

Privacy-Preserving Contagious Disease Tracking

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The recent Ebola outbreak in West Africa summed up to over 25,000 infections and over 11,000 reported deaths as of May 20, 2015 [World Health Organization 2015]. Although the outbreak could be contained and did not spread beyond the region, there were major concerns that international air travel from Guinea, Liberia and Sierra Leone could ‘export’ the virus and cause an outbreak in dense urban areas around the world. In fact, several infected persons – most of them nurses, doctors, and aid workers who had been in the outbreak region – travelled to the US and Europe and were hospitalized [New York Times, 2015].

When an Ebola case in an urban area such as New York City is confirmed, the health authorities try to reconstruct what the patient has done prior to their hospitalization – where did they go, what trains did they take, who did they meet? This information is then used to find out who may need to be tested for infection. Moreover, the public is informed so that they can get an understanding of whether they may have been in the same coffee shop or on the same subway as the patient. In the case of the one Ebola patient who arrived in New York City, his location history was reconstructed at a great level of detail, and then mapped and published [New York Times, 2014]. It was then up to the public to figure out whether they may have crossed paths with the patient, each reconstructing their own whereabouts.

From a geographic information perspective, this task can be easily automated. While the technology is in place to fully automate this process, a straightforward solution would imply constantly tracking the location of either the whole population or at least of the group that subscribes to an alert service. The approach introduced here preserves the users’ privacy by recording their location history directly on their mobile devices. Potential ‘meeting points’ with a patient are also computed directly on the device, so that an individual’s location history never leaves their mobile device. Pathogion – an acronym for *path of contagion* – is a prototype smartphone app that has been developed in parallel both for the Android and iOS operating systems. It implements constant tracking of the phone’s location and saves this location history in a database on the phone. In case a patient is hospitalized with a contagious disease, their location history is reconstructed by the health authorities as outlined above. The location history is then pushed¹ to the Pathogion app, which computes spatial-temporal intersections directly on the phone. In case the user may have been near the patient, the app provides more information about the patient’s activities at the potential meeting point (e.g., ‘patient boarded F train to Brooklyn at 42nd Street’), so that the user can make a more informed decision about their potential exposure to the disease. Moreover, the final version of the app will also provide information about early symptoms of the respective disease, as well as instructions for users who believe they may be infected. Although the NYC Ebola patient brought up the idea for the Pathogion app, it is easily applicable to other highly contagious diseases.

Several issues still remain to be addressed. These include a further optimization of the location tracking functionality in terms of battery usage, and the implementation of a better performing matching algorithm. Features that still need to be implemented include the push functionality which automatically provides the app with the location history of a patient as it becomes available. Accuracy of the locations measured is another open issue; matching of the location history to the street- and transportation network should be able to partially address this issue.

¹ Push functionality is not implemented yet; so far, the app can import patient tracks in geojson format.

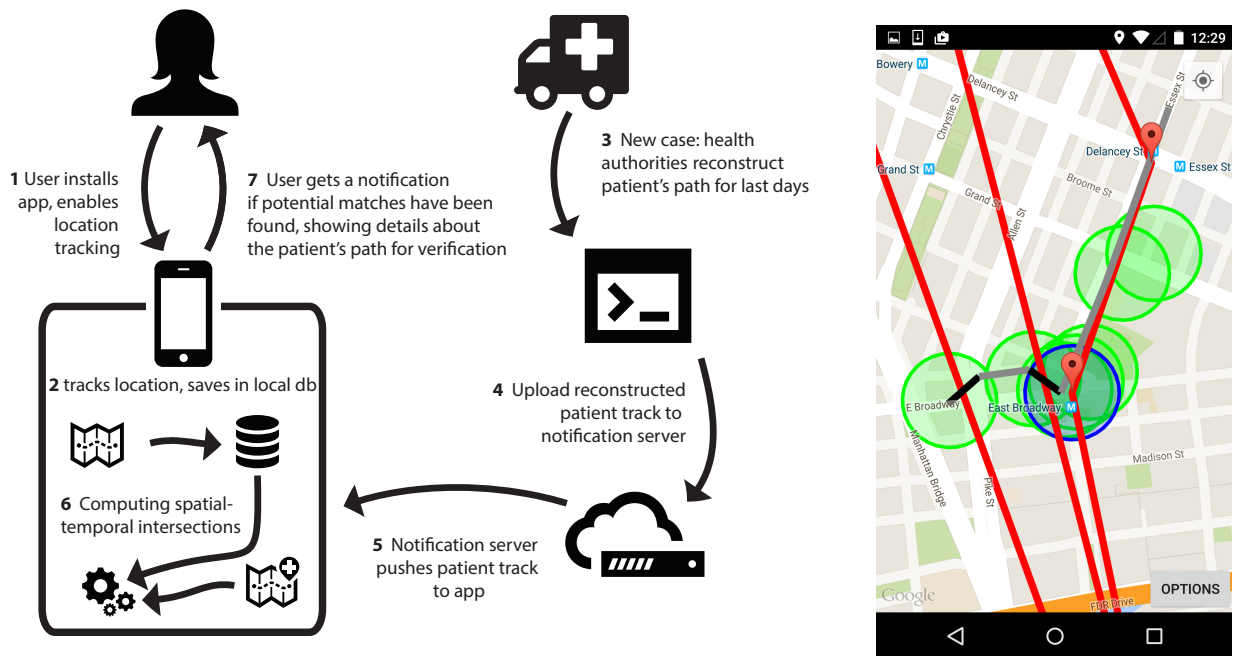


Figure 1: Workflow for the Pathogion app (left) and user interface of the Android prototype, showing the user track in grey, the patient track in red, and potential path intersections as green circles (right).

References

- World Health Organization (2015) Ebola Situation Report, 20 May 2015: http://apps.who.int/iris/bitstream/10665/171812/1/roadmapsitrepre_20May15_eng.pdf?ua=1&ua=1
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Author bios

Carsten Keßler (<http://carsten.io>) is an Assistant Professor for Geographic Information Science at the Department of Geography, Hunter College, City University of New York (CUNY). He is also associate director of the Center for Advanced Research of Spatial Information and a doctoral faculty member at the Graduate Center, CUNY. Before joining Hunter College in 2013, he was a post-doctoral researcher at Institute for Geoinformatics, University of Münster, Germany, where he coordinated the Linked Open Data University of Münster initiative (<http://lodum.de>). In 2012 and 2013, he was also a consultant for the United Nations Office for the Coordination of Humanitarian Affairs in the Humanitarian eXchange Language project. His current research focuses on analyzing and utilizing spatio-temporal information on the web of data in application areas such as environmental monitoring and disaster management. In this context, he also co-chairs the W3C Emergency Information Management Group. Carsten has also been co-chairing the Linked Science workshop series at the International Semantic Web Conference since 2011, as well as the GeoPrivacy workshop at ACM SIGSPATIAL 2014.

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