

# COVID-19: Contact Tracing or Cloud-driven “Your papers, please”

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**Abstract**— COVID-19 pandemic contact tracing involves the identification and follow-up of persons who may have physically contacted an infected person. Innovative technology assistance is required, since the wide-spread nature of the pandemic renders current labor-intensive contact tracing investigation procedures impractical. Apple, Google, and others are developing smartphone Bluetooth technology to record each close contact with other smartphones and provide an alert to possible infection contact. On the surface, this looks like a smartphone application to maintain a simple diary of all locally detected smartphone-to-smartphone Bluetooth signals. A scenario tracing the interaction between five smartphones, is used to show the benefits and risks of a smartphone-user-centric implementation versus a cloud-centric implementation. A cloud-centered approach raises concerns for privacy and possible central authority overreach. A fictional overreach police state called “your papers, please” is presented to challenge the reader’s notion of personal privacy as it relates to a public health emergency.

**Keywords**—COVID-19, Contact Tracing, Smartphone, Cloud, Privacy, Pandemic

## I. INTRODUCTION

The COVID-19 pandemic is the worst healthcare crisis to face the world in a century. We have not seen such a pandemic in a hundred years since the Spanish Flu. The spread of the novel coronavirus has been exacerbated due to the intense global travel and frequent meetings in close proximity. The world was totally unprepared to handle this pandemic. Until we have a suitable vaccine, the virus is here to stay. One solution to this pandemic is to shut down the world as long as it takes so that the virus is eventually eradicated. However, this is not possible as sick people go to hospitals and spread the virus through the healthcare workers. Furthermore, it is impossible to shut down the world as you need healthcare services, emergency services and food services to survive. Also, shutting down the world would mean complete collapse of the economy. Another solution is to develop herd immunity. But this would mean millions of deaths and the survival of the fittest. Therefore, a compromise situation is to take all the precautions such as wearing face masks, sanitizing the hands and also carry out testing and tracing. That is, if a person tests positive for COVID-19, then you trace all the people he/she has come into contact with. This paper explores alternatives for contact tracing. In particular, we examine smart-phone based contact

tracing as well as cloud-based contact tracing and explore the advantages and disadvantages of both approaches. We pay special attention to privacy issues during contact tracing.

The organization of this paper is as follows. Section 2 discusses aspects of contact tracing. Section 3 discusses smartphone vs cloud-based contact tracing. We provide an analysis in Section 4. The paper is concluded in Section 5 that also includes a discussion of the directions.

## II. CORONAVIRUS (COVID-19) CONTACT TRACING

The World Health Organization (WHO) defines contact tracing “as the identification and follow-up of persons who may have come into contact with a person infected...” [1]. The COVID-19 pandemic focuses attention on the manual process of worldwide contact tracing investigations. Apple and Google have coordinated to develop a technology designed to alert smartphone owners if they have contacted other (smartphone owners) infected by COVID-19 [2].

Figure 1 graphically shows a view of how smartphones can use Bluetooth signals to log proximity (Bluetooth signal strength) and duration (multiple timestamps) data to determine a possible individual contagion risk. The figure depicts a scenario where **Alice’s** smartphone was in proximity/contact with the smartphones of: **Bob**, **Cora**, **Dawn** and **Ella**. The smartphones exchange enough information to assume that **Alice** was in close contact with **Dawn** for over 10 minutes.

Section 3 uses the **Alice-Dawn** scenario to examine possible approaches to implementing a technology-assisted contact tracing system. The local smartphone implementation is compared to a cloud database implementation. Misuse of the information could lead to a police state called “Your-papers-please”. Wikipedia defines “Your papers, please” as an expression or trope associated with police state functionaries, as popularized in Hollywood movies [3].

## III. APPROACHES – SMARTPHONE-CENTRIC OR CLOUD-CENTRIC DATABASE?

An ideal, smartphone-centric and user-centric contact tracing system would have the following characteristics:

1. The user would remain anonymous with voluntary participation

- Use local Bluetooth signals only, do not use GPS location data
- The system should be secured from unauthorized access and data loss
- Infected contact notification should be fast, private and contain the nearest COVID-19 testing location
- The user can change status, after the results of COVID-19 testing are known, to INFECTED or not infected; to trigger the next contact tracing sequence if needed
- Personal information would not be disclosed
- No need to download a specific application
- The system operation would be discontinued after the pandemic

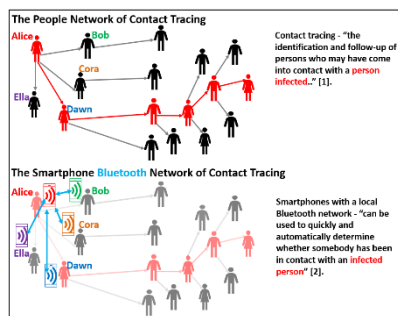


Figure 1. Contact tracing networks by Smartphone.

Given Figure 2, a detailed examination of the **Alice-Dawn** contact tracing scenario provides insight into potential benefits and risks of the implementation alternatives. Innovative technology assistance is required, since the widespread nature of the pandemic renders current labor-intensive contact tracing investigation procedures impractical.

The figure shows a contact tracing timeline with seven significant time periods ( $T_0 - T_6$ ):

- Time  $0$  – A 10-minute co-location meeting occurs between **Alice** and **Dawn** and 10 timestamps/codes are exchanged between smartphones via local Bluetooth signals.
- Time  $1$  – Two weeks later Alice tests positive for COVID-19. **Alice** could change the status on the smartphone to INFECTED or the COVID-19 official test site could change the official status on a cloud central database.
- Time  $2$  – The smartphone can automatically send Alice's INFECTED status and 10 timestamps/codes, showing contacts with **Dawn** to a Trusted Central Authority (TCA) cloud database or the TCA could request the information from the smartphone. **NOTE - Who is to be trusted to fill the role of the TCA: a private cloud-centric company or a government agency?**

- Time  $3$  – Dawn's smartphone can periodically download referenced timestamps/codes from the TCA to discover that she may have been exposed to COVID-19 or the TCA could notify her to self-quarantine and get tested.
- Time  $4$  – If the downloaded data indicated possible exposure, Dawn's smartphone alerts her that she may have been exposed to COVID-19 or the TCA could notify her to self-quarantine and get tested.
- Time  $5$  – Dawn is tested for COVID-19 and self-quarantines, or Dawn does not get tested or does not self-quarantine. **NOTE - How do health officials verify that self-quarantine and COVID-19 testing orders are followed?**
- Time  $6$  – If Dawn tests positive for COVID-19, the contact tracing time sequence 1 through 5 is initiated for **Dawn**.

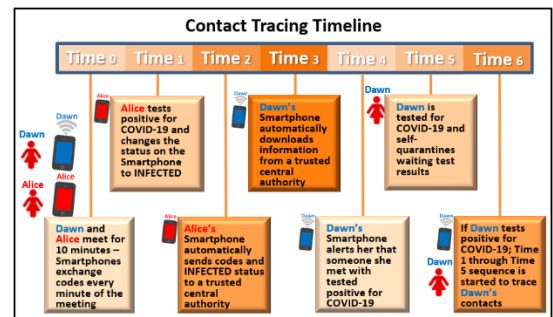


Figure 2. Smartphone-enabled Contact Tracing Scenario Timeline.

Two questions remain to be addressed by the cloud-centric database approach:

- (1) the question of authority trust [private or government] and
- (2) the question of individual compliance verification

The required cloud-centric database data elements and data structures can be replicated from the existing Record of Contact Interview Form [4] shown in Figure 3 below.

Figure 3 depicts the flow and connection between a proposed cloud-centric contact tracking database and a standard telecommunication-industry customer billing database. In this scenario, the flow of information proceeds using **Alice's** smartphone to-and-from the smartphones of: **Bob, Cora, Dawn** and **Ella**. **Alice's** smartphone (**A-Mobile Number**) is connected to **Bob's** smartphone (**B-Mobile Number**) requiring a contact interview. **Bob's** personal information is retained (available) on the telco customer billing database.

#### IV. ANALYSIS – “YOUR PAPERS, PLEASE”

How could a “Trusted Central Authority” (private company or government agency) misuse a pandemic emergency and a well-meaning contact tracing application to slip incrementally into performing police state functions? The answer could be “one small step at a time”, similar to the following fictional scenario:

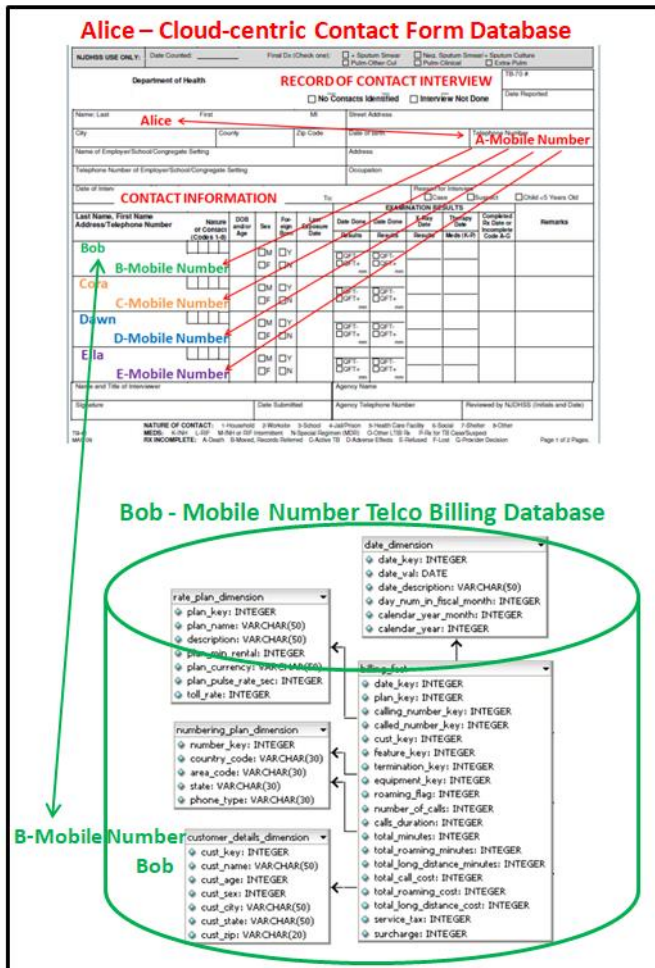


Figure 3. Cloud-centric Contact-form-based Database [4] and Telco Database [5] Integration Annotated Scenario.

1. Require all smartphone owners to carry their smartphone at all times (most smartphone owners have volunteered to perform this function without declaring a requirement). The 100% carry requirement would be needed to ensure that the contact tracing is effective.
2. The owner’s smartphone could become an Electronic Smartphone Passport (or papers) that retains vital health information (infected, not infected, recovered, tested...). The Electronic Smartphone Passport (ESP) can be

used as an access device to service establishments, public gatherings or public transportation.

3. Figure 4, below, shows the GPS-based timeline database automatically collected from an individual smartphone by Google Maps. The leftmost map panel shows red dots for all locations visited during the month of January 2020. The rightmost panel displays the same map area with the smartphone pinpointed in a single location (one red dot) during a local April 2020 shelter-in-place order. The consolidation of GPS data with contact tracing data could be used as a reporting mechanism to enforce shelter-in-place or quarantine orders (see also [6] and [7]).

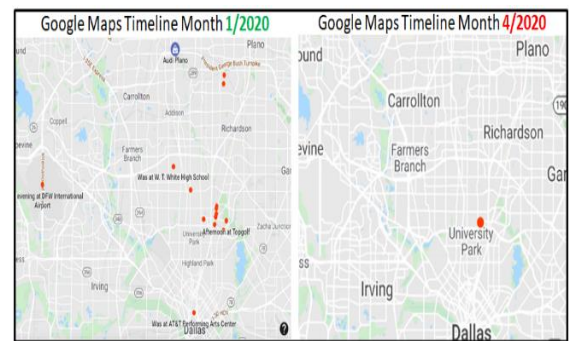


Figure 4. Google maintains a database of Smartphone locations visited [red dot] in January 2020 and April 2020.

#### V. CONCLUSION AND DIRECTIONS

This paper has discussed various approaches to contact tracing for COVID-19 and analyzed these approaches. Privacy issues were also considered in the analysis. We argue that an emergency reaction to create and empower a Trusted Central Authority, TCA, (private company or government agency) should always raise concerns. A historical perspective shows that the infrastructure necessary to buildout and support an emergency TCA does not normally evaporate when the emergency ceases. The emergency powers given to a TCA should be tempered with realistic operating constraints and the rules requiring shutdown as the emergency terminates.

Future work includes exploring the use of Data Science for contact tracing. Data Science includes Statistical techniques in language such as R for public health and epidemiology as well as the use of Machine Learning techniques in languages such as Python for making predictions of future hotspots. We need to understand the current situation, predict the future situation and ensure that the data is secured and privacy of the individuals is

maintained. We hear of horror stories such as gene editing, especially the DNA of the novel coronavirus (e.g. COVID-19) to produce even more dangerous strains. We need research to be able to detect such unauthorized modifications so that we can ensure the safety of the nations.

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