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Jan Bohnerth

Technical Report – STL-TR-2020-02 – ISSN 2364-7167

stl.htwsaar.de

Technische Berichte des Systemtechniklabors (STL) der htw saar
Technical Reports of the System Technology Lab (STL) at htw saar
ISSN 2364-7167

Jan Bohnerth: Health-, Fitness- and Corona apps and why it is important to be skeptical
Technical report id: STL-TR-2020-02

First published: July 2020
Last revision: September 2020
Internal review: André Miede

For the most recent version of this report see: https://stl.htwsaar.de/

Title image source: iXimus, https://pixabay.com/illustrations/mobile-phone-corona-warning-app-5355458/

htw saar – Hochschule für Technik und Wirtschaft des Saarlandes (University of Applied Sciences)
Fakultät für Ingenieurwissenschaften (School of Engineering)
STL – Systemtechniklabor (System Technology Lab)
Prof. Dr.-Ing. André Miede (andre.miede@htwsaar.de)
Goebenstraße 40
66117 Saarbrücken, Germany
https://stl.htwsaar.de

Health-, Fitness- and Corona apps and why it is important to be skeptical

Jan Bohnerth
htw saar – Hochschule für Technik und Wirtschaft des Saarlandes
Seminar "Computer Science and Society"
Sommersemester 2020

***Abstract*—When looking at the so-called Corona/COVID-19 apps there are a lot of differing opinions. Whether it is people who think that these apps are used to gather private information, that feel restricted using them, or others that download them to feel more secure. Analyzing the problems of similar apps in categories like health and fitness, we can see why these opinions are so mixed. This is amplified by the different approaches taken by the individual countries. Be it Corona apps with a centralized architecture, like the ones from Singapore, Australia and France or a decentralized like the Corona-Warn-App from Germany. Especially when it comes to privacy security and issues around Bluetooth, even experts seem to disagree among themselves. This paper compares the existing issues of these Corona apps with the ones of the health and fitness category and analyzes the different contact tracing app approaches with a focus on the German Corona-Warn-App and its potential flaws.**

I. Introduction

A. Why Corona/COVID-19 apps?

We are at a time, where living without being connected seems generally impossible, where people even demand to make the internet a human right [1]. Looking back 7 years, a survey showed, that around 37% of teenagers of the selected 802 in the survey had a smartphone which was a 14% increase compared to the number in 2011 [2]. We are now at a point where the amount smartphone users will be close to half of the human population, so nearly 4 billion estimated in 2021. [3]. Looking at those numbers providing an app, that tackles one of the biggest global pandemics of the modern age seems like a good idea. To clarify the term app, it is an abbreviation of the word 'application' and we understand it as a piece of software, that is installed on a mobile device. But as well as in the fitness and health app section [4] [5], there is criticism when it comes to the so called 'Corona Apps' or 'COVID-19 Apps' and with that, different design ideas to tackle these problems [6].

Since we did not have such apps before, I decided to also look at 2 similar categories, which are health and fitness apps and what we can learn from them.

B. mHealth and fitness apps

First of all, what are mobile health apps or mHealth? "Health-related mobile applications and technologies are often known as mHealth and manage the patient experiences. These health mobile apps use sophisticated data analytics and mobile technologies for healthcare professionals to provide their patients best care possible at low cost from convenient locations." (citation from: [7])

What that means is, that these apps use given information via manual user-input or devices like smartwatches. The output then varies from raw information to in depth overviews depending on the app used. These apps in general seem to be quite lucrative. Looking at the value of the mobile health app market, the estimated value of 2018 was set to nearly US$30 and is expected to reach US$100 by 2023 [7], [8].

Similar to health apps, fitness apps see an increase in popularity and market share as well and use similar information to optimize things like workout plans or diets. Looking at those numbers, it seems that incentives like staying fit and losing weight are really appealing to most users. What most people seem to forget is that, even if an app is 'free' user data and personal information is very valuable [9]. And multiple reports show that some of the mHealth and fitness apps don't have privacy policies or do not specify them in a way where they actually protect the user data [4], [5], [10]. This can even go so far, that if multiple apps are used that have a sort of privacy protection (where the data of one app does not identify an individual), a connection between all the gathered information could lead back to the individual [10]. Even though this is important to keep in mind, not all apps operate that way.

C. The "Corona-Datenspende-App"

One example of a company protecting the privacy of their users, is a start-up called Thryve. Together with the Robert-Koch-Institut(which is also involved in the Corona-Warn-App), they helped develop the Corona-Datenspende-App. The idea behind it is, that health and fitness apps/devices are used to monitor data like temperature, sleeping rhythm(disturbed or not) and more, and with that get a more precise idea whether or not an individual has symptoms or might be infected [11]. With this the RKI wanted to get more information about the general effect of the disease on the human body and the variation of symptomps [12]. The goal of it was, that the gathered information is used to create a prevention mecanism that warns a user if they have symptoms of these kinds. Looking at the privacy aspects, this app only supports a few health and fitness trackers and apps and unlike the ones above, respects and protects the pirvacy of the users. They are even approved and certified by ePrivacy to be secure and that they

provide anonimity, when it comes to the Corona-Datenspende-App and received the so called ePrivacyseal [13], [14].

What all of this should show is, that even if there are apps which protect privacy, we should not ignore that there are others that do not. Especially when it comes to new apps like the Corona/COVID-19 apps, we should keep this in mind and look closely at how they operate. But more about that in the following sections.

The remainder of this paper is structured as follows: First, we will take a look at the beginning of the pandemic with fake apps, different approaches from countries like Singapore, Australia and France and an overview of their corona apps. Following up on this, in section III we will talk about the German 'Corona-Warn-App', it's functionality and how it's design changed due to the advice from experts. Adding on to that, why there are problems with the app and when such an app would be most effective in the fourth section. And ending the paper with a summarization and outlook in the last section.

II. The different Corona/COVID-19 apps

Before we analyze how most of the contact tracing corona apps work and what their key features are, let's look at the reasoning of why there were so many of them in the beginning of the pandemic. We already discussed, that there is a lot of money that can be earned with apps in the health and fitness category. Looking at the corona apps, it seems that especially in the beginning people tried to sell their app as a cure for the disease or similar things, with the intention of luring people into spending money on them. To counter vein that, apple as well as google updated their guidelines and report functions to mitigate these scams early on [15], [16], [17]. This idea also got adopted by Amazon. They threatened to take down any product that claimed to kill or heal the coronavirus [18]. The purpose of all this was mainly to stop misinformation and people spending money on, what seem to be, obvious scams. However, especially the updated guidelines and report functions had drawbacks. People that created corona apps with a good intent and actual functionality were denied, when it came to publishing their app on the mobile app market, which sparked a lot of outrage [15].

But of course there are also official Corona apps, which are often developed in cooperation with the corresponding governments of the individual countries[1], like the Corona-Warn-App from Germany. Besides Germany, there have been other countries that already published their unique Corona apps. In Singapore one of the first official Corona apps got published, which is called TraceTogether. In Australia there is the CovidSafe app which got published around 2 months later. Then we have the StopCovid app, a project by France's national research institute for digital science and technology INRIA [20] in cooperation with Germany's Frauenhofer Institut and many more apps from other countries(TraceTogether: [21], CovidSafe: [22], StopCovid: [23], all in an overview: [24]). Let's look at the different apps and what they are supposed to do.

[1] [19] is a Wikipedia article, that contains a lot of information about the Corona/COVID-19 apps and also holds a list of all the apps and their corresponding country

A. TraceTogether app

First, the TraceTogether app. This app is based on a centralized architecture. What that means is, that the server tries to provide the main functionalities. In this case that is sending so called "TempIDs" to the user's device. These are sent every 15 minutes and stored on said device. If there is another individual for too long in close proximity, that also happens to have the app, then the devices will exchange these TempIDs. If one were to be infected and notifies health officials, then all the TempIDs that got sent from the device of the infected individual will be flagged. This is done, to ensure that other devices that did recieve those flagged signals can alarm their user. In this case the user, before being able to use the app, needs to send identification details to the server. This information alongside their mobile number, as well as a random generated, anonymised user ID is stored on their servers, so that tracking the stored TempIDs is possible [24], [25]. According to the official website of the TraceTogether app by the Singaporean Government, the number of users for the app is already above 2.1 million(date 20.07.2020) [21]. To put that in perspective, according to another official website from the Government of Singapore, the population count in June 2019 was 5.7 million, so more than one third of their population [26]. In addition to the app itself, Singapore also launched an alternative to the app, that can be used even if the person does not have a (compatible) smartphone. These devices are called "Token" and give for example older people, that do not have modern phones or individuals that do not have access to them an opportunity to help reduce the spread of the disease, or protect themselves in some way. These Token should have the same functionality as the TraceTogether app according to [27] and [28], by also using Bluetooth signals to send to and also receive signals from other TraceTogether devices(including smartphones with the app). [27], [29]

B. CovidSafe app

Following the TraceTogether app from Singapore we have the CovidSafe app from Australia. This app got released after Singapores app and also uses the Bluetrace protocol, where the user first has to register and the server sends them these TempIDs [30]. This means that the CovidSafe app is also based on a centralized architecture. The key differences looking at the functionality of CovidSafe in comparison to the TraceTogether app are, that Australia's app changed the exchange time from the TempIDs. Rather than the 15 minutes, the server shares these signals only every 2 hours(this source [24] also describes advantages and disadvantages of using such a long time rather than only 15 minutes). The also seem to use servers provided by Amazon instead of Google Cloud which is used in Singapores case. The same team from the CovidSafe app is also currently working in cooperation with the CovidShield team [31]. Their idea is to create an app that has more focus on the privacy protection aspects and utilizes Apple and

Googles exposure notification technology [32], [33], which is usually used in decentralized contact tracing architectures [24], but more about that architecture when we take a look at the Corona-Warn-App in the next section. If we look at the statistics from Australia, the number of downloads on June 28th reached 6 million [34]. Comparing this number to the projected resident population of Australia, which estimates 25.6 million [35], we nearly have 1/4 of the population instead of the 1/3 we have in Singapores case.

C. StopCovid app

Now the last app that we will look at, which uses a centralized architecture is the StopCovid app. It was developed by the Frances INRIA in cooperation Germanys Frauenhofer Institut and is not based on BlueTrace(the protocol with the TempIDs from the other two apps) but rather their own proximity tracing protocol called ROBERT. ROBERT stands for "ROBust and privacy-presERving proximity Tracing protocol [...]" [24]. The main differences are, that ROBERT only stores so-called ephemeral IDs on the server rather than storing private information identifiers in the case of BlueTrace. This should make it harder to trace back a certain individual and provide more privacy protection than the apps listed above. But that is not all, the way users get informed if they are at a potential risk because they could have had contact with someone infected is also differing from BlueTrace. In this case the ephemeral IDs will be frequently checked and if they are flagged as "at-risk" the user will be notified immediately [24], [36], [37]. Lastly ROBERT also provides more privacy protection, when it comes to the confirmation of an individual being infected. This is done by uploading the flagged ephemeral IDs in a delayed and random order, meaning that it would be harder to conclude from these IDs to a certain individual. To compare that, in the case of BlueTrace the contact IDs are all uploaded at once leaving the possibility to potentially backtrack and identify an infected person [24], [37]. I also wanted to compare the downloads for this app aswell, but I could not find an official source. However, based on the two articles [38], [39], the number of downloads at the end of June was around 1.8 million. Up to that point, already 460 thousand users had already uninstalled the app according to both sources. If we look at the population of France, which seems to be around 65 million residents [40], we get a percentage of nearly 2.77% people that downloaded the app. But we also need to take into consideration, that this app was only available for 3 weeks at that point in time.

Now that we saw 3 examples for a centralized architecture, let's look at an example for a decentralized approach: the Corona-Warn-App from Germany.

III. The "Corona-Warn-App"

This section will not be an in depth technical description of the app or of the Application Programming Interface(API) used, but rather a brief overview what contact tracing is, how the idea of it is implemented in the Corona-Warn-App and how this achieves more privacy protection than the apps above with the help of a decentralized architecture.

A. Contact tracing

When talking about the so-called Corona or COVID-19 apps it is important to understand, what contact tracing is, since it is the main idea behind those apps. Looking at other diseases there are already definitions for it: "Contact tracing is finding everyone who comes in direct contact with a sick Ebola patient. Contacts are watched for signs of illness for 21 days from the last day they came in contact with the Ebola patient. If the contact develops a fever or other Ebola symptoms, they are immediately isolated, tested, provided care, and the cycle starts again—all of the new patient's contacts are found and watched for 21 days." (citation from: [41]) Using this definition, we can generally say, that contact tracing looks at (potentially) infected individuals and who they came in contact with and ideally quarantines them. The idea behind that is, to reduce the spread of diseases like Ebola or in our case Covid-19. And this is the basis of what the app should do, tell individuals who had contact with someone that is infected and prevent them from potentially infecting others [42].

B. Functionality

As already mentioned, this is not an in depth look at the technical background but rather a brief overview, to understand how(in this case the Corona-Warn-App from Germany) works. When the app is downloaded and Bluetooth is active, it uses it to send signals and also listen if there are other devices that(use the app and) are sending signals. These signal are randomly generated character sequences, which will be stored on the user's device. If another device is in a critical range for too long, the devices will send their own stored sequences to each other and save them. In case a user that was in close proximity were to be infected, then he can tell the app. If the infection is confirmed by health officials, then his random generated sequences will be stored in a list, marked as infected. The app will in general, compare received signals(character sequences) with this list of infected ones. What then happens is, all users that received signals from the infected individual are notified, because the app noticed, that one or more of the received signals is in this list of infected ones [43] [44] [45].

C. Privacy

At first, this system sounds like it could not be implemented in a way, that it protects privacy. However, the way signals are sent, received and also checked is as anonymous as it can get. The signals are randomized and will be compared to a list of 'infected signals', meaning that the app will compare all received signals with this list. If there are any matches, the user will be notified. Information like who sent the signal and when or where the signal got received will not be stored, protecting one of the privacy aspects.(more in depth information over the API that is used to make it anonymous: [45], general idea: [46])

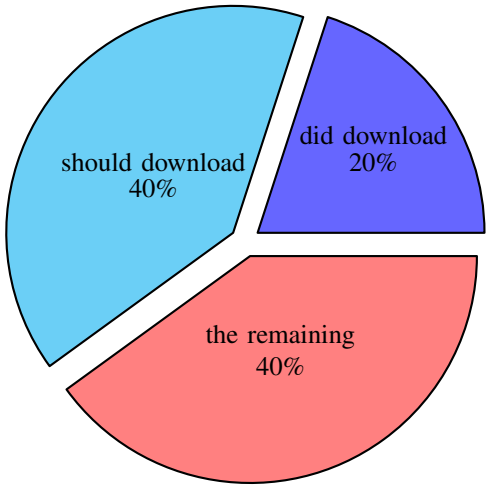
The biggest criticism at the beginning of the development of the 'Corona-Warn-App' was the centralized and closed approach of the app that a lot of other apps used as well. However, due to pressure and criticism made by different experts and the 'Chaos-Computer-Club' [47], the project switched to a decentralized architecture and open source code [48], [49]. This means, that anyone can have a look at the source code of the project [49], making it more trustworthy. The idea of the app being decentralized means, that rather than storing data and user information on a server, the device itself does all the work(as described in functionality). In this case the server is only used to receive the randomized character sequences of infected individuals and store them in a list, which is available to all app users to compare their received signals with [50]. This decentralized architecture compared to the centralized one protects privacy by a much larger margin, since the user data is not sent directly to the server but instead already anonymous before the server receives it.

We looked at the idea of contact tracing, the functionality and advantages of a decentralized architecture as well as the privacy aspects of the app, but we can see that it's not perfect. In the following section we will take a look at what might be and are problems with the Corona-Warn-App, that there seem to be better alternatives in some areas and that there is, in general, room for improvement.

IV. Problems with the German app

A. Effectiveness

To test the potential effectiveness of these apps, the University of Oxford created a test model, where they simulated a city of 1 million inhabitants. The results were, that if 60% of them would use something like a corona app, the spread of the disease and with that itself the epidemic could be stopped. They also stated, that these apps can be effective even if the amount of users is below the 60% [51]. While writing this the Corona-Warn-App got downloaded 16.2 million times(date 24.07.2020), according to the official Robert-Koch-Institut website [43]. Assuming we have 83 million inhabitants in Germany we would get the following chart:



We get those numbers if we devide the 16.2 million users by the 83 million inhbitants of Germany, resulting in 0.195181 or roughly 19.5% and rounding it up we get 20%. Then the remaining 80% are split in 2 40% parts. The 2 blue parts(20 and 40%) represent the 60% of the oxford study. The red part is 40% of the remaining people. This also assumes, that all the users would live in Germany. What this shows is, that we are nearly at 1/3 of the number we should reach, if we take the 60% threshold into consideration(and assuming that download also means using the app). Since nearly 90% of the German population have a smartphone (according to: [52]), this goal could be reached assuming this number is accurate. However, it does not show how many of these smartphones are capable of using the app.

Summarizing this, we can say, that the effectiveness of these apps varies depending on the amount of people that use them actively and that we are theoretically able to reach the threshold given by the Oxford study.

B. Accuracy

Since the beginning of the debate on how to create such an app, there have been a lot of differing opinions around Bluetooth. Experts claim, that modern smartphones have a more accurate technology when it comes to distance measurement (called Ultra-Wide-Band). Others claim, that Bluetooth would be enough and also upholds the privacy aspect of being decentralized (more about that debate in this article: [53] and here [54]). This article [55] also has differing opinions on whether or not Bluetooth being used is a good idea or not, quoting various sources. One being Ross Anderson from the University of Cambridge, saying that Bluetooth has range-problems depending on how the phone is held or where Bluetooth should be used(indoors or outside). Another problem he points out is, that there might be situations where there is no potential infection risk but the signal interprets it as one, causing so called "false positives" [55].

Adding onto that, this article: [54] by A. Ross, about contact tracing in the real world explains how there are other parameters to be taken into consideration. That being factors like the wind. When talking to someone within the critical range, while it's windy or while someone is behind a pane of glass or something similar the app does not take that into account. This means that you could get a warning on the app, even though you did not get infected. This all together leaves the accuracy in a difficult position to evaluate.[2]

C. Locality and Availability

Originally it was planned, that the app was only supposed to work in Germany. However, at the current time, the Corona-Warn-App can also be used in all 27 Mitgliedsstatateen of the EU [57]. Since the effectiveness of these apps correlates with the amount of people that use them, the ideal app would have been one that can be used anywhere on the world. However,

[2]For more details about Bluetooth in the contact tracing area, [56] is an article by Sam Biddle, with an interview of the inventors of Bluetooth talking about potential problems.

this is not the only problem. Since there are already a lot of different Corona apps all over the world, the idea of a unified app would be hard to accomplish. Also, since every country has their own different situations and requirements it would make such project even more difficult [55].

Another important aspect and connected to it and the last problem we will look at is the availability of the app. Due to the Google and Apple API being relatively new, the app will only be supported by newer version of the individual operating systems (OS). In apple case only devices with IOS 13.5 or above can download it. In Googles case, only Android 6.0 or higher use it [58], [59]. As already mentioned in the effectiveness section, the number shown(that 90% of the residents in Germany have a smartphone) does not specify if these support the required operating system(OS) version or not. The main problem here is, that this API is the core of the Corona-Warn-App making the requirement of modern smartphones that can use the needed OS basically unavoidable for its usability.

V. Summary and Outlook

Even though there are a lot of apps on the market, be it in the health, fitness or other categories, there are also ones that do not keep privacy regulations. With this information we should be mindful what to download and what not to. Since there are a lot of different Corona apps there might be some that do not have privacy protection or even good intentions at all. Looking at the Corona-Warn-App however there is few that can be criticized. Changing the project from a centralized to decentralized architecture and in addition to that switching to open source makes the whole project a lot more appealing and compared to the other apps with their centralized approaches, much more user-friendly. With the usage of the Google API [45] the promised data protection is also mainly implemented. However, the problems like Bluetooth not being able to accurately track the distance (in some cases), as well as the missing support for older operating systems should not be ignored. And lastly the main issue of the effectiveness, that is depended on how many people will actually use the app, which correlates with how the app is seen.

If we conclude all this, we can see that it is important to give projects like these apps time, feedback and with that criticism if there are problems, to help them create a tool we can use to protect ourselves and others in such a difficult time. Looking forward we can use all this information to learn and adapt in case there might come a similar situation. [3]

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