are functions and data. Very often a webpage is content oriented, i.e. is intended to deliver information (usually unstructured semantically). For example, this article could be hyperlinked and posted as content Web pages. Also a webpage component, e.g. a shopping cart, can edit an item quantity and recalculate prices (a function over data).

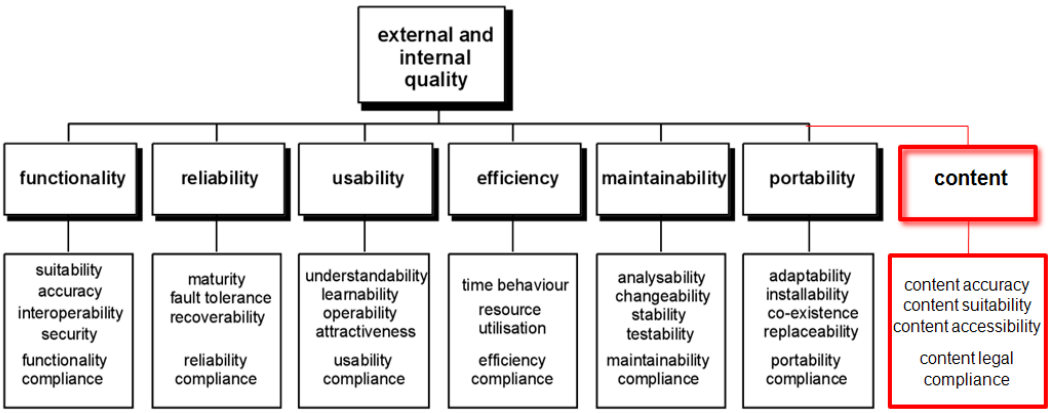

Figure 1. ISO model for internal and external quality along with our extension to the content feature.

Therefore, the central issue is how we can specify and model the content quality for WebApps from the internal and external quality viewpoints. Not only need we deal with usability, functionality, efficiency, reliability, and maintainability but also with the content quality characteristic, which in turn can be subdivided into content accuracy, suitability, accessibility, and legal compliance sub-characteristics, as shown in Fig. 1.

As a consequence, we propose to include the content characteristic and its sub-characteristics in the internal and external quality model of the ISO standard. A point worth mentioning is that in the spirit of the ISO 9126-1 standard is stated "*evaluating product quality in practice requires characteristics beyond the set at hand"*.

On the other hand, the quality in use definition may be rephrased as *"the capability of the software or WebApp product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction in specified context of use"*. Note that effectiveness, productivity, safety, and satisfaction are influenced not only by the usability, functionality, reliability, efficiency, and content of a WebApp, but also by two resource components of the context of use. The context of use depends on both the infrastructure (i.e. the computer, network, or even the physical working medium) and the user-oriented goals, i.e. the supported WebApp tasks and the properties of the user type such as level of IT training, expertise, age, and cultural issues as well. (See for example the quality in use case study for an e-learning WebApp [3] where user tasks were designed not only to deal with services and functions but with contents as well).

Next, we present the proposed ISO internal and external requirement extension in order to include the content characteristic for WebApps independently of Web eras. However, specific attributes associated to content sub-characteristics may be considered for Web 2.0 applications.

4. The Information Quality Characteristic

As aforementioned information has added value over data, and hereafter we consider Web information as Web content, which can be textual or other media. Hence, we define content as "*the capability of a Web product to deliver information which meets stated and implied needs when used under specified conditions*". Taking into account previous contributions made in the area of information quality – as we will discuss in the related work section – we have primarily identified four major sub-characteristics for the content characteristic, which can help to measure and evaluate information quality requirements for WebApps. This initial proposal was made in [9]. So we contribute here by redefining them (see Table 1) and by extending and defining the sub-sub-characteristics (see Fig. 2).

The content sub-characteristics are: First, the *content accuracy*, which addresses the very intrinsic nature of the information quality; second, *content suitability,* which addresses the contextual nature of the information quality; it emphasizes the importance of conveying the appropriate information for user-oriented tasks and goals; in other words, it highlights the quality requirement that content must be considered within the context of use and the intended audience; third, *content accessibility*, which emphasizes the importance of technical and representational aspects in order to make Web contents more accessible for users with various disabilities as

regarded in [16]; and lastly, *legal compliance*, as defined in Table 1. In Fig. 2, we define the sub-sub-characteristics for both the content accuracy and content suitability dimensions. Some of them could be just treated either as measurable attributes or as subdimensions to which attributes should be further associated accordingly. Even if we have identified some attributes to content legal compliance, we are not addressing this aspect in this work.

Sub-characteristic	Definition
Content Accuracy	The capability of a Web product to deliver information that is correct, credible and current.
Content Suitability	The capability of a Web product to deliver information with the right coverage, added value, and consistency, considering the specified user tasks and goals.
Content Accessibility	The capability of a Web product to deliver information that is accessible for all users (with or without disabilities) taking into account both technical and representational aspects.
Content Legal Compliance	The capability of the Web product to adhere to standards, conventions, and legal norms related to content as well as to intellectual property rights.

Table 1. Definition of Content sub-characteristics for specifying information quality.

In addition to the above content sub-characteristics, others to information architecture and organization could be addressed. Many of these sub-characteristics, such as global understandability, learnability, and also operability and attractiveness, can be related to the *usability* characteristic. Besides, other particular features of WebApps such as search and navigation functionalities can be specified in the functionality sub-characteristics; for example, are the basic and advanced search suitable for the end user? Or, are they tolerant of misspelled words and accurate in retrieving documents? In the same way, we can represent link and page maturity attributes, or attributes to deficiencies due to browsers' compatibility into the reliability sub-characteristics.

On the other hand, from the quality in use perspective, we have proposed to use the same ISO model (recall subsection 3.2). As a matter of fact, for the satisfaction characteristic, specific (questionnaire) items for evaluating quality of content should be included.

Finally, we have performed some preliminary studies. One of them was a quantitative evaluation for a shopping cart of a Web 1.0 app, where the content accuracy and suitability sub-characteristics have intervened [11]. Recently, a qualitative evaluation was made [13] with the aim of comparing two WebApps that belong to the tourism domain. In particular, we have evaluated the content accuracy and suitability in addition to the accessibility and legal compliance sub-characteristics on opodo.co.uk, a Web 1.0 app, and on tripadvisor.com, which belong to the Web 2.0. The external quality evaluation was based on a questionnaire considering a question for each sub-dimension of Fig. 2 as well as to the content accessibility and content legal compliance sub-dimensions (not shown here for room reasons). Two experts have intervened in the inspection. Though we have non-conclusive evidence from this study, some initial comments and observations can be drawn about content that distinguish Web 1.0 from Web 2.0 apps.

First of all, it should be highlighted that the process of content production in Web 1.0 apps pursues rather a top-down approach, i.e., only content providers supply information to users. Conversely, in Web 2.0 apps this process becomes rather bottom-up; that is, mainly final users upload and update information. Moreover, content is submitted to a social control mechanism since users can share, edit, or comment content of other users, e.g. blog, wiki, social network. In fact, initial observations have shown that some kind of information may be considered more accurate and suitable in 'tripadvisor.com' than in 'opodo.co.uk'; particularly, information referring for instance to hotel review, location comment. In contrast, information as flight timetables, holiday price lists, etc. can be considered more accurate and suitable in 'opodo.co.uk'. Lastly, in general terms we argue that the WebApp's content quality does not depend on the kind of applications – whether Web 1.0 or Web 2.0; however, some kind of contents and services are more appropriate for Web 1.0 apps, while others for Web 2.0.

Ultimately, we can state the content sub-characteristics we have specified for evaluation purposes can be applied to all WebApps, independently from which era they belong.

5. Related Work

The model presented in this paper, as an extension of the ISO 9126-1 quality models, has been elaborated taken also into account related researches about dimensions of data and information quality. We next remark the main information quality models, often called frameworks in the literature, developed over the last years. The reader can, however, find broader reviews for WebApps for instance in [6].

It is worth mentioning that the difference in meaning between data and information – as remarked in subsection 3.2 – has often been neglected in these quality frameworks. Moreover, very often – and in some cases explicitly – these terms are used interchangeably.

1. **Content Accuracy**
   - 1.1. ***Correctness***, *the extent to which information is reliable in the sense of being free of errors.*
   - 1.2. ***Believability*** (synonym: Credibility), *the extent to which the information is reputable, objective, and verifiable.*
     - 1.2.1. ***Authority*** (synonym: Reputability), *the extent to which the source of the information is trustworthy*.
     - 1.2.2. ***Objectivity****, the extent to which the content (i.e., information or facts) is unbiased and impartial.*
     - 1.2.3. ***Verifiability*** (synonym: Traceability), *the extent to which the owner and/or author of the content can be verified.*
   - 1.3. ***Currency*** (synonym: Up-to-dateness), *the extent to which the information can be identified as up to date.*
2. **Content Suitability**
   - 2.1. ***Value-added***, *the extent to which the content can be novel, beneficial, and contribute to react to a given user for the task at hand.*
     - 2.1.1. ***Novelty*** *(*synonym*:* Freshness*), the extent to which the information is fresh and contributes to make new decisions for an intended user goal.*
     - 2.1.2. ***Beneficialness****, the extent to which the information is advantageous and contributes to make new decisions for an intended user goal*.
     - 2.1.3. ***Reactiveness***, *the extent to which the information is compelling and contributes to react for an intended user goal.*
   - 2.2. ***Coverage***, *the extent to which the content is appropriate, complete but also concise for the task at hand to a given user.*
     - 2.2.1. ***Appropriateness***, *the extent to which the information coverage fits to an intended user goal*.
     - 2.2.2. ***Completeness***, *the extent to which the information coverage is the sufficient amount of information to an intended user goal*.
     - 2.2.3. ***Conciseness***, *the extent to which the information coverage is compactly represented without being overwhelming*.
   - 2.3. ***Consistency***, *the extent to which the content is consistent to the site's piece of information or page with respect to the*

Figure 2. Definition of the proposed Content Accuracy and Suitability sub-dimensions for specifying internal and external information quality requirements.

One of the first studies intended to categorize data quality dimensions was made by Strong et al [14]. The focus in their work was on considering the dimensions of data quality for three user roles, i.e. data consumer, data custodian, and data producer. According to the authors, high quality data is data that is fit for use by the intended users.

They developed a framework made up by four categories – intrinsic, contextual, representational, and accessibility – including 16 dimensions of data quality. Specifically, the intrinsic category indicates that information has its own quality *per se*. It contains four dimensions: accuracy, objectivity, believability, and reputation. The accessibility category states that information must be easily accessible but secure. It includes: accessibility, and security dimensions. The third category is contextual data quality, which indicates that information should be provided in time and in appropriate amounts. It includes: relevancy, value-added, timeliness, completeness, and amount of data. The last category is representational data quality, which focuses on format of data/information and its meaning. It includes: interpretability, ease of understanding, concise representation, and consistent representation. As a matter of fact, this quality framework was initially developed for traditional information systems. Nevertheless, this model has been used for WebApps too. For instance, Katerattanakul et al [5] reuse the four categories and the characteristics including free-of-error webpage content, workable and relevant hyperlinks, and the navigational tools provided for accessibility. Caro et al [2] have in a recent study reused the Strong et al framework for modelling data quality of Web portals from the data consumer viewpoint. All these data quality frameworks neither consider different lifecycle stages of a WebApp and therefore different quality models as we propose, nor make any distinction between data and information quality either.

A different slightly way to model and evaluate the quality of information for a WebApp – both at page and site level – is proposed by Alexander et al [1]. They take into account six dimensions (criteria) such as authority, accuracy, objectivity, currency, orientation, and navigation. Authors include a checklist for a step-by-step quality evaluation to some kind of websites, namely, for the advocacy, business, informational, personal, news, and entertainment sectors. They evaluate information rather than data without considering different information quality models at different WebApp lifecycle stages.

The first published study about extending the ISO 9126 model has been made by Zeist et al [17]. In a nutshell, the extended model consists of adding some sub-characteristics for each characteristic, with the aim of specifying data/information quality. Unfortunately, this study is quite limited because at that moment the ISO standard did not consider the internal, external, and quality in use views – these were included just in the 2001 revised standard. Finally, as mentioned in the introduction section, there exists an ongoing SQuaRE project that proposes harmonizing many ISO standards related to quality

models, measurement and evaluation processes. According to Vaníček [15] "*these standards have not a unified terminology and do not fully reflect the current state of art in software engineering*". In his contribution he proposes a data quality model regarding the three ISO views, but these models are just for data (data as a new entity) separated of the quality models for software functions. As the author is aware "*the main problem concerning the development of new SQuaRE series of standard and also concerning the data quality standard is the enormous volume of standardisation documents ... If we extend the number and span of standards, nobody will use them*". Instead of the SQuaRE approach, our aim is modeling nonfunctional requirements for WebApps' functions, services and content, taking into account the three integrated quality models and Web lifecycle views.

6. Concluding Remarks

Most WebApps, besides the increasing support to functionalities and services will continue aiming at showing and delivering content. This basic feature stemming from the early Web 1.0 applications is currently empowered by the Web 2.0 and follow-on applications. Web 2.0 applications rely strongly on actual users sharing, collaborating and performing content tasks in real contexts of use. So evaluating the quality of WebApps is still a challenge.

In the present work, we have proposed how to specify quality requirements for functionalities, services and content for WebApps employing an integrated approach. By reusing and extending the ISO 9126-1 quality models' characteristics, we have discussed the need of modeling and adding the content characteristic for evaluating the quality of information. Specifically, we have argued that the internal and external quality models with the set of six characteristics, i.e. functionality, usability, reliability, efficiency, maintainability and portability, and their sub-characteristics respectively, are not sufficient to specify WebApps' information quality requirements. As a consequence, we have proposed to include in both models the content characteristic and its sub-characteristics. Besides, from the quality in use perspective, we have proposed to use the same ISO model. Ultimately, we have tried to give a minimalist and systematic solution to the current concern which is how to identify and model WebApps' quality and quality in use requirements at different lifecycle stages.

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