In this column we plan to take a tour around different physical locations in the world with the objective of highlighting the peculiarities of the trendiest IoT-related applications in selected regions. Thus, the "IoT World" will certainly be physical, but traveling around it shall also expose to the readers how different application domains have been addressed, with particular attention to business sustainability.

IoT Technologies and Privacy in a Data-Bloated Society: Where Do We Stand in the Fight to Prepare for the Next Pandemic?

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In this article, we take a trip to this "new-world" we inherited almost overnight where people and businesses must cope with the presence of a pandemic like Covid-19, which has had unprecedented effects on our daily lives. We do so with a perspective on how the wide (and wise) use of available data-harvesting technologies can help in containing the spread of similar diseases.

Here we will try to address some questions: How and where can IoT technology help in the management of a spreading disease? In which contexts can the connected things that we use and interact with on our daily routines, become useful tools in limiting the spread of an infectious disease? And what are the hurdles that prevent us today from making use of such data? When we talk about IoT, for the purpose of this article, we focus on the "things" that can be associated with human beings and can potentially reveal their whereabouts and their health status.

The Technology Building Blocks

With the advent of smart devices and IoT, our physical world has gradually been extended, knowingly or unknowingly, into a "phygital" world where different players, physical and digital actors, are gathering information about our habits and whereabouts. Thinking about technologies in the context of infectious diseases, there are two main drivers for tackling their spread: location-based services (due to the need for social distancing) and quantified-self[1] applications (due to the importance of health monitoring). In particular we talk about:

1. Location tracking technologies: tracking people based on objects/devices they carry.
2. Body-profiling technologies: tracking people based on their physical appearance or their biometric footprint and on their health status.
3. Behavior-profiling technologies: tracking people based on their behaviors and habits.

Location tracking technologies became popular with RFID tags applied to logistics, but there is a lot more choice today. In fact, wireless technology advancements have enabled a progressive reduction of the range within which objects/devices must come close to one another, or to an anchor point, in order to infer physical vicinity to a location or between objects.

In the use of passive tagging, we see the wide adoption of QR codes (a printed 2D image used in our context to uniquely identify an object/device), printed tags and related scanners, contactless technologies that bind readers and tags to no more than a few centimeters. We also see beaconing solutions using technologies such as Bluetooth and Zigbee giving up to a few meters resolution, as well as Wi-Fi being able to sniff MAC addresses of enabled devices entering the coverage area within a radius of tens of meters.

Body-profiling technologies used for location tracking do not require users to carry any electronic tags or devices with them but expect that people have already been profiled based on their biological "representations" such as pictures (and subsequent processing like facial recognition), retina scans, or fingerprints. These vouch for the vicinity of the individual to the scanning device which is normally at a fixed location. The spatial resolution here varies from actual contact (fingerprint scans) to very close checks (retina scans) to up to a few-meters distance (facial-recognition apps). On the quantified-self front, there is a wealth of individual health related data collected through smart watches, bracelets, heart-rate monitors, etc., which can be used to infer whether or not a person is suffering from any Covid-19 related symptoms.

Behavior-profiling technologies are more "soft", since they do not require any specific hardware and are mostly software-oriented. They rely on the ability to profile users without them having to do anything simpler than just interacting with devices for shopping (e.g., Amazon Go stores), accessing buildings, using location for navigation purposes, etc. Here the emphasis is on the intelligence of the algorithms that can infer the location of a person from their interactions with devices "connected" to the virtual world.

It is important to notice that to track the spread of infectious diseases, all these technologies must be useful in assessing whether two individuals were in proximity for a prolonged period of time or whether both of them were in the proximity of a fixed anchor point of a known location, during the same period of time.

What are the Useful "Pandemic Management" Applications?

The technologies listed above are nowadays used in many applications. Being able to assess the location of consumers has driven the use of IoT for the development of "location-based services". Apps and data-harvesting processes related to access to buildings, shops, supermarkets, transport, etc. and the permanence of people for a given time in a spatially confined space are useful data sources. These scenarios usually take advantage of people passing through some sort of gate to enter/exit a given location or simply exploit the coverage of the wireless technology used to track people/devices (you are either IN or OUT of the area delimited by a given perimeter).

These are useful in assessing the potential spreading of the disease during the proactive monitoring phase. When a person has tested positive for a disease, the technologies can be used to make sure such "knowledge" is well visible and social distancing can be enforced.

Location-based information and health monitoring are key for pandemic management. To limit the spread of Covid-19, one has to make sure visibility to the whereabouts of confirmed or suspicious cases can be enhanced: it becomes important to know where these are/have been, when and for how long, but at the same time it is important to preserve the privacy of the involved people. Given that continuously tracking a person with

less than 1m precision is a hard task, especially when the carrying of a tracking device cannot be guaranteed or enforced, one would have to integrate and cross-reference additional information that ties, with certainty, a person to a physical place. Contactless payments are an example of these applications where exists a 1-to-1 association between a person and an object, and where the physical presence of that object to a scanning device can be used to also vouch for the presence of its owner in that environment. Extending this concept to smartphones (i.e., identifiable through their MAC addresses), vehicles (registration plate numbers), fidelity cards, "entry" tickets (transport, sport events, concerts) or to the way we access our social apps and interact with our smart homes, everyone quickly understands that our physical world has, indeed, a digital twin made of different compartments.

The Issues of Privacy, Trust, and Adoption

Certainly, there are many data harvesting technologies and applications that, if purposefully combined, could reveal much more than what we currently know about people's whereabouts and would help to contain the spread of infectious diseases. While technology problems seem to stop at data-silo barriers, the biggest obstacle still remains privacy and trust.

This brings us to another key factor in fighting pandemics with data: the user's adoption of these technologies. On this subject, we often read about the 60 to 70 percent minimum adoption threshold for making tracking technologies effective. Even lower levels of adoption/screening can yield some important results in fighting pandemics.[2] Aiming at the easy integration of data from different sources without affecting individuals' right to privacy is the way to go for our "connected future".

A representative example comes from one of the most adopted solutions to fight Covid-19 across many countries, leveraging Bluetooth technology.[3] Google and Apple have joined forces to produce software, known as the Exposure Notification System, enabling smartphones, running either iOS or Android, to natively support contact tracing without the need for additional and complicated configuration setup.[4]

Getting the technology side sorted out was not enough: to address concerns surrounding privacy, all technologies and apps harvesting devices/object locations are required to anonymize the data they collect (e.g., through disposable IDs) while yet being able to "contact trace" real people to inform them of potential health threats. This is how the freedom of the individual and their interests can reconcile with the good of the community. People's location data already collected through many apps should be duly processed and secured with a "privacy by design" mindset, to gain users' confidence in disclosing it for the purpose of fighting off the risk of new pandemics.

Conclusions

For Covid-19, a massive international effort brought center stage many "pandemic management apps", assuming ownership of a smart device, which is either an Android or an iOS device. Yet, the vast majority of people in different countries do not use such apps and it is clear that more than just "single app" solutions are needed for the purpose of meaningful contact tracing. Low adoption means that alternative solutions will have to be added to the portfolio gradually, seeking people's approval along the path and fixing any technical problems associated with information retrieval from different sources.

Covid-19 might be one of the first diseases, in many decades, to reach this substantial worldwide impact, but it certainly won't be the last. Investments are and will be needed to ensure that existing data-harvesting technologies can be leveraged and adopted, to ensure that people's interests are still preserved as much as the interests of the communities those individuals live in. The pivotal point is the right to privacy that places a huge impact on wide adoption. Access and use of personal data outside the purpose of controlling pandemics outbreaks should, therefore, be forbidden and banned also on legal terms. But we are not there yet, as there is still a lot of work that could be done and agreed to before reaching the ambitious target of fighting pandemics as a "bloated with data" society.

Biography

Raffaele Giaffreda (rgiaffreda@fbk.eu) is a chief IoT scientist at FBK, Italy. He has worked in the telecom R&D environment since the beginning of his career, focusing in the last decade on IoT and related technology transfer activities. In his role, he is now responsible for setting research and innovation directions, acquisition of funding, and the execution of a number of collaborative projects in the IoT domain. He has worked in Italy and the United Kingdom (10 years), acquiring experience in both corporate telco environments (R&D of BT and Telecom Italia) as well as in a small research organization (CREATE-NET before its merger with FBK), where the ability to acquire funding was key to ensuring continuity of operations. He is a recognized expert with a substantial record with IEEE publications and conference presentations, a patent, and various book chapters and tutorials on IoT. He is an experienced speaker and chair of IoT related events. He serves as an EU reviewer, has served on the TPCs of a number of international conferences, and he is the Editor-in-Chief of the *IEEE IoT Newsletter*.

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Footnotes

[1] https://en.wikipedia.org/wiki/Quantified_self

[2] https://www.technologyreview.com/2020/06/05/1002775/covid-apps-effective-at-less-than-60-percent-download/

[3] https://www.technologyreview.com/2020/05/07/1000961/launching-mittr-covid-tracing-tracker/

[4] https://techcrunch.com/2020/09/01/apple-launches-system-level-covid-19-exposure-notification-express-with-ios-13-7-google-to-follow-later-this-month/