# Interaction Patterns for User Interface Design of Large Web Applications

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In an increasingly competitive market, there is a growing demand for Web applications with good usability, which has challenged developers, interaction designers and web designers to constantly adopt efficient strategies to control and improve the quality of such applications. Faced with these challenges, interaction patterns have been an important artifact to aid practitioners to design user interfaces with good usability. We present three interaction patterns for user interfaces, specially focusing on Web applications that provide a large amount of information. Patterns usually be used to transfer knowledge about the usage requirements and to improve the communication between the development team, resulting in a better satisfaction of users of interactive systems. The proposed interaction patterns define solutions for common problems in user interface design based one of the best-known set of usability heuristics.

## 1. INTRODUCTION

The demand for Web applications[1] has grown considerably over the past years. Developers, interaction designers and web designers are constantly challenged to control and improve the quality of such applications aiming at satisfying users' expectations [Rivero et al. 2013]. Nowadays, Web-based software represents a fundamental structure for any type of business in a market increasingly competitive that seeks to maximize profit either by promotion of products and services, or interactive commercial transactions [Fernandez et al. 2011] [Cebi 2013]. Furthermore, modern Web applications has required more and more an high quality in order to run large-scale software applications, such as e-commerce, content distribution, entertainment, collaborative working, social networking, and countless other activities [Offutt 2002].

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[1] A Web application is defined by Kappel et al. [2006] as a software system based on technologies and standards of the World Wide Web Consortium (W3C) that provides Web specific resources, including content and services through a user interface.

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Usability is considered an important metric to evaluate the quality of any type of web application [Bevan 2001]. Besides the structural dimension and its features, the usability of web applications depends on its user satisfaction [Nagpal et al. 2016]. For the users, software with good usability should provide a friendly user interface, easy to use and easy to understand. Unfortunately, the lack of usability may be one of serious reasons for Web applications' failure, especially when these were poorly designed. Therefore, one of the primary factors for a software's success is directly related to the quality of the experience that will provide to its target audience [Gkantouna et al. 2016]. Users need software applications designed in such a way that allow them to quickly learn about the features, to easily interact with the system, and to efficiently meet their needs.

Concerning user interfaces design (UID), typical solutions to common usability problems have been addressed through interaction patterns [Folmer and Bosch 2004]. Interaction patterns aim mainly at incorporating user-centered aspect into the software design process [Tidwell 1999b]. Therefore, interaction patterns can provide the best solutions for UID of large web applications, ensuring its usability.

In this paper, we present three interaction patterns for user interfaces, especially, focusing on large web applications that provide a large amount of information to its end users. The proposed interaction patterns were centered on the user's needs seeking to achieve their satisfaction. Despite user satisfaction to be considered a subjective issue, it can be measured and/or observed by a set of usability principles used commonly to guide the design of user interfaces. The remainder of this paper is organized as follows. Section 2 describes the essential aspects related to interaction patterns and usability. Sections 3 presents our interaction patterns proposed for UID of large web applications; Section 4 provides an overview of the related work; finally, Section 5 provides some conclusions and directions for future work.

## 2. INTERACTION PATTERNS AND USABILITY

Interaction patterns are used to generalize a solution that involves designing interactive systems to support the way people communicate and interact [Rogers et al. 2013]. In other words, these patterns are focused on solutions to problems caused by difficulties in the interaction of users with the system. The knowledge expressed by interaction patterns captures the essence of a successful solution within a given context to a recurring problem regarding user interface design [Perzel and Kane 1999].

Obviously, interaction patterns are also written to describe aspects about user experience and to allow designers to reuse it. Another important aspect of these patterns is that they are also used to facilitate communication among people involved in software development from different areas, for instance, software engineers, interaction designers, usability experts, end users, and others stakeholders [Acosta and Zambrano 2004]. Consequently, these patterns focused on interaction design should ideally be readable and understandable by professionals and non-professionals alike [Borchers 2000].

From User-Centered Design's perspective, usability is an essential and indispensable factor for the quality of interactive systems [Abras et al. 2004]. Van Welie and Trætteberg [2000] point that a pattern for UID require a special format, since its primary focus is on improve the usability of the system in use. Usability can be measured by five quality components: learnability ("Easy to learn"); efficiency ("Efficient to use"); memorability ("Easy to remember how to use"); errors ("Easy to recover from the errors"); and satisfaction ("Pleasant to use") [Nielsen 2012]. Hence, each pattern should highlight its impact based on these components, as usage indicators.

Taking into account the aforementioned aspects, we will present our interaction patterns in the following format:

**Pattern:** identifies the interaction pattern.

**Context:** describes the context under which this pattern is used.

**Problem:** describes system-related problems that impair its usability.

**Usability guidelines:** general principles based upon best practices in usability for interaction design that underlie the solution. We have adopted the usability heuristics proposed by Jacob Nielsen [Nielsen 1995], since

they are more general rules, widely known by interaction designers and UI experts, and that can be applied to any interface. The Nielsen's 10 heuristics are:

H1 - Visibility of system status: "The system should always keep users informed about what is going on, through appropriate feedback within reasonable time."

H2 - Match between system and the real world: "The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order."

H3 - User control and freedom: "Users often choose system functions by mistake and will need a clearly marked "emergency exit"to leave the unwanted state without having to go through an extended dialogue. Support undo and redo."

H4 - Consistency and standards: "Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions."

H5 - Error prevention: "Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action."

H6 - Recognition rather than recall: "Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate."

H7 - Flexibility and efficiency of use: "Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions."

H8 - Aesthetic and minimalist design: "Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility."

H9 - Help users recognize, diagnose, and recover from errors: "Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution."

H10 - Help and documentation: "Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large."

**Solution:** presents proposed solution to the problem.

**Known Uses:** shows examples of Web applications that apply the proposed solution.

In practice, Nielsen's heuristics can be used both to guide and evaluate software design. It is worth noting that, a evaluation based on heuristics can to explain each observed usability problem with reference to established usability principles. Nevertheless, an heuristic evaluation does not provide a systematic way to generate fixes to the usability problems [Nielsen 2012]. Regarding to interaction patterns presented here, the heuristics are indicate according to the type of problem described in the pattern. However, each problem described may violate more than one usability heuristic.

3.  INTERACTION PATTERNS FOR UID OF LARGE WEB APPLICATIONS

3.1   Light background

**Context**

On the same page, and at the same time, a large amount of information (including images, texts, animation, illustrations, etc.) is displayed in different formats and styles like fonts, colors, size, textures, etc.

**Problem**

Users want to quickly recognize the type of information available in order to locate subjects of their interest. However, there are many information which are not properly highlighted because of the dark background. Consequently, the viewing and reading process tends to be more time-consuming and tiring.

**Usability guidelines**

The aforementioned problem violates three usability principles. First, "Aesthetic and minimalist design (H8)"– since it refers the overall appearance of the user interface, including contrast and combination of colours, content organization, etc. Second, "Consistency and standards (H4)"– because it involves paying attention to the font size, typography, images and graphics size, alignment, distance between the content blocks, etc. Third, "Match between system and the real world (H2)"– because the content should be familiar to those who are going to be using it. These guidelines aim to improve the readability, understanding of the information presented, and minimize navigation effort.

**Solution**

The content of the page can stand out clearly against a light-colored or white background, greatly improving the its readability. Such contrast is more soothing and relaxing than contrast with very dark backgrounds which are considered more stressful and somber [Tidwell 2010]. Further, a margin of at least 10% (left: 5% and right: 5%) between the content blocks may allow each block to receive a focus of attention without influence of the neighboring blocks. As shown in Figure 1, the content blocks appear more prominently against an entirely white background. The margins left between the blocks allow the user to focus on one block at a time, until find a content of his interest.
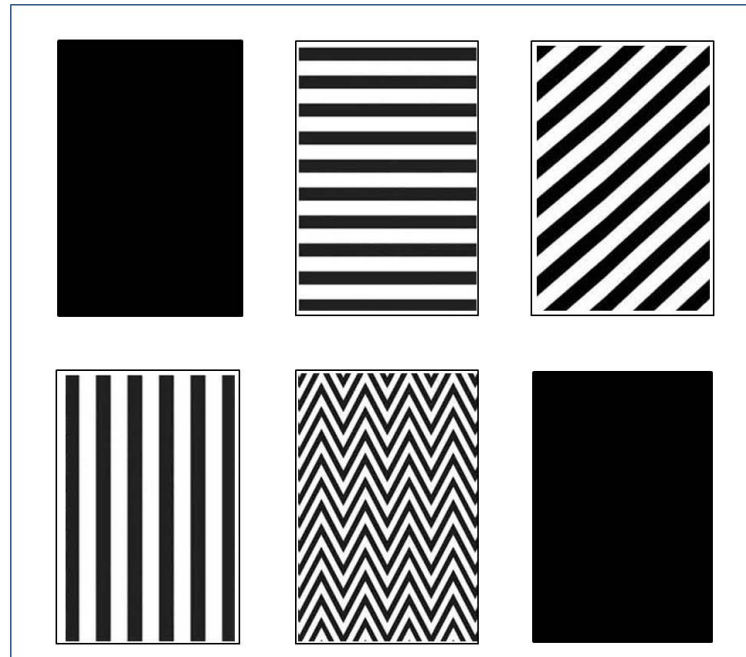


Fig. 1.   Light background pattern.

Next, we provide a suggestion of CSS code to implement this interaction pattern, where two layers are defined: *#back* (first layer), and *#block* (above the first layer). Each content block should be individually allocated in a particular layer, and each block should have a margin of 5% of the width and total height in relation to other blocks. In addition, a thin border can be used (especially in image blocks) in order to improve the definition between block and background.

**CODE 1:** Light Background

```
#back   {
        background-color: #FFFFFF;
}

#block {
        margin: 5%;
        border: 2px solid #000000;
}
```

**Known Uses**

There are several news websites that implements this pattern. Figure 2 shows a screenshot of the CNN International's page – one of the most popular news websites in the world. Note that the white background contrasts with the colors of the images by highlighting them. Also, the typography readable reduces the effort required to read and comprehend the news.
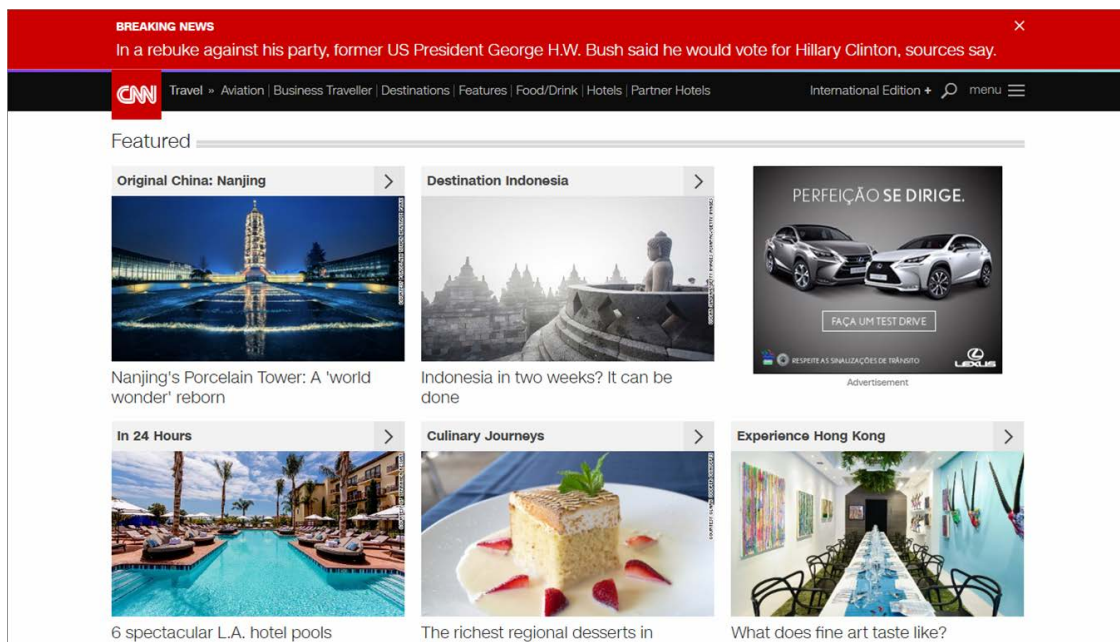


Fig. 2.   CNN International. Source: http://edition.cnn.com/

## 3.2  INFORMATION MENU

**Context**

Different types of contents - texts, images, animations and videos - are displayed on the same page. However, there is no standardization in design, texts are very long, images have different sizes and resolutions. There is a interface very confusing, and user-system interaction is inefficient.

**Problem**

Users find a confusing interface, and the information seems disorganised. Sometimes, a large image draws more attention than a smaller image. A long text discourages reading, and search for more interesting contents can become very tiresome. They barely notice the short texts. Animations and videos attract their attention, but it can also bother their peripheral vision. Faced with an enormous amount of information, the scrolling process becomes excessive and tiring.

**Usability Guidelines**

From usability perspective, this problem violates three principles. First, "Consistency and standards (H4)"– due to the lack of standards, for instance, on typography, size of text and images, margins between content blocks. Second, "Aesthetic and minimalist design (H8)"– because it involves combination of colours, content organization, etc. in order to improve readability and understanding information for users. Third, "Match between system and the real world H2"– because the content should be familiar to end-users.

**Solution**

In order to better arrange the content, page layout may be split in 2 or 3 columns, and all information blocks – texts, images, animations and videos – should be presented in standard size and shape, and properly aligned, as shown in the Figure 3.
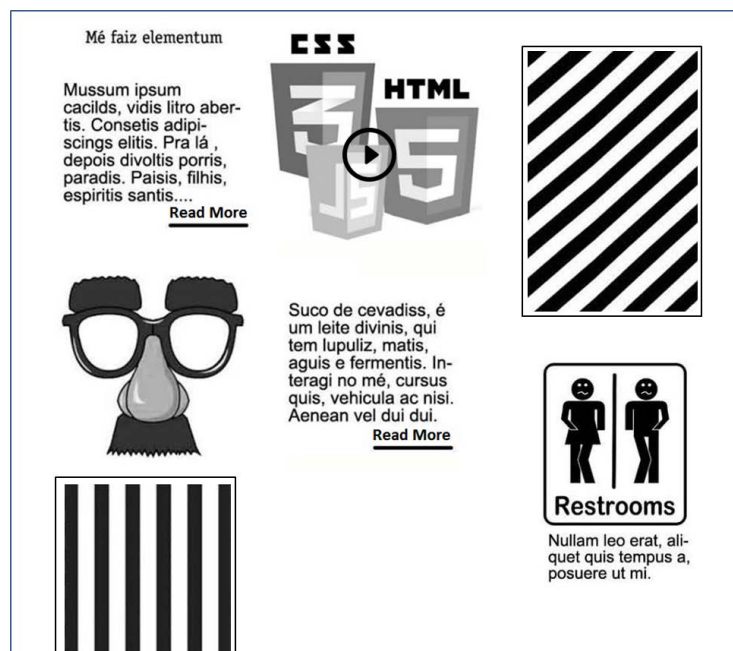


Fig. 3.   Information menu pattern.

To avoid excessive scrolling, textual information can be displayed in small snippets, where a hyperlink with the text "Read More"directs the user who wishes to read full article – including to view details of the images, animations, or watch videos. Thus, this pattern suggests a menu of information, where users are free to choose the information on which they want to know more details.

Next, we provide a CSS code to implement this interaction pattern. First, we defined three layers for three columns, where each column represents 30% of the page-width. All columns will be positioning to the right of the previous one. Also, we defined a margin to central column of 5% of the width relative to the other two columns. Second, we delimited the block-height by 250px, including an internal margin of 2%.

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**CODE 2:** Information menu

```
#left{
        width: 30%;
        float: left;
}

#center{
        width: 30%;
        float: left;
        margin−left: 5%;
        margin−right: 5%;
}

#right{
        width: 30%;
        float: left;
}

#block {
        height: 250px;
        padding: 2%;
        border: 2px solid #000000;
}
```

---

**Known Uses**

There are some content distribution websites and e-commerce that implement this pattern. Figure 4 shows a screenshot of the CNN International's page about sport news. Note that, the layout has been delimited by three columns. All texts, images and videos are arranged in standard size blocks. There are three static images that are aligned side by side. Just below, short texts are listed in topics that are links to access the full news, photos and videos – working as an information menu. In the bottom row, three videos-pictures are grouped and aligned to the upper blocks.
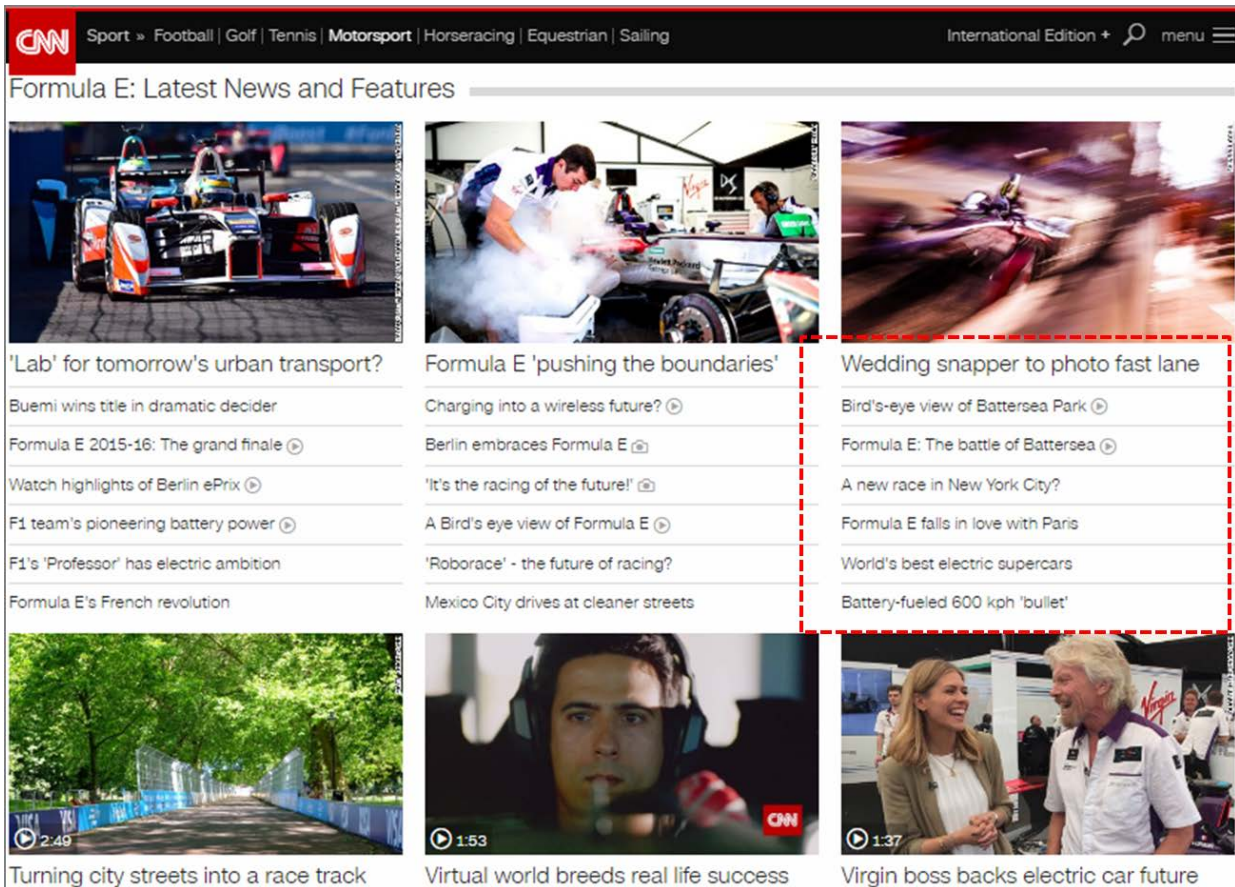
Fig. 4.  Screenshot of CNN Internacional Edition. Source: http://edition.cnn.com/

## 3.3  LOADING IN PARTS

**Context**

The page continuously receives new content which is dynamically updated. Each time the database is updated, the amount of information displayed on the same page increases, becoming too long.

**Problem**

Users search for content of their interest. The search returned thousands of options on the same page for what they are looking for. The page loads all information at once. Uploading might be too slow when the quantity of data is too large. In the worst case, it may not load due to the amount of data.

**Usability Guidelines**

This problem violates two usability principles. First, "Flexibility and efficiency of use (H7)", since a good practice of usability is to implement mechanisms to improve the user interaction with the system in terms of agility and flexibility. For example, the users sometimes do not need to see all search results, because they may find what they were looking for as soon in the first results. Second, "Visibility of system status (H1)", because it is very important to communicate users that the page is being loaded.

**Solution**

In order to balance the amount of information with the loading time, one solution is to release content loading on demand. Thus, as the user drags the scroll bar down, a site resource is tasked to display more data that is on the server. We have implemented such resource using Javascript and XML (AJAX). AJAX allow us to load and render the page through client side scripts, searching and loading data in the background without having to reload them. Data is loaded in parts enough to fill, for example, twice the size of the screen. Then, as users drag the scroll bar down, other parts are loaded. As shown in the Figure 5, this pattern seeks to reduce loading time of page, by loading partial results according to the user's demand. In addition, it highlights the need to keep the user always informed about the state of the system, especially when the page is being loaded.
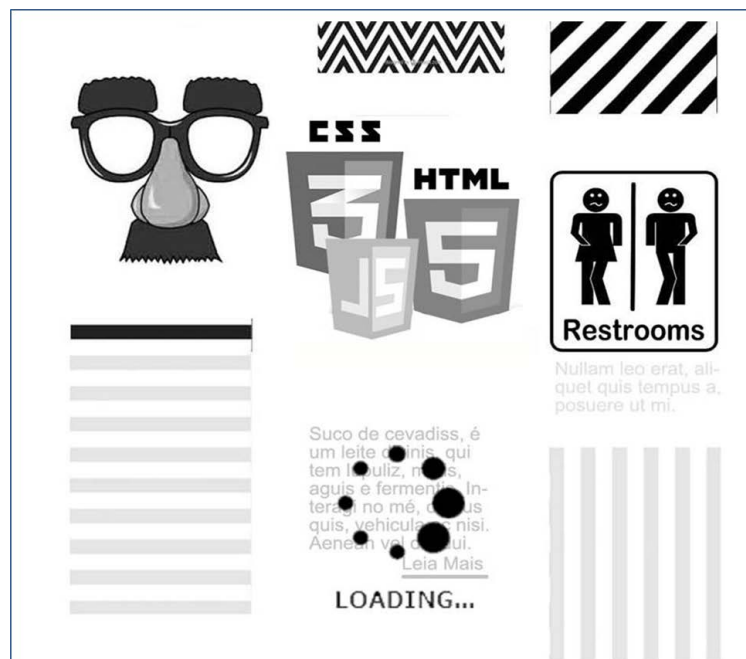


Fig. 5.  Loading in parts pattern.

In Code 3, we present a Javascript function in order to implement this interaction pattern. This function checks if the scroll bar has reached the end of the screen, and if so, another function will call the file responsible for loading the data from database, and then adding them to the code that render the page.

**Known Uses**

This pattern is more common in social networks (e.g. Facebook and Instagram), where content loading is done according to the position of the scroll bar. One of the oldest application that adopt this pattern is Google's page that displays search results by images. The application loads the images in parts, showing system status. There is a feature that indicates that the page is being loaded. When the list of images is too long, the system loads part of the content and displays an option for the user to see more results by pressing a button to run this action.

**CODE 3:** Loading in parts

```
$(window).scroll(function(){
        if ($(window).scrollTop() == $(document).height() - $(window).height()){
                loading();
        }
});

function loading(){
        $('#loading').html("Loading...").fadeIn('fast');
        $.ajax({
                url: "Loading data from the database",
                   cache: false, success: function(html){
                        $('#loading').fadeOut('fast');
                        $("#content").append(html);
                }
        });
};
```

## 4.   RELATED WORK

Interaction patterns focused on design of user interfaces is no novelty. For example,Tidwell [1999a] developed one of the first set of interaction design patterns called Common Ground. Martijn van Welie's Interaction Design Patterns [Van Welie and Trætteberg 2000] is the first collection to make the explicit distinction between the user perspective or the designer perspective, and establish a language of their own. However, such patterns are more intended for the desktop applications.

Perzel and Kane [1999] identified a set of usability pattern that cover part of the web aspects, including system patterns and user interface widgets. The patterns developed by Borchers [2001] were focused on public-access systems where typical users are first-time and one-time users with short interaction times and no time for a learning curve.

Montero et al. [2003] proposed design patterns for website development, categorizing them into three levels: (i) website level for dealing with information architecture issues and navigability; (ii) web page level for dealing with content organization; and (iii) ornamentation level, in order to explore visual features such as colors and sizes of interface elements.

Seffah et al. [2008] have identified specific scenarios where "invisible software components"– any software entity or architectural attribute that does not have visible cues on the presentation layer – can affect the usability of system. Thereafter, they provided a list of patterns reconciling usability and interactive system architecture.

## 5.   CONCLUSIONS AND FUTURE WORK

In this paper, we have presented three interaction patterns that were specially developed aiming to improve the usability of Web applications that provide a large amount of information, which are constantly updated. Our patterns covers both the level that deals with information architecture issues and navigability such as the level involving content organization. Further, we explore visual features, such as background color and the size of the content blocks, in order to propose more pleasant interfaces.

Looking for objective and functional solutions for user interfaces design, we sought to address typical usability issues from user experience perspective. To accomplish that aim, we have adopted a set of usability guidelines proposed by Nielsen in order to highlight the impact of the use of the pattern from the usability point of view.

As future work, we intend to validate the proposed patterns. Also, we expect to identify new patterns to establish a collection specifically dedicated to this application domain.

# 6. ACKNOWLEDGMENTS

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