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Cloud based Co-authoring platform for visually impaired people

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***Abstract*—Due to the lack of confidence and vision capability, it becomes very difficult for blind individuals to perform group activities with sighted persons. By use of modern technology, we can easily overcome this issue. Google Docs, Microsoft word add-in, and other available tools do not provide voice-based notifications about dynamic actions for the visually impaired in a shared environment. Communication is done through comments which are not helpful for blinds. Our cloud-based collaborative writing platform is designed especially for the visually impaired where they write, manage and share documents. Co-authors communicate and receive voice notifications about the activities along with popups. The basic objective of this research is to encourage blind people to participate in group-based authoring activities with each other and sighted people. For this purpose, a questionnaire was distributed among people of blind institutes. The results of the survey show that blind people highly need a collaborative platform.**

Keywords—cloud collaboration, collaborative authoring, visually impaired, quality of service, human computer interaction

I. INTRODUCTION

According to the world health organization(WHO), the population of the world is 7.7 billion, of whom 2.2 billion people are blind or visually impaired [1]. Since they make up a significant part of society, it is important to ensure that they can engage actively in group activities, effectively communicate and collaborate with others. Collaborative writing is imperative for many organizations to share ideas and composing a complete document. The aim should be to assist them to become confident and self-reliant. Existing collaborative authoring tools are designed for the normal people, visually impaired face accessibility, usability and awareness issues while interacting with the user interfaces (UI) [10]. To use collaborative editors, they use assistive technologies which include voice recognition tools, screen readers/speech synthesizers [2].

Cloud collaboration systems are the ones in which multiple users can work simultaneously on a common task from the same or different locations at the same or different times. Co-authoring generates a major issue of writing conflicts between single-user and shared environment. In the case where the task is in form of a single shared document, then it is called co-authoring [16]. Co-authoring platforms ease the task of group members working on a common project by providing them a platform to coordinate thus eliminating the possibility of duplication of data. It also saves them from the traditional method of working separately and encountering the issues which arise due to manual integration. In co-authoring platforms, an author needs to be aware of every change made by his co-authors. The scheduling of these changes should be accurate and an important factor is a communication among the authors. There should be no communication gap in cooperative projects and this is achieved by awareness.

Computer supported co-operative work (CSCW) tools helps the user to work in a group work environment more efficiently. Individuals can work more proficiently in a collaborative environment by sharing knowledge, skills and experience [3]. However, visually impaired people struggle with these applications because these are not specially designed for them. Add-ons, Interface wrappers and plugins are developed to assist visually impaired people so they can interact with the environment. They are still facing accessibility, awareness and collaboration issues. In a collaborative environment awareness about group activities and communication among different authors are the major challenges for visually impaired people [5] [15]. The system must also provide an interactive environment for users so they can easily complete their tasks and be aware of the activities performed by the other authors. Generally, awareness features are designed as pop-up notifications and through text formatting. These methods are visual so these are not helpful for visually impaired people. Normal users interact with the applications using standard input/output devices mouse, keyboard, monitors, liquid crystal displays (LCD) and visually impaired people use specially designed devices (braille keyboard, braille monitors, braille printers) for interaction with user interfaces [22].

The purpose of our study is to enable visually impaired people to become confident, self-reliant and independent and to facilitate them to work effectively in a group work environment with each other and normal people. This platform includes a speech recognition engine that allows blind people to input through voice commands. Awareness is also provided through voice-based notifications. Interaction through voice allows them to use our platform easily and effectively. Both of them complement each in the development of an intelligent and interactive user interface. The application is integrated with well-structured notification components and has a convenient to use interface. Notifications are sent to each participant to keep them on the same track. Besides, a communication facility is introduced so that information can be exchanged among co-authors.

II. LITERATURE SURVEY

While working on a shared document, the group members need to know about the activities of participants, actions they are performing and the results that occurred as a consequence of group activity [18]. They must work collaboratively to produce something worthy. Collaborative technologies refer to tools and software used to accomplished tasks in a groupware environment. Whether the collaborators are working at the same time (synchronous collaboration) or at different times (asynchronous collaboration), at the same place (face-to-face collaboration) or different places (distance

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collaboration) cooperation is necessary among them. It is used by giant organizations [6][8]. The major issue in these systems is inconsistency and duplication of data in a document due to multiple authors. li et al. proposed a cloud collaboration system for secure and concurrent sharing of documents. Their approach solves the concurrency and resource allocation issues among a large number of users. Parallel computing helps to calculate the trust rate and resource usage for large data, users and connections [7]. Sharma et. al. proposed cloud-based architecture for the file-sharing consisting of central cloud, local cloud and remote cloud [4].

In the current era, there are some prominent speech-based assistive applications in competition to facilitate the visually handicapped people for a different learning point of view [9]. John G. Schoeberlein et al, came up with some additional features in Microsoft Word add-in, to overcome the challenges faced by blind people in collaborative writing [12]. The solution was proceeded by taking initial usability studies, then forwarding prototype of MS Word add-in and finally a pilot review of MS Add-In. Initially, test study sessions were conducted to see the usability of Microsoft Word and Jaws screen reader sideways in the blind community. It was observed that it took a comparatively longer duration for most of the users to complete their assigned tasks and almost 37 percent of the users were unable to complete the tasks. Major problem was difficulty in accessing MS Word features and track changes occurring in the document making it impossible to work collaboratively for inexperienced blind users [14][22].

Giulio Mori et al. [13] proposed a solution for blind people facing problems in interacting with Google Docs UI via JAWS Screen Reader. Google Docs that allows one to work with different types of documents, can be used by blind people via Screen Reader. While working with Screen Reader, inaccessibility issues like delivering visual features with their appropriate meaning, interface overview, working with form control, mixing content, etc. may occur because of the aural and sequential interaction with blind users. In Google Docs, blind people normally navigate through keyboards so there must be an awareness property when dealing with a groupware system. A modified UI of Google Docs was proposed. It maintained the same look like that of the original one but its basic goal was to be more interactive and usable by everyone. The modified UI had interactive XHTML elements like menus, buttons which were easily operable through the keyboard. To solve the formatting and editing issues, TinyMCE 3 editor was substituted with the current Google Docs editor that allows correctly editing via keyboard and access to toolbar [11][21].

A speech-based Web Application Blind Co-Authoring Platform (BCAP) helps blind people to work easily on a shared document. The system uses SMIL and XML technologies to help blind individuals in collaborative writing. This multiuser shared document works by generating alerts for every event (e.g., the user joins or leaves the session.) Here, Amaya Library is used to update and edit documents [18].

Another platform WCFB was proposed by Waqar M. M in [19]. This platform can be used by people belonging to a different group (e.g., partially / fully blind). The system is designed specifically for blind users to collaborate with normal or blind users to achieve reliable and dignified outcomes. The system allows its users to share, update and edit the document easily and also notify each user about the changes being made by his co-authors through alert messages. A three-layered architecture is used by the system which is composed of Amaya Thot Library (to manage modifications in the document and for communication with other layers), facts and event catcher (to record every event) and presentation layer. Table I shows the comparison of existing systems used by the visually impaired people [17].

Currently available collaborative writing tools are designed for normal people. Visually impaired people struggle while interacting with such applications, as they are not designed for them. A lot of work has been done in different environments for different purposes to support the visually impaired vision and blind community. But all the research and development work lack features and interfaces.

III. CLOUD BASED CO-AUTHORING PLATFORM (CBCP)

A web-based cloud collaboration platform is proposed where visually impaired users can engage in collaborative writing activities with sight-bearing individuals. Users can use the system at any time from any location. It supports speech-based commands for blind individuals whereas sighted users can provide input via a standard keyboard and mouse. Both types of users can take help of shortcut keys for input purposes. The authors can communicate with co-authors using the messenger. For the development of the system, Standard web technologies such as Synchronized Multimedia Interface Language (SMIL), XML, Hypertext Transfer Protocol Secure (HTTPS), have been used. Fig. 1. shows that the proposed system is a three-layered model including several sub-modules.

A. Web Based Document Access and Reporting

For users to work in a shared environment, they must have an interactive interface through which they collaborate. This intelligent interface uses the HTTPS protocol and is provided by this layer. Exchanging of information from a client to server and vice versa is managed by this protocol which contains a set of rules. This secure protocol guarantees the security of content moving over the internet by converting it into an encrypted format. Within the framework, the session manager keeps track of every login and logout and monitors user access to content. It identifies authors and grant them access to a shared document and also protect them against unauthorized access. In the case where multiple authors are working on a shared document, it is necessary to keep track of every user starting or leaving the session. These notifications are provided by the notification manager. As the proposed system is for both sighted and blind individuals, so the notification manager generates notifications of various types. All notifications are passed to the speech synthesis module for speech alerts. Fig. 2. shows the Web-based user interface.

These notifications include beeps and sound alerts for visually impaired persons and popup and alert boxes for normal vision persons. For example, whenever an author joins the session, the sound of the opening door along with the user's name is produced to indicate that an author has joined the session. Similarly, a short beep shows that an author has done some changes in the document and a long beep is to update about co-author's role change.

B. Speech Recognition and Speech Synthesis

The proposed system helps blind users to give input to the system through speech. Annyang - a speech to text the JavaScript library. This open-source library (source code is easily accessible) converts speech into text for further processing. To read the content and notifications displayed on the screen, the speech synthesizer library is integrated which converts text to speech alerts.

TABLE I. COMPARISON OF EXISTING SYSTEMS USED BY VISUALLY IMPAIRED PEOPLE

Applications/ Parameters	Application Platform	Application Objective	Target Audience	Input Method	Output Method	Work Space	Time Space
Google Docs UI [13]	Web Application	Collaborative Writing	Blind Individuals	Tab Keys, Keyboard	Auditory via Screen Reader	Multiuser and Shared	Different Time/Different Place
Word add-in [12]	Microsoft Word add-in	Collaborative Writing	Blind Individuals	Keyboard, Mouse	Message Boxes, Auditory via Screen Reader	Single User	Different Time/Same Places
WCFB [19]	Web Application	Collaborative Writing	Both Blind and Sighted Persons	Speech Based Commands	Sound Beeps, Text-to-Speech	Multi-user	Same/Different Times and Places
BCAP [18]	Web/Mobile App	Collaborative Writing	Both Blind and Sighted Persons	Speech Based Commands	Text-to-Speech	Multi-user and shared	Same/Different Times and Places
EtherPad	Web-Based	Collaborative Writing	Sighted	Keyboard	Screen	Multi-user	Same/Different Times and Places
Dropbox Paper	Web/Mobile App	Collaborative Writing	Sighted Persons	Keyboard, Mouse	Text Form	Multi-user	Same/Different Times and Places
Talk Maths	Desktop Application	Mathematical Formulas Writing	Blind Individuals	Dictating, Select and Say	Auditory Speech	Single User	Same Time, Same Place

Blinds can read the documents and messages using this module. These are used by blind users in particular and are enabled on demand.

C. Intent Parser

Speech recognition engine converts speech data into a textual form which is parsed through intent parser module to categorize it into content or command. Commands are reserved keywords used to perform certain actions including navigation queries, Document management, File sharing commands, Text selection, formatting and inquiry commands. If text is not in the commands list then the text is used as input to document editor, message box and input fields whichever has the user focus.

D. Event Manager

This middle layer is responsible for creating awareness among authors. One of the important components of this layer is the Facts and Events Catcher which captures all events that occurs while working collaboratively. This includes the session start, the session ends, opening and closing of shared documents, what changes are made and who is responsible for these changes. All the events generated locally are managed by the Local Event Manager. Such events are handled in an order list based on their arrival time and are stored as a circular buffer. Subsequently, these events are sent to other users operating in a shared environment to raise awareness about other user's activities. The intent is used to comprehend the user's request. All these events are then sent to the inference engine. Data Presenter's job is to collect inference engine data, make it presentable, and transmit it to the HTTP host which provides the authors with an interface to use the request.

E. Cloud Collaboration Architecture

Central cloud maintains the multi-version of the documents and merges them concurrently into a single shared document. Users connected to the local cloud and remote cloud have secure connections and work collaboratively in the cloud domain. updating the changes in the local domain to the remote domain is a challenging task due to conflicting activities of different users. To resolve this issue a log is maintained at the local cloud which keeps track of the time and changes made by each author. Each change is considered and a sequence is developed among all the changes by different users. A shared document consists of several objects, each object has its editing and viewing policies. Editors can lock, hide and highlight a block in a document. Cloud services ensure a secure sharing among the user from different local and remote clouds so the third party cannot access the documents.

F. Inference Engine

This layer explains the core architecture of the system. It is responsible for coordination and cooperation among authors. The major component of this layer is the groupware awareness manager. Computer-based systems that assist groups of people engaged in a common task (or objective) and provide shared application interfaces are called groupware and awareness means knowing something. In a cooperative environment, collectively this term means having information about co-author's activities [2].

It informs the user about the actions performed by another co-author. By providing information like when does a co-author start the cooperative session? when does a co-author leave the session? what action does a co-author perform? what object does a co-author process? System aware author about the state of another co-author. This is called work-space awareness. This ability to see who is currently active in a shared work-space is called Presence / Social Awareness. While working on a shared document, the author needs to keep track of the activities performed by other co-authors. He needs to check whether his co-author is working or sitting idle. An author can set focus on a particular co-author to check for how much time his co-author is inactive.

Communication and awareness support help authors to communicate with each other and discuss tasks. While working on a document, a user can select a particular item (text, table, figure) and send a reference of that selected item to his friend for communication. This kind of communication is called Context-Based Communication. The Coordination and Awareness Support is included for authors to coordinate with each other. Coordination means managing dependencies between co-authors. In a shared environment, there is a possibility of conflicts among coauthors.

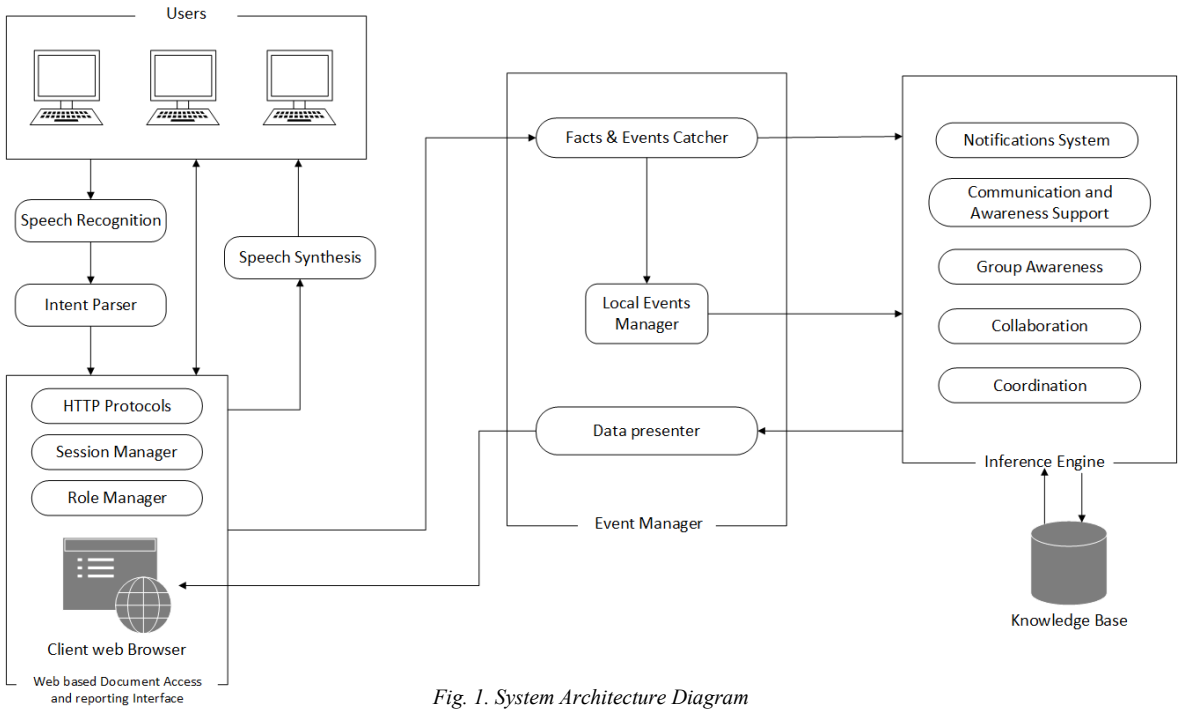

Fig. 1. System Architecture Diagram

This includes work proximity which means two or more authors working on the interrelated section of the document. For example, a user is working on the table and another user is working on the legend of the table. As both users are working on the same document so they must coordinate with each other to avoid possible conflicts [19].

G. The Knowledge Base

The Knowledge Base contains a set of rules. All the events (from the inference engine) are analyzed by the use of rules stored in the knowledge base and corresponding actions are performed. Rules are written using first-order predicate logic and can be divided into two parts: the premise and the action. The rules are well defined and reviewed with great care so the possibility of all type of errors (lexical, syntactical, semantically) have been eliminated. To define the rules structure, predefined keywords are written in boldface. String and constants are written in (" "). Constants are written in All Caps format. Function names are written in italics. Comments start by /* and end with */. A double equal sign is used to compare the two terms. while single = is used to assign value to the operand. For example, when a co-author begins the cooperative session and opens/closes a shared document some events are created. The following rules are triggered.

1) A Reviewer Opens shared document: The rules below inform co-authors when the shared document is opened by a reviewer/writer. Document name and the names of co-authors will be spoken through speech notifications to all collaborators. The rule is shown as follows.

Rule Start "*a reviewer opens a shared document*"
If
Collaborator(section_1) = X
Role(X) = "writer"
Session_on(X) = "true"
Collaborator(section1) = Y
Role(Y) = "reviewer"
Review(section_1)= "true"
Action (Y) = "open_document"
Then
SpeechNotification(X, "Reviewer opened the document")
Rule End

The semantics of the above rule are as follows

- Use Collaborator(section_1) = X, checks X is the co-author of the document or not.
- role(X) = "Writer", role(Y) = "Reviewer" checks the roles of Collaborators X and Y.
- session_on(X) = "true" checks whether Collaborator is currently logged in or not.
- Review(section_1)= "true", checks the review property of the section 1.5 speakNotification(X, Message), "Reviewer opens document", Send voice message to participants.

2) User Inactivity: Whenever a user remains inactive for a specific period of the time. The system checks the activity of collaborators and sends a notification to co-authors. Users can check active collaborators through speech commands. The rule is described in the knowledge base as follows.

Rule Start "*user inactivity*"
If
Collaborator(section1) = X
Role(X) = "writer"
Session_on(X) = "true"
Inactivity_time > 15 /* minutes */
Collaborator(section1) = Y
Role(Y) = "manager"
Blind(Y) = "true"
User_focus(Y) = X
Then
SpeakNotification(Y, "X about inactivity of the Y")
Rule End

3) Virtual Proximity: When two users working on the same section of the document. The inference engine keeps gathering information about the author's activities and sends notifications to other collaborators about changes. As shown in Figure 2. The rule is defined as follows.

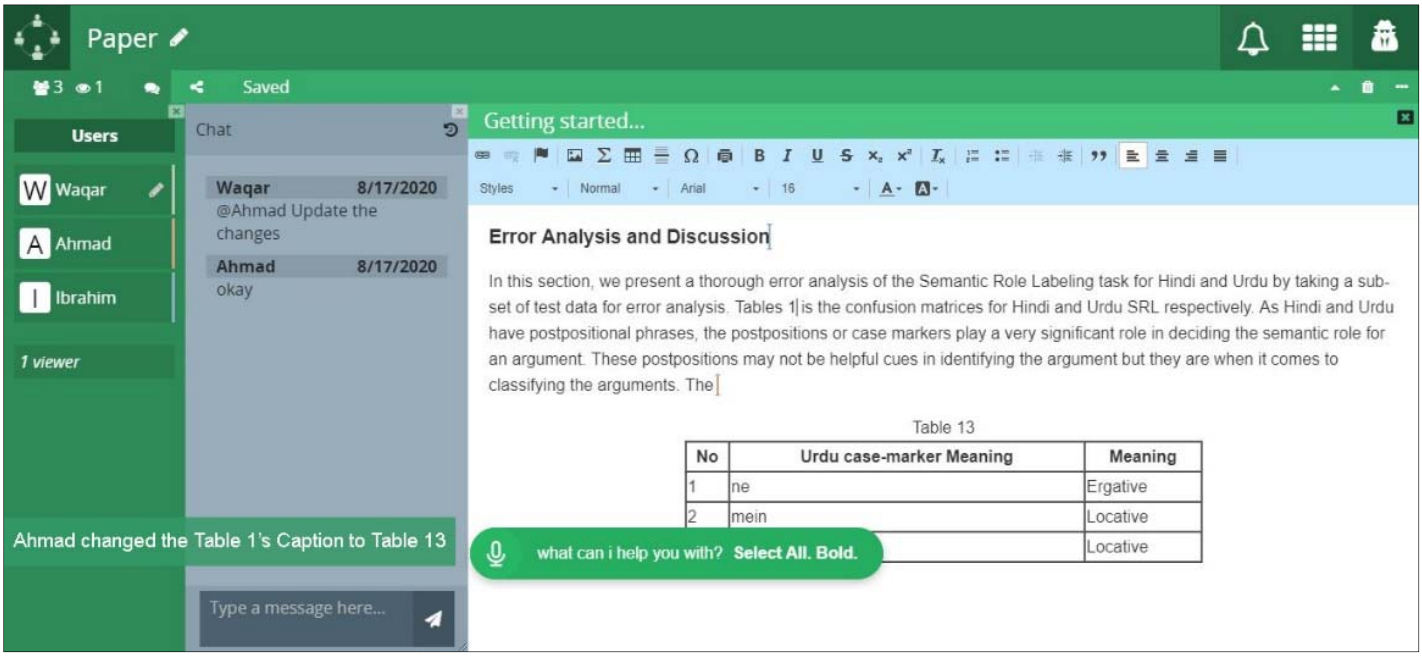

Fig. 2. User Interface

Rule Start "*virtual proximity voice notifications*"
If
Collaborator(section_2) = X
Role(X) = "writer"
Session_on(Y) = "true"
Collaborator(section2) = Y
Blind(Y) = "true"
Role(Y) = "writer"
Action(Y) = *Edit*(row-no, table), *Delete*(row-no, table), *Edit*(title, table)
Then
SpeakNotification(Y, "X edited/deleted", row-no , " of the " , table")
SpeakNotification(Y, "X changed the title of table " , table")
Rule End

IV. Results and Discussions

To evaluate the system, we had conducted the experimental sessions in which blind and sighted users were engaged. They were 47 in totals and divided into 10 groups, which means 4 to 5 members in each group. They were asked to perform a group writing activity on the topic "The importance of democracy". For this, they first used Google Doc environment and then CBCP. After that activity, they were asked to give a rating from a range [1 (means low) to 10 (means high)] to both systems based on 5 attributions: Interaction, Collaboration, Coordination, Awareness, Communication and Recommendation. We took the averages of the scores and applied the Wilcoxon Signed Rank evaluation to analyze whether the CBCP is better than Google Doc or not. Table II presents the results of the Wilcoxon Signed-Rank [20].

We can see, only the collaboration's *p*-value is greater than 0.05 whereas all the other factors have values less than 0.05. So, the test accepts that CBCP has a more effective interface for its use as compared to Google Doc UI. To determine whether blind people had any previous experience of group activity and if they had, then the challenges and limitations they encountered while working collaboratively, a survey was conducted. The results of the survey are presented in Table III.

TABLE II. TEST STATISTICS FOR THE WILCOXON SIGNED RANKS TEST

Category	Average Scores		Wilcoxon Signed-Rank Results	
	CBCP	Google Doc	*Z*	*p*
Interaction	7.31	6.96	−2.484	0.013
Collaboration	7.52	7.12	−1.944	0.052
Coordination	7.54	6.73	−3.472	0.0005
Awareness	7.96	6.82	−5.813	0.0001
Communication	6.95	6.32	−3.801	0.0001
Recommendation	7.91	6.72	−5.625	0.0001

V. Conclusion and Future Work

From the analysis of existing systems, it can be concluded that many systems allow users to work collaboratively with other co-authors but none of them is designed especially for blind individuals. Such a system that provides a platform for the blinds to work with sighted individuals on a shared document is rare. Some systems lack interactive interface for blinds while others do not provide communication facilities. The proposed system is designed to overcome all these problems. In the future, our focus is on the implementation of modules to incorporate usage of more complex objects e.g. images, diagrams and writing mathematical formulas.

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TABLE III. RESULTS OF SURVEY

No	Questions	Yes	No	Don't know
1	Do you think technology solves the issue of using a computer system for blinds?	30%	50%	20%
2	Is there a need for special computers for blinds	64%	30%	6%
3	Which tools use to write a text?	Windows Speech Recognition 30%	MS Word speech Recognition 20%	Google Docs Speech Kit 50%
4	Do you use voice or speech commands to write into a document?	32%	68%	0%
5	How do you read output or text from the screen?	Use any Software 74%	Take help from normal persons 26%	0%
6	Which tool/software (if any) do you use for reading output from the screen?	JAWS 58%	Windows Narrator 24%	NVDA 18%
7	Have you ever used a collaborative editor?	22%	70%	8%
8	Have you worked on a shared document?	45%	60%	5%
9	Have you worked on a shared document with normal vision people?	10%	90%	0%
10	Have you worked on a shared document with visually impaired people?	20%	80%	0%
11	Do you like to work with sighted people?	70%	30%	0%
12	How do you communicate with your team members when working on a shared document?	Skype 60%	Yahoo 21%	Google Talk 19%
13	Do you want to get notifications about co-author's activities?	10%	90%	0%
14	Do you think the need for Text-to-Speech?	100%	0%	0%
15	Would you like to do a computer related job in the future?	100%	0%	0%

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