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Trust in Web GIS: the role of the trustee attributes in the design of trustworthy Web GIS applications

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Since the introduction of Xerox PARC Map Viewer, there is a high growth in the number of Web GIS (Geographical Information System) applications for public use in different contexts. These applications instruct, advise and provide the tools for spatial analysis to their users, and the people who use them depend or rely on these systems. Many of these users are non-experts who have no GIS expertise and a limited understanding of spatial data handling. These inherent characteristics of non-expert interaction establish risk and uncertainty, which are further increased due to the complexity of Web GIS interfaces. These issues of uncertainty, risk perception and dependence are all trust-related aspects. Online trust has been repeatedly identified as a major concept for online information systems and its value recognised as it influences the intentions to use and the acceptance of online systems and the overall user experience. However, there is a very limited understanding as to exactly how trust is constructed when people, especially non-experts, interact with Web GIS. To improve knowledge in this domain, this article explores the theoretical foundations on how trust can be investigated in this context. Trust studies (mainly from the e-commerce domain) suggest that a trust-oriented interface design may improve the trustworthiness of online systems, and such attention can be given to Web GIS interfaces. Such studies are reviewed and their applicability is considered in the Web GIS context, taking into consideration their special characteristics. A case study is used to discuss how some features may potentially influence the trustworthiness of Web GIS applications. This article concludes by suggesting future research directions for the implementation of a holistic approach, which is necessary to investigate trust in this context.

Keywords: Web GIS; HCI; trust; usability; WIYBY

1. Introduction

Trust has been a topic of research in different disciplines and it is widely recognised as a vital element in a well-functioning society (Wang and Emurian 2005). However, trust does not exist only in human relationships. The ways in which people interact with computing devices and web applications demonstrate that they respond socially to technology and that they relate to computers in ways that are somewhat similar to interactions with other human collaborators (Lee and See 2002, Fogg 2003). Trust is therefore considered an important element of human–computer interactions (HCIs), and this realisation has resulted in the
new field of trust research, in the context of online and offline environments. Existing studies suggest that people’s trust perceptions of online environments influence their intentions to engage, to use and to accept these systems and influence the perceived user experience (e.g. Shneiderman 2000, Egger 2001, Fogg 2003).

It has been almost 20 years since the introduction of the World Wide Web (the Web), which since its inception has been heralded as important in facilitating wider public access to spatial information and knowledge and in its contribution to the democratisation of Geographical Information Systems (GIS) (Dragicevic 2004, Dunn 2007). More geographical information than ever before is now available to users, but, as with Wikipedia, the reliability of this information is a major issue. This aspect of assessing and trusting geographical information has received almost no attention from researchers in the area of GIS. Web GIS – defined broadly in our context as the myriad of applications that allow users to browse, view and potentially contribute geographical information – are powerful and popular tools. Although the majority of research papers on online trust focus on e-commerce applications, it is important to extend this research to the area of Web GIS, so that such systems, especially when they are used to involve the public in decision-making processes, can be designed to be trustworthy, while also taking into consideration their special characteristics that emanate from the use and manipulation of geographical information.

The complexity of Web GIS interfaces and the fact that they are mostly used by non-experts are both widely acknowledged (Unwin 2005, Haklay and Zafiri 2008). These inherent characteristics of Web GIS directed the attention of the GIS community to HCI, and more specifically to usability engineering principles, which are gradually being incorporated into their design and development. The complexity of geographical data and Web GIS interfaces further increases the elements of risk and uncertainty that, according to the literature, are preconditions of trust and therefore reduce trust in the system (Mayer et al. 1995, Grabner-Kräuter et al. 2006).

Moreover, Web GIS applications are used in domains in which uncertainty is inherent, as in environmental decision-making. For example, research on Public Participation GIS suggests that Web GIS can enhance public participation and engagement (Carver et al. 1998, Haklay 2003). The trust literature provides evidence that people engage with systems that they perceive as trustworthy and avoid those that they mistrust (Sillence et al. 2006). However, to our knowledge, trust in the Web GIS context has yet to be explored.

The aim of this article is to investigate and highlight the importance of trust in the design of effective Web GIS applications. By reviewing online trust and considering the special features of Web GIS, this article sets the theoretical foundations and provides suggestions as to how trust can be examined and improved in the Web GIS context, through interface design. This trust-oriented interface design emphasises the improvement of those specific attributes that influence the trustworthiness of the system.

This article begins with a conceptual overview of trust, and the discussion then narrows down to online trust perspectives. The most influential studies of online interface design are discussed. In the second part, this theoretical overview is applied in the Web GIS context and a case study is provided to understand which interface design elements are most likely to influence the trustworthiness of Web GIS applications. This article concludes with suggestions for future trust-based research in the Web GIS context.

2. Overview of trust

From the outset, we should note that there is no single definition of trust. One reason for this is that trust has been a topic of research in several different disciplines (Corritore
et al. 2001). Each of these disciplines approached trust from its own perspective, resulting in ‘a confusing potpourri of definitions’ (Shapiro 1987, p. 625). For example, in philosophy, trust was described as confident reliance on somebody else ‘to take care of something which we care about, but which they could harm or steal if they wished’ (Bailey 2002, p. 1). In psychology, trust was examined as a personality characteristic (interpersonal trust) and as a social and institutional construct (social, institutional trust). For sociologists and economists, however, the emphasis was on how people cope with the uncertainty associated with transactions, and in management studies the main interest was on trust within organisations (organisational trust).

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). For example, credibility, reliability and honesty are all trust-related concepts that, although conceptually different, are used interchangeably. For example, Fogg (2003) suggested that trust and credibility are similar terms, but credibility is the believability of something (e.g. a system), whereas trust can be described as dependability on something.

Despite the lack of a commonly agreed definition, researchers agree on the importance of trust in different contexts. Deutsch (1962) and Mayer et al. (1995) argued that trust allows people to handle risky and uncertain situations. Luhmann (1979) and Barber (1983) suggested that trust can decrease the complexity of our otherwise complex world, by eliminating the number of options in given circumstances. Putnam (1995) and Misztal (1996) described trust as a part of social capital, which is a form of social networking. Koehn (1996) suggested that trust in business is the key to successful transactions and long-term relationships.

Finally, there are specific components of trust that are used to explain trust, and these can help to conceptualise trust effectively, so that it becomes a measurable attribute. These general trust components, which are also applicable to online trust perspectives, are introduced in the next section.

2.1. Trust components

Any trusting relationship involves two parts: a trustor and a trustee (Figure 1); within the general context of trust, the trustor is a person, whereas the trustee may be, for example, another human collaborator, a governmental body or an organisation. These two parts interact in such a way that the trustor is willing to depend on the trustee, while being confident that the trustee will act according to his/her benefits (Kini and Choobineh 1998). If the trustor is not willing to depend or rely on the trustee then trust is either limited (Blomqvist 1997) or there is distrust: a concept with very different implications.

In addition from the willingness to depend, the elements of risk and uncertainty are also trust preconditions. Chopra and Wallace (2003) suggested that ‘The presence of risk creates a need for trust’ (p. 3), and Wang and Emurian (2005) explained that ‘Trust is only needed, and actually flourishes, in an environment that is uncertain and risky’ (p. 111). In this perspective, trust is described as a mechanism that reduces complexity and as a mental shortcut that reduces uncertainty in situations where limited cognitive resources are available (Grabner-Kräuter and Kaluscha 2003).

A trusting relationship is influenced by the trustor’s properties and the trustee’s attributes. The trustor’s properties involve two elements. First, the disposition or propensity to trust, which encompasses ‘a person’s general willingness to trust others’ (Grabner-Kräuter et al., 2006, p. 237). Second, the trustor’s trusting beliefs about the trustee explain how specific attributes of the trustee are perceived by the trustor (e.g. the trustee’s honesty and reliability).
The trustee’s attributes influence the trustor’s beliefs, and as a result the willingness to depend. The literature describes several attributes associated with the trusted party, including such concepts as ability, integrity and predictability. These attributes depend on the context of the trusting relationship, which is further influenced by who the trustee is (e.g., a friend, a relative, a computerised system). As this article focuses on online trust, where the trustee takes the form of an online environment/information, in the next section more emphasis will be paid to those attributes that influence their perceived trustworthiness. The reason for this is that these may be very different from those of a human collaborator.

Trust has both affective and cognitive dimensions. The cognitive dimension is based purely on a search for evidence or knowledge that will make the trustor willing to depend on the trustee. For example, if there is no prior interaction or knowledge about the trustee, then trust is built on cognition and an exploration of the trustee attributes, which will determine whether the trustor enters the trusting relationship or not. However, there are situations where there is a mutual identification between the two trusting parties that further establishes a bond and where trust also has affective dimensions (Rousseau et al. 1998).

3. Trust in online environments
People not only respond socially to technology but also rely on technology for many daily activities, and therefore it is not surprising that a trustee may take the form of a computerised system. Lee and See (2002) suggested that trust research can explain this reliance of people on technology, including online environments and web applications. Moreover, Nielsen (1999) suggested that people’s trust dispositions and beliefs are not favourable for the Web, and although many more people are using online banking and systems such as Facebook, to which they disclose many personal details, there are also ongoing discussions on privacy issues, identity theft, hackers’ attacks and several other elements that make people cautious and suspicious, and therefore influence their online behaviour and action.
It is therefore no surprise that online trust has become a critical research area. The next section first explains the components of online trust, and is followed by a discussion of online trustee attributes, and of the studies that suggest that a trust-oriented interface design can improve the perceived trustworthiness of computerised systems.

3.1. Online trust components

The trust components that exist in an online electronic context do not differ significantly from those described in Section 2.1 and in Figure 1. Chopra and Wallace (2003) explained that the following elements are relevant to online trust: 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 that influence the perceived trust (propensity to trust and trusting beliefs); the dimensions of trust (cognitive and affective trust); and the trustee attributes.

One important difference from the trust components reviewed in Section 2.1 is associated with a trustee who is not another human collaborator. In the context of online trust, the trustee may take the form of online information, an online information system, an e-commerce website or a system that supports online relationships (Chopra and Wallace 2003). Therefore, the trustor is a person who is willing to depend or rely on that system/information and who is confident that the system will act to protect or promote his/her benefits.

As noted, risk and uncertainty are also trust preconditions in the context of online trust. For example, if there is a need for a person to depend on a system, but there is no fear of losing something, then there is no uncertainty and thus no need to undertake any risk, and therefore also no reason to develop any trust perceptions. However, if the trustee is, for example, an e-commerce environment, and the trustor wants to depend on this system to make an online purchase, then the risk associated with losing money can lead to the development of trust perceptions.

In this context, the trustee attributes play an important role, because they have a major influence on the decision to rely on the system. Several studies explain how trustee attributes can be designed such that the system’s trustworthiness can be improved. For example, such an online trustee attribute, or a trust cue, is a seal of approval that can increase the trustor’s confidence and eventually result in the decision to depend on the trustee (cognitive trust).

In the particular case of Web GIS, there is no knowledge of the attributes that influence the trustworthiness of such systems, or for what reasons, if any, they are trusted by their end users. By and large, the popularity of public mapping websites, and the willingness of their users to use them to undertake visits to unfamiliar places, and to choose travel routes, indicates that some level of trust is associated with Web GIS. Beyond this indirect and potentially false observation (maybe the users know that the information is not trustworthy), we do not know what exactly the trust relationships between these systems and their users are. However, before exploring Web GIS, it is necessary to review the online trustee attributes, as suggested by previous studies, and then consider their applicability in the Web GIS context.

3.2. Online trustee attributes

Understanding the trust-related attributes of a system may facilitate the design process of more trustworthy systems. However, in the literature the trustee attributes are not consistently described in the same way, and in several cases these attributes have been shown to
be difficult to measure or evaluate. For example, Chopra and Wallace (2003) argued that the
trustee attributes of online environments are the trustee’s competence, positive intentions,
ethics and predictability. In this case, how easily or objectively ethics or positive intentions
can be measured and evaluated, so that they can be improved, is of critical concern.

Although different studies describe trustee attributes in different ways, as is evident
from Table 1, in almost all cases there are two categories of attributes. The first cate-
gory of attributes, defined in this article as perceptual attributes, refers to the source itself.
According to Grabner-Kräuter et al. (2006), such perceptual attributes are the source’s
honesty, integrity and reliability, which define the source’s trustworthiness and influence
its reputation. McKnight et al. (2002) suggested that the source’s reputation is a crit-
ical perceptual attribute. In fact, Barnes and Vidgen (2000) found that the reputation
of Amazon.com increased its sales significantly, and Jarvenpaa et al. (1999) found that
perceived reputation had a positive effect on trust formation about e-vendors.

The second category of attributes (defined herein as functional attributes) refers to the
system itself and, as McKnight et al. (2002) explain, to the system quality. For example, the
aesthetics of a system may influence its perceived trustworthiness. In this sense, Sappho’s
popular quotation that ‘what is beautiful is good and what is good will soon become beau-
tiful’ seems relevant here. Dion et al. (1972) found that participants in an experimental
study considered the physically attractive person a good person, rather than the opposite,
and Fung and Lee (1999) suggested that a high-quality website with a good interface
design increases perceived trust levels. Additional functional attributes are the system’s
functionality, which influences the system’s usability (Corritore et al. 2003) and which is
strongly linked to the system’s predictability (e.g. an easy to use system can be more pre-
dictable and thus minimise the degree of risk involved, thus influencing the formation of
trust perceptions).

Fogg (2003) used the term credibility (believability) rather than trust, which also has
two dimensions: perceived trustworthiness (perceptual attribute) and perceived system’s
expertise (functional attribute). It is interesting that, as Fogg suggests, these two dimensions
may vary, so that ‘If one dimension of credibility is strong while the other dimension is

Table 1. Perceptual and functional trustee attributes.

<table>
<thead>
<tr>
<th>Perceptual attributes (refer to the source)</th>
<th>Functional attributes (refer to the system)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trustworthiness (refers to the source’s</strong>&lt;br&gt; Competence, Positive Intentions, Ethics, Benevolence, Honesty, Integrity, Credibility)</td>
<td><strong>Predictability</strong>&lt;br&gt; Chopra and Wallace (2003), Grabner-Kräuter et al. (2006)</td>
</tr>
<tr>
<td><strong>Reputation</strong>&lt;br&gt; McKnight et al. (2002), Fogg (2003)</td>
<td><strong>Aesthetics</strong>&lt;br&gt; McKnight et al. (2002)</td>
</tr>
<tr>
<td><strong>Expertise (as a function of Knowledge, Skill and Experience)</strong></td>
<td><strong>Functionality</strong>&lt;br&gt; Fogg (2003)</td>
</tr>
<tr>
<td></td>
<td><strong>Corritore et al. (2003), McKnight et al. (2002)</strong></td>
</tr>
</tbody>
</table>
unknown the computing product may be perceived as credible, due to the “halo effect” (p. 124).

Thus, in summary it can be said that there are two categories of attributes that influence the perceived trustworthiness of a system. The perceptual attributes are related to the source and its reputation, which is influenced by such attributes as honesty, credibility and reputation (left column of Table 1). The functional attributes (right column of Table 1) are related to the evidence collected through interaction with the trustee and the assessment of its quality (aesthetics, usability, predictability, expertise and functionality). Also, there is enough evidence, derived mainly from the HCI literature, that both categories of attributes can be improved through interface design. The next section reviews some of these studies.

3.3. HCI studies for trust-oriented interface design

Based on the previous discussion, we can conclude that functional attributes are easier to evaluate and improve than perceptual attributes, which are more abstract and subjective. However, it is noteworthy that several studies argue that a trust-oriented interface design can improve both types of attribute.

Perceptual attributes can be improved by such elements as seals of approval and branding, which emphasise the credibility and reputation of the source (Cheskin Research Report 1999). Shneiderman (2000) also suggested that the perceived trustworthiness of a system can be improved by trust cues, such as branding (e.g. logos) and references of past performance (testimonials). Trust cues, such as testimonials and feedback, have a direct or indirect impact on perceived trustworthiness. Ba and Pavlou (2002) examined the website of eBay and found that feedback mechanisms that provided comments about sellers influenced buyers’ trust levels. Fogg (2003) also provided a detailed list of the additional elements that potentially increase the perceived trustworthiness, and which include, among others, providing contact details and external links that direct the user to credible and reputable sources.

Concerning functional attributes, the Cheskin Research Report (1999) further suggested that navigation and presentation are important trust-building blocks, whereas Shneiderman (2000) explained that, for trust enhancement, good design, based on clear commitments and usability, is necessary. Fogg (2003) provided further examples of functional attributes and explained that elements such as professional design, regular updates and working links influence trust perceptions.

More evidence that a trust-oriented interface design can increase trustworthiness is provided by Egger (2001), who suggested that trust cues are particularly important because they create the first impressions about the website, as is also noted by Wang and Emurian (2005). Wang and Emurian (2005) suggested four design dimensions for trust enhancement: Graphic, Structure, Content and Social-cue design dimensions.

The Content and Social-cue designs refer to the use of trust-inducing features. In particular, the Content design suggests the use of features such as logos and seals of approval, as well as correct and accurate information. The Social-cue design emphasises design features that create an atmosphere of social presence, as, for example, photographs, videos and chats. Blogs or forums that connect people can also be considered trust-inducing features.

The system’s quality attributes in the context of online trust refer to usability, functionality and aesthetical elements. Wang and Emurian (2005) suggested that the Graphic design dimension includes such elements as the use of pastel and cool tones and the use of high-quality photographs. Design quality is also mentioned not only by the Cheskin Research Report (1999), but also by several other studies (e.g. Nikander and Karvonen...
Moreover, Karvonen (2000) linked aesthetics to trustworthiness and discussed, in particular, how the beauty of simplicity (clean and clear design) influences usability and affects online trust.

In summary, the literature provides ample evidence that trustworthiness can be enhanced by a trust-oriented interface design. The trustee attributes that are linked to trustworthiness are the website’s quality (e.g. aesthetics, functionality and usability), trust-inducing features that emphasise the source provider and its reputation (e.g. logos) and additional trust cues, such as testimonials, feedback and forums. It should also be noted that the presence of trust cues clearly depends on the context of the specific application and on the user needs.

The context of the application has a major effect on those trustee attributes that influence perceived trustworthiness, and all the previous studies derive mainly from the e-commerce domain. The main user consideration in the context of an e-commerce website is to make a purchase successfully and easily, but this is not the case with Web GIS applications, and therefore interface design elements, such as videos or chats, may not be relevant in this context. At the same time, usability and aesthetics are suggested as particularly important elements in the formation of trust perceptions in the e-commerce domain, which are usually simple websites. However, the usability and aesthetical elements of a Web GIS application may be more complex, as these refer not only to the rest of the website but also to the cartography of the map, the legend, the spatial navigation tools and so on.

It should be noted that a user, especially a non-expert, may have several trust concerns while using such a system: for example, whether the data are correct and up to date, whether the maps were constructed by a professional and thus do not contain any errors and whether the analysis and the results are correct and accurate. However, a non-expert rarely has the expertise to assess all these elements and make an informed decision. Even so, the functional and perceptual attributes of the system can still influence trust perceptions. This means that a non-expert can still evaluate the aesthetics and usability, and the source’s reputation, and develop any trust perceptions accordingly. Thus, apart from focusing on the information provided, it is also important to emphasise both the perceptual and functional attributes, as well as the trust cues that can be used in this domain, so that the users’ confidence can be improved and trust will increase.

Web GIS have their own special characteristics, which influence the ways in which people interact with these systems and also their decisions to rely on them. At the same time, it is as yet unknown what, if any, usability, aesthetical or functional elements influence trust in the Web GIS context, or if there are any additional interface elements that can be considered as trust-inducing features.

### 4. Trust in Web GIS

Based on Figure 1, the trust components of a Web GIS include a trustee (a Web GIS application) and a trustor who is willing to undertake some risk, based on the confidence that the trustee will act according to his/her benefits (i.e. data, analysis results and additional information are all accurate and reliable). Such a trusting relationship is influenced by the trustee’s properties, the trustee’s attributes, the cognitive and affective dimensions of trust and the context of the application itself. Risk and uncertainty should be existent. These trust components are now discussed separately for the Web GIS context.

**Web GIS as the trustee:** Fogg (2003) suggested that computers’ credibility matters when computerised systems ‘instruct or advise users, report measurements, provide
information and analysis... (p. 126). It can be argued that Web GIS serve all three of these functions. For example, there are now several Web GIS applications that enable people to find places or to provide driving directions (e.g. Google Maps) and measure distances. If the systems are usable but the instructions or measurements provided are not accurate, then the system will lose credibility, and vice versa. Moreover, there are also more sophisticated Web GIS applications that provide additional information, and also guide users in the spatial analysis and decision-making processes, and there is also a need for people to rely on the system and its results.

The trustor properties: A trustor is a person who is willing to rely on the Web GIS application and the information it provides. In this perspective, it is necessary to differentiate between a trustor as a person with GIS education and a trustor as a non-expert user, as this knowledge can influence the trustor’s properties, and especially his/her trusting beliefs about the trustee. This means that a trustor with GIS education assesses some of the trustee attributes, for example, the data source provider and how the maps were constructed, almost immediately, but this can have an influence on the formation of overall trust perceptions. However, this is not the case with non-expert users, which makes trust an even more important consideration, taking into account also the increasing number of non-expert users who use Web GIS applications. In Section 4.1, some Web GIS user aspects and their HCI considerations are briefly introduced, along with some of the interaction barriers that also refer to specific trustee attributes (e.g. usability).

Risk and uncertainty: As explained in the first part of the article, the elements of risk and uncertainty play a role in trust along with the context. First, Monmonier (1996) explained that, apart from the deliberate lies that can be told with a map (e.g. political propaganda, advertising), map attributes such as scale, symbolisation and projection may misinform and confuse the users, whereas non-expert users have limited experience in understanding these elements and in assessing the trustworthiness of the final map. For Web GIS applications, especially where the screen’s size and the resolution are not the same for all users and can be poor, elements such as generalisation or symbology can further increase uncertainty and risk.

Second, to realise further the importance of the context in Web GIS, for a trustee, we here provide two examples, both of which refer to environmental decision-making, but their risk elements differ. The first system was designed by Steve Carver for the identification of a suitable location for a nuclear waste repository in the UK\(^1\), and the second is the Environment Agency (EA)’s ‘What’s In Your Back Yard’ (WIYBY) website\(^2\). The latter provides information to the public about floods, air quality and other environmental issues, using a GIS interface, and it is a tool that influences decision-making. For example, a user who wants to buy a house might first refer to the website to assess the flood risk in various different locations.

The context in these two examples is different and so is the risk, and this influences the willingness to depend on the system. In the first case, a wrong decision regarding the location of a nuclear waste repository could have catastrophic consequences. Even in the second example, accepting the information provided might well have higher risks than buying something from an e-commerce website. This is because the wrong information could have health consequences (e.g. wrong data about air quality, which misinform a person with breathing problems) or even threaten the user’s financial security (e.g. buying inappropriate home insurance). Indeed, in reality the risk involved in house purchase is so high that an environmental information search is part of the task of the lawyer who carries out the conveyancing.
However, it is not the only element of risk that is definitely present in this context. Haklay (2002) suggested that accuracy and uncertainty are integral to environmental information and that errors in its analysis are unavoidable. Even when data accuracy is established, geographical information can be very complex and requires a complicated set of techniques for its analysis. In the GIS area, there is an extensive research literature on uncertainty, concerning especially data quality and issues such as fuzziness, errors and precision. Couclelis (2003) further addressed additional uncertainty sources in the geospatial domain, such as the lack of skills and confusion, which further influence geospatial knowledge production. However, communicating such uncertainty to end users remains an open research problem.

In addition, the fact that non-experts have limited knowledge about spatial data handling and GIS operations creates additional complications. Usability, learnability and predictability are crucial factors for successful use of these systems, but these alone are not enough. To ensure that users will be willing to depend on the system, to accept its results and to engage with it, it is necessary to ensure that they will first trust it.

4.1. GIS: user aspects and HCI considerations

The capabilities and benefits of GIS for the exploration, analysis and visualisation of geographical data are widely recognised. Although the usability of GIS has improved over the years, modern desktop GIS environments remain complex, and they are used mainly by experts. The Web, therefore, is critical in creating and delivering GIS applications and maps to the public, thus leading to the democratisation of spatial data (Dragicevic 2004).

Since the introduction of Xerox PARC Map Viewer in 1993 (Putz 1994), a plethora of web-mapping applications has been developed, allowing end users to interact in new and innovative ways. Web GIS provide the tools to explore geographical data and to perform spatial analysis, and in some cases they provide the tools for public involvement in decision-making processes. Extensive research in the Public Participation GIS area examines how GIS can be used to enhance public participation, because this changes the ways in which people interact and communicate with maps, and it can also support visual thinking (MacEachren 1994, MacEachren and Kraak 1997, Sieber 2006, Dunn 2007).

A common characteristic of Web GIS is that these systems provide tasks that may seem extremely complex to a non-expert. The increased complexity creates interaction barriers and thus makes HCI principles particularly important. Recent usability studies of Web GIS show that non-experts have significant interaction problems, which increase complexity, reduce predictability and thus establish uncertainty. Skarlatidou and Haklay (2006) performed a usability evaluation study and compared some of the most popular public web-mapping sites, in terms of user performance. They found that a considerable number of people failed to perform fundamental tasks. A similar study by Nivala et al. (2008) reported the identification of 403 usability problems and concluded by presenting some usability guidelines for the development of public web-mapping sites.

Moreover, Ishikawa et al. (2005) evaluated climate maps and found that users were not able to interpret the map in the way that the map designer had intended, which demonstrates that experts are not always capable of producing effective and easily understood visualisations, or even systems. A subsequent solution is the implementation of design approaches that consider users’ needs and expectations. For example, Kramers (2008) described the benefits of a user-centred design approach, as a way of overcoming the difficulties that non-experts face when the tools are based entirely on technology-driven
designs. The significance of a user-centred design approach is also acknowledged by Van Elzakker (2005) in his study of maps’ usability.

As we have seen, usability is only one of the system attributes that contribute to the formation of the overall trust perceptions. The next section illustrates, through the WIYBY example, some Web GIS trustee attributes and problematic features that could influence trust in this context and that could result from improved interface design intended to increase trustworthiness.

5. Examination of trust on WIYBY website

We selected the EA’s WIYBY website for several reasons. First, it has a GIS element, which allows the user to explore and interact with environmental maps. Second, it incorporates the elements of risk and uncertainty, which are trust preconditions. Finally, previous studies (Alsop 2008, Francis 2009) have shown that the website has significant usability problems that may influence its trustworthiness.

As explained above, trust is multidimensional and there are several factors that influence the formation of trust perceptions, such as the trustor’s propensity to trust, trusting beliefs and trustee attributes. For a holistic approach as to how trust is constructed, elements such as the trustor’s trust perceptions regarding the Internet, Web GIS applications, data source providers and governmental organisations, such as the EA, should be considered and researched further.

Moreover, trust in a Web GIS application also refers to confidence that the data, the analysis results and also any additional information provided are accurate and reliable, although this is not always easy for a non-expert user to assess. However, a review also found that trust can be improved through a trust-oriented interface design, which focuses on such elements as usability, aesthetics, functionality and other trust cues, which emphasise the website provider and its reputation. The aim of this section is to demonstrate, using the example of the WIYBY website, how these functional attributes, which are suggested in the general trust literature, can influence trust in this context.

In terms of the trust-based design principles suggested by Wang and Emurian (2005), it can be argued that the website complies with several of them. For example, as Figure 2 shows, simple, clear, pale colour tones are used, the green colour used in the website increases trust, based on Plutchik’s Wheel of Emotions (Plutchik 1980), the EA logo is clearly visible, there are links to online communities (e.g. Facebook) and also links to Privacy Policy and contact details for enquiries (perceptual attributes). One negative aspect may be that the menu does not match popular menu visualisations, which for Web GIS is an important consideration, because non-experts need additional time to familiarise themselves with the GIS component, and this has implications for their learning curve.

To enter the GIS interface, the user must click on the ‘Go straight to maps’ link, then select a topic (e.g. flood, air pollution) and also enter the postcode of interest. The GIS interface for the topic of air pollution for the postcode WC1E 6BT is illustrated in Figure 3.

At this stage a preliminary investigation based on the literature reviewed, on the GIS usability guidelines suggested by Nivala et al. (2008) and also on the author’s expert judgement, based on the experience in Web GIS evaluation, reveals several problematic features which might further influence trust, although some trust-inducing features, such as the EA logo and the Crown Copyright, are still present.

The search box is clearly visible, although a significant problem is the small map size, which is further blocked by the legend, even though there is a significant amount of unused white space on the right-hand side of the website. As yet it is unknown whether map
size influences trust perceptions, although a previous study by Skarlatidou (2005) showed that users prefer large map interfaces. A large map size supports greater spatial cognition, because it presents more spatial elements on the same map tile. The need to drag the map is reduced, as is the possibility of losing any reference points during map navigation. Previous studies have showed that satisfaction is linked to trust and loyalty (Flavian et al. 2005), and thus it is believed that a larger map interface could provide users with more control, confidence and satisfaction, all of which could subsequently increase their trust in the system.

Another issue is that the results overlap and the top layer hides the bottom layers, and a non-expert may be unfamiliar with the GIS functionality of selecting/deselecting layers to reveal all important information. In that case, users might have the impression that the website is trying to hide some data from them. Trust is fragile and easily broken, and it may take a considerable amount of time to rebuild. Taking this into consideration, different transparency levels in the colours used to describe the results, or guidance about how to use specific functions, could increase the perceived trustworthiness.

Below the map there is a link ‘Text version of results’ where the user can find more information about each result. However, the user cannot explore each feature while navigating on the map, because the link directs the user to a new page. If the user was able to read the text version results and to refer to the map at the same time, this would increase his/her confidence and trust regarding the data and the map.

Aesthetics, as explained above, also influences the perceived trustworthiness. Some other elements that may influence trust are the base maps, which might not be perceived as particularly pleasant aesthetically, but they are professionally designed for the context of
Figure 3. GIS interface of the WIYBY website, after searching for air pollution in the area of WC1E 6BT (http://www.environment-agency.gov.uk).

this specific application. The base maps include spatial features not explained by the legend, and in several cases these features can create confusion because they are represented using the same colours as the results.

One critical feature that is missing from this part of the website is direct and clear links to additional information, information as to how the maps were constructed and when the data were last updated. This information could potentially help to build and improve trust.

The website exhibits additional problems, such as broken links and some functions that do not work properly, acronyms that are only explained once, textual information that requires linear reading and other problems which decrease trust, according to the trust-based literature.

As reviewed above, additional trust cues can increase perceived trustworthiness (e.g. feedback mechanisms, logos, chats, testimonials, forums or seals of approval). It is probably the case that not all of these features are relevant to the Web GIS context; however, user expectations and needs were never investigated in relation to trust in this particular context.

6. Summary and conclusions

Based on the general trust and online trust literature, it can be concluded that trust is an important consideration when there exist risk and uncertainty that influence the decision to rely or depend on a system. The risk and uncertainty elements in the Web GIS context were thoroughly explained in the previous sections. At the same time, increasing numbers
of people are using these systems on a daily basis, and the sophistication of Web GIS is
growing, and this potentially increases the need to research trust further in this context.

Only a few years ago, with the appearance of the first web-mapping applications (e.g.
Multimap and MapQuest, which were developed in 1995 and 1997, respectively), people
first used them to query locations, but have now progressed to performing tasks such as
customised routes (e.g. Google and Bing). Through neogeography, and as non-expert users
become more familiar with Web GIS environments, the future of Web GIS use involves
exposure to applications such as ‘Where can I live?’ and to even more sophisticated Web
GIS that supports more advanced decision-making processes. In such cases, first, there
might be a need for people to rely on these systems and accept the analysis results, which
could subsequently generate questions about their trustworthiness.

Web GIS provide online maps, and thus it can be suggested that they support visual
thinking, understanding and easier communication of spatial information, as was pre-
viously suggested for maps and their use in stimulating visual thinking (Kraak 2004).
However, interaction with these systems, more particularly non-expert interaction, fur-
ther establishes uncertainty and risk. For example, the increased complexity of Web GIS
interfaces, the uncertainty and risk associated with the context of these applications, the
geographical information and spatial analysis and the fact that non-experts have limited
knowledge about GIS operations all increase the elements of risk and uncertainty and
could further influence their trustworthiness.

The existing online trust literature, as it was previously discussed, suggests that a sys-
tem’s trustworthiness is influenced by the person’s propensity to trust, his/her trusting
beliefs about the trustee and its attributes. For a holistic research approach for trust in Web
GIS, all these elements should be investigated. First, for trustor’s trust propensity in the
Web GIS context, this involves further researching the end users’ trust perceptions about
the Web, and more specifically about online maps as mediums for communicating spatial
information. This investigation could potentially help to answer research questions such as
‘Do people trust online maps?’, but could also improve our understanding of what people
think about online maps and the tactics they develop to assess their trustworthiness (e.g.
Do people check the data source provider before trusting an online map?). Other attributes
of particular interest that such an investigation might involve include what map features
(e.g. scale, map size, map tutorials, symbology) and aesthetic elements (e.g. map colours)
potentially influence trust, focusing on both cognitive and affective elements.

Second, HCI studies from the online trust literature provide evidence that trust can
be improved by improving the functional and perceptual attributes of the trustee and by
incorporating trust-inducing features (or else trust cues) into the interface design of these
systems. However, most of these studies focus on e-commerce environments, which are
very different from Web GIS applications. For example, it is not clear whether the use of
pictures or chats and blogs in the Web GIS context does indeed improve their trustworthi-
ness. Thus, further research is required to identify the specific Web GIS trustee attributes
that influence users’ trust perceptions. An HCI-based approach can support such an inves-
tigation. It should not be forgotten that as the trust perceptions of different user groups may
be formed based on different attributes, it is essential to clearly define the user group (e.g.
experts or non-experts) to which such investigations refer.

Specifically, HCI methodology can first guide GIS researchers in a trust evaluation of
different existing Web GIS applications, preferably with the involvement of real users. This
will help to understand people’s trust concerns, their expectations and needs in the wider
context of Web GIS applications and also to understand how the functional attributes, the
system’s reputation and other trust cues interact with each other in the formation of the
overall trust perceptions. For example, such an investigation would help to identify whether map size is indeed a functional attribute that influences trust perceptions in this context. After understanding which attributes influence trust, a subsequent research approach might involve the development of alternative Web GIS interfaces for the same information (context) to measure the influence of specific trust-related features in a more controlled environment and to understand how these should be designed (e.g. provide users with the same map in different sizes, to understand which one is perceived as most trustworthy).

The previously described research approach could potentially assist the development of a set of trust-based guidelines in the Web GIS context. Existing interface design guidelines, derived mainly from the e-commerce domain, can help designers to build trustworthy systems while emphasising on the Graphic, Structure, Content and Social-cue design dimensions. Although it might be the case that these design dimensions are relevant to Web GIS, further research is required to categorise the problematic features in each specific design dimension and subsequently build a set of trust-based guidelines for Web GIS. For Web GIS it might be necessary to investigate the map functionality and map visualisation aspects as a separate dimension of a trust-based design. It is not known how map visualisation and functionality influence trust perceptions although previous studies proved that users had significant interaction problems with both elements.

A set of interface design guidelines that can potentially increase the perceived trustworthiness can be an advantage for Web GIS design and implementation, as it can improve interaction with these systems and the overall user experience. Trust design in this context can further be beneficial from the user perspective as it can reduce the uncertainty associated with the rapid development and use of Web GIS applications (Skarlatidou 2010).

The recent trends in Web Mapping 2.0 and neogeography had a significant impact on the development and use of online maps (Haklay et al. 2008) and increase the urgency of investigating trust in this context. For example, Web GIS applications can now be easily developed, using application programming interfaces, by anyone (including non-experts), thus the users cannot only rely on the skill of the cartographer before trusting a map. The users probably do not have the knowledge or expertise to judge whether these features are correct, valid or up to date, nor are they aware that there is no intention to misinform them. This should probably raise further concerns in the GIS community, which should start considering the establishment of trust standards and the subsequent development of trust-inducing features that would ensure users that an application complies with these standards. In addition, the GIS community should further consider investigating the spatial literacy of these non-expert users and identify ways to improve their spatial abilities, as this might well assist them in their trust assessments when they interact with online maps.

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Notes
1. Where to dispose of Britain’s nuclear waste: http://www.ccg.leeds.ac.uk/teaching/nuclear waste/
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