# Technobubble

Marc Langheinrich, *Università della Svizzera italiana (USI), 6900 Lugano, Switzerland*

*One and a half years ago, I wrote here about the worldwide race to contain the spread of COVID-19 with the help of smartphone contact tracing. While we are still very much living with the virus, most parts of the world seem to have silently given up on these apps. Have we overestimated the power of pervasive technology to solve real-world problems?*

DP-3T. PEPP-PT. TCN. PACT. GAEN. Not too long ago, these acronyms[a] were almost a staple of everyday discussions, as the world tried to figure out the right way to track the spread of the coronavirus. Centralized or decentralized? GPS-based on BLE-based? How are infections registered and subsequently communicated to prior contacts?

For months, the download numbers of the subsequently developed apps topped national news headlines. As summer neared here in Europe, many of these national solutions would only register contacts between identical apps, making contact tracing while vacationing in neighboring countries impossible.

Many months of fine-tuning exposure detection algorithms, adding extra functionality (such as check-ins), and engineering pan-European interoperability ensued. By the time the second wave arrived in October 2020, the technology seemed to have been as ready as it would ever get. Yet, in most countries, app installations never seemed to reach the critical mass that experts considered necessary to fully contain the virus spread.

Here in Switzerland, with over 92% of all adults owning a smartphone, the active number of COVID-19 contact-tracing app installations never even reached 30% (the peak was in mid-January 2021, at the tail end of the third wave, with 28%). Few countries apparently managed to get even close to or above 40% (e.g., 41% in Germany, 38% in Iceland), with the exception of countries that made app installation mandatory (e.g., Singapore, where the government recently reported that "almost all above the age of six are on board").

Initially, countries around the world sought to reach at least 60% of app penetration, based on a popular misinterpretation of a University of Oxford study. While the authors since clarified that the use of contact-tracing apps would bring tangible benefits even at lower penetration levels, the overall enthusiasm for using pervasive technology to battle the virus has waned significantly. Still, as of today, more than 100 such tracking apps are in use worldwide.

## BUT DOES IT WORK?

If you remember my last column, the design of digital contact-tracing apps had to balance the power of the app to properly ascertain exposure to a potentially infected person with the need to safeguard participants' privacy. Additionally, the technology used also influenced the ability of national health authorities to quickly and accurately assess the state of infections in the country.

At one end of the spectrum were decentralized, anonymous apps that relied on Bluetooth proximity detection and anonymous codes to alert potentially exposed users and invite them to get tested and/or to quarantine. Google and Apple, who maintain the two dominant smartphone OSs in the world, co-developed and subsequently updated their most recent OS versions with the "Google/Apple Exposure Notification" (GAEN) protocol, allowing for low-power, cross-platform proximity detection. The Swiss COVID contact-tracing app was one of the first to be built atop GAEN, and many European apps followed (e.g., Germany and France).

At the other end of the spectrum were apps from countries like Singapore, Qatar, U.K., and Norway, which used location data instead of (or in addition to)

[a]For what it's worth, the acronyms stand for: Distributed Privacy-Preserving Proximity Tracing (DP-3T); Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT); Temporary Contact Numbers (TCN); Private Automated Contact Tracing (PACT); Google/Apple Exposure Notification protocol (GAEN). All refer to protocols that propose a method for digital proximity/contact tracing.

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proximity detection in their national contact-tracing apps. To detect possible exposure situations, a centralized server would compare location data from all users and identify at-risk pairs. Under pressure from security experts and privacy activists alike, both Norway and U.K. eventually switched to a decentralized model based on GAEN, while Singapore, e.g., continues using its centralized "TraceTogether" app.

It did not take long for the first critical assessments of the apps utility to appear. Already in May 2020, health officials in Iceland started calling their "Rakning C-19" app—by then one of the most widely deployed national COVID apps—"not a game changer." In the United States, over 20 states do not even use a mobile app for proximity tracing, while those states that do report low uptake among citizens. In Canada, health officials reportedly have given up on contact tracing altogether and are asking people to simply reach out themselves to anybody they remember seeing prior to their infection.

## SOCIAL EMBEDDINGS

Why did those apps fail to live up to expectation? Three reasons come readily to mind. First, only countries with a mandatory app installation regime such as Singapore saw the originally purported 60% penetration rate—most countries with voluntary installations never even reached 40%. Furthermore, many people that installed the app subsequently blocked it from accessing the necessary sensors (e.g., Bluetooth), thus preventing the app from functioning properly. Installation numbers as tracked by app store providers thus are upper bounds only, with the true number of active app installs being even lower. With low penetration rates, the chances that two people meeting both have the app installed go down significantly (though in real-world populations, app activation is far from randomly distributed, i.e., if you are a COVID-19 tracking app supporter, chances are that so are people in your social circles—thus, the low penetration rate effect is somewhat mitigated).

Second, the decentralized nature of many systems made actual contact tracing hard to scale. The "SwissCovid" app, for example, initially required cantonal authorities to manually generate a unique code for each positively tested person, which they would then need to enter into their app for alerting others. When cases mounted in the second wave, this quickly became a bottleneck, resulting in app codes that were delivered days after a positive test result.

Third, as both the use of the app and the insertion of codes are voluntary, many of those that test positively decide not to enter the code into the app. In Switzerland, over 30% of all codes are not entered, while the *Washington Post* recently reported that only 3% of those testing positive in California actually updated their status in the app!

As the second wave manifested itself right after many of these apps had been released to great fanfare, it immediately seemed to demonstrate their failure to curb the spread of the virus, further lowering public support. Finally, with the widespread availability of vaccines in most countries that had deployed such apps, phone-based tracing moved from poster child to neglected sibling. Certificate checks have now largely replaced the QR-based "check-ins" previously promoted when entering a restaurant or event hall; the few public services announcements promoting the apps have long since ceased in favor of encouraging vaccination. The recent age of proximity tracing seems to already have come to an end.

## CONTEXTS OF USE

In his introductory article to the 1997 book *Reinventing Technology, Rediscovering Community: Critical Explorations of Computing as a Social Practice*, co-editor Philip Agre writes that one has to look "beyond the neat opposition between technical utopianism, with its visions of social good produced by new technologies, and technical dystopianism, with its equally simple visions of social evil produced by the same technologies." Discussions surrounding COVID-tracing apps fell squarely into these two camps: many saw in them the end of democracy, while other praised them as the viable alternative to an as-of-yet missing vaccination. As so often, the answer ended up being more complicated.

When its developer at first described the basic workings of their tracing apps, all eyes focused on preventing a dystopian tracking tool while promising a technology-supported utopia that would hold a deadly virus at bay until we would have had sufficient time to develop a cure. It seemed obvious that codes would be generated quickly, that people would enter them as soon as possible, and that those that received an alert would stay home and quarantine.

Today, it seems to surprise no one anymore that none of this can actually be assumed. Dourish and Bell's "messiness of everyday life" often puts a spoke in technology's wheel. With Omicron cases mounting again across Europe, many people now avoid official testing places in order to avoid sending both their families and their contacts into officially imposed quarantine. Thanks to existing home office rules and readily available self-tests at home, they can easily "ride-out" an infection (which tend to be milder with Omicron) without risking cutting school or day-care for their children and still allowing them the occasional dash to the supermarket.

Clearly, incentive structures, institutional support, as well as technical reliability are key factors when it comes to deploying technology in our lives. We have all been guilty of following the so-called "law of the instrument" (aka "If you have a hammer, everything looks like a nail"), and one cannot really fault us for proposing solutions involving pervasive computing. However, the recent experience with COVID-tracking apps should teach us to be mindful of what "soft" disciplines like sociology, psychology, behavioral economics, and legal science can teach us when it comes to making technology work in the real world, so we do not end up getting stuck in our local little technobubble!

## IN THIS ISSUE

The title of this special issue is "Out-of-the-lab Pervasive Computing," and Guest Editors Florian Alt, Vassilis Kostakos, and Nuria Oliver present five articles that discuss how pervasive computing experimentation can be done outside the lab—a challenge well known to researchers in the field but which is being redefined by the ongoing COVID-19 pandemic. You can find more details in their Guest Editors' Introduction later in this issue.

We also have three feature articles in this issue. In "A Compact Representation of Indoor Trajectories," Fariña *et al.* present a new approach to an old problem in pervasive computing: trajectory tracking. This well-known issue has seen renewed interest in the face of the rigorous health measures needed in hospitals and nursing homes, and the authors present a very efficient algorithm, both in terms of storage space and query processing, to record and retrieve a person's movements around a building.

In our second feature article titled "In-Ear PPG for Vital Signs," Ferlini *et al.* explore how the increasingly popular "Earables"—in-ear headphones enriched with sensors—can be used to measure vital signs more reliably.

Our last feature article, "Applying Compute-Proximal Energy Harvesting to Develop Self-Sustained Systems for Automobiles" by Park *et al.*, follow up on our theme of "Computational Materials" (see our July–September 2021 issue) and explore how smart sensors on a car can harvest their needed energy directly, without having to be wired into the car's electronic wiring. Thad Starner has written about energy-harvesting sensors in this magazine before, no less than 17 years ago! It is both inspiring to see how "pervasive" pervasive computing has become since then, yet also frightening to realize how little progress we have made in the space of energy harvesting. Hopefully, their article will inspire our community to renew their efforts in this space!

## TEAM UPDATES

In this issue, we say good-bye to three editorial board members: James Scott, Steve Hodges, and James Landay.

James Scott joined the editorial board eight years ago, and during this time contributed as both author and guest editor to the magazine. I very much appreciate his strong support for the magazine over the years!

Steve Hodges joined 11 years ago and spent no less than seven of these as an AEIC! During his tenure, Steve was a guest editor on three special issues: "Energy Harvesting and Power Management" (2016), "Smart Vehicle Spaces" (also 2016), and "Printing and Fabrication" (2014). I had the pleasure to work with Steve for over six years and have come to rely on his methodical and thorough approach to everything he did—from organizing and summarizing a manuscript review, to running a special issue. Steve surely will be hard to replace!

Finally, we need to say good-bye to James Landay, who has been with the magazine in one role or another for over 18 years! James has co-edited three special issues: "Smarter Phones" and "Cross-Reality Environments," both in 2009, and "Conversational User Interfaces and Interactions," in 2019. His great sense of hot topics has strongly shaped the magazine's special issue calendar over the years, and several of our editorial board meetings were graciously hosted by James. He will be missed!

## ABOUT THE EDITOR-IN-CHIEF

**MARC LANGHEINRICH** is currently a Professor with the Faculty of Informatics, Università della Svizzera Italiana, Lugano, Switzerland, where he heads the Research Group for Ubiquitous Computing. His main research interests include usable privacy, pervasive displays, and ubiquitous computing. Langheinrich received the Ph.D. degree in computer science from ETH Zürich, Zürich, Switzerland. Contact him at langheinrich@ieee.org.