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An Alternative Information Web for Visually Impaired Users in Developing Countries

Nitendra Rajput
IBM Research Division
IBM India Research Lab
4, Block C, ISID Campus, Vasant Kunj
New Delhi - 110070, India.

Sheetal Agarwal
IBM Research Division
IBM India Research Lab
4, Block C, ISID Campus, Vasant Kunj
New Delhi - 110070, India.

Arun Kumar
IBM Research Division
IBM India Research Lab
4, Block C, ISID Campus, Vasant Kunj
New Delhi - 110070, India.

Amit Anil Nanavati
IBM Research Division
IBM India Research Lab
4, Block C, ISID Campus, Vasant Kunj
New Delhi - 110070, India.

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Nitendra Rajput, Sheetal Agarwal, Arun Kumar, Amit Anil Nanavati
IBM India Research Laboratory
4, Block C, Vasant Kunj, Institutional Area, New Delhi - 110070, INDIA.
{rnitendra, sheetaga, kkarun, namit}@in.ibm.com

ABSTRACT

Websites in World Wide Web are primarily meant for visual consumption. Accessibility tools such as screen readers that render the visual content in audio format enable the visually impaired to access information on the websites. Despite standards that are available to make websites more amenable for screen reading softwares, not many website authors embed the required metadata information that feeds into such tools. Moreover, the wide variety of visual controls available make it harder to interpret the websites with screen readers. This problem of accessing information and services on the web escalates even further for visually impaired in developing regions since they are either semi-literate/illiterate or cannot afford computers and high-end phones with screen reading capability.

In this paper, we present an alternate platform — the World Wide Telecom Web (WWTW), for delivering information and services to the visually impaired. WWTW is a network of *VoiceSites* that can be created and accessed by a voice interaction over an ordinary phone. We present user studies which demonstrate that the learning curve for using applications on the Telecom Web is relatively low and does not require extensive training. The study leads us to believe that the Telecom Web can be the mainstream Web for blind users.

Categories and Subject Descriptors

K.4.2 [**Social Issues**]: Assistive technologies for people with disabilities; H.4.3 [**Communications Applications**]: Information browsers

General Terms

Design, Human Factors

Keywords

World Wide Telecom Web, information access, visually impaired, developing countries

1. INTRODUCTION

For a common person, access to information is a key requirement today. Over the last decade, the World Wide Web has grown tremendously to become the largest source of information. It is also being used by governments and enterprises to provide services to their citizens and customers. There are several existing efforts at making the content on the Web accessible to visually impaired users. These include software tools such as screen readers, web accessibility standards and government laws to make websites accessible.

However, of the 37 million blind people worldwide, 90% live in developing regions [18] and more than half are in India (9 million), Africa (7 million) and China (6 million). Only 17% of the entire world's population has access to Internet, and for developing regions it is even lower (5% in India, 4.7% in Africa and 16% in China)[1]. Second, 53% of the remaining world population lives below USD 2 per day [15] and cannot afford a computer or high end phones required to access the Internet. Third, a significant portion of the remaining 30% are illiterate and semi-literate people [17] and are not IT savvy. These statistics clearly suggest that the World Wide Web is *not accessible* to a very significant segment of visually impaired users.

Compared to Internet penetration, last few years have seen a tremendous growth in mobile phone penetration in these developing regions. The phone penetration in developing countries had reached 32.4% in 2006[2]. The actual penetration is even higher when we consider the fact that a phone is usually shared in the family (which has an average size of four people) in such countries [6]. In this paper, we present an alternative mechanism for delivering information services to the visually impaired that leverages the pervasive reach of the phone network. Since the majority of visually impaired population is from developing countries, it is pertinent that the solution be affordable and easy to learn and use. We use the concept of VoiceSites [12], that can be accessed through voice by a phone, as a mechanism for information upload and access for visually impaired users. The contribution of this paper is threefold:

- We propose VoiceSites based Telecom Web as more suited to visually impaired in developing regions than the existing World Wide Web.
- We perform user studies with 43 blind users to evaluate the (a) initial learning difficulties, (b) ease-of-use of

[1]http://www.internetworldstats.com/stats1.htm
[2]http://www.itu.int/ITU-D/ict/statistics/ict/graphs/mobile.jpg

VoiceSites, and, (c) accessibility of VoiceSites for blind users.

- We summarize the user studies and provide insights gained from the interaction of blind users with the VoiceSite.

In this paper, we will first describe the underlying concepts of VoiceSites and the World Wide Telecom Web (Section 2) and will then describe the application scenario that was used for performing the user study (Section 3). We will present the profile of the subjects and present the user study method (Section 4) and the results of the user study (Section 5). Finally, we will discuss some potential applications that can be hosted on VoiceSites (Section 6) before concluding the paper.

2. TECHNOLOGY BACKGROUND

In this section, we briefly describe our vision of a web of VoiceSites which we propose can become the mainstream information web for the visually impaired in developing regions.

VoiceSites are voice driven applications that are created by the subscribers and hosted in the telecom network [12]. They are represented by a phone number and can be accessed from any phone instrument, mobile or landline through an ordinary phone call to that number. The phone does not require any extra features or software to be installed on the device. VoiceSites thus are analogous to websites in the WWW and can link to other VoiceSites through Hyperspeech Transfer Protocol (HSTP) [1]. A network of such interconnected VoiceSites results into a World Wide Telecom Web (WWTW) [11] as shown in Figure 1.

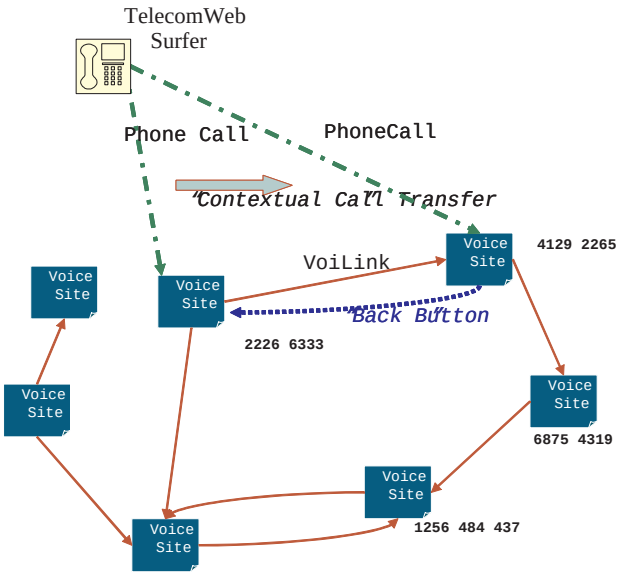

Figure 1: The World Wide Telecom Web

This WWTW has tremendous implications:For the visually impaired this means that they do not have to spend months learning how to use a computer and the various accessibility softwares such as screen readers. It also enables the non-PC literate people to access information and services that were hitherto unavailable to them through IT systems.

VoiceSites can be created through a simple voice driven interface, VoiGen [12], over a phone call. The ease of creation of VoiceSites enables the subscribers to become information providers as opposed to being simply information consumers. Several applications of Telecom Web and similar voice-based systems are emerging [10, 9]. Next, we describe a sample VoiceSite that we created for the purpose of studies done in this paper.

3. APPLICATION SCENARIO

To demonstrate the usability of the concept of VoiceSites, we developed a sample VoiceSite based on the website of the Ministry of Social Justice, Government of India, that enables people to lodge their complaints at the ministry. In the current practice, complaints are lodged either through written applications or through the ministry website.

The VoiceSite emulates the web based form that is used to lodge complaints. It takes the caller's personal details before asking the caller to record his complaint. After recording the complaint, a complaint reference number is given to the caller which can be used to call the site later and check on the status of the complaint. Figure 2 shows the structure of the VoiceSite. The VoiceSite does not take all the data that a web based form asks the user for, but only takes in the mandatory information. Figure 3 shows a snapshot of the web based grievance registration form.

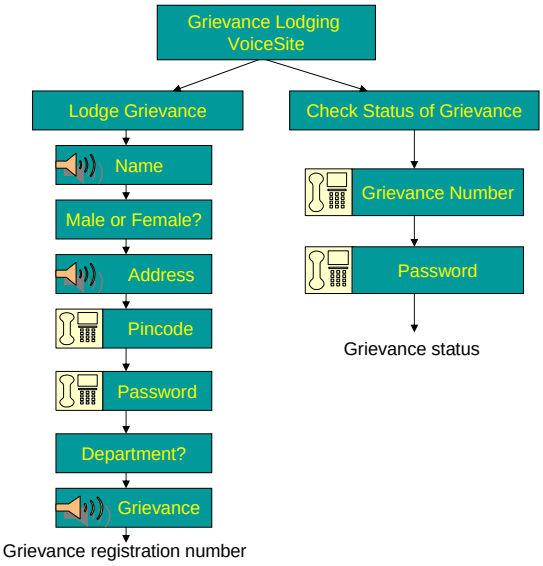

Figure 2: Call Flow for Grievance VoiceSite

The VoiceSite records the audio of some inputs such as the caller name, address and the actual grievance. It takes number inputs such as pincode (zipcode) and password through the phone keypad. It also performs speech recognition for simple inputs such as the gender and the name of government department.

4. STUDY METHODOLOGY

For our study, vision impairment was the only criterion to select the subjects. The study was conducted at two institutes: the National Association for the Blind, New Delhi,

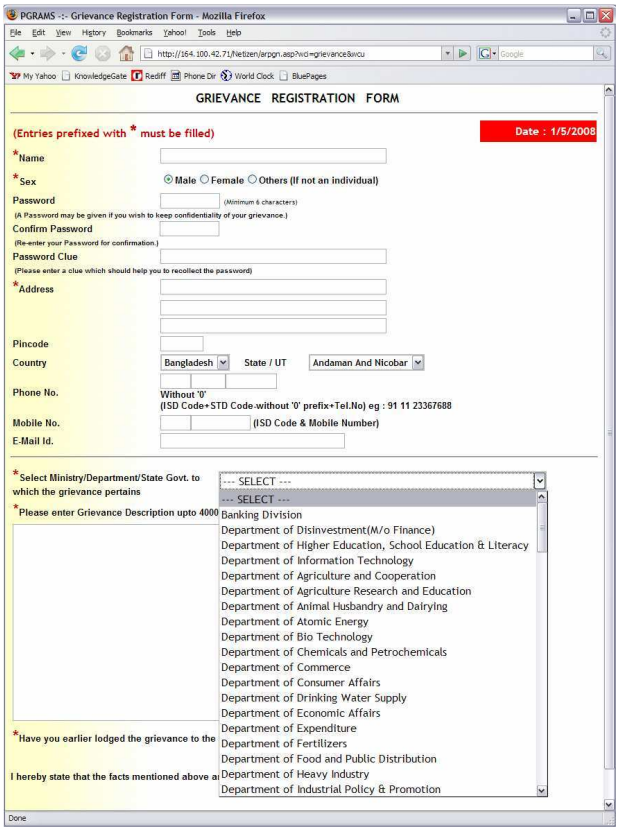

Figure 3: Web based form for Grievance Registration

and the Blind Relief Association, New Delhi. The staff at both institutes quickly grasped the concept of VoiceSites and readily agreed to help us with the user study of our prototype. The subjects were interviewed at the institute locations in the computer labs on campus.

4.1 Subject Profile

Of the 43 people that were interviewed, five were partially blind, remaining were completely blind. The mean age of subjects was 25 years, with a standard deviation of 8. The youngest subject was 12 year old and the eldest was 50 years, both male. There were six female subjects, all within the age-group of 17 to 35 years. Figure 4 shows the age histogram of the subject profile.

44% of the subjects had completed graduation in college. Figure 5 shows the histogram of the number of years of education of the subjects. 50% of the subjects were students, 22% were unemployed and the remaining were working in NAB, banks, or other government offices. About 60% subjects were familiar with the English language, but preferred to interact in Hindi.

The average computer experience of this set was about 2.8 years, with a high standard deviation of 3.15 years. Therefore, the set had people who had no knowledge of computers to people who were using computers for the last 10 years.

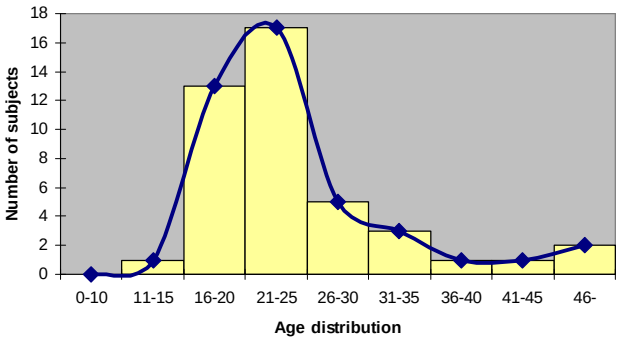

Figure 4: The Age histogram of subjects.

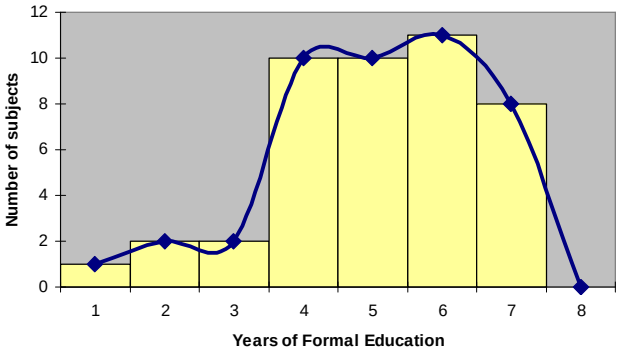

Figure 5: The education histogram of subjects.

All computer-literate subjects use JAWS[3] as a screen reading software. 55% of the subjects had used Internet before. However there were people who had used the computer (softwares such as Word, Excel) but not used the Internet.

4.2 Survey Process

The usability study procedure was divided in three parts. Initially to set the participant at ease, we introduced our group and asked regular questions such as name, education, professional status, age and their comfort levels in terms of using the PC to gather the profile of the subject. Subsequently, we introduced the concept of VoiceSites and in specific Grievance VoiceSite and explained the need for conducting such a user study. Some subjects had several questions about the concept of the VoiceSites. Once we satisfied the subject queries, we moved on to the second phase of the study.

In the second part of the usability study, we were silent observers and the subjects were asked to interact with the Grievance VoiceSite. In a few cases, we had to provide some help to subjects when they had problems navigating the VoiceSite. We observed the number of times a user had to repeat a particular step and the total time of interaction with the VoiceSite.

Once a subject was able to lodge a grievance, we concluded the study by gathering feedback from the subject through an interview session. We specifically asked the following

[3]http://www.freedomscientific.com/fs_products/software_jaws.asp

questions about the usability of the Grievance VoiceSite:

- Was the call flow simple to follow?
- Are you comfortable using the phone keypad?
- Was the audio clear and understandable?

We then asked some open-ended questions about the usefulness of the Telecom Web for blind users. We also asked them to brainstorm on some of the applications that they would be interested in browsing on the Telecom Web.

Figure 6: Subjects interacting with the VoiceSite at a lab in NAB.

Though we had a dedicated computer laboratory and a classroom to ourselves at the NAB (Figure 6) and BRA respectively, there was a lot of background noise at at the NAB location. This noise was of the screen readers on a couple of machines in the room that were being used by students while we were conducting the user study. The subjects used a low-end Nokia 1600 mobile phone, which costs approx 45 USD, in speaker mode to interact with the VoiceSite. Though the speaker mode was more sensitive to noise, but that allowed us to listen to the entire conversation and we could make detailed observations.

The entire interview process took about 20 minutes for each subject. Of this, we spent about 5-10 minutes on the initial introductory session, 4-6 minutes on the application and 4-6 minutes on seeking the feedback. These interviews were conducted in 4 days with 10 subjects interviewed per day.

5. USER STUDY RESULTS

In this section, we will present the results of the user study that is based on the Grievance VoiceSite. This section covers results from part 2 and part 3 of the study process where we observed the subjects interacting with the VoiceSite and then interviewed them subsequently. Since the observations and insights from different users were significantly different, we present the results in three separate categories. In the first category, we present the statistical results that were derived from common observations and answers across all subjects. The second category of results has some specific observations that we noted at the time when subjects were interacting with the VoiceSite. The third category of results are interesting and important anecdotes that some subjects provided during the interview process. We would like to clarify to the readers that the last two categories of results are not statistically driven, since they are influenced by just one subject in some cases. However, we believe that these observations provide valuable insights about the usability and applicability of VoiceSites and hence have included them.

5.1 Statistical Analysis

The average time for completing the grievance registration task for the subjects was 218 secs, with a standard deviation of 60 secs. This time ranged from a minimum of 120 secs to a maximum of 380 secs. The graph in Figure 7 shows the histogram of the time taken by subjects.

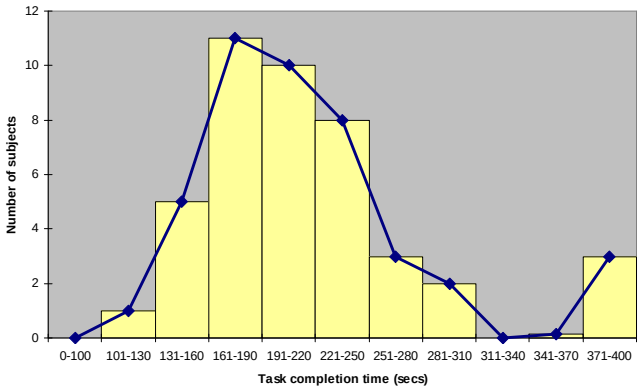

Figure 7: The task completion time histogram.

An interesting observation is that the correlation between the number of years of computer experience of a subject and his/her task completion time is very low (0.28). This is reflected in Figure 8 which shows that if we sort the subjects in increasing order of the number of years of computer usage, there is no corresponding decrease in the time that it took to complete the grievance task. Moreover, there are a lot of subjects whose task completion time is high, despite the fact that they are experienced in using the computer (see subjects 40 and 41).

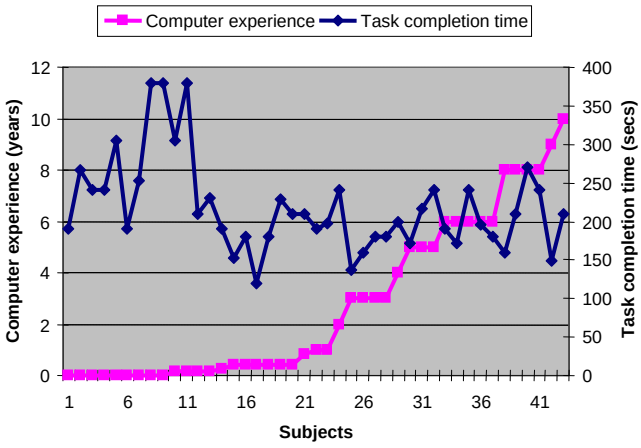

Figure 8: Correlation of computer experience with task completion time.

Statistical Insight 1: *We attribute this lack of correlation as a proof point that using VoiceSites on the Telecom Web is easy and is not dependent on the computer skills of people.*

Table 1: Summary of responses from subjects

Questions	Yes	No
Is VoiceSite structure ok?	100%	0%
Comfortable in punching digits?	72%	28%
Had used a mobile earlier?	91%	9%

As seen in Table 1, all 43 subjects were satisfied with the structure of the VoiceSite, which is a reflection of the sequence of questions that were asked by the VoiceSite. When asked whether they were comfortable in punching digits on the mobile keypad (to enter zip code and password), 72% subjects answered affirmatively. Of the remaining 28% subjects who were not comfortable using the keypad, some mentioned that they find it difficult when using a different mobile device than theirs. 9% of the subjects were using the mobile phone for the first time, so they did not know how to use the keypad – we had to input the keys for these subjects. Even though 72% subjects said that they are comfortable using the keypad to punch digits, only 39% were able to complete the task without having to repeat the keypad-input step. The Grievance VoiceSite was designed such that it used to wait for 5 secs to receive 6 digits from the subject. *We identified this as a bad VoiceSite design, since the timeout could have been increased without affecting any other usability aspect of the VoiceSite.* If a subject was unable to enter the digits within this time, we counted this as a repeat attempt. Some subjects were generally comfortable using the keypad, but still could not enter the digits in time. They took time to think about the answer and that reaction time was enough to trigger the timeout.

We also observed the number of interactions each subject had to repeat, either because the system was unable to understand the user voice or the user was unable to provide the input in time. Figure 9 shows the histogram of the repeat attempts ("repeats") done by the subjects.

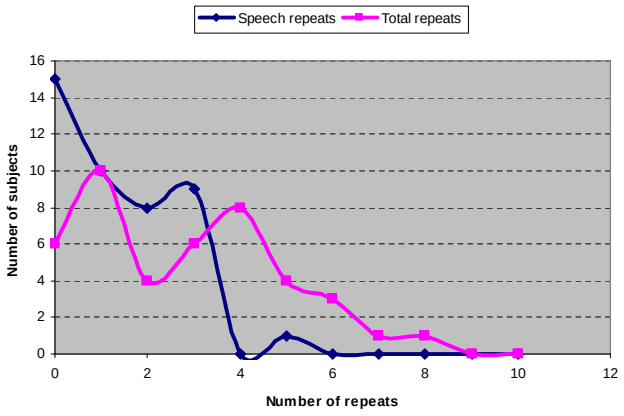

Figure 9: The repeats histogram.

The average number of repeats per subject were 2.7, with a standard deviation of 2. However *all subjects (except one) were able to complete the grievance registration task in a single phone call.* 11.6% subjects were able to complete the task without having to repeat even a single utterance. The maximum repeats were 8, which was observed in one subject.

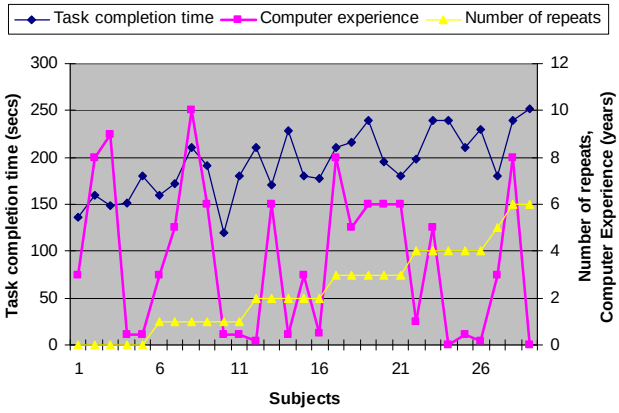

Figure 10: Correlation of repeats, task completion time and computer experience.

Not surprisingly, there was a high correlation between the number of repeats with the task completion time (0.74). However, as was clear with Statistical Insight 1, the correlation of the number of years of computer experience with the task completion time was very low (0.28). Figure 10 shows that if we order the subjects in increasing order of the number of repeats that were observed during their conversation with the Grievance VoiceSite, then the correlation with task completion time is visible. It is also clear the computer experience is not related to the number of repeats.

Even though the average number of repeats is high (2.7), most repeats were due to the fact that the timeout for digit input through the keypad was very low. This can easily be modified in the implemented VoiceSite. If we discard the repeats due to keypad input, the average number of repeats was only 1.3 per subject, with a standard deviation of 1.2. This number is even more encouraging considering the fact that a majority of these were conducted in a lab where people were working in normal conditions and so there was ample background noise and people movement. Also the recognition errors are expected to decrease when the users move from a speaker phone to a regular voice mode.

Once the subjects were able to lodge the complaint on the Grievance VoiceSite, we had asked them whether they think that the concept of VoiceSites and Telecom Web is useful. An overwhelming 90% subjects believed this concept to be *very useful.* The remaining 10% subjects mentioned that this *may be useful* for visually impaired people.

We derive the following conclusions from the statistical analysis of usability study:

1. It was easy to use the VoiceSite since everyone (except one subject) was able to register a complaint.
2. The ease-of-use of the VoiceSite is not related to the computer experience of the subject.
3. The most difficult task for subjects was to input numbers using the phone keypad which was infact due to a bad design (short timeout) in the VoiceSite.

5.2 Observations

The statistical details explained above treat each study with a subject as an independent event. However when we were conducting studies, some subjects were observing when others were interacting with the VoiceSite. There were 8 such subjects. Interestingly, these subjects were able to complete the grievance registration task in a smaller time (174 secs, 13% less than the general average). They made fewer repeats (average of 1.5) than the general subject average of 2.7 (44% less).

Observational Insight 1: *The improvement in usability of the VoiceSite by subjects who were one-time observers leads us to claim that the learning curve involved in interacting with the VoiceSite is extremely low. Users can have improved VoiceSite interaction just by observing one user interact with it.*

When we compare this learning curve with the time that it takes an average blind person to learn computer and Internet, Telecom Web provides a significantly low technology barrier. Most computer-literate subjects had taken a five month course (offered at NAB) before they could operate the computer. A majority of them mentioned that they had problems in understanding the synthetic voice that is used in the screen-reader softwares. This is especially true for people in developing regions such as India, China and Africa where English is not the first-language of most speakers, and, where the accent of English is significantly different from the UK or US accent that is available on screen-readers. Notably, Indian accent English screen-readers are not available in the market. In the initial part of the study, we had designed the VoiceSite such that it used a synthesized English voice in a US accent to interact with the subjects. Of the 9 subjects that interacted with the synthesized English voice, three did not understand English and so we had to prompt them with the translations in Hindi. Five subjects were able to understand the voice but mentioned that they would prefer an Indian accented English voice.

Based on these comments, we modified the VoiceSite for Hindi language and this improved the usability significantly.

Observational Insight 2: *Since creating VoiceSite in a local language is extremely easy, we believe that the literacy requirements will be far less in the Telecom Web world.*

We also observed that unlike the case of a webpage where users respond through their keyboard, the VoiceSite has to be responded through voice or through the phone keypad. In order to keep the interaction alive, the VoiceSite times out and repeats the question if there is no user input within the timeout limit. Therefore a VoiceSite expects a user input as soon as it provides some information or a question to the user. However users take some time to understand the question and think of the right answer. For some users, this time is greater than the VoiceSite timeout for that interaction. In our usability testing, some users had to repeat the interaction because of such timeouts. We observed that due to the different interaction style, a VoiceSite is more spontaneous than a Website. Perhaps this is the reason why a lot of subjects asked for a user–initiated *repeat* feature so that if they are unable to understand a VoiceSite utterance the first time, then they can listen to it again before attempting to answer.

Observational Insight 3: *Due to the spontaneous nature of the VoiceSite, a user should have the option to pause or repeat the interaction at any time.*

Finally, we identified the usability of the VoiceSite by subjects with varying literacy in terms of education, mobile-usage and computer usage. For this, we categorized the subjects in four categories: (a) subjects who are completely illiterate, (b) subjects who were mobile and computer illiterate, (c) subjects who are mobile literate but computer illiterate, and (d) subjects who are computer and mobile literate. The task completion time for the four categories is shown in Figure 11.

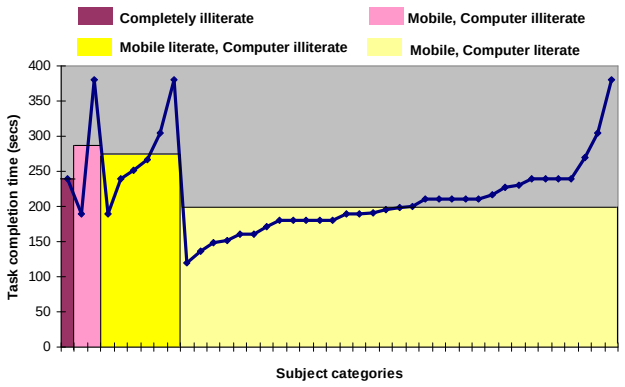

Figure 11: Correlation of repeats, task completion time and computer experience.

We had only one subject who was completely illiterate. Since we helped him in punching digits, his task completion time was comparatively lower than that of other categories. However for the other three categories, it is clear that as the literacy with different devices increases, the task completion time improves. The blue line shows the individual task completion time for subjects in that category.

5.3 Anecdotal Inputs

The accessibility efforts for the visually impaired mainly focus on how to deliver existing content. Though standards exist for making websites more amenable for screen-reading softwares, the standards are not necessarily followed by all websites. Moreover, websites are not really designed from an accessibility point of view. Though most softwares are designed for sighted users, the blind users become fairly adept at using them barring some difficulties. During our interactions with the subjects, we received a lot of useful and interesting comments about their existing pain-points. Here are some of the paint points users mentioned regarding the use of websites and accessibility softwares:

"I had studied in a government school, so understanding the foreign accent English in JAWS was a problem initially. It took me about two months to get used to a computer."
"The GUI should be more accessible. All menus should have alternate keys."
"We cannot work on all computers, we need computers that have JAWS installed on them."

"The structure of each website is different, this is a problem. There are too many different options."
"Screen readers convert everything in accessible format. Pictures are the only problem, not all have alternate text."

Some of the difficulties were related to the process of learning how to use a PC. *"I could never figure out how to type on the computer. I still don't know."*
"Windows 98, 2000 was not as comfortable. Now it is much better."

When asked what they thought of the Telecom Web, besides unanimously agreeing that the concept is especially useful for the visually impaired, here are some specific comments:
"We cannot see everything on screen, But with voice, we know that a VoiceSite is linear so we know that we are not missing any content."
"One or two attempts and you are all set. This is too easy to use."
"There should be a key for repeating whatever was asked."
"This is very useful. Women can lodge a grievance for police complaints."
"This could be a window to the world for us."
"I would prefer to answer through the keypad then we will not have speech recognition errors."
"Speech recognition in crowded places will be an issue."
"a Help button should be provided at every interaction. For example, people may not know what is a password. So that help key can tell you more details about that question."
"First time it was a problem for me, else I will be able to use it."
"Talking software on mobiles is very expensive, moreover, it is available only for high-end mobiles therefore it is not good."
"I would prefer a language option to choose between Hindi and English."
"When I get to create a VoiceSite, I hope I will be able to edit to ensure that I can overwrite bad prompts."

In our discussions they also raised other interesting points. For example, most of the subjects use their memory to make note of things. After the study one of the subjects asked *"How can I remember my password? If I forget it how can I recall my password"*. Another subject was an English major and very fond of writing, but he did not have a channel to publish his work or indulge in writing since he does not own a PC. Simple services that are available for sighted users such as reminders, scratchpads and calendaring are not widely available for the blind. VoiceSites can become that channel to access such services. In the following section we will describe some applications that could enable the blind publish their content and reach out to a wider community. Since the access to VoiceSites is a simple phone call, it can become a pervasive and low cost IT access mechanism for the blind.

6. POTENTIAL APPLICATIONS

In this section, we present a few potential applications for the visually impaired, the need for some of which came up during our interviews with them.

- Personal Digital Assistant

  Visually impaired do not have the luxury of using notebooks for recording information that they may want to refer at a later date. Aids such as Braille slate, memo recorder, talking or Braille watch, talking calculator, Braille timer etc. have their drawbacks. It is inconvenient to carry all of these individual instruments at all times. Also users in developing countries cannot afford to buy such instruments. With huge penetration of mobile phones, such features can be made available through a VoiceSite designed to be a Personal Digital Assistant accessible over a telephone call.

- Business VoiceSites

  The Telecom Web framework enables a very easy and intuitive mechanism for uploading content through a very affordable means. In that way, it becomes a very convenient vehicle for individuals to offer and advertise their services to the external world through their professional VoiceSites. This is especially true for the visually impaired micro-entrepreneurs some of whom currently rely on their mobile phones for all their business activities.

- Books Access, Authoring and Editing

  The current state-of-the-art method of delivering book content to visually impaired is through the DAISY format [4]. It provides a very good medium for easy navigation and search of books through audio and players are available for a wide variety of devices. However, a book made available as a VoiceSite designed for book editing would enable a content authoring mechanism for the visually impaired, using VoiGen [12]. Different chapters of the book/article could be organized as different menu options with editing rights to different people thus enabling collaborative editing as well.

- VoiceSite Master

  Analogous to Website Master profession for creation and maintenance of websites, Telecom Web opens up the opportunity of a new profession of VoiceSite Master for the visually impaired.

- Social Networking

  VoiceSites designed as Audio Blogs and interlinked through VoiLinks while including features such as Voice-Messaging, voice-mailing, voice chat, referrals etc., could enable social networking services for the visually blind.

7. RELATED WORK

Providing IT benefits to blind people has been a very well studied field of research. WebinSitu [4] provides an extensive study of the browsing behavior of blind users and compares them with the sighted users. The Aibrowser [14] provides uninterrupted accessibility to multimedia content such as flash on the websites. The benefits of these innovations are however limited to blind users who use a computer. Voice Diary [3] tries to combine various aids used by visually impaired such as braille slate, braille watch, talking calculator, etc. into a single unit.

With the increasing penetration of mobile phone devices, researchers have started to investigate the use of mobile phones to provide services to blind users. Pharos [13] and

[4]http://en.wikipedia.org/wiki/DAISY_Digital_Talking_Book

Drishti [5] are services that use GPS and a talking map software to provide location based services to blind users. In FETCH [8], the authors propose the use of cell phones for visually impaired people to find lost items. Handheld audio devices have been used to generate audio books for science learning for blind users [16]. The DAISY book format [7] is a standard format to enable navigation of audio books by features such as book skimming, providing jumps to pages, chapters, section headers and note-taking. Although several point applications have been built on the mobile phone, the Telecom Web is a good enabling platform where such applications can be hosted as VoiceSites and thus such applications can have a far reaching impact on the blind users.

The Telecom Web has earlier been used to provide mechanisms to organize the unorganized workforce in developing countries to increase the income of mobile workforce [10]. A voice kiosk based solution has also been proposed to provide information access and upload for villagers in developing countries [2].

8. CONCLUSION

In this paper, we presented the Telecom Web as an alternative to World Wide Web for delivering information services to visually impaired people. Telecom Web provides a low-cost, completely accessible platform, especially for people in developing countries. We performed usability study with a sample VoiceSite and derived interesting insights. Based on the user feedback, we conclude that the learning curve involved in using VoiceSites is very low as compared to learning the PC and Internet for interacting with websites. We presented several potential applications that can be delivered to the blind population through the Telecom Web. In future, we plan to develop some of these applications and study their benefits to the visually impaired. We also plan to investigate user-driven input mechanisms, rather than system-driven, for this population segment.

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