

ANALYSIS OF PUBLIC E-PROCUREMENT WEB SITE ACCESSIBILITY

Giuseppe Bruno, Emilio Esposito, Michele Mastroianni, and
Daniela Vellutino*

ABSTRACT. A vast amount of literature has highlighted that accessibility is becoming crucial in evaluating e-procurement web site effectiveness. In this context, this paper shows some results of multidisciplinary research whose aim is to identify a model to evaluate e-procurement web site accessibility. The specific goal is to identify a group of web site attributes and characteristics that can be measured using quantitative indicators. For this purpose, a model based on a three-level hierarchical system has been introduced. The proposed model has been used to evaluate three Italian public e-procurement web sites. Finally, the conclusions and some indications on future developments of research are illustrated.

INTRODUCTION

The nineties were characterised by profound social, economic and administrative changes. A wide range of literature has shown how Information and Communications Technology (ICT) has been the driving force of the changes that are currently under way (Kautz & Pries-Heje, 1996; Organisation for Economic Cooperation and Development, 1997; Lengrand & Chatrue, 1999). Due to its all-pervading character, ICT has deeply influenced and transformed every sector of society (Burkhardt, 1990; Adams, Nelson & Todd, 1992; Davis, 1993; Igbaria, 1993; Keil, Beranek & Konsynski, 1995; Taylor & Todd, 1995; Agarwal & Prasad,

* *Giuseppe Bruno, Ph.D., and Emilio Esposito, Ph.D., are an Assistant Professor and a Full Professor, respectively, Department of Business and Managerial Engineering University of Naples Federico II, Italy. Michele Mastroianni is a System and Network Manager, Second University of Naples, Italy. Daniela Vellutino is a Researcher, Department of Communication Sciences University of Salerno, Italy.*

1997; Commission of the European Communities, 2000). In universities and research centres, small and medium firms, national and local government bodies, hospitals, schools and families, ICT has spread at a pace unprecedented in the history of technology (Halal, 1993; Agarwal, Ahuja, Carter & Gans, 1998; Baskerville, Pries-Heje, 1998; Hauptman, Tomczyk & Kiggundu, 1998; Esposito & Mastroianni, 2002).

In this context, the public sector appears to be more and more involved in the realisation of user (citizen)-orientated information systems (Commission of the European Communities, 2000; EITO, 2002). Moreover, many industrial countries are developing relevant initiatives to improve public e-procurement services. At the beginning of 2000, the Federal government of the United States launched an on-line reverse tender pilot project for the Navy, Army, Air Force and US Postal Service (O'Hara, 2000). Thanks to this activity, the Navy saved about 38.8 million US dollars during the first step of the project (Hardy, 2003). Nowadays, many U.S. Federal Government Agencies, such as the U.S. Department of State, currently use e-procurement systems (U.S. Department of State, 2004).

In general, three main factors are pushing the public sector to ICT:

- stimulating organisational change;
- improving efficiency, effectiveness, and cost reduction (e-administration);
- improving the relationship between citizens and the public sector (e-democracy), in terms of transparency of the administrative action and of participation (Bertelsmann Foundation, 2002).

In these circumstances the problem of accessibility of ICT services websites is becoming crucial. The "Okinawa Charter" points out that accessibility to public services through web sites must also be possible for users who suffer from any type of disability, be it physical or cultural. A cultural disadvantage is certainly the case of a low level of education, which can be tackled by publishing documents written in a simple and direct language instead of using bureaucratic terminology that is often incomprehensible. Another category of cultural disability is insufficient familiarity with the tools of Information Technology; for this reason web sites have to be designed in such a way that non-computer science users can easily access them.

In this context, this paper focuses on the problem of accessibility of public e-procurement web sites. In particular, the paper shows some results of multidisciplinary research whose aim is to identify and test a support model for the improvement of accessibility of e-procurement systems. The specific goal is to identify a group of attributes and characteristics that can be measured using quantitative indicators, which allow a comparison of e-procurement web sites. The output of the model should provide useful suggestions for web site designers in order to improve the accessibility of services.

The paper is organised in six parts. In the second section some problems connected to the process of evaluation of e-procurement web sites are illustrated. The third section highlights the methodology. In the fourth section a set of quantitative indexes to measure web site accessibility is introduced. In the fifth section three Italian Public e-procurement systems are analysed. Finally, a discussion and some indications on possible further developments of research are illustrated.

FRAMEWORK

The definition of e-procurement in literature is not unequivocal. Van Weele (1994) defines e-procurement as the use of Internet technology in the process of providing goods and services. In a review of methods supporting supplier selection, de Boer (2002) analyses e-procurement systems considering their main function. Bruno, Esposito, Mastroianni and Vellutino (2004) classify e-procurement systems focusing on three variables: their main function, the impact on costs and organisational aspects (Table 1).

In the process of evaluation of e-procurement systems it is necessary to consider that the system is essentially a web site. Consequently, it is useful to look at a preliminary synthetic analysis of methodologies and variables currently used in the evaluation of web sites.

In the nineties, various studies and research were developed to analyse web sites (first approach). Most studies focus on the aspects concerning the evaluation of web site quality and generally use indicators that are largely estimated in a subjective manner (Nielsen, 1993, RUR, 2001). Moreover, almost all these studies evaluate web site quality using either the criterion of accessibility or usability.

TABLE 1
Classification of E-Procurement Systems

Type of e-procurement system	Main function of the system	Impact on direct/indirect costs of purchase	Impact on the organisational aspects
e - MRO	Acquisition of services of maintenance, repairs and operations	Low/elevated	Extended to the entire organisation
Web - based ERP	Integration of the process of purchase in the ERP of the agency	Low/limited to the operative phase	Extended to the entire organisation
e - sourcing	Singling out of the providers through internet technologies	Low/limited to the tactical phase	Limited to the purchasing department
e - tendering	Sending requests for information and prices to the providers and the collection of offers via internet	Low/limited to the tactical phase	Limited to the purchasing department
e - reverse - auctioning	On - line auctions	Relevant/low	Limited to the purchasing department

Source: Bruno et al. (2004).

The most important reference for the definition of accessibility is to be found in the WAI (Web Accessibility Initiative) guidelines, proposed by the W3C consortium, which represent the main platform of the technical rules for improving accessibility (the W3C Consortium, 1999). They regulate the accessibility of the web site through a series of recommendations, authoring tools and user agents (Table 2). A checklist document is connected to each recommendation, which indicates priorities for setting up accessible sites. The WC3 checklist considers 14 items that concern, above all, the writing of the code to favour the accessibility of users with physical disabilities (colour-blind and visually-impaired people). The checklist only generically considers the comprehensibility of the written message that represents a relevant and highlighted aspect of the Okinawa agreement (G8, 2000). The WAI guidelines have also been taken up by many nations, including the United Kingdom (Guidelines for UK Government websites) and Italy.

TABLE 2
WAI Recommendations for Web Sites Accessibility

Guidelines	Recommendation
1. Provide equivalent alternatives to auditory and visual content.	Provide content that, when presented to the user, conveys essentially the same function or purpose as auditory or visual content.
2. Don't rely on colour alone.	Ensure that text and graphics are understandable when viewed without colour.
3. Use mark up and style sheets and do so properly.	Mark up documents with the proper structural elements. Control presentation with style sheets rather than with presentation elements and attributes.
4. Clarify natural language usage.	Use mark up that facilitates pronunciation or interpretation of abbreviated or foreign text.
5. Create tables that transform gracefully.	Ensure that tables have necessary mark up to be transformed by accessible browsers and other user agents.
6. Ensure that pages featuring new technologies transform gracefully.	Ensure that pages are accessible even when newer technologies are not supported or are turned off.
7. Ensure user control of time-sensitive content changes.	Ensure that moving, blinking, scrolling, or auto-updating objects or pages may be paused or stopped.
8. Ensure direct accessibility of embedded user interfaces.	Ensure that the user interface follows principles of accessible design: device-independent access to functionality, keyboard operability, self-voicing, etc.
9. Design for device-independence.	Use features that enable activation of page elements via a variety of input devices.
10. Use interim solutions.	Use interim accessibility solutions so that assistive technologies and older browsers will operate correctly.
11. Use W3C technologies and guidelines.	Use W3C technologies (according to specification) and follow accessibility guidelines. Where it is not possible to use a W3C technology, or doing so results in material that does not transform gracefully, provide an alternative version of the content that is accessible.
12. Provide context and orientation information.	Provide context and orientation information to help users understand complex pages or elements.

TABLE 2 (Continued)

Guidelines	Recommendation
13. Provide clear navigation mechanisms.	Provide clear and consistent navigation mechanisms - orientation information, navigation bars, a site map, etc. - to increase the likelihood that a person will find what they are looking for at a site.
14. Ensure that documents are clear and simple.	Ensure that documents are clear and simple so they may be more easily understood.

Source: The W3C Consortium (1999).

For Italy, the references are represented by the Authority for Computer Science in the Public Sector's document No. 3/2001. As far as *usability* is concerned, Guidelines 924-11 for the ISO standardisation define usability as the effectiveness, efficiency and satisfaction with which specified users can reach specific aims in particular environments.

In the middle of the nineties, Ratner, Grose and Forsythe (1996) demonstrated that accessibility and usability are weakly correlated to each other; consequently, it is not possible to evaluate a web site by measuring only one of these aspects. At the end of nineties, models that take into consideration a wide range of variables including accessibility, usability, and other parameters were proposed (recent approach). Such models, finalised at benchmarking research activities and web site ranking, introduce a set of variables (mostly qualitative) based on the content, the scope of the web site and the type of users (Nielsen 1994; 2000). The indicators are grouped together in thematic indexes that synthesise complex concepts, such as accessibility, usability, communication, functionality, availability of services, etc. Unfortunately, even if such models are well finalised at benchmarking they are not equally efficient in individualising the critical aspects and the type of intervention needed to improve web site performance.

As far as the first approach is concerned, our hypothesis is in line with that of Ratner, in that the two concepts of accessibility and usability are complementary and not independent of each other; therefore it is not possible to separate them. The logical consequence of this hypothesis is that it is not possible to individualise an indicator (or a set of indicators) able to measure only either accessibility or usability. In line with this consideration, our approach is that evaluation of a public e-procurement

web site should be based on a set of indicators that represent both concepts. For this reason, in the following sections we use the word accessibility to mean both concepts (accessibility and usability). Regarding the second approach, we underline the necessity to use quantitative indexes (instead of qualitative ones) grouped in such a way that it is possible to individualise the critical aspects, the professional skill involved and the type of intervention needed to improve the web site performance.

Starting from these considerations, this paper introduces a quantitative methodology to evaluate the accessibility of public e-procurement web sites. The proposed methodology allows the individualisation of professional skills that could result in improved accessibility.

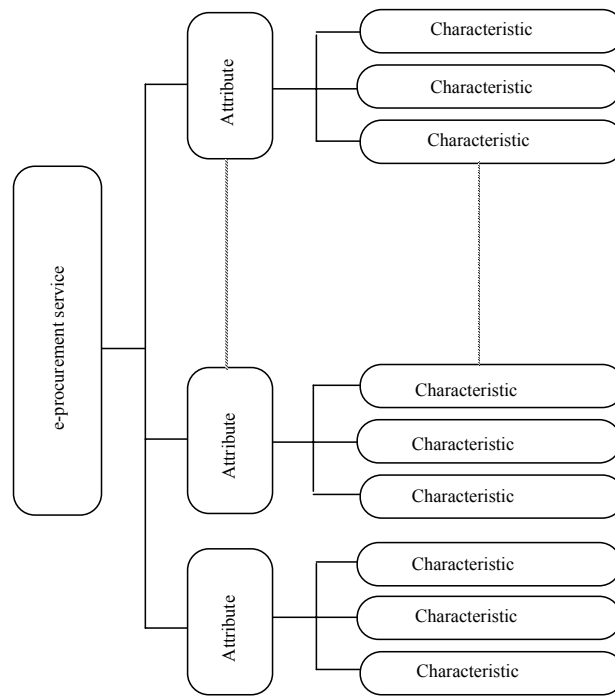
METHODOLOGY

Even if the factors affecting the accessibility of e-procurement web sites in the public sector are various and different, they can be grouped according to the following aspects (G8 Member States, 2000; Nielsen, 2000):

- Information and services must be accessible to users with every kind of disability, social and cultural;
- Navigation in the system should be the simplest and most comfortable possible, in such a way that users are stimulated to use it; and
- The public manager should be able to co-ordinate and evaluate the work of all the various professionals and consultants involved in the construction of the web site (e.g., the webmaster, graphic designers, communicators, system administrators, et cetera).

On the basis of these considerations, we assume that the main objective of such sites is to allow the widest possible number of users to access the services (Mastoianni & Vellutino, 2002; Esposito, Mastoianni & Vellutino, 2003, Bruno, Esposito, Mastoianni & Vellutino, 2004). For this purpose, we introduce a model based on a hierarchical system articulated on three levels. The first level represents the e-procurement service, which is divided into a set of attributes (second level). Each attribute is defined through a set of characteristics (third level) (Figure 1).

FIGURE 1
The Hierarchical System



More precisely, four attributes have been identified: textual language, visual language, digitalisation and digital communication. Each attribute is associated to a specific skill that is able to modify the characteristics of the related attribute (Table 3). In this way the model, together with the evaluation of each attribute, indicates the skill that can improve accessibility. For instance, low values of indexes relative to the

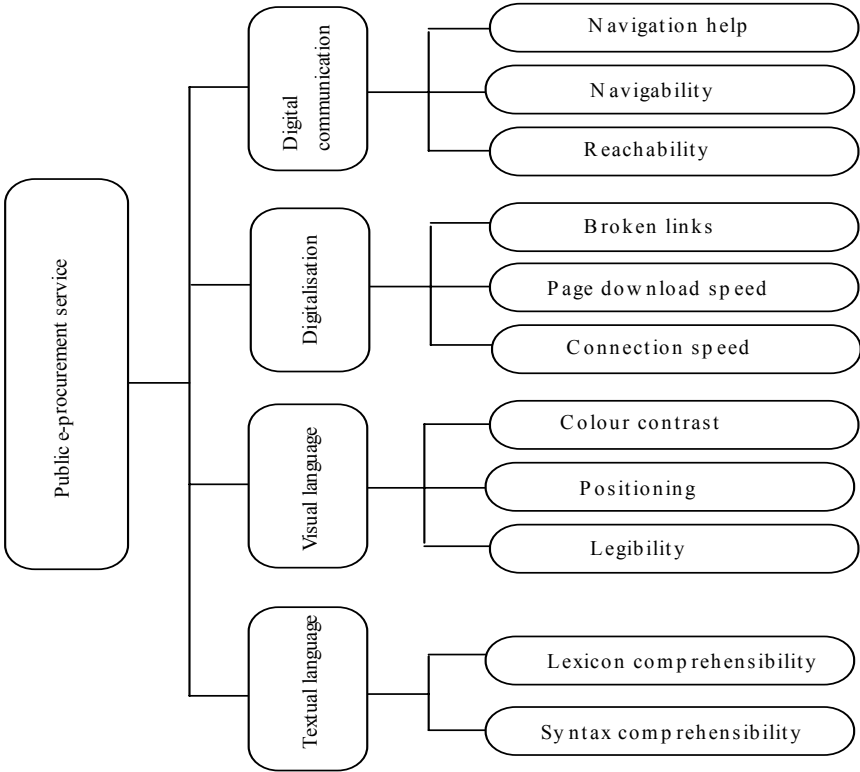
TABLE 3
Attributes and Associated Profession Skills

Attribute	Associated skill
Textual language	Text writer
Visual language	Designer / Graphics expert
Digitalisation	Computer science professional (system or network)
Digital communication	Web designer

visual language attribute indicate that an improvement in graphic quality is required and that the intervention of a designer or of a graphic expert is needed.

In turn, each attribute has been associated with two or three characteristics. In total, eleven characteristics have been defined: syntax comprehensibility, lexicon comprehensibility, legibility, positioning, colour contrast, connection speed, page download speed, broken links, reachability, navigability, and navigation help (Figure 2). The set of characteristics can be measured using quantitative indexes and computed using automatic and/or semiautomatic tools.

FIGURE 2
Attributes and Characteristics for the Evaluation of an E-Procurement Web Site Accessibility



The proposed attributes and characteristics can be enlarged in order to take into account other factors and aspects affecting the general evaluation of an e-procurement system. For instance, indexes of quality and efficiency of the e-procurement service (such as security, costs, organisation and management, etc.) could be also considered.

The addition of further attributes does not influence the general architecture or functionality of the proposed hierarchical model. In its current state, the choice of attributes comes from the objective of measuring the accessibility of the web service.

MEASUREMENT OF CHARACTERISTICS

This section illustrates the indexes introduced to measure the characteristics identified. According to the hierarchical model the indexes are divided into four groups: indexes relative to the textual language attribute, indexes relative to the visual language attribute, indexes relative to the digitalisation attribute, and indexes relative to the digital communication attribute.

For each index, we also calculate an acceptable minimum value. These values are calculated in relation to an average user (for indexes relative to the textual language and visual language attributes) and to ICT technology generally available on the market (for indexes relative to the digitalisation and digital communication attributes).

Textual Language Indexes

The indexes relative to the textual language attribute measure characteristics of the textual content with reference to ease of comprehension. To ensure accessibility to the services offered by the site, the language used should meet the needs of a large number of users, who are different from a social and cultural point of view. For this purpose, two indexes of textual comprehensibility have been used: syntax comprehensibility and lexicon comprehensibility.

Flesch (1951) and Gunning (1973) have demonstrated that a text is more or less comprehensible if some quantitative characteristics, objectively measurable and testable, reflect some criteria drawn from the use of formulas. On these bases, an index (Flesch index) has been proposed to measure the comprehensibility of a document written in American English, with a score system from 0 to 100. Starting from

analogous considerations, the so-called Gulpease index has been developed for the Italian language (Lucisano & Piemontese, 1988). Considering a text sample of at least 100 words the Syntax Comprehensibility Index (SCI) or Gulpease index is calculated using the following formula:

$$SCI = 89 - (Lp/10) + (3*Fr)$$

Where:

Lp = the number of letters * 100 / the number of words;

Fr = the number of phrases * 100 / the number of words.

The value of such an index may vary from 0 (hardest to read) to 100 (easiest to read). The score may be translated into school grades: a minimum value of 80, for example, indicates that the text proves to be comprehensible for a user with an elementary/junior school level of education, 60 for the Italian "scuola media" (ages from 10 to 13) and 40 for the high school.

The index of lexicon comprehensibility represents an index of the presence of commonly used words in the text. It is evaluated as the percentage of the presence in the text of words of basic vocabulary, which is defined in the lexicon of frequency in Italian (de Mauro, Mancini, Vedovelli & Volhera, 1993). The Lexicon Comprehensibility Index (LCI), which varies between 0 and 100, is constructed using the following formula

$$LCI = (Npl/Np) * 100$$

Where:

Np = the number of words in the text;

Npl = the number of words in the text contained in basic vocabulary.

The higher the index, the more comprehensible the text.

If we assume that the average user of a public e-procurement web site is educated to at least high school level, the minimum acceptable value for both the SCI and the LCI indexes is equal to 40.

Visual Language Indexes

The indexes relative to visual language measure the visible legibility of messages, referring to the screen layout of the site (position of objects on the screen, font and size of characters, and colour contrast). Three indexes proposed by Bernard have been used to measure the recurrence

of the equal elements in all the pages and the readability of the characters (Bernard, 2001; Bernard et al., 2002).

The index of legibility measures the average value of text legibility, as speed of reading (characters/seconds) of a sample text in terms of font and size. Bernard (2002) has measured the speed of reading and has set out these values in a table. The values can vary from 0 to 4. For example, the index value is 2.72 characters / second for the schoolbook 12 and 3.97 characters / second for the Tahoma 12. As a minimum value of reference for the index of legibility, a value that corresponds to a reading speed of 50% of the maximum (therefore equal to 2.0) is used

The index of positioning measures the percentage of correct positioning of objects, of text and of the functions of interaction in the area of the page on the basis of a standard layout (Bernard, 2002). According to such a layout, an ideal position on the screen is assigned to each object in such a way as to assure a more rapid and simpler access to the system functions. The minimum acceptable value of the index of positioning is 50.0, which corresponds to 50% of the objects positioned correctly compared to the standard layout.

The index of colour contrast is calculated through numerical representation of the background and foreground colour in web pages. In HTML language, the colour is identified using an additional representation called RGB (Red - Green - Blue) with three values, which represent the intensity of each fundamental colour (Foley, van Dam, Feiner & Hughes, 1990). The index is then calculated as the Euclidean distance between the two colours of background and foreground. Even if such a measurement is not necessarily representative of a great contrast, it has been chosen for the simplicity of the calculation. Alternative indexes could be the distance in the representation CIO XYZ (Cowan & MacIntyre, 1992) or in the system HSV (Foley et al. 1990). The index varies between 0 and 442. In line with WAI W3C recommendations (the W3C Consortium, 2000), the minimum acceptable value is 290.

Digitalisation Indexes

The indexes relative to digitalisation measure the technical performance of the web site. Three indexes have also been used in this case. The index of connection speed measures the speed of connection of the site in bytes/seconds; it is calculated as the inverse of the average time of "ping", measured by 13 public Italian "trace route" servers

included in the list of www.traceroute.org. Therefore, the index is calculated as follows:

$$\text{Connection speed} = 32 \cdot 13 / \sum_{i=1,13} (\text{Tping}_i)$$

Where: Tping_i indicates the average time of the ping relative to the traceroute i . The minimum value of reference is defined as a user with a V90 56.000 bit/s modem and is therefore equal to 500.

The index of downloading speed measures the speed of page downloading calculated by dividing the average size in bytes by pages for the value of 7.000 (= 56.000 bit/s, the maximum theoretical speed obtainable by a modem for domestic use). A special web analysis program has been used to calculate the average size.

$$\text{Downloading speed} = \text{average size of the pages} / 7.000$$

Where the average size of a page is measured in Bytes. 0.20, has been chosen as a minimum reference value and corresponds to a download speed of a page every 5 seconds.

The index relative to the unconnected links represents the percentage of links that are not connected with respect to the number of total links present in the site. The two values are calculated using a web site analysis tool.

Given the specific nature of the sites analysed, the absence of a document can affect whether companies purchase or not and therefore 95.0, which corresponds to a maximum of 5% of documents not available, is used as a minimum value.

Digital Communication Indexes

The indexes relative to digital communication measure the quality and level of interaction between users and the service provider. Three indexes have been used for this purpose.

The index of reachability calculates the average position of the site according to three different search engines: two international (Google and Altavista) and one Italian (Virgilio). The position is evaluated by using the full name of the service as the search key and analysing the first 100 results. For coherence with the other indexes (all growing with the goodwill of the service) the complement to 100 of the average position has been used.

$$\text{Reachability} = 100 - (\text{Position}_{\text{Google}} + \text{Position}_{\text{Altavista}} + \text{Position}_{\text{Virgilio}}) / 3$$

The value 50.0 is used as a minimum value of reference for the index of reachability. This represents the average of the site presence in the first two pages of all the search engines chosen.

According to Bernard (2001 and 2002), we propose to evaluate the index of navigability as a percentage of the links present in the first 2 levels of the structure, with respect to the total. The two values are calculated using a special program of web analysis of web sites.

$$\text{Navigability} = 100 * A/B$$

where:

A = number of links present in the first two levels of the structure.

B = the total number of links

The value 50.0 is used as a minimum value of reference for the index of navigability. This indicates that at least 50% of the site pages are reachable from the home page by no more than two clicks of the mouse. The index of the presence of help and support for navigation indicates the presence of support tools for site navigation such as internal search engines, on-line help, site maps, etc. The value 2 is used as a minimum value of reference for this index (for a site to be acceptable it must offer the user at least two different types of navigation support). In Table 4 the complete list of the attributes and relative indexes is shown with the indication of the unit of measurement, of the scale of measurement and of the tools necessary for their calculation.

RESULTS

The system of attributes and of indexes previously described has been used, for exemplification purposes, to evaluate three Italian e – procurement web site systems operating in and for the Public Sector:

- The site of the Ministry of Finance for public sector purchases on - line of the (Consip);
- The experimental system of provision of goods and services of the Liguria Region; and
- The system of on - line auction of the Province of Naples.

The Consip site is conceptually subdivided into two parts. The first, reserved for “providers”, presents the procedures for purchasing goods and services. The second is reserved for the “public sector managers” of

TABLE 4
Attributes and Indexes of Evaluation

Attributes	Characteristics	Unit of measurement/ scale/tools
Textual Language	Syntax comprehensibility	Adimensional value / [0,100] / computation formula
	Lexicon comprehensibility	A dimensional value / [0,100] / dictionary of the basic Italian lexicon
Visual Language	Legibility	Characters / seconds / [0,4] / table of character legibility
	Positioning	Adimensional value / [0,100] / diagram of objects positioning
	Colour contrast	Adimensional / [0,442] / RGB colour representation
Digital communication	Connection speed	Bytes / seconds / [0,1 million] / ping command
	Page download speed	Pages / seconds / [0,50] / utility
	Broken links	Adimensional value / [0,100] / utility
Digitalization	Reachability	Adimensional / [0,100] / public access search engine
	Navigability	Adimensional value / [0,100] / utility
	Presence of help and support for navigation	Adimensional / [0,3] / direct observation

purchasing departments and offers a catalogue of available goods and services. Each user, once registered by the site, can participate in the tender using his username, PIN and digital signature. The evaluation of the web site service has been performed only from the point of view of the final user (the public sector managers).

The site of e-procurement of the Liguria Region and Province of Naples are based on a system of auction on-line. The firms, previously identified through registration in a specific register, participate by presenting their respective offers through on-line transactions. The proposed system of indexes for the three case studies is presented in Table 5.

For the Consip site, Table 5 shows that four indexes are below the reference minimum (colour contrast, page downloading speed, navigability and navigation help). The syntax comprehensibility index is equal to the minimum, while the other indexes have satisfactory or high

TABLE 5
Evaluation of Three Italian E-Procurement Web Sites

Indexes	Measures			Minimal acceptable value
	CONSIP	Liguria Region	Province of Naples	
Attribute of textual language				
Syntax comprehensibility	40.0**	41.0**	55.0	40.0
Lexicon comprehensibility	82.3	87.9	83.8	40.0
Attribute of visual language				
Legibility	2.9	3.6	2.9	2.0
Positioning	80	77	71	50
Colour contrast	277*	442	365	290
Attribute of digitalisation				
Connection speed	769	1111	560**	500
Page downloading speed	0.11*	0.65	0.60	0.20
Broken links	100.0	95.8**	98.3	95.0
Attribute of digital communication				
Reachability	63.3	99.3	95.2	50.0
Navigability	9.1*	81.7	49.0*	50.0
Navigation help	1*	1*	1*	2

Notes: * = the measured values are less than minimum.

** = the measured values are near minimum.

values. This indicates that the site has a combination of colours that does not make reading easy, the pages are generally very slow to download and the site has a complicated structure that makes navigation difficult. There is also not enough user support and the text published is not simple to read. On the other hand, the page layout is easy to understand and the connection speed is good. Three different types of action, with different levels of priority are needed to improve the accessibility of the site. The highest priority action is to improve the digital communication index. A web designer (see Table 3) needs to be employed to restructure the architecture of the information and the site instruments. A second, less important, action could be to improve the visual language and digitalisation attributes, using a graphic designer and an ICT technician to tune up the site performance. A third course of action, with the lowest

priority could be to improve the textual language attribute, by employing an editor to rewrite the texts used in order to make them easier for users to understand.

Analysis results for the Liguria Region site show that the navigation help index is lower than the minimum of reference. The syntax comprehensibility and broken links indexes are slightly higher than the minimum, while the other indexes show values that are satisfactory or high. This shows that the site does not have sufficient user support, that the text used is not easy to understand and that a certain number of pages cannot be easily reached by the user. On the other hand, the page layout is easy to understand and the connection speed is excellent. Also in this case the hierarchical structure of the model allows us to identify possible ways to improve site accessibility. Two courses of action in particular emerge. The higher priority action must be to improve the digital communication index. A web designer (see Table 3) is needed to create user support tools for the site. A second, though less important action, would be to improve the textual language and digitalisation attributes by employing both an editor and an ICT technician, one to rewrite the texts in order to make them easier for users to understand and the other to check site links.

For the Province of Naples site, the navigability and navigation help indexes are lower than the minimum of reference. The connection speed index is slightly higher than the minimum, while the other index values are satisfactory or high. This indicates that the site has a complicated structure and is difficult to navigate, this it does not have enough user support and that the speed of the Internet connection is only sufficient. On the other hand, the text used is easily understandable. The analysis carried out with the proposed model suggests two different types of action with different priorities to improve site accessibility. The higher priority action should be to improve the digital communication index. A web designer (see Table 3) should be employed to restructure the architecture of the information and the site instruments. A second course of action, with a lower priority, could be to improve the digitalisation index by employing an ICT technician to improve Internet performance.

Finally, we must underline an element common to the three sites and that is a clear lack of support for users. Users only have one kind of help and there is no internal search engine or site map. This lack has also been found in other Italian e-procurement analysed using the same model and

is in sharp contrast to an approach that focuses strongly on these characteristic found in leading e-commerce sites (e.g. Ebay and Amazon).

DISCUSSION

This paper has highlighted that the introduction of a quantitative methodology to evaluate the accessibility of e-procurement web sites appears crucial and represents a fundamental aspect in the process of evaluation of the e-procurement service's effectiveness.

On the basis of these considerations, a quantitative model based on a hierarchical system articulated on three levels has been introduced. The first level represents the e-procurement service, which is divided into a set of attributes (second level). Each attribute is defined through a set of characteristics (third level).

According to this approach, four attributes have been singled out:

- *Textual language*, which refers to the textual content of the web site with reference to the *comprehensibility*;
- *Visual language*, understood as visual message legibility with reference to the layout of the site (position of objects on the screen, type of character and colour contrast);
- *Digitalisation*, which measures the technical performance of the web site; and
- *Digital communication*, which deals with the quality and degree of interaction.

To evaluate these four attributes, eleven characteristics that can be measured using quantitative indexes have been introduced: syntax comprehensibility, lexicon comprehensibility, legibility, positioning, colour contrast, connection speed, page download speed, broken links, reachability, navigability and navigation help. The values of the indexes can provide useful indications for improving e-procurement service accessibility.

The proposed approach has been used, as part of the process of exemplification, to evaluate and compare the characteristics of three Italian public e-procurement web sites. The experimental results have highlighted the diverse peculiarity of three analysed systems.

These final conclusions offer a starting point for planning a research agenda. In particular, it will be interesting to define a synthetic measure of accessibility. In this way, it will be possible to rank different public e-procurement web sites. For this purpose, the perception of the relative importance that users assign to each characteristic and attribute will be investigated. The final aim will be the definition of a multi-objective (or multi-criteria) function that represents a global measurement of accessibility. From this point of view the problem of evaluating e-procurement service accessibility should be analysed considering both the web site (technical aspects and performance) and the user (needs and perceptions). For this reason the proposed approach represents a first step in the building process of a more complex model for the evaluation of public e-procurement web site accessibility, which includes both web site performance and user perceptions.

ACKNOWLEDGEMENTS

We are grateful to two anonymous reviewers of this journal for their helpful comments and invaluable suggestions.

REFERENCES

- Adams, D., Nelson, R.R., & Todd, P. (1992). "Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication." *MIS Quarterly*, 16 (2): 227-248.
- Agarwal, R., & Prasad, J. (1997). "The Role of Innovation Characteristics and Perceived Voluntariness in the Acceptance of Information Technology." *Decision Science*, 28 (3): 557-582.
- Agarwal, R., Ahuja, M., Carter, P.E, & Gans, M. (1998). "Early and Late Adopters of IT Innovations: Extensions to Innovation Diffusion Theory" (Unpublished paper).
- Baskerville, R., & Pries-heje, J. (1998). "Information Technology Diffusion: Building Positive Barriers." *European Journal of Information Systems*, 7: 17-28.
- Bernard, M. L. (2001). "Developing Schemas for the Location of Common Web Objects." *Usability News*, 4 (1). [Online]. Available at http://psychology.wichita.edu/surl/usabilitynews/3W/Web_object.

- Bernard, M. L. (2002). "Examining User Expectations for the Location of Common E-Commerce Web Objects." *Usability News*, 4 (1). [Online]. Available at http://psychology.wichita.edu/surl/usabilitynews/41/web_object-ecom.htm.
- Bernard, M., Lida, B., Riley, S., Hackler, T., & Janzen, K. (2002). "A Comparison of Popular Online Fonts: Which Size and Type is Best?" *Usability News*, 4 (2). [Online]. Available at <http://psychology.wichita.edu/surl/usabilitynews/41/onlinetext.htm>.
- Bertelsmann Foundation (2002). *E-Government-Connecting Efficient Administration and Responsive Democracy*. [Online]. Available at www.begix.de.
- Bruno, G., Esposito, E., Mastroianni, M., & Vellutino, D. (2004). "A Multi-Criteria Approach to Evaluate E-Procurement Web Sites." In *Proceedings IPSERA Conference*, April 4-7, in Catania, Italy.
- Burkhardt, M.E. (1990). "Changing Patterns or Patterns of Change: The Effects of Change in Technology on Social Network Structure and Power." *Administrative Science Quarterly*, 35: 104-127.
- Commission of the European Communities (2000). *eEurope*. [Online]. Available at http://europa.eu.int/information_society/eeurope/2002/action_plan/index_en.htm.
- Cowan, W. B., & MacIntyre, B. (1992). "A Practical Approach to Calculating Luminance Contrast on a CRT." *ACM Transactions on Graphics*, 11 (4): 366-347.
- Davis, F.D. (1993). "User Acceptance of Information Technology: System Characteristics, User Perceptions and Behavioral Impacts". *International Journal of Man-Machine Studies*, 38: 475-487.
- de Boer, L., Harink, J., & Heijboer, G. (2002). "A Conceptual Model for Assessing the Impact of Electronic Procurement." *European Journal of Purchasing & Supply Management*, 8: 25-33.
- De Mauro, T., Mancini, F., Vedovelli, M., & Voghera M. (1993). *Lessico di frequenza dell'italiano parlato*. Milan, Italy: ETASLIBRI.
- EITO (2002). *European Information Technology Observer 2002*. Frankfurt, Germany: Millennium Edition.
- Esposito, E., Mastroianni, M., & Vellutino, D. (2003). "Evaluation of E-Marketplaces: A Model Proposed for Systems Operating in and for

- the Public Sector.” In *Proceedings IPSERA Conference*, April 14-16, in Budapest, Hungary.
- Esposito, E., & Mastroianni, M. (2002). “Information Technology and Personal Computers: The Relational Life Cycle.” *Technovation*, 22 (1): 41-50.
- Flesch, R. (1951). *How to Test Readability*. New York: Harper & Row.
- Foley, J. D., van Dam, A., Feiner, S. K., & Hughes, J. F. (1990). *Computer Graphics: Principles and Practice* (2nd ed.). New York: Addison-Wesley Publishing Company.
- G8 Member States (2000). “Okinawa Document on the International Information Society.” Paper Presented at the G8 World-Wide Summit of Kyushu-Okinawa, Okinawa, July 23.
- Gunning, R. (1973). *The Technique of Clear Writing*. New York: Mc Graw Hill.
- Halal, W. E. (1993). “The Information Technology Revolution. Computer Hardware, Software, and Services into the 21st Century.” *Technological Forecasting and Social Change*, 44 (1): 69-86.
- Hardy, M. (2003). “Reverse Auctions Save Navy Millions.” *Federal Computer Week*. [Online]. Available at <http://fcw.com/fcw/articles/2003/0428/pol-auctions-04-28-03.asp>.
- Hauptman, O., Tomczyk, M.S., & Kiggundu, M. (1998). “The Emerging Role of Telecommunication: Extrapolation of Novel Applications Around the Word.” *Technological Forecasting and Social Change*, 57 (1): 1-6.
- Igbaria, M. (1993). “User Acceptance of Microcomputer Technology: An Empirical Test.” *Omega*, 1 (21): 73-90.
- Kautz, K., & Pries-Heje, J. (Eds.) (1996). *Diffusion and Adoption of Information Technology*. London, UK: Chapman and Hall.
- Keil, M., Beranek, P.M., & Konsynski, B.R. (1995). “Usefulness and Ease of Use: Field Study Evidence Regarding Task Consideration.” *Decision Support System*, 13: 75-91.
- Kolence, K.W., & Kiviat, P.J. (1973). “Software Unit Profiles and Kiviat Figures.” *Performance Evaluation Review*, 2 (3): 2-12.

- Lengrand, L., & Chatrie, I. (1999). *Business Network and the Knowledge-Driven Economy*. Luxemburg: European Community.
- Lucisano, P., & Piemontese, M. E. (1988). "Gulpease: Una Formula per la Predizione Delle Difficoltà dei Testi Nella Lingua Italiana." *Scuola e Città*, 49 (3): 110-124.
- Mastroianni, M., & Vellutino, D. (2002). "DA.MA: A Model for Automatic Evaluation of Public Sector Web Sites." Paper presented at the 2nd European Conference on E-Government, October 1-2, at St Catherine's College, Oxford.
- Nielsen, J. (1993). *Usability Engineering*. Boston, MA: Academic Press.
- Nielsen, J. (1994). *Usability Inspection Methods*. New York: John Wiley & Sons.
- Nielsen, J. (2000). *Designing Web Usability*. New York: MacMillan Computer Publishing.
- O'Hara, C. (2000, August 14). "Feds Buy in to Reverse Auction." *Federal Computer Week*. [Online]. Available at <http://www.fcw.com/fcw/articles/2000/0814/pol-reverse-08-14-00.asp>.
- Organisation for Economic Cooperation and Development (1997). *Information Technology Outlook 1997*. Paris, France: Author.
- Ratner, J., Grose, E.M., & Forsythe, C. (1996). "Characterisation of and Assessment of HTML Style Guide." *Conference on Human Factors in Computer Systems*, 2: 115-116.
- RUR (2001). *Le Città Digitali in Italia - Rapporto 1999-2000*. Milano, Italy: Franco Angeli.
- Taylor, S. & Todd, P. (1995). "Understanding Information Technology Usage: A Test of Competing Models." *Information Systems Research*, 6 (2): 144-259.
- The W3C Consortium (1999). *Web Content Accessibility Guidelines 1.0. W3C Recommendation*. [Online]. Available at <http://www.w3.org/TR/1999/WAI-WEBCONTENT-19990505/>.
- The W3C Consortium (2000). "Techniques for Accessibility Evaluation And Repair Tools." (W3C Working Draft). [On line]. Available at <http://www.w3.org/TR/AERT>.

- U.S. Department of State (2004). *Electronic Commerce at the State Department*. [On line]. Available at <http://www.statebuy.state.gov/eleccon.htm>.
- Van Weele, A. (1994). *Purchasing Management: Analysis, Planning and Practice*. London, UK: Chapman & Hall.