



Connecting federated learning instances in NephroCAGE

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NEPHROCAGE
German-Canadian consortium on AI for
improved kidney transplantation outcome
3rd 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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2

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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Chart 3

CODA partners



Hôpital général juif
Jewish General Hospital



McGill University
Health Centre



HÔPITAL DU SACRÉ-CŒUR
DE MONTRÉAL



CHU
de Québec
Université Laval

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

Québec



CHU Sainte-Justine
Le centre hospitalier
universitaire mère-enfant

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

Québec

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Chart 4



NEPHRO CAGE

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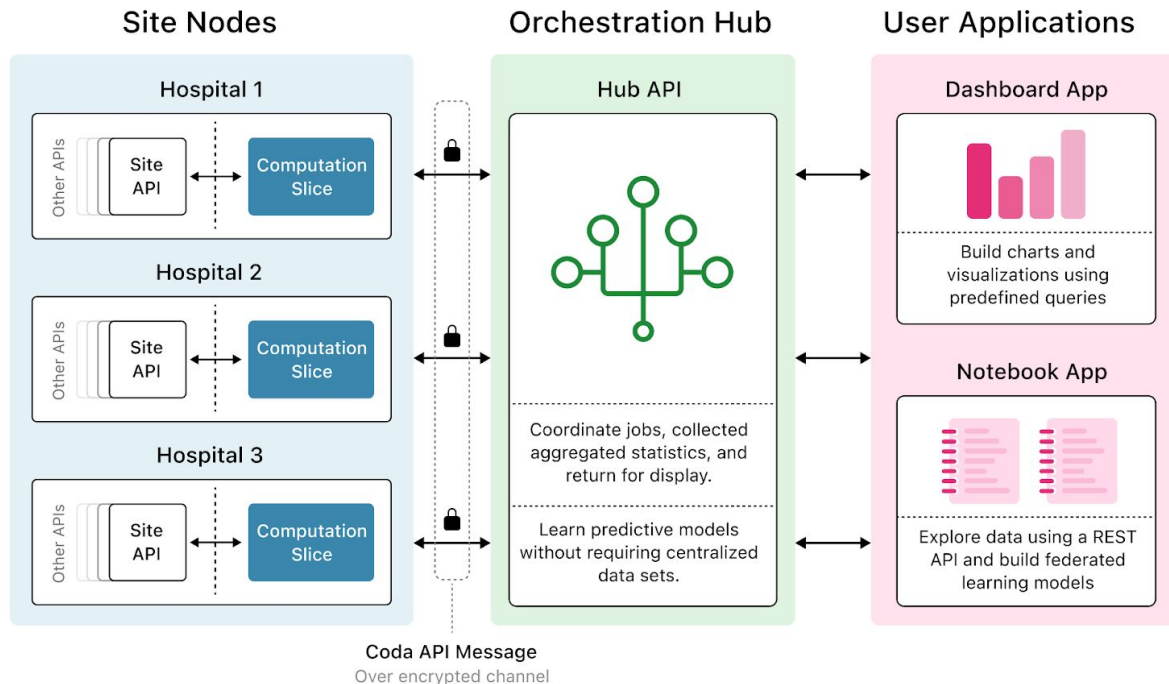
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CODA platform architecture overview



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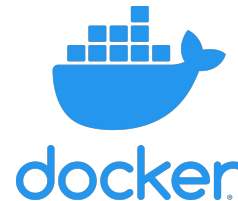
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Technologies used for implementation



ANSIBLE



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Data standards, coding terminologies and FHIR resources



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

CODA Home Stats Learning Active Connections API 2023-01-12 [Logout](#) [Fr](#)

Select hospitals to include:
 Site A Hospital Site B Hospital Site C Hospital Site D Hospital X

Measures
 Continuous: count mean min max p95 X
 Discrete: count mode X

Resources
 Patient X Add (+)
 Filters: AND OR NOT Add filter
 Fields: deceased deceased.dateTime age

Breakdown
 DISABLE BREAKDOWN
 Breakdown by: Resource type (Patient) Resource attribute (age)
 start: 0 end: 100 step: 10
[Run query](#)

Results
 Table 1. Distribution de l'âge par site

0	10	20	30	40	50	60	70	80	90	Site	Total
0	1962	5815	3708	3082	3664	3191	2390	1834	844	Site C	26495
0	1968	5810	3666	3223	3577	3218	2430	1818	861	Site B	26574
0	1974	5804	3714	3053	3506	3145	2444	1824	873	Site A	26361
0	1961	5743	3662	3122	3572	3193	2402	1824	838	Site D	26319
0	7865	23172	14750	12480	14319	12747	9686	7300	3416	all	105749

 Figure 1. Distribution de l'âge par site

CODA Home Stats Learning Active Connections API 2023-01-12 [Logout](#) [Fr](#)

Select hospitals to include:
 Site A Hospital Site B Hospital Site C Hospital Site D Hospital X

Measures
 Continuous: count mean min max p95 X
 Discrete: count mode X

Resources
 Patient X Add (+)
 Filters: AND OR NOT Add filter
 Fields: deceased deceased.dateTime age

Breakdown
 DISABLE BREAKDOWN
 Breakdown by: Resource type (Patient) Resource attribute (deceased.dateTime)
 start: 2023-01-01 end: 2030-01-01 step: 365
[Run query](#)

Results
 Table 1. deceased.dateTime

Site	Total	2022-12-19	2023-12-19	2024-12-18	2025-12-18	2026-12-18	2027-12-18	2028-12-17	2029-12-17
Site Total	4863	1630	1281	443	310	217	185	127	132
Site D	4799	1728	1277	416	286	250	205	167	134
Site C	4907	1785	1302	431	294	245	199	175	155
Site A	4873	1823	1290	419	280	231	178	183	144
Site B	19442	7166	5150	1709	1170	943	767	652	565

 Figure 1. deceased.dateTime

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8

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 .

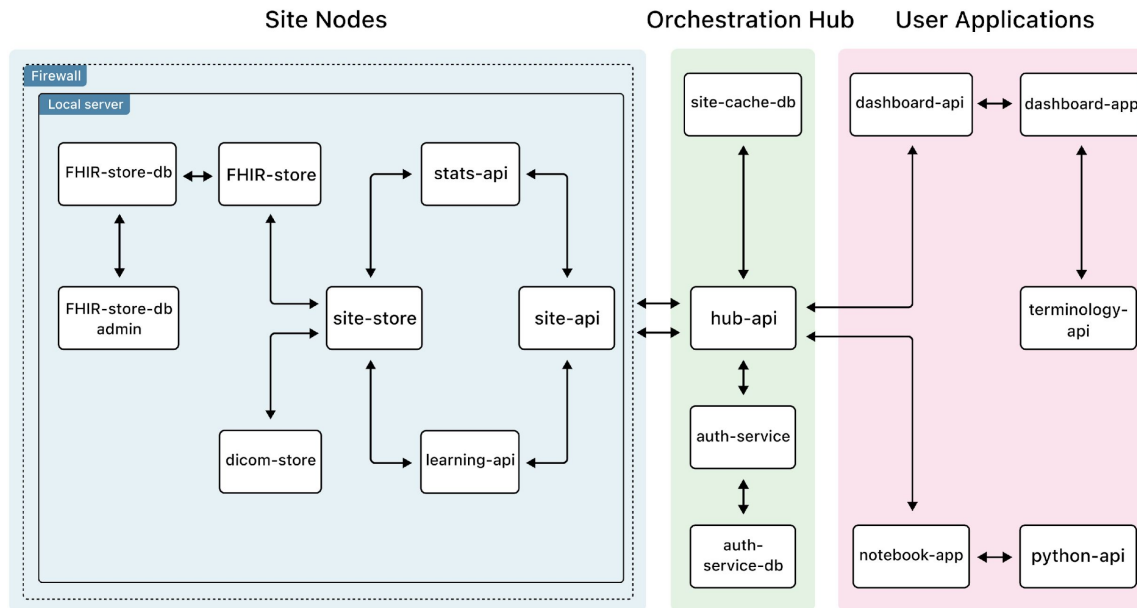
```
1: Initialize global model  $w_0$ .
2: for  $r = 1, 2, \dots, R$  do
3:   for each client  $k$  in  $C_k$  do
4:     Receive global model  $w_{r-1}$ .
5:     Initialize local model  $w_{k,0} = w_{r-1}$ .
6:     for  $e = 1, 2, \dots, E$  do
7:       Sample a mini-batch  $B$  of data from client 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

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9

Platform architecture details



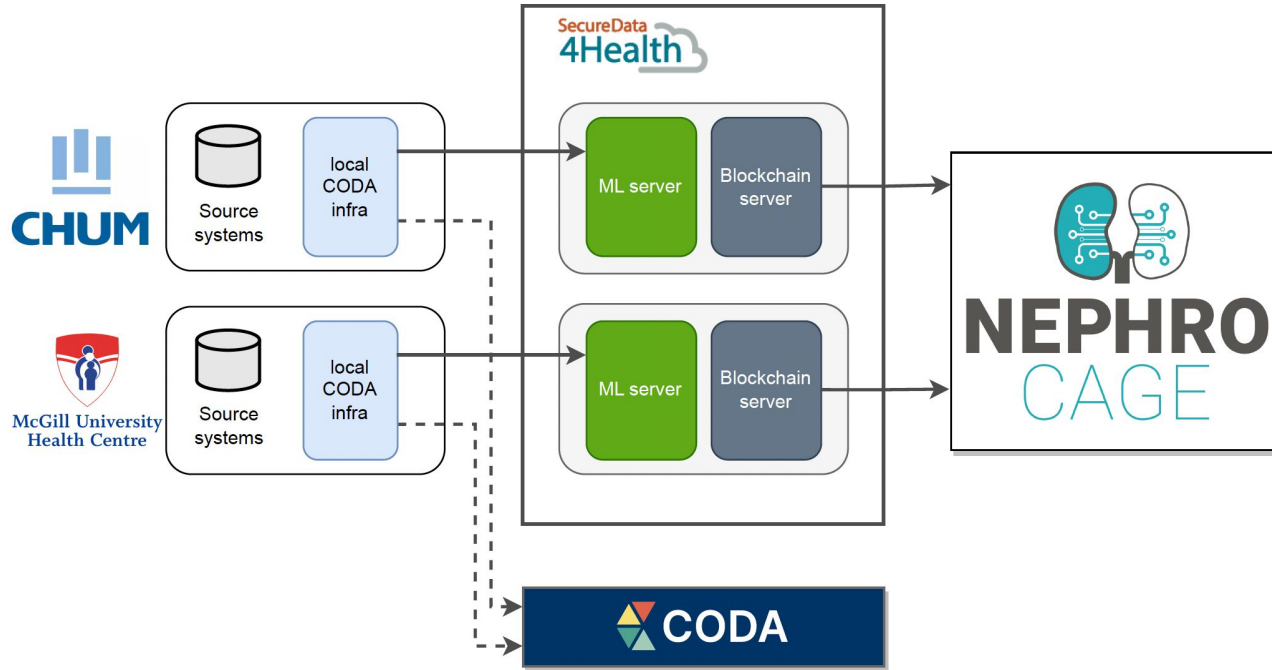
Source code available at: <https://github.com/coda-platform>

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10

Connecting CODA to NephroCAGE



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11

Thank you!

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