Disaster Mitigation Using a Peer-to-Peer Near Sound Data Transfer System

R. Padma Priya, Ritumbhara Bhatnagar, and Shaaran Lakshminarayanan

1 Introduction

When we consider managing and saving crowds in the times of crisis, for instance indoor fire hazards or natural calamities (floods, earthquakes, etc.), the lack of access to crucial information and failure to access help at a concerned area normally happens due to compromised network towers or servers. Additionally, in view of the ongoing COVID-19 pandemic and pre-empting any other pandemic in the near future, we have taken into consideration the concept of social distancing to manage crowds in places of hazards effectively. We aim to solve this problem with the help of largely, near sound data transfer (NSDT) technology along with peer-to-peer (P2P) networking.

Sound is a great medium to transfer data when it comes to proximity, taking in view the high speed and no need of an external setup. This is the reason many industries are using NSDT to transfer crucial data within their own premises.

NSDT concerns itself with transmission of data over near sound frequencies, for instance over ultraviolet rays. This technology has gained popularity over the past three to four years, and such efforts to increase data transfer rate using NSDT have been promising, through one such technology "ChirpCast: Data Transmission via Audio" [1]. Chirp Software Development Kit (SDKs) have made it very easy for developers to send data over audio. Data is provided to the SDKs in the form of an array of bytes [1]. Transmission of the data can be via audible or inaudible ultrasonic audio depending on the configuration of the Chirp SDK [2]. Another breakthrough, LISNR is an advanced, near ultrasonic, ultra-low power data transmission technology that enables fast, reliable, and secure communication between devices via a speaker and/or microphone [3]. A device enabled with LISNR soft-

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ware can detect, transmit, and receive data from LISNR audio technology within audio range. Once a LISNR signal is detected, the SDK demodulates the data sent over the audio and performs the specified function on the device based on the data [3]. LISNR's ultrasonic platform consists of 3 core product optimizations—close range data transmissions called "Point," mid-range transmissions called "Zone" and long range transmissions called "Radius" [3]. NSDT has also disrupted the financial industry, in the form of Google's Tez (Google Pay in India) transferring payment data from one device to another by the use of its speakers and microphone [4]. This information is also highlighted in Table 1.

Apple and Google together have developed a contact tracing technology. The two tech giants have used Bluetooth technology to enable the same, using a strong security driven backend [5]. Singapore uses Trace Together to manage contact tracing to evade COVID-19 spread [6]. Whereas, India used Aarogya Setu App for COVID-19 contact tracing and mitigation [7]. India has also effectively proposed a 4Ts approach tracing, tracking, testing, and treating to deal with COVID-19.

We have proposed an effective model for contact tracing and mitigation, which is more accessible to the user, by making use of an amalgamation of NSDT and peer-to-peer networking, so that internet and Bluetooth connectivity never pose a plausible necessity in terms of safety from COVID-19.

This paper is organized as follows. Section 2 portrays the literature review. In Sect. 3, we explain about the methodology used. Two scenarios are proposed, and their application has been discussed in Sect. 4.

2 Literature Review

Over the past few years, milestones have been achieved in both NSDT and P2P networks. Let us discuss a few of these that we have come across in order to receive aid for our own proposition.

Authors in [1] investigated a few balance methods for sending and getting information utilizing sound waves through item speakers and underlying PC mouthpieces. Requiring just that PC clients run a little application, the framework effectively gives powerful room-specific broadcasting at information paces of 200 bit/s.

Table 1 Details of various currently prevailing companies that make use of NSDT technology

Company	NSDT use case	Description
Chirp	Chirp Audio SDK	A SDK which allows people to transfer textual information through sound [2]
LISNR	LISNR Sonic SDK	A SDK which allows people to transfer files, textual information, and security keys through sound [3]
Google	Google Pay (Tez)	Transfers payment data from one device to another by the use of its speakers and microphone [4]

Data in the form of music is proposed in paper [8]. In this work, the authors have proposed a sound information concealing framework that shrouds data into signals not known previously. The framework can shroud information into unrecorded music, or encompassing sounds when all is said in done and can be utilized to convey data acoustically starting with one gadget then onto the next.

Diving deeper into Near Field Communication (NFC) we come across “Dhwani” in paper [9]. They address the test of empowering NFC-like ability on the current base of cell phones. To this end, Dhwani, a novel, acoustics-based NFC framework that utilizes the receiver and speakers on cell phones, accordingly killing the requirement for any specific NFC equipment [9]. Another breakthrough has been achieved through “Acoustic communication system using mobile terminal microphones,” where in DoCoMo has built up an information transmission innovation called “Acoustic OFD” that inserts data in discourse or music and communicates those sound waves from an amplifier to a receiver [10].

Use of the ultrasonic spectrum of rays for data transmission as suggested by the authors of paper [11], implements a close ultrasonic correspondence convention in the 18.5–20 kHz band, which is unintelligible to most people, utilizing ware cell phone speakers and mouthpieces to communicate and get signals [11].

When it comes to data security in the light of NSDT, in paper work [12], authors have designed and proposed “EnGarde” (a small system) that can be stuck on the rear of a telephone to give the capacity to stop malevolent communication [12]. EnGarde is altogether detached and collects power through a similar NFC source that it monitors, which makes the equipment plan moderate, and encourages inevitable incorporation with a mobile [12]. L. Deshotels, author of paper [13] actualized an ultrasonic modem for android and found that it could impart signs up to 100 feet away [14]. Moreover, likewise confirmed that this assault is viable with the transmitter within a pocket. Android gadgets with vibrators can deliver short vibrations which make detached sound [14].

If we focus on mobile devices, authors of paper [15] proposed android-based middleware that goes about as the interface point between versatile hubs and higher application layers for versatile pervasive computing [15]. The middleware basically targets supporting and upgrading the conventions for direct P2P correspondence among clients in the troupe versatile climate [15]. Additionally, the paper presents a conversation of the accessible P2P middleware for the versatile climate alongside its applications [15]. Moreover, “Enabling Mobile Peer-to-Peer Networking” presents a P2P file distributing network with an upgraded system for mobile networks [16]. It examines the pertinence of current P2P methods for asset access and intercession with regards to 2.5G/3G portable organizations. They explore a versatile P2P engineering that can accommodate the decentralized activity of P2P document offering to the interests of organization administrators, e.g., control and execution and depends on edonkey convention [16].

In view of usage of P2P networks for disaster management, paper [17] investigated the Geo Collaborative applications utilized for disaster recovery. As catastrophe the executives naturally happens in exceptionally unique conditions, these applications experience the ill effects of lack of a reasonable connection with the server system. The server in this case is the only carrier of information [17]. They propose to effectively use P2P networking in order to interconnect various nodes. Subsequently, one dynamic association between each node and the server room in turn is adequate to sustain the fiasco that has taken place [17]. Authors in [6] have proposed image stitching, google API-based street view retrieval, and distant matrix APIs-based solutions aiding the first responders to save the lives of the victims in the disaster areas. Also in paper [18], authors have explored the Google voice over protocols-based IoT framework for detecting emergency situations in smart office environments.

A huge part of the proposition from the authors of paper work [13] deals with a highly accurate, efficient, and reliable location system. It presents a novel ultrasonic area framework which uses broadband transducers [13]. They depict the transmitter and beneficiary equipment and portray the ultrasonic channel data transmission [13].

Our proposition seeks to aid during pandemic times thus aids in following social distancing norms, for which inspiration is drawn from paper [19], which intends to give an idea to develop networking related to proximity and distance, dependent on high-recurrence sound waves transmitted and caught by the speaker and receiver found on phones [19].

Considering accessibility and ease of usage, wearable devices assist further in passing on crucial information while not making users absent from the real world. Authors of [20] center on the plan and advancement of an ETSI M2M Gateway (GW) on a cell phone, started up in a smartphone [20]. G.E. Santagati and T. Melodia in "U-wear" presented in paper [14], recommend a wearable gadget UWear which comprises of a lot of programming characterized multi-layer functionalities that can be executed on broadly useful preparing units, e.g., chip, microcontrollers or FPGAs, among others, to empower arranged activities between wearable gadgets outfitted with ultrasonic networks [21].

Finally, in paper [22], the authors have examined the essentials of ultrasonic engendering in tissues and investigate significant tradeoffs, including the decision of a transmission recurrence, transmission force, and transducer size [22].

The papers we reviewed, proposed an imminent solution without having a proper directive to the implementation, in addition to that usage of the NSDT and peer-to-peer technology in combination wasn't discussed appropriately. Both of these technologies have a great combined impact in various fields of engineering, especially in disaster mitigation systems. In our paper, we have discussed these technologies and their implementation in detail.

3 Proposed Mitigation Scenarios Using Peer-to-Peer Near Sound Data Transfer System

In this section of the paper, we present the basic implementation of a peer-to-peer system in a mobile device for two scenarios. Exit path retrieval and indoor mitigation is considered as our first scenario. An outdoor environment with COVID-19 victims presence detection is considered as our second scenario. Unlike traditional P2P methods, we have used the “Data Over Sound” technique to transmit data between the individuals simultaneously. The data to be transferred is first transformed into byte sized arrays and then converted into an audio signal, which can be transmitted by any device with a speaker and consequently received by any device with a microphone. As the data over sound technique employs a near ultrasonic sound wave, it is thus possible to transfer data reliably over distances of several meters and even in noisy everyday environments. All the transmissions take place entirely through audio signals (near ultrasonic sound waves) and so, no internet connection or cellular connectivity is required to transmit the data.

In our current scenario, we’re exploiting the same technique of Near Sound Data Transfer (NSDT) for disaster management through an app. When a user installs the app for the first time, the user will be prompted with a form where he/she will be required to enter their details. This information is then compressed and stored in the user’s device. During a calamity, the app when prompted starts streaming the data to nearby devices forming a mesh network. The data comprises key information such as name, last known location, and phone number to help the rescue team take reliable actions in a much lesser time.

3.1 Exit Path Retrieval and Indoor Mitigation: (Scenario 1)

When a disaster occurs in a closed highly dynamic environment, despite a well laid disaster management plan there’s always widespread panic among the people which leads to chaos and stamping. Our proposed solution can greatly aid this problem by providing reliable information towards identifying an optimal exit path in indoor situations to the victims and the volunteers to take necessary actions at a faster pace.

1. The person’s GPS coordinates are logged in real time by the app.
2. Anyone in the affected area reaching the exit can share their route to other victims through the app.
3. The app uses a NSDT-based peer-to-peer network to transmit the information to all the victims without any cellular connectivity.
4. In order to reduce chaos and jamming, the app checks for newer routes and transmits the information to the people for better crowd awareness and management.
5. When a person reaches an area with cellular connectivity, the location data along with the data of the victims in the calamity is transferred to the cloud.
6. The victims and the volunteers can thus take faster and reliable actions with the acquired data. Readers are requested to look Figs. 1, 2 and 3 to acquire detailed information on the above mentioned steps visualized through relevant flowchart, system diagram and demo scene captured from the implemented app respectively.

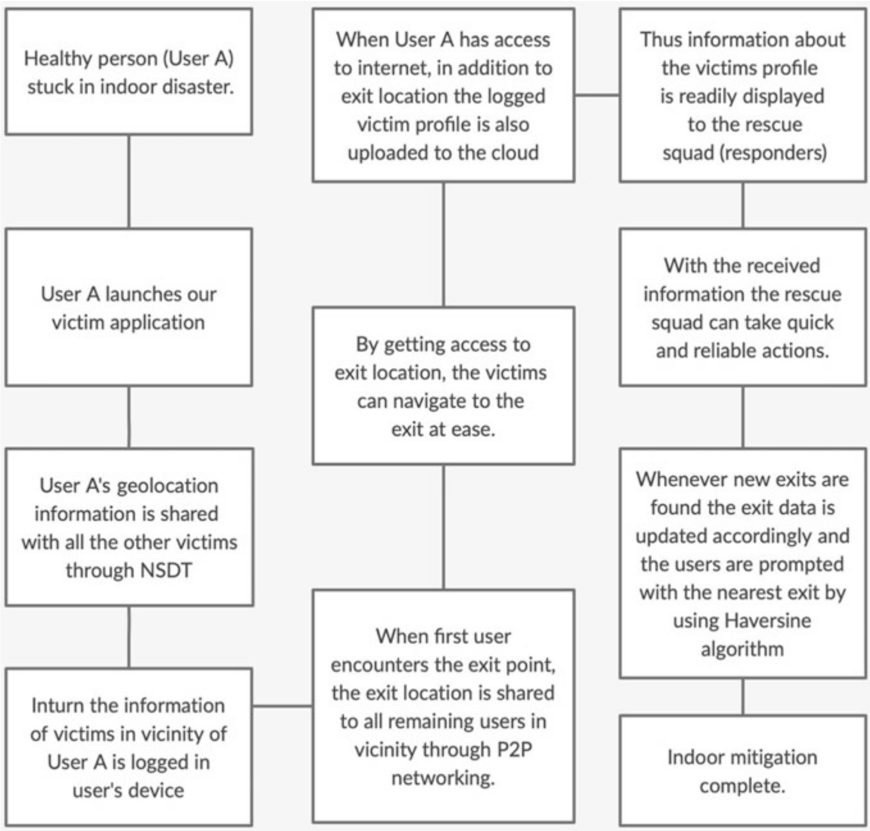

Fig. 1 Flowchart depicting indoor disaster mitigation during a pandemic using the aid of a mobile application. Implemented using NSDT and P2P networking

3.2 Enhancing Biosecurity by Exploiting Near Sound Data Transfer: (Scenario 2)

The 2019 coronavirus sickness brought about by serious intense respiratory condition has risen exponentially influencing all districts of the world. More than 14.3 million cases have been accounted for equivalent to eighteenth July 2020. By every logical means, the world is going through a COVID-19 pandemic. Without any drug mediation, the best way to secure oneself and the others against COVID-19 is to diminish the blending of conceivable irresistible individuals through early ascertainment or decrease of contact with other sound people.

We have proposed a solution that exploits the technique Near Sound Data Transfer (NSDT) to alert a healthy individual whenever a possible vector is in vicinity. The risk analysis for each individual was outsourced from Aarogya

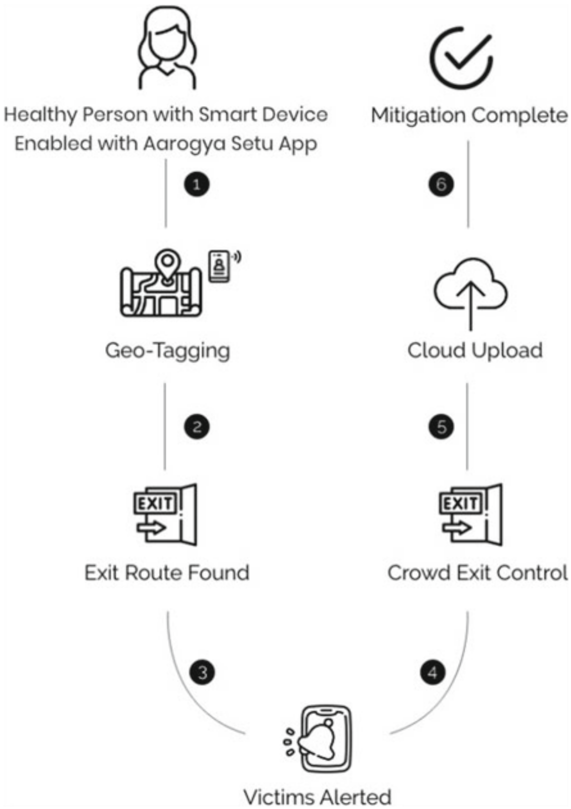

Fig. 2 System diagram depicting disaster mitigation during a pandemic using the aid of a mobile application. Implemented using NSDT and P2P networking

Setu [23]. Aarogya Setu is a COVID-19 contact tracing app developed, approved and used in India.[1]

4 Conclusion

In this paper, we have come up with an efficient solution to replace cellular communications during a disaster. Near Sound Data Transfer (NSDT) has unique capabilities that provide the potential for it to become a vital device-to-device (D2D) connectivity solution, particularly in times of disaster and calamities. Moreover, the concept of opportunistic networks on top of the NSDT technology holds great potential in building complex offline decentralized systems of the future that would create a greater impact in times of distress.

[1] Also readers are requested to look Figs. 4 and 5 to acquire detailed information towards the implementation of our proposed methodology using NSDT.

Fig. 3 Live Demo of the First Responders Application developed, healthy and unhealthy vectors can be identified in real time through the same. Red dots depict “Rescue Squads,” blue dots depict victims, green dots are for “Paramedic,” whereas orange dots are for “Fire Department” in the place of calamity

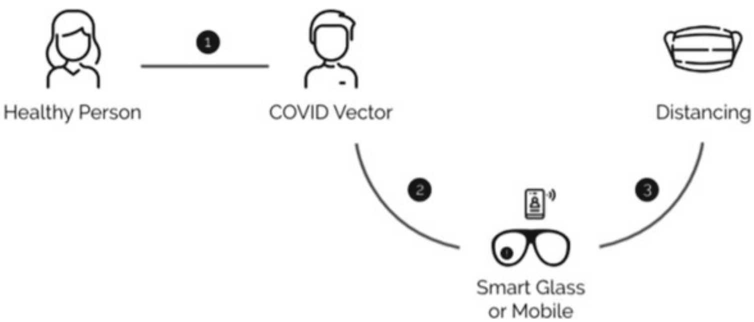

Fig. 4 (i) Healthy person comes in the vicinity of a possible vector. (ii) The mobile app recognizes the vector and sends an alert to the device. (iii) The Healthy Person is alerted and takes the necessary measures

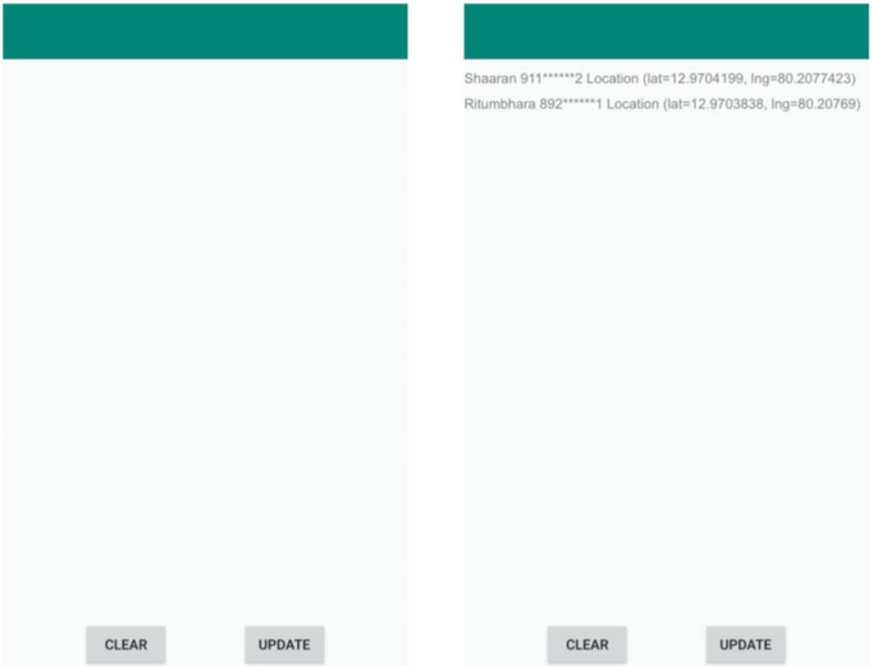

Fig. 5 Application developed on NSDT displaying identities of humans in vicinity of the carrier of the smartphone along with location coordinates. Note: The readers are reminded about the disabled internet connection in the smartphone

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