X-Road Pseudonymization Service

How (not) to design a security architecture

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Cybernetica

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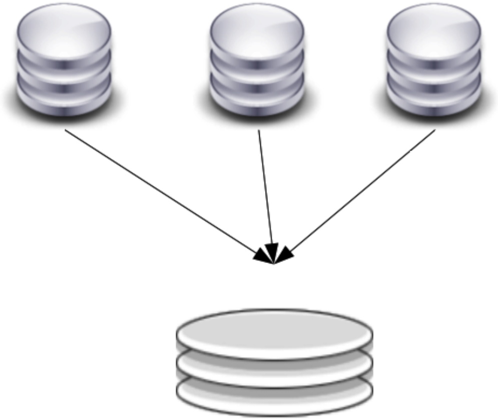
Theory Days

Why Pseudonymization?



Why Pseudonymization?

- There are datasets containing sensitive, personally identifiable information
  - Medical, financial, social
- There is a need to perform statistical surveys and produce aggregated results based on several of those datasets
- The statistician is not granted to see the personal details, but standard IDs are needed for linking
- Sometimes, fully cryptographic methods (secure MPC, homomorphic encryption) are not applicable
  - Performance issues
  - High implementation costs
  - No need for strong security guarantees
  - Political fear of everything unknown
- So we will replace the IDs with *pseudonyms*

What are the Security Requirements?

- Who should be able the access the IDs?
  - Data donor. TTP?
- Who should be able to access the data fields?
  - Data donor. Researcher. A person him/herself? A relative? TTP?
- Is reidentification using the data fields a threat?
  - The Netflix/IMDB case
  - Usually this threat is ignored even though it renders most of the heavy-weight pseudonymization techniques void
- What are the "bad" guys/coalitions and what can they do?
  - Data donors? Researchers? Sysadmins? Users? TTP?
- Who and how should be able to grant linking?
  - Researcher? TTP?

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Conclusion:

There is no universal definition of security for pseudonymization

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Give us all the data so that we could link anything as we please to do a lot of research.

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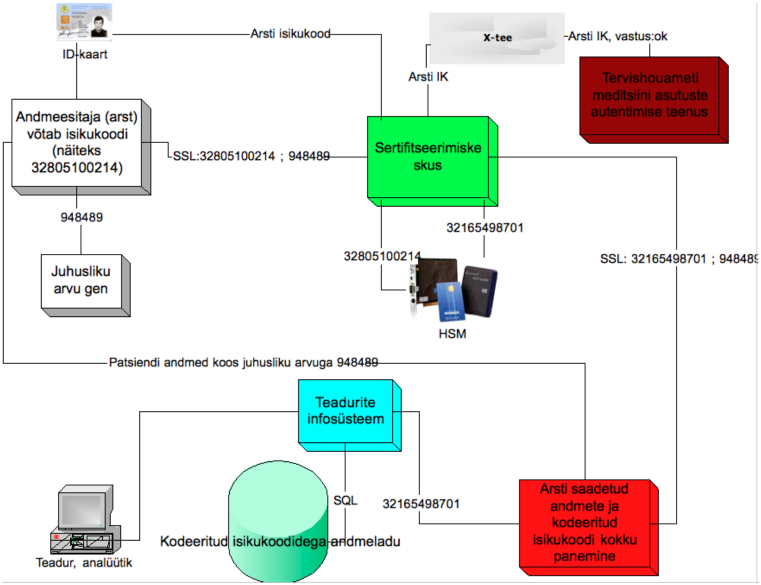
Read it as: Aggregated databases may not be used to create new aggregated databases. You will have to start from the original sources.

Pseudonymization in Estonia: the First Attempt



ID-kaart

Arsti isikukood

X-tee

Arsti IK, vastus:ok

Arsti IK

Tervishouameti meditsiini asutuste autentimise teenus

Andmeesitaja (arst) võtab isikukoodi (näiteks 32805100214)

SSL:32805100214 ; 948489

Sertifitseerimiske skus

948489

Juhusliku arvu gen

32165498701

32805100214

SSL: 32165498701 ; 94848

HSM

Patsiendi andmed koos juhusliku arvuga 948489

Teadurite infosüsteem

SQL

32165498701

Kodeeritud isikukoodidega andmeladu

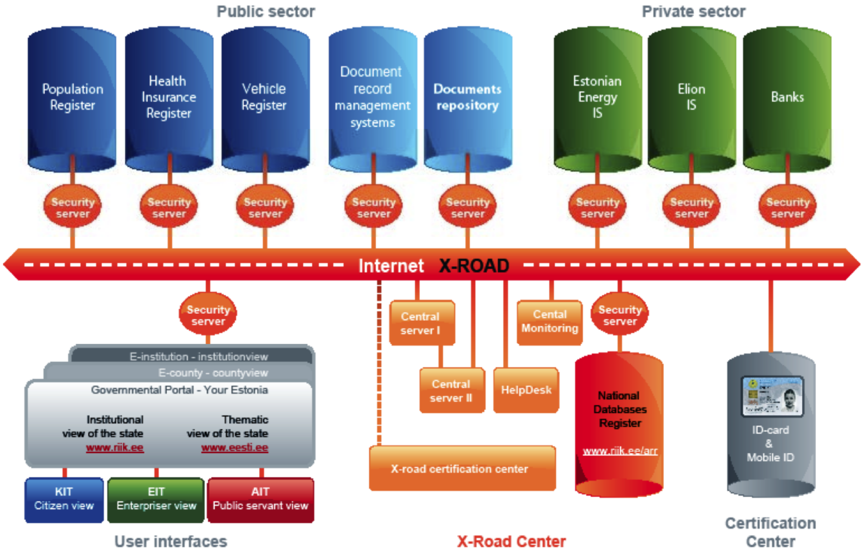
Arsti saadetud andmete ja kodeeritud isikukoodi kokku panemine

Teadur, analüütik

Pseudonymization in Estonia: the First Attempt Highlights

- In order to reconnect the pseudonymized IDs with data fields, random transport identifiers were used
- Pseudonymization was implemented via encryption by the HSM of Estonian national CA
    - Essentially, the CA acted as a TTP, seeing all the sensitive IDs
- Since the people at the CA only knew, how to perform public key operations on the HSM, they generated a key pair and threw half of it away
- During the first live tests it occurred that the HSM was unable to handle simultaneous encryption requests coming from different sources
- When a queueing mechanism was added, under certain circumstances the whole operation of the CA needed restarting

X-Road Infrastructure



X-Road Infrastructure: Characteristics

- Unified XML-based data exchange format
- Each database is supplied with a security server acting as a simple, but flexible HSM
- Minimal number of central services
  - Certification
  - Logging
  - Monitoring
- All the data exchange happens point-to-point and typically presumes an explicit agreement

X-Road Pseudonymization Service: General Principles

- No new TTP/centralized services, if possible
  - Instead, make full use of the existing infrastructure (security servers)
  - Since the security servers will hold the pseudonymization keys anyway, they may as well generate and distribute them
- Pseudonymization does not have massive performance requirements, but it should be as robust as possible
- No need for further actions with the aggregated database
  - Hence, no need for commutative cryptography or public key cryptography in general
  - We will use symmetric encryption
  - One-wayness based on public key encryption does not add much, since the ID space is small ($\approx 70 \cdot 10^6$ in case of Estonian IDs) and can be brute forced by the owner of the key anyway

X-Road Pseudonymization Service: Protocols

- Key generation and distriubution
  - (Security server of) data donor D_1 will generate an AES-256 key K_R
  - He will send a sigcrypted blob $Sig_1(Enc_i(K_R))$ to another data donor D_i
  - D_i will verify the signature and decrypt the key
- Database aggregation
  - When sending data from D_i to the aggregated researcher database R, the IDs are encrypted with the key K_R so that the records become $(Enc_{K_R}(ID), Data(ID))$
  - After all the pseudonymized datasets are transmitted, R links them based on the values $Enc_{K_R}(ID)$ as identifiers

X-Road Pseudonymization Service: Implementation and Benchmarks

- Key transmission is performed by a physical carrier
- Identifying the ID to pseudonymize is performed by standard XPath technology using pugiXML library
- Testing was done on security servers running Ubuntu Linux 10.04 LTS on Intel Core2 8200 processors
- Pseudonymization can happen in several parallel threads (8 in default settings)
- Data throughput achieved was 120MBps
- Memory requirement 45 . . . 55 MB per thread
- Our pseudonymization service was included into X-Road version 5, deployment of which in Estonia started on January 1st 2011

Thank you!

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- Logically, I did not say anything about the people who do not ask questions. They can go to have lunch, too