Enabling Computation on Encrypted Data

Scaling-up Privacy-Preserving Techniques in Healthcare AI Applications

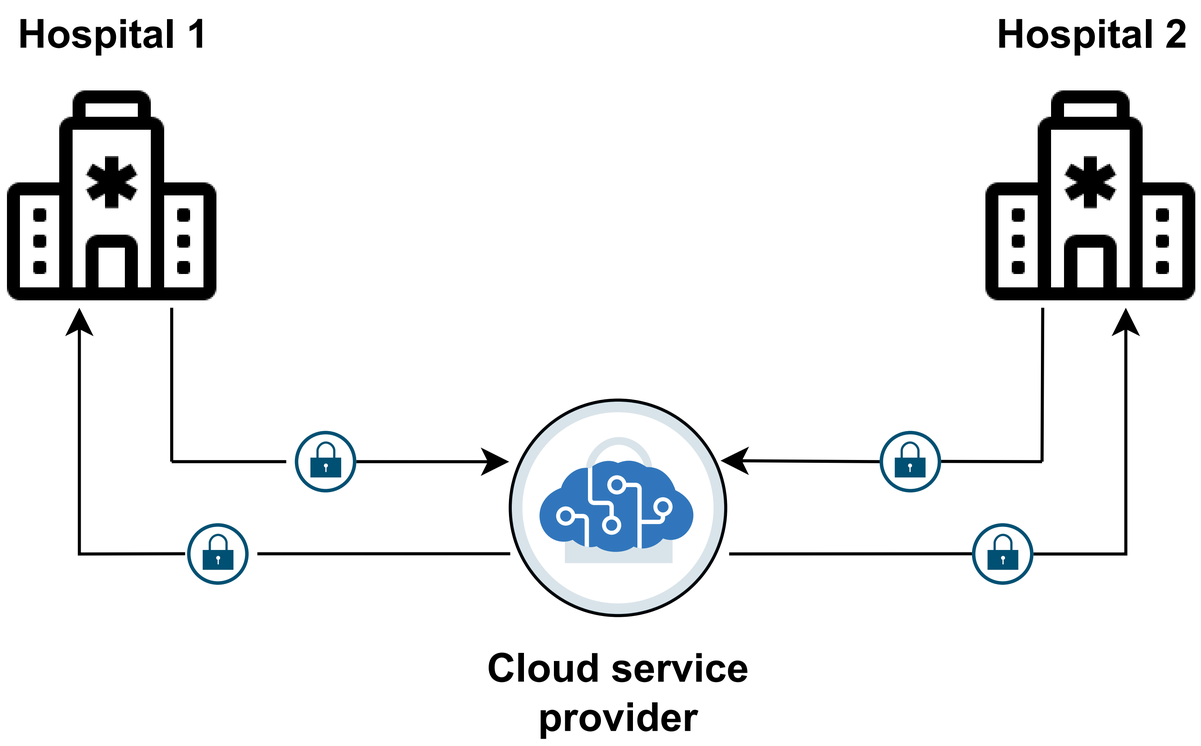
Motivation

What happens if a hospital wants to use a cloud AI application on its patients' data.

By sharing sensitive patient data with a third-party the hospital could face legal implications (GDPR) and additionally risk the privacy of the patient's data.

Cryptography offers a way to surpass these obstacles with a technique called Homomorphic Encryption (HE).

Homomorphic Encryption allows computations to be done on *encrypted* data without having to decrypt them first!



Example of hospital HE setting

- **Hospital 1** located in the Netherlands, wants to use a (collectively) trained model from various (maybe cross-country) hospitals
- **Hospital 2** located in Spain, wants to use the same model from the same cloud service provider
- **Homomorphic Encryption** enables both hospitals to train or do inference on the same model
- Even though the model is held by a third-party, **privacy** is not compromised!

What's the catch here?

Cryptography offers solutions to problems that sometimes intuitively seem impossible. But always at a cost...

The execution time overhead for operating on Fully Homomorphically Encrypted data is significant.

Even for very simple operations the execution time overhead could be **millions** of times slower, thus making real-world applications **impractical**.

How to scale-up?

Strategies to scale-up real-world FHE applications:

- Optimised implementations, usually leveraging large vector processor instructions (RISC-V "V" extension)
- Custom hardware Instruction Set Extensions (ISE)
- Implementation optimisations for specific FHE schemes, assuming an ML model and some configuration.

Take-home messages

1. **Healthcare applications** leverage Machine Learning to provide better and more accurate services but the **privacy concerns** of treating patient's data form a significant barrier.
2. Cryptography promises to remove this barrier with **Homomorphic Encryption**, a technique that allows computations to be made **on encrypted data**.
3. The **tremendous overhead** introduced by these techniques must be tackled with various methods: providing fast, **optimised implementation** leveraging large vector processor instructions, **custom hardware ISEs** and FHE **scheme-specific optimisations** for specific ML models and configurations.

Find out more

https://secured-project.eu

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