A Comparative Analysis of Development Environments for Voluntary Geographical Information Web Systems

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Abstract. *As mobile devices, access to geographical information, and migration from web 1.0 to web 2.0 advance, users started playing the role of consumers, producers, and communicators. As a result, several internet systems have spawned that collect Volunteered Geographical Information (VGI). VGI collection systems often need to be developed within short timeframes. This paper presents a comparative analysis between two environments for VGI-system development: Ushahidi Platform and ClickOnMap. This comparison employed a model based on system-quality norms ISO 9126. The results of this comparison may help VGI system developers choose the tool with the most appropriate characteristics to the goal intended when creating the system.*

1. Introduction

The technological and conceptual evolution of the Web in the 1990s and 2000s brought a new outlook to its users. In the current Web format, users may play the role of consumers, producers, and communicators within this environment. Thus, they become largely responsible for the creation, storage, and dissemination of information [Carvalho 2008]. In this context, the concept of user-generated content (UGC) arises in the contemporary scenario, in which sites such as Flickr[1] and YouTube[2] every day receive many contributions and shares. Likewise, other social media systems thrive and take up a key role in publicizing worldwide events with information being shared nearly in real time by users, such as through Facebook[3] or Twitter[4] [Amaral 2012].

During the consolidation of new Web, a specific type of UGC arose, in which the data involved have a spatial component for location and shape. Goodchild (2007) termed this phenomenon Volunteered Geographic Information (VGI), which involves associating concepts of Neogeography [Turner 2006], Collective Intelligence [Lévy

[1] https://www.flickr.com/
[2] https://www.youtube.com/
[3] https://www.facebook.com/
[4] https://twitter.com/

1999], and Web 2.0 resources [O'reilly 2007]. In this type of system, citizens are voluntarily and collaboratively used as human remote sensors, collecting data from events and making them available through Geobrowsers [Goodchild 2007].

User participation in acquiring the data that feed such systems is closely related to the popularization and convenience of using GPS (Global Positioning System) in several new forms of technologies such as smartphones. These tools allow the user to participate in the production of geographic information in an easy way. These activities were previously restricted to technicians specializing in Geographic Information Systems, typically linked to governmental organizations and private businesses that provide geospatial data [Silva 2008].

Collaborative data acquisition is advantageous in several ways, such as cutting down the cost and time of data production. This gain in dada collection may be crucial in several situations, mainly in emergencies such as natural disasters, since collecting and distributing data nearly instantaneously may be a requirement [Georgiadou 2011]. If no VGI system is available that meets the needs of the population at that moment, a framework should be used that enables easy and quick creation and customization of such a system [Souza et al. 2014].

This paper aims to present, discuss, and compare the construction and functionality of VGI systems developed with the aid of two distinct frameworks, namely Ushahidi Platform [Okolloh 2009] and ClickOnMap [Souza et al. 2014]. The experiments were developed within the Spatial Databases course of Graduate Program on Computer Science at Federal University of Viçosa. The remaining of the paper is structured as follows. Section 2 describes the tools used in the VGI system development process. Section 3 reports on the systems developed. Section 4 describes the comparison model applied, besides approaching the results obtained. Section 5 presents the study's conclusions.

2. Environments for Collaborative System Development

A collaborative system often needs to be developed within a short timeframe. In order to achieve this, some frameworks exist that speed up its creation, such as ClickOnMap, Ushahidi Platform, and Davis's framework. ClickOnMap is a framework that enables creating and customizing a collaborative Web system quickly and intuitively [Souza et al. 2014]. Ushahidi Platform is another framework developed from a site called Ushahidi. This site aimed to map violent events in Kenia in 2008 [Okolloh 2009]. Davis's framework is intended for the creation of VGI applications able to receive contributions via the Web and mobile devices [Davis Jr, et al. 2013].

After these environments were analyzed, Ushahidi Platform and ClickOnMap were compared within each to verify the quality of both collaborative system development environments. These tools were chosen for being freely available on the Internet and for having good supplementary material to aid in installation, which minimizes difficulties and the time spent configuring a new collaborative Web system. At the time of the comparison, Davis's framework was not available to be used. Below, the two frameworks compared are described.

2.1. Ushahidi Platform

This platform can be freely obtained at the company's website[5]. It is quick and intuitive to install, requiring only the administrator's name and e-mail address, the system's name, slogan, and database information. This environment provides one pre-configured system. In order to change the system's configurations, the administrator must access the management panel, shown in Figure 1.

This panel allows the name, slogan, banner, e-mail, language, and other pieces of system information to be changed. In addition, the time zone, default map location, zoom level, and map provider can be changed. The system is able to use the four main base map services, from ESRI, Google, Bing, and OpenStreetMap. This environment also enables creating, editing, and excluding categories, subcategories, users, and contributions. Several plugins are available that enhance the system's functionality.

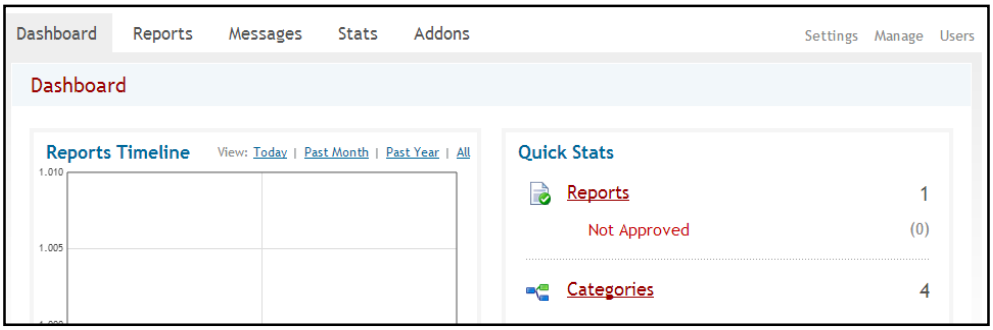

Figure 1. Management panel of Ushahidi Platform

Ushahidi Platform enables creating an online collaborative system with no need for hiring a hosting service. The tool that provides this feature is called Crowdmap. With it, administrators only need to make an account to create their own collaborative system. However, the system created on Crowdmap will be linked to the company's domain. This tool does not provide access to the system's source code.

The systems created using this platform enable point, line, or polygon collaborations that may be filtered according to the categories and subcategories on record. Both registered and anonymous users may collaborate, therefore the administrator must evaluate and approve all contributions. Besides these functionalities, users may comment on a given contribution and evaluate on its reliability. A mobile application is available.

2.2. ClickOnMap

This framework is laid out so that a programmer can, quickly and in few steps, customize a system and begin using its features [Souza et al. 2014]. Actually, ClickOnMap does not require advanced knowledge with programming language, since it has a simple and intuitive customization interface, as shown in Figure 2.

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[5] http://www.ushahidi.com/

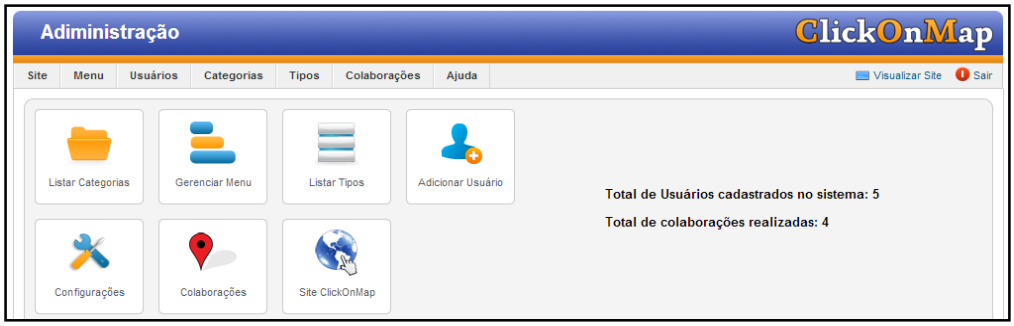

Figure 2. Management panel of ClickOnMap

In the management panel, the system administrator can manage settings, users, and contributions. It enables changing the site's name, system login options, type of map used, and other features. Moreover, categories and types (subcategories), users, and contributions can be added, edited, or excluded [Souza et al. 2014]. ClickOnMap has some features to guarantee and validate VGI quality, namely: VGI score, in which each user rates the VGI between 0 and 5; and user score, through which each action generates a positive or negative score to that user. This score is used for a User Rank, divided into point-range classes. All system users are Moderators, i.e., they can edit any VGI, while Administrators can validate a VGI [Souza et al. 2014].

In addition, the systems created with ClickOnMap have VGI filters and statistics that are shown to the users as graphs, which help in decision-making processes. The system has tools for dynamically analyzing the data of a region. ClickOnMap uses template Dynamic Metadata for VGI (DM4VGI) with dynamic metadata to document and validate VGI quality [Souza et al. 2013]. Therefore, this framework standardizes and facilitates VGI documentation, making searching and accessing a VGI more efficient. DM4VGI also has elements to capture statistical data on VGI use, besides of data about VGI quality.

3. VGI Systems Developed for the Comparison Between the Frameworks

In order to compare the Ushahidi Platform and ClickOnMap frameworks, two different systems were implemented in each of these platforms. Each implementation was carried out by two programmer students. The subjects chosen for these systems were advertising parties around the city and identifying accessibility features/difficulties in public areas. Both systems were applied to Viçosa city, MG, Brazil. Based on the implementation of these systems it was possible discover the functionality of frameworks, allowing to make a comparison between the Ushahidi Platform and the ClickOnMap.

The first system allows its users to inform the place and date of a party. This subject was chosen since college-oriented cities hold many parties and advertising them is key to their success. Using a system to this end makes the advertising process both quicker and cheaper. The second system collects information regarding accessibility in public areas by people with some type of special physical needs. This subject was chosen given the large number of complaints about poor accessibility found in social networks. Moreover, both systems are helpful to the general public and receive its attention for being dynamic [Hirata et al. 2013]. Next, the implementations of the two systems in both frameworks are described.

3.1. Party Advertising - ClickOnMap

The system implemented with ClickOnMap, called *Roteiro de Festas*[6] (Party Guide, in free translation), offers four login options: Using an account on the system, a Facebook or Google+[7] account, or anonymously. Besides this login setting, other settings were also changed: the system's name, contact e-mail address, central coordinates of the area of interest, initial zoom level, and type of map used. Three categories were created: Free Parties, Paid Parties, and College Parties. For each category, a few subcategories were created. Figure 3 shows, on the left, the system's homepage and, on the right, the options for the user to filter contributions according to category and VGI type.

In order to post a contribution, the user must log into the system using one of the four methods mentioned above. In case the user chooses to post anonymously, any contribution they make will need to be approved by the administrator before it is visible to all users. However, it the user is not anonymous, the contribution will be instantly available to all users. Contributions approved by the administrator have icons in a different color than the ones yet to be approved. This makes it easier to differentiate each contribution in the map.

3.2. Party Advertising - Ushahidi Platform

This system was developed using Ushahidi Platform's Crowdmap tool. Thus, a server did not need to be hired since the platform itself offers such service. Nevertheless, the service has a few limitations, e.g., the application source code cannot be directly accessed, which keeps some system features from being customized.

Some initial features were changed, such as the site's name (Party In The Map[8]) and slogan, default language, time zone, e-mail address, and page header image. For the complete customization of the environment, the map information such as default location, map provider, and zoom level were edited, and ten VGI categories were created for music: "Brazilian popular music (MPB)", "Samba/Pagode", "Sertanejo", "Forró", "Rock", "Electronic", "Gospel", "Axé", "Funk", and "Country". An icon was created to represent each category. Figure 4 illustrates the system's home page.

The system allows a point, line, or polygon report to be sent with no need for registration. This way, the reports are not shown in the system until approved by the administrator. When approved, these reports can be visualized in a list or on the map. Besides the settings above, a plugin was installed to enable the map to be visualized full screen.

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[6] http://www.ide.ufv.br:8008/roteirodefestas/
[7] https://plus.google.com
[8] https://partinthemap.crowdmap.com/

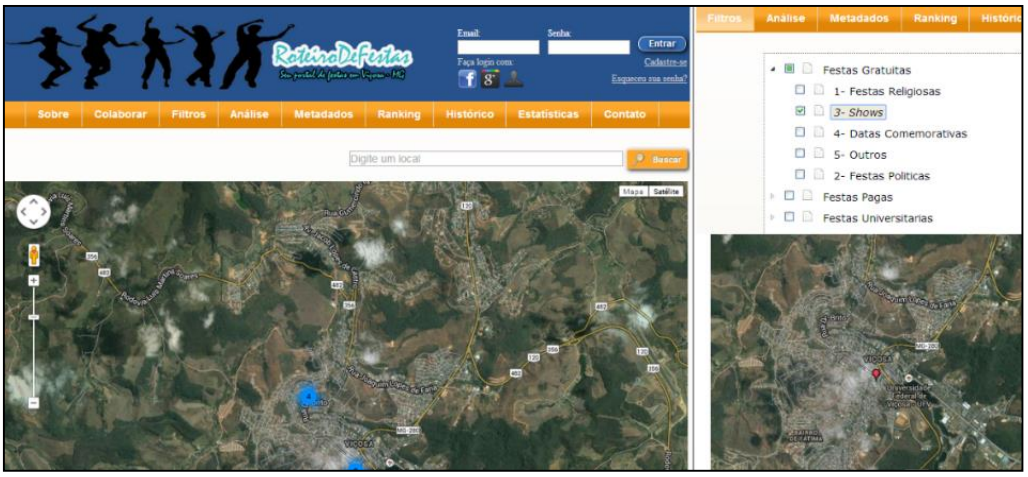

Figure 3. Homepage and filter of the *Roteiro de Festas* system

Figure 4. Party system developed with Ushahidi Platform

3.3 Urban Accessibility - ClickOnMap

A new collaborative environment was created by installing the ClickOnMap framework in a server. The customizations consisted in changing the system's name to *Mão na Roda Viçosa*[9] (Come in Handy Viçosa, in free translation), the contact e-mail, and the visualization as a map for the city of Viçosa. In addition, the same login options as those in section 3.1 were enabled.

The following categories were created: "Buildings", "Urban spaces", and "Furniture and urban equipment". The types related to these categories were registered. Figure 5 illustrates, on the left, the system's home page and, on the right, the window that collects collaborative information such as the title, description, category, type, image, file, video, etc.

[9] http://www.ide.ufv.br:8008/acessibilidade/

3.4 Urban Accessibility - Ushahidi Platform

This system also used the Crowdmap tool of Ushahidi Platform given the upsides already described in previous sections. The following changes were made: name (*Acessibilidade Viçosa*[10], or Accessibility in Viçosa in free translation), default language, time zone, and contact e-mail, among others.

Four categories were added: Great accessibility, Regular accessibility, Poor accessibility, and Reliable contributions. The new contribution alert e-mail feature was enabled in the system. The mobile device application was available for download on the system's page so as to allow contributions to be sent on the go. Figure 6 shows the system's home page.

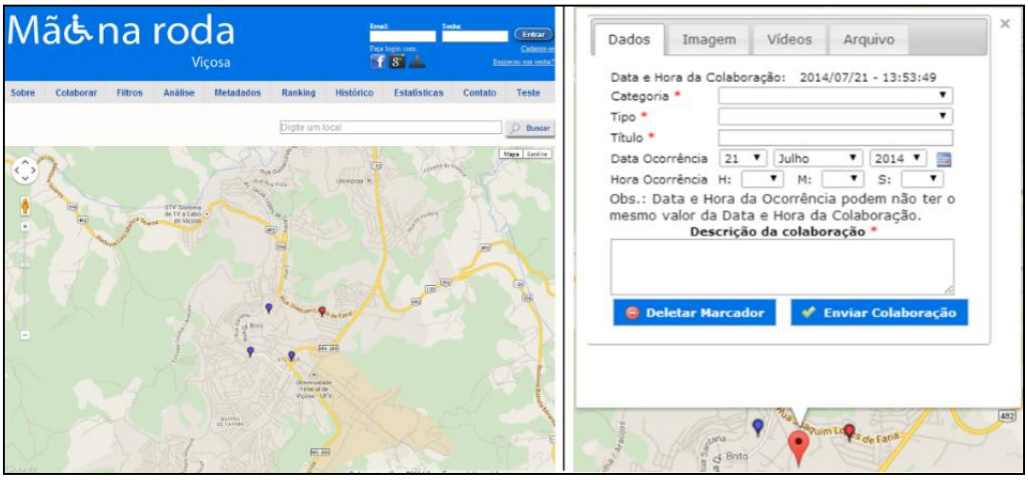

Figure 5. Home page and collaboration form of the *Mão na Roda Viçosa* system

Figure 6. Home page of the *Acessibilidade Viçosa* system

[10] https://acessibilidadevicosa.crowdmap.com/

4. Analysis of Results

The results were assessed based on the evaluation model ISO/IEC/9126-1, used to assess software quality, with a few changes. Therefore, the requirements and attributes needed for a VGI environment were identified and each requirement received a specific weight. This weight is related to its importance class in the system. The levels at which the systems met the requirements were defined. Furthermore, a table was created to assess and compare Ushahidi Platform with ClickOnMap.

4.1. Assessment Model

When evaluating software, well-defined models must be used, and ISO/IEC/9126-1 [NBR ISO/IEC 9126-1 2003] is used as a reference in software quality assessment. However, a Web system must be evaluated differently from a traditional system. The characteristics, the production and execution environments are not the same. Hence, since ISO 9126 is generic, it had to be customized.

According to Moraes (2003), a Web system is a complex environment and evaluating it is a tough task. Thus, Pressman (2001) considers that five of the six features of ISO 9126 apply to Web systems: Usability, Functionality, Reliability, Efficiency, and Maintenance. Table 1 shows the characteristics according to the goals of the VGI systems that fit the generic context presented by ISO 9126 and by Presman (2001).

4.2. Evaluation System

The requirements and attributes needed for a VGI environment were listed. Moreover, two systems were developed using each of the platforms assessed. This enables the results to be analyzed. The platforms were analyzed based on the document that assessed Web system quality since VGI systems fall into this category. However, some attributes particular to collaborative system development environment were added.

Once all attributes and specific characteristics of a VGI system were listed, each attribute must be assigned a weight regarding its importance class in the system. Thus, the attributes were classified as “Essential,” “Important,” or “Desirable,” with weights of 3, 2, and 1, respectively. Besides the weight, it is also important to set the level at which the systems meet the needs of each attribute. These levels may be “Satisfactory” (S), “Partially Satisfactory” (P), or “Non-satisfactory” (N), scoring 2, 1, and 0, respectively.

The software quality evaluation documentation of ISO 9126 (particularly Web systems) has generic characteristics inherent to all systems in this category. Based on this document, all particular attributes were related to the voluntary collaboration systems. Hence, these attributes were evaluated so that the experimental results were analyzed.

4.3. Results

VGI system quality can be measured according to characteristics and functionalities, among which the possibility of anonymous contributions, integration with social networks, friendly interface, and easy installation stand out. Based on the use of the Ushahidi Platform and ClickOnMap environments to develop a VGI system, all key attributes could be related to a VGI system. These attributes were assessed and classified in both systems according to the criteria set previously. Thus, a table (Table 1) was created

to evaluate and compare the two frameworks. Classification (X) is given by the sum of the products of importance weigh (P) and fulfillment level (E) of each attribute (n), represented by formula (1):

$$X = \sum_{i=1}^{n} E_i . P_i \qquad (1)$$

Regarding Usability, it can be seen that none of the systems analyzed is able to meet the requirements of users with some type of physical disability. Therefore, frameworks that support contributions from people with or without physical disabilities may the subject of further research. ClickOnMap has a feedback system so that the user who created the VGI can be informed, via e-mail, about the status of the contribution after it is analyzed by the administrator.

Regarding Functionality, Ushahidi Platform allows for point, line, and polygon contributions, besides allowing collaborations via administrative tool and supporting several map servers. Creating a collaborative system is faster using Ushahidi's Crowdmap since the server does not need to be configured, however, there are fewer features and customizations. Ushahidi Platform also supports several languages and has an application for mobile devices. This facilitates contributions from regions such as rural areas and locations with no wired internet.

ClickOnMap has more types of visualizations than Ushahidi Platform, besides having dynamic data analysis tools. The VGIs could be visualized using markers, kernel maps, or informative clusters. Any user could edit the VGIs (Wiki-Review) and a change log was kept. The dynamic data and statistics analysis tools used pie charts, which were nearly instantaneously redrawn whenever the user visualized another region. It was also possible to analyze data on a specific set of categories and types of a region of interest.

VGI acquisition and documentation in this environment was standardized, thus the data and metadata are interoperable, i.e., data can be collected from different environments that use ClickOnMap and DM4VGI and, for instance, be overlapped for analyzes and information gathering. The databases can also be seamlessly searched and accessed. Another advantage was the possibility of searching the metadata textually, temporally, spatially, and/or thematically, which allowed data to be recovered more efficiently than in Ushahidi Platform.

The ranking system can be an interesting tool to motivate the users to collaborate more and better since they will stand out in the system by making more high-quality contributions. This may lead the users to keep contributing so as to rank even higher or at least to maintain the rank, which leads to a sort of positive competition. This technique to bring users and software closer is widely used in games and satisfactorily reaches its goals. The VGI scores are weighed regarding the user's rank, i.e., users with a better rank position have more weight in the calculation of the final VGI score.

Table 1: Evaluation result

Characteristics	Description	Importance	Ushahidi	ClickOnMap
Usability	Instruction messages	Important	S	S
	Accessibility attributes (e.g., font size)	Important	**N**	**N**
	Help menu	Important	S	S
	Contribution feedback by e-mail	Desirable	N	S
Functionality	Simple and intuitive installation	Important	S	S
	Minimizes development time	Essential	S	S
	Has contribution categories and subcategories	Essential	S	S
	Navigation resources	Important	S	S
	User registration	Essential	S	S
	Information recovery	Important	P	**S**
	Open-source platform	Important	S	S
	Permission levels	Essential	S	S
	Allows anonymous contributions	Essential	S	S
	Supports map servers	Important	S	**P**
	Supports metadata	Important	**N**	S
	Social network integration	Important	S	S
	Mobile device application	Important	S	**N**
	Supports multiple languages	Important	S	**N**
	Shows statistics to users	Essential	**N**	S
	Dynamic content analysis	Desirable	**N**	S
	User score and ranking	Important	**N**	S
	Contribution evaluation	Essential	S	S
	Allows exporting/importing contributions	Important	S	S
	Contribution deletion	Important	S	S
	Contributions created on the management panel	Desirable	S	**N**
	E-mail sent at each contribution	Essential	S	S
	Contribution as different geometric shapes	Important	S	**P**
	Wiki review	Important	**N**	S
Reliability	Intuitive error messages	Important	S	S
	User-validation mechanism	Essential	S	S
	Access credential creation	Important	S	S
	Content-filtering system	Important	S	S
Efficiency	Good user interaction response	Essential	S	S
Maintenance	Supports installing extensions	Important	S	S
	Customization mechanisms	Important	S	S
Total (in points):			126	136

Regarding Reliability, Efficiency, and Maintenance, both systems behaved similarly and had no advantages or disadvantages between each other. Overall, both systems met the goals of a framework intended to easily and quickly create VGI environments. Moreover, they have interesting features to facilitate collaboration, information recovery, and future data analysis.

5. Conclusions

This paper compared two collaborative Web system development environments, Ushahidi Platform and ClickOnMap. The comparison was carried out in a qualitative way, by developing two different systems using each of these platforms, implemented by four groups of programmers. These systems used the subjects of party advertising and accessibility features/difficulties. In face of the results obtained, it can be seen that both Ushahidi Platform and ClickOnMap frameworks have relatively close maturity levels, especially regarding Usability, Reliability, Efficiency, and Maintenance, with a slight advantage for ClickOnMap concerning Functionality.

However, it must be pointed out that each framework has its perks. Ushahidi Platform has a mobile application, supports several languages and different map servers, and allows contributions as points, lines or polygons. ClickOnMap, by its turn, features wiki review, metadata support, dynamic map content analysis, user score and rank, contribution score weighed by user rank, and more efficient information recovery since it allows for textual, temporal, thematic, and spatial searches on standardized metadata.

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