Design Principles of a Web Interface for Monitoring Tools

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Abstract.

A monitoring tool of a complex Grid system can gather a huge amount of information that have to be presented to the users in the most comprehensive way. Moreover different types of consumers could be interested in inspecting and analyzing different subsets of data. The main goal in designing a Web interface for the presentation of monitoring information is to organize the huge amount of data in a simple, user-friendly and usable structure. One more problem is to consider different approaches, skills and interests that all the possible categories of users have in looking for the desired information. Starting from the Information Architecture guidelines for the Web, it is possible to design Web interfaces towards a closer user experience and to deal with an advanced user interaction through the implementation of many Web standard technologies. In this paper, we will present a number of principles for the design of Web interface for monitoring tools that provide a wider, richer range of possibilities for what concerns the user interaction. These principles are based on an extensive review of the current literature in Web design and on the experience with the development of the GridICE monitoring tool. The described principles can drive the evolution of the Web interface of Grid monitoring tools.

1. Introduction

Monitoring tools in large Grid infrastructure such as EGEE (Enabling Grid for E-science), has reached a noticiable number in these last years. Several of them publish their data in the Web-based network so that a huge number of Grid users access Web interfaces where monitoring information is collected.

Such Web contents must be organized with the final goal to meet both the needs and the requirements that possible users have accessing the Web interfaces. Therefore Web developers have to build a model able to consider all the different skills and interests that different kind of consumers have accessing their Web interface, such model has to come at a first step in creating your Web interfaces in order to formalize key elements like users skills and expectations, the main organization of the Web pages together with their presentation characteristics and functionalities.

This paper is intended to propose an approach to Web develpment based on the current Web design principles and guidelines that can improve the usability of Grid monitoring tools through

more user-centered Web interfaces, furthermore such an enthusiastic suggestion is stimulated by the experience with the development of the Web presentation layer for the GridICE[1] monitoring tool.

We will divide a Web project workflow in three main categories: the Project definition where discovery and analisys processes target the Web tool audience and higher-goals, the Structural design where the main Information Architecture (IA) guidelines can be utilized to properly organize the contents, build the Navigation systems and define a set of Labeling systems. The last category, named the Visual design, is concerned with the development of the mark-up code based on the World Wide Web Consortium (W3C) principles and guidelines that reduce maitenance effort and ensure long-term growth for your Web interfaces.

This paper is organized as follow: Section 2 gives the motivation for a user-centered approach to the Web design, Section 3 describes the Project definition, the Structural design and the Visual design categories, Section 4 draws up the conclusions.

2. Work Motivations

In production quality Grids, the need to understand how the performance and problems within the infrastructure is massive, furthermore the huge activity of job submission and data management requires the possibility to analyze the usage of the Grid System in terms of user defined events[2]. Both in the former and in the latter cases the correlation of several monitoring data from applications, network, operating system and Grid middleware can be collected and aggregated in a relational database in order to deal with a powerful and general language for extracting data[3] with the final goal to publish them in different contexts. Taking into account the possibility to meet the wide range of Grid users spread over large geographical regions, the most suitable context is the Web-based network, where the information design and the content strategies have been constantly evolving towards a more intuitive user interaction.

These evolutions are mainly based on two paradigms: the presentation of the Web contents in the most comprehensive way and the different needs that different kind of consumers have accessing the Web Interfaces. As an example, concerning Grid monitoring in the EGEE infrastructure the typical consumers can be depicted in four main roles [4]: the Grid operator manager, the Grid site manager, the Virtual Organization (VO) manager and the VO end-user, each of them interested in inspecting and analyzing different subsets of monitoring data. So that a Grid operator can access a Web interface to understand the general state of the Grid (es. how many sites compose the Grid and where they are located, how many computing and storage resources are available) in order to optimize the planned operations and notice fault situations on Grid services while the Grid site manager can be considered as a Grid operator restricted to his own resources. At the same time the VO manager can inspect monitoring tools to find out the Grid resources available to the VO and analyze the job submission and the data management activity (es. how many jobs failed with a certain exit status in a given period, what is the percentage of success in the replication of data into the available storage elements), finally the VO end-user can examine his processing jobs to improve his planned computation.

As a result we have several scenarios in which every kind of Grid users access monitoring tools to search for what they consider relevant information, therefore what we have to focus on is an exhaustive model to understand the needs and the typical behaviors of Web users when they look for information on a particular Web interface. Such an important model has to come at the first step in creating your Web interfaces since every navigation systems, labeling systems and content organization systems adopted in your Web Interface have to be coherent with the needs and the behaviors of your potential Web users[5].

3. Web Project Workflow, Principles and Guidelines

Given these motivations it is easy to understand how can be arduous to design Web interfaces for Grid monitoring tools able to target the audience needs. In fact, during the design and process definition many different issues have to be considered. How can we properly know the users skills and expectations? What will be the main content and how it will be presented, what about its maintenance plan? Do we know the users functional requirements? What about the technology requirements instead?

Although the typical Web developers team approach is based on intuition by mistake, we can observe that many clues can be found in the majority of the principles and guidelines that can be adopted in the Web development processes. Consequently we can have a better user-centered design and implementation organizing the Web project workflow in three main categories: the Project definition, the Structural design and the Visual design.

3.1. Project Definition

The Project definition is the first stage of any Web project, hence in that phase the first key decisions that will reflect the success of your Web tool have to be taken; just to give few examples of them we can mention the project higher-order goals, its audience profiles as well as the content needed in the final product. The typical approach to that definition is based on three main steps: the first one can be considered as a discovery process where stakeholder interviews and competitive analysis take place together with the seeking for possible users interested in data presented by the Web interface. Once gathered these information we can proceed through the next two steps that require the analysis for the functionality of the project in the presentation of the information provided, and the project strategy based on the formalization of its main objectives in conjunction with the definition of the communications plan and the success metrics.

3.2. Structural Design

One of the topics, encountered in the project definition phase and related to the audience profiles, is crucial to deal with the user-centered design for the Web interface mentioned before, in fact once potential users have been targeted, we need to present to them the information in the most usable way especially in contexts where huge amount of heterogeneous data have to be presented like the Grid monitoring itself.

In order to do that, users' typical needs, skills and expectations have to be analyzed with the final goal to optimize the organization of the Web interface contents, thus given the latter organization as one of the biggest issue to be addressed in developing successful Web interfaces what we need is some standard methods to transform the information collected in the discovery process in a system able to properly organize the Web contents. In order to prevent the aforementioned approach based on intuition, the Structural design phase can be based on the principles of the Information Architecture (IA), that has been defined as the art and science of organizing and labeling websites, intranets, online communities and software to support usability[6].

Taking into account the task to structure and classify a Web interface that aims to present Grid monitoring data, given the reasons why the users would visit our Web tool, we can use the IA to structure and classify the information starting from the main information needs and seeking behaviors on the Web: the Known-item, the Exploratory and the Exhaustive searching. The former can be considered for users who have a knowledge of the services provided by the Web tool and need to rapidly access key information (es. Grid operator seeking for possible Grid services down, VO manager who wants to know the percentage of jobs failed on a particular site in a certain period), the Exploratory searching occurs when users access your Web tool for the first time and would like to find helpful information (es. VO managers who want to know how many CPUs are available for their VO, VO users who need to geographically locate the

file replicated on the Grid), at last we have to consider the Exhaustive searching as the need to have an in-depth search (es. Grid operator that need to run post-mortem analysis, Grid site manager interested in understand the causes of some problems). It is worth remembering that these three needs are not mutually exclusive, for instance a typical user can run, at the same time, an Exploratory searching finding out something that requires an in-depth searching, therefore they have to be integrated when building the main components of the IA for your Web interface:

- The Organization systems - the categorization of the information (es. geographically, chronologically, based on a particular subject)
- The Labeling system - that is the way to represent the information and the meta-information in our Web interface (es. main menu labels, page title, terminology to adopt for the technical information)
- The Navigation systems - the way to move around the Web interfaces seeking for information (es. globally to the main sections, locally to a single section, contextualized to a given page)
- The Search systems - hence how your users will search for information into the Web interface (es. Site-maps, Site-indexes, internal search engine)

Since the Structural design plays a key role to successfully meet users needs, skills and requirements, in the following paragraphs we will describe the main purposes and guidelines for the first three aforementioned systems. The omission of the Search systems in mainly due to an inclusion of Search systems like Site-indexes and Site-maps in the Navigation systems and to a little experience on search-engines algorithms.

3.2.1. The Organization Systems

They consist of the organization schemes and structures, the former can be divided in what we can call the *Exact* and the *Ambiguous* schemes and define the shared characteristics of content items in order to influence the logical grouping of those items. The Exact organization divides information into well-defined and mutually exclusive sections, it is best for *Known-item* searching when users know what they are looking for but it is not recommended for users that are running *Exploratory* searching, in fact while it is true that Grid experts such as Grid operators deal with the concept of site and VO name everyday so that it seems reasonable to organize a list of sites or VOs alphabetically, users not really skilled on Grid topics, such as new VO users, usually do not know Grid terminology and acronyms.

On the contrary the Ambiguous schemes divides information into categories that defy exact definition, it is best for browsing and associative learning when users have a vague information need. Typical example of such schemes are that based on:

- Topic - the most challenging schemes that gives the best results when properly planned since it is important to define the breadth of coverage defining the range of content that users will expect to find within an area of the Web interface
- Task - can be successfully adopted in Web interface sub-sections where a certain number of high-priority tasks that users will want to perform such as the possibility to set a downtime advice for a Grid site by means of *insert*, *modify*, *remove* processes

At the same time the organization structures define the types of relationships between content items and groups, thus designing the way users navigate through the Web interface pages and sections. Major structures include the *Hierarchy*, the *Database* and the *Hypertext* model.

The Hierarchy model can be considered as the foundation for the organization structures, such top-down approach can be quickly and easily adapted for the main structure of a Web interface since information organized via hierarchy are familiar to the users and can be used to

help them during their typical approaches to the Web interface when questions and doubts like: what is available on this pages, where am I, how do I find out about, how do I get back to the main page instinctively come.

The Database model is a bottom-up approach that helps Web designers understand the underlying small pieces that make everything work in content-driven sub-sections of a Web interface, in fact metadata have to be carefully defined designing all that sub-sections characterized by a relatively homogenous content such as help sections or charts gallery. In the former example possible metadata are information source, unit and description while in the latter example we can have chart name, legend and units.

The Hypertext model is often used as complementary to the others organization structures, since it involves items or chunks of information to be linked and the links between the chunks it can be potentially very complex and confusing for users, but on the other hand it can be thought to quickly cross-refer in depth searching about a certain information by means of the hypertext navigation among Web pages.

Given the above organization systems it is easy to understand how complex can be the design of cohesive organization systems for your Web interface. Do its Web contents have to be organized using exact or ambiguos schemes? Which of the aforementioned structures can the users utilize to navigate into Web pages?

In order to tackle these overwhelming questions, it is better to break down the Web interfaces into small components of homogeneous contents, since it is easier to identify high effective organization systems in narrow domains than considering the entire Web interface[7].

3.2.2. The Labeling Systems

Beside the overall organization of the Web interface, labeling is another key concern for the Structural design phase, in fact through labeling we are able to represent the larger pieces of information present in a Web tool.

The goal of labeling is to communicate information efficiently, so that labels have to be easily and clearly understood by the users while reflecting the interface content, furthermore they can also educate the user about new concepts and provide explanations when necessary.

For istance the importance of having coherent Labeling systems is crucial for Grid monitoring tools either for that designed for Grid experts such as Grid operators or for VO users, in fact while in the first case it is better to focus the attention on Labeling systems able to efficently spot and explain fault situations in the latter case what have to be considered is the possibility to improve a sort of Grid awareness able to optimize their Grid activity.

As for the organization systems, dealing with proper Labeling systems in Grid monitoring contexts do not get any usability success if the approach is based only on the Web developers intuition, in this latter case it is easy to create labels that do not speak the same language as the users indeed[8].

Thus IA principles and guidelines again help in defining such systems, so that a Web interface can be mainly composed of the following Labeling sytems:

- Contextual links - description for the hyperlinks to external Web interfaces, they are also used to link hypertext within the body of a Web paget and occur within the context of the surrounding text. Since they rely on context their definition have to be based on the question *what kind of information do the diffent users expect to be taken?*
- Headings - mostly used in Web documents such as help sections, they describe the chunck of information that follows in order to establish a hierarchy and visual consistency simply with the text through numbering, font size, color, style that need to be defined with a high level of coherence

- Navigation labels - generally repeated throughout the interface, they have to be built to help users to quickly understand what the tool is referred to and where relevant information can be found. For that reasons it is best to define labels as much as possible familiar for the users for which it can be also provided an explanation by means of tooltip effects

In addition to the above systems in the Grid monitoring context another type of Labeling systems that often occurs is related to the Grid terminology sas weel as acronyms that try to describe computational and storage resources together with Grid services, components and test results. They are usually used in tables header and charts, so that in addition to the guidelines for the Headings and the Navigation labels we also need to build a thesauri[9] able to include standard established labels.

As a result users can experience a sense of familiarity with these recurring labels as for the many standard labels utilized in the majority of Web sites (es. Home, Main, Contact us, News, About). In order to accomplish with a high level of coherence such a useful thesauri, possible guidelines to follow are mainly related to:

- Style and presentation - use of a systematic way for puntuation, upper/lowercase letters, font sizes and colors
- Syntax - Labeling systems based on a single syntax approach (es. verb based) have a higher level of coherence than that based on multiple approaches (es. verb based and question based)
- Granularitly - definition of an equal level of specifity in the Labeling systems adopted avoid users to encounter a set of labels that cover different levels of granularity (es. Computing Element, Queues, Total CPU)
- Comprehensiveness - comprehensive Web interfaces help users understanding the available content, so that a Labeling system has to include the description for all the possible content categories
- Audience - labels have to speak the same language as the users do, if each different type of audience uses very different terminology ad hoc customizations are needed for the Labeling systems in order to meet the different users skills

3.2.3. The Navigation Systems

Helping the targeted users fulfil their information needs accessing a specific Grid monitoring tools means that they have to interact with the organization and Labeling systems through the Navigation systems, so that they always know where they are located in the Web interface[10].

The IA divides all the possible Navigation systems in three main categories: embedded, supplemental and advanced. Embedded Navigation systems are integrated into the context of the site to help users understand where they are and where they can go, they mainly consist of:

- Global navigation - intended to be present on every page of a web site such as the navigation bar for the main menu
- Local navigation - provides access to subsections within the main Web interface such as a charts gallery menu
- Contextual navigation - hyperlinks to a particular page, document, or object such as help section

In order to provide alternative ways to access information on a Web interface, supplemental systems can be taken into account whenever direct access to subsections or detailed guides for specific audiance, topic or task are required.

Site-maps for instance are not very used in Grid monitoring Web interface, but they can provide an overview on the information hierarchy useful for new users running Explorative

searching when they need to quickly access to the content, at the same time Site-indexes provide direct access to content through keywords or phrases, normally organized alphabetically, they work well with users who run Known-item searching since they have to know the name of the item they are seeking.

Guides and Wizards can be included as supplemental systems as well, since they assist users in specialized tasks introducing new users to the tool content and functionality; possible utilization in Grid monitoring tools for these systems are related to the possibility to provide explanation of fault situations together with step-by-step ways to solve them.

Advanced Navigation systems rely on the introduction of Web 2.0[11] functionalities in Web interfaces development, since it involves a user experience similar to that provided by desktop applications, useful systems to be taken into account are, for istance, navigational features that allow users to select what content they wish to have presented at a particular time through what IA calls Personalization and Customization.

Understanding how to proper include the described Navigation systems in the Global, Local and Contextual navigation of a Grid monitoring tool can be better accomplished following few ideas it is possible to overcome intuitive approaches and decide which is your best design choice. Thus providing tools so visitors can decide where they would like to go (es. links to related pages or sections) as well as help and suggestions so users know their options and what they might do next, furthermore the navigation has to be consistent throughout the website so users always know where to look when they would like to move to other sections.

3.3. Visual Design

In complex Web interfaces for Grid monitoring tools, with several sections and a big number of pages, it is useful to spend a lot of time to decide how visualize the huge amount of monitoring data. The different kinds of users requirements and the continuous evolution of the needs about Grid data fruition, oblige the developers to modify the code in order to update the presentation of data.

Another crucial point in developing a complex Web interface is to offer the possibility to visualize and use the Web pages with different browsers and obtain always the best result in terms of presentation functionality; in general you have to find a way to produce an interface usable at least with all the most common Web browsers.

The best way to reach this aims is to embrace the World Wide Web Consortium (W3C) specifications and recommendations[12] in your Web development processes, in fact the W3C is an international consortium that works to develop protocols and guidelines that ensure long-term growth for the Web. The most fundamental Web technologies must be compatible with one another and allow any hardware and software used to access the Web to work together.

In this context, a good work in organizing the Visual design before start writing the mark-up code let the developers gain a lot of time maintaining and updating the code iteself; for instance a possible approach can be based on the separation of the presentation from the structure in the visualization of the Grid monitoring data in order to optimize maintenance costs since Web graphic designers and business logic experts can work independently.

Concerning W3C specifications for the structure, a good choice is XHTML[13], an extremely portable markup language, that, if constantly validaded with the W3C validator[14], works in all the most used Web browser, screen readers as well as textual browsers. On the other hand the CSS[15] presentation language formats the Web pages, controlling fonts, disposition, colors and more generally all the stuff related to the Web interface style.

While the presentation is separated from the structure, it is also possible to change the former without cause problems to the latter, at the same time the developers can quickly change the XHTML code without any interferences to the style language.

Another W3C specification that can be taken into account in such Web projects is concerned

with the behavior of the Web pages when client-side events are triggered, it is defined as the Document Object Model (DOM)[16] and it permits to create client-side effects on many platforms and browsers with the final goal to avoid Web servers overload and introduce advanced Web 2.0 features based on the AJAX[17] techniques.

3.3.1. The GridICE Approach to the Visual Design

We will now briefly explain how the Visual Design choices have been carried out in the development of the GridICE monitoring tool for Grid systems. Its presented data is mainly divided in two sections, grouping Grid monitoring information by the administrative site and by the VO. For each of the two main sections we have a set of views that show aggregated data for all the site belonging to the monitored Grid and for all the VOs enabled to use the resources. This division make easier the navigation into the Web pages for users interested mainly in VO-oriented or site-oriented information. Thanks to a drill-down navigation, the user can perform his analysis from the general to the detailed information.

Concerning the mark-up code, it has been developed, both at the beginning of the first GridICE redesign and during the maintenance activity, with a high consideration for the separation between the structure and the presentation layers. The presentation style has been grant to the CSS; in particular two different styles was designed, one for the screen and one for printing, while in the structural code there are no style specifications. All the modifications to the presentation have been assigned to the CSS code, so that adding a particular CSS "class" or "id" referred to a general element existing in the structural code, approximately 30 pages will be affected by this change; contemporary whenever we need to modify the structure of a Web page, unless we refer to the defined CSS classes and ids we can twist the structure at all without any worries about its current style.

Moreover, we took care of validating all the XHTML code following the W3C standards, in particular our mark-up code observe the majority of the specifications and constraints described as mandatory by the W3C guidelines. The result is a code extremely essential, without any deprecated object no more supported by the most used Web browsers.

4. Conclusions

The Web design principles and guidelines described in this paper can be considered as a starting point for the development of usable Web interfaces for Grid monitoring tools in order to move from an intuition-based to a user-centered approach. Such user-centered approach can be efficently succeeded making a lot of effort in what we have defined as Structural design, hence analyzing the key components of the IA for the creation of Web interface Organization, Navigation and Labeling systems. Therefore our suggestions, for both future Web interfaces and redesign of current ones, is that as Grid monitoring data become more detailed and Grid users become more demanding, the integration of IA principles and guidelines have to be seriously considered.

Furthermore, during the developmet of the GridICE Web presentation layer, we have experienced that it is possible to build more powerful Web interfaces using , in the Visual design context, the W3C open standars on condition that mark-up code used for the Web pages is validated by the W3C itself and a real separation between content presentation and content structure occurs.

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