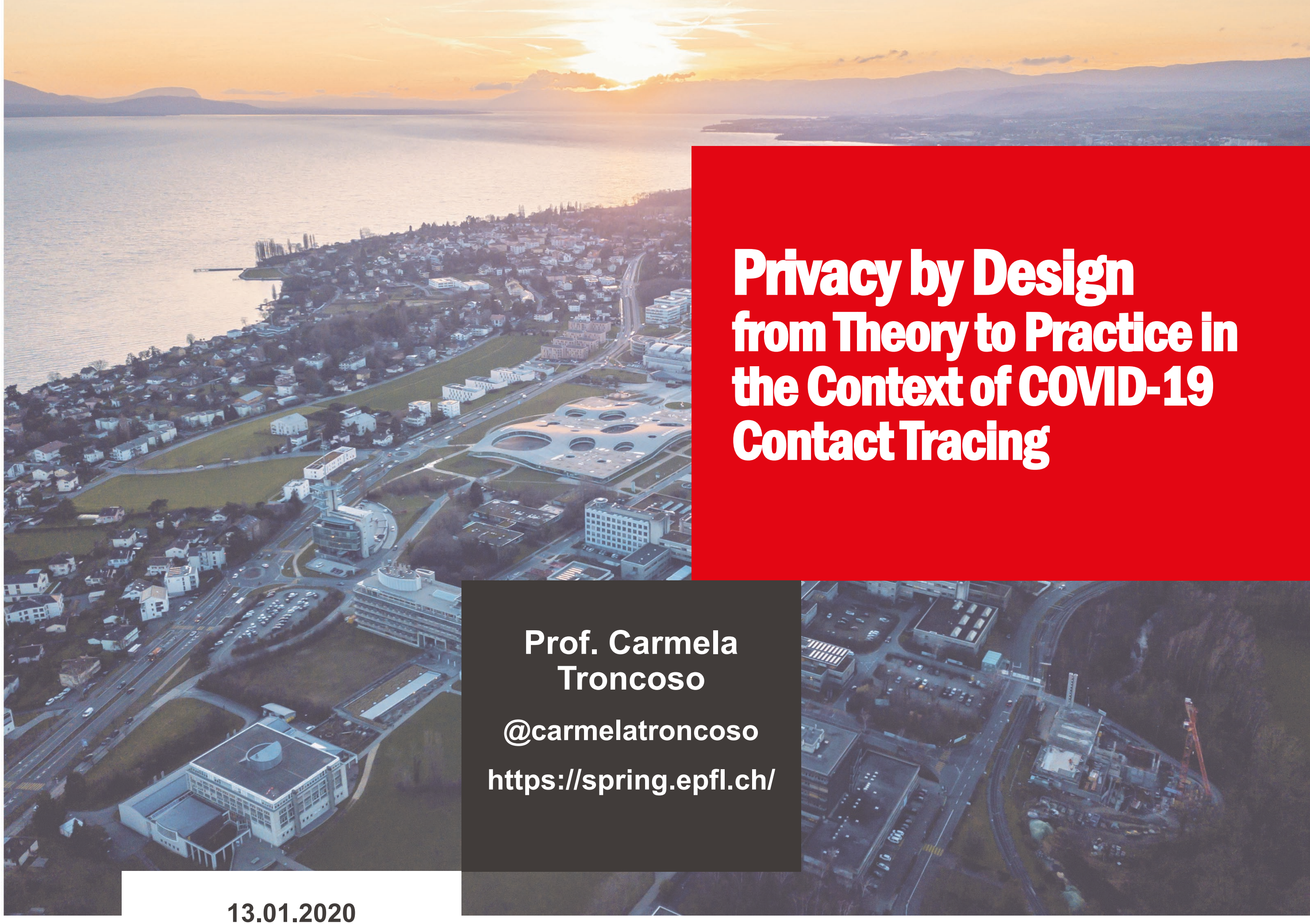
EPFL



Privacy by Design from Theory to Practice in the Context of COVID-19 Contact Tracing

Prof. Carmela Troncoso

@carmelatroncoso

https://spring.epfl.ch/

13.01.2020

École
polytechnique
fédérale
de Lausanne

Technology to help with pandemic contention

- **Manual tracing overwhelmed**

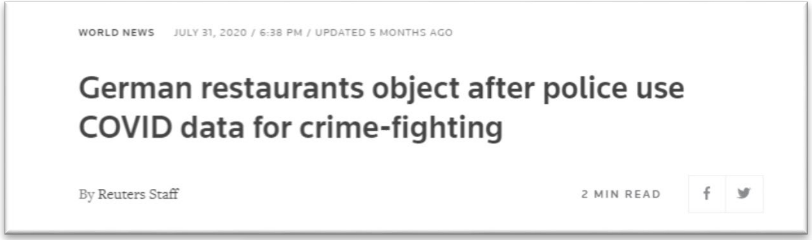
- **The need**
  - **A complement** to **notify** users that have been exposed to COVID19 and they are at risk of infection
  - In a **timely, efficient, and scalable** manner

The constraints: Security and Privacy

- Protect from misuse (surveillance, manipulation, etc)
  - **Purpose limitation by default**

Seda Gurses, Carmela Troncoso, Claudia Diaz. Engineering Privacy by Design.Computers, Privacy & Data Protection. 2011

The constraints: Security and Privacy

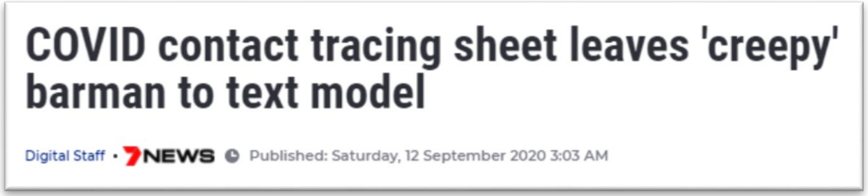


WORLD NEWS JULY 31, 2020 / 6:38 PM / UPDATED 5 MONTHS AGO

German restaurants object after police use COVID data for crime-fighting

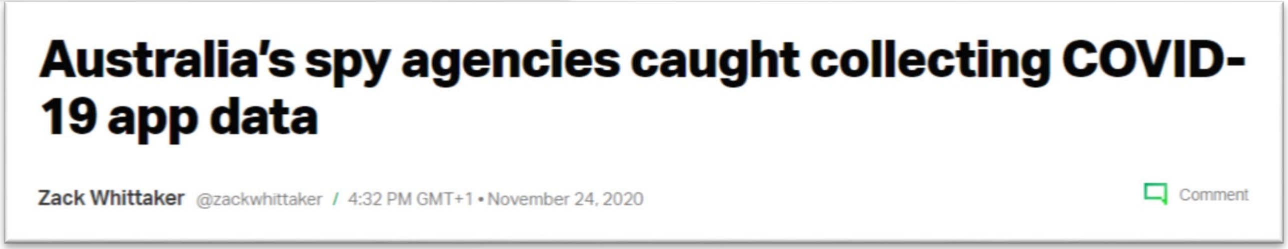
By Reuters Staff

2 MIN READ



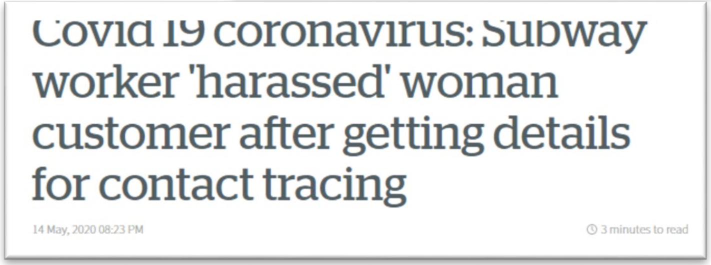
COVID contact tracing sheet leaves 'creepy' barman to text model

Digital Staff • 7NEWS Published: Saturday, 12 September 2020 3:03 AM



Australia's spy agencies caught collecting COVID-19 app data

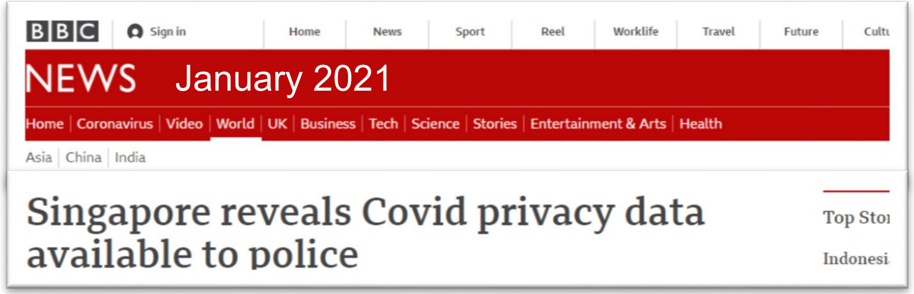
Zack Whittaker @zackwhittaker / 4:32 PM GMT+1 • November 24, 2020



Covid 19 coronavirus: Subway worker 'harassed' woman customer after getting details for contact tracing

14 May, 2020 08:23 PM

3 minutes to read



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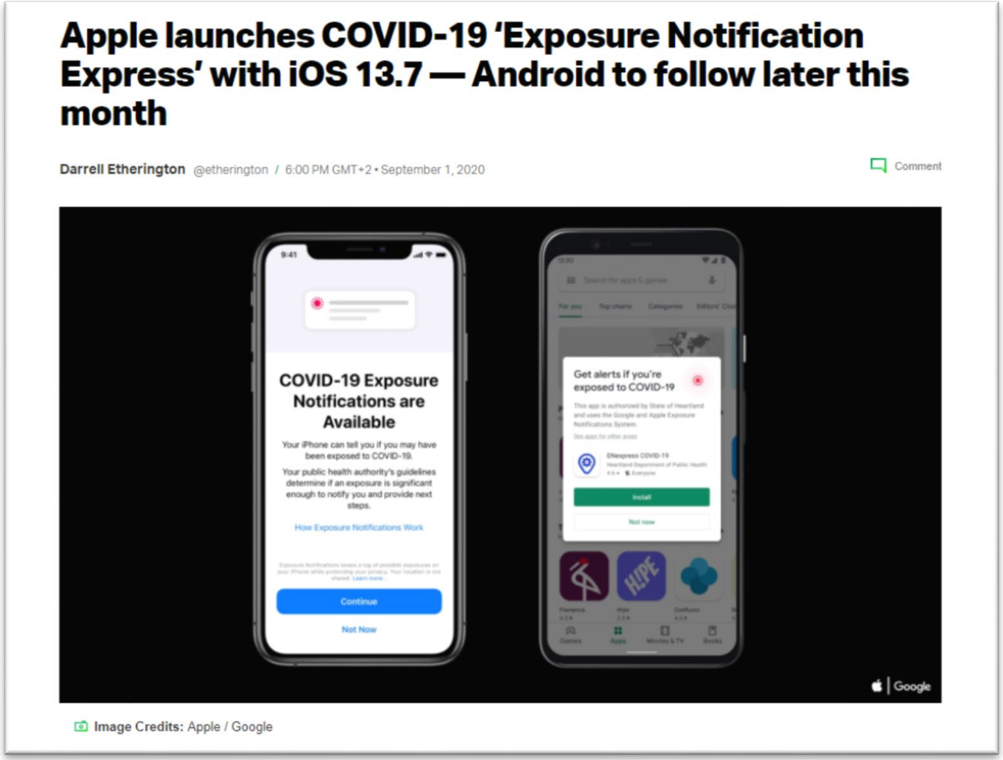
January 2021

Singapore reveals Covid privacy data available to police

The constraints: Security and Privacy



Apple launches COVID-19 'Exposure Notification Express' with iOS 13.7 — Android to follow later this month

Darrell Etherington @etherington / 6:00 PM GMT+2 • September 1, 2020

Comment

9:41
COVID-19 Exposure Notifications are Available
Your iPhone can tell you if you may have been exposed to COVID-19.
Your public health authority's guidelines determine if an exposure is significant enough to notify you and provide next steps.
How Exposure Notifications Work
Continue
Not Now
Get alerts if you're exposed to COVID-19
This app is authorized by State of Heartland and uses the Google and Apple Exposure Notifications System.
ENexpress COVID-19
Heartland Department of Public Health
Install
Not now
Google

Image Credits: Apple / Google

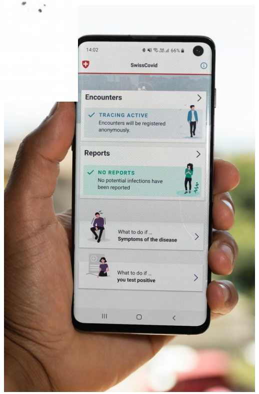
The constraints: Security and Privacy

- Protect health-related data
- Protect from misuse (surveillance, manipulation, etc)
  - **Purpose limitation by default**
  - hide users identity, location, and behavior (social graph)
- Preserve system integrity
  - Prevent false alarms & Denial of Service

Seda Gurses, Carmela Troncoso, Claudia Diaz. Engineering Privacy by Design.Computers, Privacy & Data Protection. 2011

The “hidden” constraint
Reality

- High scalability and reliability
- Design under time pressure!
  - Need fast, robust verification
    - KISS principle: Keep It Simple Stupid
    - Avoid new technologies or non-mainstream
  - Use existing infrastructure
    - BLE beacons
- Dependencies, dependencies, dependencies



14:02 66%

SwissCovid

Encounters

✓ TRACING ACTIVE
Encounters will be registered anonymously.

Reports

✓ NO REPORTS
No potential infections have been reported

What to do if ...
Symptoms of the disease

What to do if ...
you test positive

Blagovesta Kostova, Seda Gürses, Carmela Troncoso. Privacy Engineering Meets Software Engineering. On the Challenges of Engineering Privacy By Design

A collaborative (continued) ~~sprint~~ ~~Marathon~~ Ironman

Apps Maintenance and support

March 2020 – **Start DP3T**

April 2020 – **GAEN is announced**

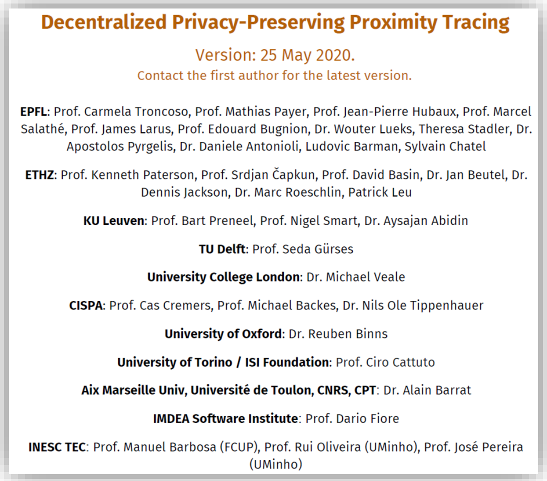
May 2020 – **Final version DP3T**

June 2020 – **Pilots EU apps**

July/August 2020 – **CT Apps launching**

August/September 2020 – **Towards EU interoperability**

Since September – **Presence tracing**
(some members) **Immunity Certificates**



Decentralized Privacy-Preserving Proximity Tracing

Version: 25 May 2020.
Contact the first author for the latest version.

EPFL: Prof. Carmela Troncoso, Prof. Mathias Payer, Prof. Jean-Pierre Hubaux, Prof. Marcel Salathé, Prof. James Larus, Prof. Edouard Bugnion, Dr. Wouter Lueks, Theresa Stadler, Dr. Apostolos Pyrgelis, Dr. Daniele Antonioli, Ludovic Barman, Sylvain Chatel

ETHZ: Prof. Kenneth Paterson, Prof. Srdjan Čapkun, Prof. David Basin, Dr. Jan Beutel, Dr. Dennis Jackson, Dr. Marc Roeschlin, Patrick Leu

KU Leuven: Prof. Bart Preneel, Prof. Nigel Smart, Dr. Aysajan Abidin

TU Delft: Prof. Seda Gürses

University College London: Dr. Michael Veale

CISPA: Prof. Cas Cremers, Prof. Michael Backes, Dr. Nils Ole Tippenhauer

University of Oxford: Dr. Reuben Binns

University of Torino / ISI Foundation: Prof. Ciro Cattuto

Aix Marseille Univ, Université de Toulon, CNRS, CPT: Dr. Alain Barrat

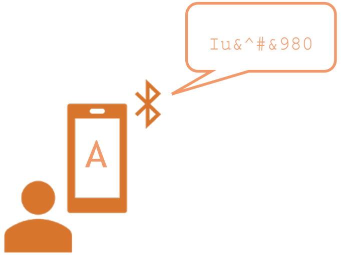
IMDEA Software Institute: Prof. Dario Fiore

INESC TEC: Prof. Manuel Barbosa (FCUP), Prof. Rui Oliveira (UMinho), Prof. José Pereira (UMinho)

Key ideas:

- BLE beacons broadcast/ recorded by devices
- Cryptography for unlinkability
- Decentralization of matching operations for privacy and purpose limitation

The system design
The theory…



- The App creates a **secret k y (SK**) and from this key it derives **om identifiers (EphID** roadcasts via Bluetooth
- Secret keys a ry day SK_{t+1}=H(SK
- $EphID_1$ || … || SK_t,“broadcast key”))
- A random for a limited amount o
- Without the key, no-one can link two identifiers

https://github.com/DP-3T/documents/blob/master/DP3T%20White%20Paper.pdf

Reality
Use existing infrastructure

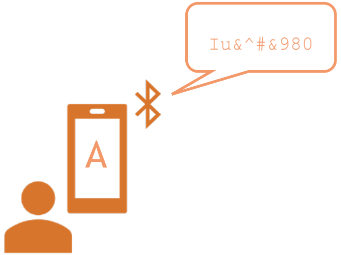
- Battery and CPU usage
  - Limited round trips
  - Google and Apple **must** be involved
- Run in the background
  - Apple **must** be involved
- Compatibility Android - iOS
  - Google and Apple **must** be involved

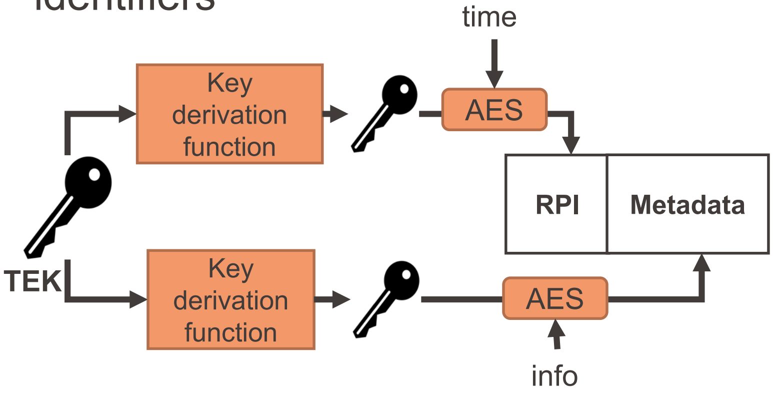
- Google and Apple implement the protocol **and the API**
  - Implications on privacy engineering
  - Implications for epidemiology and exposure estimation (no time in this talk…)
  - Implications for privacy when internationalizing (no time in this talk…)

Blagovesta Kostova, Seda Gürses, Carmela Troncoso. Privacy Engineering Meets Software Engineering. On the Challenges of Engineering Privacy By Design

The system design
The practice
Google and Apple decide

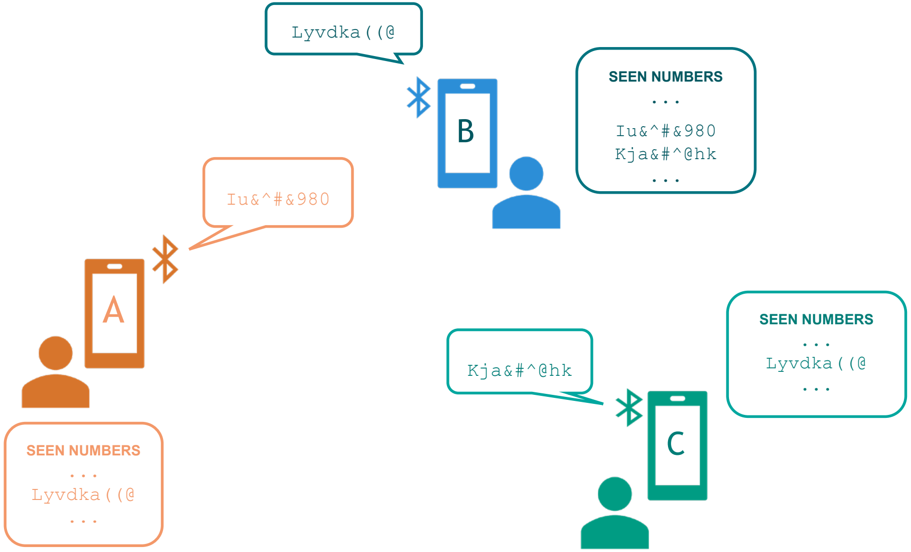
- The App creates a **secret every day** (**TEK**) and from this key it derives **random identifiers (RPIs)** that it broadcasts via Bluetooth
- A random identifier is used for a limited amount of time
- Without the key, no-one can link two identifiers



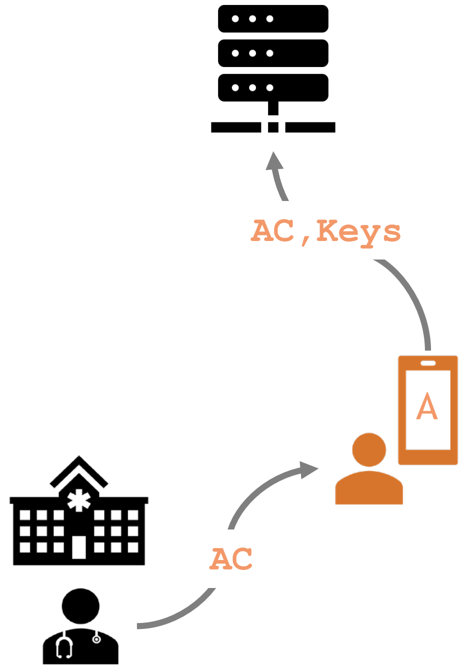


https://blog.google/documents/69/Exposure_Notification_-_Cryptography_Specification_v1.2.1.pdf

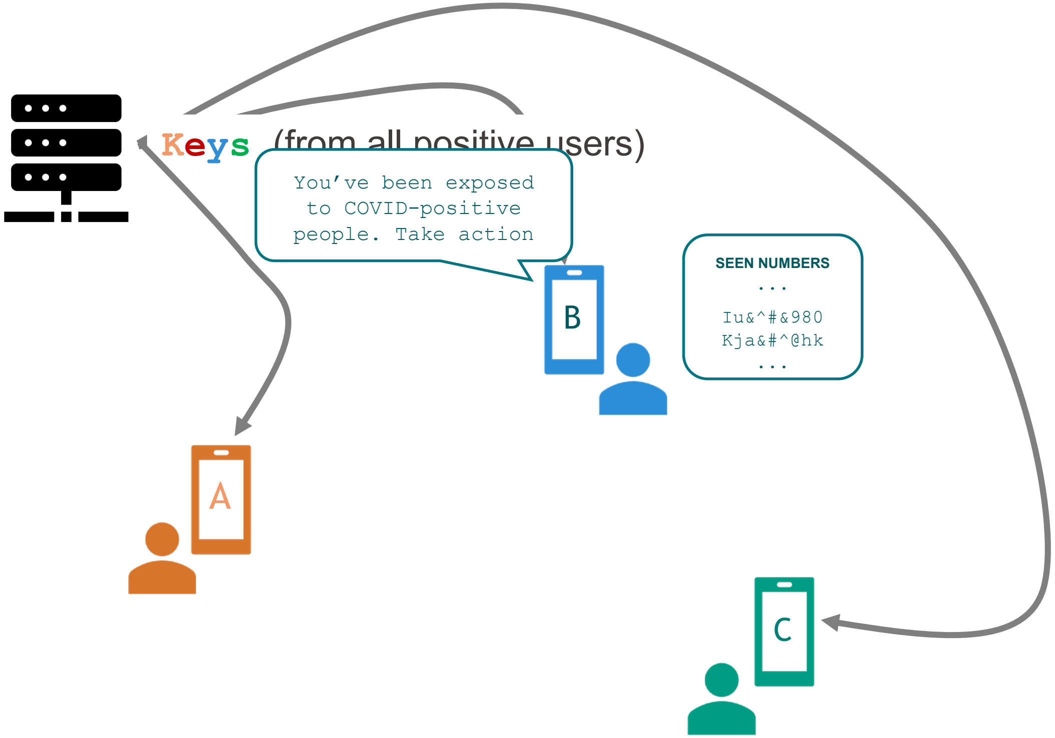
The system design



The system design



The system design



Keys (from all positive users)

You've been exposed to COVID-positive people. Take action

SEEN NUMBERS

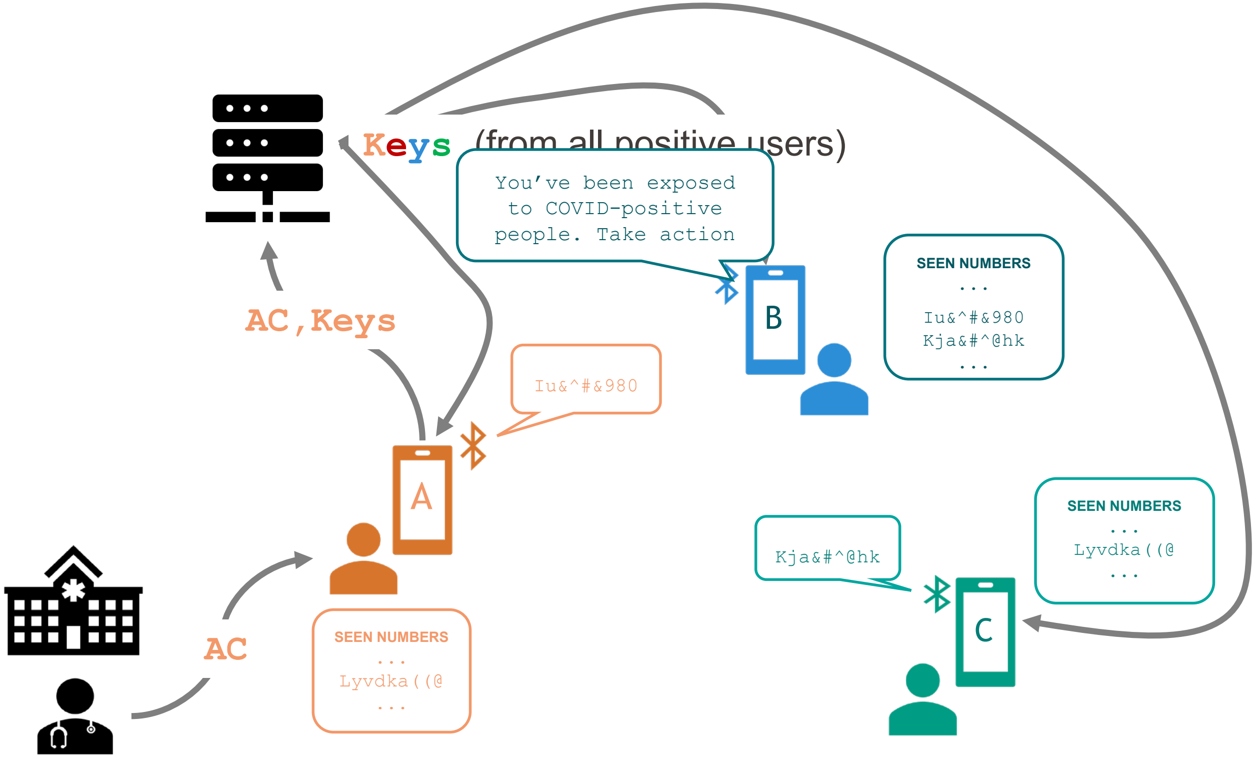
...

Iu&^#&980

Kja&#^@hk

...

The system design



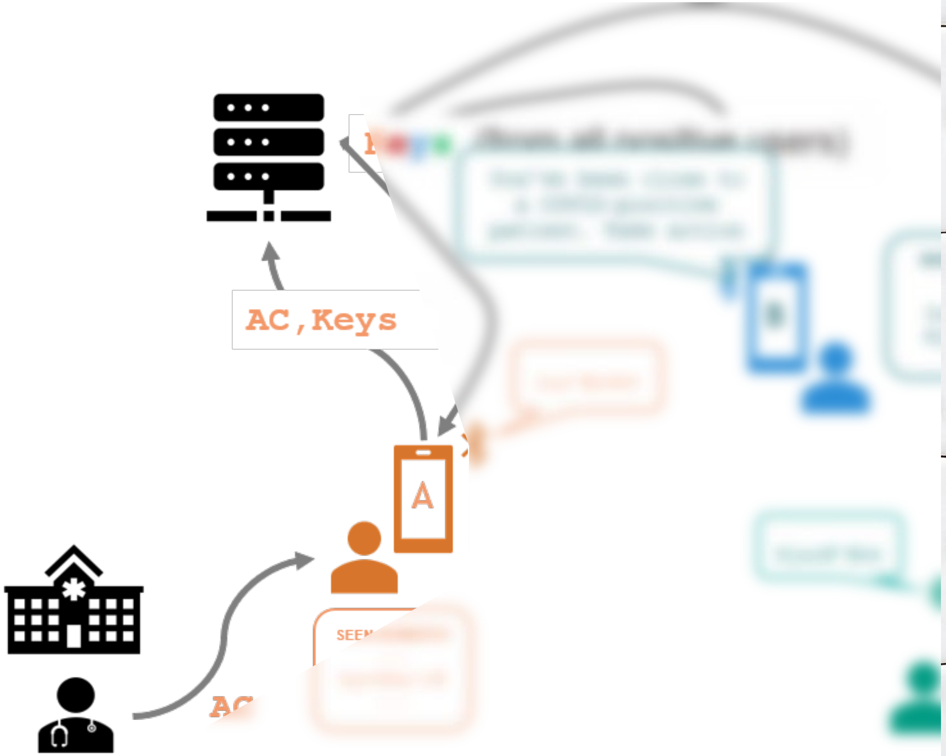
Only information that ever leaves the phone are the **TEKs broadcasted** during the contagious period.

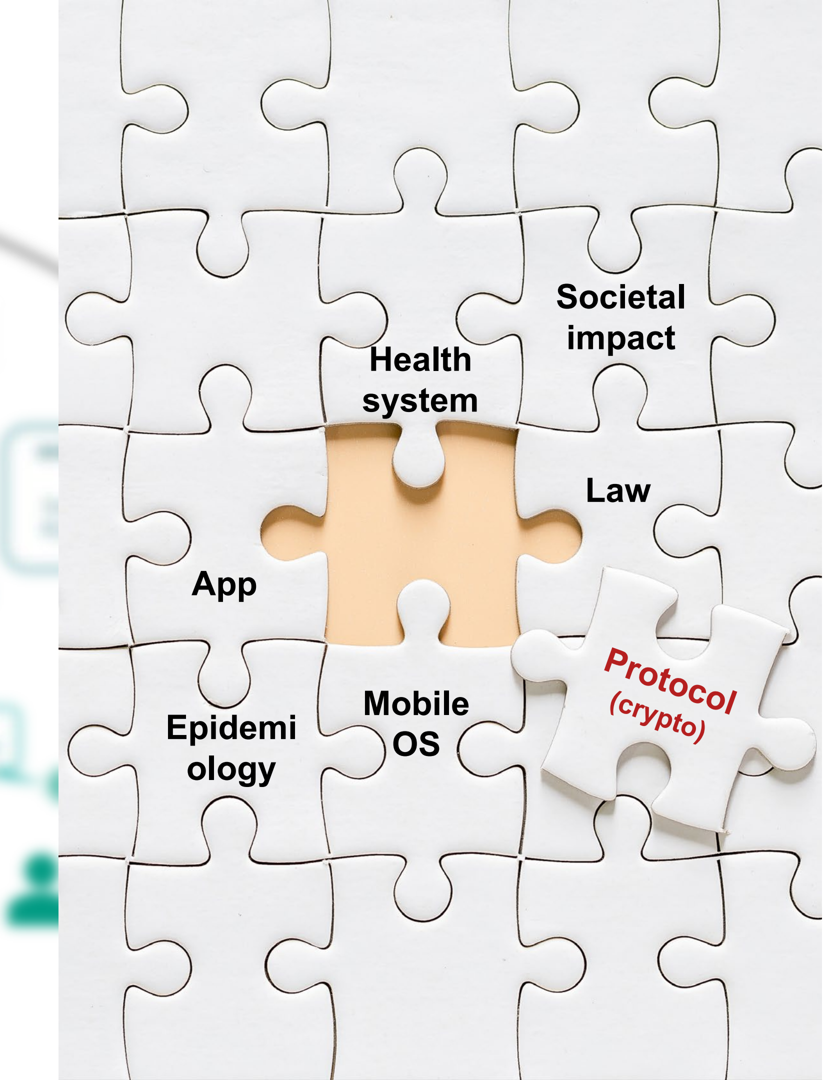
No identity, **no** location, **no** information about others

No information available for abuse

System **sunsets-by-design**

The system design

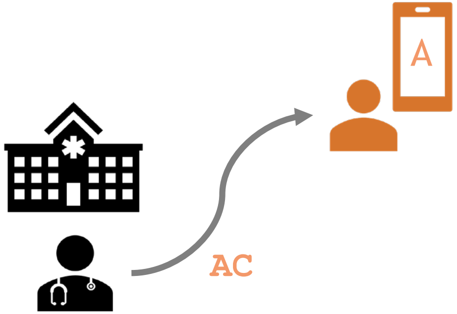




Authorization mechanism
Theory

- Crucial for security: only *true* positives can upload
  - Desired properties:
    - Privacy
    - Hard to delegate

  - Crypto FTW! commit to content in authorization token!



Secure Upload Authorisation for Digital proximity tracing. DP-3T project. https://github.com/DP-3T/documents/blob/master/DP3T%20-%20Upload%20Authorisation%20Analysis%20and%20Guidelines.pdf

Authorization mechanism
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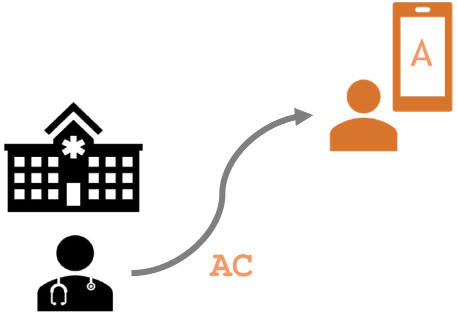
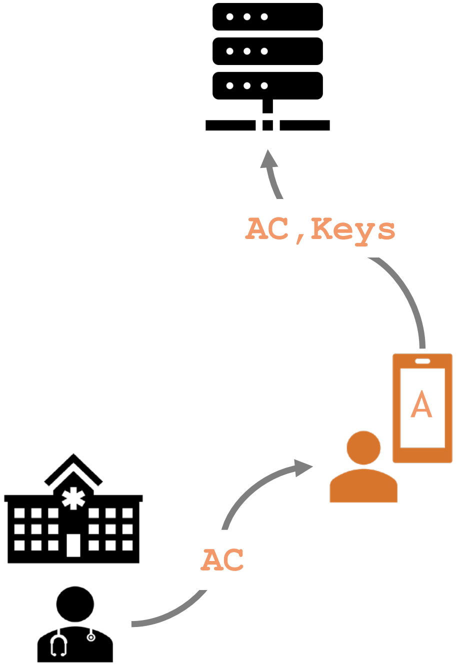


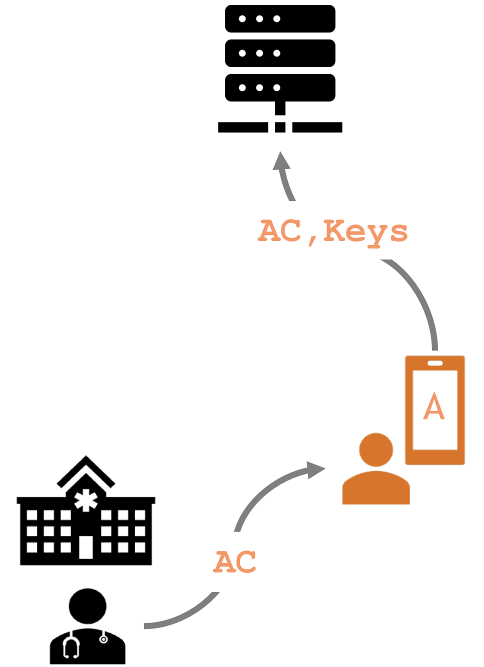
- Health systems/staff are not digitalized everywhere
  - Simple activation codes sent via phone/mail/sms
  - Different level of automatization
  - Belgium went for (light) commitments!

Secure Upload Authorisation for Digital proximity tracing. DP-3T project. https://github.com/DP-3T/documents/blob/master/DP3T%20-%20Upload%20Authorisation%20Analysis%20and%20Guidelines.pdf

Privacy engineering
Are we done?



Privacy of uploads Theory

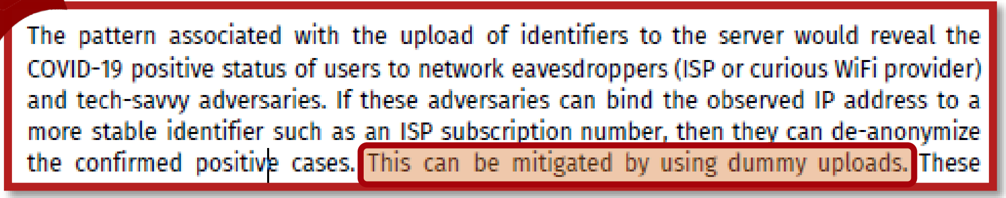


Existence of upload

⇓

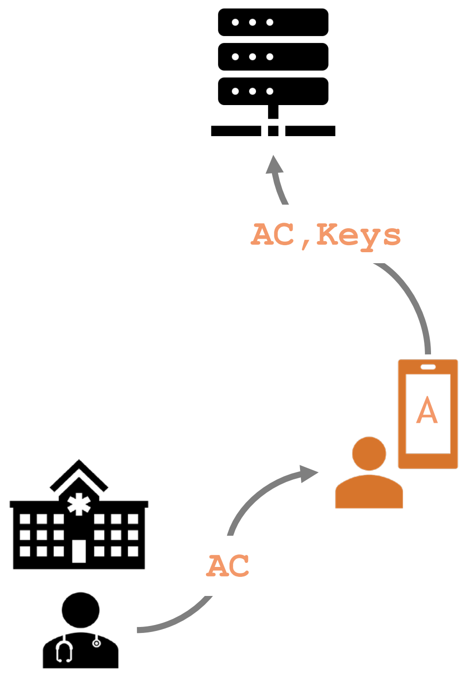
the user is COVID+

DP3T design paper


The pattern associated with the upload of identifiers to the server would reveal the COVID-19 positive status of users to network eavesdroppers (ISP or curious WiFi provider) and tech-savvy adversaries. If these adversaries can bind the observed IP address to a more stable identifier such as an ISP subscription number, then they can de-anonymize the confirmed positive cases. This can be mitigated by using dummy uploads. These

https://github.com/DP-3T/documents/blob/master/DP3T%20White%20Paper.pdf

Privacy of uploads Practice



- Unknown environment
  - What is users' behavior?

- Constraints associated to the platform
  - Bandwidth
  - Server capacity
  - Battery

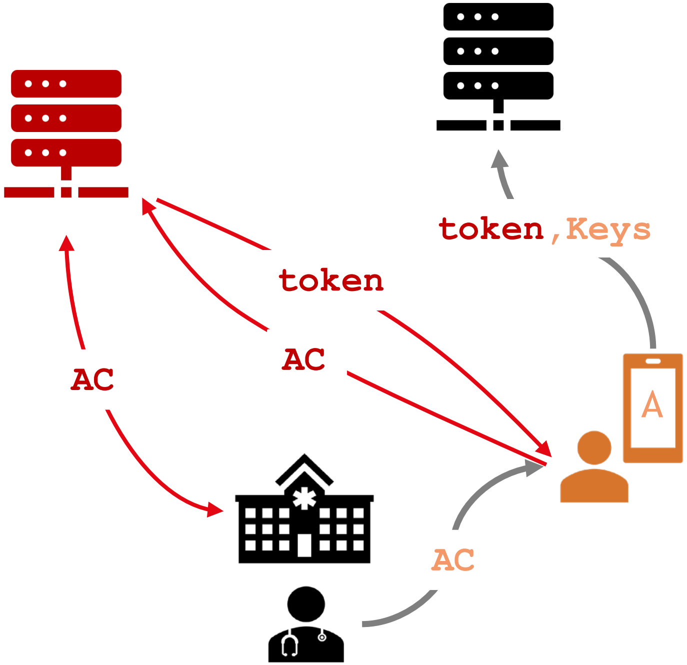
- Anonymity and delays not possible

⇩

Plausible deniability
(constant time & size)

https://github.com/DP-3T/documents/blob/master/DP3T%20-%20Best%20Practices%20for%20Operation%20Security%20in%20Proximity%20Tracing.pdf

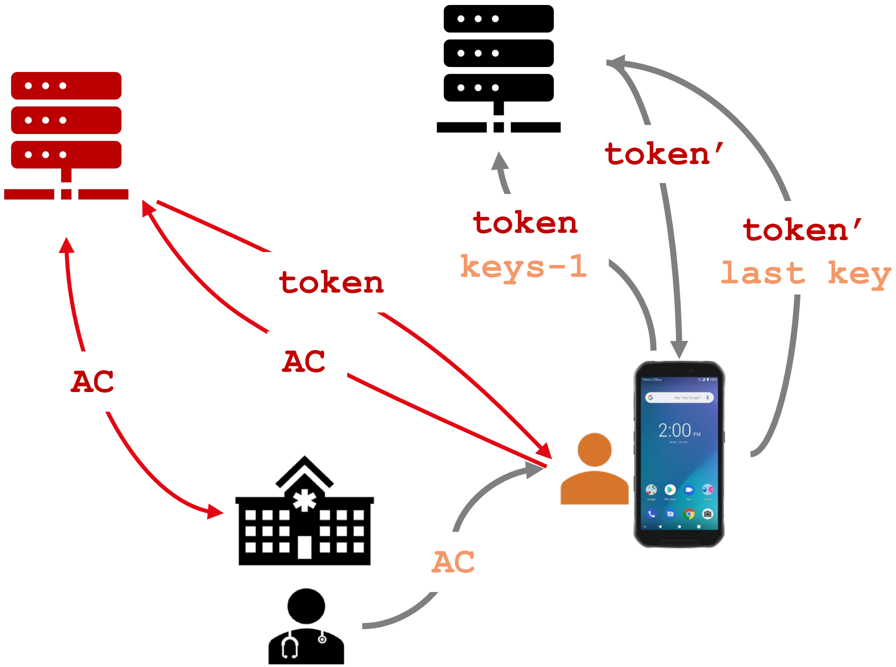
Privacy of uploads
Practice – there is authentication!



- Dummies also must realize the authentication step
  - Servers must consider dummies
  - Ensure equal timing and volume

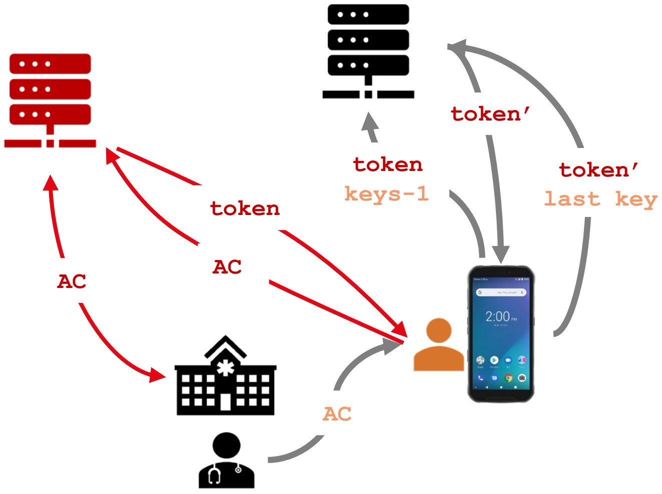
- https://github.com/DP-3T/documents/blob/master/DP3T%20White%20Paper.pdf

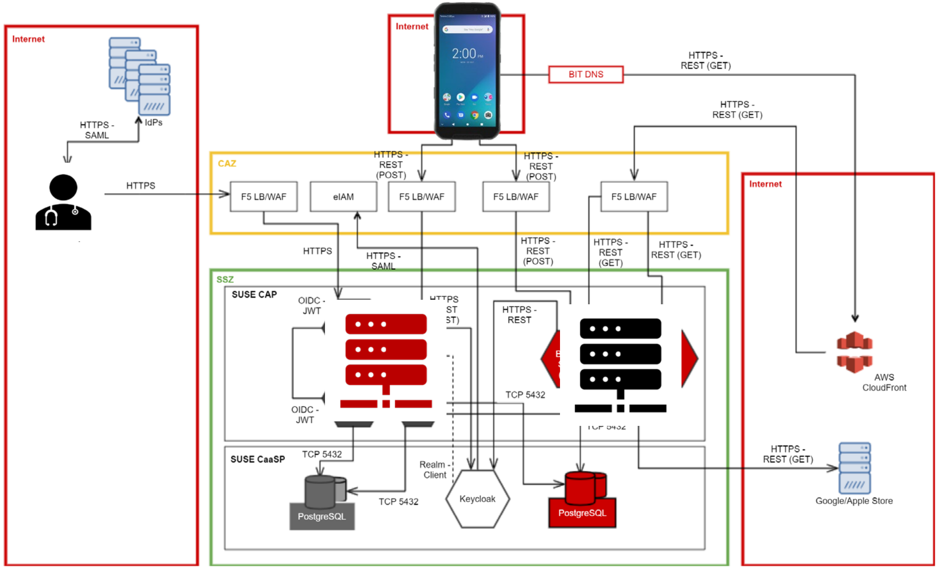
Privacy of uploads Practice –



- Exposure Notification API (<v1.5) had one security mechanism:
  - Only reveal key after it expires
  - (Not needed, it is an implementation decision)
- Implications on authorization and dummy strategy
  - Cannot delay all keys!
  - Dummies must mimic second upload
- Phone does not always wake up…

Privacy of uploads
Practice – servers don’t exist in the vacuum





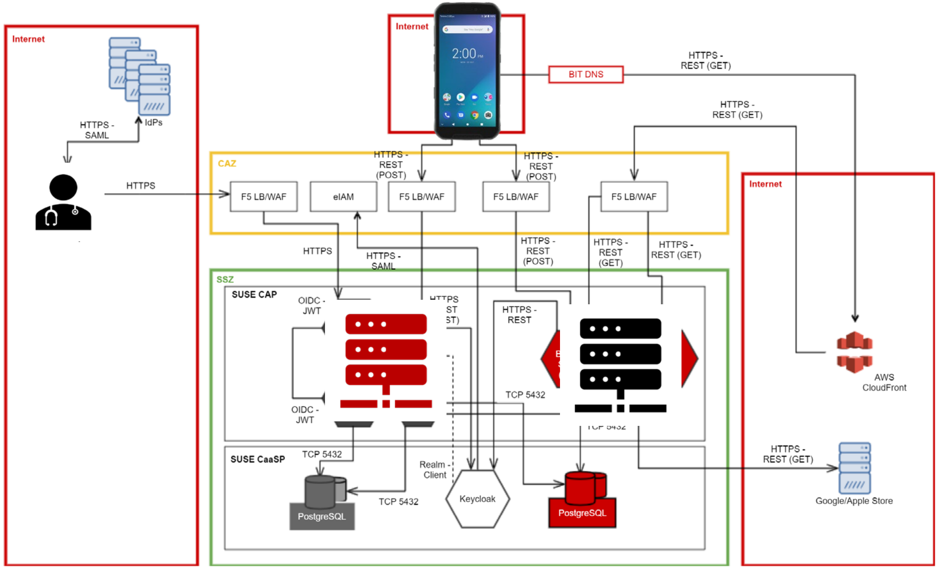
- https://github.com/DP-3T/documents/blob/master/DP3T%20-%20Best%20Practices%20for%20Operation%20Security%20in%20Proximity%20Tracing.pdf

Privacy of uploads
Practice – servers don't exist in the vacuum

- Load Balancer, Firewall
  - More information than expected!
  - Off the shelf cloud managing tools

- Careful design of logging to avoid forensics
  - Coarse logging at key server
  - Only counts logged for statistics
    - e.g, active users based on dummy traffic

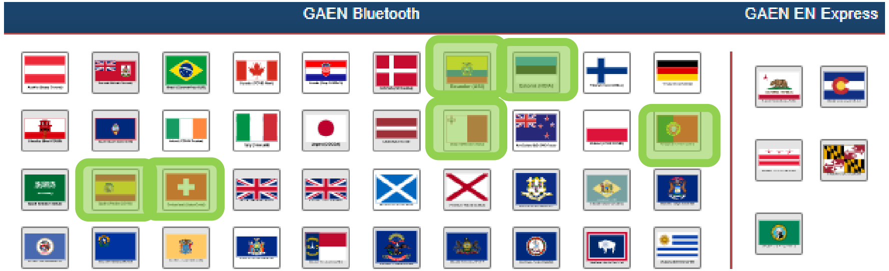
- Logging strategy re-designed N times

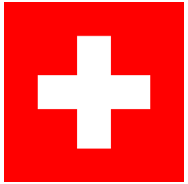


https://github.com/DP-3T/documents/blob/master/DP3T%20-%20Best%20Practices%20for%20Operation%20Security%20in%20Proximity%20Tracing.pdf

Carmela Troncoso

Where is this deployed?





1.87 Million active users (~22% population)

~18000 COVID-positive users uploaded their keys in December (15% of PCR in Switzerland)

Field experiment in Zurich October 2020

- 80% COVID-positive app users upload their codes
- 22% sent quarantine
- 1 in 10 tested positive after notification
- 5% of positives with respect to Manual Contact Tracing in Zurich
- Speed: ~1 day faster notification for non-household exosures (70% of the cases)

https://www.experimental.bfs.admin.ch/expstat/en/home/innovative-methods/swisscovid-app-monitoring.html
https://github.com/digitalepidemiologylab/swisscovid_efficacy/blob/master/SwissCovid_efficacy_MS.pdf
https://www.ebpi.uzh.ch/dam/jcr:5fc56fb7-3e7e-40bf-8df4-1852a067a625/Estimation%20of%20SwissCovid%20effectiveness%20for%20the%20Canton%20of%20Zurich%20in%20September%202020_V1.5.pdf
https://www.medrxiv.org/content/10.1101/2020.12.21.20248619v1.full.pdf

Key lessons

- Data is not a must!
- Privacy engineering goes well beyond crypto
- Privacy engineering in an agile/service world is exhausting
  - Platforms and requirements continuously change
- Good socio-technical integration is key to success and it is **hard**
  - Purpose limitation and abuse prevention is a must

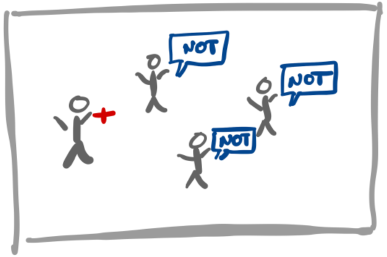
Where to go from here
Digital contact tracing solved?

- Google/Apple dependency (and also Amazon!)
  - Can it be eliminated?
  - Device-based contact tracing is a possibility? (free from Bluetooth?!)

- At least reduce trust?
  - Can we verify the randomness of the keys?
  - Can we verify their libraries without seeing them?

- Can we eliminate beacon-authentication related attacks?
  - Without Google and Apple's collaboration?

The pandemic is still here
More technologies to the rescue 🚨🚨🚨



Goal: **notify** everybody that shared an indoor space with a SARS-CoV-2-positive person

Locations

- + Restaurant
- + Bar
- + Church
- + Lecture room

Events

- + Party
- + AA meeting
- + Reading group
- + Lecture

SAFE FOOD PRO

Food Safety & Contact Tracing

Welcome to
Sophie's Cafe | Main Entrance

8TMDMR

Please register your visit by scanning the QR Code with your car
or entering the code 8TMDMR at https://track.safefoodpro.co.nz

Don't enter this building if you are unwell or have any of these symptoms:
- fever
- cough
- shortness of breath
- sneezing or a runny nose

Contact Tracing

Physical Distancing

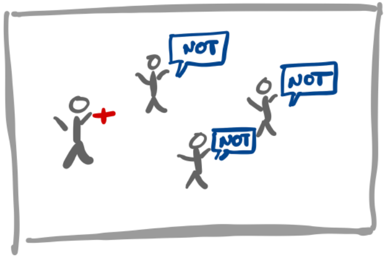
track.safefoodpro.co.nz | www.covid19.govt.nz

Unite against COVID-19

Implementations appearing

- Databases of positive **and negative** people
- Unique identifiers (phone / name / address)
- Register of (any) events

The pandemic is still here
More technologies to the rescue



Goal: **notify** everybody that shared an indoor space with a SARS-CoV-2-positive person

Locations

- Restaurant
- Bar
- Church
- Lecture room

Events

- Party
- AA meeting
- Reading group
- Lecture

https://notify-me.ch/en
(link to white paper at the bottom)
(new pairing-based version soon!)

Our proposal

- Privacy for users (from locations, databases)
- Privacy for SARS-CoV-2-positive location
- Abuse prevention by design

The pandemic is still here
More technologies to the rescue 🚨🚨🚨

Implementations ???

- Danger of…
  - central database
  - global tracking of users
  - discrimination
  - function creep

The pandemic is still here
More technologies to the rescue 🚨🚨🚨

Cannot limit the purpose by design

(nor the longstanding impact)

EPFL

Post-doctoral position
SPRING Lab

SPRING
SECURITY AND PRIVACY ENGINEERING LABORATORY

Do you want to use your crypto skills to deploy socially-responsible technologies?

Come help us in our privacy-engineering efforts. Example partners:

COMITE INTERNATIONAL GENEVE

ICIJ The International Consortium of Investigative Journalists

Position for 1 year (extendable)

More info: https://spring.epfl.ch/

Our projects: https://github.com/spring-epfl

Applying: email carmela.troncoso@epfl.ch