A Thesis

UNDERSTANDING AND STRENGTHENING TWO WAY INFORMATION FLOW IN RURAL COMMUNITIES

by

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Abstract

Through this project, an end-to-end, first-of-its-kind citizen journalism interface is developed and deployed on WhatsApp. The WhatsApp channel is a supplement, instead of a substitute, for the traditionally existing Interactive Voice Response (IVR) channel for CGNet Swara, an NGO. With the Jio effect and increased smartphone penetration, many Indian users are now getting internet access, and this number is growing very fast.

Traditionally, the NGO used Interactive Voice Response (IVR) and smartphone-based app to collect audio stories. However, through this project, users and employees in the organisation can submit audio, image and video stories via the WhatsApp chat interface. Additionally, the interface enables users to request the latest stories submitted by a particular user by typing in a phone number. Various design strategies were explored to ensure that users require to do minimum typing and prevent language barriers. The project also discusses other opportunities and future use cases of the WhatsApp chat interface.

This technical intervention taps an excellent opportunity to help low-literate and digitally disadvantaged communities contribute their views to the internets. The finalised video stories received via WhatsApp are uploaded on YouTube, which helps connect contributors with a global audience. The project contributes to the research community by sharing design ideas and deployment challenges. This platform is in daily use by the NGO and helps them receive and disseminate richer media like images and videos for their journalism stories.

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Chapter 1

Introduction

1.1 Background

In India, the press is also known as the fourth pillar of democracy as it plays a vital role in shaping public opinion. It is the role of the media to bridge the gap between ordinary citizens and bureaucrats. The media are often the 'central battleground' for social movements [1].

In recent times, there has been a disruption in traditional models of journalism with the rise of information and communication technology, mainly social media platforms. The emerging paradigm of journalism- citizen journalism [2], which includes citizens as producers as well as consumers of information. Starbird expressed the changing role of journalists as crowdsourcerers [3], to 'incorporate the crowd as co-collaborators' to 'collect, curate, synthesise, and re-broadcast information across technological divides'. Similarly, Bruns [4] highlights the role of journalists to be shifting from "gatekeeping" to "gatewatching", which requires harnessing the collective intelligence and knowledge of dedicated communities and not in ownership or control of information.

However, not all individuals in the social pyramid have access to mainstream media outlets. While social media has revolutionised information sharing, its usage is constrained in rural areas due to technical proficiency, infrastructural and literacy barriers. This poses severe barriers to the socio-economic development of low-resource communities, as their grievances, opinions and exploitation remain unvoiced. Additionally, when Indian mainstream media is in question for its credibility for being dominated by big players and those in power, it is essential to encourage the democratisation of media. It becomes imperative to design citizen journalism platforms that are inclusive to all sections of society.

The low-literate populations need additional interventions to be able to contribute to online platforms. Hence, there needs to be technical assistance, especially in areas where there are no mainstream media, enabling ordinary citizens to report issues of local interest to higher authorities. Information and Communications Technology (ICT) also help mitigate poverty by improving poor people's access to education, health, government and financial services, as confirmed by past study [5].

In recent times, the production of content by low-literate users has been made possible through innovations in voice User Interfaces (UIs) like IVR that have helped transcend issues of textual literacy, local language and device constraints [6]. Some forums using Interactive Voice Response (IVR) to enhance information flow in rural areas are CGNet Swara [7], Gram Vaani [8] and Avaaj Otalo [9]. While such IVR platforms are beneficial for people who do not have access to smartphones and the internet, these are difficult to scale up and are not cost-efficient.

Fortunately, there is an increase in technological penetration in India. There has been a growing number of internet users from rural India because of the affordability of mobile data (Jio Effect) and rising smartphone adoption due to cost-effectiveness. The study by Internet and Mobile Association of India (IAMAI) and Nielsen [10] shows that in 2019, rural internet users (277 million) outnumbered internet users in urban areas (227 million) by 10 per cent, with solid growth of 18% in the rural market. This increase in internet and smartphone penetration has been leveraged by past work [11, 12, 13, 14] to design interventions for low-resource communities.

It is interesting to note that 61% of the rural users access the internet daily, and activities like Social networking/Chatting and entertainment contribute to most (80%) of their usage of the internet [10]. India is the biggest market for WhatsApp as there are more than 400 million users in India [15]. Hence, platforms like WhatsApp, YouTube open up an opportunity to act as bridge technologies to enable the rural population to contribute to citizen journalism.

This project explores the use of WhatsApp Business API for enhancing information flow in rural communities. Through WhatsApp, organisations can scale up their connections and strengthen interactions with each user without having users install a separate app. The overall architecture and technical details are elaborated in the following sections.

1.2 About CGNet Swara

CGNet Swara is a citizen journalism platform working primarily in the Central Gondwana region in India. It works with low-literate and low-resource communities underserved by mainstream media to democratise journalism with the help of technology. This is broadly done by enabling local community members to record and listen to meaningful local stories. The audio stories submitted by users are reviewed, edited by the CGNet staff (moderators) and either published or discarded. The published stories are available to users for listening via their mobile phone or accessible through their website. Users can contribute diverse content like stories, poems, grievances.

Current platforms to interact with users is Interactive Voice Response (IVR) and CGNet Swara smartphone app. For using IVR, CGNet users would call a phone number using any mobile (or fixed line) phone. Callers are prompted to press ”1” to record a new message and ”2” to listen to messages that have already been recorded [7]. The content is available for users to listen to at their convenience. Users who have smartphones could use the CGNet Swara smartphone app, which provides some more features than the IVR system. It allows users to share various audio files with other smartphone users. Users can also record and broadcast associated images with audio messages for broadcasting. The app allows users to save their favourite files on phone storage. Additionally, each audio file is transcribed and displayed as text for users to read. Though, the app provides for a better user experience and interactions than the IVR system but has additional overheads of installation and user training.

Chapter 2

User Interaction Design

This chapter explores various interaction flows for WhatsApp chat interface for low-literate users.

2.1 Interaction flows for WhatsApp

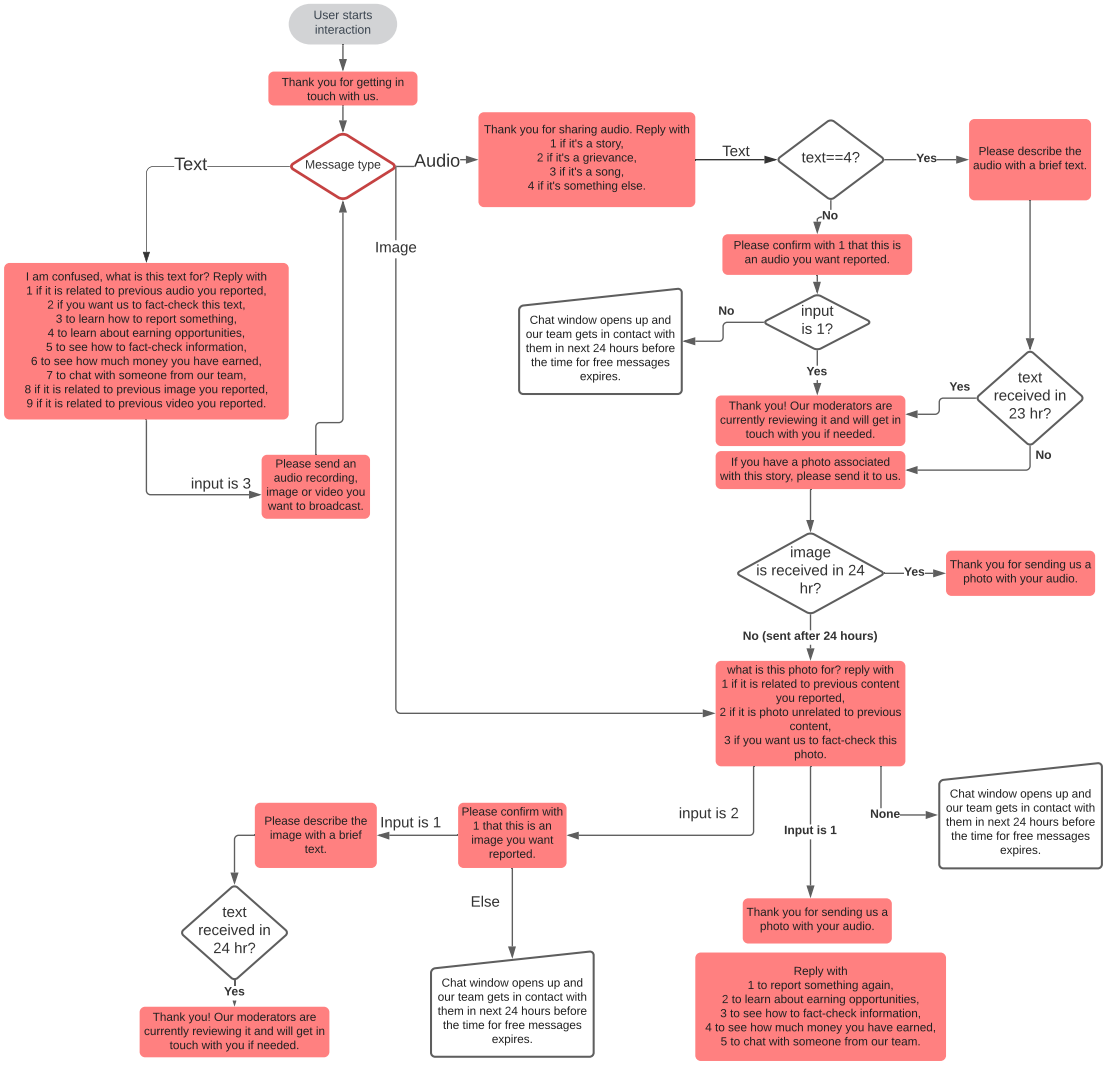
2.1.1 Design 1

This design Figure 1 is partly derived from the current IVR based user interaction flow for submitting content. Whenever a media was received from a user, a designated reply was sent back to keep the maintain the casual chat like feeling for users, as recommended by Prasad et al. [13]. Based on the recommendations by Agrawal et al. , from their work on smartphone app for low-literacy users [14], that low literate users can understand numbers relatively comfortably, numbers are used instead of text, to allow users are required to type in to navigating between different options.

While this design works well for call based IVR, it is complex for illiterate or less literate users as the instructions are lengthy. It does not clearly state to users what part of the content submission flow is optional and what is mandatory. It takes users deep down into hierarchy but past research shows that hierarchical structures should be minimised [16].

Figure 1

Interaction flow for accepting content from users.

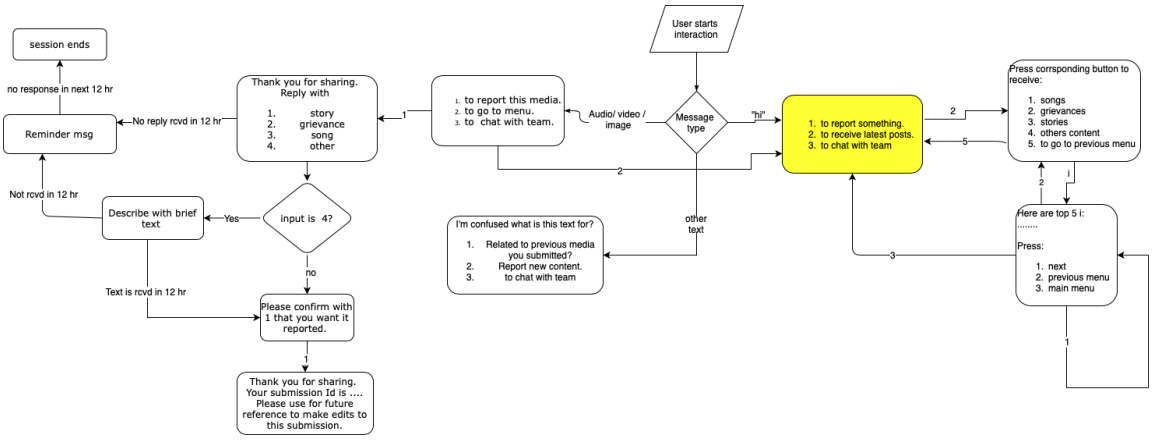


2.1.2 *Design 2*

The following design Figure 2 included feature to remind users if they do not respond to a message within 12 hours. While this design simplifies previous design, it does not specify instructions to return to main menu at all stages. It involves a long series of steps before confirming the successful submission of content. This might cause problems when internet connection is poor like story not being submitted due to delay in confirmation message.

Figure 2

Interaction flow for content acceptance and dissemination with users.

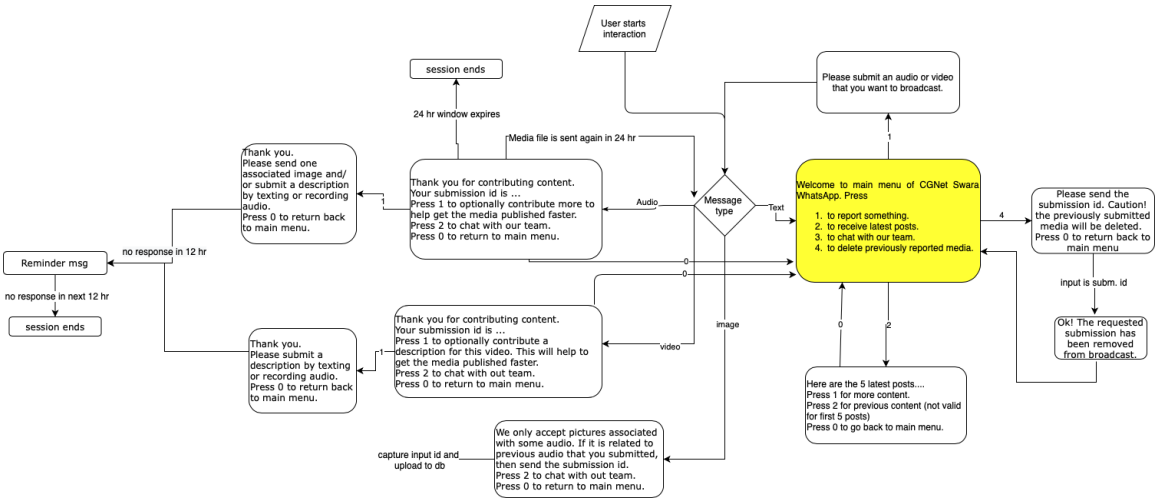


2.1.3 *Design 3*

The following design version Figure 3 improves on limitations of previous interaction flows. This design provides the back button at all the steps in every user interaction [17, 18]. It simplifies the task of users by directly accepting any media submitted by them. However, the images are requested optionally after audios are submitted; technically once the audio is received email is triggered and after that second email for image is generated if image is sent by user. This way it is difficult to keep track that image sent in email is associated with which particular audio entry, especially in case of network issues.

Figure 3

Interaction flow for content acceptance and dissemination with users.



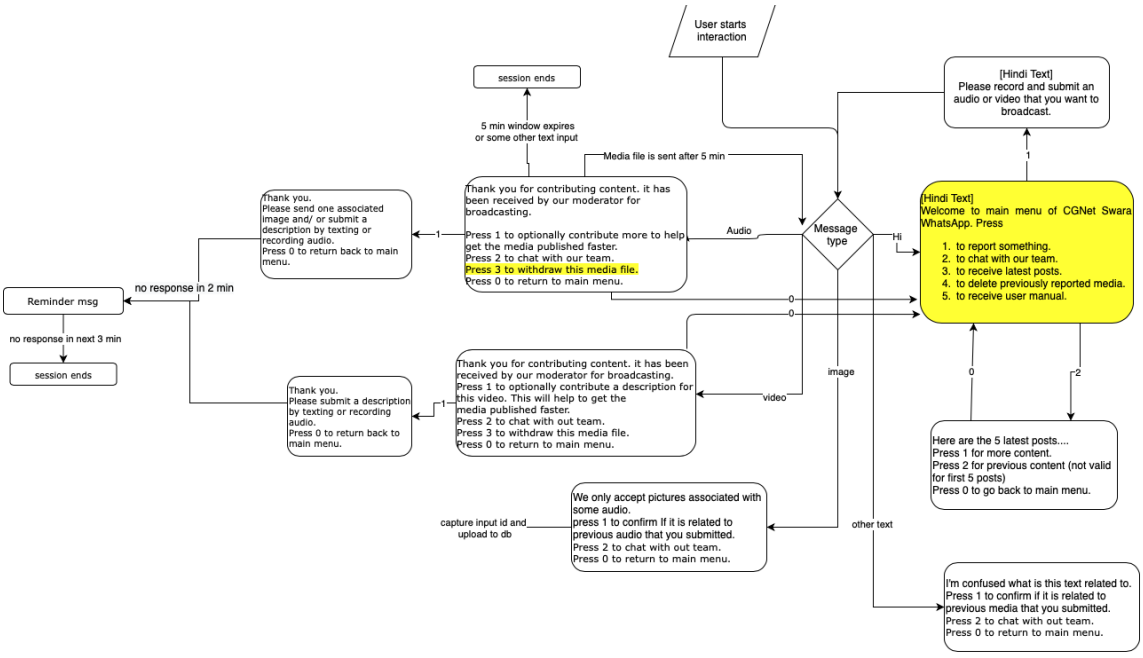
2.1.4 Design 4

This interaction flow Figure 4 further simplifies user experience. If users submit a text message other than 'Hi', they are redirected to a menu which asks them if they want that text to be associated with their previous submission- a method to receive tags for stories after submission. It removes the option for deletion of entries at a later stage with story id, as it would add risk of unnecessary deletions. Instead, the option to delete their submission is provided at the same time when they submit a media entry, which is also technically easier to implement. A new feature of sending user manual is added, wherein users would be sent a help guide explaining various functionalities.

However, this flow still requires users to make use of their keyboard for typing in numbers to navigate between different functionalities. It is dependent on timers for users to provide optional submissions like images, description, which might be confusing for them. The instructions to contribute the optional content would be difficult to understand for low-literate users. The option to ask to image after audio is technically difficult to implement.

Figure 4

Interaction flow for content acceptance and dissemination with users.



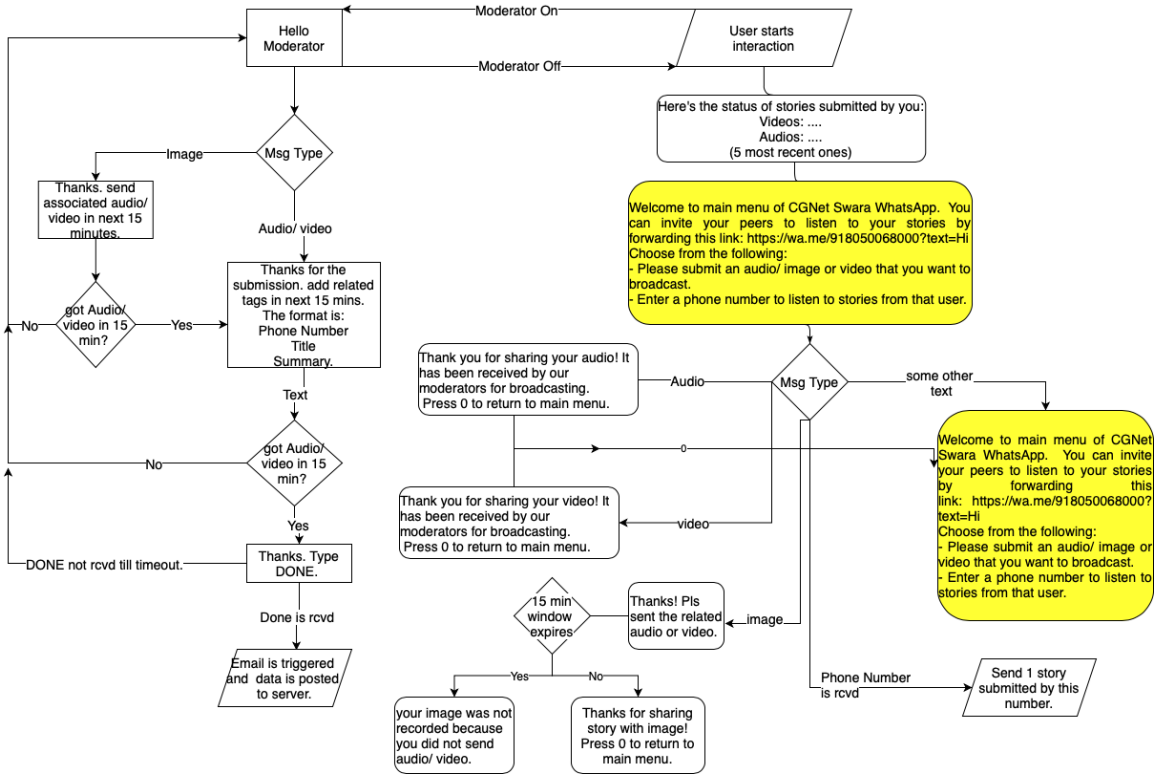
2.1.5 Design 5: Final Flow

This interaction flow Figure 5 further simplifies interactions of users. Users can anytime move back to the main menu by typing 0, which is the same as what they would do on IVR. Unlike in previous flows, images are received before the corresponding audio/video so that the email is triggered only once when the second media file is received. The benefit is that the interface can be operated universally by people of all literacy levels, including an illiterate person as the users are not dependent on typing anything. The choice for language would be Hindi but written in English characters (English is used in this document for ease). Another feature to increase user engagement is- whenever a user sent a contact number, the WhatsApp bot would return the links for the stories submitted by that user. Additionally, it adds the option for moderators to submit stories with tags. This specifically solves for the need of distinguishing between the submissions from users versus moderators, which was a major issue in previous designs. The key words ‘moderator

on' and 'moderator off' are used to allow moderators to switch modes between moderator and user mode in a covert manner. Once a moderator enables 'moderator on', he/she can continue to submit stories with tags till he/she chooses to switch back to 'moderator off'. The users are also shown the updates for the stories submitted by them that are then unpublished as a personalised engagement mechanism. This feature also helps to build accountability in the organisation by enabling users to contact the staff if their story has been left unattended for multiple days.

Figure 5

Final interaction flow.



Chapter 3

Development

3.1 System Overview

The new interface uses WhatsApp Business API (section 3.2) to receive and disseminate audio and video stories with or without images. It is a hybrid multi-modal system where the same phone number used by the IVR system is registered on WhatsApp. The story submitted by users/moderators are sent from IMIConnect [19] platform to loudblog server via email (section 3.3). The relevant video stories, after reviews and edits, stories are published on YouTube (section 3.4) by the staff and are also available on the CGNet website (section 3.7). There is the flexibility offered to staff to separately play, edit and disseminate (via IVR) audios, as they are automatically separated from the corresponding video (section 3.4). The users can navigate to the main menu in the chat anytime during their interaction by typing the designated number(0). The users are also shown the status (section 3.6) for the stories submitted by them that are then unpublished as a personalised engagement mechanism. The interface enables users to request the latest stories submitted by a particular user by typing in a phone number (section 3.6).

These details are elaborated in the following sections.

3.2 WhatsApp Business API

It is an API by Facebook that allows companies to communicate at a large scale with their customers. It uses a REST API Architecture with JSON data formats and follows the standard HTTP request-response exchange [20]. According to the Facebook rules, when a user starts an interaction then any reply to the user is free for 24 hours from the last message they sent us. If the bot initiates the chat with user outside of the 24 hour window then it

requires pre-approved of the message by Facebook and costs USD 0.005 per message.

3.3 Receiving content from Users via email

The process was to get WhatsApp media via IMIConnect into email in real time. The IMIConnect platform uses Amazon Web Services (AWS) to allow users to receive data via email. However, AWS was avoided to prevent the exuberant costs and bills. SendGrid API was used to receive content from IMI and send email to a designated email id. The subject of email carried media type and user phone number in subject e.g., "$video| < phonenumber >$ " or "$image|audio| < phonenumber >$ " and the url of media was sent in email body. The emails received from moderator mode would have 'moderator' key word in the subject too. The content from email was downloaded in the server and uploaded to the database. In case of video, audio was extracted from it and saved too. The audio from whatsApp were in .ogg or .mpeg format and were required to be converted to .wav (for loudblog website) and .mp3 (for loudblog website) format. '.mp3' files were stored in '/home/swara/audiowiki/web/audio' and '.wav' files in '/home/swara/audiowiki/web/sounds'. Loudblog is a Content Management System (CMS) for publishing media content on the web [21].The script to read emails and download media files from the media url was automated by scheduling a cron job. The command used to edit cron jobs was crontab -e, where I entered the command '$*/2 * * * * pythondownload\_media.py$'. To configure the parameters and login settings for server and database configure files named *swara.conf* was used.

3.4 Design architecture for videos

Various methods for having audio and video files on the loudblog website were deliberated. It was decided that draft videos would be kept in server and once the video is finalised it would be uploaded from our server onto YouTube to prevent overflow of disk space and slowing of speed. At a later stage all the draft videos would be periodically

cleaned from the server. We extracted audios too from the videos so that the audios can be disseminated over the IVR and/or WhatsApp. We deliberated over multiple design architectures to manage audio and video files on loudblog.

3.4.0.0.1 Method 1 The idea was to have good audios (extracted from videos) stored separately from videos on the loudblog website, such that there would be two different entries in the database with the same title of the post. This is because not all videos would have audios that would be worth listening independently without the videos. The problem is that this design would create redundancy to have similar files (say 12345.mp3 and 12345.mp4) on the main CGNet website. It would also be problematic as multiple posts could have same title.

3.4.0.0.2 Method 2 Another possibility was to have the audio extracted from the video file automatically whenever a video is uploaded in the server. Whenever a video is re-uploaded to replace the previous video after editing, the audio file should get generated automatically again and re-upload. This reduces the efforts of moderators. However, the challenge is that video and audio editing works fundamentally differently. There is difference in technical proficiency of the CGNet Staff, wherein some only have the technical know-how of editing audios and not videos.

3.4.0.0.3 Method 3 The possibility of having all the videos only on YouTube was considered, wherein the draft videos would be kept in private channel and the finalised video would be made public. While this idea helps in saving space on Apache server and adds robustness as YouTube server is less likely to crash than Apache server at CGNet, it has multiple drawbacks. It would be difficult to organise and keep track of statuses, edits of videos. YouTube does not provide many functions to edit videos like it doesn't allow separating out audios, so moderators would anyways require to locally download video which would defeat the purpose.

3.4.0.0.4 Method 4 In this method, we thought to not download the video files on our server to save space. Instead, whenever the video link is available in the email it could be posted in loudblog website, from where the moderators could access, download, edit and upload the final version on YouTube. However, this may cause problems, as the video link comes from AWS server, where videos are stored for only upto 4 weeks. So, if a story is unattended for that duration then it would get lost. If in case, WhatsApp/ AWS later change their policy for media storage then the architecture would have to be altered again. Hence, this is not a long term solution.

3.4.0.0.5 Method 5: Finalised architecture The video link received in email is used to download the video locally and then upload to the loudblog website, with the extracted audio too, through the email script which checks for new email every second. This way moderators are saved from the extra work of extracting audio from video. Moderators can download videos from loudblog, edit them and re-upload without affecting the previously extracted audio file. Similarly, the audio file can be separately accessed, edited and re-uploaded on loudblog. When video editing is complete, moderator uploads the final video on YouTube and its YouTube link is entered in the loudblog website, from where it is automatically entered in the database. Moderators can select on which IVR channels should the extracted audio be played over. By default no channels are selected, implying that it won't play over IVR.

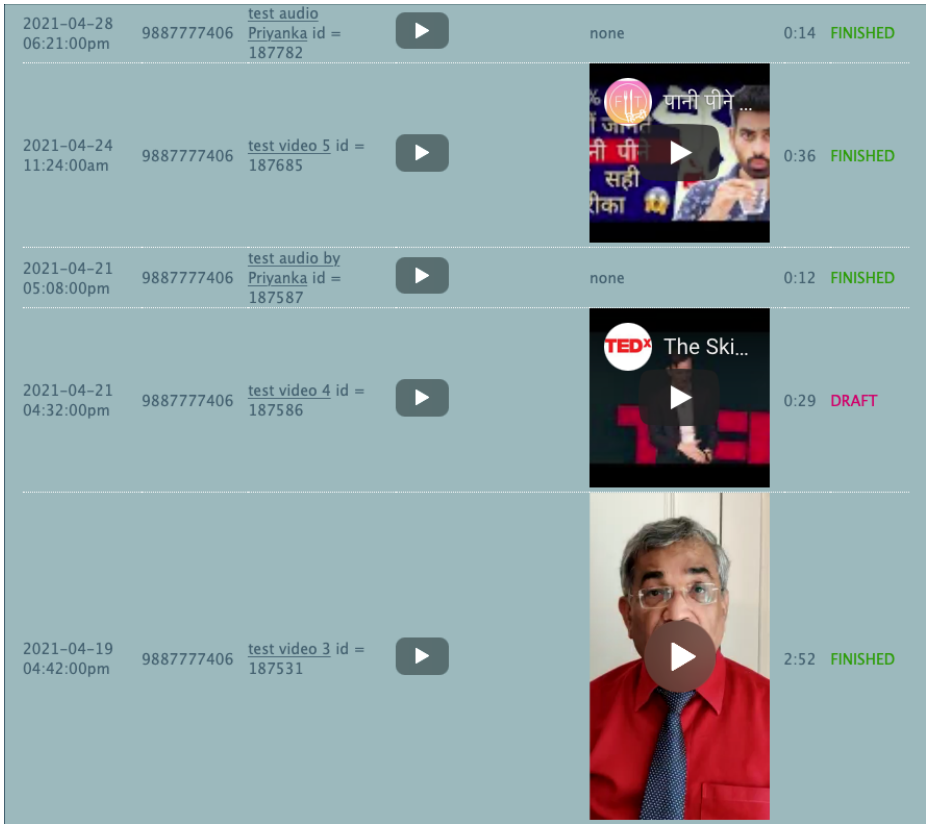
This method is beneficial as there is division of labour- some can edit the video and others can edit the audio files. It was earlier thought that when a video is finalised and uploaded on YouTube it should be automatically deleted the apache server. However, this would be too rigorous a deletion policy. So in the final architecture, deletion of videos is supposed to happen from the server manually when the videos' occupancy cross a threshold space.

This final design is implemented on the loudblog website, which the interface for

private review of submissions by moderators. To implement these functionalities changes were made to scripts 'backend_record2.php' and 'backend_postings.php'. The image shows Figure 6 the loudblog 'postings' page (that lists all stories) with the new feature of video previews.

Figure 6

Loudblog 'Postings' page displaying video previews.



3.5 Uploading content to database

All the functions of MySQL required to connect and interact with database were in the file *database.py*. Any new entry is uploaded as the last row of 'lb-postings' table of Audiowikiswara database, with the row number as its unique identifier, called postid. This postid is user to name a file to be stored in the loudblog server. The status tag of files uploaded on the website becomes 3. An entry was created in cgnet database at the last row

of the '$lb\_postings$' table in 'audiowiki' swara database using functions defined in the file 'database.py'. Function 'addVideoCommentToChannel' was added to 'database.py' so that video files are added to $'audio\_file'$ of database.

3.6 Exporting content from loudblog server to IMI

This step was very significant as it determines the dissemination of content to WhatsApp users. It was also challenging to enable data flow to IMI without using an intermediate webspace (to avoid exuberant costs). This is because IMI platform can communicate with external servers/webspaces via HTTP requests. While SendGrid can be used to send email, it can not be used to read emails and deliver the data to IMI via HTTPs request. Then, I tried working on the online portal Pipedream to process HTTPs requests from the apache server. The apache server sends data to it via a HTTPs POST request. The IMI platform can receive response back from the server. So the solution was to send HTTP POST request from IMI Connect to server and read the server data in HTTP response generated by the server. Additionally, this method will be suitable to process real time requests of users from IMI. This approach was used to implement the features- sending status of stories and send links of published stories.

3.7 Updates to CGNet Website

The HTML script (index.html) for the website consists of user defined tags. The definition of those user defined html tags were present in php file named *loudblogtags.php*. The .html scripts would be re-interpreted by loudblog and the html tags would translate to the function calls in the php file. For example: the tag in html $< lb : if\_audio >$ and $< /lb : if\_audio >$ were defined with the following function in php file Figure 7:

It could be inferred that the input parameter to functions would mostly be the html content and output parameters were strings. Hence, I was able to embed YouTube videos on the website. I also added the option of 'Read More'/ 'Read Less' links for large paragraphs

Figure 7

Example function definition for a user defined tag '< lb : if_audio >' in HTML.

```
function if_audio ($content) {
        global $postings;
        global $currentid;

        if (!veryempty($postings[$currentid]['audio_file'])) {
                return trim(fullparse (stripcontainer($content)));
        }
        else {
                return "";
        }
}
```

and a subscription button to their YouTube channel.

3.8 Other technical details

3.8.0.0.1 Log Files I understood the use of Log files, which are used to understand and observe the activities and behaviours on the network. A log file is a computer-generated data file that contains information about usage patterns, activities, and operations within an operating system, application, server or another device [22].

3.8.0.0.2 Mounting file system It was helpful to mount remote server directory on my local system to be able to better understand file structure and easy accessibilty of files. For example [23], if one has a web site stored in /home/desk/website and the web site has become very popular and someone is running out of space on his/ her 36 GB hard drive, then one can simply go out and purchase a new 73 GB hard drive, install it in the computer, and then mount that entire drive as /home/desk/; hence the /home/desk mount point has increased total space of 73 GB. 'SSHFS' (SSH filesystem) command can be used to mount to remote directory. The steps followed to enable sshfs on my mac are listed here. To check all the mounted files type the command 'mount' in terminal. To unmount directory use the command 'sudo diskutil umount force '$< filePath >$'.

3.9 Some of the implementation difficulties encountered

3.9.0.0.1 ModuleNotFoundError I understood how module searching happens when a script is executed in python. Then I was able to easily debug the problem of ModuleNotFoundError

3.9.0.0.2 VideoUrl from IMI Retreiving video data from IMI was difficult as VideoUrl variable was not working. Whenever an email was sent the VideoUrl variable would be empty. To debug this problem I had made use of RequestBin web portal, which collect and displayed HTTP requests from IMI Connect Platform. Through this, I was able to see that it was 'attachments' variable that was carrying the link to video.

3.9.0.0.3 Automating script to download media To see what error was coming in execution of cron tab job, I first understood what a log file is and how to view it in linux. I checked the log files in /var/log/httpd folder, which was not helpful. I found the cron log files, where most log files can be found, in the location: /var/log. I then redirected the crontab output to a text file to debug it.

Chapter 4

Discussion and Future Work

This project extends the existing IVR number to the WhatsApp chat interface for CGNet Swara, thereby enabling the organisation to work as a hybrid multi-modal citizen journalism platform. It is challenging to scale IVR based platforms as IVR is costly. So through this project, we demonstrate how IVR based platforms can evolve as more and more people get access to the internet and smartphones. With no training or installing overheads, the WhatsApp interface enables users to be journalists themselves and report stories. This solution is one step above earlier efforts as WhatsApp offers richer media over the traditional IVR system; no training/installation is required, unlike in other smartphone-based apps.

The use of WhatsApp in India has been transcending class boundaries [24]; hence the developed chat interface has the potentital be used by multiple sections of society. The developed intervention is smartphone-based so, it has the potential to ensure the last mile, low-cost dynamic information dissemination among rural users, as almost all (99%) users in rural India access the internet from their mobile devices [10]. Smartphones and mobile internet offer a futuristic scope for disseminating information, unlike telecenters, information kiosks based interventions, which have not proven very successful in the past [25]. The interaction flow has been designed keeping in mind the challenges faced by low-literate adult users [6]: (i) textual non-literacy, (ii) difference in cognitive abilities.

In future, the WhatsApp channel can be further used to conduct short polls, surveys, interviews for collecting grassroots level data. WhatsApp Pay can be used for providing monetary benefits and rewards for user participation. It would be of interest to replicate studies like Learn2Earn [26]. To further lessen the burden of CGNet Swara moderators, future work can enable requesting tags and rating of content from users and automation of

uploading videos directly on YouTube. The organisation also plans to customise the user experience by providing the functionality to enable users to request locally relevant stories by asking them to share their location via the 'Share current location' feature of WhatsApp. An introduction video demonstrating the use of different features can be provided to new WhatsApp users to enable them to understand the technical details easily. That would be better than sending a set of abstract instructions, as based on the recommendation by Sherwani et al. [27] who find that low-literate users learn better in-situ, embedded in concrete situations and practical experience.

Chapter 5

Conclusion

Through this project I have built a system to strengthen information flow into and from rural communities via WhatsApp. WhatsApp has been traditionally used by low-income population for communication among themselves and YouTube for passive streaming of content without acting as contributors. This technical intervention will help low-income communities to submit richer media content like images and video and with an intuitive chat like feature. The CGNet moderators will upload informative / relevant videos over Youtube, hence taking local voices to global level. This entire technical intervention fits in the existing workflow of the organisation, where moderators can also view video thumbnails where all the stories are reported in server and loudblog website. Overall, the interface developed can be operated universally by people of all literacy levels, including an illiterate person and deploying it in different regions will not cause any language barriers as users can interact without having to type anything.

5.1 Deployment

The chat interface receiving image with corresponding audio, video and audio stories from users Figure 8, Figure 9 and Figure 10, respectively. The choice for language would be Hindi written in English characters (WhatsApp chats in English is used in this document for ease). Feature to send user the link to published stories submitted by the contact number typed by them, as shown in Figure 12.

The usage numbers achieved after 18 days of deployment are shown in Table 1. The system has been robust for all these submission of stories over the past one week. There were no errors or bugs that happened.

Figure 8

Receiving image and audio based story from user.

Figure 9

Receiving of video file from users.

Table 1

Usage data within 18 days after deployment

Parameter	Number
Total stories received via WhatsApp	188
Stories published on web	123
Distinct users	19
Total video stories received	21
Increase in YouTube subscribers	4

Figure 10

Receiving of audio files from users.

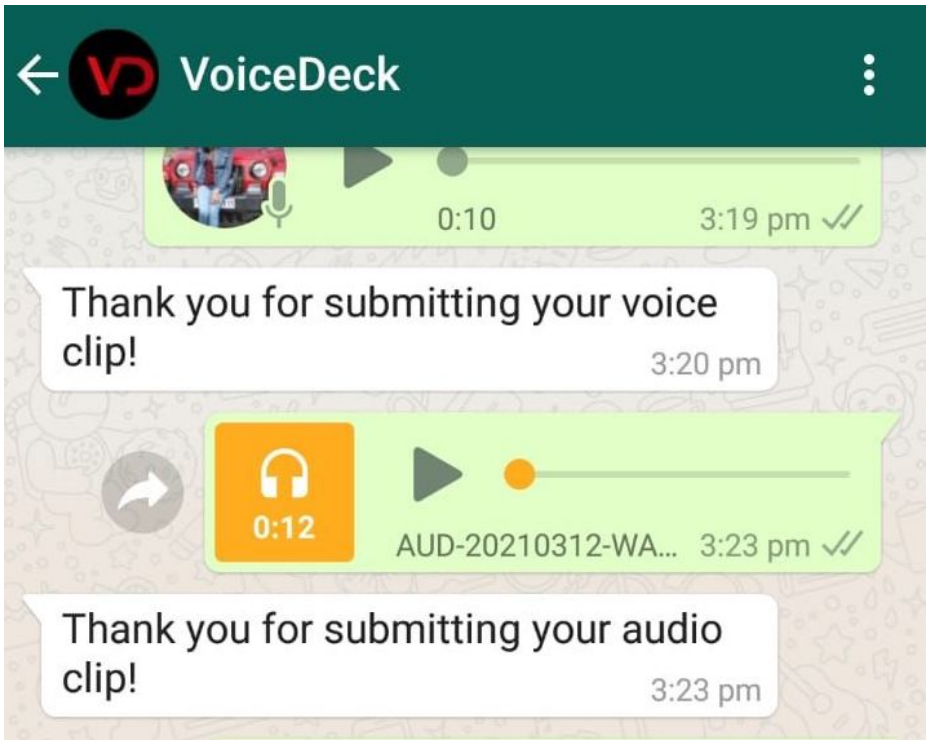


Figure 11

Receiving story from moderator with tags.

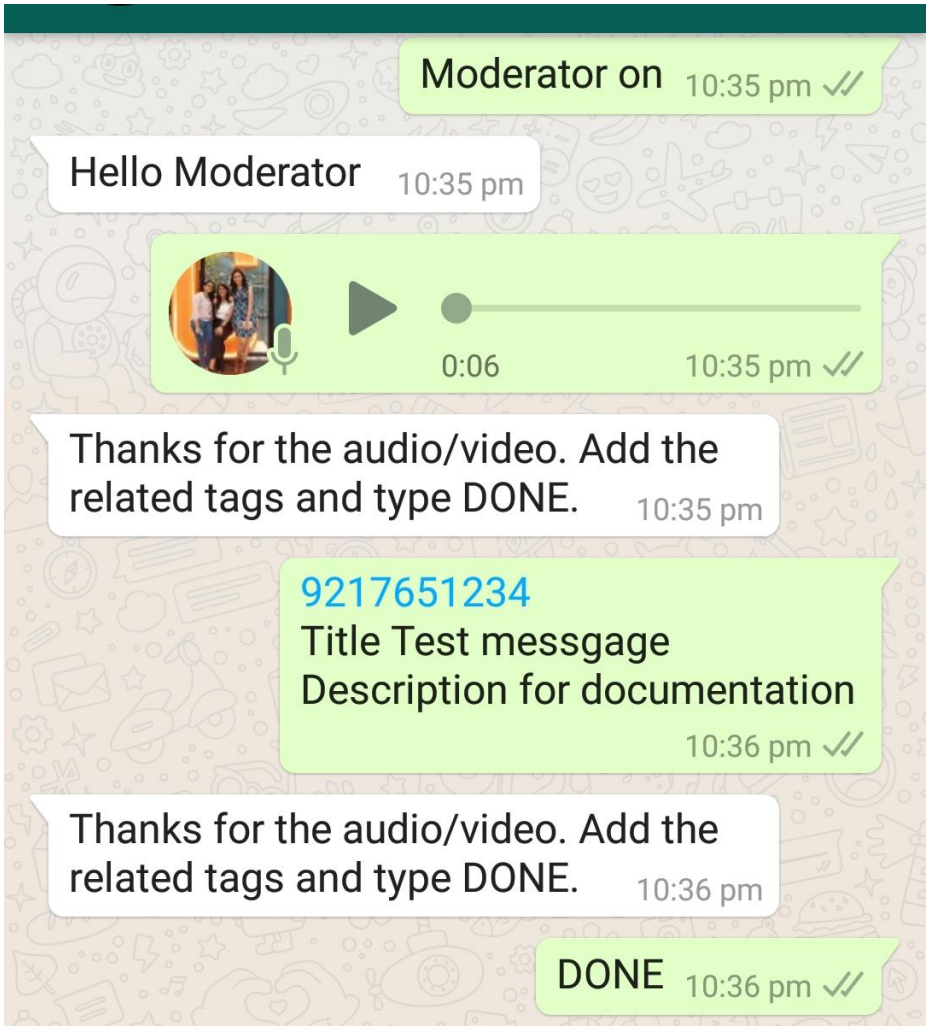
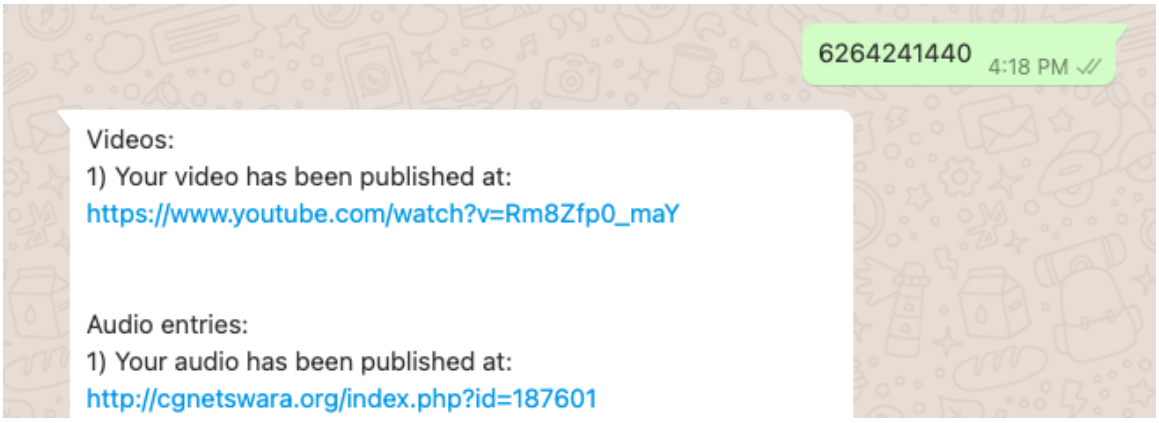


Figure 12

Sending users stories submitted by the contact number typed by them.



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Appendix A

File Structure

Table A1

Relevant Files

Name	**Function**
appemailhandler.py (/home/swara/audiowiki)	Downloads the media files received via app and puts it into relevant directory in server.
database.py (/home/swara/audiowiki)	Defines all relevant functions to interact with database, especially fetching postid to enter a new database entry.
loudblogtags.php (/home/swara/audiowiki/web/loudblog/inc)	defines various functions to interact with media files
backend_postings.php (/home/swara/audiowiki/web/loudblog/inc)	Backend script for 'Postings' page in loudblog website
backend_record2.php	controls recording page step 2