ASCAPE – An Intelligent Approach to Support Cancer Patients

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Agenda

- Introduction
- ASCAPE Architecture
- Federated Learning in ASCAPE
- Conclusion

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Introduction

- Nowadays the number of people living with cancer is constantly increasing
- In 2019 in the United States, **1.7M of new cases were reported** [1]. One in every five deaths in the U.S. is due to cancer.
- Cancer research is the focus in numerous fields

[1] Data collected by the CDC - https://gis.cdc.gov/Cancer/USCS/?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcancer%2Fdataviz%2Findex.htm#/AtAGlance/

Introduction

- ASCAPE – **A**rtificial intelligence **S**upporting **CA**ncer **P**atients across **E**urope
  - Horizon 2020 project
- Use of contemporary techniques in Big Data, Artificial Intelligence and Machine Learning to support cancer patients
- **Goal:** Creating a powerful and open AI/ML infrastructure to support and increase the Quality of Life (QoL) of people suffering from cancer
  - Focus: breast and prostate cancer

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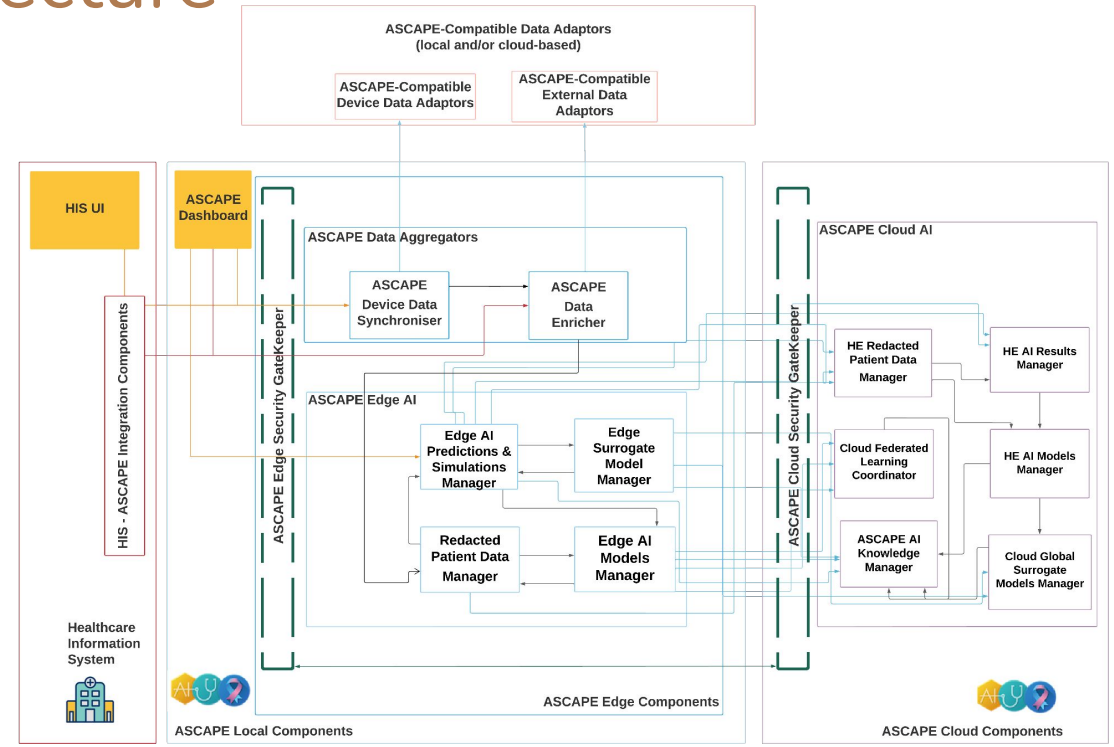
ASCAPE Architecture

- Challenges:
  - Integrating Hospital Information Systems (HIS)
  - Providing **support to doctors and patients** using quality ML models
  - **Privacy protection**
- **How to protect sensitive patient data?**

ASCAPE Architecture

- ASCAPE Architecture:
  - The HIS
  - The Edge
  - The Cloud



ASCAPE Architecture

- Workflows:
  - **Data ingestion** – transferring data from the HIS to the ASCAPE edge components installed at the hospital.
  - **ML model training** – Training and validation of various ML models against locally available data. The best performant models are selected for use in production environments.
  - **Predictions & Simulations**
    - Generating personalized QoL predictions for patients when requested by doctors.
    - Simulating the effects of various interventions on QoL.

ASCAPE Architecture

- The architecture was set having privacy protection as a main concern
- **3 different strategies** for training ML models were implemented:
  - Local model training
  - Global homomorphic model training
  - Global federated model training
- These models aim to:
  - Predict the future QoL of patients at each stage of their treatment
  - Simulate their possible QoL following different treatment suggestions

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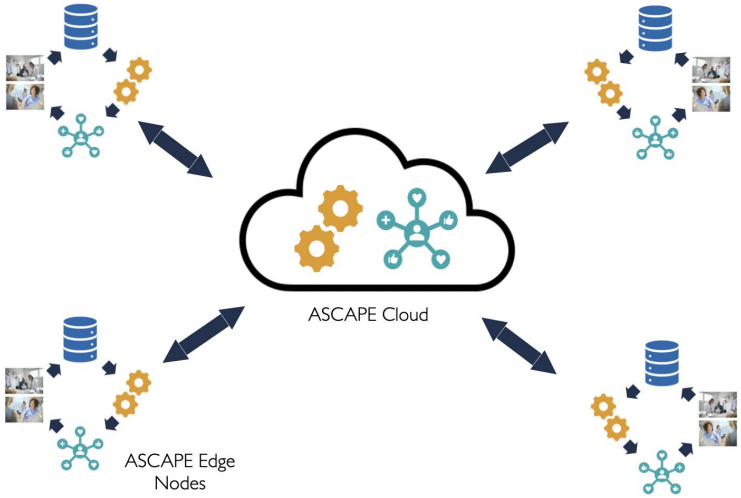
Federated Learning in ASCAPE

- Federated Learning (FL) is a **privacy preserving** technique for **decentralized** machine learning
- The ASCAPE ecosystem supports training of **deep federated models**
    - No sensitive data is being transferred
    - Only updated weights are sent through the network

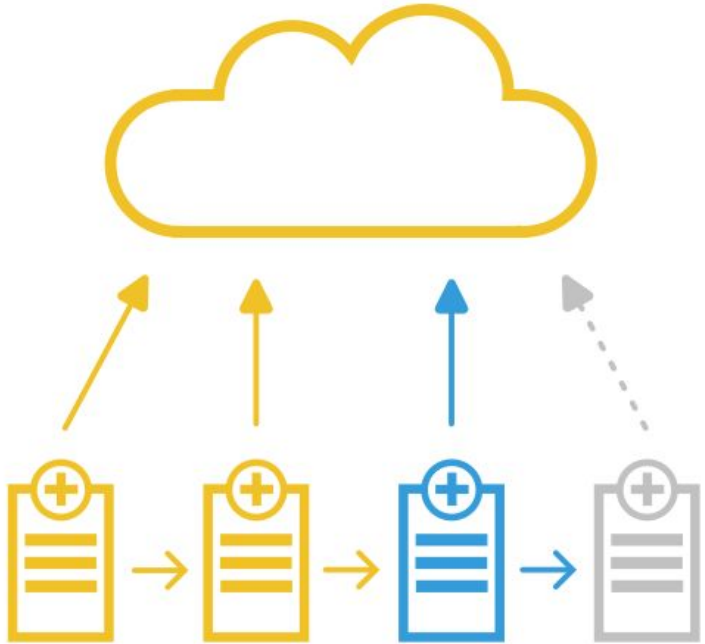


Federated Learning in ASCAPE

- Multiple modes of FL are supported
  - **Incremental FL** – Hospitals take turns in updating the global model.
  - **Concurrent FL** – The learning steps of all hospitals are synchronized.
  - **Semi-concurrent FL** – The FL process is not orchestrated by the server. Each hospital may update the global model as soon as data becomes available.
- The setup:
  - *k* edge nodes (hospitals)
  - Each edge node E_i owns a local subset D_i of the global dataset

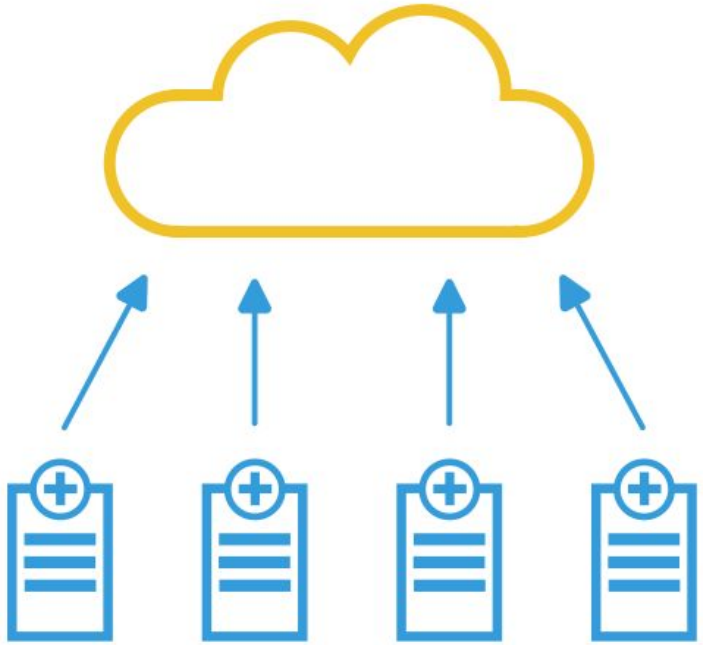
Federated Learning in ASCAPE

- **Incremental FL**
  - The global model M is created by E_1 and updated using D_1
  - Following this, E_2 updates M using D_2
  - The process is finished once the final updates are made by E_k using D_k



Federated Learning in ASCAPE

- **Concurrent FL**
  - All edge nodes $E_1 \ldots E_k$ update the global model M simultaneously
  - Training is split into rounds (most commonly epochs) at each E_i, having the process synchronized by the ASCAPE Cloud
  - After each round, the Cloud aggregates all of the submitted updates by using the **Federated Averaging** algorithm



Federated Learning in ASCAPE

- **Semi-concurrent FL**
  - A more flexible approach to FL
  - When new data becomes available at the edge E_i, the training process is initiated without moderation by the Cloud
  - This mode allows **seamless switching** between incremental and concurrent FL

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Conclusion

- Treatment of cancer patients usually negatively influences their everyday activities
- Privacy preserving ML methods need to be developed in order to harness the power of existing private medical data
- The ASCAPE project offers an implementation of an **open ML infrastructure** which will support cancer patients and improve their QoL through **predictive modeling** and better **medical intervention suggestions**