Enabling Accessibility Characteristics in the Web Services Domain

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Abstract. Accessibility in ICT and web-based applications has become an issue of great importance during the last years. However, the notion of accessibility was until recently undervalued in the web services domain. Trying to fill this gap, this paper presents work conducted towards enabling web services (WS) with accessibility characteristics, trying to ensure that HCI through applications utilizing them is accessible. For this purpose, a WS accessibility assessment framework has been deployed, having as basis guidelines which if followed, can ensure that accessible WSs are developed. In order to further facilitate the development of accessible WSs, a WS accessibility assessment tool has been developed on the basis of the proposed framework. In its current implementation, the tool is capable to automatically assess whether SOAP- or REST- based services conform to proposed guidelines. Thus, by using this tool, developers can be significantly facilitated towards developing accessible web services, or also enriching their already developed not-accessible ones with accessibility characteristics and so as to make them accessible.

Keywords: Web Services, accessibility, assessment, Human Computer Interaction, User-centered design.

1 Introduction

People with disabilities hold an important amount of worldwide population and their proper inclusion in everyday life activities commands for special attention to be taken during design and development of ICT applications. In this line, accessibility in ICT has become a research field of great importance during the last years. As the Internet plays a major role in everyday life, a large number of research efforts have been conducted towards accessibility in the Web (e.g. [1-6]). Currently, the major steering body for Web accessibility is the World Wide Web Consortium (W3C) [7] and its Web Accessibility Initiative (WAI), which has three main working drafts: Web Content Accessibility Guidelines (WCAG) [8], Authoring Tool Guidelines and User Agent Guidelines. Although the accessibility of web applications and content delivered through the Internet has drawn much attention from the research community

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during the past years, no similar care has been taken so far in the web services domain. Web services (WSs) [9] play a key role for content delivery and service provision through the Internet. A vast amount of companies and non-profit organizations provides content and services through the Web by using this still evolving technology. To the present, two types of WSs can be considered as the most widely used, SOAP- [9][10] and REST-based [11] ones. The utilization of Web Services has been boosted through standardization efforts which have already been made regarding their proper specification and interoperability [12][13]. However, standards deployed so far do not take under consideration the fact that the content and functionality derived from WSs, delivered through end-user client applications should be accessible also to people with disabilities. As a result, Human-Computer Interaction (HCI) with end user applications that provide content or functionality derived through WS utilization may become inappropriate for users with special needs. Trying to fill this gap, this paper presents work conducted towards enabling web services with accessibility characteristics, trying to ensure that HCI through user agents utilizing them is accessible.

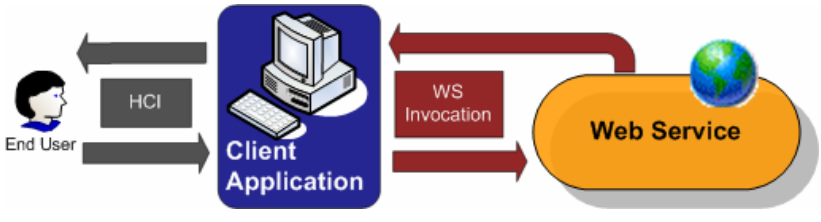

Fig. 1. The typical Web Service Utilization chain

Considering the typical web service utilization chain (Fig. 1), an end-user application typically contacts a WS and retrieves content, which is then presented to the end user through an appropriate interface. In the context of end users with special needs, there could be cases however where the content delivered cannot be presented through the user agent appropriately, due to the fact that no appropriate accessibility-related information (e.g. appropriate alternative text for image delivered) is provided through the service. Furthermore, even if the user agent is capable to present the retrieved content appropriately, there could be cases where the content itself is inappropriate for the end user. For instance, a lower-limb impaired end user could be directed from an info-mobility service to a restaurant which is inappropriate regarding her/his special needs (e.g. has no ramp at its entrance for wheelchair users). The present work tries exactly to fill these gaps, by building upon the notion of "accessible web service" and deploying a framework which ensures that web services are developed so as to allow for WS – based HCI be accessible both on presentation and content level. In this context, an "accessible web service" is defined as a WS that is 1) well-defined, well-working and easy to integrate within client applications, 2) has accessibility features that enable client applications to show the delivered content to end users with special needs, and 3) provides content that contains appropriate information, in order for the content itself to be actually helpful for end users with special needs.

Within the proposed framework, developed in the context of ACCESSIBLE [14] project, web service accessibility guidelines are defined, which if followed, are capable to ensure that the "WS invocation" part of the WS utilization chain allows for accessible HCI interaction at the end user – user agent level. These guidelines are categorized in three layers, the "core functional", "basic accessibility" and "extended accessibility" ones. Following the proposed guidelines during design and development of web services can lead to development of "accessible" ones, enhanced with accessibility features. In this context, trying to further facilitate the design of accessible services, these guidelines form the basis of a WS accessibility assessment framework deployed, capable to assess whether a service can be regarded as accessible. Within this framework, three accessibility classes are defined (Class "A", "AA" and "AAA"), which build upon the three layers of WS accessibility guidelines. The accessibility classes provide the means for service categorization in terms of accessibility guidelines followed. WS accessibility assessment is then further enhanced by an appropriate tool that has been developed, capable to automatically assess whether the service under evaluation conforms to the proposed accessibility guidelines. This tool facilitates accessibility assessment of both SOAP- and REST-based WSs. Thus, by elaborating a concrete WS accessibility assessment framework, and developing a tool for automatic WS accessibility assessment, the present work aims to facilitate the future development of accessible web services, which can be enriched by appropriate accessibility characteristics that will ensure accessibility at the HCI level of the web service utilization chain.

2 Web Service Accessibility Assessment Framework

The main idea behind this work is that interaction between client applications and web services can be enhanced with accessibility features. The intent of these features is to ensure that the Client Application – WS interaction part of the WS utilization chain (Fig. 1) allows for accessible HCI at the "End User - Client Application" level. For this purpose, the WS Accessibility Assessment framework developed assesses whether web services are accessible. Within this framework, WS accessibility is defined on the basis of a three-layer-architecture (Fig. 2); comprised of the "core functional", "basic accessibility" and "extended accessibility" layers. The rationale behind the proposed layers of accessibility is that in order for a service to be considered as fully accessible it has to:

1. Be well-defined, well-working and easy to integrate within client applications, so as for developers of client applications to be able to use the service's functionality and/or provided information effectively within their developed application's operational context. This requirement defines the concept behind the core functional layer.
2. Have accessibility features that will enable the client applications invoking the service to show the delivered content in an accessible way, in respect to the special needs of impaired user groups. This requirement defines the concept behind the basic accessibility layer.

3. Provide data which contains enough information, in order for the content itself to be helpful for impaired users, containing information adapted to their special needs. Based on this requirement, the extended accessibility layer is defined.

Whereas the two latter layers deal exactly with accessibility-related issues, the first one deals with characteristics that a WS has to have so as for it to be properly functional and easy to integrate within client applications. Obviously, dependencies exist among the above layers of accessibility. As an example, in order for a service to be able to have "basic accessibility", first it has to have those core functional features that will ensure its proper "core functionality". The concept behind this particular dependency can be considered as: "In order to make a service better in terms of accessibility, it should be working (well enough) first".

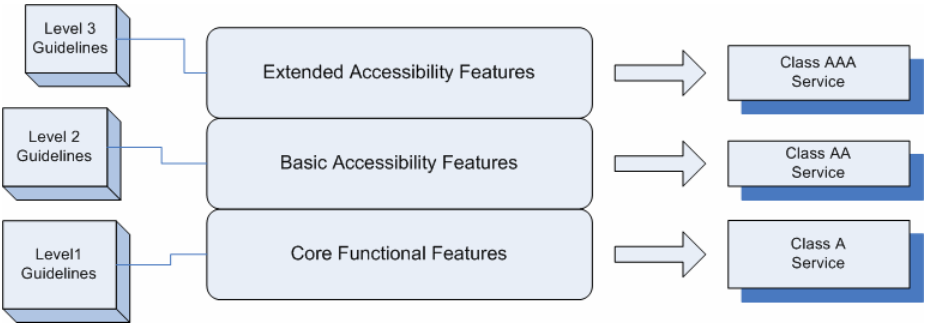

Fig. 2. Accessible Web Service Evaluation framework base

2.1 WS Accessibility Classes and Guidelines

The three aforementioned accessibility layers (core, basic and extended accessibility respectively) form the basis for defining three service accessibility classes (A, AA and AAA), which provide the means for service categorization based on service accessibility features. As shown in Fig. 2, within the proposed framework, a set of guidelines is defined in respect of each accessibility layer. If these guidelines are followed, they are able to provide a web service with functional and accessibility features (core, basic and extended) that will enable it to belong to the corresponding accessibility class. Furthermore, for each guideline proposed, a set of specific techniques are defined within the framework, which can be used to assess whether an already developed service belongs to a specific accessibility class or not.

Focusing more on the meaning of each accessibility class and its relation to the accessibility levels, it can be fist considered that "Class A" accessible services are accessible for "typical use", since they have features that ensure their proper "core functionality". In this context, "typical use" refers to a service's ability to provide, through the exchange of appropriate messages, functionality and information that can be delivered to users through "basic" User Interfaces (UIs) of client applications; these are UIs of client applications which not necessarily provide access to user groups with special needs, but provide content to not impaired users in an proper, effective and useful way. The guidelines that should be followed so as for the service

to belong to this class refer to general functional / operational characteristics of a service, which ensure the effective and efficient integration of its functionality and information delivered within appropriate "basic" client applications. Such an example is the Level 1 guideline defining that no one-way operations should be defined within a WS, since the client should always be properly informed that the WS it tried to invoke was indeed properly invoked through the invocation request message sent.

Then, "Class AA" accessible services are defined as those which are considered to be "accessible for Typical Use" (they have core functional features), and also have features that enable client applications to use their functionality and show the retrieved content appropriately to various user groups with special needs. Thus, these services have basic accessibility features as well. As an example, following the rationale behind the WCAG guidelines defined for web content; and in particular, the one denoting that alternative text should accompany any non-text content delivered through the web, one of the level 2 WS guidelines suggests that a service providing non-text content (e.g. images) upon invocation should also provide a text element that contains all the important information conveyed through the images.

Finally, "Class AAA" Services are those which are "Accessible for Typical Use", thus first of all they have core functional and basic accessibility features as well; and furthermore, the content that they provide contains adequate accessibility information, in order for it to be useful enough to impaired users. For instance, a service that provides route calculation functionality, may return apart from maps also textual information that can be presented to the end user through an assistive device (integrated in the client application). However, if the service has not taken into account the needs of the impaired end user during the route calculation process, the route returned may eventually be inaccessible. These services thus have extended accessibility features which allow them to provide content with information adapted to the special needs of impaired user groups. As an example, a level 3 guideline of the framework proposes that WS operations that deliver information regarding "points of interest" (e.g. restaurants, cinemas etc. in a city) should also provide for each point of interest information regarding its accessibility status in respect of different impaired user groups (e.g. wheelchair user).

As was also shown from the level 2 WS accessibility guideline example provided above, the guidelines defined within the proposed WS accessibility assessment framework were formed after thoroughly reviewing W3C's WCAG standardization guidelines regarding the accessibility of Web Content, in an effort to enhance Web Services with the concepts behind the Web Content Accessibility Guidelines proposed by W3C. Concluding, the proposed accessibility guidelines are categorized on the basis of three Guideline levels: Level 1, Level 2 and Level 3. These levels correspond to the three accessibility classes, Class A, Class AA and Class AAA respectively. In order for a service to belong to a specific class, it should meet guidelines that belong to the corresponding level and thus have the required, respective functional and accessibility features. At this point however, it has to be noted that the defined guidelines follow the SHALL-SHOULD-MAY convention, as outlined in RFC 2119 [15], and a distinction has been made between "mandatory" and "not mandatory" WS guidelines of each level. This was done due to the fact that some guidelines (e.g. alternative text accompanying images delivered) can be thought of higher importance than others towards ensuring that a service belongs to a specific

class of accessibility. Thus, even if all guidelines defined are suggested to be followed by WS developers where applicable, specific subsets of guidelines are defined as "mandatory" (and others as "not mandatory") at each level. Thus, for a service to belong to each accessibility class, the respective level's mandatory guidelines "shall" be followed. All of the proposed guidelines have been stored in an appropriate ontology in order to be used for the Web services assessment process described in the following.

3 Web Service Accessibility Assessment in Practice

In order to enable developers assess whether their WSs are enabled with necessary accessibility characteristics, a Web Service Assessment module has been developed (Fig. 3), responsible for the evaluation of Web Services through the above-described WS assessment framework. If regarded as a black box, this module takes as input the relevant "Web Service Description Language" (WSDL) [16] or "Web Application Description Language" (WADL) [17] file describing the WS under evaluation and the WS Accessibility Guidelines defined within the Accessible Ontology, and produces as output the result of the WS Accessibility Assessment process. During service assessment, the module communicates with (a) the WSs Ontology in order to get information regarding the Web Services Accessibility Guidelines defined and (b) an EARL (Evaluation and Report Language) [18] -based Reporting tool, responsible for translating the assessment result into EARL-based reports. These reports follow a standardized format, and thus can be used for present the result to the tool users in an appropriate way.

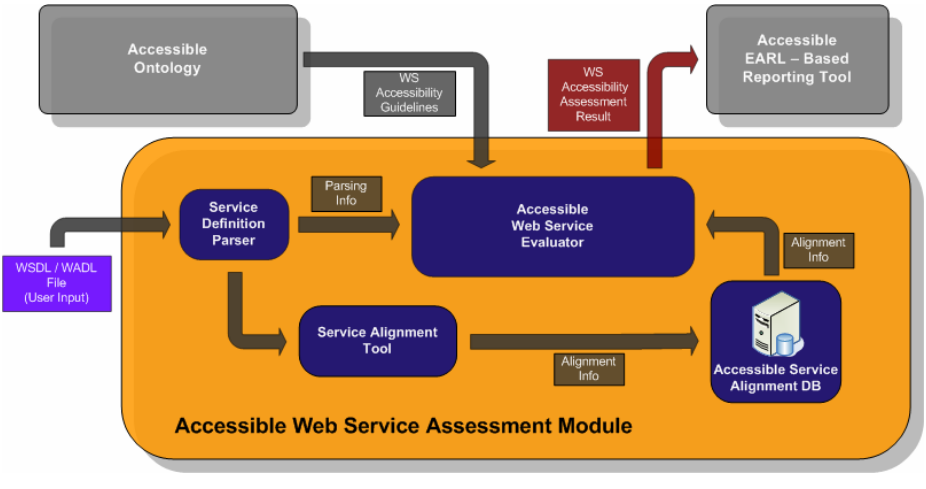

Fig. 3. Block Diagram of the Accessible Web Service Assessment Module

As depicted in Fig. 3 the accessible Web Service Assessment module consists of the following main components:

The Service Definition Parser: It is responsible for the parsing of formal XML-based files describing a Web Service. In the current implementation, these files can either be WSDL or WADL -based. The tool takes as input the WSDL or WADL file describing a Web Service (SOAP- or a REST- based respectively) and produces Java structures that hold information regarding the WS, appropriate for further processing and accessibility evaluation. It has to be noted at this point that since WADL files are not at the moment a commonly used standard followed to describe REST WSs, the tool also offers its users the capability to define the structure of their WS through an appropriate UI, without needing to provide any WADL file describing the service. Thus, in this case the use of the service definition parser is omitted. Finally, it has also to be noted that the service definition parsing module is extensible so as to allow (after the integration of further appropriate modules) the parsing of further service types that could be defined in the future, given that these services can be regarded as black boxes with specific input and output data structures.

The Service Alignment Tool: This tool offers the service evaluator the capability to "align" Web Services to the Accessible WS "Ideal Operations" defined within the ACCESSIBLE Ontology. The alignment process enables the tool to identify specific requirements that the input/output structures of the service under assessment should have, on the basis of the service category. For instance, a web service operation that returns information related to points of interests has to follow some level 3 WS accessibility guidelines that are different from some level 3 followed by a service offering route calculation capabilities. For the purposes of this process, currently a set of ideal operations has been defined. Some of them refer to general purpose WSs, such as: Image, Audio, Video or Textual Info Provider operations, whereas others are more specific and deal for instance with "info-mobility" WSs, such as the "points of interest" info provider and "route calculation" operations. As example, two of the already defined ideal operations are shown in more detail in Fig. 4.

Image Provider operation	**Points of Interest Provider Operation**
Inputs: -	**Inputs**: User Category
Outputs: Image Object, Image Object URL, Alternative Text	**Outputs**: Point of Interest {User Group, POI Accessibility Status, POI Accessibility Status Details}

Fig. 4. Example ideal WS operations defined in the ACCESSIBLE ontology

The image provider ideal operation holds the minimum necessary elements that a Web Service delivering images (e.g. maps) should have, in order for it to be considered as accessible. In particular, as denoted in its output (Fig. 4), an alternative text element should accompany every image delivered through the WS. This alternative text should be a description of the image, capable to be handled for example by appropriate text-to-speech modules integrated in the end user app utilizing the service, so as for the information conveyed through the image to be accessible also to blind end users. Similarly, the Points of Interest info provider ideal

operation defines that a web service of this kind should provide in each delivered block of information that regards a specific "point of interest" (e.g. a restaurant), additional information regarding the POI's accessibility status in respect of different end user categories (e.g. wheelchair user etc.). Apart from enabling the tool identify the WS type and whether specific elements exist in the input/output data structures, these ideal operations provide the developers also with a more direct guide over accessibility characteristics that their service should have (in respect of the WS category it belongs to) so as for it to be regarded as accessible.

The Accessible Web Service Evaluator: This component is responsible for interpreting and combining information gathered from the above-described modules, so as to conclude whether the service under assessment belongs to a specific accessibility class or not. In particular, it takes as input the (a) information derived from the parsing of the WSDL file, (b) the information derived from the alignment of the Service's operations to the concepts defined within the "Ideal" ones and (c) the Web Service Accessibility Guidelines defined within the Ontology. The Accessible WS Evaluator combines these three inputs and produces as output the WS Accessibility Assessment result, which is then passed to the Accessible EARL – based reporting tool responsible for the EARL-based Accessibility Report generation.

3.1 WS Accessibility Assessment Procedure

The assessment procedure supported from the Web Service Assessment tool consists of the following steps:

1. *Parsing of a Web Service's definition (WSDL or WADL) file*: During this initial step, the definition file Parser acquires information regarding the operations defined within the Service under evaluation. During the parsing process, all the information contained in the WSDL or WADL file is transferred in Java-based structures, appropriate for further processing and evaluation of the Accessible WS Accessibility Guidelines.
2. *Automatic evaluation of the Service's accessibility status based on information acquired from step 1*: Within this step, all information acquired from step 1 is used from the Web Service Evaluator in order to evaluate a limited set of the Service Accessibility Guidelines. This limited set contains all Accessibility Guidelines that can be automatically checked by using the information acquired so far from step 1.
3. *Alignment of the service's operations to the Accessible "Ideal Operation" elements, defined within the Ontology:* By utilizing the service alignment capabilities offered from the ASK-IT Service Alignment Tool, the Accessible Web Service Assessment Module acquires more information regarding the Service's operations and their input and output structures. Within this process, the service assessment tool is asked to align the operations defined within the Service's WSDL file and their input and output elements to corresponding ones, defined within the "Ideal Operations". The alignments produced are then ready to be used from the Accessible WS Evaluator during Step 4.
4. *Automatic evaluation of the Service's accessibility status based on the combined information acquired from steps 1 and 3:* Within this step, all information acquired

from steps 1 and 3 is used in order for the Accessible WS Evaluator to evaluate a broader set of Guidelines than the one assessed during step 2.

5. *Manual evaluation of the Guidelines that cannot be assessed automatically by using the information acquired from steps 1 and 3:* During this step, the (user) evaluator of the service manually evaluates the service against the Guidelines not previously checked until step 4. The evaluator, for the purposes of this task, is offered the capability to invoke the Web Service's operations by using the dynamic invocation option provided from the Accessible WSDL Parser, in order to check more accessibility Guidelines.

4 Conclusions

This paper presents work conducted towards enabling accessibility characteristics in the WS domain. The target is to ensure that the "Client Application – WS interaction" part of the WS utilization chain allows for accessible HCI at the "End User - Client Application" level. For this purpose, this work takes a step forward and proposes a three-layer WS accessibility assessment framework, which can form the basis towards the future development of "accessible web services"; namely services that are well-defined, well-working and easy to integrate within client applications, provide content which is accessible to impaired users and conveys information that can be actually helpful to them, adapted to their special needs. The WS accessibility assessment tool developed on the basis of the proposed framework is then capable to facilitate WS developers, towards creating services that conform to the accessibility guidelines, and thus are enabled with characteristics that make them accessible.

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