PRELIMINIARY INVESTIGATION OF WEB GIS TRUST: THE EXAMPLE OF THE "WIYBY" WEBSITE

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ABSTRACT:

Public access to environmental information is now a common requirement by national, international and European Union legislation. It is widely recognized that web-based GIS can enhance access to environmental information and can support public participation in environmental decision-making. Yet when these systems are used by non-experts might be challenging because of the GIS complexity. Considerations about data accuracy and errors during the analysis further increase the elements of risk, complexity and uncertainty, which are preconditions of trust. Many lay users are partially aware of the technicalities related to spatial data handling. Thus, the issue of trust in such systems, and how user's trust is built is an important consideration. Online trust has been repeatedly identified as a major concept for online information systems and its value recognised, especially in the context of e-commerce, as it influences the intentions to engage, the use and acceptance of online systems and the overall User Experience. However, there is very limited, if at all, knowledge about how trust is constructed in web-mapping systems. To improve knowledge in this domain, this paper describes the concept of online trust and its characteristics and models developed in different fields. The UK Environment Agency 'What's In You Back Yard' (WIYBY) website is examined using techniques derived from the Human-Computer Interaction field. A Heuristic Evaluation and a Cognitive Walkthrough were undertaken by three evaluators, to identify what influences trust and how perceived trustworthiness can be enhanced through interface design. Trust cues suggested in the literature were also considered for their applicability and relevance in web-mapping. Based on the findings a set of guidelines is presented which covers the dimensions of graphic, content, structure, map functionality and trust-cue design.

1. INTRODUCTION

Existing Web GIS applications instruct, advise users and provide information and analysis, which according to Fogg (2003) are amongst these situations where computers' credibility matters. Furthermore, Web GIS incorporate the element of risk especially when they are used in domains such as environmental decision-making, a popular domain especially for web-based Public Participation GIS (PPGIS). Although uncertainty is an inherent characteristic of geographical data, the uncertainty in Web GIS is further increased because of the complexity of these interfaces and the fact that mostly used by non-experts (Unwin, 2005; Haklay and Zafiri, 2008). For all these reasons, trust in the context of Web GIS establishes an important area of research which, no one to our knowledge yet considered.

There is not a commonly agreed definition for trust. Trust was examined in different disciplines, with each approaching trust from a different perspective and the result was *"a confusing potpourri of definitions"* (Shapiro, 1987, p.625). Another aspect of trust, which challenges scientists to agree on a common definition (Wang and Emurian, 2005) is that trust encapsulates different meanings (Williamson, 1993), as for example, credibility, reliability, honesty and confidence. Despite the lack of a commonly agreed definition, trust researchers agree on specific trust components which can help conceptualize trust.

Online trust can be defined as a trustor's willingness to depend or rely on a trustee, which can be an online system or online information (Chopra and Wallace, 2003). In the context of online trust the following components are of particular importance: a specific context; the preconditions of dependence, uncertainty and risk; the trustor's confidence that trust will be upheld and the willingness to act on that confidence; the factors, which influence trustor's trust perceptions (e.g. propensity to trust); the dimensions of trust (cognitive and affective trust); and the trustee attributes (Chopra and Wallace, 2003).

Online trust is a well-researched area from a Human-Computer Interaction (HCI) perspective and particularly for the e-commerce domain (Riegelsberger et al., 2005). Existing studies suggest that people's trust perceptions about electronic online environments, influence the intentions to engage, the use and acceptance of these systems, enhance cooperative behaviours and influence the User Experience (UXP) (Shneiderman, 2000; Egger, 2001; Fogg, 2003). Several studies focus on the online trustee attributes as these influence the people's perceptions about the trustworthiness of online systems and thus it is suggested that a trust oriented interface design which emphasizes on the improvement of these attributes can subsequently enhance the perceived trustworthiness.

As it is unknown what influences public trust in Web GIS, the wider research framework that this study follows is based on an investigation of different interfaces with non-expert users using HCI methodology in order to understand how trust perceptions are formed. In particular the aim of this study is to identify the interface elements and functionality attributes which influence the trustworthiness of Web GIS and to subsequently build a set of preliminary trust-based guidelines which can eventually improve the trustworthiness of these systems.

2. BACKGROUND

Chopra and Wallace (2003) think that for a system to be trustworthy it should be competent, predictable, and ethical and should have positive intentions. Grabner-Krauter et al. (2006) suggest two trust dimensions, a soft dimension which encapsulates attributes such as benevolence, honesty, integrity and credibility and a hard dimension which is referred to the system's functionality and encapsulates attributes such as reliability, correctness, and availability and so on. McKnight et al. (2002) believes that the trustworthiness of a system is influenced by the system's reputation (competence, benevolence and integrity) and the system's quality (functionality and aesthetics). In a similar perspective, Fogg (2003), who uses the term credibility instead of trust, believes that the credibility of a system is influenced by its reputation, integrity and expertise. Finally, according to Corritore et al. (2003) the ease of use (usability) affects the perceived credibility and risk about the system, which in turn influences its trustworthiness.

It can be concluded that two categories of attributes are of particular importance in the discussions about the online trustee attributes. The first category involves perceptual attributes which refer mainly to the source's reputation (e.g. is the source perceived as honest and reliable?). The second category involves attributes which refer to the system's functionality and overall quality. In this category aesthetics, professional look and feel and usability are of critical importance.

Shneiderman (2000) highlights that a good design emphasizing on clear commitments and usability can improve trustworthiness. Wang and Emurian (2005) amongst others suggest the use of pastel and cool tones and colour combinations and the use of high quality photographs. The design quality is also mentioned in the Cheskin Research Report (1999) but also in several other studies (Nikander and Karvonen, 2000). Karvonen (2000) links aesthetics to trustworthiness and in particular focuses on how the beauty of simplicity (clean and clear design) influences usability and affects online trust (affect-based trust). Fogg (2003) also provides a detailed list of elements which increase the perceived trustworthiness of a system (e.g. external non-broken links).

Trust-inducing features are also widely recognized as interface elements which can further improve trustworthiness. For example, several studies emphasize on elements such as seals of approval (Cheskin Research Report ,1999), branding and logos (Cheskin Research Report,1999; Shneiderman,2000), feedback mechanisms (Ba and Pavlou, 2002), external links, citations and contact details (Fogg, 2003), photographs, videos and chats (Wang and Emurian, 2005), which influence positively the formation of trust perceptions.

The majority, if not all, of the previously cited studies focus on e-commerce environments while Web GIS have their own special characteristics. There are several studies in the GIS literature which investigated user aspects of mainly offline environments or stand-alone web-based applications. These studies investigate amongst others, geovisualisation barriers (e.g. Ishikawa et al., 2005), different map functionality interaction options and cognitive aspects of users (e.g. Hornbaek et al., 2002; Fabrikant, 2001; Harrower and Sheesley, 2005). Issues such as the usability of Web GIS applications has only recently considered with Skarlatidou and Haklay (2006) who published the first, to our knowledge, study investigating how public web-mapping sites are used by novices.

Concerning the usability element of Web GIS, existing studies highlight that the end users and especially non-experts have significant problems while interacting with these systems (Skarlatidou and Haklay, 2006). Nivala et al. (2008) performed a usability evaluation of public web-mapping sites (Google Maps, MSN Maps & Directions, MapQuest and Multimap) where they found 403 usability problems and they provide the first list of usability guidelines for the design of similar applications. It is not surprising that some GIS research studies emphasize on the importance of User-Centered Design (UCD). For example, Kramers (2008) described the benefits of a UCD approach in order to overcome difficulties that the non-expert face when tools are purely based on technology-driven designs. The significance of a UCD approach is also acknowledged by Van Elzakker (2005) in his study about maps' usability.

Although usability is linked to trustworthiness, it was never considered as for its relevance to trustworthiness and thus it is not clear what usability problems influence trust. Usability is yet only one of the attributes which influence trustworthiness. Other elements that should be considered in the context of Web GIS, involve amongst others the content of these websites, if the information provided satisfy the user needs, and the aesthetics and functionality of the GIS element. Also, trust cues should be explored separately in order to understand how trust can be induced in this context according to the trust-based needs and expectations of the end users.

3. METHODOLOGY

The Web GIS selected to be evaluated as for its trustworthiness is the "What's In Your Back Yard" (WIYBY) website provided by the Environment Agency. The WIYBY website provides environmental information to the UK public (e.g. about air pollution, water quality, and risk of flooding, waste sites) and it was selected for different reasons. First, as it is anticipated by national, European and international legislation, the public should have access to environmental information and several studies suggest that GIS can be used to enhance public access and participation, exactly because it changes the ways that people can interact and communicate with maps, and can support visual thinking in the decision-making process (MacEachren, 1994; MacEachren and Kraak, 1997; Sieber, 2006; Dunn, 2007). In this context the WIYBY website serves this purpose, however before the people rely on the system and make a decision based on the information that it provides (e.g. where to buy a house based on flood occurrences), they should trust it.

Another reason for selecting the WIYBY website is that the elements of uncertainty and risk, which are necessary preconditions for examining trust, are existent. Environmental problems involve conflicting views and ethical considerations and are usually ill-defined, which increases the element of risk. Also, as Haklay (2002) suggests, accuracy and uncertainty are internal to environmental information and errors through its analysis are always existent. The fact that non-experts users have a limited knowledge about spatial data handling, GIS operations and expertise in this domain creates additional trust concerns. Finally, a previous usability study of the WIYBY website revealed that end users had significant interaction problems (Alsop, 2008), which further increases the

complexity, while it is acknowledged that in complex situations people develop mental shortcuts one of which is trust (Grabner-Krauter and Kaluscha, 2003).

In order to identify what elements of the system influence its trustworthiness, and how the quality and the usability are linked to trustworthiness, the method of Heuristic Evaluation (HE) was firstly applied. HE Evaluation is a popular and informal inspection method, where the evaluators judge the system based on a list of usability principles (Nielsen, 1994). A list of the heuristics from Xerox Corporation was used for the evaluation of the overall User Interface. Especially for the Web GIS element the GIS heuristics which were developed by Nivala et al. (2008), were used. The evaluators were asked for each problem identified, to document whether they think that influences trust and to also provide a severity rating. The severity rating scale used in this study was from 1 (minor problem) to 5 (critical problem).

One limitation of the HE is that focuses mainly on popular usability problems and it does not take into consideration the cognitive and affective processing of the end user. To overcome this problem the method of Cognitive Walkthrough (CW) was further implemented. Nielsen (1994) explains, that CW is a method that simulates the users' problem solving practices, thus it was expected that the method of CW would help to capture more trust related problems. The evaluators were provided with two persona-based scenarios which reflected the user needs' and expectations. The first persona reflected the needs of a scientist with extensive experience in both environmental data and Web GIS applications. The second persona, involved a novice user with increased Internet suspicion.

During the CW, the evaluators were provided with a list of questions to consider for each task, which amongst others included questions, such as: What is the effect that the user will try to produce? Are there any elements which might decrease user's trust perceptions? As it was expected, the CW allowed the evaluators to add into their observations more elements and concerns (including cognitive and emotional aspects of the interaction) that a potential user has while interacting with the WIYBY interface, capturing in that way problems that are not provided by usability heuristics.

Moreover, a list of trust inducing features and elements suggested in the literature (e.g. branding, testimonials/stories, pictures, videos, chats, blogs, external links, contact details) was given to the evaluators, in order to judge their applicability in the Web GIS context. In addition to that the evaluators were asked to document additional interface elements, which they thought that can further induce trust.

A critical concern with the implementation of both methods, is the number of evaluators that inspect the user interface. It is generally recommended that three to five evaluators can identify the majority of the user interface and thus the subjectivity can be eliminated. For the purposes of this study three evaluators were recruited. All the evaluators were GIS experts, which was essential in order to ensure that the GIS element was examined thoroughly. The first evaluator had used in the past the method of Heuristic Evaluation (HE), the second evaluator was experienced in both methods (HE and CW), while the third evaluator had never performed neither a HE nor a CW.

4. RESULTS

Tables 1 and 2 summarize the number of problems found by each evaluator during the HE and the CW, respectively. The trust related problems, which considered most critical (the Severity Rating given was either 4 or 5), are listed separately. Also note that the problems associated with the GIS element, are listed separately from the general User Interface (UI) problems.

Method: CW	Problem Type	No. of Problems	No. of Trust problems	SR*=5,4 (&T*)
First Evaluator	GIS	22	16	15 (12)
	UI	19	10	9 (7)
	Total	**41**	**26**	**24 (19)**
Second Evaluator	GIS	13	11	11 (10)
	UI	14	9	10 (8)
	Total	**27**	**20**	**21 (18)**
Third Evaluator	GIS	3	3	3 (3)
	UI	6	4	4 (2)
	Total	**9**	**7**	**7 (5)**

Table 1. Heuristic Evaluation- Problems Found
SR* =Severity Rating, T* =Trust

Method: HE	Problem Type	No. of Problems	No. of Trust Problems	SR*=5, 4 (&T*)
First Evaluator	GIS	31	15	12 (9)
	User	15	10	6 (6)
	Total	**46**	**25**	**18 (15)**
Second Evaluator	GIS	18	11	14 (10)
	UI	19	9	13 (8)
	Total	**37**	**20**	**27 (18)**
Third Evaluator	GIS	5	3	5 (3)
	UI	2	1	1 (1)
	Total	**7**	**4**	**6 (4)**

Table 2. Cognitive Walkthrough – Problems Found
SR* =Severity Rating, T* =Trust

All evaluators consistently considered the majority of the identified problems as trust related. Although the third evaluator who was a GIS expert but with no significant experience in using methods such as the HE and CW found less problems, the pattern between total problems found and trust related problems is the same. For example, with the method of HE and for the first evaluator, 54.3% of the total problems found were considered as trust-related. The percentages for the second and third evaluator are 54% and 57%, respectively. Thus, more than half of the problems identified by each evaluator were considered as trust related.

The majority of the trust related problems were considered as being critical (with a severity rating of either 5 or 4). A 60% of the general trust problems were considered to be critical by the first evaluator with the method of HE and 73% with the method of CW. For the second evaluator a 90% of the trust problems were found to be also critical with the method of HE and 90% with the method of CW. Finally, the third evaluator considered as critical all the trust related problems (100%) that found with the method of HE and a 71.5% with the method of CW.

The HE resulted in the identification of more general problems compared with the problems found with the CW, although the CW resulted in the identification of more trust-related problems. This was an expected result as the method of CW supports the consideration of the cognitive and affective needs of a potential end user. It should be mentioned that although some of the problems found were common between the two methods and between the evaluators, the method of CW identified more identical trust-related problems.

The specific trust related problems found during the preliminary expert evaluations provided the basis for the establishment of a list of trust-based guidelines in the context of Web GIS and which are discussed in the next section.

5. DISCUSSION OF GUIDELINES

The majority of the trust related problems found, are similar to those described in the e-commerce literature. Wang's & Emurian's (2005) trust model was modified to effectively group the problems found and introduce a preliminary list of trust-based guidelines in the Web GIS context (Table 3 – Appendix A). The guidelines are grouped in five dimensions and for each dimension the User Interface and GIS guidelines are listed separately, except from the last dimension which is concerned with the trust cue design.

The Graphic Design dimension is concerned with the quality of graphics and other interface elements that are used in the Web GIS context. For example, it should not be ignored that the GIS component increases the complexity of these applications as non-experts require additional time to familiarize themselves with it. Thus it is believed that other interface elements should match popular visualisations (e.g. menus, visited links) so that the users can concentrate on the GIS component.

Concerning the Graphic Design dimension of the GIS element, the evaluators documented that in cases where information on map or legend was not communicated easily (e.g. because of the colour combinations and overlapping symbols), this could potentially reduce trust. The map size was also considered important for the formation of trust perceptions, as a small map size reduces the amount of information on screen and this might give the impression that the operator is trying to "hide" something from the users.

Several of the trust-related problems found were associated with the Structure Design dimension of the website. An efficient structure brings transparency, thus it is necessary to efficiently group information and also provide the users with well organized menus. In this perspective a menu item for the GIS component is essential.

For the Content Design it is critical amongst others that the vocabulary is simple, information is updated and the expectations and needs of both novices and experts are met. For example, information as for how the maps were constructed might not be important for novices, but taking into consideration the user's progress from a novice to an expert level when the application is used constantly, this information might be essential in the future. In the same perspective, instructions and tutorials about the GIS tasks should be provided for the novices. Generalization and scales used are important considerations for trust formations, but these features should be further explored using HCI techniques which involve real users.

The GIS functionality Design should focus on consistency and on users' expectations. If a feature is not functioning in the way that it is expected to be, the system will be considered as being unpredictable and the evaluators thought that predictability in this case is strongly linked to trustworthiness. It should be also mentioned that for example the GIS component of the WIYBY website is only working with Internet Explorer (IE) while there is no direct error response when a user attempts to access the website using a different web browser. In such cases it is very likely that the user assumes that the GIS component is not working at all and thus the whole website loses credibility.

The fifth dimension is concerned with the trust inducing features. In general, the evaluators thought that aesthetics, usability, professionalism and other elements such as the existence of external links are important attributes which can increase trustworthiness in the Web GIS context. Features such as videos, chats, blogs are probably not directly relevant to the GIS context, although further research is required in order to investigate the users' trust expectations and needs in this context. The evaluators suggested that features such as data copyrights and logos of the data providers could eventually help increase trust. The evaluators' suggestions as for the trust inducing features are summarized in Table 4.

Trust – Cue Design
1. The logo of the site operator or provider should be clearly visible from all pages and of high quality. 2. Copyright and data issues (e.g. data provider) about maps should be immediately visible. 3. In case of external links, the website operators should check regularly each link provided. Messages such as "We are not responsible for the content of the websites" can decrease trust. 4. Professionalism and Aesthetics are significant in trust improvement. 5. The layout and functionality of both the User Interface and the Map element should be of high quality. 6. Vocabulary should be simple. 7. Contact details should be easy to find. 8. When additional services, such as the "Sign up for floodline warnings" are used, it is essential to clarify how user data is used and that it is not passed to third parties.

Table 4. Trust-based Guidelines for Trust-Cue Design

6. CONCLUSIONS

Based on simple inspections methods and the example of the WIYBY website this study provides a preliminary set of trust-based guidelines that can be applied in the wider context of Web GIS in order to improve trustworthiness. However, as web- based GIS applications are used in different contexts, and trust perceptions vary according to context, it is necessary to investigate these elements separately. Simple, time efficient and easy to apply methods such as the HE and CW can guide this process.

The majority of the trust-related problems identified by the evaluators, match the problems that are described in the trust-

based literature and which refer to mainly e-commerce websites. However, for Web GIS, it is essential to run additional HCI-based experiments which involve real users and who might have additional problems. Although the evaluators considered separately the trust-inducing features, experiments with non-experts can help to identify the users' trust expectations and thus recommend additional features which can be incorporated into this context in order to increase trust.

Finally, it should not be ignored that not only the functional attributes influence trust, but also elements such as the trustor's propensity to trust and the source's (or the website's provider) reputation and credibility. Therefore, in order to understand trust in depth these different elements should be combined and only experiments with real users can reveal how these elements interact with each other, for the formation of the overall trust perceptions in the Web GIS context.

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9. APPENDIX A

	Graphic Design	Structure Design	Content Design	Functionality Design
USER INTERFACE	1. The menu should match popular menu visualisations. 2. The Graphical User Interface elements should offer affordance and should be designed according to Internet standards (e.g. visualisation of links should match expected colour codes and visualisation patterns). 3. The Visualisation of page elements or features should be throughout the website. 4. Use high quality graphics to reveal professionalism.	1. Fix broken links or "Not Found" pages. 3. Group menu in a logical manner. 4. Provide links and hyperlinks to increase the accessibility of information from different pages. 5. Textual information on different pages should be grouped effectively and should be relevant to the context. 6. Titles, headings and subheadings should me meaningful. 6. Provide an index. 7. Provide a menu item for the GIS element.	1. Vocabulary and Terminology should be easy to understand. 2. Information should be recently updated. 3. Advice and error messages should be easily communicated. 4. The website must support both experts and novices. (e.g. in case an expert user expects additional information, provide external links)	-
GIS ELEMENT	1. Colour combinations should be effective (consider colour deficiency). 2. Map results should be communicated clearly and efficiently (not overlapping symbols, different colours or shapes and transparency levels to communicate information). 3. Map size should not be too small. 4. Selected objects should be easy to identify. 5. Base maps should be of high quality and relevant to the context of the application. 6. Scales should be chosen so that each provides high quality and useful maps. 7. Legend should be of high quality and easily communicated.	1. Legend should not block the map. 2. Search box should be immediately visible.	1. Information about map features and results should be easily accessible (ideally next to the map). 2. Generalization should not be such that leads to perceptions for limited accuracy or make maps difficult to read. 3. Scales should be selected, so that they support and are meaningful to the tasks. 4. Map information should support both experts' and novices' needs and expectations. 5. Information as for how the maps were constructed should be provided. 6. Provide Help & Documentation/instructions/or tutorials about maps' tasks.	1. Ensure browser compatibility. 2. Map functionality should be consistent and unique (do not design more than one function for the same task). 3. Map functionality should be consistent at all scales. 4. An undo or cancel feature should be provided. 5. The search box should handle gazetteer.

Table 3. Trust-based Guidelines -Graphic, Structure, Content and GIS functionality Design dimensions