

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

accessiBe Ltd.,
Petitioner

v.

AudioEye, Inc.,
Patent Owner.

Patent No. 11,061,532

IPR Case No.: IPR2022-01492

DECLARATION OF SYLVIA D. HALL-ELLIS, PH.D.

I. INTRODUCTION

1. My name is Sylvia D. Hall-Ellis. I have been retained as an expert by accessiBe Ltd. (“Petitioner”).

2. I submit this Declaration to provide my expert opinions regarding the date of public availability or accessibility of two publications attached hereto as Exhibits 1001 and 1002. My Declaration sets forth my opinions in detail and provides the bases for my opinions.

3. I reserve the right to supplement or amend my opinions, and bases for them, in response to any additional evidence, testimony, discovery, argument, and/or other additional information that may be provided to me after the date of this Declaration.

4. I am being compensated for my time spent working on this matter at my normal consulting rate of \$325 per hour, plus reimbursement for any additional reasonable expenses. My compensation does not in any way depend on the content of this Declaration, the substance of my opinions, or the outcome of this litigation. I have no interest in this proceeding or in any of the parties.

5. All of the materials that I considered are discussed explicitly in this Declaration.

II. QUALIFICATIONS & BACKGROUND

6. I am currently an Adjunct Professor in the School of Information at

San José State University. I obtained a Master of *Library Science* from the University of North Texas in 1972, a Master of *Professional Studies* from the University of Denver in 2014, and a Ph.D. in *Library Science and Information Science* from the University of Pittsburgh in 1985. Over the last fifty years, I have held various positions in the field of library and information resources. I was first employed as a librarian in 1966 and have been involved in the field of library sciences since, holding numerous positions.

7. I am a member of the American Library Association (ALA) and its Association for Library Collections & Technical Services (ALCTS) Division, and I served on the Committee on Cataloging: Resource and Description (which wrote the new cataloging rules) and as the chair of the Committee for Education and Training of Catalogers and the Competencies and Education for a Career in Cataloging Interest Group. I also served as the founding Chair of the ALCTS Division's Task Force on Competencies and Education for a Career in Cataloging. Additionally, I have served as the Chair for the ALA Office of Diversity's Committee on Diversity, as a member of the REFORMA National Board of Directors, as a member of the Editorial Board for the ALCTS premier cataloging journal, *Library Resources and Technical Services*, and as a Co-Chair for the Library Research Round Table of the ALA.

8. I have also given over one hundred presentations in the field,

including several on library cataloging systems and Machine-Readable Cataloging (MARC) standards. My current research interests include library cataloging systems, metadata, and organization of electronic resources.

9. I have previously served as an expert witness in approximately 600 cases over the course of the last decade. I have extensive experience opining on the publication status of printed references in patent litigations in federal district courts and in proceedings before the Patent Trial and Appeal Board. I have been deposed twenty-one times. I have not testified at trial.

10. My full curriculum vitae is attached hereto as Exhibit 1.

III. SCOPE OF OPINIONS

11. I am not an attorney and will not offer opinions on the law. I am, however, rendering my expert opinion on the dates of public accessibility of the references discussed herein, including when and how each reference was disseminated or otherwise made available to persons interested and ordinarily skilled in the subject matter or art, exercising reasonable diligence. In particular, I am rendering opinions on how such persons could have located, before March 18, 2016, the references discussed below.

IV. LEGAL STANDARDS

12. I am informed by counsel and understand that a printed publication is deemed publicly accessible as of the date it was disseminated or otherwise made

available such that a person interested in and ordinarily skilled in the relevant subject matter could locate it through the exercise of ordinary diligence.

13. I also understand that public accessibility is a case-by-case determination based on circumstances particular to an individual publication. I further understand, however, that a printed publication is rendered “publicly accessible” if a person of ordinary skill in the art, exercising reasonable diligence, would have located the publication, or would have known to look for it. I further understand that a printed publication is thus rendered “publicly accessible” if it is filed in an online database that is cataloged and indexed such that a person interested in the relevant subject matter could locate it (*i.e.*, I understand that cataloging and indexing by an online database is sufficient, though there are other ways that a printed publication may qualify as publicly accessible). One manner of sufficient indexing is indexing according to subject matter category. I understand that the cataloging and indexing by a database of a single instance of a particular printed publication is sufficient, even if that database is hosted by a foreign country. I understand that, even if access to a database is restricted, a printed publication that has been cataloged and indexed therein is deemed publicly accessible if the public concerned with the relevant subject matter would know of the printed publication. I also understand that the cataloging and indexing of information that would guide a person interested in the relevant subject matter to

the printed publication, such as the cataloging and indexing of an abstract for the printed publication, is sufficient to render the printed publication publicly accessible.

14. I understand that routine business practices, such as general database and library cataloging and indexing practices, can be used to establish an approximate date on which a printed publication became publicly accessible.

V. PERSONS OF ORDINARY SKILL IN THE ART

15. I am informed by counsel that the subject matter of this proceeding relates to website accessibility remediation.

16. I am informed by counsel that a “person of ordinary skill in the art at the time of the inventions” is a hypothetical person who is presumed to be familiar with the relevant field and its literature at the time of the inventions. This hypothetical person is also a person of ordinary creativity, capable of understanding the scientific principles applicable to the pertinent field.

17. I am informed by counsel that the parties have offered two, competing definitions of the qualifications necessary for a person of ordinary skill in this subject matter. I am informed by counsel that Patent Owner’s expert in the related district court proceedings has opined that persons of ordinary skill in this subject matter or art would have had a bachelor’s degree in software engineering, computer science, computer engineering, or related field, with at least two years of

experience developing and commercializing websites, web applications, and distributed software systems or (1) more formal education (such as a master's of science degree) and less technical experience or (2) less formal education and more technical or professional experience.

18. I also am informed by counsel that Petitioner contends that a person of ordinary skill in the art would have had at least a bachelor's degree in software engineering, computer science, computer engineering, or related field, with at least two years of experience with developing software with accessibility applications. A person could also qualify as a person of ordinary skill with some combination of (1) more formal education (such as a master's of science degree) and less technical experience or (2) less formal education and more technical or professional experience with accessibility-focused software development.

19. Regardless of which party's definition of a "person of ordinary skill in the art" is adopted, my opinion remains the same. It is my opinion that such a person would have been engaged in research, learning, study, and practice in the field, and possibly formal instruction so that bibliographic resources relevant to his or her research would be familiar. Before March 18, 2016, such a person would have had access to an array of long-established print resources in computer science, software engineering, computer engineering, or related field as well as online resources providing indexing information, abstracts, and full text services

for resources in the aforementioned fields.

VI. LIBRARY PROFESSIONAL PRACTICES

20. In preparing this Declaration, I used authoritative databases, including the OCLC bibliographic database, the Library of Congress Online Catalog, the Library of Congress Subject Authorities, the Association for Computing Machinery's *ACM Digital Library*, *ResearchGate*, and *Semantic Scholar*, to confirm citation details of the publication discussed.

21. ***Indexing.*** A researcher may discover material relevant to his or her topic in a variety of ways. One common means of discovery is to search for relevant information in an index of periodical and other publications. Having found relevant material, the researcher will then normally obtain it online, look for it in libraries, or purchase it from the publisher, a bookstore, a document delivery service, or other provider. Sometimes, the date of a document's public accessibility will involve both indexing and library date information. However, date information for indexing entries is often unavailable. This is especially true for online indices.

22. Indexing services use a wide variety of controlled vocabularies to provide subject access and other means of discovering the content of documents. The Library of Congress Subject Authorities includes standard forms of terms and cross references that are included in bibliographic records. Subject headings are

terms that an individual seeking a document regardless of format can enter in the search bar of the online catalog. Subjects also connect an authenticated term (one included in the Library of Congress subject headings list) with related, broader, and narrower terms.

23. Online indexing services commonly provide bibliographic information, abstracts, and full-text copies of the indexed publications, along with a list of the documents cited in the indexed publication. These services also often provide lists of publications that cite a given document. A citation of a document is evidence that the document was publicly available and in use by researchers no later than the publication date of the citing document.

24. Databases and digital repositories like those mentioned in paragraph 24 provide search capabilities through title, author, subject, keyword, and standard numbers (ISBN and ISSN) that enable information professionals and individuals to locate books, articles, conference papers, and other publications. The databases and digital repositories include retrospective collections of scanned or digitized materials and are updated regularly. Collegiate and university studies at the undergraduate and graduate level require that students develop familiarity and proficiency using indexing services, databases, and digital repositories.

V. LIBRARY CATALOGING PRACTICES

25. I am fully familiar with the library cataloging standard known as the MARC standard, which is an industry-wide standard method of storing and organizing library catalog information. MARC was first developed in the 1960's by the Library of Congress. A MARC-compatible library is one that has a catalog consisting of individual MARC records for each of its items. Today, MARC is the primary communications protocol for the transfer and storage of bibliographic metadata in libraries.¹

26. Since at least the early 1970s and continuing to the present day, MARC has been the primary communications protocol for the transfer and storage of bibliographic metadata in libraries.²

27. You could devise your own method of organizing the bibliographic information, but you would be isolating your library, limiting its options, and

¹ Almost every major library in the world is MARC-compatible. *See, e.g., MARC Frequently Asked Questions (FAQ)*, Library of Congress, <https://www.loc.gov/marc/faq.html> (last visited July 25, 2022).

² A complete history of the development of MARC can be found in *MARC: Its History and Implications* by Henrietta D. Avram (Washington, DC: Library of Congress, 1975) and available online from the Hathi Trust (<https://babel.hathitrust.org/cgi/pt?id=mdp.39015034388556;view=1up;seq=1>; last visited July 25, 2022).

creating much more work for yourself. Using the MARC standard prevents duplication of work and allows libraries to better share bibliographic resources. Choosing to use MARC enables libraries to acquire cataloging data that is predictable and reliable. If a library were to develop a “home-grown” system that did not use MARC records, it would not be taking advantage of an industry-wide standard whose primary purpose is to foster communication of information.

28. Using the MARC standard also enables libraries to make use of commercially available library automation systems to manage library operations. Many systems are available for libraries of all sizes and are designed to work with the MARC format. Systems are maintained and improved by the vendor so that libraries can benefit from the latest advances in computer technology. The MARC standard also allows libraries to replace one system with another with the assurance that their data will still be compatible.

29. You could devise your own method of organizing the bibliographic information, but you would be isolating your library, limiting its options, and creating much more work for yourself. Using the MARC standard prevents duplication of work and allows libraries to better share bibliographic resources. Choosing to use MARC enables libraries to acquire cataloging data that is predictable and reliable. If a library were to develop a “home-grown” system that

did not use MARC records, it would not be taking advantage of an industry-wide standard whose primary purpose is to foster communication of information.

30. Using the MARC standard also enables libraries to make use of commercially available library automation systems to manage library operations. Many systems are available for libraries of all sizes and are designed to work with the MARC format. Systems are maintained and improved by the vendor so that libraries can benefit from the latest advances in computer technology. The MARC standard also allows libraries to replace one system with another with the assurance that their data will still be compatible.

31. Thus, almost every major library in the world is MARC-compatible. See, e.g., *MARC Frequently Asked Questions (FAQ)*, Library of Congress, <https://www.loc.gov/marc/faq.html> (last visited July 25, 2022) (“MARC is the acronym for MACHine-Readable Cataloging. It defines a data format that emerged from a Library of Congress-led initiative that began nearly fifty years ago. It provides the mechanism by which computers exchange, use, and interpret bibliographic information, and its data elements make up the foundation of most library catalogs used today.”). MARC is the ANSI/NISO Z39.2-1994 standard (reaffirmed in 2016) for Information Interchange Format. The full text of the

standard is available from the Library of Congress.³

32. A MARC record comprises several fields, each of which contains specific data about the work. Each field is identified by a standardized, unique, three-digit code corresponding to the type of data that follow. For example, a work's title is recorded in Field 245; the primary author of the work is transcribed in Field 100; an item's International Standard Book Number ("ISBN") consisting of ten or thirteen digits is transcribed in Field 020; an item's International Standard Serial Number ("ISSN") is transcribed in Field 022; the Library of Congress classification notation is recorded in Field 050; and the publication date is recorded in Field 260 under the subfield "c." If a work is a periodical, then its publication frequency is recorded in Field 310, and the publication dates (e.g., the first and last publication) are recorded in Field 362, which is also referred to as the enumeration/chronology field.⁴

33. The library that created the record is recorded in field 040 in subfield "a" with a unique library code. When viewing the MARC record online via Online

³ See *MARC 21 Format for Bibliographic Data*, Library of Congress, <http://www.loc.gov/marc/bibliographic/> (last visited July 25, 2022).

⁴ See *3XX - Physical Description, Etc. Fields - General Information*, Library of Congress, <http://www.loc.gov/marc/bibliographic/bd3xx.html> (last visited July 25, 2022).

Computer Library Center's ("OCLC") bibliographic database, hovering over this code with the mouse reveals the full name of the library. I used this method of "mousing over" the library codes in the OCLC database to identify the originating library for the MARC records discussed in this Report. Where this "mouse over" option was not available, I consulted the Directory of OCLC Libraries in order to identify the institution that created the MARC record.⁵

34. MARC records also include several fields that include subject matter classification information. An overview of MARC record fields is available through the Library of Congress.⁶ For example, 6XX fields are termed "Subject Access Fields."⁷ Among these, for example, is the 650 field; this is the "Subject Added Entry – Topical Term" field.⁸ The 650 field is a "[s]ubject added entry in which the entry element is a topical term."⁹ These entries "are assigned to a

⁵ See *Directory of OCLC members*, OCLC, <https://www.oclc.org/en/contacts/libraries.html> (last visited July 25, 2022).

⁶ See *MARC 21 Format for Bibliographic Data*, Library of Congress, <http://www.loc.gov/marc/bibliographic/> (last visited July 25, 2022).

⁷ See *6XX - Subject Access Fields-General Information*, Library of Congress, <http://www.loc.gov/marc/bibliographic/bd6xx.html> (last visited July 25, 2022).

⁸ See *650 - Subject Added Entry-Topical Term (R)*, Library of Congress, <http://www.loc.gov/marc/bibliographic/bd650.html> (last visited July 25, 2022).

⁹ See *id.*

bibliographic record to provide access according to generally accepted thesaurus-building rules (e.g., *Library of Congress Subject Headings* (LCSH), *Medical Subject Headings* (MeSH)).”¹⁰ Further, MARC records include call numbers, which themselves include a classification number. For example, the 050 field is the “Library of Congress Call Number.”¹¹ A defined portion of the Library of Congress Call (LCC) Number is the classification number, and “source of the classification number is *Library of Congress Classification* and the *LC Classification-Additions and Changes*.”¹² Thus, included in the 050 field is a subject matter classification. Further, the 082 field is the “Dewey Decimal Call Number.”¹³ A defined portion of the Dewey Decimal Call (DDC) Number is the classification number, and the “source of the classification number is the *Dewey Decimal Classification*.”¹⁴ Thus, included in the 082 field is a subject matter classification.

¹⁰ *See id.*

¹¹ *See 050 - Library of Congress Call Number (R)*, Library of Congress, <http://www.loc.gov/marc/bibliographic/bd050.html> (last visited July 25, 2022).

¹² *See id.*

¹³ *See 082 - Dewey Decimal Classification Number (R)*, Library of Congress, <http://www.loc.gov/marc/bibliographic/bd082.html> (last visited July 25, 2022).

¹⁴ *See id.*

35. Each item in a library has a single classification number. A library selects a classification scheme (*e.g.*, the Library of Congress classification scheme just described or a similar scheme such as the Dewey Decimal classification scheme) and uses it consistently. When the Library of Congress assigns the LCC classification number, it appears as part of the 050 field. When the Library of Congress assigns the DDC classification number, it appears as part of the 082 field. If a local library assigns the classification number, it appears in a 090 field.¹⁵ In either scenario, the MARC record includes a classification number that represents a subject matter classification.

36. The OCLC was created “to establish, maintain and operate a computerized library network and to promote the evolution of library use, of libraries themselves, and of librarianship, and to provide processes and products for the benefit of library users and libraries, including such objectives as increasing availability of library resources to individual library patrons and reducing the rate of rise of library per-unit costs, all for the fundamental public purpose of furthering ease of access to and use of the ever-expanding body of worldwide scientific,

¹⁵ See *09X - Local Call Numbers*, Library of Congress, <https://www.loc.gov/marc/bibliographic/bd09x.html> (last visited July 25, 2022).

literary and educational knowledge and information.”¹⁶ Among other services, OCLC and its members are responsible for maintaining the WorldCat database (<http://www.worldcat.org/>), used by independent and institutional libraries throughout the world.

37. OCLC also provides its members online access to MARC records through its OCLC bibliographic database. When an OCLC member institution acquires a work, it creates a MARC record for this work in its computer catalog system in the ordinary course of its business. MARC records created at the Library of Congress were tape-loaded into the OCLC database through a subscription to MARC Distribution Services daily or weekly. Once the MARC record is created by a cataloger at an OCLC member institution or is tape-loaded from the Library of Congress, the MARC record is then made available to any other OCLC members online, and therefore made available to the public. Accordingly, once the MARC record is created by a cataloger at an OCLC member institution or is tape-loaded from the Library of Congress or another library anywhere in the world, any publication corresponding to the MARC record has been cataloged and indexed

¹⁶ Third Article, Amended Articles of Incorporation of OCLC (Online Computer Library Center), Incorporated (revised July 25, 2022), <https://www.oclc.org/content/dam/oclc/membership/articles-of-incorporation.pdf> (last visited July 25, 2022).

according to its subject matter such that a person interested in that subject matter could, with reasonable diligence, locate and access the publication through any library with access to the OCLC bibliographic database or through the Library of Congress.

38. When an OCLC member institution creates a new MARC record, OCLC automatically supplies the date of creation for that record. The date of creation for the MARC record appears in the fixed Field (008), characters 00 through 05. The MARC record creation date reflects the date on which, or shortly after which, the item was first acquired or cataloged. Initially, Field 005 of the MARC record is automatically populated with the date the MARC record was created in year, month, day format (YYYYMMDD) (some of the newer library catalog systems also include hour, minute, second (HHMMSS)). Thereafter, the library's computer system may automatically update the date in Field 005 every time the library updates the MARC record (*e.g.*, to reflect that an item has been moved to a different shelving location within the library). Field 005 is visible when viewing a MARC record via an appropriate computerized interface, but when a MARC record is printed to hardcopy, no "005" label appears. The initial Field 005 date (*i.e.*, the date the MARC record was created) does appear, however,

next to the label “Entered.”¹⁷ The date upon which the most recent update to Field 005 occurred also appears, next to the label “Replaced.” Thus, when an item’s MARC record has been printed to hardcopy—as is the case with the exhibits to this Report—the date reflected next to the label “Entered” is necessarily on or after the date the library first cataloged and indexed the underlying item.

39. Once one library has cataloged and indexed a publication by creating a MARC record for that publication, other libraries that receive the publication do not create additional MARC records—the other libraries instead rely on the original MARC record. They may update or revise the MARC record to ensure accuracy, but they do not replace or duplicate it. This practice does more than save libraries from duplicating labor. It also enhances the accuracy of MARC records. Further, it allows librarians around the world to know that a particular MARC record is authoritative (in contrast, a hypothetical system wherein duplicative records were created would result in confusion as to which record is authoritative).

40. *Serials.* In addition to creating records for books, OCLC also hosts records for serial publications. Serial publications have the same collective title

¹⁷ Field 005 is visible when viewing a MARC record via an appropriate computerized interface. But when a MARC record is printed directly to hardcopy from the OCLC database, the “005” label is not shown. The date in the 005 field instead appears next to the label “Replaced.”

but are intended to continue indefinitely with enumeration such as a volume or issue number (*e.g.*, magazines, journals, etc.). In the OCLC bibliographic database, the first issue of the serial publication is typically cataloged, but the date is left open-ended with the use of a punctuation mark such as a dash. Individual issues are not cataloged according to the current national cataloging rules outlined in *RDA: Resource and Access*.

41. MARC records for serial publication in OCLC represent the entire run of the serial title. With knowledge of the first issue published, future issues can be predicted. In my extensive professional experience, is it highly unusual for a library to stop collecting and shelving a serial publication prior to the end of its publication run. If a subscription to a serial publication ends its run or is cancelled before the end of its run, the library will denote that it has stopped receiving new volumes by filling in the end date in the local MARC record.

42. The foregoing process has been standard library practice longer than I have been working in the profession. I first learned the steps in the process in the late 1970s and later supervised it. Although the checking in process has become automated and now links electronically to holdings records for the MARC record for each serial title, the manual placement of a stamp or label and placing the issue in a public area has not changed for 50 years. Unless I note otherwise below in reference to a specific serial publication, it is my expert opinion that this standard

protocol was followed for the serial publications discussed below.

VII. PUBLICATIONS

A. Publication 1, Exhibit 1001, “WebInSight: Making Web Images Accessible” by Jeffrey P. Bigham, Ryan S. Kaminsky, Richard E. Ladner, Oscar M. Danielsson, and Gordon L. Hempton (“Bigham”)

43. Attached hereto is Exhibit 1001, which I understand is being submitted along with my declaration, is a copy of a conference paper published in the *Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility* found in the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. The conference paper titled “WebInSight: Making Web Images Accessible” by Jeffrey P. Bigham, Ryan S. Kaminsky, Richard E. Ladner, Oscar M. Danielsson, and Gordon L. Hempton (hereafter “Bigham”) appears beginning on page 181. The 8th International ACM SIGACCESS Conference on Computers and Accessibility was held on October 23-25, 2006, in Portland, Oregon.

44. Exhibit 1001 is a true and correct copy of the cover, title page, copyright page, table of contents, and the Bigham conference paper (pages 181-188). I obtained this copy of the conference paper from the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. Specifically, the text of the Bigham conference paper is complete; no pages are missing, and the text on each page appears to flow seamlessly from one page to the next; further,

there are no visible alterations to the document. Exhibit 1001 was found within the custody of a library – a place where, if authentic, a copy of this conference proceedings volume would likely be. Exhibit 1001 is a true and correct copy in a condition that creates no suspicion about authenticity.

45. The Bigham conference paper is also available in the *ACM Digital Library*.¹⁸

46. Attached hereto as Attachment 1a is a true and correct copy of the MARC record for this monographic serial of conference proceedings volumes from the University of Wisconsin – Madison Libraries online catalog. The library ownership is indicated by the presence of the library’s code (GZM) in the 049 field. The library continues to update this MARC record and enhanced the MARC record to meet current cataloging rules. The most recent enhancement to the MARC record occurred on March 16, 2011, as shown in field 005 (“20110316”). I personally identified and retrieved the library catalog record which is Attachment 1a.

47. Based on finding a print copy of Exhibit 1001 in the University of Wisconsin – Madison Libraries and MARC record in its online library catalog attached as Attachment 1a, it is my opinion that the book *Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility* was

¹⁸ <https://dl.acm.org/doi/10.1145/1168987.1169018>

publicly available at the University of Wisconsin – Madison Libraries as of January 18, 2007. The Bigham conference paper was available in print and online in the *ACM Digital Library*.¹⁹

48. Attached hereto as Attachment 1b is a true and correct copy of the MARC record for the print monographic serial titled *Proceedings of the International ACM SIGACCESS Conference on Computers and Accessibility* obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 1b. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 1b, that library code is “TXH,” which means that the MARC record for this monographic serial was cataloged in the University of Houston Libraries (Houston, Texas). As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the University of Houston Libraries created OCLC record number 57135454 on December 2, 2004, as shown in the “Entered” field (“19900921”). The library continues to update this MARC record the MARC record to meet current cataloging rules. The most recent enhancement to the MARC record occurred on May 23, 2022, as shown in the “Replaced” field (“20220523”).

49. Attachment 1b further includes an entry in field 050 (“HV1569.5 \$b

¹⁹ *Ibid.*

.A26a”)—as described above, a subject matter classification number consistent with the Library of Congress classification system (analogous to the Dewey Decimal classification system) and an entry in field 082 (“621”)—as described above, a subject matter classification number consistent with the Dewey Decimal classification system. Attachment 1b also shows that the monographic serial was catalogued with two descriptor terms reading “Computers and people with disabilities \$v Congresses” (see Attachment 1c, Library of Congress subject heading sh86002534 and Attachment 1d, Library of Congress subject heading sh85031115) and “Computerized self-help devices for people with disabilities \$v Congresses” (Attachment 1e, Library of Congress subject heading sh86002525 and Attachment 1d, Library of Congress subject heading sh85031115) in the 650 fields. Thus, as of its cataloging, the publication corresponding to the MARC record attached hereto as Attachment 1b was indexed according to its subject matter by virtue of at least three independently sufficient classifications: the field 050 entry, the field 082 entry, and the field 650 entries. Further, as of December 2, 2004, the MARC record attached hereto as Attachment 1b was accessible through any library with access to the OCLC bibliographic database or the online catalog at a library that acquired the monographic serial, which means that the corresponding publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

50. Attachment 1b indicates that the volume titled *Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility* as cataloged at the University of Houston Libraries is currently available from 80 libraries. In view of the above, the print version of the volume titled *Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility* was publicly available on or shortly after January 18, 2007, because by that date it had been received, cataloged, and indexed at the University of Houston Libraries, made part of the OCLC bibliographic database, and available in the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. For these reasons, it is my opinion that Exhibit 1001 was published and publicly accessible on or shortly after January 18, 2007.

B. Publication 2, Exhibit 1002, “Collaborative Web Accessibility Improvement: Challenges and Possibilities” by Hironobu Takagi, Shinya Kawanaka, Masatomo Kobayashi, Daisuke Sato, and Chieko Asakawa (“Takagi”)

51. Attached hereto is Exhibit 1002, which I understand is being submitted along with my declaration, is a copy of a conference paper published in the *Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility* found in the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. The conference paper titled “Collaborative Web Accessibility Improvement: Challenges and Possibilities” by Hironobu Takagi, Shinya Kawanaka, Masatomo Kobayashi, Daisuke Sato, and Chieko

Asakawa (hereafter “Takagi”) appears beginning on page 195. The 11th International ACM SIGACCESS Conference on Computers and Accessibility was held on October 26-28, 2009, in Pittsburgh, Pennsylvania. Exhibit 1002 is a true and correct copy of the cover, title page, copyright page, table of contents, and the Takagi conference paper (pages 195-202).

52. I obtained this copy of the conference paper in the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. Specifically, the text of the Takagi conference paper is complete; no pages are missing, and the text on each page appears to flow seamlessly from one page to the next; further, there are no visible alterations to the document. Exhibit 1002 was found within the custody of a library – a place where, if authentic, a copy of this conference proceedings volume would likely be. Exhibit 1002 is a true and correct copy in a condition that creates no suspicion about authenticity.

53. The Tagaki conference paper is also available in the *ACM Digital Library*²⁰ and the digital repositories *ResearchGate*²¹ and *Semantic Scholar*.²²

54. Attached hereto as Attachment 2a is a true and correct copy of the MARC record for this monographic serial of conference proceedings volumes from the University of Wisconsin – Madison Libraries online catalog. The library ownership is indicated by the presence of the library’s code (GZM) in the 049 field. The library continues to update this MARC record and enhanced the MARC record to meet current cataloging rules. The most recent enhancement to the MARC record occurred on March 16, 2011, as shown in field 005 (“20110316”). I personally identified and retrieved the library catalog record which is Attachment 2a.

55. Based on finding a print copy of Exhibit 1002 in the University of Wisconsin – Madison Libraries and MARC record in its online library catalog attached as Attachment 1a, it is my opinion that the book *Proceedings of the 11th*

²⁰ <https://dl.acm.org/doi/10.1145/1168987.1169018>

²¹

https://www.researchgate.net/publication/221652046_Collaborative_web_accessibility_improvement_Challenges_and_possibilities

²² <https://www.semanticscholar.org/paper/Collaborative-web-accessibility-improvement%3A-and-Takagi-Kawanaka/c81b4fc6e00501d20d337fd5075d7ab2e01a9042>

International ACM SIGACCESS Conference on Computers and Accessibility was publicly available at the University of Wisconsin – Madison Libraries as of October 27, 2009. The Takagi conference paper was available in print and online in the *ACM Digital Library*.²³

56. Attached hereto as Attachment 2b is a true and correct copy of the MARC record for the print monographic serial titled *Proceedings of the International ACM SIGACCESS Conference on Computers and Accessibility* obtained from the OCLC bibliographic database. I personally identified and retrieved the MARC record that is Attachment 2b. As previously noted, the library that created the record is recorded in field 040 with a unique library code. For Attachment 2b, that library code is “TXH,” which means that the MARC record for this monographic serial was cataloged in the University of Houston Libraries (Houston, Texas). As can be seen in the “Entered” field in the MARC record for this exhibit, a cataloger at the University of Houston Libraries created OCLC record number 57135454 on December 2, 2004, as shown in the “Entered” field (“19900921”). The library continues to update this MARC record the MARC record to meet current cataloging rules. The most recent enhancement to the MARC record occurred on May 23, 2022, as shown in the “Replaced” field (“20220523”).

²³ <https://dl.acm.org/doi/10.1145/1168987.1169018>

57. Attachment 2b further includes an entry in field 050 (“HV1569.5 \$b .A26a”)—as described above, a subject matter classification number consistent with the Library of Congress classification system (analogous to the Dewey Decimal classification system) and an entry in field 082 (“621”)—as described above, a subject matter classification number consistent with the Dewey Decimal classification system. Attachment 2b also shows that the monographic serial was catalogued with two descriptor terms reading “Computers and people with disabilities \$v Congresses” (see Attachment 1c, Library of Congress subject heading sh86002534 and Attachment 1d, Library of Congress subject heading sh85031115) and “Computerized self-help devices for people with disabilities \$v Congresses” (Attachment 1e, Library of Congress subject heading sh86002525 and Attachment 1d, Library of Congress subject heading sh85031115) in the 650 fields. Thus, as of its cataloging, the publication corresponding to the MARC record attached hereto as Attachment 1b was indexed according to its subject matter by virtue of at least three independently sufficient classifications: the field 050 entry, the field 082 entry, and the field 650 entries. Further, as of December 2, 2004, the MARC record attached hereto as Attachment 2b was accessible through any library with access to the OCLC bibliographic database or the online catalog at a library that acquired the monographic serial, which means that the corresponding

publication was publicly available on or before that same date through any library with access to the OCLC bibliographic database or through an individual library.

58. Attachment 2b indicates that the volume titled *Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility* as cataloged at the University of Houston Libraries is currently available from 80 libraries. In view of the above, the print version of the volume titled *Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility* was publicly available on or shortly after October 27, 2009, because by that date it had been received, cataloged, and indexed at the University of Houston Libraries, made part of the OCLC bibliographic database, and available in the Kurt F. Wendt Engineering Library at the University of Wisconsin – Madison. For these reasons, it is my opinion that Exhibit 1002 was published and publicly accessible on or shortly after October 27, 2009.

VIII. SUMMARY OF OPINIONS

59. In view of the foregoing, it is my opinion that the publication described above was publicly available no later than the corresponding date listed in the table below:

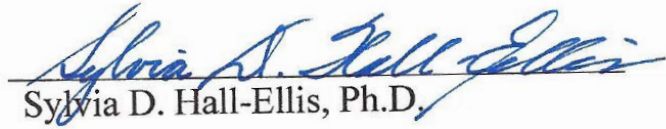
Exhibit	Publication	Publicly Available No Later Than
1001	Bigham, Jeffrey P., Ryan S. Kaminsky, Richard E. Ladner, Oscar M. Danielsson, and Gordon L. Hempton. “WebInSight: Making Web Images Accessible.” <i>Proceedings of the 8th International ACM SIGACCESS Conference on Computers and Accessibility</i> (pp. 181–188). Assets '06. New York: ACM 2006.	January 18, 2007
1002	Takagi, Hironobu, Shinya Kawanaka, Masatomo Kobayashi, Daisuke Sato, and Chieko Asakawa. “Collaborative Web Accessibility Improvement: Challenges and Possibilities.” <i>Proceedings of the 11th International ACM SIGACCESS Conference on Computers and Accessibility</i> (pp. 195-202). Assets '09. New York: ACM, 2009.	October 27, 2009

60. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

61. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine

or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

September 1, 2022



Sylvia D. Hall-Ellis, Ph.D.

Exhibit 1001

HV
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A272
8

WENDT

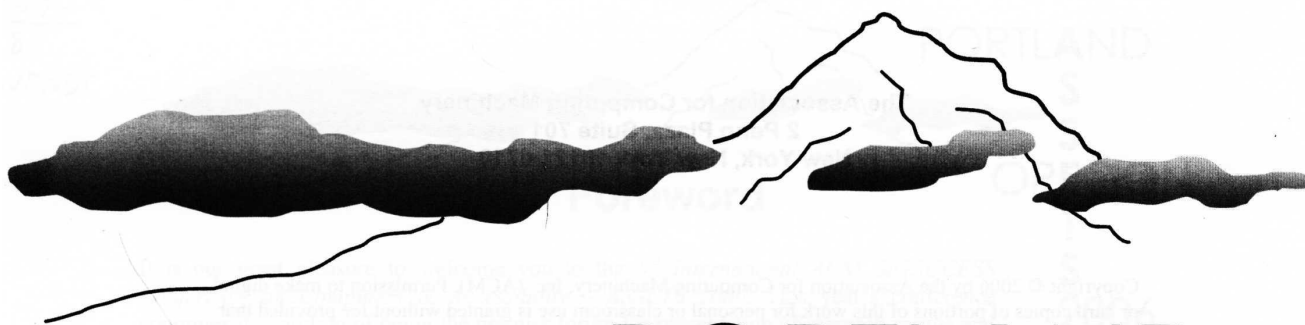


PORTLAND S S OREGON T S 2006

The Eighth International
ACM SIGACCESS Conference
on Computers and Accessibility

October 23-25, 2006 • Portland, Oregon, USA

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ACM's Special Interest Group on Accessible Computing



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WebInSight: Making Web Images Accessible

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ABSTRACT

Images without alternative text are a barrier to equal web access for blind users. To illustrate the problem, we conducted a series of studies that conclusively show that a large fraction of significant images have no alternative text. To ameliorate this problem, we introduce WebInSight, a system that automatically creates and inserts alternative text into web pages on-the-fly. To formulate alternative text for images, we present three labeling modules based on web context analysis, enhanced optical character recognition (OCR) and human labeling. The system caches alternative text in a local database and can add new labels seamlessly after a web page is downloaded, resulting in minimal impact to the browsing experience.

Categories and Subject Descriptors

K.4.2 [Social Issues]: Assistive technologies for persons with disabilities; H.5.2 [Information Interfaces and Presentation]: User Interfaces

General Terms

Design, Human Factors

Keywords

Web accessibility, web studies, transformation proxy, optical character recognition

1. INTRODUCTION

Blind users do not currently have equal access to the web. Images are used in navigation bars, as form buttons and to display textual and visual content, but, unless web authors provide alternative text for these images, blind users employing screen readers and refreshable Braille displays are left to guess the images' contents. In our studies we found that a large fraction of images lack alternative text. For example, of the significant images found on the homepages

of the 500 most high-traffic websites[1], only 39.6% were assigned alternative text.

Illustrating the problem, the homepage of the UCLA Computer Science Department (Figure 1) contains 30 images that should have alternative text, but only two (6.67%) were assigned any text at all. As a result, a blind user may have difficulty navigating this page. As another example, the University of Michigan Computer Science and Engineering Department provides a listing of all faculty on its website along with their contact information (Figure 2). Unfortunately, each e-mail address is presented as an image without equivalent alternative text, presumably in a misguided attempt to thwart e-mail harvesters.¹ The unintended consequence, however, is that blind users who want to e-mail these professors either cannot do so or must find their e-mail addresses through other means. The problems highlighted here are characteristic of many sites throughout the web.

The W3C accessibility guidelines recommend that each image be assigned a textual equivalent[23], and the HTML standard includes easy ways to provide such *alternative text* with the `alt` and `longdesc` attributes of the `img` tag. The `title` attribute is another non-standard method of providing alternative text that is recognized by many accessibility tools, such as screen readers and refreshable Braille displays. The negligence of web authors in providing alternative text is one cause of web inaccessibility. Complicating matters, the proper selection of alternative text is considered by many to be more of an art than a science, which increases the difficulty of construction and verification of alternative text. Images that are crucial for understanding or navigating a page should have appropriate alternative text. Images that only serve to enhance the visual appeal of a page should have a zero-length `alt` attribute defined to make this intention clear[20]. Deviation from these accessibility guidelines generally leads to web pages that are less accessible.

Images that either have an action associated with them (i.e., links or buttons) or are multicolored and larger than a certain size are of particular concern. When such images do not have alternative text, accessibility can be severely reduced. The WebInSight system presented in this paper targets such significant images and provides a mechanism for automatically inserting appropriate alternative text. It does this by processing web requests and transforming the returned pages on-the-fly. As part of the transformation process, it coordinates three novel, underlying image-labeling

¹All of the e-mail addresses listed on the page were also found in the Google index at least once, meaning e-mail harvesters could look elsewhere to find them.

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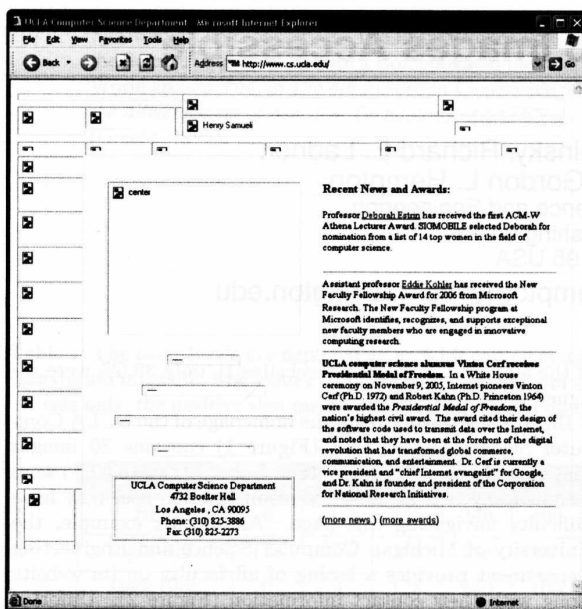


Figure 1: A screenshot of the UCLA Computer Science Department's homepage with images removed. Only 2 of the 30 significant images on the page have alternative text, including only one of the linked images.

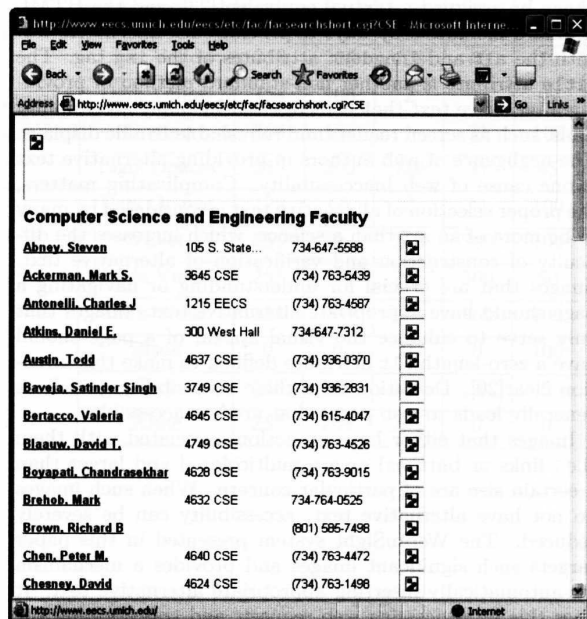


Figure 2: A screenshot of the directory listing for the Computer Science and Engineering faculty at the University of Michigan. With images turned off, the right column of e-mail addresses is inaccessible.

modules targeted to this domain, utilizing methods based on enhanced web context analysis, optical character recognition (OCR) and human labeling.

In this paper, we present a series of web studies that demonstrate the observed problem, discuss the architecture and implementation of WebInSight and, finally, describe the labeling modules used to assign alternative text to arbitrary images on the web.

2. RELATED WORK

To the best of our knowledge, our system is the first to automatically generate alternative text for web images and dynamically add this alternative text to the parent web page. However, it is not the first system to perform web personalization for particular users or user groups nor is it the first to do so via a transformation proxy[3]. Petrie *et al.* observed that the lack of proper alternative text needs to be addressed for web accessibility, but hoped only to encourage web designers to provide it[17]. Ahn *et al.* suggested that alternative text could be stored in a centralized database and be added to web pages by a browser plugin or extension[22].

Three previous web studies found that less than half of img tags found on the web contain an alt attribute. The first found that 24.9% [22] of images in a random selection of web pages were labeled. In the second 47.7% and 49.4% [7] of images found in two random sets of web pages derived from Yahoo and Google were labeled, respectively. These studies considered random web pages uniformly, but the web is known to contain a few very popular websites and many unpopular websites[5]. Considering each web page equally during analysis may not as accurately capture the experience of a user compared with a study that weights popular pages more highly. These studies also failed to distinguish between images of differing importance. The third study found that 45.8%² of nearly 6300 images contained in 100 homepages considered were assigned alternative text[17]. This study manually differentiated images based on their function and, as a result, only considered a small sample of web pages. The web studies presented in the next section seek to improve upon the shortcomings in these previous studies.

Much previous work exists on the difficult task of deriving textual labels for arbitrary images for keyword-based image retrieval tasks. These textual labels are also an attractive source of alternative text for web images. One focus has been on content-based image retrieval, but determining an accurate textual label for an arbitrary image using computer vision techniques is generally unsolved[9]. Most image retrieval systems instead rely largely on image context rather than image content. In such work, a valuable source for labels is derived from pre-existing alternative text, meaning that these systems are best at indexing the images that are already accessible[18]. Work in this area constructs textual labels by statistically associating images with nearby text. While useful for building an index for image retrieval, users of WebInSight are unlikely to benefit from automated natural language analysis of contextual text to which they already have immediate access. In contrast, WebInSight uses text found on the pages pointed to by linked images, which is not directly available to users without leaving the page, to formulate alternative text from context for images.

Another approach is to have humans label images. The

²This number has since been changed by the authors to 32%.

ESP Game[21] and Phetch[22] are computer games designed to generate keywords and explanatory sentences for arbitrary images. Photo-sharing sites, such as Yahoo's flickr[8], are becoming quite popular and provide a mechanism for users to caption their photos. These captions are already being used as alternative text. Related work has also suggested semi-automated semantic labeling of images in order to narrow the space of possible labels for use in the semantic web[15]. Instead of always requiring human labeling, WebInSight allows users to choose when to incur this added cost. Furthermore, for an important subset of images, including images not already in its database, WebInSight is capable of generating alternative text automatically.

3. WEB ACCESSIBILITY STUDIES

To gauge the current accessibility of web images, we designed and executed a series of web studies that measure the prevalence of alternative text currently on the web. Ideally, our studies would determine if appropriate alternative text has been provided for each image, but, unfortunately, automated studies cannot perfectly judge this. Instead, we placed images into two categories that are generally easily distinguishable: images that are used to convey content and images that are used for decorative or structural purposes. We call these images *significant images* and *insignificant images*, respectively.

Significant images provide information to a user and add to the content of a web page. As examples, these images can be part of a website's navigation menu, a map describing the layout of a building, a picture accompanying a news article, or an e-mail address. Significant images should have alternative text that is a textual equivalent to the content or function of the image. Insignificant images are used to add visual appeal or to assist in web page layout and should have a zero-length alternative text because their function is inherently visual. Longer alternative text for insignificant images adds little value to the browsing experience and can detract from the important content of the page when the page is viewed serially with a screen reader[20]. The specific methods used by each study to determine significance are presented later along with the description of each study.

While we do not attempt to measure the specific appropriateness of the alternative text provided for images, our studies improve upon previous work[22, 7, 17] in three important ways.

First, our studies distinguish between significant and insignificant images and do so automatically. While significant images should be assigned descriptive alternative text, insignificant images should be assigned a zero-length `alt` attribute to indicate their insignificance, according to accessibility guidelines[20]. Ahn *et al.* and Craven ignored significance and treated spacer GIFs and images forming a navigation menu equally. Petrie *et al.* manually differentiated images into five categories based on their function, but did so for images found on only 100 homepages. Automatically determining the significance of images allows us to properly measure the presence of insignificant images with alternative text and significant images without alternative text on a large number of webpages.

Second, our studies consider multiple methods of providing alternative text for images. Previous studies counted only the presence of the `alt` attribute of the `img` tag as properly assigned alternative text. To address this, we record

the presence of the `title` and `longdesc` attributes, which are often used to convey alternative text and are properly utilized by most screen readers. We also counted linked images that occurred within the same anchor tag with text as being properly labeled even if no alternative text is directly specified. Screen readers can correctly associate alternative text specified in this manner.

Finally, our studies explicitly consider the popularity and importance of websites to determine the effect the accessibility of each is likely to have on the average user's experience. In our first series of studies we explicitly choose websites based on their observed traffic and importance. In the second, we consider all traffic generated by our department and count all observed `img` tags. In effect, this weights each image by its popularity, better approximating the average user's web experience.

For our studies, we used the following labeling criteria. A significant image was properly labeled if its associated `img` tag contains a non-zero length `alt`, `title` or `longdesc` attribute, or if the image is contained in the same anchor (link) tag as additional text. An insignificant image was properly labeled if it contained a zero-length `alt` attribute. In our studies, we first focused on university, government and high-traffic websites. Next we looked at the traffic generated by members of the University of Washington Computer Science Department.

3.1 Important Websites

We first examined five high-traffic and important groups of websites. These include the homepages of (i) the 500 most high-traffic international sites[1], (ii) the top 100 international universities[2], (iii) the 158 Computer Science departments listed in the Taulbee Report[24], (iv) the 137 U.S. Federal agencies listed on whitehouse.gov, and (v) the 50 U.S. states plus the District of Columbia.

To gather the image data for this portion of the study, we created a web crawler that loads each web page with Internet Explorer. Using the Document Object Model (DOM), we extract all relevant information from each image on the web page, including those images that have been dynamically loaded. This method provides more accurate data than simply parsing the HTML text of a web page as we also have access to images loaded using dynamic scripting.

We then analyzed the image data collected for each group of web pages to determine which images should be classified as significant. Images containing more than one color and having both width and height greater than 10 pixels are classified as significant. Images that are clickable, either because they are contained within anchor tags or because of defined script events, are also considered significant. Our criteria for classifying an image as significant for this portion of the study was determined from manual observation and we have found it to be quite accurate.

Once the significant images are identified, we examine each for alternative text according to the labeling criteria described in the introduction to this section. We then compute the aggregate image statistics for each homepage to determine the percentage of significant and insignificant images that are properly labeled. Table 1 summarizes this information for each group.

The results show that the web pages of the U.S. states and U.S. federal agencies have the highest percentage of labeled significant images. Federal agencies in the United States

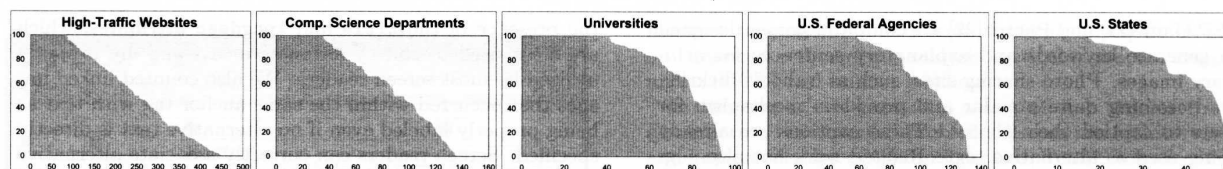


Figure 3: Study results for five groups of websites. Each bar graph shows the percentage of significant images labeled for each web page in the group and is arranged in descending order.

Group	Sig.	Insig.	> 90%	N
High-traffic	39.6	27.4	21.8	32913
Computer Science	52.5	41.6	27.0	4233
Universities	61.5	70.2	51.5	3910
U.S. Federal Agencies	74.8	66.6	55.9	5902
U.S. States	82.5	77.1	52.9	2707

Table 1: The percentage of significant images with alternative text, percentage of insignificant images with zero-length alternative text, percentage of web pages with greater than 90% of significant images labeled for each of five important website groups and the total number of images observed.

are required to make their web content accessible pursuant to Section 508 and many U.S. states have adopted similar policies[20]. The percentage of insignificant images correctly labeled with a zero-length `alt` attribute follows a similar pattern. Only 7.3% of insignificant images observed were assigned non-zero-length alternative text, which matches with our expectations and suggests that a common mistake is to assign insignificant images no alternative text instead of zero-length alternative text. These results are in contrast to the results of Petrie *et al.* who used a different methodology to choose web pages and found that 76.9% of significant images and 12.8% of insignificant images were assigned alternative text[17].

Figure 3 contains a bar graph for each group that presents the percentage of significant images that were labeled on each individual web page. This figure shows, for instance, that 87 of the 500 high-traffic web pages had 100% of significant images labeled, and that all of the state web pages had at least some significant images labeled.

3.2 Department Traffic

We next examined all web traffic generated by members of the University of Washington Department of Computer Science and Engineering during a period of approximately one week. This was made possible using a machine sitting on the network between the computer science department and the Internet. Because of privacy concerns we only kept counts and no identifying information. For this reason, we define a significant image as one that is clickable either because it is contained within an anchor tag or because of a defined script event.

This study should most accurately represent statistics on the accessibility of pages as experienced by the average user because each image is weighted by its observed popularity. The study ran for approximately one week and observed all unencrypted web content entering the department during this period. This captured 11,989,898 images, and, of those,

4,889,948 (40.8%) were significant. Of these images, 63.2% were assigned alternative text.

4. WEBINSIGHT SYSTEM

The WebInSight system addresses the accessibility shortcomings that we observed in the studies we conducted. When a user loads a web page, the system retrieves alternative text from its database for each image when it is present and requests that alternative text be calculated for any image not already in its database. It then dynamically inserts alternative text into the web page, instead of relying upon web authors to have added accessibility information. To calculate alternative text automatically the system utilizes OCR and web context labeling. While many images lend themselves to these automatic labeling, images that cannot be labeled automatically can be sent to human labeling services if the user desires. The system, including the labeling processes, operates with only a small delay, allowing WebInSight to provide alternative text for most images, including those that have not been previously viewed.

4.1 Architecture

The WebInSight system consists of two main components: a transformation proxy that sits between the user and the Internet, and a labeling framework that is queried to supply alternative text for arbitrary images (See Figure 4). A blind user accesses the web through the proxy, which arranges for images to be labeled on his or her behalf. When alternative text is present in the database for an image viewed by a user of the system, the proxy automatically appends the alternative text and the name of the module that generated it to the value of the `alt` attribute of the associated `img` tag. When users reach the image on the page, the alternative text is then available.

If alternative text is not immediately available in the database, then it is calculated by the labeling framework. Because calculating alternative text for all images on a web page may take some time (generally less than a few seconds per image), the proxy inserts Javascript code into web pages that allows them to dynamically query the labeling framework after the main content has loaded. This allows users to begin reading a web page without requiring them to wait for the labeling framework to attempt to assign alternative text to all of the images. Because the modifications made to the web page are not immediately apparent, the system appends an information bar to the page informing the user that the page has been altered by WebInSight. The bar is appended to the end of the page to be easily accessible but unobtrusive to users employing serial interfaces, but is visually stylized to appear at the top of the page to be readily apparent to users employing graphical displays. The

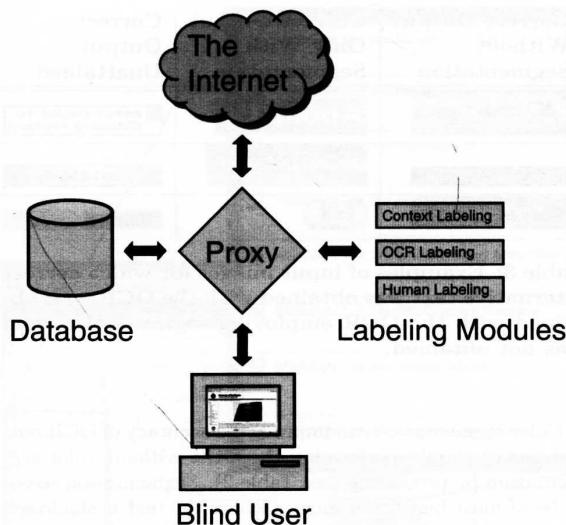


Figure 4: The architecture of WebInSight.

bar is dynamically updated as additional alternative text is requested and added.

While current screen reader products have limited support for dynamic HTML content, such support is expected to be a critical feature in future releases as this technology is becoming prevalent on the web. Current versions of popular screen reading software can be configured to reevaluate the page DOM upon changes. Other groups have recognized the importance of making dynamic web content accessible and have proposed extensions that would facilitate its use[10].

To setup and use the WebInSight system, a user simply configures his or her web browser to connect via the WebInSight proxy (a simple change in both the Internet Explorer and Firefox web browsers). WebInSight requires the user to specify login information to prevent misuse of the system. A proxy-based implementation has a number of advantages that make it easy to both use and administer. Because the proxy is centralized, updates and changes can be managed from one location and will immediately be propagated to all users. In addition, each user can create a customized experience through the web interface provided by the proxy. WebInSight could also be implemented as an Internet Explorer plugin or Firefox extension without substantial changes to how the system transforms web pages, calculates alternative text, or interacts with the database. This decentralized solution does not have the proxy as a bottleneck and has the additional benefit of working with secure sites. The database currently contains a record of which images were viewed, but does not contain a record of who viewed which image. No personal information or user-specific browsing data is stored, preserving privacy expectations.

4.2 Implementation

The transformation proxy is an enhanced version of the open source webserver, Apache HTTP Server. The main additions are two modules which target requests for HTML and image content. The first captures web pages and alters them to include both cached alternative text and the code allowing pages to be dynamically updated as described pre-

viously. The second module calculates the MD5 hash of each observed image and records the mapping between this hash and the image's URL in a local database. An MD5 hash serves as a unique identifier for each image, irrespective of its location on the web. This allows us to detect when the image at a given URL changes and allows us to recognize images that appear in more than one web location.

5. IMAGE LABELING

At the core of the WebInSight system are the image-labeling modules that provide a mechanism for labeling arbitrary web images. Content-based image labeling of arbitrary images is beyond the state-of-the-art in computer vision [9]. Consequently, our system takes the approach of combining many modules, each with different strengths, costs and capabilities to tackle the problem. Below we describe those modules that are currently implemented.

5.1 Web Context Labeling

The context in which an image appears has previously been leveraged to reveal its contents[11, 14]. Just as anchor text is often an accurate summary of the linked page[6], the converse is also often valid: summaries of pages linked to by images appearing within anchor tags often accurately describe the images. As an example, web authors often use an image of the logo of an organization to link to its homepage and the name of the organization usually appears in the title of its homepage. In such cases, the text in the title of the linked page accurately describes the contents of the image.

WebInSight retrieves the contents of pages linked to by images within anchor tags and uses this text to formulate alternative text. Currently, it does so by returning text found in **title** or **h1** tags on the linked page. These text strings are often a succinct summary of the page on which they are found. We have discovered empirically that taking the longer of the strings, up to 50 characters, is a good heuristic for choosing the text to use.

More advanced methods of summarizing web pages are available[4, 13], but such systems target the production of longer descriptions than what is desired for alternative text. Many operate by selecting existing sentences or phrases from the document, and our method simply chooses between text found in the **title** and **h1** tags, which we have found to generally be short, accurate summaries. Often, even when the method does not produce alternative text that matches the image, it produces alternative text that matches the function of the image. The user still benefits because of the value in knowing what is behind the unlabeled link.

5.2 OCR Image Labeling

Many of the web's significant images contain some form of text[19]. In an analysis performed by Kanungo *et al.*, it was determined that 42% of images on the web contain text. Petrie *et al.* found that 79.4% of graphical text images on the homepages of 100 major organizations were assigned alternative text[17]. Because graphic text images convey information, even 20% of such images lacking alternative text is a problem for web accessibility. Examples of images that typically contain text include image buttons, navigation bars, informational banners and e-mail addresses. Considering the high accuracy of OCR techniques[16], it would follow that much of this text should be extractable. However, the performance of OCR is closely tied to its application on

Highlight	Resulting Image	Text Retrieved
None		qmmppmm.
		d i
		W .tgwkim
		Upgrade Now
		-

Table 2: The OCR originally produces incorrect output on this image. Color segmentation yields an image that the OCR can correctly process.

black and white documents scanned at known resolutions. This poses a problem when performing OCR on web images as they are found in a variety of resolutions, colors, image formats and compression levels. We address this below.

To implement this labeling module we used Nuance OmniPage Capture SDK, which provides an extensive API for OCR processing. The system properly formats the input image for the OmniPage OCR engine, which in turn is highly configurable. With the correct image format and OCR engine configuration, we can accurately capture text from many web images. However, different images require different formatting options and OCR engine settings to achieve the most accurate OCR output. For a given image we can automatically conduct a structured search for optimal settings and use a confidence measure produced by the OCR engine to differentiate between good and bad results. Searching for the optimal settings does not produce acceptable output for all images, as shown by the results at the end of this section.

The output of the OCR is verified by a custom spell checker. First, a dictionary is searched to verify the OCR output. If there are no matches, the output is passed to Google's spell-checking API, which can verify and correct many words that do not appear in traditional dictionaries. If this still fails to properly verify the output and if the string is sufficiently long as to make a chance occurrence on the web unlikely, the system issues a web query for the output. If any results appear, we assume that the output is valid. This multi-tiered verification allows the system to correctly verify a variety of strings including misspellings and e-mail addresses.

To enable the OCR to properly extract text from more images, we implemented a color segmentation process similar to that explored by Jain *et al.* that we apply to images as a preprocessing step[12]. For this process, we use a color histogram-based algorithm to identify the major colors in an image. Once all these colors are discovered, we create a set of black and white *highlight images* for each identified color. To create a highlight image we color all shades of the major color black and all other pixels white. The OCR engine can then be fed each highlight image separately and in many cases one of these highlights will create the ideal OCR situation of black text on a white background. The OCR labeling module chooses among the outputs for the highlight images using a score output by the spell checker.

Correct Output Without Segmentation	Correct Output Only With Segmentation	Correct Output Unattained

Table 3: Examples of input images for which correct alternative text was obtained with the OCR, was obtained with the OCR employing segmentation, and was not obtained.

Color segmentation can improve the accuracy of OCR output versus simply performing the OCR without color segmentation preprocessing (see Table 2). Segmentation seems to be of most benefit on images where the text is shadowed or when the contrast between the text and the background is poor. Images with text in different colors are even more difficult to process correctly.

The performance of the OCR and the usefulness of segmentation were evaluated and the results are below. The test set consisted of 100 multicolored images that contained text collected from the web (mainly images for navigation, buttons and information banners). The output was considered correct if all text in the image was contained in the output string. Overall, the OCR correctly processed 52% of the images when segmentation was not used. When segmentation was enabled, 65% of images were correctly processed. Thus, segmentation helped on 13% of all images or on 27% of the images where normal OCR failed. Some examples of images from the test set are shown in Table 3.

5.3 Human Labeling

The automatic labeling methods mentioned earlier work well for the large subset of significant images, but they do not apply to all web images. To generate labels for these images, the WebInSight system provides a mechanism for users to request that an image be sent to a labeling service for labeling by humans.

The ESP Game[21] and Phetch[22] are two recent computer games designed to effectively encourage humans to label images with keywords and descriptions. Both are modeled such that a service could be built to allow users to request alternative text and receive a reply with an acceptable latency. Because of the benefit to blind users, such a service may also be eligible for charitable or governmental support. WebInSight currently implements a simple web-based application for humans to label images.

Because the cost of labeling is greater for services that involve humans, WebInSight provides a framework that allows users to decide when to incur this additional cost. To facilitate user requests, the WebInSight system inserts a link immediately following each image that users can select to request additional alternative text. The link clearly states its function as a means to request additional labeling for an image and it clearly identifies the associated image. The presence of these request links can be toggled depending on a user's preferences. The current state of the system is reflected in the information bar inserted by WebInSight.

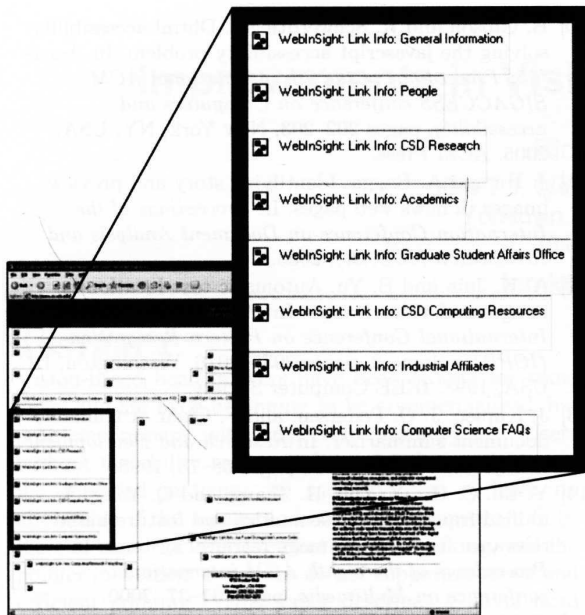


Figure 5: The UCLA Computer Science Department homepage as presented by WebInSight.

6. RESULTS

WebInSight is capable of automatically providing alternative text for a significant portion of the most important web images. To evaluate the performance of our system we reran the series of studies presented earlier over important websites through WebInSight. We then randomly selected 2500 significant images that were not originally provided alternative text, and, of those, WebInSight automatically provided alternative text for 1079 (43.2%). We manually verified the alternative text provided by the system and found that it was correct on 1015 (94.1%) of the images. We found that labels provided for linked images are particularly reliable because they reflect the contents of the **title** and **h1** tags of the linked page. The results are promising because they indicate that almost half of unlabeled, significant images can be labeled automatically. The rest can be labeled by humans using the human labeling module.

Next, we revisited the example web pages offered in our introduction. Figure 5 shows the UCLA Computer Science Department's homepage as viewed using WebInSight. The system provided valid labels for 18 of the 21 images that served as links on this page by using context-based image labeling. The errors occurred because one document had the title "Untitled Document", another pointed to a PDF file which our system cannot currently parse, and the last pointed to a document without a title.

Figure 6 shows the faculty directory on the University of Michigan Computer Science and Engineering web page as viewed through WebInSight. Fifty-two of the 65 email images were correctly recognized by the OCR labeling module and inserted by the system. For the majority of the others, the OCR software gave no output. When the output was incorrect, the spell checker suppressed insertion because the text did not appear on the web. As a result of WebIn-

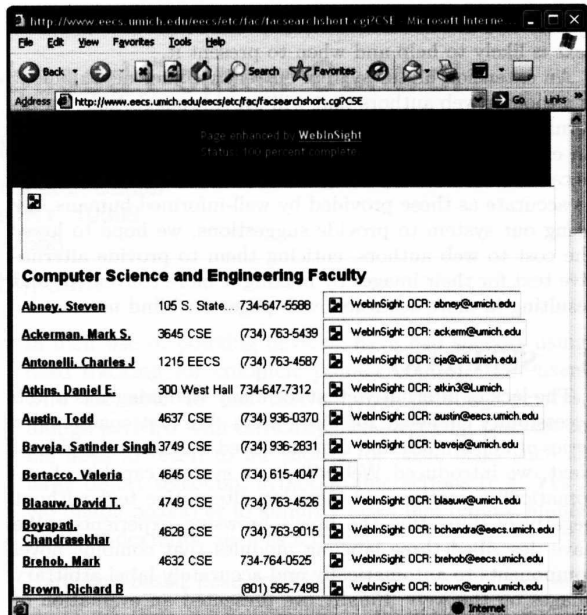


Figure 6: A screenshot of the directory listing for the Computer Science and Engineering faculty at the University of Michigan. WebInSight recovers many of the hidden email addresses using OCR.

Sight, both of these web pages are more accessible to blind users.

7. FUTURE CHALLENGES

We hope that as we continue to improve and refine our system, it will make the web more accessible to a large number of users, but challenges remain.

Given the recent legal troubles faced by image search engines, copyright issues and responsibility for the labels produced must be considered. Another important consideration is misuse of the system. The human labeling methods are most successful when many labelers are available and private companies are likely in the best position to offer such a service. However, such companies may want to retain control of their labels, potentially limiting access. Users also could potentially exploit the system to build their own image index or to facilitate denial-of-service attacks.

Many of these problems can be mitigated by requiring users to login to the system and/or by limiting usage. A question that remains, however, is who should be allowed to access such a system. Potential ideas include making the system a government service, a subscription-based service, or relying on a trusted third party for verification.

We also hope to improve our system to automatically generate alternative text for even more images and to combine the results from the various labeling modules in a way that is most helpful to users. To this end we plan to first conduct a focus group in order to determine what users want out of WebInSight and use their guidance to shape its future. A vital concern is the impact to users when the system provides incorrect alternative text. We plan to conduct user studies to quantify the value of the alternative text provided by the

system and use this information to decide which alternative text is likely to help and when to present it.

An extension of our system currently under development is a tool for web authors that will provide suggestions for alternative text and coordinate the labeling of images across an entire site. We see this as a promising future direction because automatically assigned alternative text will not be as accurate as those provided by well-informed humans. By using our system to provide suggestions, we hope to lower the cost to web authors, enticing them to provide alternative text for their images by making it more convenient and resulting in more accessible web pages for blind users.

8. SUMMARY

The lack of alternative text for many web images is a web accessibility challenge for blind users. We first conducted a series of web studies that demonstrated the current problem. Next, we introduced WebInSight, a system capable of automatically creating and inserting alternative text without negatively impacting the user's browsing experience. We have described three labeling modules that combine novel components to automatically and accurately label arbitrary images on the web. Finally, we presented an evaluation of the system that shows that WebInSight is capable of producing correct alternative text for nearly half of the unlabeled images in a large collection of web pages.

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Collaborative Web Accessibility Improvement: Challenges and Possibilities

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ABSTRACT

Collaborative accessibility improvement has great potential to make the Web more adaptive in a timely manner by inviting users into the improvement process. The Social Accessibility Project is an experimental service for a new needs-driven improvement model based on collaborative metadata authoring technologies. In 10 months, about 18,000 pieces of metadata were created for 2,930 webpages through collaboration. We encountered many challenges as we sought to create a new mainstream approach. The productivity of the volunteer activities exceeded our expectation, but we found large and important problems in the screen reader users' lack of awareness of their own accessibility problems. In this paper, we first introduce examples, analyze some statistics from the pilot service and then discuss our findings and challenges. Three future directions including site-wide authoring are considered.

Categories and Subject Descriptors

K.4.2 [Social Issues]: Assistive technologies for persons with disabilities; H.3.5 [Information Storage and retrieval]: Online Information Services

General Terms

Human Factors, Standardization.

Keywords

Web, accessibility, social computing, metadata, collaboration.

1. Introduction

We are witnessing a great shift from traditional media to the Web in every aspect of our daily activities. Online shopping services are changing the behavior of consumers, online courses are making learning more democratic, and remote work is allowing our society to benefit from white collar services provided by employees who are working in their own homes. These changes are profound. Web access is becoming an urgent social issue.

In spite of the importance of the Internet, barriers are still appearing in many Web-related services, isolating various groups of users. Visually impaired people are one of these groups.

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Thanks to recent Web accessibility activities, there are bright spots in various categories of websites, such as e-government sites, news and publication sites, and text-oriented consumer-generated content such as wikis and blogs. At the same time, new types of services are emerging with new accessibility problems. Blind users are often unable to buy goods, to learn vital skills, or to apply for remote work.

Collaborative accessibility improvement is a new approach to improve accessibility through collaboration among users, developers, site-owners, and any Web users who have a passion for accessibility. The basic strategy is the “wisdom of crowds”, making the Web more accessible through collaborative metadata authoring. The Social Accessibility is one such project, launched in July 2008. The service is characterized by its exploitation of advanced external metadata technologies such as easy-to-use authoring tools, an open database scheme, and support of many browsers and screen readers.

This paper discusses successes and failures in the experience, and then proposes future directions not only for this specific project, but also for similar projects that aim at achieving accessibility through collaboration. Our central theme is: How can the collaborative approaches make the Web more adaptive and improve its usability? In order to answer this central theme, we decomposed our analysis into three sub-themes:

- Can supporters fix the reported problems in a timely manner? What types of metadata support can they create?
- How can users report their problems to the service? What types of requests were reported on what types of sites?
- How can we create a self-sustaining service with active participation?

Based on our experiences, the productivity of supporters was higher than we had anticipated. They were able to work effectively to respond to the requests from users in a timely manner. At the same time, challenges exist on the user side. Many users are not even aware of the problems they are facing, and we had not expected this. It encouraged us to design a new collaboration model with more advanced functions as described in the “next steps” section. The goal is to help end users to access more usable sites through collaboration while also helping the site owners with accessibility, including guideline-based compliance.

2. Related Work

The strategy of collaborative accessibility improvement is a new solution to address accessibility needs by gathering the power of society. Bookshare.org [4] is an example of this approach. This is a “social scanning” service for printed books. Registered users can access the books on the site that are collaboratively scanned by volunteers. Helen [11] is a website rating service created by

American Foundation for the Blind. Users can submit and share ratings and comments about the accessibility of various websites.

Social captioning for the deaf and hard of hearing is also becoming popular, especially for movies. YouTube Subtiter [26] is an experimental service for YouTube videos. Welcome [8][9] is a captioning system for e-learning content. Nico-Nico Douga [17] is a Japanese movie sharing service with an overlay comment function, which is often used to create collaborative captions.

Social labeling allows users to add and share labels, mainly alternative texts and landmarks. The 1997 ALT-server [7] was the earliest proposal for social labeling. WebInsight [2] is a unique system combining social approaches with automatic optical character recognition to generate appropriate alternative texts. Serotek [18] is providing a commercial service for users of their browser while WebVisum [25] is a free service for Firefox users.

In these ways, collaborative improvements are becoming popular because they generate accessibility metadata without disrupting daily activities. To date, only a few projects have been notably successful, but the knowledge and experience are accumulating in the accessibility industry. Our Social Accessibility is also seeking to contribute to society by providing experience with an advanced collaborative service.

Metadata-based transcoding technology is a key underlying technology for our collaborative Web accessibility improvements [20]. HearSay [5] is an experimental voice browser with advanced automatic metadata generation and labeling by users. IBM's transcoding system was characterized by its template-based metadata matching for site-wide metadata [20][21]. SADIE [10] is an approach to utilize styling information for transcoding. aiBrowser [15] has a function for transcoding DHTML and Flash content with declarative metadata and AxsJAX [6] is a library for transcoding Ajax applications with procedural JavaScript code.

3. Social Accessibility Pilot Service

3.1 Overview

Social Accessibility [23] is characterized by its use of external metadata and the participation of an open community. It allows improving the accessibility of any webpage without asking the site owners to modify the website. The pilot system consists of the three components shown in Figure 1: end-user tools for problem reporting and client-side webpage transcoding based on external metadata; volunteer tools for metadata authoring; and a public server as the metadata repository. Both end users and volunteers (also called supporters) access the repository using client-side tools, which interact with the server through Web APIs. They can also access the repository by visiting the portal site with their Web browsers. Figure 2 shows a typical interaction for accessibility improvement. First, an end user reports an accessibility problem on a webpage. This report goes to the supporter community instead of to the site owner (as with a contact form). Then a supporter creates external metadata to fix the reported problem. As a result, the end user can browse the webpage made accessible with the metadata. This reporting-based strategy allows quick solutions to accessibility problems, while reducing the supporters' work, and focuses on problems that end-users actually encounter. The public repository allows that metadata to benefit every end user, not just the first user who reported the problem.

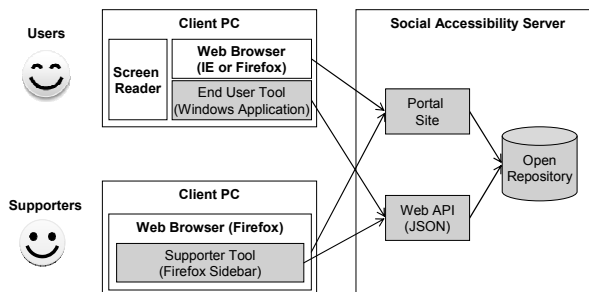


Figure 1. Basic Architecture of Social Accessibility Service

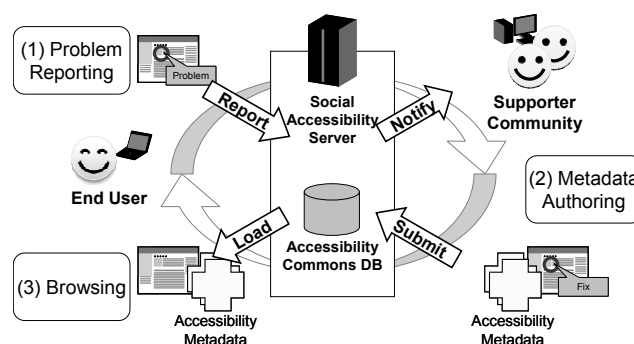


Figure 2. Current Process Model

3.2 Recent Improvements

Considering the feedback we received and the analyses of user activities in the pilot study, we have frequently updated our prototype service. As of April 2009, two major updates have been made since the study started at July 2008.

3.2.1 Screen-reader-independent end-user tool

The original end-user tool was offered as a plug-in for Jaws®, the most popular screen reader in the U.S. This prevented many blind users with other screen readers from using the pilot service.

For that reason, we also developed a native application for Windows® as an alternative to the Jaws-based end-user tool. This resident utility shows a menu dialog when the user presses a short-cut key. The menu includes problem reporting and metadata loading. The resident utility works by injecting special JavaScript code into the webpages for the selected functions. This approach is independent of the screen reader and supports two major Web browsers, Microsoft Internet Explorer® and Mozilla Firefox®.

This native application also added an advanced feature to handle elements ignored and inaccessible with earlier approaches. These elements include images with no alternative text and Flash movies in the opaque mode. Since screen readers ignored these elements they were completely inaccessible, our new feature creates a menu. It also creates a submenu allowing the user to navigate in the sub-elements of an opaque Flash movie. This addresses one of the major new gaps between visual browsers and screen readers for exploring modern webpages with multimedia content. In addition, these menus allow expert users to create alternative text labels for the previously inaccessible elements based on the context. Once specified, the text labels are stored in the public

repository. This is another way blind users can participate in the project as metadata authors, not just as problem reporters.

3.2.2 Visual metadata authoring interfaces

The original supporter tool had a text-based interface for metadata authoring. That forced the supporter to locate the problems in the HTML representations of the webpages. This unfriendly interface discouraged supporters from participating in the pilot study.

To address this problem, we added two visual interfaces, a *page map* (Figure 3) and a *quick fix wizard*.

The page map is a WYSIWYG-style editor for metadata authoring. It creates an image of the webpage and allows supporters to quickly choose a webpage element for external metadata by just clicking on that element. The created image adds exclamation marks for such metadata targets as inaccessible images to help the supporters add useful metadata (Figure 3 (a)). Inaccessible images include those without alternative text or with useless alternative text (such as “banner” or “spacer”). Also marked are image links pointing to the same destinations as nearby text links. Clicking on an exclamation mark invokes a dialog box with a description of the accessibility problem and how to fix it, with an easy-to-use form for new metadata. This visual editor also uses our brightness-gradation technique [22] to visualize the estimated times required for a screen reader to reach each element to help supporters with headings metadata. Darker elements take longer to access, indicating that additional headings may help. When a supporter clicks on such an element, a dialog box appears to specify a heading level (h1-h6) with an optional text description. The same dialog box also has options for other types of metadata such as alternative text for an image that the system failed to recognize as inaccessible. Once metadata is created, an icon indicating the metadata type is shown at the position where the metadata was added (Figure 3 (b)). A supporter can edit and improve metadata by clicking on a metadata icon.

The quick fix wizard is a simpler interface for making alternative text metadata. It sequentially displays each of the inaccessible images. Each image is followed by the description and the same form for new metadata. This wizard allows a supporter to quickly fix all of the image-related accessibility problems in a webpage by simply filling in the fields and clicking on the “next” button, as long as the heuristics successfully detect all of the inaccessible images.

4. Examples of Collaboration

The collaboration among users and supporters yielded various collaboration patterns. We regard a successful case as one that helped real users with problems and a failure case as one for which the service was unable to provide a solution. In this section we review three examples, two successes and one failure.

4.1 Case 1: Hospital Website

In this success case, a user found that a website for a local hospital was not understandable, and sent a request saying “I feel this page is too complicated and not easy to understand.” The underlying problems were things that the user was not even aware of when the request was sent. Within seven hours of the request, an active supporter analyzed the request and decided to respond to the request by addressing some basic problems in the page. The supporter created 10 alternative texts and 121 heading tags for 22 of the webpages near the original target page. During the same



(a) Before metadata authoring

(b) After metadata authoring

Figure 3. Page Map

period, a member of our development team created four alternative texts for buttons in a Flash movie on the target page, and described that work on the discussion board. On the following day, the first supporter created another alternative text and 61 heading tags for four additional pages, and changed the status to “resolved”. The status decision seemed to include reference to the public comment about the Flash movie. In this case, the initial solution was provided within 7 hours, and the final decision was made within 49 hours.

4.2 Case 2: Radio Station Website

This success involved a user who commented on a radio station page that “[the] heading jump function of my screen reader does not work well on this page and also it seems like some images don’t have alternative texts.” In this case, the request was concrete, since the user was aware of the problems. Two supporters created 5 alternative texts and 8 headings, and the status was changed to “resolved” 20 hours after the request was submitted. However, the user also requested some “site-wide” metadata for related pages. Four supporters responded, eventually creating 140 alternative texts and 96 heading tags. Finally the request was fully resolved in 6 days after the initial request.

4.3 Case 3: Sight Seeing Information Site

We classify this failure as an example of a technical gap that cannot be addressed with current technology. A user visited a webpage about sightseeing spots in a particular town. The request was “Please explain the map.” However the map was actually a scrollable widget which was mashed up into the page from a major map service website, which made it difficult to describe. After 30 minutes, a supporter changed the status to “call for experts” with the comment “It is difficult to describe the scrollable map. I want to call for the experts.” The accessibility of such visual information is an old research topic and it was difficult to provide any immediate help, so the appropriate status was “technical pending” for this case.

5. Activity Analysis

In the previous section, three example collaborations were summarized. This section presents some overall statistics about the service.

5.1 Problem Solving by Supporters

The supporters created 18,296 metadata records in response to requests from the users. Table 1 shows the ratio of metadata types. The most frequent metadata type was the “alttext”. This metadata covers alternative texts for non-textual objects, labels for input forms, and textual descriptions added to content. The script to apply the metadata directly modifies the DOM as appropriate for each target HTML element. There were only 47 items of metadata of this type that were created by users with the latest authoring function. The label “h+” refers to text added as a heading (even though the target may be inaccessible). “Landmarks” are new destinations added for navigation within a page.

The supporters resolved 275 requests (85.1%) of the 323 submitted requests and only 19 requests (5.9%) remained unresolved as of May 1, 2009. The requests are first labeled as “unanswered” and supporters can change the status with the authoring tool for supporters. When supporters cannot resolve a problem, there are two options. If the service is not technically capable of resolving the request, “technical pending” is the right option. Only 17 requests (5.0%) were classified this way, mostly in relation to Flash or DHTML. If a request (or solution) was unclear to the supporters, then the “call for experts” option was appropriate. Only 14 requests (4.2%) were given this status.

Figure 4 shows the accumulative time for solving requests. The vertical axis shows the percentage of requests resolved up to that time on the horizontal axes. All of the requests resolved within one week are included in this figure. A total of 45% of the requests were solved within one day (24 hours), increasing to 50% by 34 hours. However 25% of the resolvable requests required more than a week.

5.2 Requests from Users

Our requests came not only from the request mechanisms in the Access Tool but also from a mailing list, from interviews, and from our work in experimental sessions, so it is difficult to estimate the exact number of requests addressed by the supporters. In this section, we focus on deeper analysis of the requests submitted via the tool, a total of 323 as of 1 May 2009. Many users, especially novices, used the simple guest account, which prevents us from doing a deeper user-oriented analysis.

Table 2 shows a classification of the requests as reported by the users. For example, if a user misunderstood a DHTML problem as being a problem with a missing heading, then the request is categorized as “Request for heading tags” as perceived by the user. The largest numbers of requests were reported as problems with alternative texts for images or for non-textual objects (124/323 = 38.4%), followed by requests for heading tags (24.8%). This was an expected result, since these are major problems on the Web and since our service was especially designed to target these two kinds of problems.

Beyond that, some non-obvious items appear. The third most-common item (4.6%) is problems related to Flash. Based on our previous work, around 50% of the Flash content is hidden from screen reader users [1]. This means that typical users are not even aware of half of the Flash-related problems. In spite of that, the users were still often aware of the existence of inaccessible Flash content. This may reflect the popularity of multimedia content on the Web.

Metadata Type	Count
Alttext	11,969 (65%)
h+ (h1-6)	6,069 (33%)
Landmark	122 (1%)
h-	119 (1%)
Others	17 (0%)
Total	18,296 (100%)

Table 1. Ratio of Metadata Types

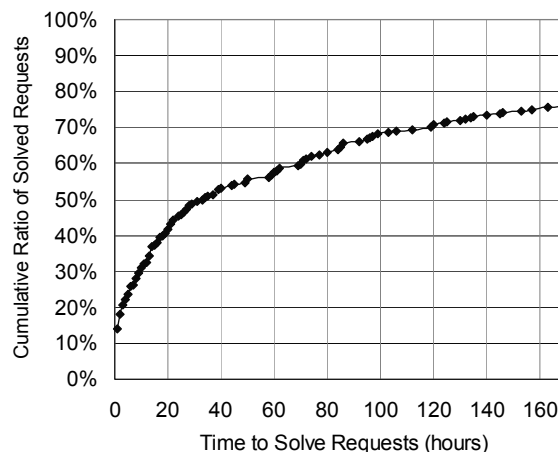


Figure 4. Ratio of Time for Solving Requests (from 0 hour to 1 week)

Collectively, questions were a large category. When a user was unsure of the exact nature of a problem, they would send questions to the service. There were several types of questions, such as asking why something couldn’t be done (e.g. “Why can’t I edit the reply message?”), whether a certain object existed (e.g. “Where is the list of links?”), or if there was any workaround for a problem (e.g. “How can I move to the next page?”). A wide-variety of websites were involved in the requests, such as public services, online-shopping, e-learning sites, news sites, sport event sites, video sharing services, social networking site and others. The list of target websites was fairly representative of the variety to be found on the Internet.

5.3 Sustainability

Figure 5 shows a historical metadata authoring activities. The horizontal axis shows the time and the vertical axis shows the cumulative amount of metadata created for each category of participants. The development team members tried to reduce their activities over time to encourage the participants. Most of the activities were metadata authoring by the supporters after the page-map release. Some of the activity was authoring activities for landmarks and alternative texts added by the users themselves. Most of the participants worked for brief periods, though a few supporters were contributing for longer periods, such as one supporter who answered many requests from the Japanese community.

6. Findings and Challenges

This section considers the statistics in the previous section to clarify the essential and common challenges for collaborative accessibility improvement services. Solutions are discussed in Section 7.

6.1 Time Effectiveness

Can supporters fix the requested problems in a timely manner? What types of metadata can supporters create?

Before starting the project, we expected that encouraging the activities of the supporters might be the most important challenge for the project. However, the supporters worked much more effectively than we had anticipated. The results (Figure 4) show that almost half (45%) of the requests were resolved within only 1 day (24 hours). Giving the gap between the resolution work and the decision making (mentioned in Section 3), many the users actually benefited even more quickly.

Compared to the existing source-code modification approaches, the time effectiveness of the approach is clear. Those approaches will involve at least one iteration of the development process, possibly two weeks but typically much longer. Our service allows users to access the improved sites within a few days. This is clearly a huge leap beyond the previous methodology.

The productivity of the metadata authoring tool was a key success factor for the supporters' work. The new page map function was released in November 2008 (20 weeks), and the supporters' activities increased dramatically (Figure 5). Also, the participants who joined after the new tool became available were much more likely to continue contributing to the service. They evidently felt that working with the service was valuable as a use of their time.

The page-map approach dramatically lowered the required skill for the metadata authoring. Looking at the metadata that was created, it appears that many of the supporters had some knowledge about Web accessibility. They seemed to understand the basic rules for alternative texts and how users would use the heading tags for navigation. These two skills may be the minimum required knowledge for supporters using the current page-map tool. To further reduce the required skills, new authoring technologies may be required.

It took more than 1 week (168 hours) for 25% of requests. One of the reasons is that the current mechanism for status changes did not work very well because of supporters' reservations about their own solutions. Status changes can be made by the supporter who worked on a request, but sometimes the supporter hesitated to change status to "resolved" because of uncertainty about the quality of their solution.

6.2 Request-first Model

How can users report their problems to the service? What types of requests users were reported and for what types of sites?

One of our findings is that "challenges exist on the user side." In our process model, the starting point of each collaboration is always a request (Figure 2), and this proved to be a challenge. We found that making requests was more difficult than we had expected. In this section, we consider three of the major reasons revealed by analysis of our results and in interviews and discussions with participants. Among these issues, the issue of the lack of awareness is crucial and severe for the blind community.

Request types	Count
Request for alternative texts	124
Request for heading tags	80
Questions	43
Request for making Flash accessible	15
Request for alternative texts and headings	13
Report for Form related issues	12
Request for removing repetitive information	9
Request for landmarks	7
Others (color-related, CAPTCHA, DHTML, etc.)	20
Total	323

Table 2. Classification of User Requests

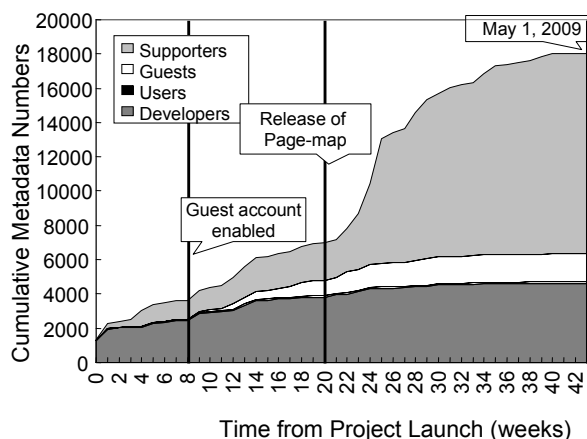


Figure 5. History of Supporters' Activities

6.2.1 Users' unawareness of problems - "They don't know what they don't know."

One of most important findings of the service was the high ratio of users who are not aware of the nature of the problems they are facing. Skilled and experienced users are aware of their problems, and they can easily report them. However, we were surprised by how many users were unaware of the real causes of their difficulties. Patrie et al. reported on the awareness issue in their investigation on remote usability evaluation [18] and we also described such problems in an analysis of voice browsing behavior [24]. However, the severity of this problem looms larger the more we study it.

About 30 blind computer users joined a seminar-style discussion that we organized. However, most of them were not actively accessing the Web, but only accessing certain "selected special sites for the blind". Many had tried to access general websites, but they found such websites "totally confusing and time consuming", and most of them soon quit trying. In other words, they gave up on the wider Web without even knowing much about the world's information and services. Some of the users that we interviewed mentioned that this phenomenon is "a major concern for the visually impaired community." Without wider public awareness of the real problems, this situation will not change.

Another awareness problem involves the major screen readers that silently skip certain objects, such as unlinked images without alternative texts or Flash movies with the opaque setting. In such cases the users are quite unaware of the objects regardless of their importance. A related example involves inappropriate or misleading headings. If such a heading tag appears near the bottom of a page, most users will jump directly to the heading, and thus miss most of the actual content of the page. As long as something is found after the heading the user will usually report that the page has “no problem”, as a result of being misled about the true content of the page.

This raises an epistemological question: *How can users report problems that they cannot recognize?* They may be able to infer the existence of problems through from other content, and we found some examples of this among the actual requests we received. For example, one request said that an instruction should appear on the page, but complained that there was no readable information there. In this case, the user was able to report the problem because the missing information was obvious and easy to infer, but such situations seem relatively unusual.

6.2.2 Too many basic problems

The interview sessions revealed that another factor that discouraged users from submitting any request was finding too many problems on a page. The most common requests were basic accessibility errors, such as missing alternative texts and missing headings (Section 5.2). That is why so much of the supporters’ work was devoted to such basic and repetitive improvements (Sections 4.1 and 4.2). In addition, such problems often appear repeatedly on a website that uses pages with a similar layout. For example, if an article does not have a heading tag, all pages with a similar layout may lack heading tags. As a result, many users feel uncertain about when to send requests. This phenomenon is consistent with the results reported by Monkoff et al [16] in their investigation for thoroughness of detected errors by blind experts.

6.3 Sustainability

How can we create a self-sustaining service with active participation?

There are two sides of sustainability. One is motivating the supporters to continue helping users. As described in Section 4.3, a few supporters contributed frequently for months. Their activities were sufficient to respond to the current numbers of requests from users.

The other side of sustainability is the ongoing participation of the end users. We found significant challenges on this side. In order to sustain ongoing participation, we need organizations to educate and encourage the users as they address the problems. The problems will be there, but the users need the skills to imagine the improved Web environment resulting from the solution of these accessibility problems. The collaboration approach is a method to make this goal more achievable, but special skills are required to reach the goals.

To encourage the users, collaboration with existing organizations seems to be the most promising approach. We have already been contacted by nonprofit organizations worldwide who hope to offer such service for more accessible content for their blind communities. If they can fill the roles of educating and encouraging users, the situation will be dramatically improved.

7. Next Steps

As described in the previous section, the most important challenges are on the user side, and therefore we need to consider sustainable social mechanisms and technologies to support those mechanisms. This section discusses some of the most promising technical and organizational extensions and improvements for the service.

7.1 Site-wide Metadata Authoring

As introduced in Section 3, some of users explicitly and most of the users implicitly requested improvements not only for specific pages but also for other pages on the target site. To address those requests, some supporters worked tirelessly on surrounding pages to cover as many pages as possible, thus encouraging users to access the entire website, not just the original target pages.

Therefore, **site-wide metadata authoring** support would dramatically improve the effectiveness of the service. Site-wide metadata can cover thousands of suitable pages on a site, for example by adding heading tags to pages with similar layouts [20]. The current Accessibility Commons database is capable of site-wide metadata [13], but it is technically difficult to make the site-wide authoring tool easy-to-use for a broad community of supporters. New technologies should be invented to make site-wide metadata easier to create, more robust, and more practical.

Our team has been working toward these goals. Our **site-wide annotation inference algorithm** and its integration into our authoring tool is one of these efforts. The algorithm is capable of presenting possibly applicable metadata for a new page by analyzing the similarity between the new page and the pages with existing metadata. If a supporter creates a set of metadata for one page and opens another page with a similar layout on the same website, then a list of recommendations will be presented. If the supporter accepts a recommendation, that metadata will be generalized to cover all of the similar pages, perhaps thousands, by generalizing the matching patterns for the URI and the description that selects an element (using Xpath).

Creating site-wide metadata is generally considered to be tedious and time-consuming, but that is not an intrinsic limitation. From our experiences, we have found ways that site-wide authoring technologies can reduce the work of supporters. This is evident when we see similar metadata created for many pages on a website. We have estimated the potential workload reductions by analyzing the created metadata. The results show that 4,667 metadata records out of the total of 11,969 alternative texts and 1,206 metadata records among the 6,388 headings seem to be redundant. Beyond the saved work, the coverage of websites can be dramatically broadened.

Once site-wide authoring technologies have been developed, new process models are possible by integrating the site-wide authoring phase before the request phase. Figure 6 shows the new process flow. The point is basic accessibility improvement “in advance.” The new process starts with the selection of a target site. The site can be selected in various ways, such from users’ requests for site-wide improvement, through discussions among end users and supporters, or in collaboration with a site owner who is eager to make a site accessible.

7.2 Activating the End Users

In order to encourage active participation by users beyond the challenges summarized in Section 6.2, three types of technologies should be created. First is a method for a **site request**, a request to improve the basic accessibility of a target site. This is already partially addressed in the previous section, but there should be a special focus on users who have given up their hopes of accessing the Web. We believe that a site-based service could help lure back some of these users.

Second would be an **accessibility checking functions** for end users. This would be a relatively small but important function to help users be aware of the problems they are facing. Some of the existing screen readers have functions to give an overview of the accessibility by announcing statistics for the content when the page is loaded, such as the number of links. With improvements, using intuitive and non-intrusive functions to present the accessibility problems, users will be more aware and more motivated to address their problems.

Another required feature would involve functions for **user-side metadata authoring**. In our interviews we found that expert users are eager to improve the accessibility by themselves and to contribute to other users. Actually user-side “labeling” of images is one of the major functions of leading screen readers [12] and of some existing collaboration services [19][25].

Our Access Tool has been gradually improved in the direction of integrating checking and authoring functions. The function to list and navigate among images without alternative texts allows users to be aware of problems without disrupting their daily use of the Internet. A natural extension of this function would be an alternative text authoring function. If a user is aware of an appropriate alternative text for an image, the user could create and submit the alternative text for the image. AccessMonkey [3] is an example with a combination of accessibility checking and authoring functions for inappropriate alternative texts for blind end users. Integration and convergence with these technologies will be a clear future direction, and the core database of Social Accessibility is originally designed to enable such integration [13].

The Flash-access function also allows users to be aware of the existence of opaque Flash movies. Beyond awareness, the tool converts such Flash movies into non-opaque movies and allows the users to access their content. In addition, users can add appropriate labels to the buttons in the content.

These recently added functions are small steps, but they increase the power of users to be aware of their own problems while allowing them to resolve more problems by themselves. However, it is clear that new technologies to empower blind users could allow them to access various types of content and help them discover the gaps between visual and non-visual information.

7.3 Collaboration with Site Owners

The collaborative model is often seen as a competing approach to the compliance-oriented model, but we feel this is an overly limited perspective. One of the reasons is that collaboration between “supporters” and “users” can be regarded as an approach to crowd-sourcing. In reality, the special advantages of external metadata, timeliness and adaptivity, can also contribute value to the site owners. The collaborative model will also accelerate the process of compliance by helping to connect with the stakeholders

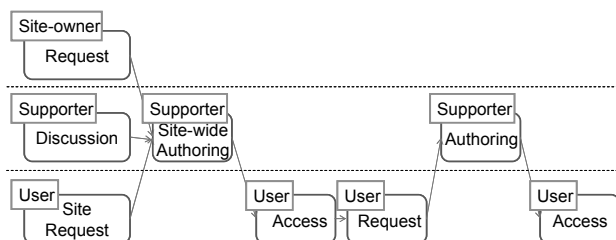


Figure 6. Process of the New Site-wide First Model

on the site-owner side, such as the designers, developers, content authors, and system vendors.

The **back-stage model** will enable site owners to integrate external metadata into their pages. This is a simple mechanism for applying metadata inside of webpages without any external tools. With support from the site owners, a special HTML tag could be inserted into the page templates. Then the tag (script) can automatically access the database, acquire the metadata, and apply it to the page. Users may not even notice the existence of the metadata mechanism. End users could access accessible content without installing any tools. The process could be done behind the scenes. This approach would also improve the compliance of the website, since the improvement is a part of the similar webpages as handled by the general JavaScript libraries. The dynamic improvement approach by using a JavaScript library is already used by Google with AxsJAX technology [6].

The combination of the **back-stage model** with **site-wide metadata authoring** will be a new approach to make websites not only compliant but also adaptive for end users. For example, one of our preliminary experiments, one supporter needed only an hour to fix an existing government agency website with 3,500 accessibility validation errors in 82 pages. This involved creating 142 metadata records.

If a site owner is actively working to improve the accessibility of a website and wants to promise end users that requests will be addressed quickly, then **request redirection** may be the best way to contribute. This method redirects the submitted requests to a specific channel provided by the site's owner. In this case the collaboration system will work as a hub for gathering users' requests. The **portal for site owners** would be a channel for improving websites by providing summary metadata and requests as a set of objective instructions. The requests can be regarded as a set of results of real-world usability testing, and the metadata can be regarded as examples to improve the website. Currently, the information is hidden inside the database. Therefore, we are now planning to create portals for site owners so they can see the summarized information about their websites.

The collaboration approach or technologies in collaboration services have great possibilities to reduce the work for compliance and to improve accessibility. We, the research community, should consider ways to work with site owners and new technologies to support them.

8. Conclusion

In this paper, we summarized the 10 months of an experimental service, Social Accessibility, and tried to foresee future directions to make collaborative accessibility improvements into a mainstream approach. Three topic areas for the end users, the

volunteers (supporters), and for the sustainability of the approach were presented to clarify the challenges of the approach. We reviewed our work, summarized examples and the statistics of the experimental service, and considered some of the technical innovations included as this new service evolved. We found that the supporters were surprisingly productive, but that users were often unsure what to ask for. We also considered some of the features and technologies that seem most promising as next steps, with special focus on site-wide tools and approaches.

The experiment is still continuing. We are planning to publish more about the technologies introduced in this paper, especially for site-wide authoring tools and accessories. More importantly, we have been discussing with various organizations around the world about how we can integrate these approaches and technologies into their ongoing activities. For example, the system could be utilized by a public agency to address the accessibility issues on their websites based on users' actual requests. In their situation, the new metadata will be created by official metadata authors. In school, the system can be utilized as a part of education course for information accessibility based on real user difficulties. Also, research institutes can utilize the system as part of their searches for future collaborative methodologies. We hope that these efforts will collectively create new services in the near future to help those users who find themselves on the edges of our information society.

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053 _0 |a AS

150 __ |a Congresses and conventions

360 __ |i subdivision |a Congresses |i under subjects; and names of individual congresses

450 __ |a Colloquia

450 __ |a Colloquiums

450 __ |a Conferences

450 __ |a Conventions (Congresses)

450 __ |a International conferences, congresses and conventions

450 __ |a Symposia

450 __ |a Symposiums

550 __ |w g |a Intellectual cooperation

550 __ |a Convention facilities

670 __ |a Random House Kernerman Webster's college dictionary, ©2010, via TheFreeDictionary.com, Aug. 29, 2013 |b (colloquium n., pl. -quiums, -quia a conference at which scholars or other experts present papers on and discuss a specific topic)

670 __ |a The American heritage dictionary of the English language, ©2000, via TheFreeDictionary.com, Aug. 29, 2013 |b (colloquium n. pl. colloquiums or colloquia 1. An informal meeting for the exchange of views. 2. An academic seminar on a broad field of study, usually led by a different lecturer at each meeting.)

670 __ |a Merriam-Webster online, Aug. 29, 2013 |b (colloquium plural colloquiums or -quia: a usually academic meeting at which specialists deliver addresses on a topic or on related topics and then answer questions relating to them)

906 __ |t 9921 |u te04 |v 0

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150 __ |a Computerized self-help devices for people with disabilities

450 __ |w nne |a Computerized self-help devices for the handicapped

550 __ |w g |a Self-help devices for people with disabilities

670 __ |a Work cat.: Cattoche, R.J. Computers for the disabled, 1986.

670 __ |a Hennepin |b (Disabled persons--Self-help materials)

670 __ |a IEEE Computer Society Workshop on Computing to Aid the Handicapped, 1980, 1981.

952 __ |a 2 bib. records to be changed

953 __ |a fh10 |b tc03

906 __ |t 1123 |u tc03 |v 0

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111 2_ \$aInternational ACM SIGACCESS Conference on Computers and Accessibility.
245 10 \$aAssets :\$bthe ... International ACM SIGACCESS Conference on Computers and Accessibility /\$csponsored by ACM's Special Interest Group on Accessible Computing.

- 246 30 \$aInternational ACM SIGACCESS Conference on Computers and Accessibility
- 246 30 \$aACM SIGACCESS Conference on Computers and Accessibility
- 260 \$aNew York, N.Y. :\$bAssociation for Computing Machinery,\$c2004-
- 300 \$avolumes :\$billustrations ;\$c28 cm
- 310 \$aAnnual
- 336 \$atext\$btxt\$2rdacontent
- 337 \$acomputer\$bc\$2rdamedia
- 338 \$aonline resource\$bcr\$2rdacarrier
- 362 0_ \$a6th (2004)-
- 500 \$a6th issue (2004) published as part of the journal Accessibility and computing: "A combined issue of Accessibility and computing, number 77 (September 2003) & number 78 (January 2004)."
- 500 \$aPublication became annual with 7th conference (2005).
- 530 \$aAlso issued online.
- 650 _0 \$aComputers and people with disabilities\$vCongresses\$vPeriodicals.
- 650 _0 \$aComputerized self-help devices for people with disabilities\$vCongresses\$vPeriodicals.
- 710 2_ \$aAssociation for Computing Machinery.
- 710 2_ \$aAssociation for Computing Machinery.\$bSpecial Interest Group on Accessible Computing.

710 2_ \$aACM Digital Library.

730 0_ \$aACM Digital Library conferences.

730 0_ \$aAccessibility and computing.

780 00 \$aInternational ACM Conference on Assistive Technologies.\$tAssets\$x1541-6666\$w(DLC) 2002201423\$w(OCOLC)47353619

856 41 \$zAvailable through ACM Digital Library: 6th (2004)-\$uhttp://portal.acm.org/proceedings/assets/

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245 10 Assets : \$b the ... International ACM SIGACCESS Conference on Computers and Accessibility / \$c sponsored by ACM's Special Interest Group on Accessible Computing.

246 30 International ACM SIGACCESS Conference on Computers and Accessibility

260 New York, N.Y. : \$b Association for Computing Machinery, \$c ©2004-

300 volumes : \$b illustrations ; \$c 28 cm

310 Annual, \$b 2005-

321 Biennial, \$b 2004

336 text \$b txt \$2 rdacontent

337 unmediated \$b n \$2 rdamedia

338 volume \$b nc \$2 rdacarrier

362 0 6th (2004)-

490 1 Accessibility and computing ; \$v no. 77-78 etc.

500 Issue for 2004: "A combined issue of Accessibility and computing, number 77 (September 2003) & number 78 (January 2004)."

588 Latest issue consulted: 7th (2005).

650 0 Computers and people with disabilities \$v Congresses.

650 0 Computerized self-help devices for people with disabilities \$v Congresses.

650 6 Ordinateurs et personnes handicapées \$0 (CaQQLa)201-0151412 \$v Congrès. \$0 (CaQQLa)201-0378219

650 6 Aides fonctionnelles informatisées \$0 (CaQQLa)201-0206718 \$v Congrès. \$0 (CaQQLa)201-0378219

650 7 Computerized self-help devices for people with disabilities. \$2 fast \$0 (OCoLC)fst00872772

650 7 Computers and people with disabilities. \$2 fast \$0 (OCoLC)fst00872893

655 4 Congresses.

655 7 Conference papers and proceedings. \$2 fast \$0 (OCoLC)fst01423772

710 2 Association for Computing Machinery.

710 2 Association for Computing Machinery. \$b Special Interest Group on Accessible Computing.

730 0 Accessibility and computing.

776 08 \$i Online version: \$a International ACM SIGACCESS Conference on Computers and Accessibility.
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