Crypto-Covid: Privacy challenges in BlockChain and Contact Tracing

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Initial methods for privacy preservation[1]

1. k-anonimity
2. l-diversity
3. t-closeness

[1] S. Ghilezan, S. Kašterović, T. Stefanović: A report describing models for privacy management, AI4TrustBC WP1 deliverable D1.5

k-anonimity

- An individual cannot be distinguished from at least k-1 other individuals whose information also appear in the record.

Advantages: prevents linking the released data to other information sources (background information).

Shortcomings: vulnerability to Homogeneity Attack and Background Knowledge Attack.

l-diversity

- Promotes intra-group heterogeneity of sensitive attributes by at least l different values.

Advantages: control the level of protection by modifying parameter l.

Shortcomings: Data utility loss, vulnerability to Skewness attack and Similarity attack.

t-closeness

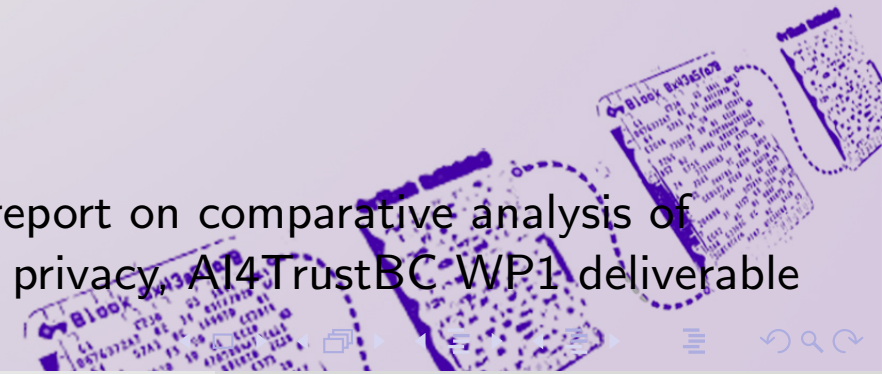
- The distance between the distribution of a sensitive attribute in a class and the distribution of the attribute in the whole table is no more than a threshold t.

Advantages: it ensures attribute disclosure.

Shortcomings: it does not deal with identity disclosure and problem to find better distance measure between distributions.

Advanced lines of privacy research [2]

1. Differential Privacy
2. Contextual Integrity
3. Inverse Privacy

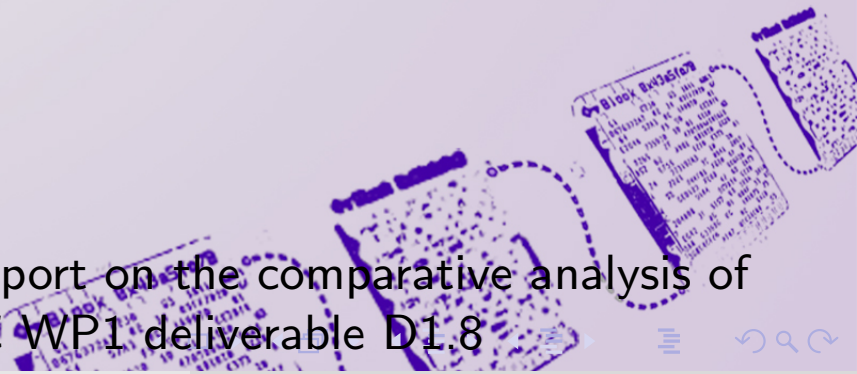


[2] S. Ghilezan, S. Kašterović, T. Stefanović: A report on comparative analysis of differential privacy, contextual privacy and inverse privacy, AI4TrustBC WP1 deliverable D1.6

Differential Privacy

- Incorporates random noise so that everything an adversary receives is noisy and imprecise.

- Tools[3]:
  - Static: Fuzz, DFuzz, Fuzzi, LightDP, Duet, HOARe2.
  - Dynamic: PINQ, SmartNoise, Diffprivlib, ϵktelo, DDuo.



[3] S. Ghilezan, S. Kašterović, T. Stefanović: A report on the comparative analysis of existing tools for privacy management, AI4TrustBC WP1 deliverable D1.8

Contextual Integrity

- Considers privacy from the perspective of information flow.
- Captures the idea that people act as individuals in certain roles in distinctive social context.

Inverse Privacy

- Inversely private data is the data that some party has access to but the individual itself does not.

Privacy and BlockChain[4]

Privacy Protection of BlockChain (*ongoing research*)

- Identity privacy
  - mechanisms: mixing services, ring signature, and zero-knowledge proof.
- Transaction privacy
  - mechanisms: non-interactive zero-knowledge proof and homomorphic encryption.

Privacy-preserving Approaches Based on BlockChain (*ongoing survey*)

[4] S. Ghilezan, S. Kašterović, T. Stefanović: An environment for privacy management based on trustworthy BC technology, AI4TrustBC WP1 deliverable D1.7

BubbleAntiCovid19 - *BAC19*[5]

Covid Pandemics

Goal: Slow down the spreading of SARS-CoV-2 virus.

Means: **Contact tracing**.

- Manual contact tracing does not give satisfactory results.
- Countries are developing DCT Apps - digital contact tracing applications.

[5] S. Ghilezan, Luigi Liquori, Bojan Marinković, S. Kašterović, Zoran Ognjanović, T. Stefanović Federating Digital Contact Tracing using Structured Overlay Networks, submitted

DCT Apps

They work on the principle of **automatic data exchange** with nearby devices.

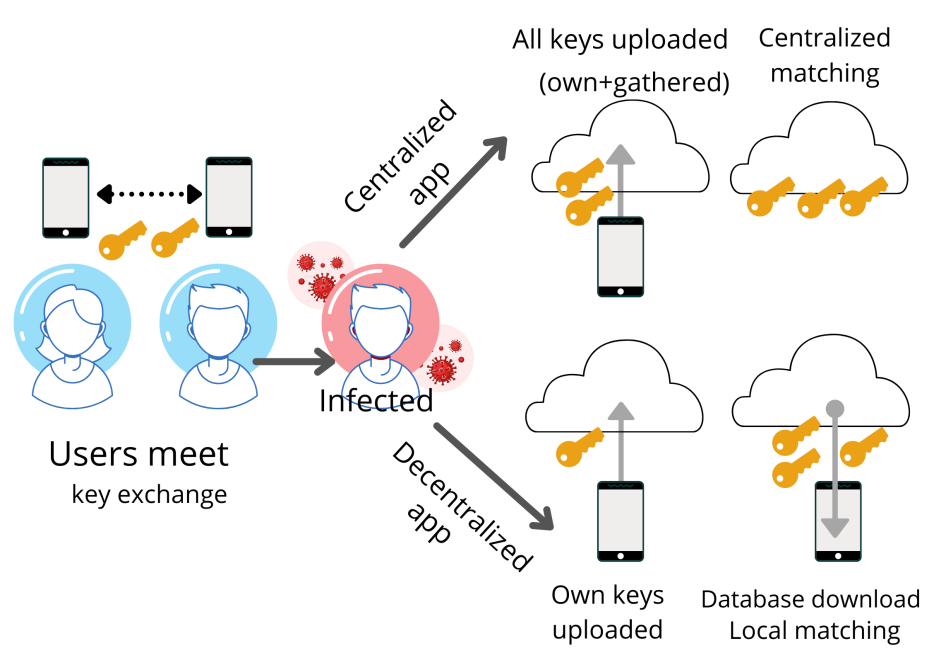


Figure: Digital Contact Tracing

DCT Apps Classification

- **System Architecture:** Centralized, Hybrid, Decentralized.
- **Contact Tracing Technology:** GPS, BlueTooth.

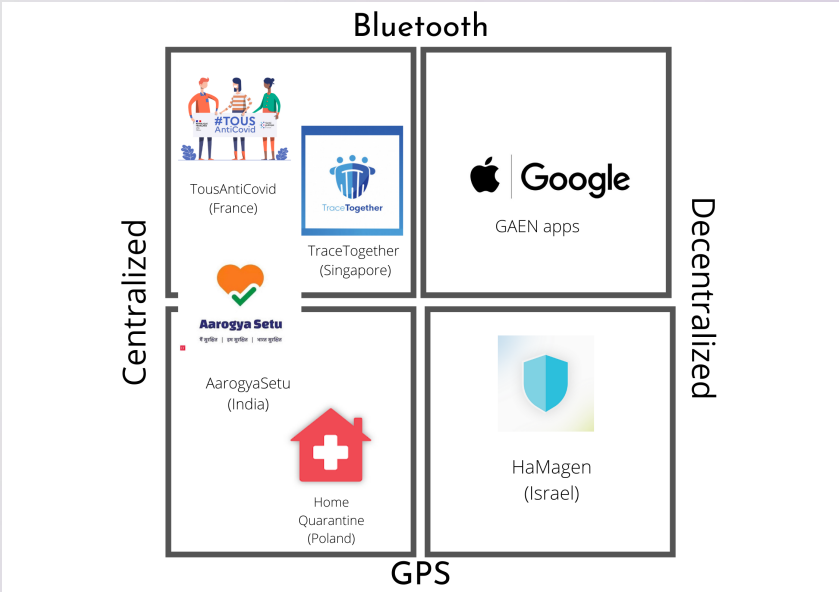


Figure: DCT Apps Classification

Problem with DCT Apps

Example: Alice is using centralized DCT System A, while Bob is using centralized DCT System B. Both of them are traveling together side by side with negative RT-PCR tests. However, Bob developed symptoms of Covid-19 after couple of days and was confirmed as positive.

NO INTEROPERABILITY!

Solution: BubbleAntiCovid19 - *BAC19*

The model is based on the well-known model of Structured Overlay Network protocols like **Chord** and **Synapse**.

The basic idea: all contacts of one person should be stored in one overlay network and the contact between persons could be seen as "the synapse nodes".

BubbleAntiCovid19 Architecture

BAC19 consits of:

- **Gateways** for communication with original systems;
- **Networks for each person/device** of his/her first contacts (black circles);
- **Red network** for connecting all infected persons (red circle);
- **Amber network** for connecting all the first contacts of infected persons (orange circle).

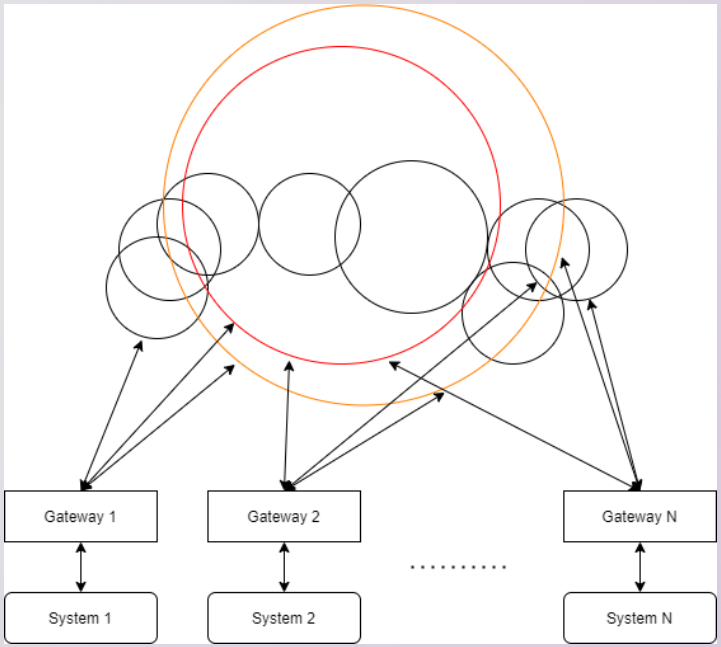


Figure: *BAC19* Architecture

Changes in the Search Procedure

```
FindSuccesor=
For Given key
  if member_of(key, id(Me), successor(id(Me))) then
    Respond With successor(id(Me))
  else
    Forward Query To Closes Predecessor From finger(id(Me))
  endif
```

Figure: Original Search Procedure in Chord

```
FindSuccessor =
For Given key
//successor(id(Me)) is responsible for key
if member_of(key, id(Me), successor(id(Me))) then
  Respond With successor(id(Me))
else
  //Me forwards query to its successor
  Forward Query To successor(id(Me))
end
```

Figure: Search Procedure in *BAC19*

BubbleAntiCovid19 Advantages

- Interoperability - “Alice and Bob problem” solved.
- Does not store any personal information.
- Supports manual entry of contacts.
- No new highly complicated calculations.
- Simulation in Python.

References

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Federating Digital Contact Tracing using Structured Overlay Networks
(submitted).

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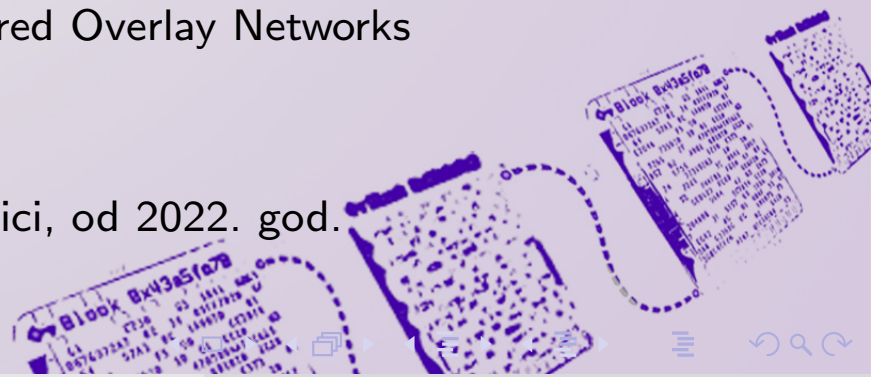
Fakultet tehničkih nauka.



Ongoing

- Privacy protection of BlockChain - differential privacy, directed graphs, trees, ethereum (*ongoing research*)
- Privacy-preserving approaches based on BlockChain - in medical data, smart vehicles (*ongoing overview*)


“Data is the pollution problem of the information age, and protecting privacy is the environmental challenge.”
Bruce Schneier