Connecting federated learning instances in NephroCAGE

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CHUM

NEPHROCAGE

German-Canadian consortium on AI for improved kidney transplantation outcome

3nd International NephroCAGE Symposium, Aug 2, 2023

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Background

- Traditional model (pooling of patient data across sites using data sharing agreements) **slow, costly and inefficient.**
- Distributed data analyses techniques can **facilitate multi-institutional research** while protecting patient privacy.
- Deploying these technologies in real-world healthcare environments poses **several unique challenges.**
- Create a **legal and ethical framework** for inter-institutional collaboration towards developing distributed analysis capacities.

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Collaborative Data Analysis (CODA) platform

- An **open-source** platform that enables collaborative data analysis without need to pool data in centralized repositories.

- Including support for both:
  - **Meta-analyzed aggregate statistics** (e.g. “What is the average ICU mortality this month at hospitals X, Y and Z?”)
  - **Federated machine learning** (collaborative training of machine learning models by sharing weights rather than data)

- Should be **rapidly deployable** in real-world healthcare setting.

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CODA partners

Hôpital général juif
Jewish General Hospital

McGill University
Health Centre

HÔPITAL DU SACRÉ-CŒUR
DE MONTRÉAL

Centre intégré de santé et de services sociaux de Chaudière-Appalaches
Québec

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant

Centre intégré universitaire de santé et de services sociaux de l'Estrie – Centre hospitalier universitaire de Sherbrooke
Québec

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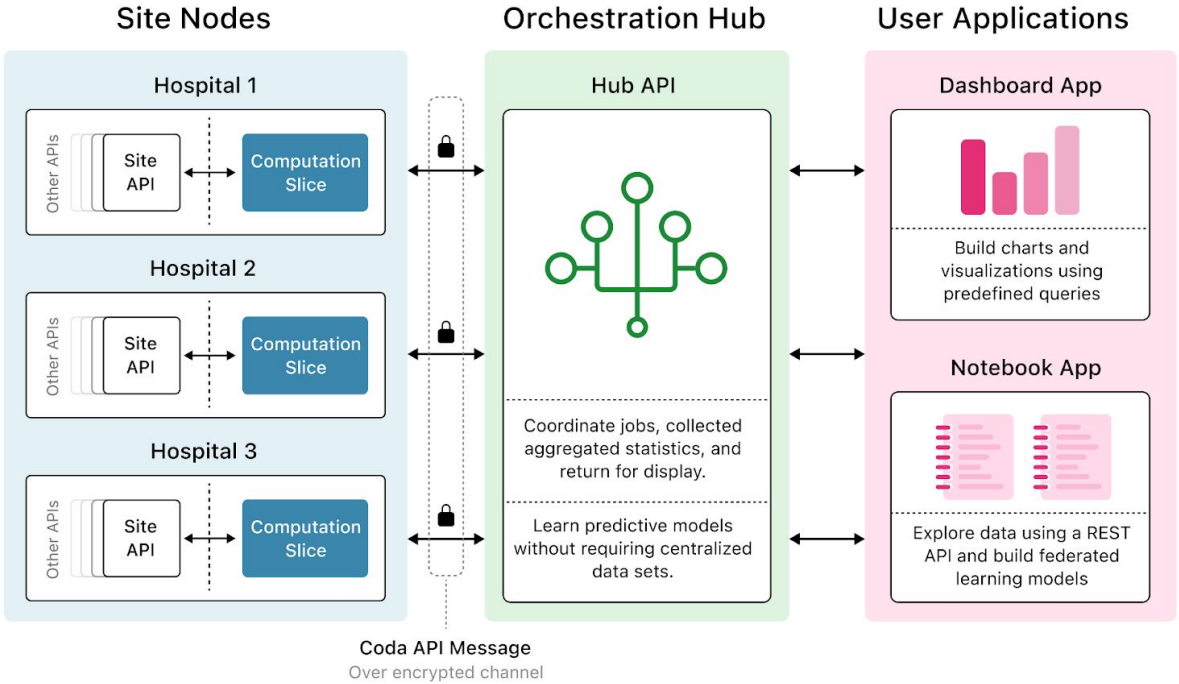
Chart 4

CODA platform architecture overview



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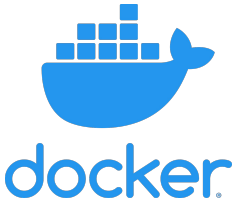
Technologies used for implementation



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Data standards, coding terminologies and FHIR ressources

Type	Examples	FHIR Resource	Coding Standard(s)
Demographics	Age, gender, sex at birth, vital status, race, religion, marital status	Patient	HL7 CS
Past medical history	Past and new diagnoses	Condition	HL7 CS, ICD-10
Clinical encounters	Clinic or ED visit or hospital admission	Encounter	HL7 CS
Patient flows	Bed/unit arrival and departure time	Location	HL7 CS
Observations (clinical examination)	Weight, height, vital signs	Observation	LOINC
Observations (laboratory tests)	Biochemistry, haematology, serology, cultures, PCR tests	Observation	LOINC, SNOMED
Clinical interventions	Surgery, interventional radiology	Procedure	SNOMED, CPT
Medication history	Medications administered	MedicationAdministration	AHFS
Laboratory tests	Biochemistry, haematology, serology, cultures, PCR tests	Observation	LOINC
Imaging tests	X-rays, CT scans	ImagingStudy	DICOM
Continuous signals	Electrocardiogram, arterial waveform	Observation	DICOM
All resource types	Date and time, country codes, units of measure		ISO 8601, ISO 3166, UCUM

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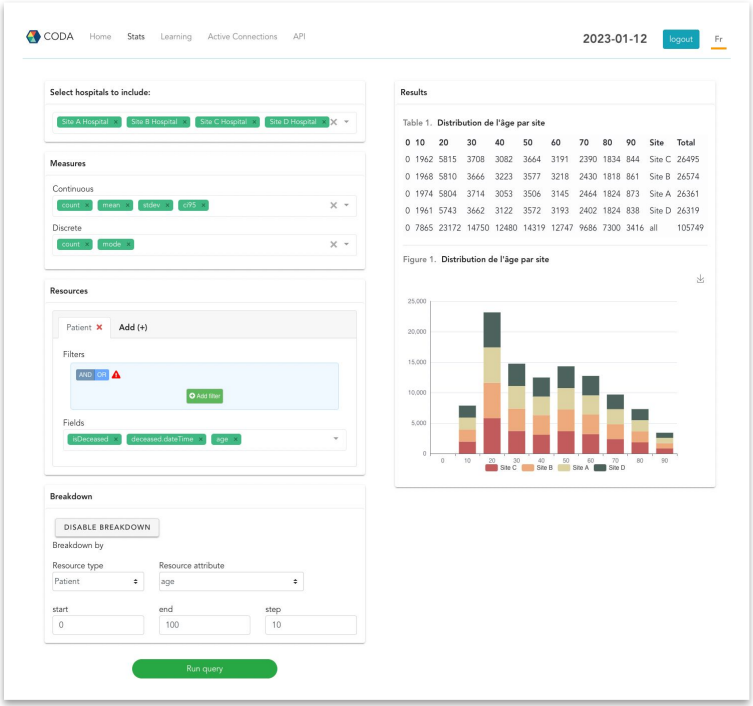
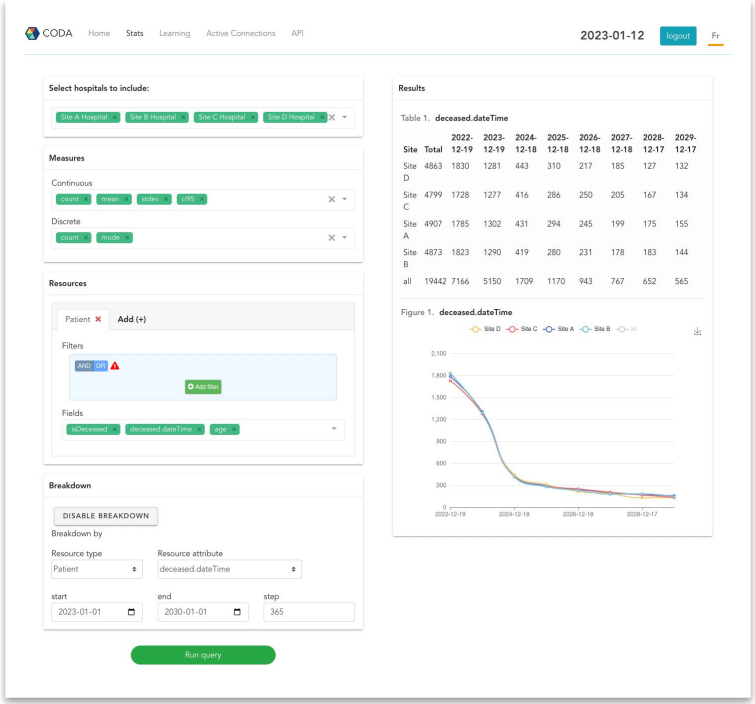
Data visualization interface – Native integration with FHIR ontology





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Federated learning

- CODA implements basic FL capabilities. Two options:
  - FedSGD
  - FedAVG
- **TensorFlow** is presently supported as a backend
  (Pytorch support in progress)
- Models are specified using Keras standard JSON format.

Algorithm 1 Federated Averaging

Require: Number of clients K, number of local epochs E, batch size B, learning rate η, model w_0, and global rounds R.

Ensure: Trained global model w_R.

Initialize global model w_0.
for $r = 1, 2, ..., R$ **do**
  for each client k in C_k **do**
    Receive global model w_{r-1}.
    Initialize local model $w_{k,0} = w_{r-1}$.
    for $e = 1, 2, ..., E$ **do**
      Sample a mini-batch B of data from client k.
      Compute gradient $\nabla f_k(w_{k,e-1}; x_i, y_i)$ using mini-batch.
      Update local model $w_{k,e} = w_{k,e-1} - \eta \nabla f_k(w_{k,e-1}; x_i, y_i)$.
    end for
    Send updated local model $w_{k,E}$ to the server.
  end for
  Aggregate models from clients: $w_r = \frac{1}{|C_k|} \sum_{k \in C_k} w_{k,E}$.
end for
return w_R.

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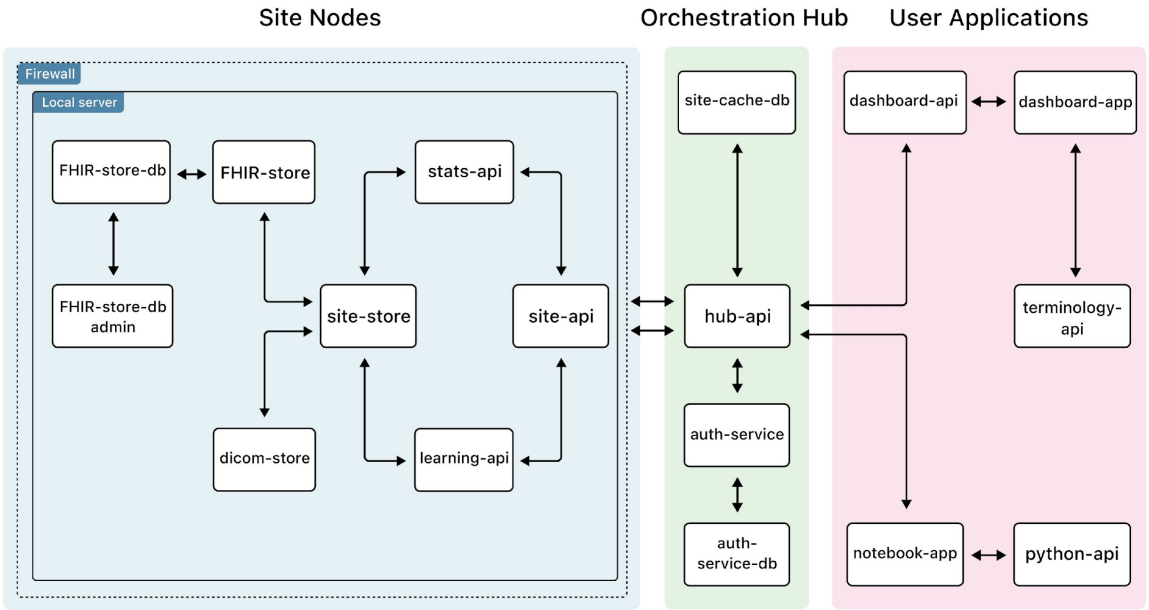
Platform architecture details



Source code available at: https://github.com/coda-platform

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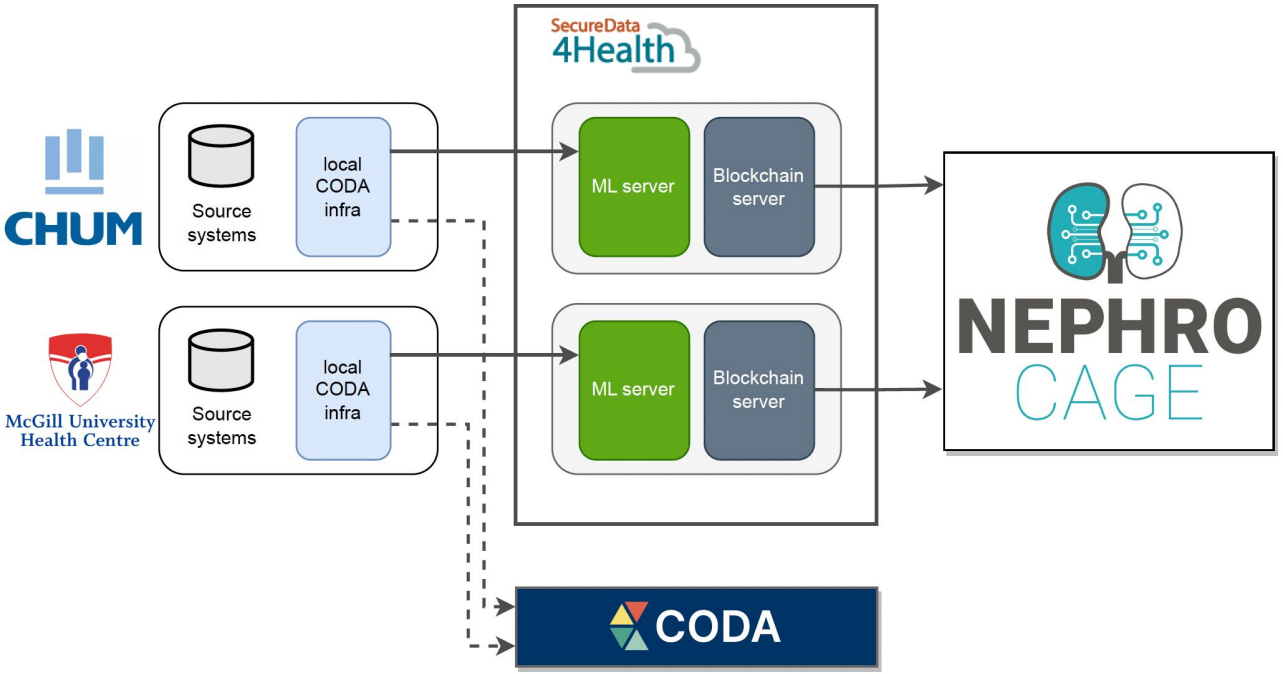
Connecting CODA to NephroCAGE



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Thank you!

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