



C3-Cloud architecture and technical solution

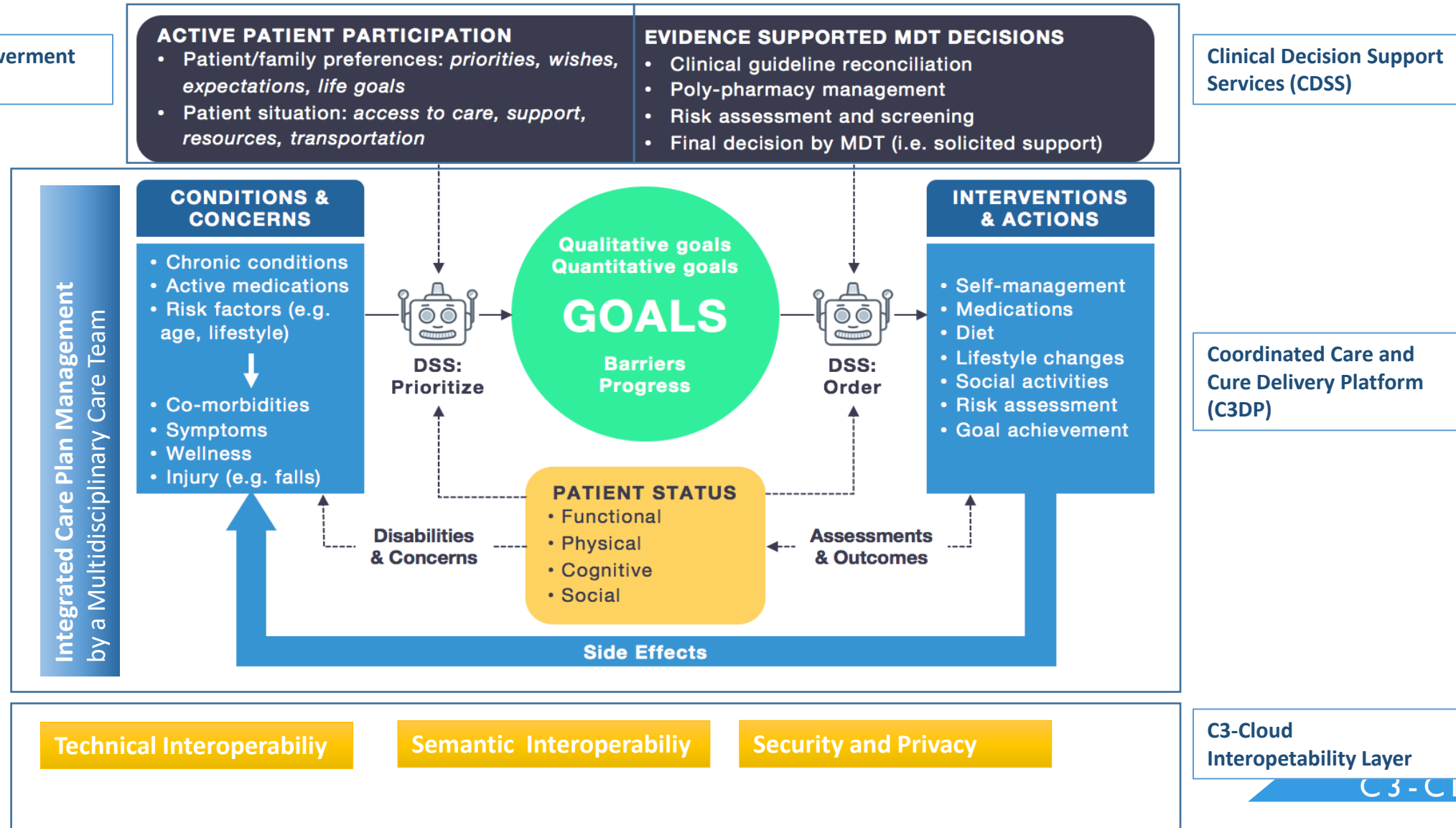
Dr. Gökçe Banu Laleci Ertürlmen



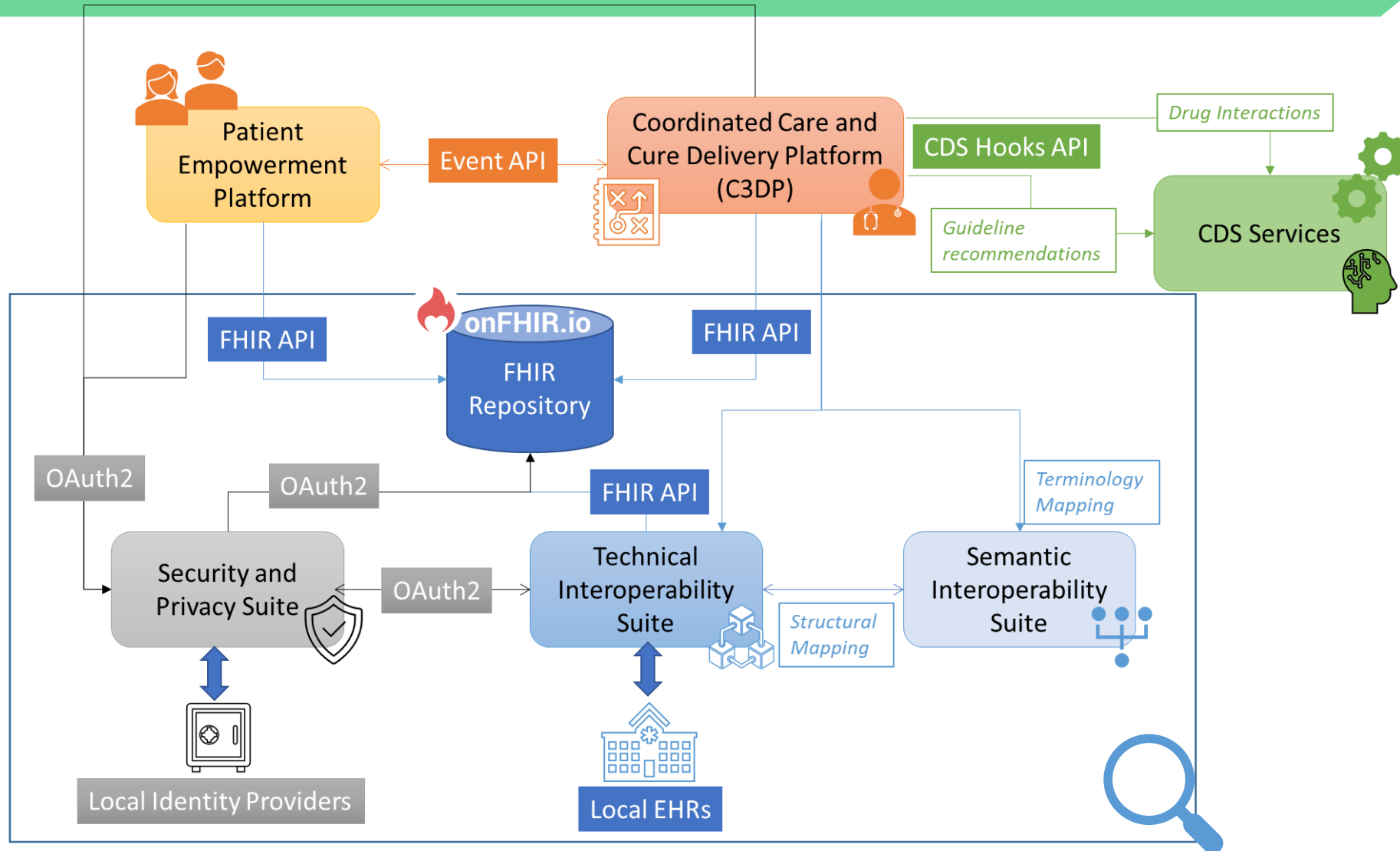
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C3-CLOUD ARCHITECTURE: FROM IDEA TO HIGH LEVEL COMPONENTS

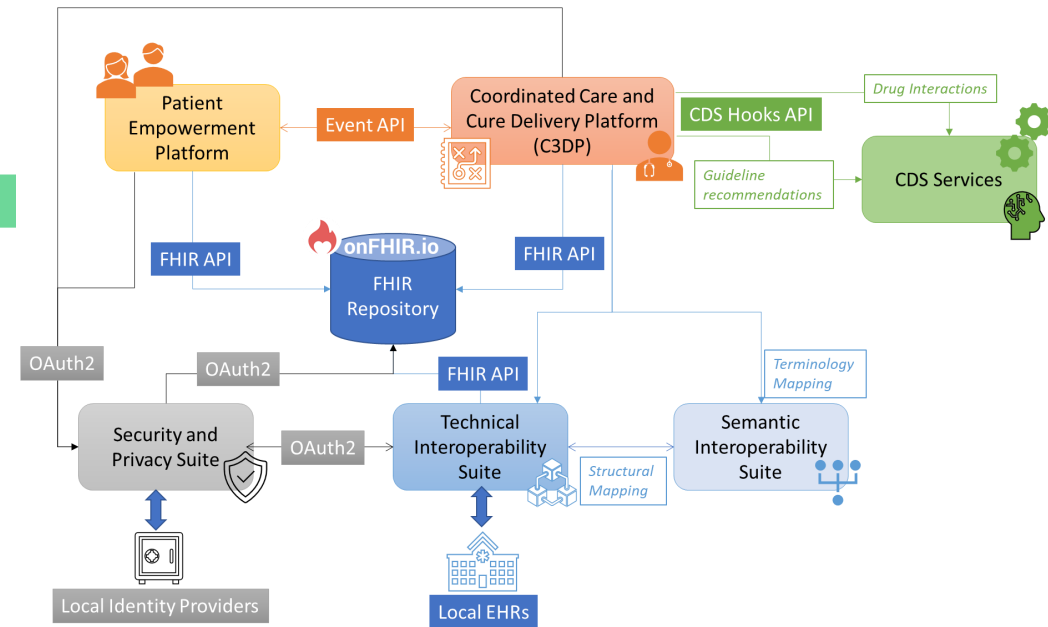


C3-CLOUD INTEGRATED SYSTEM ARCHITECTURE



INTEROPERABILITY LAYER

- HL7 FHIR has been chosen as the common model
- C3-Cloud's common shared repository is a secure, scalable **FHIR Repository**
- **Technical Interoperability Suite**
 - Enables data exchange between the local EHR systems of the pilot sites and the C3-Cloud components via FHIR Repository
- **Semantic Interoperability Suite (SIS)**
 - Structural transformation from local EHR formats to HL7 FHIR & Terminology mapping
- **Security and Privacy Suite (SPS)**
 - Care Team Member authentication and authorization
 - Implements OAuth 2.0, OpenID Connect 1.0 and Smart App Authorization specifications
 - Integration with pilot site IdP systems (e.g. MS ADFS)
 - Audit Record Repository



HL7 FHIR AS THE COMMON DATA MODEL

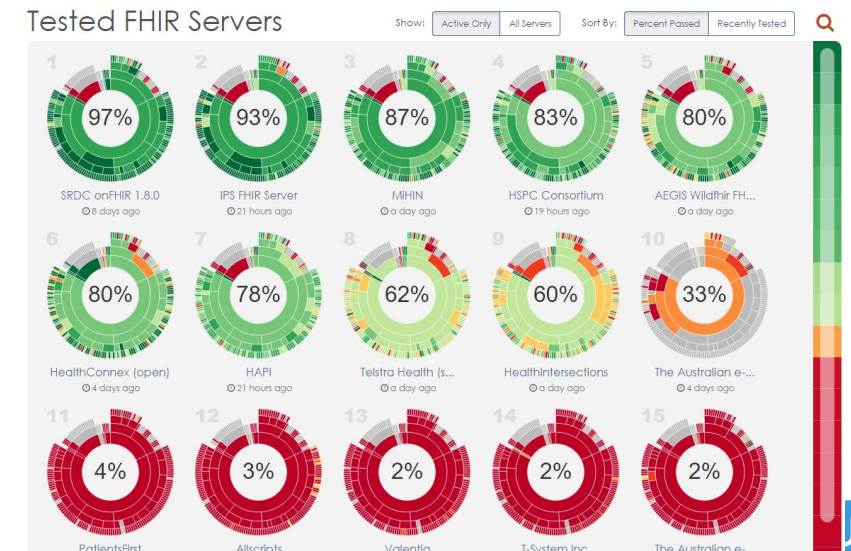
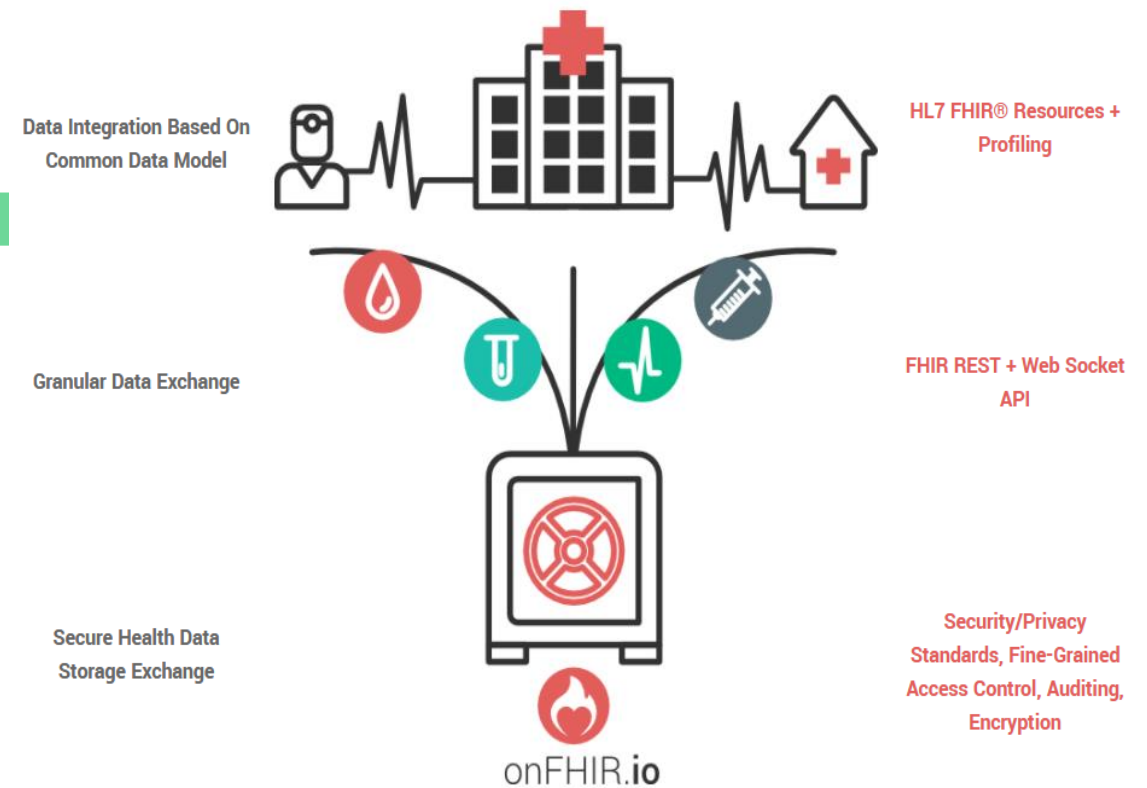
➤ Used FHIR STU3 Resources:

- CarePlan
- CareTeam
- Goal
- Appointment
- ReferralRequest
- MedicationRequest
- ProcedureRequest
- DeviceRequest
- Device
- CommunicationRequest
- Communication
- Questionnaire
- QuestionnaireResponse
- + tens of others for medical data, e.g. Condition, Observation, MedicationStatement, AllergyIntolerance, FamilyMemberHistory, Patient, Practitioner
- + foundation resources, e.g. AuditEvent, ValueSet

Name	Flags	Card.	Type	Description & Constraints
CarePlan			DomainResource	Healthcare plan for patient or group Elements defined in Ancestors: id , meta , implicitRules , language , text , modifierExtension
Identifier		Σ	0..*	Identifier External Ids for this plan
definition		Σ	0..*	Reference(PlanDefinition Questionnaire) Protocol or definition
basedOn		Σ	0..*	Reference(CarePlan) Fulfills care plan
replaces		Σ	0..*	Reference(CarePlan) CarePlan replaced by this CarePlan
partOf		Σ	0..*	Reference(CarePlan) Part of referenced CarePlan
status		?! Σ	1..1	code draft active suspended completed entered-in-error cancelled CarePlanStatus (Required)
intent		?! Σ	1..1	code proposal plan order option CarePlanIntent (Required)
category		Σ	0..*	CodeableConcept Type of plan Care Plan Category (Example)
title		Σ	0..1	string Human-friendly name for the CarePlan
description		Σ	0..1	string Summary of nature of plan
subject		Σ	1..1	Reference(Patient Group) Who care plan is for
context		Σ	0..1	Reference(Encounter EpisodeOfCare) Created in context of
period		Σ	0..1	Period Time period plan covers
author		Σ	0..*	Reference(Patient Practitioner RelatedPerson Organization CareTeam) Who is responsible for contents of the plan
careTeam			0..*	Reference(CareTeam) Who's involved in plan?
addresses		Σ	0..*	Reference(Condition) Health issues this plan addresses
supportingInfo			0..*	Reference(Any) Information considered as part of plan
goal			0..*	Reference(Goal) Desired outcome of plan
activity		I	0..*	BackboneElement Action to occur as part of plan + Provide a reference or detail, not both
outcomeCodeableConcept			0..*	CodeableConcept Results of the activity Care Plan Activity Outcome (Example)
outcomeReference			0..*	Reference(Any) Appointment, Encounter, Procedure, etc.
progress			0..*	Annotation Comments about the activity status/progress
reference		I	0..1	Reference(Appointment Activity details defined in specific resource

ONFHIR - HL7 FHIR® BASED SECURE DATA REPOSITORY

- Common, standardized, HL7 FHIR® compliant way for health data access and storage
 - Highest scores in FHIR testing tools Crucible and Touchstone
- Dynamically configurable
 - Everything is configured from the original FHIR specifications (i.e. definitions)
 - Can support a new version of FHIR within an hour
 - Support for new custom FHIR operations via a library
- Security & Privacy
 - OAuth 2.0 and Smart App Authorization compliant via onAuth
 - Structural and functional role based access control
 - Automatic audit trail creation
- High performance and scalability
 - Outperforms the publicly available FHIR repositories in both reads and writes
 - Direct Json manipulation with MongoDB
- For more information: onfhir.io
 - available at GitHub under GPL license: <https://github.com/srdc/onfhir>



TECHNICAL INTEROPERABILITY LAYER

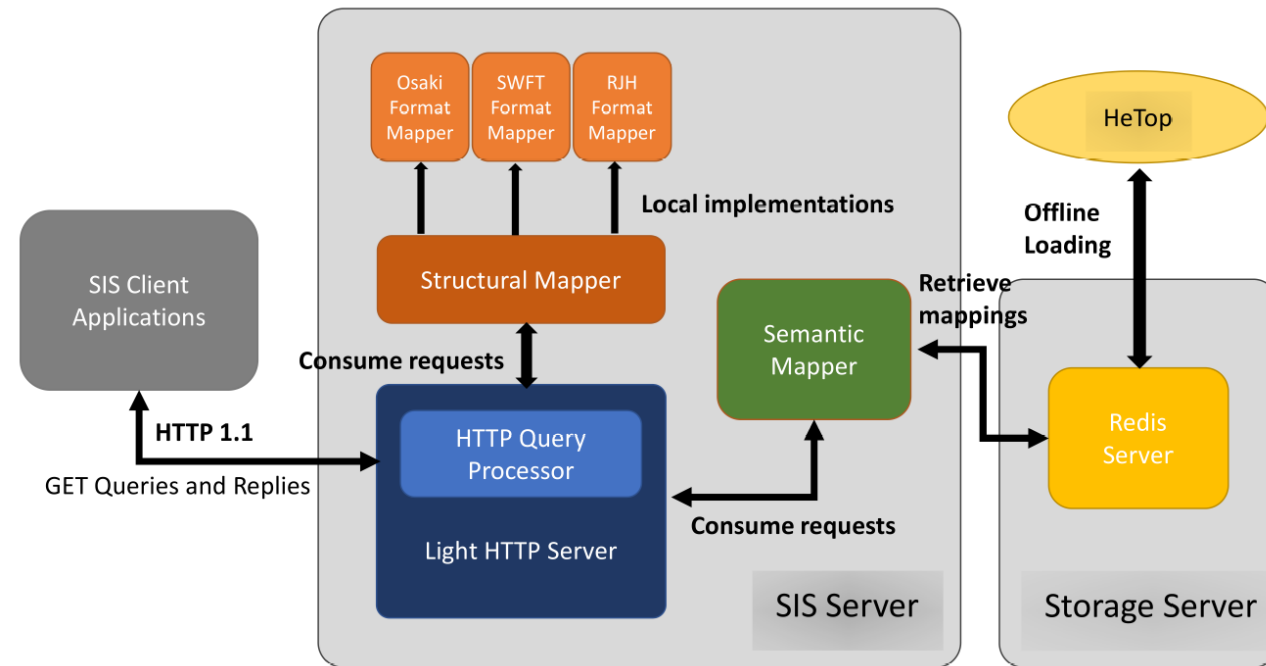
- Enables patient data synchronization from local health and social care systems to C3-Cloud FHIR Repository
- Follows an Extract-Transform-Load (ETL) approach,
 - extracts patient data from local EHRs by either querying their accessible endpoints or through upload of formatted extracts
 - parses the data into JSON
 - transforms the data into FHIR resources using the SIS Structure Mapping Service
 - loads the FHIR data into the C3-Cloud FHIR repository using the HL7 FHIR communication standard

Pilot Site	Supported Interfaces
OSAKI	A SOAP service to return CDA data for a patient, A SOAP service to return observation data for a patient in XML
RJH	Several REST Services to return parts of EHRs as JSON files
SWFT	A CSV files containing all patient primary care, secondary care and community care data exported every day from Lorenzo EMIS

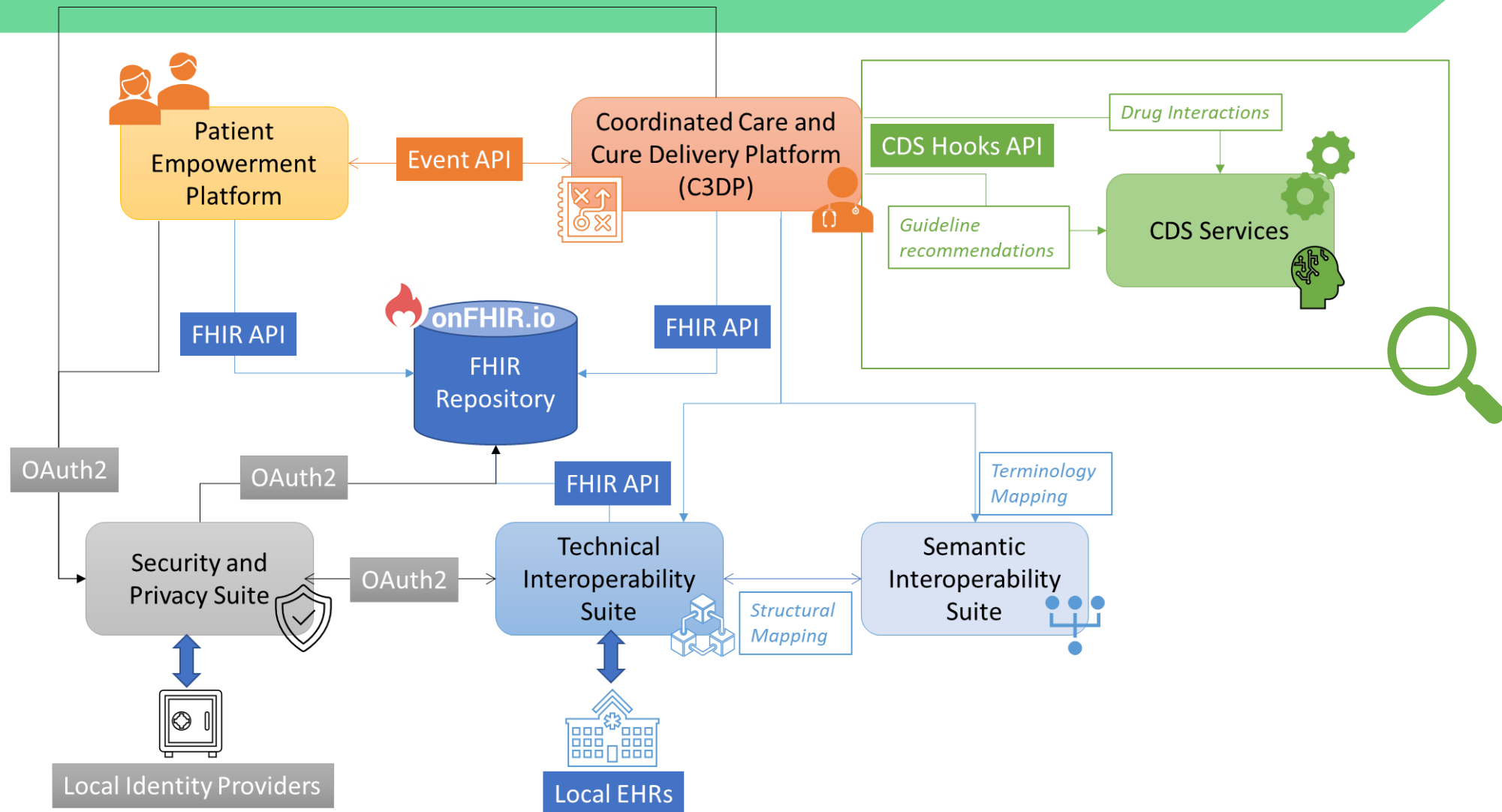
- Task execution engine allows scheduling and management of the execution of ETL pipelines
- Web-based control panel is available that allows users to register patients
- exposes a REST service that allows a data integration pipeline to be triggered by
- The TIS framework has been released on GitHub (<https://github.com/C3-Cloud-eu/tis>) as an open source solution under the Apache 2.0 license

SEMANTIC INTEROPERABILITY LAYER

- Structural mappings are involved in the transformation between local pilot sites data in local format and FHIR resources data format used in C3-Cloud
 - pilot site dedicated local format mappers
- Semantic mappings perform the transcoding between coding systems used in local sites and the C3-Cloud components
 - Using the Health Terminology/Ontology Portal (HeTOP) service
 - Clinical concept mapping table is being maintained as the source of truth
 - 218 common clinical concepts including conditions, active ingredients of medications, procedures, lab results, vital signs, immunizations and family member history
 - SNOMED-CT, LOINC and WHO ATC, and all the local codes (e.g., Spanish and Swedish versions of ICD-10, local terminologies for laboratory tests)



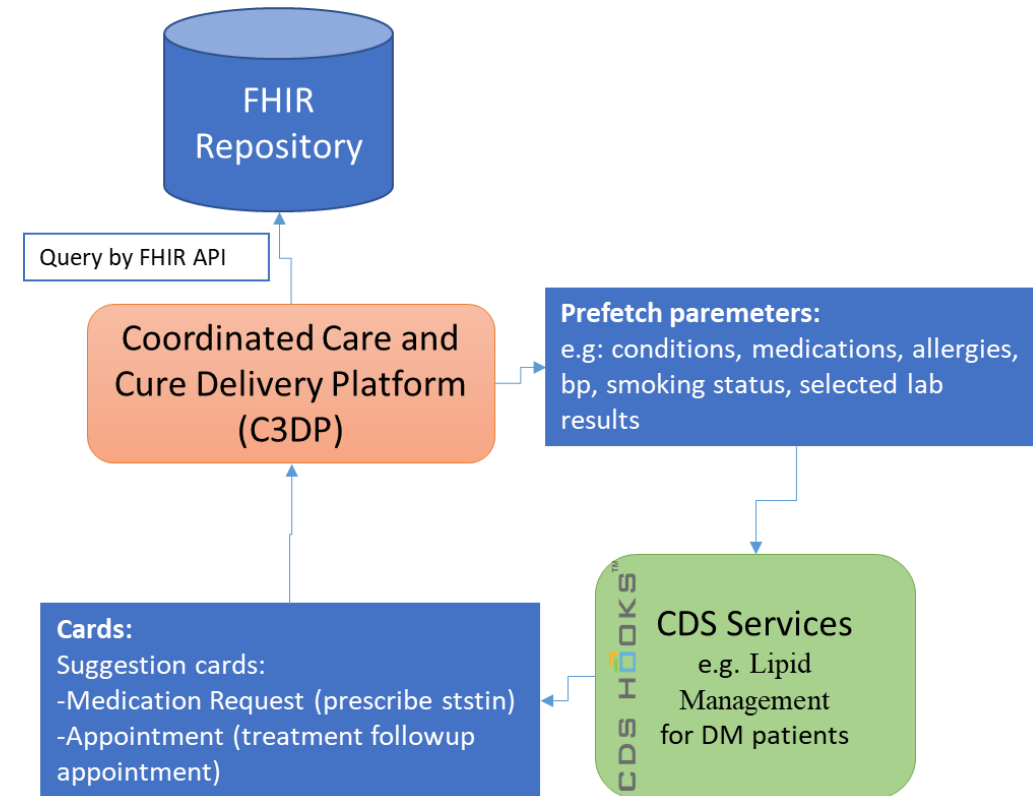
C3-CLOUD INTEGRATED SYSTEM ARCHITECTURE



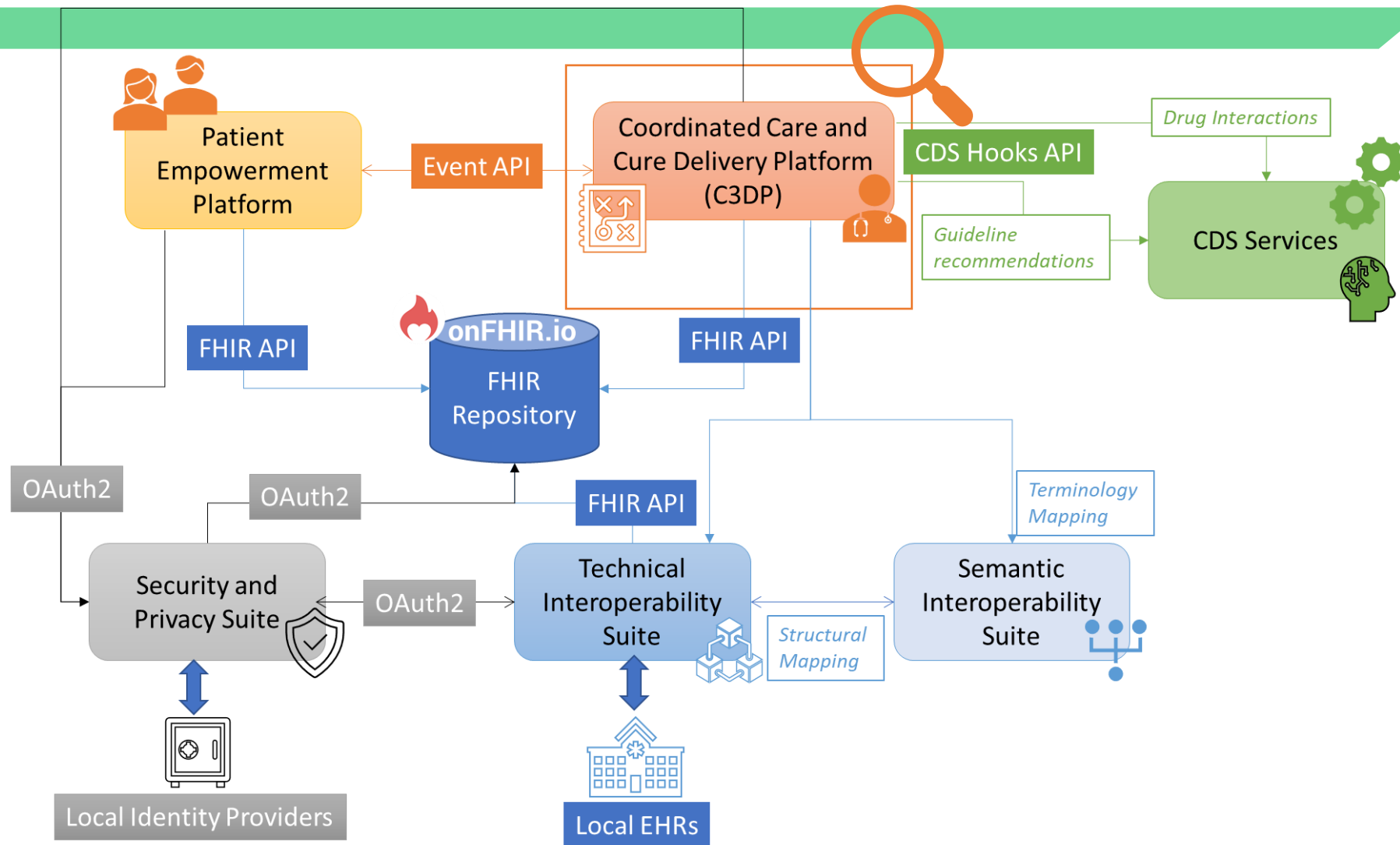
CLINICAL DECISION SUPPORT (CDS) SERVICES

➤ Types of CDS Services in C3-Cloud:

- Clinical guideline based CDS services recommending personalized goals and recommendations to health professionals
 - Type 2 Diabetes, Renal Failure, Heart Failure and Depression (A total of 28 CDS Services)
 - All based on NICE clinical guidelines with minor local deviations
 - Guideline Definition Language 2 (GDL2) via the GDL2 Editor. (www.gdl2.org)
 - **Fully CDS Hooks compliant** (<http://cds-hooks.org/>)
- Reconciliation rules analysed for the 4 major diseases
- Drug-drug interaction service
- Drug-disease interaction service



C3-CLOUD INTEGRATED SYSTEM ARCHITECTURE



COORDINATED CARE AND CURE DELIVERY PLATFORM (C3DP)

➤ The Web application for **collaborative and personalised care plan management** by the members of a multidisciplinary team of care (MDT). Main functions:

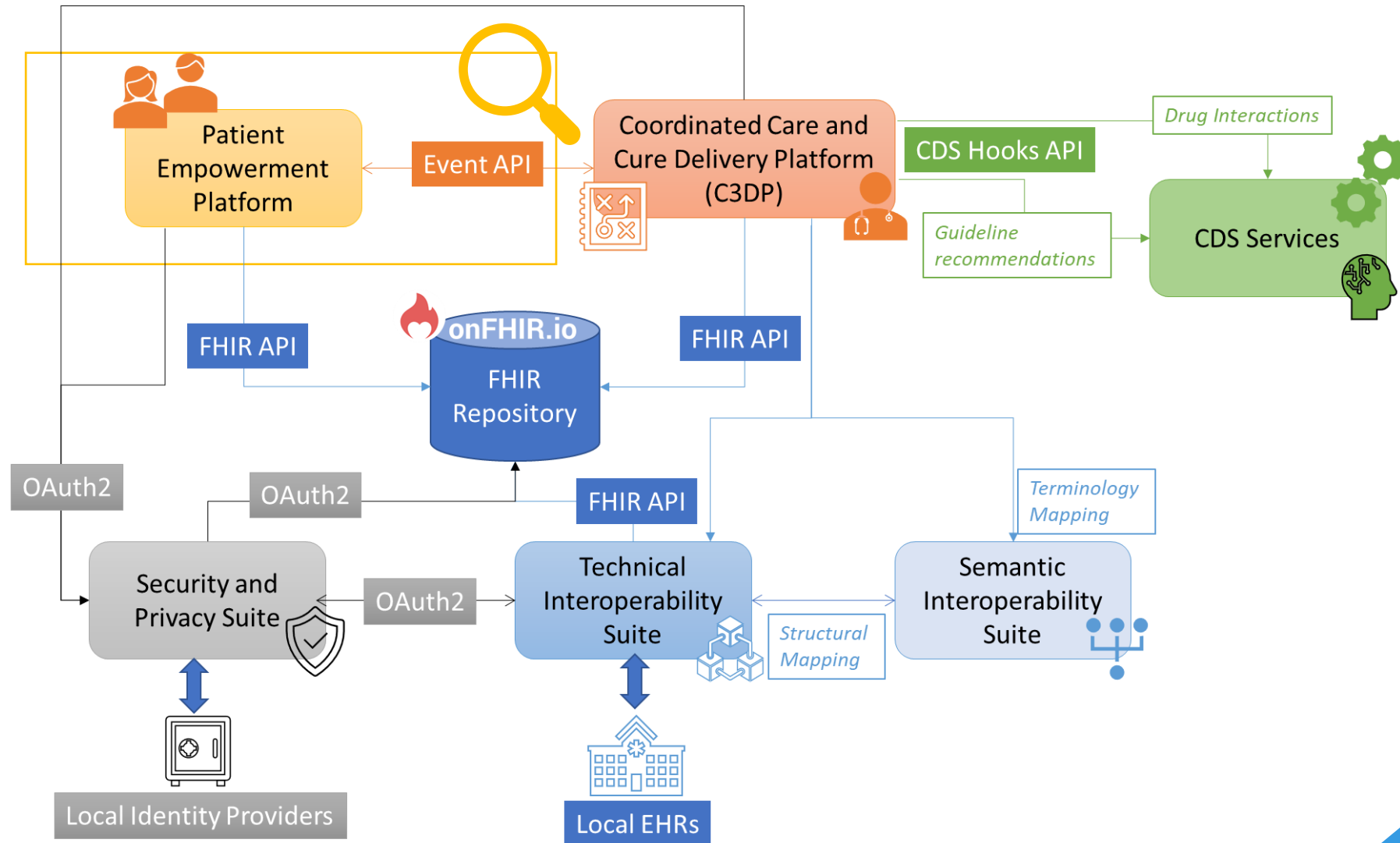
- Review of medical summary
- Cross-check of all patient data that are needed as input by the CDS services
- Management of the care plan building blocks; goals, activities and education materials
 - Manual entry from scratch
 - Recommendations from the CDS services
- “Execution” of a care plan
 - Updating the progress of goals and activities
 - Re-execution of CDS services during planned and unplanned encounters
 - Display of patient provided data
 - Commenting on the care plan items
- Management of the care team
- Communication among care team members and with the patient / informal care giver
- Dashboard view
- Patient provided data screen
- Activity calendar
- Real-time system notifications

The screenshot displays the kronIQ web application interface. On the left is a sidebar with a patient profile for Ahmet Kiliç (ID: 123321, Age: 57, Male) and a menu with options like Medical Summary, Care Plan, and Patient Provided Data. The main area is divided into sections: Goals, Activities, and Patient Provided Data. The Goals section shows two active goals related to HbA1c and blood pressure management. The Activities section shows a list of tasks such as GP appointments, follow-ups, and medication orders. The Patient Provided Data section is currently empty.

Title	Start Date	Target Date	Target	Actions
Treatment target is supposed to be 46 mmol/mol (\pm 6.4%)	25 May 2020	25 Aug 2020	HbA1c < 46 mmol/mol	[-]
Keep blood pressure under control	25 May 2020	25 Aug 2020	Blood pressure panel Systolic Blood Pressure < 130 mmHg Diastolic Blood Pressure < 80 mmHg	[-]

Title	Type	Start Date	Actions
GP Appointment for management of nephropathy	Appointment	25 May 2021	[-]
Follow-up to check the results of the treatment	Appointment	06 Jul 2020	[-]
NA - Self Efficacy for Diabetes	Questionnaire (Repeating)	25 May 2020	[-]
Mediterranean diet with reduced sodium level (salt intake)	Diet	25 May 2020	[-]
Self-measurement of blood pressure	Patient Order	25 May 2020	[-]
Self monitoring of Blood Glucose	Patient Order (Repeating)	25 May 2020	[-]
HbA1c Test	Lab Request	05 Jun 2020	[-]
Prescribe DPP4 inhibitor	Medication	25 May 2020	[-]
Acetylsalicylic acid	Medication	10 Nov 2018	[-]
Lansoprazole	Medication	31 Mar 2011	[-]

C3-CLOUD INTEGRATED SYSTEM ARCHITECTURE



PATIENT EMPOWERMENT PLATFORM (PEP)

- The Web application providing access for a patient to the published care plan and its associated information
- Based on the Medixine Suite PHR product of Medixine
- Core user functionalities:
 - Care plan access
 - Reminders to increase adherence
 - Actively collect data related to the care plan activities.
 - Safe messaging
 - Access to relevant self-management material.

The screenshot displays the C3CLOUD Patient Empowerment Platform (PEP) interface for a user named George Kitchen. The top navigation bar includes links for Home, Careplan, Tracking, Questionnaires, Messages (with a red notification icon), and Info. The main content area is titled "Careplan" and indicates it was updated on 23/11/2018 at 15:00 by Anna Svensson. The interface is divided into two main columns. The left column, titled "Activities", lists tasks for the user to complete, categorized by type: GENERAL (Apply nicotine patch or gum), MEDICATION (erythromycin), OBSERVATION (Self-measurement of blood pressure), and OBSERVATION (Submit photo for dietary intake assessment). Each activity includes a calendar icon, a due date, and an "Add new" button. The right column, titled "Goals", lists targets set by the care team, including "Reduce weight", "Stop smoking", "Avoid diabetic foot complications", "Maintain & improve mobility", and "Keep blood pressure under control". Each goal includes a "Feedback" link and detailed information such as priority, status, start date, due date, and target values. At the bottom right, an "Info" section provides links to educational materials for Type 2 Diabetes and Diabetes Foot Care.

C3CLOUD

George Kitchen

Home Careplan Tracking Questionnaires Messages 1 Info

Careplan
Updated at 23/11/2018 15:00 by Anna Svensson

Activities
Activities you should do to achieve your goals.

- ▼ **Apply nicotine patch or gum** (GENERAL)
When: between 06/11/2018 and 06/12/2018
- ▼ **erythromycin** (MEDICATION)
When: every 2 days from 20/09/2018
- ▲ **Self-measurement of blood pressure** (OBSERVATION)
When: every 1 day 1 time from 06/10/2018 to 06/12/2018
Add new Open tracker →
Introduced by: Anna Svensson
- ▼ **Submit photo for dietary intake assessment** (OBSERVATION)
When: between 23/10/2018 and 23/11/2018
Add new View photos →

Goals
Goals and targets set by your care team.

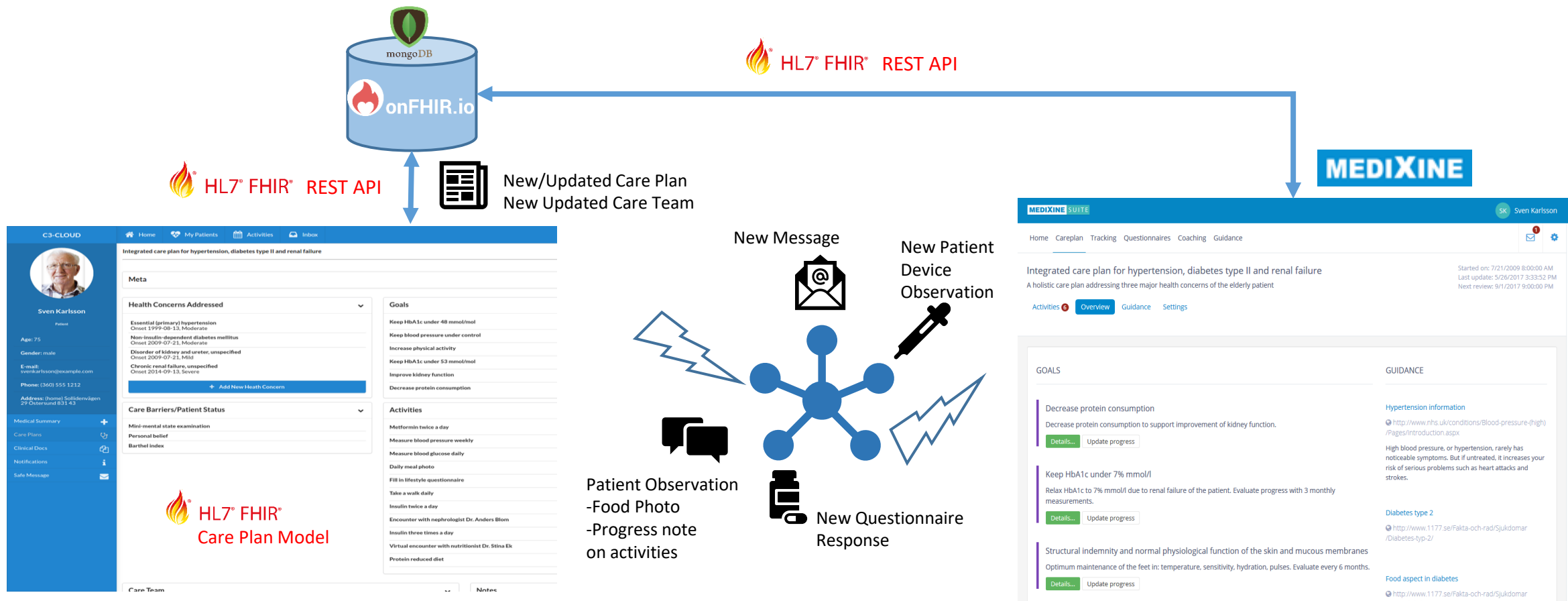
- ▼ **Reduce weight** Feedback
- ▼ **Stop smoking** Feedback
- ▼ **Avoid diabetic foot complications** Feedback
- ▼ **Maintain & improve mobility** Feedback
- ▲ **Keep blood pressure under control** Feedback
 - Priority: High Priority
 - Status: In Progress
 - Start: 07/08/2018
 - Due date: 08/11/2018
 - Target:
Systolic Blood Pressure < 130 mmHg
Diastolic Blood Pressure < 80 mmHg
 - Expressed by: Anna Svensson

Info
Information materials assigned to you to help you understand your conditions and increase your confidence to manage your health.

Type 2 Diabetes <https://patient.info/health/type-2-diabetes>

Diabetes, Foot Care and Foot Ulcers

CARE TEAM – PATIENT COLLABORATION



Personalised Care Plan Management

Event Notification Integration

C3DP (for professionals)

PEP (for patients / care givers)

THANK YOU



Any questions?
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