SMI Swiss Medical Informatics
SGMI SSIM SSMI
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Privacy preserving interoperability for personalised medicine

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Towards personalisation of the treatment

The treatment of certain diseases such as cancer, HIV, or other serious medical conditions relies on a regular administration of critical drugs that are necessary to keep those life-threatening diseases under control. Those drugs (e.g. Efavirenz, Imatinib, Tacrolimus, Tobramycin) have a narrow therapeutic range and a poorly predictable relationship between the dose and the blood drug concentration, which may vary greatly among individuals. Therapeutic Drug Monitoring (TDM) aims at improving patient care by monitoring drug levels in the blood to individually adjust the dosage for targeting drug concentration in the therapeutic interval. In order to ensure a better prediction of the relationship between dose and drug concentration, the ISyPeM2 project (a continuation of the Nano-Tera project: Intelligent Integrated Systems for Personalized Medicine, ISyPeM, http://www.nano-tera.ch/projects/368.php) has developed a Bayesian TDM approach [GWM$^+$12] based on studies in general or special populations. This approach requires population health data (covariates, dosages, drug concentrations) to be collected and analysed by researchers, in order to enhance the prediction models. Therefore the following question arises: *how is it possible to share and aggregate medical data for research purposes while preserving the patients' privacy?*

Challenges

Trying to answer this question we face the following challenges:

- Achieving interoperability in the distributed environment (patients data may be distributed over many medical systems, involving a range of IT systems with different interfaces, which have to follow the requirements of regulations and standards (e.g, HL7, EC Data Protection Directive 95/46/EC)).
- Ensuring protection of patients' privacy (medical data are sensitive, aggregation of the distributed anonymised data about the patient can still reveal sensitive information, the patient has to be able to set up the access control policy in a convenient and efficient way)

Ongoing work

We are tackling these challenges by: (1) Developing an interface for the TDM software compliant with HL7 and integrating it with the laboratory system MOLIS deployed at CHUV (Lausanne). (2) Constructing a secure and scalable architecture of an eHealth system for primary and secondary use of the health data. We propose an eHealth infrastructure that does not require the existence of a fully trusted party. Patients' data are pseudonymised (based on the scheme for multi-key searchable encryption [PZ13]) and stored in an encrypted form, such that no unauthorised party can learn neither identity of the patient, nor the content of the Electronic Health Record (EHR). Nevertheless, the EHR can be accessed according to the access control policy in an efficient manner. We also build an anonymised research database applying a *k, k^m-anonymisation* approach proposed in [PLGD13] in a distributed setting. In addition, we employ the pseudonymisation principle that is used for storing EHR. Such construction allows a caregiver to update information about a particular patient and re-contact him/her if needed, while satisfying privacy requirements.

Conclusion

We address the problem of achieving interoperability and data integration while ensuring users' privacy in the context of a new approach for TDM. Sharing health data for research will help to put into practice TDM, which will assist medical doctors and, in turn, will significantly improve patient care.

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Privacy Preserving Interoperability for Personalized Medicine

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How to share and aggregate medical data for research purposes while preserving the patients' privacy?

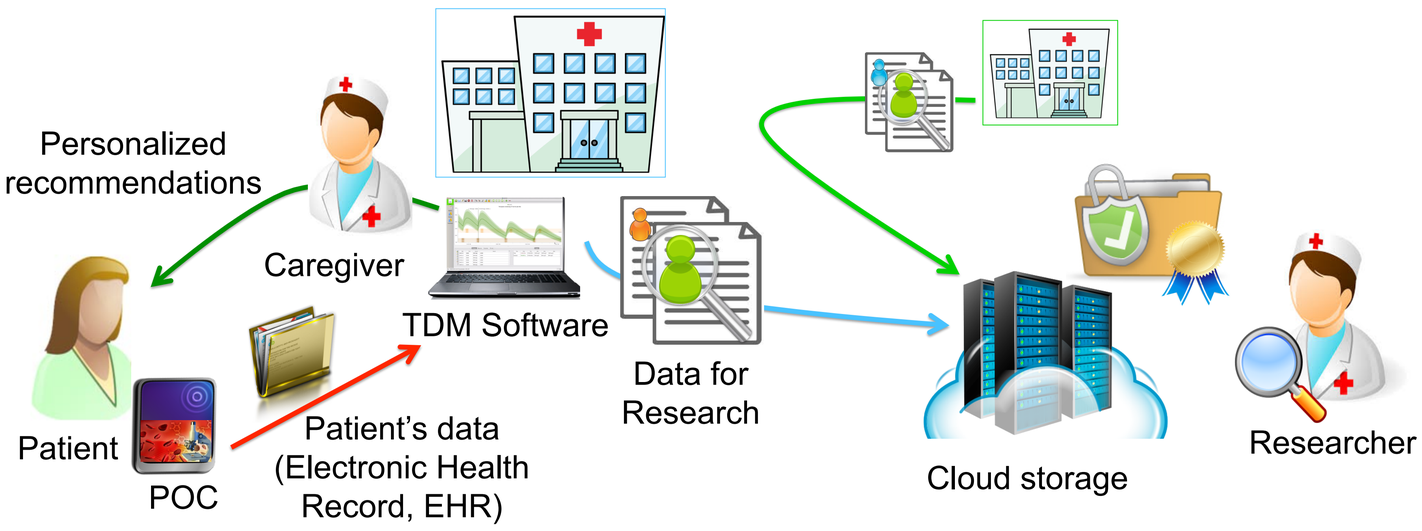
Towards Personalization of the Treatment

Why do we need personalization?

- Some drugs have a narrow therapeutic range and a poorly predictable relationship between the dose and the blood drug concentration, that may also vary greatly among individuals

Therapeutic Drug Monitoring (TDM) aims at improving patient care by monitoring drug levels in the blood to *individually* adjust the dosage in order to target drug concentration in the therapeutic interval. Bayesian TDM ensures a better prediction of the relationship between dose and drug concentration and is based on studies in the general or special populations. This requires population health data (covariates, dosages, drug concentrations) to be collected and analyzed by the researchers.

Dataflow Overview



POC – Point-Of-Care system, that will be able to:

- Perform and collect measurements of the drug concentration in the blood samples
- Provide the medical doctor with all necessary data about the patient
- Share drug intake information and concentration measurement records for research purposes

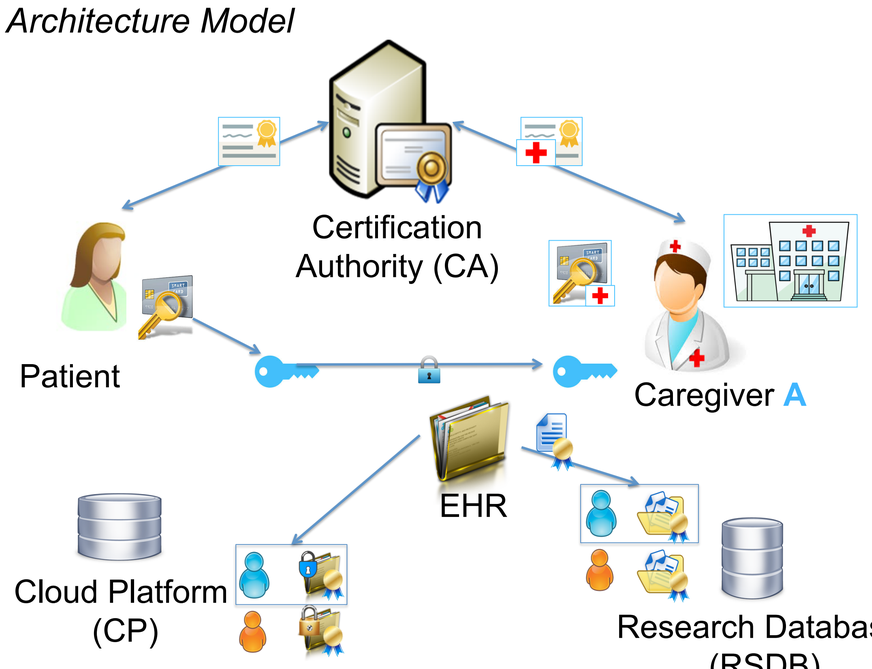
Challenges

- *Achieving interoperability in the distributed environment*
  - Dynamicity of the data
  - Regulations and standards
  - Different interfaces
- *Protection of patients' privacy*
  - Sensitivity of medical data
  - Aggregation of the distributed data about the patient (can reveal sensitive information!)
  - Consent management
  - Access control policy requirements

Ongoing Work

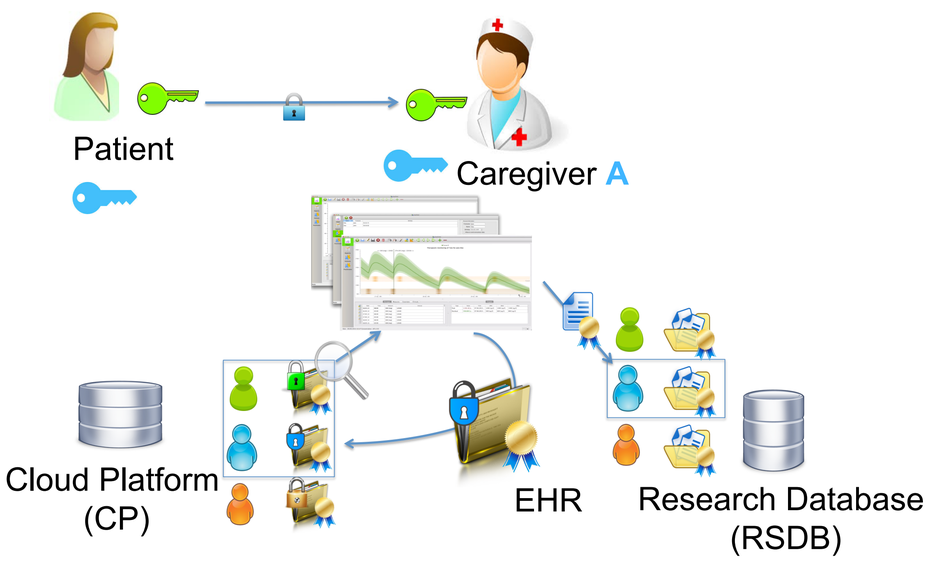
- Developing an interface for the TDM software compliant with HL7 and integrating it with the laboratory system in CHUV (Lausanne)
- Constructing a secure and scalable architecture of an eHealth system for primary and secondary use of the health data:

Architecture Model



- Caregivers and Patients have their secret keys and corresponding public keys certified by CA
- Patient generates from her secret key a shared key with each caregiver she visits
- The sensitive data are encrypted with the shared key and signed with the public key of a caregiver
- De-identified data are signed and sent to RSDB

Access control management



- Caregiver can search for all entries associated with Patient (,) iff he has corresponding keys (,) in an efficient way without revealing identity of the patient or a content of the medical record

RSDB:

- Pseudonymization based on the scheme for multi-key searchable encryption [PZ13]
- k, k^m−anonymization [PLGS13] in a distributed environment

Conclusion

- We address the problem of achieving interoperability and data integration while ensuring users' privacy in the context of a new approach for TDM
- Sharing health data for research will help to put into practice TDM, that will be assisting medical doctors and will significantly improve patient care

References

- [PZ13] Raluca Ada Popa and Nickolai Zeldovich. Multi-key searchable encryption. Cryptology ePrint Archive, Report 2013/508, 2013
- [PLGS13] G. Poulis, G. Loukides, A. Gkoulalas-Divanis, and S. Skiadopoulos, "Anonymizing Data with Relational and Transaction Attributes", in European Conference, ECML PKDD 2013