C3-Cloud

"A Federated Collaborative Care Cure Cloud Architecture for Addressing the Needs of Multi-morbidity and Managing Poly-pharmacy"

PRIORITY Objective H2020-PHC-25-2015 - Advanced ICT systems and services for integrated care

D6.1 C3-Cloud Technical Interoperability Implementation Guidelines and Open Source Toolkits

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EXECUTIVE SUMMARY

WP6 is responsible of the Interoperability Middleware design and development. The provided solution must address technical, semantic and privacy/security interoperability challenges to seamlessly integrate with the existing health care, social care and home/community care information systems for enabling patient-centric interoperable care coordination in an informed manner with the involvement of all stakeholders.

Task 6.1 concerns the technical layer of interoperability, in close relation with the pilot sites, according to the deliverables 8.1 Requirements and Use Cases of C3-Cloud Pilot Application, D3.2 Requirements Specification of the C3-Cloud Architecture, and the Description of Action. The WT 6.1 started in month 9 (1 January 2017) and has ended in month 18 (31 October 2017).

The deliverable D6.1 is a description of the demonstrator of the C3-Cloud Technical Interoperability Suite (TIS). This document defines the objectives of the task and tools by referencing to requirements. The document provides also a description of the implementation strategies as well a manual for the tool. The main purpose of the demonstrator and the document is to show the progress of the implementation of TIS components to implement the use cases in a concrete way. The software demonstration will be given at the project review on 8 December 2017.

TABLE OF CONTENTS

1. DOCUMENT OVERVIEW

1.1. Purpose

The deliverable D6.1 is a description of the demonstrator of the C3-Cloud Technical Interoperability Suite (TIS). This document defines the objectives of the task and tools, by referencing to requirements. The document provides also a description of the implementation strategies, as well a manual for the tool. The main purpose of the demonstrator and the document is to show the progress of the implementation of TIS components to implement the use cases in a concrete way.

1.2. Outline of the deliverable

The report on the Technical Interoperability demonstrator is organized as follows:

Section 2 summarizes the basic objectives of the task and tools that must be demonstrated by referencing to task requirements in Description of Action (DOA).

Section 3 details the implementation strategies that were adopted for delivering the demonstrator.

Section 4 provides some information on how to use the demonstrator in the specific example designed with the pilot sites.

Section 5 addresses some future plans to continue the integration work with the other components.

1.3. Scope

Following description of action (DOA), T6.1 determines the actors, transactions and data necessary to perform coordinated patient-centred care plan management. Transactions are bound to the best suitable standards (i.e. FHIR STU3), based on the state-of-the-art investigation in work package 3, for enabling medical data representation, exchange of patient data, exchange of treatment plans and communication with decision support modules. Following a profiling approach, C3-Cloud Technical Interoperability Implementation Guidelines are developed upon C3-Cloud FHIR profiles, together with open source toolkits implementing these guidelines. The open source toolkits are integrated with the patient data sources in C3-Cloud, including OSAKI, RJH and SWFT.

1.4. Context

C3-Cloud TIS provides interoperability interfaces to enable seamless data exchange with the local care systems although the data exchange protocols and clinical data representation formats may be heterogeneous across C3-Cloud components and the IT systems utilized in local care sites. TIS provides a **standard based data exchange protocol** to enable information exchange between local care systems and C3-Cloud components. In the conceptual design of C3-Cloud architecture (Figure 1),

- FHIR is adopted as the standard for data exchange between C3-Cloud components;
- TIS imports patient data and/or clinical documents from local care system into C3-Cloud via either push or pull based mechanisms;
- TIS utilizes the structural mapping and terminology mapping services provided by Semantic Interoperability Suite (SIS) to transform data into FHIR format;
- TIS pushes data into C3-Cloud FHIR repository (provided as part of Coordinated Care and Cure Delivery Platform) through FHIR RESTful API;

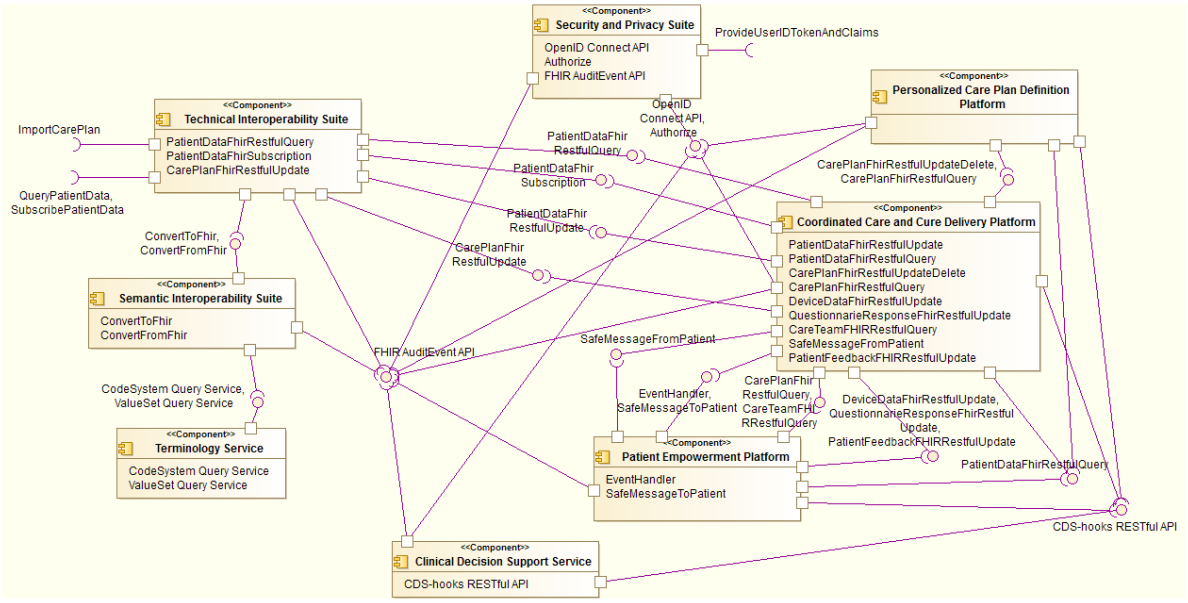

Figure 1 C3-Cloud Component Diagram from D3.3- Conceptual Design of the C3-Cloud Architecture

1.5. Abbreviations and Acronyms

Abbreviation / Acronym	Definition
C3DP	Coordinated Care and Cure Delivery Platform
CDSM	Clinical Decision Support Module
DOA	Description of Action
EHR	Electronic Health Record
ETL	Extract, Transform and Load
FHIR	Fast Healthcare Interoperability Resources
OSAKI	Servicio Vasco de Salud Osakidetza
PCPDP	Personalised Care Plan Development Platform
PEP	Patient Empowerment Platform
PHR	Personal Health Record
RJH	REGION JAMTLAND HARJEDALEN
SIS	Semantic Interoperability Suite
SPS	Security and Privacy Suite
SWFT	SOUTH WARWICKSHIRE NHS FOUNDATION TRUST
TIS	Technical Interoperability Suite

2. TECHNICAL INTEROPERABILITY OBJECTIVES

TIS technical requirements and conceptual design were elicited and documented in D3.2 and D3.3. Following the progress of the project, changes to the original requirements and design are made to meet the needs and constraints of the EHR data sources. This section defines the objectives of the task 6.1 and the delivered software tool, by referencing to the original requirements and design in D3.2 and D3.3 and describing their changes.

2.1. Original Use Cases for Technical Interoperability Suite

Five TIS use cases were identified and described in D3.2 (section 3.2):

- TIS-1: Query Patient Data

  This use case queries and extracts patient data from local care systems (including primary care, secondary care, social care, home/community care), at the request of C3-Cloud components, e.g., C3DP. This use case implements the "pull" model of system integration.

- TIS-2: Share Care Plan

  This use case exports the integrated care plan created by the C3-Cloud system to local care systems. The objective of this use case is to allow local care systems to import C3-Cloud care plan and manage it within local environment.

- TIS-3: Push Patient Observations

  This use case pushes patient observations collected by a tele-monitoring system or PHR to C3-Cloud components, e.g., PEP or C3DP. The assumption of this use case is PEP and other C3-Cloud components will use TIS to integrate tele-monitoring devices.

- TIS-4: Map Information Models and Terminologies

  Local care systems have diverse information models and coding schemes of patient datasets. This use case uses the semantic interoperability platform to map information models and terminologies between the C3-Cloud system and local care systems. This use case is a sub-use case triggered by other use cases.

- TIS-5: Push Patient Data

  This use case pushes patient data from local care systems to C3-Cloud components e.g. C3DP. The assumption of this use case is that the local care system is able to subscribe C3-Cloud to its internal events on patient data update and when an update is available the local care system can push data to C3-Cloud. This use case implements the "push" model for data integration.

Six use case actors were identified in the original use cases (Figure 2), including:

- Personalised Care Plan Development Platform (PCPDP)
- Coordinated Care and Cure Delivery Platform (C3DP)
- Patient Empowerment Platform (PEP)
- Semantic Interoperability Suite (SIS)
- PHR or tele-monitoring devices
- Local care system EHR

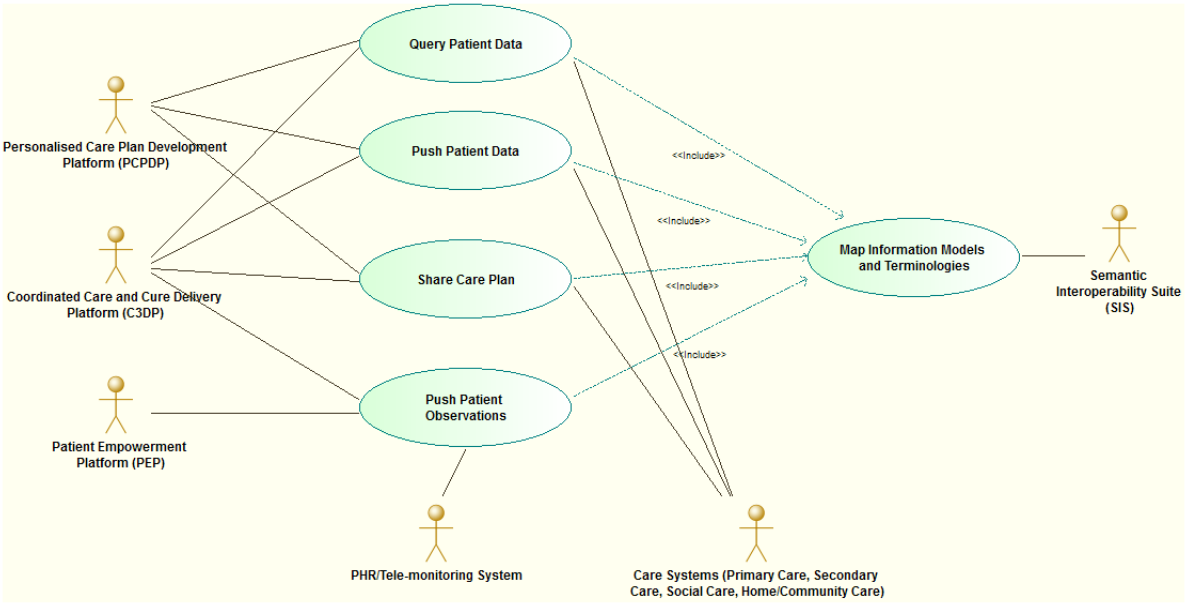

Figure 2 Original Use Case Diagram for TIS (D3.2 Figure 5)

2.2. Updates to Original Use Cases

During the conceptual design phase and integration development in T6.1, a number of changes are introduced to the original use cases:

- MEDIXINE SUITE, the product being used to implement PEP, has built-in functions to connect medical devices and has already integrated a range of devices. PEP prefers local integration and will share device observations directly with C3DP. To make the integration more efficient, TIS-3 is decided obsolete during the conceptual design phase in D3.3.
- Due to constraints of resource and operational model, the EHR data sources to be integrated in the project do not support the push-based model for data exchange. Instead, they provide either Web services or file based mechanisms for C3-Cloud to pull data.
- On the other hand, in C3-Cloud architecture, all C3-Cloud components (including TIS, PCPDP, PEP and CDSMs) are required to exchange data through a central FHIR resource repository, which is provided as part of C3DP. Therefore, a push-based model is preferred for TIS to push data into the FHIR repository.
- The EHR data sources in the project share data per individual patient. TIS should only pull data for patients upon whom data exchange has been agreed. Administrators of the local care system have the full control over when and what data is imported into C3-Cloud and allow only the patients who have consented to be included. The evaluation study in WP9 needs to maintain a one-to-one mapping between patient real identifier and study identifier, so that study data that are collected during pilot studies are exported for analysis with only pseudonyms (i.e. pseudonymisation). All this requires TIS to maintain patient identifiers and mappings to study identifiers.
- During the conceptual design phase in D3.3, PCPDP was decided to merge with C3DP as a single software component. The new component is still named as C3DP.

As a consequence, three original uses cases TIS-1, TIS-3 and TIS-5 were eliminated and two new use cases were developed in order to meet the needs of C3-Cloud architecture and constraints of EHR data sources: (1) “Import Patient Data” (TIS-6), which combines TIS-1 and TIS-5 and (2) “Register Patient” (TIS-7). Figure 3 represents the new version of the UML use case diagram following the changes.

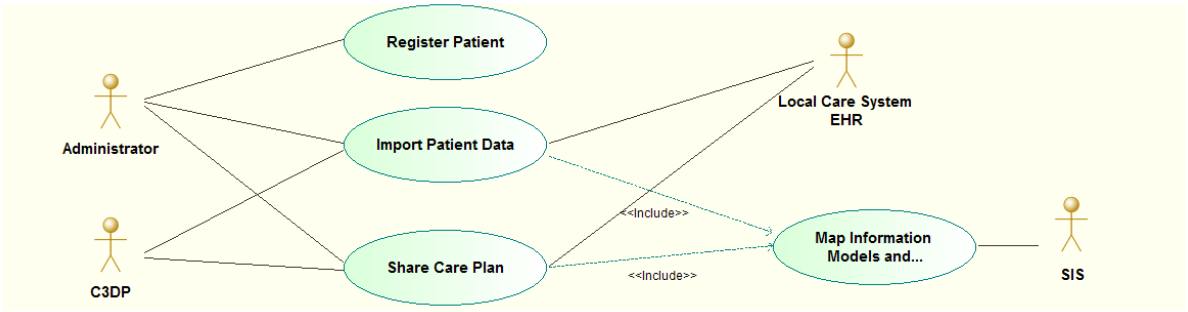

Figure 3 Technical Interoperability Suite Use Case Diagram Version 2

2.2.1. TIS-6: Import Patient Data

Title	TIS-6: Import Patient Data
Description	This use case queries and extracts patient data from local care system EHR and pushes into C3DP FHIR repository.
Purpose	So C3-Cloud components C3DP and CDSMs can use patient medical information to create, update or execute care plans, and generate decision support suggestions.
Information	Clinical documents captured as part of clinical workflow (e.g. visit summary, consultation note, operative note, discharge summary, etc.) Discrete data elements in care records
Parent	-
Included sub-use cases	TIS-4: Map Information Models and Terminologies
Extended sub-use cases	-
Scope	Technical Interoperability Platform
Actor(s)	Administrator C3DP Local Care System EHR
Trigger	Triggered by Administrator or C3DP to import latest patient data
Frequency	When Administrator or C3DP need to import patient data

Preconditions

1. A local care system EHR is integrated with TIS.
2. Organisational policies are in place to allow patient data to be shared between the local care system and C3-Cloud.
3. Security mechanisms are established between the EHR and TIS to authenticate and authorize the request, audit the access, and protect data transport.

4. Structural mapping and terminology mapping are available at SIS.

Minimal Post-conditions

1. TIS logs the operation outcome, whether the operation succeeds or fails.

Success Post-conditions

1. Patient data for the requested patients are retrieved from the local care system EHR.
2. Patient data are transformed into FHIR and saved into C3DP FHIR repository.

Main Flow

1. Administrator or C3DP requests TIS to import patient data for one patient or a group of patients from local care system EHR.
2. TIS sends a data extraction request to the EHR for requested patients.
3. EHR returns requested data to TIS.
4. TIS transforms the patient data into FHIR resources using the use case "TIS-4: Map Information Models and Terminologies".
5. If a FHIR patient resource is generated, TIS adds the patient's study id (which is added via use case "TIS-7: Register Patient") to the patient resource as a business identifier.
6. TIS saves the FHIR resources into C3DP FHIR repository.

Alternative Flows

3a. Request rejected

1. The local care system EHR rejects the data extraction request because the requested patient data is not allowed to share
2. TIS logs the rejection and optionally notifies system administrator.

3b. Data not available

1. The local care system EHR has no data for the requested patients.
2. TIS logs the failure and optionally notifies system administrator.

3c. EHR failure

1. The local care system EHR fails to respond because of internal error.
2. TIS logs the failure and optionally notifies system administrator.

4a. SIS failure

1. SIS fails to respond because of internal error.
2. TIS logs the failure and optionally notifies system administrator.

5a. C3DP FHIR repository failure

1. C3DP FHIR repository fails to respond because of internal error.
2. TIS logs the failure and optionally notifies system administrator.

Notes

This use case combines the pull model in TIS-1 and the push model in TIS-5 into a single use case, in which TIS pulls data from data source and pushes data into C3DP FHIR repository.

2.2.2. TIS-7: Register Patient

Title	TIS-7: Register Patient
Description	This use case adds or removes patient identifiers and their mapping to C3-Cloud study identifiers.
Purpose	So TIS can pull data of a specific patient using his/her identifier and add C3-Cloud study id to the generated FHIR resources.
Information	Patient identifiers Study identifiers
Parent	-
Included sub-use cases	-
Extended sub-use cases	-
Scope	Technical Interoperability Platform
Actor(s)	Administrator
Trigger	Triggered by Administrator to add or removes patient identifiers
Frequency	When a new patient joins or a recruited patient withdraws

Preconditions

1. Organisational policies are in place to allow patient data to be shared between the local care system and C3-Cloud.
2. A new patient consents and joins or an existing patient withdraws.
3. The patient has been allocated a study id.

Minimal Post-conditions

1. TIS notifies administrator the operation outcome, whether the operation succeeds or fails.

Success Post-conditions

1a. Patient id and its associated study id are added.

1b. Patient id is removed.

Main Flow – Add Patient

1. Administrator requests TIS to add a new patient id.
2. TIS prompts administrator to provide a study id.
3. Administrator provides the study id.
4. TIS adds the patient id and study id.

Main Flow – Remove Patient

1. Administrator requests TIS to remove an existing patient id.
2. TIS removes the patient id.

2.3. Specifications for Technical Interoperability Suite

The functional requirement specification can be summarized as follows:

- TIS registers patient identifier and associated study identifier when a patient is recruited and added into C3-Cloud.
- TIS deregisters patient identifier when a patient withdraws from C3-Cloud.
- TIS extracts patient records and/or clinical documents from local care system EHR using provided native API.
- TIS transforms patient records or clinical documents received from local care system EHR into FHIR resources using the structural mapping service and terminology mapping service provided by SIS.
- TIS adds study identifier into generated FHIR patient resource as an additional business identifier.
- TIS pushes FHIR resources into C3DP FHIR repository using standard FHIR RESTful API.

The non-functional requirements can be summarised as:

- The call to other components (local care system EHR, SIS, C3DP) should return results in reasonable time.
- The system shall not fail if other components fail to respond.
- All data communications with local care system EHR and C3-Cloud components should be protected and audited.

The detailed system requirement specifications for TIS, including functional, non-functional, interface and information requirements, are described in D3.2 (section 4.2). The requirements are maintained in WP3 using a requirement traceability matrix.

3. TIS IMPLEMENTATION STRATEGIES

The Technical Interoperability Suite enables data exchange between the EHR system in local care settings and C3-Cloud components. The transactions that TIS needs to support are described by the use cases in section 2. The implementation of TIS is based on the emerging FHIR standard for interoperability and the data exchange protocols imposed by local care system EHR API. The details of the local EHR API are described in section 3.4. The architecture and implementation details of TIS are described in section 0. One of the key issues of data exchange is interoperability of clinical data

elements. TIS follows a profiling approach to develop C3-Cloud specific profiles based on FHIR standard. The profiles establish a common data standard within C3-Cloud operational environment to enable semantic interoperability. The details of the C3-Cloud profiles are described in section 3.2. TIS uses the security and privacy suite (SPS) to integrate into the local EHR's security environment. The details of SPS are covered in the deliverable D6.3.

3.1. Data dictionary

T6.1 designed a data dictionary template and circulated to all three pilot sites in C3-Cloud: OSAKI, RJH and SWFT. The template was inspired by FHIR STU3 resource definition, but instead of using formal FHIR data types with which pilot sites are not familiar, the template used loosely defined types to make it easier to understand. The objective of the templates is to understand the data capability of each site, namely what data elements are supported and what are not. The templates were filled in and collected from all pilot sites and consolidated into a single data dictionary. The data dictionary is used as the basis to inform the development of C3-Cloud FHIR profiles.

Table 1 C3-Cloud data dictionary

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
Patient	identifier	YES	1..1	identifier
	given name	YES	1..3	text
	family name	YES	1..1	text
	gender	YES	1..1	coded
	birth date	YES	1..1	date
	birth sex	NO		
	marital status	NO		
	mobile phone	YES	0..3	text
	email address	YES	0..1	text
	physical address	YES	0..2	Province, municipality, town, town, street, nº, building, floor, hand, postal code
	photo	NO		
	general practitioner	YES	1..1	identifier
	managing organization	YES	1..1	identifier
	informal care giver	NO		
	general nurse	YES	0..1	identifier
Health Professional / Social Care Worker	identifier	YES	1..1	identifier
	given name	YES	1..3	text
	family name	YES	1..1	text
	gender	YES	0..1	coded
	birth date	YES	0..1	date
	specialty	YES	0..1	coded
	organization	YES	1..1	identifier
	mobile phone	YES	0..1	text

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
	work phone	YES	0..1	text
	email address	YES	0..1	text
	physical address	NO		
	photo	NO		
Informal Care Giver (Nurse Platform or HIS)	identifier	YES	0..1	identifier
	given name	YES	1..3	text
	family name	YES	1..1	text
	gender	NO		
	birth date	NO		
	relationship	YES	0..1	coded
	mobile phone	NO		
	email address	NO		
	physical address	NO		
	photo	NO		
Encounter (appointment or clinical episodies?)	identifier	YES	0..1	identifier
	status	YES	1..1	coded
	class	YES	0..1	coded
	type	YES	0..1	
	patient	YES	1..1	identifier
	start time	YES	1..1	datetime
	end time	YES	0..1	datetime
	reason	YES	0..1	coded
	location	YES	1..1	coded
Condition / Problem / Diagnosis	identifier	YES	0..1	identifier
	patient	YES	1..1	identifier
	clinical status	YES	1..1	coded
	verification status	NO		
	severity	YES	1..1	coded
	problem name	YES	1..1	text
	problem code	YES	1..1	coded
	actual start date	YES	1..1	date
	actual end date	YES	0..1	
	asserter	YES	1..1	identifier
	record date	YES	1..1	date
	note	NO		
	encounter	YES	1..1	identifier
Allergy / Intolerance	identifier	YES	0..1	identifier
	clinical status	YES	0..1	
	verification status	YES	0..1	coded
	type	YES	1..1	coded

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
	category	YES	0..1	
	criticality	YES	0..1	
	code	YES	1..1	text
	patient	YES	1..1	identifier
	onset	YES	0..1	
	recorder	YES	0..1	
	asserter	NO		
	last occurrence	NO		
Procedure	identifier	YES	0..1	identifier
	status	YES	0..1	coded
	category	YES	1..1	coded
	code	YES	1..1	coded
	subject	YES	1..1	identifier
	encounter	YES	1..1	identifier
	performed date	YES	1..1	date
	performer	YES	1..1	identifier
	location	YES	1..1	identifier
	reason	YES	1..1	coded
	not performed	NO		
	reason if not performed	NO		
	outcome	NO		
	complication	NO		
Lab Result	identifier	YES	0..1	identifier
	status	YES	1..1	coded
	code	YES	1..1	coded
	subject	YES	1..1	identifier
	encounter	NO		
	effective	NO		
	recorded date	YES	1..1	date
	recorded by	YES	0..1	identifier
	result value	YES	1..N	decimal or coded
	result value unit	YES	1..N	coded
	reason if data absent	NO		
	reference range	YES	0..1	
Vital Sign	identifier	YES	0..1	identifier
	Status	NO		
	code	YES	0..1	
	subject	YES	1..1	identifier
	encounter	YES	0..1	identifier
	effective	NO		

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
	recorded date	YES	1..1	date
	recorded by	YES	1..1	identifier
	value	YES	1..1	text
	unit	YES	1..1	text
	reason if data absent	NO		
	reference range	NO		
	component	NO	0..*	
	component.value			decimal or coded
	component.unit			coded
	component.reason if data absent			coded
Prescription / Medication Statement	identifier	YES	0..1	identifier
	status	YES	0..1	coded
	medication	YES	1..1	coded
	subject	YES	1..1	identifier
	encounter	YES	1..1	identifier
	effective	YES	0..1	date or date range
	prescription date	YES	1..1	date
	prescribed by	YES	1..1	identifier
	reason for the prescription	YES	1..1	coded
	category	YES	0..1	coded
	dosage timing	YES	1..1	
	site	NO		
	route	YES	0..1	coded
	method	NO		
	total amount	YES	0..1	
	rate	NO		
Immunization / Vaccination	identifier	YES	0..1	identifier
	status	YES	0..1	coded
	administration date	YES	1..1	date
	vaccine code	YES	1..1	coded
	reason for immunization	NO		
	patient	YES	1..1	identifier
	was not given	YES	1..1	boolean
	reason for not given	YES	0..1	
	performer	YES	1..1	identifier
	requester	YES	0..1	identifier
	encounter	YES	1..1	identifier
	location	YES	0..1	text

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
	site	YES	0..1	coded
	route	NO		
	dose quantity	NO		
Medical / Implanted Device	unique device identifier	NO		
	device type	NO		
	manufacturer	NO		
	manufacture date	NO		
	expiration date	NO		
	model	NO		
	version	NO		
	patient	NO		
	owner	NO		
	contact	NO		
Social History	identifier	YES	0..1	identifier
	status	NO		
	code	YES	0..1	coded
	subject	YES	0..1	identifier
	encounter	YES	0..1	identifier
	effective	NO		
	recorded date	YES	0..1	date
	recorded by	YES	0..1	identifier
	result value	YES		coded
Family Member History	identifier	NO		
	patient	YES	0..1	identifier
	recorded date	YES	0..1	date
	status	NO		
	family member name	NO		
	relationship	YES	0..1	coded
	gender	NO		
	date of birth or age	NO		
	deceased	NO		
	condition	YES	0..1	
	condition.code	YES	0..1	coded
	condition.outcome	NO		
	condition.onset	NO		
Functional Status	identifier	YES	0..1	identifier
	patient	YES	0..1	Identifier
	start date	YES	0..1	date
	end date	NO		
	value coded	YES	0..1	coded
	value text	YES	0..1	text
	asserter	YES	0..1	Identifier

Entity	Attribute	Present?	Cardinality	Data Type [text / integer / identifier / coded / date / boolean / binary]
Mental Status	identifier	YES	0..1	identifier
	patient	YES	0..1	Identifier
	start date	YES	0..1	date
	end date	NO		
	value coded	YES	0..1	coded
	value text	YES	0..1	text
	asserter	YES	0..1	Identifier
Assessment Scale	identifier	YES	0..1	identifier
	patient	YES	1..1	identifier
	assessment date	YES	1..1	date
	scale	YES	1..1	coded
	value quantity	YES	1..1	integer
	reference range	NO		integer
	asserter	YES	0..1	identifier
Risk Assessment	identifier	NO		
	patient	NO		
	assessment date	NO		
	assessment type	NO		
	outcome	NO		
	effective date range	NO		
	assessment performer	NO		
Personal Belief	identifier	NO		
	patient	NO		
	record date	NO		
	belief text	NO		
	asserter	NO		
Care Barrier Observation	identifier	NO		
	patient	NO		
	record date	NO		
	barrier coded	NO		
	barrier text	NO		
	asserter	NO		

3.2. FHIR C3-Cloud profiles

C3-Cloud architecture builds on FHIR based data exchange protocols. Clinical data elements need to map to FHIR resources in order to be computable. Following a profiling approach, T6.1 defines C3-Cloud FHIR profiles to describe the data elements necessary to perform coordinated patient-centred care plan management. The profiles are based on FHIR STU3 base specification. Note that while some data elements, as being identified in the data dictionary in section 3.1, might not be available from local care system EHRs, the profiles may still include the data elements, by taking into account the

personalised care planning and decision support requirements. The FHIR profiles establish a common data model within the C3-Cloud system and are the structural mapping target in T6.2 for semantic interoperability. In Table 2, the ValueSet column indicates for coded data type (i.e. FHIR code, coding and CodeableConcept) where the value set is from. FHIR means it is a FHIR defined value set. Local means it is the original code being used in the source EHR system. C3-Cloud means it is a value set defined by the project.

Table 2 C3-Cloud FHIR Profiles

FHIR Resource	Attribute	Cardinality	Type	ValueSet
Resource	id	0..1	id	
	meta.versionId	0..1	id	
	meta.lastUpdated	0..1	instant	
	meta.profile	0..*	uri	
Reference	reference	0..1	string	
	identifier	0..1	Identifier	
	display	0..1	string	
Patient	identifier	1..*	Identifier	
	name	1..1	HumanName	
	telecom	0..*	ContactPoint	
	gender	1..1	code	FHIR
	birthDate	0..1	date	
	address	0..*	Address	
	generalPractitioner	0..*	Reference (Practitioner)	
	managingOrganization	0..1	Reference (Organization)	
	photo	0..1	Attachment	
RelatedPerson	identifier	1..*	Identifier	
	active	0..1	boolean	
	patient	1..1	Reference (Patient)	
	relationship	0..1	CodeableConcept	FHIR
	name	1..1	HumanName	
	telecom	0..*	ContactPoint	
	address	0..*	Address	
Practitioner	identifier	1..*	Identifier	
	active	0..1	boolean	
	name	1..1	HumanName	

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	telecom	0..*	ContactPoint	
	address	0..*	Address	
	gender	0..1	code	FHIR
	birthDate	0..1	date	
	qualification	1..*	BackboneElement	
	qualification.code	1..1	CodeableConcept	Local
	photo	0..1	Attachment	
Organization	identifier	1..*	Identifier	
	active	0..1	boolean	
	type	0..*	CodeableConcept	Local
	name	1..1	string	
	alias	0..*	string	
	telecom	0..*	ContactPoint	
	address	0..*	Address	
	partOf	0..1	Reference (Organization)	
Encounter	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	class	0..1	Coding	FHIR
	type	0..*	CodeableConcept	Local
	subject	0..1	Reference (Patient)	
	period	0..1	Period	
	reason	0..*	CodeableConcept	Local
	location	0..*	BackboneElement	
	location.location	1..1	Reference (Location)	
	location.period	0..1	Period	
Location	identifier	0..*	Identifier	
	status	0..1	code	FHIR
	name	0..1	string	
	alias	0..*	string	
	description	0..1	string	
	mode	0..1	code	FHIR
	type	0..1	CodeableConcept	FHIR

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	address	0..1	Address	
AllergyIntolerance	identifier	1..*	Identifier	
	clinicalStatus	0..1	code	FHIR
	verificationStatus	1..1	code	FHIR
	type	0..1	code	FHIR
	category	0..*	code	FHIR
	code	1..1	CodeableConcept	Local
	patient	1..1	Reference (Patient)	
	onset	1..1	dateTime	
	recorder	0..1	Reference (Practitioner | Patient)	
	lastOccurrence	0..1	dateTime	
	reaction	0..*	BackboneElement	
	substance	0..1	CodeableConcept	Local
	manifestation	1..*	CodeableConcept	Local
	description	0..1	string	
Condition	identifier	1..*	Identifier	
	clinicalStatus	0..1	code	FHIR
	severity	0..1	CodeableConcept	Local
	code	0..1	CodeableConcept	Local
	subject	1..1	Reference (Patient)	
	context	0..1	Reference (Encounter)	
	onset	0..1	dateTime	
	abatement	0..1	dateTime	
	assertedDate	0..1	dateTime	
	asserter	0..1	Reference (Practitioner)	
	note	0..*	Annotation	
Procedure	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	notDone	0..1	boolean	
	notDoneReason	0..1	CodeableConcept	Local
	category	0..1	CodeableConcept	Local
	code	1..1	CodeableConcept	Local

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	subject	1..1	Reference (Patient)	
	context	0..1	Reference (Encounter)	
	performed	1..1	dateTime | Period	
	performer	0..*	BackboneElement	
	performer.actor	1..1	Reference (Practitioner)	
	location	0..1	Reference (Location)	
	reasonCode	0..*	CodeableConcept	Local
	outcome	0..1	CodeableConcept	Local
	bodySite	0..*	CodeableConcept	Local
	note	0..*	Annotation	
FamilyMemberHistory	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	patient	1..1	Reference (Patient)	
	date	0..1	dateTime	
	name	0..1	string	
	relationship	1..1	CodeableConcept	Local
	gender	0..1	code	FHIR
	born	0..1	date	
	age	0..1	Age	
	deceased	0..1	boolean | Age | date	
	condition	0..*	BackboneElement	
	condition.code	1..1	CodeableConcept	Local
	condition.onset	0..1	Age | Period	
	note	0..*	Annotation	
Observation	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	category	0..*	CodeableConcept	FHIR
	code	1..1	CodeableConcept	Local
	subject	1..1	Reference (Patient)	
	context	0..1	Reference (Encounter)	
	effective	0..1	dateTime | Period	
	issued	0..1	instant	

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	performer	0..*	Reference (Practitioner | Patient | RelatedPerson)	
	value	0..1	Quantity | CodeableConcept | string | boolean | Attachment	Local
	referenceRange	0..*	BackboneElement	
	referenceRange.low	0..1	SimpleQuantity	
	referenceRange.high	0..1	SimpleQuantity	
	referenceRange.age	0..1	Range	
	referenceRange.text	0..1	string	
	component			
	code	1..1	CodeableConcept	Local
	value	0..1	Quantity | CodeableConcept | string | boolean | Attachment	
	referenceRange	0..*	referenceRange	
	interpretation	0..1	CodeableConcept	FHIR
	interpretation	0..1	CodeableConcept	FHIR
	device	0..1	Reference (Device | DeviceMetric)	
	comment	0..1	string	
MedicationStatement	identifier	1..*	Identifier	
	context	0..1	Reference (Encounter)	
	status	1..1	code	FHIR
	category	0..1	CodeableConcept	Local
	medication	1..1	CodeableConcept	Local
	effective	0..1	dateTime | Period	
	dateAsserted	0..1	dateTime	
	informationSource	0..1	Reference (Patient | Practitioner | RelatedPerson)	
	subject	1..1	Reference (Patient)	
	taken	1..1	code	FHIR

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	reasonCode	0..*	CodeableConcept	Local
	reasonReference	0..*	Reference (Condition | Observation)	
	dosage	0..*	Dosage	
Immunization	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	notGiven	1..1	boolean	
	vaccineCode	1..1	CodeableConcept	Local
	patient	1..1	Reference (Patient)	
	encounter	0..1	Reference (Encounter)	
	date	0..1	dateTime	
	primarySource	1..1	boolean	
	location	0..1	Reference (Location)	
	doseQuantity	0..1	SimpleQuantity	
	practitioner	0..*	BackboneElement	
	practitioner.role	0..1	CodeableConcept	FHIR
	practitioner.actor	1..1	Reference (Practitioner)	
	explanation	0..1	BackboneElement	
	reason	0..*	CodeableConcept	Local
	reasonNotGiven	0..*	CodeableConcept	Local
Dosage	text	0..1	string	
	patientInstruction	0..1	string	
	timing	0..1	Timing	
	asNeeded	0..1	boolean	
	route	0..1	CodeableConcept	Local
	dose	1..1	Range | SimpleQuantity	
	maxDosePerPeriod	0..1	Ratio	
	maxDosePerAdministration	0..1	SimpleQuantity	
	maxDosePerLifetime	0..1	SimpleQuantity	
	rate	0..1	Ratio | Range | SimpleQuantity	
CarePlan	identifier	1..*	Identifier	
	status	1..1	code	FHIR

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	intent	1..1	code	FHIR
	category	0..1	CodeableConcept	C3-Cloud
	title	1..1	string	
	description	0..1	string	
	subject	1..1	Reference (Patient)	
	period	1..1	Period	
	author	1..*	Reference (Practitioner)	
	careTeam	1..1	Reference (CareTeam)	
	addresses	0..*	Reference (Condition)	
	supportingInfo	0..*	Reference (Observation)	
	goal	0..*	Reference (Goal)	
	nextReviewDate	0..1	Extension (DateTime)	
	activity	0..*	BackboneElement	
	activity.outcomeCodeableConcept	0..*	CodeableConcept	Local
	outcomeReference	0..*	Reference (Observation)	
	progress	0..*	Annotation	
	title	1..1	Extension (string)	
	reference	0..1	Reference (Appointment | CommunicationRequest | DeviceRequest | MedicationRequest | ProcedureRequest | ReferralRequest | RequestGroup)	
	detail	0..1	BackboneElement	
	category	1..1	CodeableConcept	FHIR
	definition	0..1	Reference (Questionnaire)	
	code	0..1	CodeableConcept	C3-Cloud
	reasonCode	0..*	CodeableConcept	C3-Cloud
	reasonReference	0..*	Reference (Condition)	
	goal	0..*	Reference (Goal)	
	status	1..1	code	FHIR
	statusReason	0..1	string	

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	prohibited	0..1	boolean	
	scheduled	0..1	Timing | Period	
	location	0..1	Reference (Location)	
	performer	0..*	Reference (Practitioner | Patient)	
	product	0..1	CodeableConcept	C3-Cloud
	dailyAmount	0..1	SimpleQuantity	
	quantity	0..1	SimpleQuantity	
	description	0..1	string	
	identifier	1..1	Extension (Identifier)	
	introducedBy	1..1	Extension (Reference [Practitioner])	
	replacedBy	0..1	Extension (Identifier)	
Goal	identifier	1..*	Identifier	
	status	1..1	code	FHIR
	category	1..*	CodeableConcept	FHIR
	priority	0..1	CodeableConcept	FHIR
	description	1..1	CodeableConcept	C3-Cloud
	subject	1..1	Reference (Patient)	
	start	1..1	date	
	target	0..1	BackboneElement	
	measure	0..1	CodeableConcept	C3-Cloud
	detail	0..1	Quantity | Range | CodeableConcept	
	due	0..1	date	
	statusDate	0..1	date	
	statusReason	0..1	string	
	expressedBy	1..1	Reference (Practitioner)	
	addresses	0..*	Reference (Condition | Observation)	
	note	0..*	Annotation	
	outcomeCode	0..*	CodeableConcept	C3-Cloud
	outcomeReference	0..*	Reference (Observation)	
	title	1..1	Extension (string)	

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	goalRelationship	0..*	Extension (complex)	
	type	1..1	CodeableConcept	FHIR
	target	1..1	Reference (Goal)	
CareTeam	identifier	0..*	Identifier	
	status	1..1	code	FHIR
	category	0..1	CodeableConcept	FHIR
	name	1..1	string	
	subject	1..1	Reference (Patient)	
	period	1..1	Period	
	participant	1..*	BackboneElement	
	role	0..1	CodeableConcept	C3-Cloud
	member	1..1	Reference (Practitioner | RelatedPerson)	
	onBehalfOf	0..1	Reference (Organization)	
	period	0..1	Period	
	isManager	0..1	Extension (boolean)	
Appointment	identifier	0..*	Identifier	
	status	1..1	code	FHIR
	serviceCategory	0..1	CodeableConcept	FHIR
	serviceType	0..1	CodeableConcept	FHIR
	specialty	1..1	CodeableConcept	FHIR
	appointmentType	0..1	CodeableConcept	FHIR
	reason	0..*	CodeableConcept	C3-Cloud
	priority	0..1	unsignedInt	
	description	0..1	string	
	start	1..1	instant	
	end	0..1	instant	
	created	1..1	dateTime	
	comment	0..1	string	
	incomingReferral	0..*	Reference (ReferralRequest)	
	participant	1..*	BackboneElement	
	type	0..1	CodeableConcept	

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	actor	0..1	Reference (Patient | Practitioner | RelatedPerson | HealthcareService | Location)	
	required	0..1	code	FHIR
	status	1..1	code	FHIR
	pertainsToGoal	0..*	Extension (Reference [Goal])	
ReferralRequest	identifier	0..*	Identifier	
	status	1..1	code	FHIR
	intent	1..1	code	FHIR
	type	0..1	CodeableConcept	Local
	priority	0..1	code	FHIR
	serviceRequested	0..*	CodeableConcept	Local
	subject	1..1	Reference (Patient)	
	occurrence	1..1	dateTime | Period	
	authoredOn	1..1	dateTime	
	requester	1..1	BackboneElement	
	agent	1..1	Reference (Practitioner)	
	specialty	0..1	CodeableConcept	Local
	recipient	1..*	Reference (Practitioner | Organization)	
	reasonCode	0..*	CodeableConcept	Local
	reasonReference	0..*	Reference (Condition | Observation)	
	description	0..1	string	
	note	0..*	Annotation	
	pertainsToGoal	0..*	Extension (Reference [Goal])	
ProcedureRequest	identifier	0..*	Identifier	
	status	1..1	code	FHIR
	intent	1..1	code	FHIR
	priority	0..1	code	FHIR
	category	0..*	CodeableConcept	Local

FHIR Resource	Attribute	Cardinality	Type	ValueSet
	code	1..1	CodeableConcept	Local
	subject	1..1	Reference (Patient)	
	occurrence	1..1	dateTime | Period	
	authoredOn	0..1	dateTime	
	requester	0..1	BackboneElement	
	agent	1..1	Reference (Practitioner)	
	performerType	0..1	CodeableConcept	Local
	recipient	1..*	Reference (Practitioner | Organization | Patient)	
	reasonCode	0..*	CodeableConcept	Local
	reasonReference	0..*	Reference (Condition | Observation)	
	note	0..*	Annotation	
	pertainsToGoal	0..*	Extension (Reference [Goal])	
CommunicationRequest (used for educational material)	identifier	0..*	Identifier	
	status	1..1	code	FHIR
	category	0..*	CodeableConcept	C3-Cloud
	recipient	0..*	Reference (Patient)	
	payload	1..*	BackboneElement	
	content	1..1	Attachment	
	occurrence	1..1	Period	
	authoredOn	1..1	dateTime	
	sender	0..1	Reference (Practitioner)	
	reasonCode	0..*	CodeableConcept	C3-Cloud
	note	0..*	Annotation	

3.3. TIS implementation

The EHR API and operational environment vary from local care system to system. In order to provide maximum flexibility and extensibility, TIS is implemented as an extract, transform and load (ETL) software development kit (SDK). ETL refers to a process in database systems especially in data warehousing where data is extracted from homogeneous or heterogeneous data sources, transformed into one consolidated format, and loaded into the final target database. The ETL model matches well the data integration scenario in C3-Cloud, where patient data is pulled out of local EHR through its native API, converted into FHIR, and pushed into C3DP FHIR repository. Inspired by the model, TIS is designed to provide an extensible library of components so as to make it easy to assemble an ETL pipeline to integrate EHR data sources.

The UML component diagram of **Error! Reference source not found.** describes the TIS architecture and its interfaces to other components. TIS provides both a web-based user interface (Control Panel UI) and a Web service API (Import Patient Data Service). The subcomponent Control Panel UI provides the user interface for end users such as system administrator to register patient id and schedule patient data integration jobs. The patient id is the primary key to retrieve and link patient records at each site. Users can execute a predefined data integration job at once or schedule it as a periodic task to run at regular intervals or times. The subcomponent Import Patient Data Service provides a RESTful API for other application components such as C3DP to trigger the data integration process in order to get a snapshot of the latest patient data.

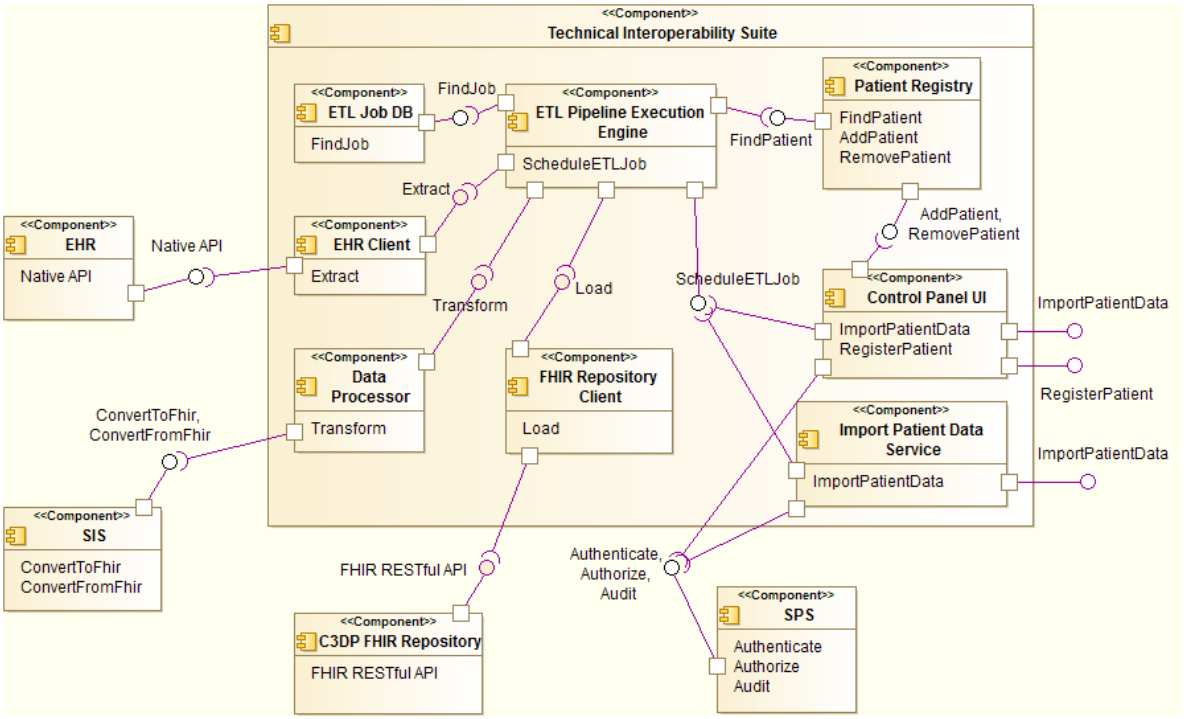

Figure 4 Technical Interoperability Suite Architecture

All data integration jobs are defined as ETL pipelines and saved in an ETL job database (ETL Job DB). An ETL pipeline specifies all data processing steps necessary to extract from EHR, transform into FHIR and load into C3DP FHIR repository. An example of ETL pipeline, encoded in JSON format, is shown in Figure 6, which describes the process of integrating OSAKI's CDA service: calling the SOAP service, extracting CDA xml content, passing to SIS to generate FHIR resources, and saving to C3-Cloud FHIR server.

The core of TIS is the ETL Pipeline Execution Engine. When it receives a request of importing patient data, the engine finds the patient in the Patient Registry, retrieves ETL pipeline definition from the ETL Job DB, parse the definition, and execute the specified operations by calling other SDK components. For example, the engine will call the EHR Client to extract data using the EHR's native API, call a Data Processor to generate FHIR resources which in turn calls SIS structural mapping service, and call the FHIR Repository Client to push data into C3-Cloud FHIR repository, which completes the pipeline process. The UML sequence diagram in Figure 5 shows a typical TIS interaction workflow. The implementation of the engine leverages Java 8 streams library and Java thread pool executors.

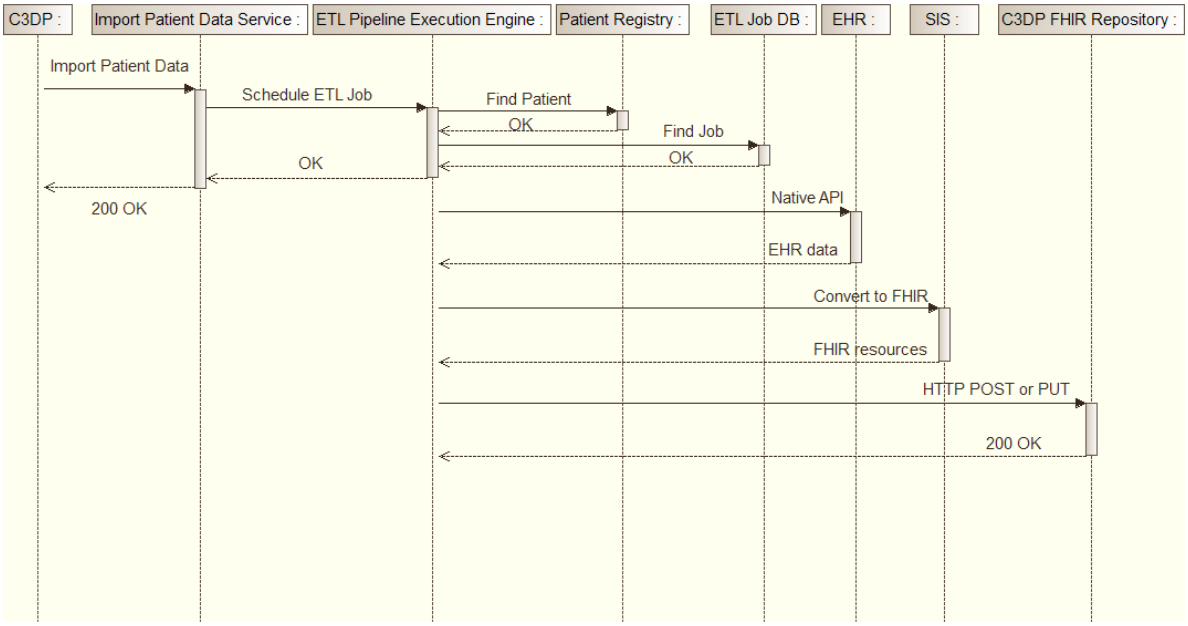

Figure 5 Example TIS Interaction Workflow

TIS uses SPS to integrate into C3-Cloud security framework within which single sign-on (SSO), secure communication, and audit logging are supported. The integration will be completed in T7.4.

The TIS server is built as a Spring Boot v1.5 application. MySQL 5.7 is used as the database backend to store ETL pipeline definitions, leveraging its JSON capability. The UI is implemented using a progressive JavaScript framework Vue.js.

```
{
  "name": "OSAKIDETZA-CDA",
  "version": 1,
  "description": "Extract from OSAKI CDA service and load into C3DP.",
  "dateModified": "2017-09-12T13:06:06Z",
  "extractTask": {
    "type": "foreach",
    "outputQueue": {"@id": 1, "capacity": 0},
    "parallelism": 2,
    "inputExpression": {
      "type": "SpEL",
      "expression": "get('PatientList').![{'patient.id':patientId}]"
    },
    "transformations": [
      {
        "url":                "http://pre.osb.osasunet:80/osakidetza/negocio/asistencial
/OsabideGlobal/HCRWS_v1/HCRWS",
        "type": "soap",
        "envelopeTemplate":          "<soapenv:Envelope          xmlns:soapenv=\"http://
schemas.xmlsoap.org/soap/envelope/\"                xmlns:tem=\"http://tempuri.org/\">\n
<soapenv:Header/>\n  <soapenv:Body>\n  <tem:getInformeHCRCDA3_V2>\n    <!--Optional:-->\n
<tem:Cic>${patient.id}</tem:Cic>\n                                          <!--Optional:-->\n
<tem:IdIdioma>1</tem:IdIdioma>\n      </tem:getInformeHCRCDA3_V2>\n    </soapenv:Body>\n
</soapenv:Envelope>"
      }
    ]
  },
  "transformTask": {
    "type": "sequence",
    "inputQueue": 1,
    "outputQueue": {"@id": 2, "capacity": 0},
    "parallelism": 2,
    "transformations": [
      {"type": "xpath", "expression": "//HCR_CDA/text()"},
      {"type": "sis", "model": "OSAKIDETZA-CDA"}
    ]
  },
  "loadTask": {
     "type": "fhir-sink",
     "url":  "http://app.srdc.com.tr/c3cloud/fhir",
    "inputQueue": 2,
    "parallelism": 1
  }
}
```

Figure 6 ETL Job Definition Example

3.4. Current status of TIS integration with pilot sites

C3-Cloud will run pilot studies in three sites: OSAKI, RJH, and SWFT. TIS is integrated with the patient data sources at three pilot sites using different methods. This section describes the data sources and the access mechanisms provided by each site and current status of integration.

3.4.1. OSAKI

All Osakidetza centres, including both hospitals and primary care centres, have deployed a unified EHR system called Osabide Global. The system contains all health-related information on a patient, facilitating service delivery and enabling the provision of new forms of healthcare such as tele-

consultation between primary and specialized healthcare. To support integration with C3-Cloud for pilot studies, Osabide Global exposes a number of SOAP and RESTful web services (Table 3), including a CDA service HCRWS which is compliant with Spanish Health Minister Implementation Guide for Clinical Summary History in HCDSNS. TIS integrates with HCRWS as the primary data source to get patient medical summary.

Table 3 OSAKI data sources

Data source	Access API	Description
HCRWS	SOAP	The web service returns for a patient the document Summarized Clinical History (HCR) in HL7 CDA R2 format for any Community wishing to exchange this document within the HCDSNS project.
PacientesWebServiceWS	SOAP	Data Service of the Corporate Patient Data Catalog
PacientesRestWS	REST	Service for consulting the Patients catalog
DiagnosticosWS	SOAP	Service for obtaining data related to diagnoses.
ConsultaTratamientoWS	REST	Return active prescription dispensations in hospital pharmacy of a patient
ConsultaPrescripcionWS	SOAP	Return active prescription information originate from Primary Care
DocumentosPacientesWS	SOAP	This service is to provide the clients who request a report (PDF) which details the active treatment of a patient.
AlertasPacienteWS	SOAP/REST	Returns the summary of allergies of a patient as presented in the patient's view in Osabide Global, with different types of alerts, allergies, rams, programs, active principles, migration of primary allergies.
ConstantesWS	REST	The service for registration and query of patient constants or vital signs from the Hospitalization and Home Hospitalization area at Osabide Global: Systolic and athletic pressure, Heart Rate, Breathing frequency, Temperature (measurement, pathways and blood cultures), Oxygen Saturation (Measurement, Device and Flow), Glucose, Weight, Pain.
ServiciosIPLWS	SOAP	Returns the laboratory requests and the request date of the request.
CuidadosPacienteWS	SOAP	Returns diagnoses, results and interventions of the patient in a specific nursing process.

3.4.2. RJH

Cambio Cosmic is the medical record system for both primary and secondary care in Region Jämtland Härjedalen (RJH). Doctors in home care and at special housings are supplied by the primary care. Over 99% of all primary and secondary care in the region uses Cosmic. The X-ray department and the different hospital laboratories have their own different IT-systems but they are fully integrated with Cosmic. Standard e-prescriptions to the national database for pharmacies is fully integrated (one-way information) in Cosmic. RJH exposes a number of COSMIC Connect Publish (CCP) web services to support integration with C3-Cloud (Table 4). Some of the CCP services implement national service contracts defined by Swedish regulatory framework for interoperability in health and social care. The

message format of these services is based on the NPÖ RIV 2.2.0 and is compatible with HL7 CDA v2. Other services such as PatientService are COSMIC specific API. The integration with RJH CCP services is in progress. RJH is planning to deploy COSMIC Open Services by the end of 2017. COSMIC Open Services is an open platform provided by COSMIC to encourage third-party integration. The project is evaluating the new platform and may migrate to Open Services in future.

Table 4 RJH data sources

Data source	Access API	Description
PatientService	SOAP	PatientService a CCP internal API which fetches patient demographic data from the CCP framework.
ContactService	SOAP	ContactService returns a patient's care and care contacts. The service implements the national service contract GetCareContacts.
DiagnosisService	SOAP	Returns the diagnosis that a patient has been diagnosed with, i.e. return an initial diagnosis by the diagnosis time. The service implements the national service contract GetDiagnosis.
AttentionSignalService	SOAP	Returns information about a patient is particularly important for health professionals to know, for example, hypersensitivity to drugs, serious illness or health limitation. The service implements the national service contracts GetAlertInformation.
LabService	SOAP	This service is used when fetching chemistry, microbiology & radiology data from the CCP framework. The service implements the national service contract GetLaboratoryOrderOutcome.
PrescriptionService	SOAP	This service is used when fetching prescription data from the CCP framework. The service implements the national service contract GetMedicationHistory.
JournalNoteService	SOAP	This service a CCP internal API that returns a patient's journal note data, including vital signs, social history, family member history etc.

3.4.3. SWFT

There is no integrated system across South Warwickshire (SWFT). A range of commercially purchased or bespoke/in-house systems are owned and managed by different stakeholders in different care environments. EMIS Web is the GP Electronic Patient Record (EPR) system in all South Warwickshire (SWFT) GP surgeries. EMIS collects all data for patients and sends prescriptions electronically to local pharmacies. Lorenzo, a Web based and cloud hosted EPR system, is used in both secondary/acute care and community care. Lorenzo is a patient administration system with some clinical noting in outpatients and coding for clinical & business reporting and payments. GAP is an in-house open source community scheduling tool developed by SWFT ICT for use in community care. The low level of integration between these systems makes data sharing challenging. Due to resource limitation, SWFT cannot provide API integration with EMIS. Instead, a patient extract is generated from EMIS reporting service on a daily basis and is made available as CSV files through FTP. TIS will regularly import the CSV files from SWFT FTP server to synchronise the daily snapshot. Data export from Lorenzo and GAP are under investigation at the moment. They will probably be shared through similar file based mechanisms.

4. SOFTWARE DEMO

This section describes the software demonstration. TIS depends on the SIS structural mapping service to be able to demonstrate an end-to-end data integration workflow. Given the current progress of SIS, D6.1 will present an integrated demo based on OSAKI CDA service, SIS OSAKI CDA mapping, and C3DP FHIR repository. The following sections describes the component workflow in the demonstration, installation and configuration of the software tool, and example screenshots.

4.1. Demonstration workflow

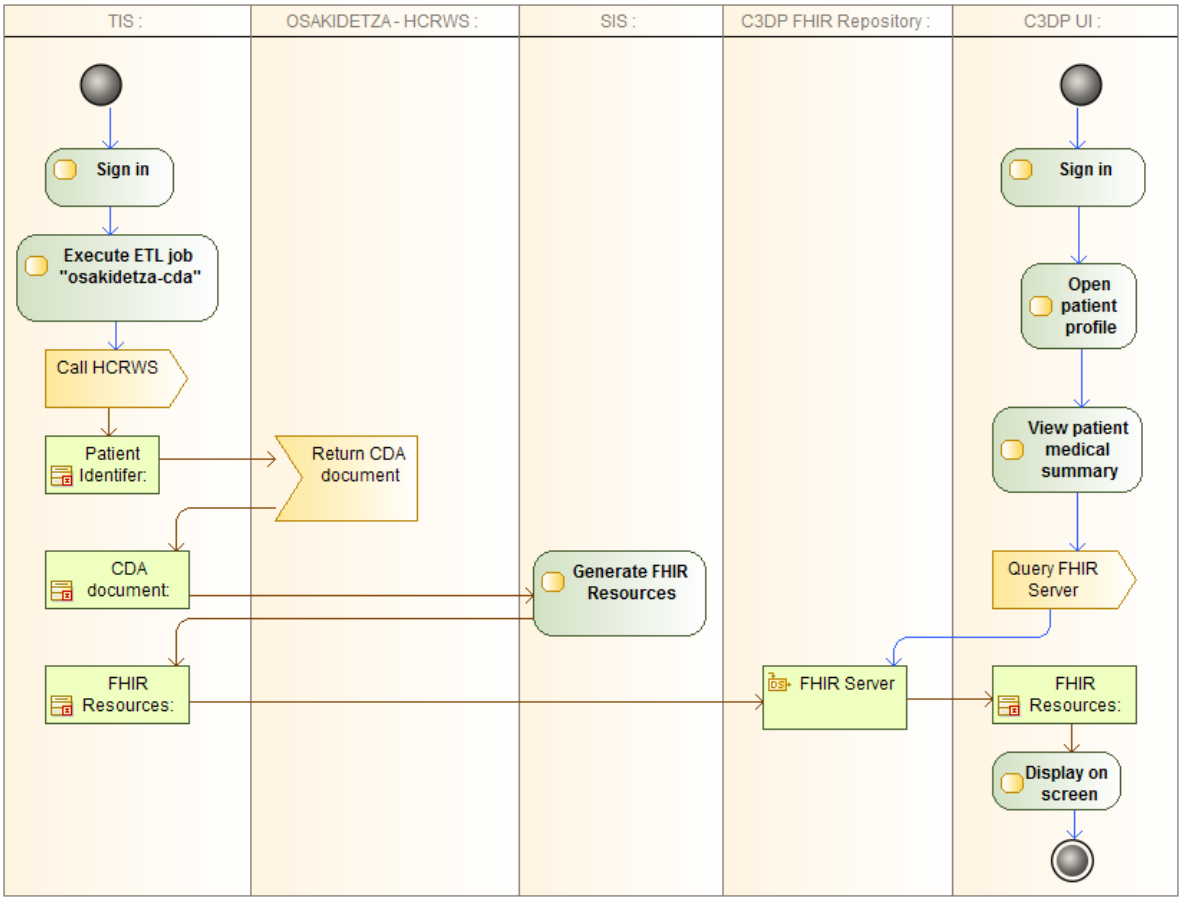

Figure 7 Software demonstration activity diagram

The UML activity diagram in Figure 7 describes the interaction workflow between different components involved in the software demonstration. A user (e.g. administrator) signs into TIS and triggers a pre-defined ETL job “osakidetza-cda”. On executing the job, TIS calls OSAKIDETZA web service HCRWS to get a CDA document of a patient. TIS then passes the CDA document to SIS for transformations. Finally TIS pushes the generated FHIR resources into C3DP FHIR Repository. To see the actual data, a user can sign into C3DP UI, open the patient profile, and view the patient’s medical summary, which will query the FHIR server, get related FHIR resources and display them on screen.

4.2. Software configuration

TIS implementation is based on Spring Boot and is built and delivered as an executable jar file using Maven. The software only depends on MySQL 5.7 as the database backend, so the installation and configuration is straightforward. The only required configuration is the server port and MySQL connection settings. Follow the steps below to configure and run the software:

- Download and unzip tis.zip to a folder you want to run the software (assume the installation folder is <TIS_HOME>)
- Download and install Java 8
- Download and install MySQL 5.7
- Create a MySQL user account (e.g. c3cloud)
- Import <TIS_HOME>/sql/tis.sql into MySQL to initialize the database for TIS (default database name is tis)
- Find the configuration file application.properties in <TIS_HOME>/config/
- Set server port

  The default port is 80. If you want to change the default port, find the line "server.port=80" in application.properties and change 80 to any port number you want to listen on, for example 8080.
- Set MySQL username and password

  Change the values of "spring.datasource.username" and "spring.datasource.password" in application.properties to MySQL account name and password created in the step above. The default username and password both are "c3cloud"
- Run java –jar tis.jar to start the application

4.3. Screenshots

The following screenshots demonstrate how to use the software.

- Log into TIS control panel UI with username "Admin" and password "Admin"

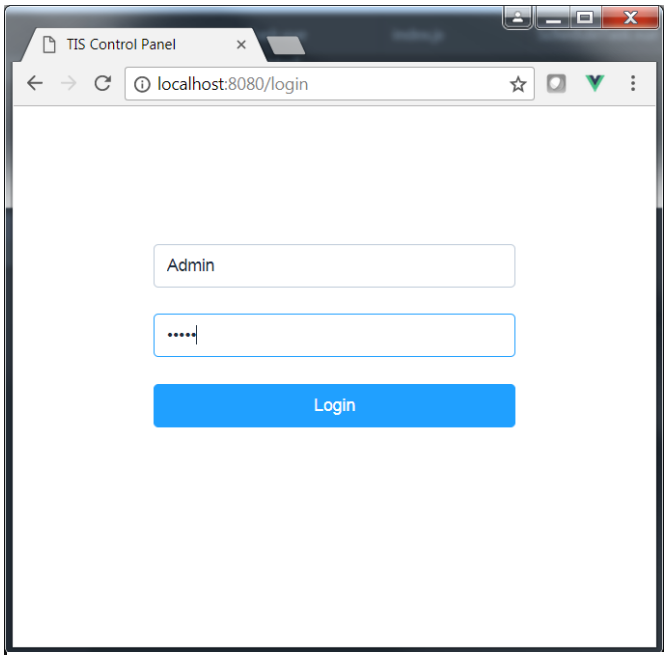

Figure 8 Log in to TIS Control Panel

- After login, the screen displays a list of ETL tasks ready to be scheduled. In Figure 9 for example, there is one task available for execution.

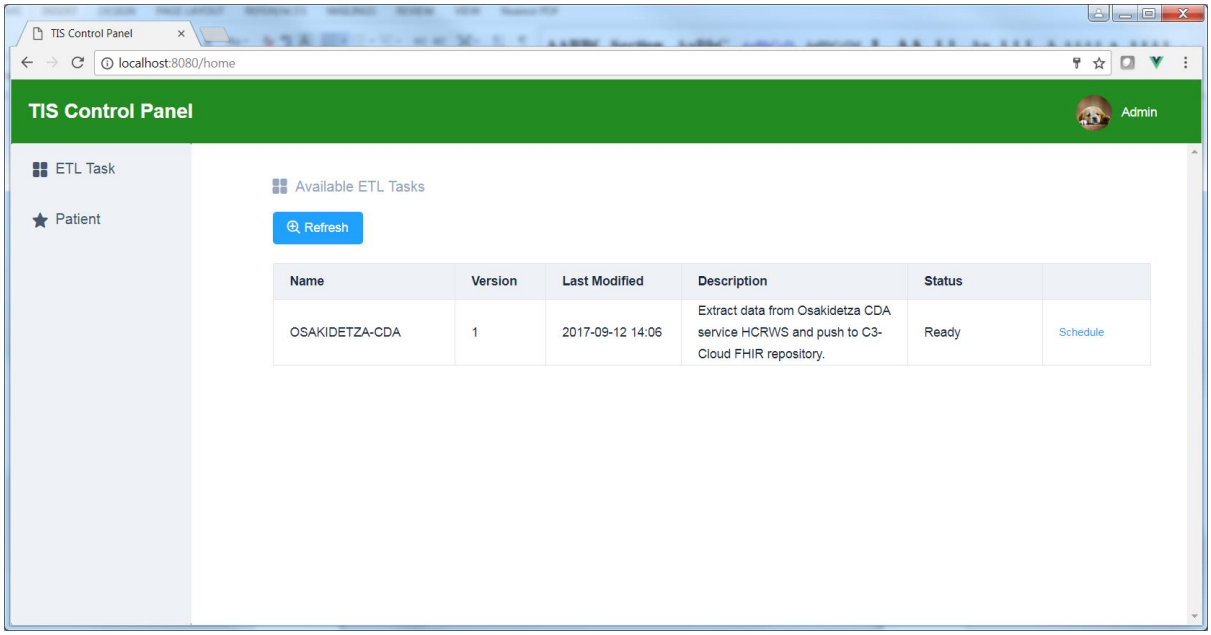

Figure 9 ETL tasks ready for scheduling

- We need to have some patients registered with the system before executing any task. The 'Patient' link on the left hand side displays registered patients in the system. As shown in Figure 10 no patients have been registered yet.

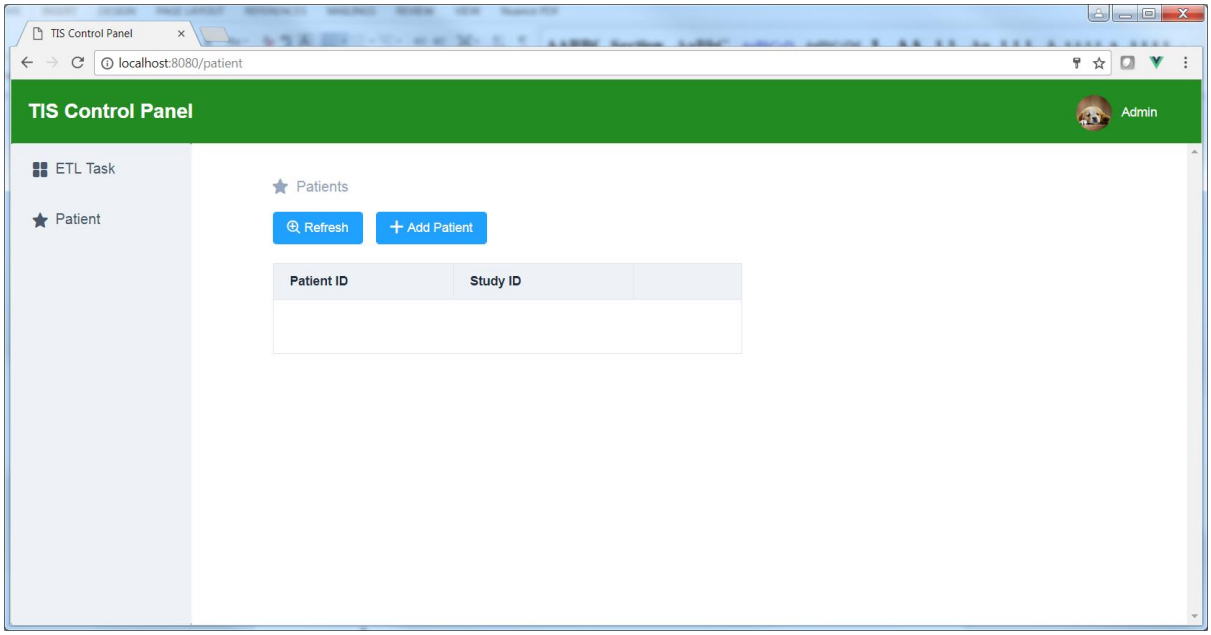

Figure 10 Registered Patients

- So click the button "Add Patient" to add a new patient Id as shown in Figure 11.

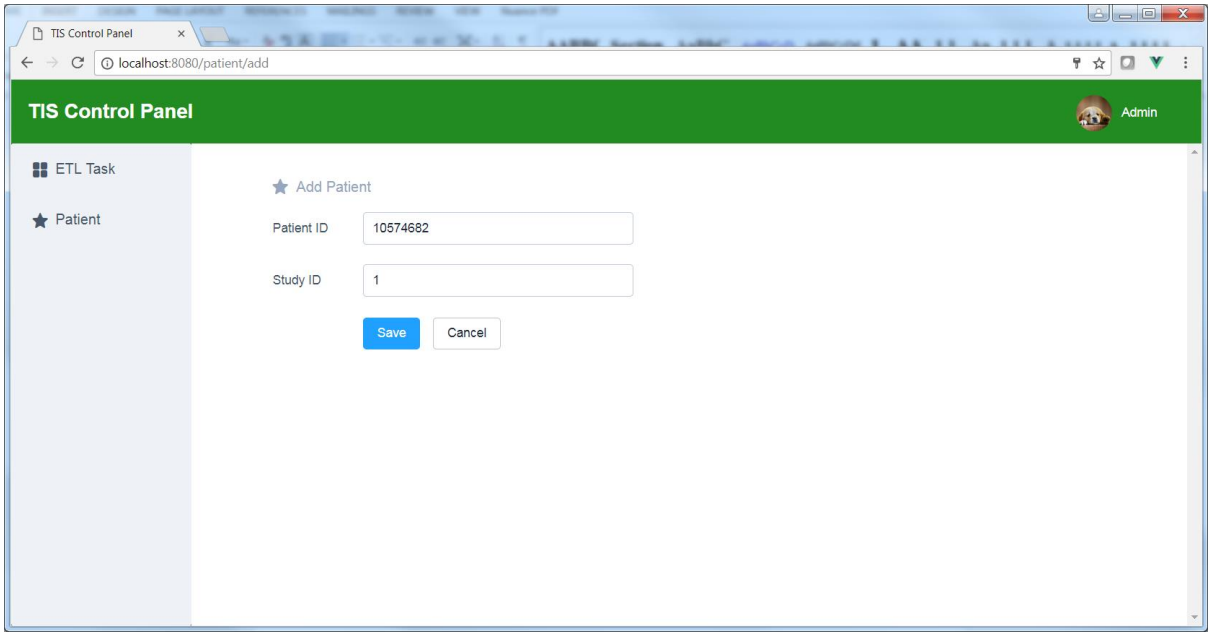

Figure 11 Add Patient

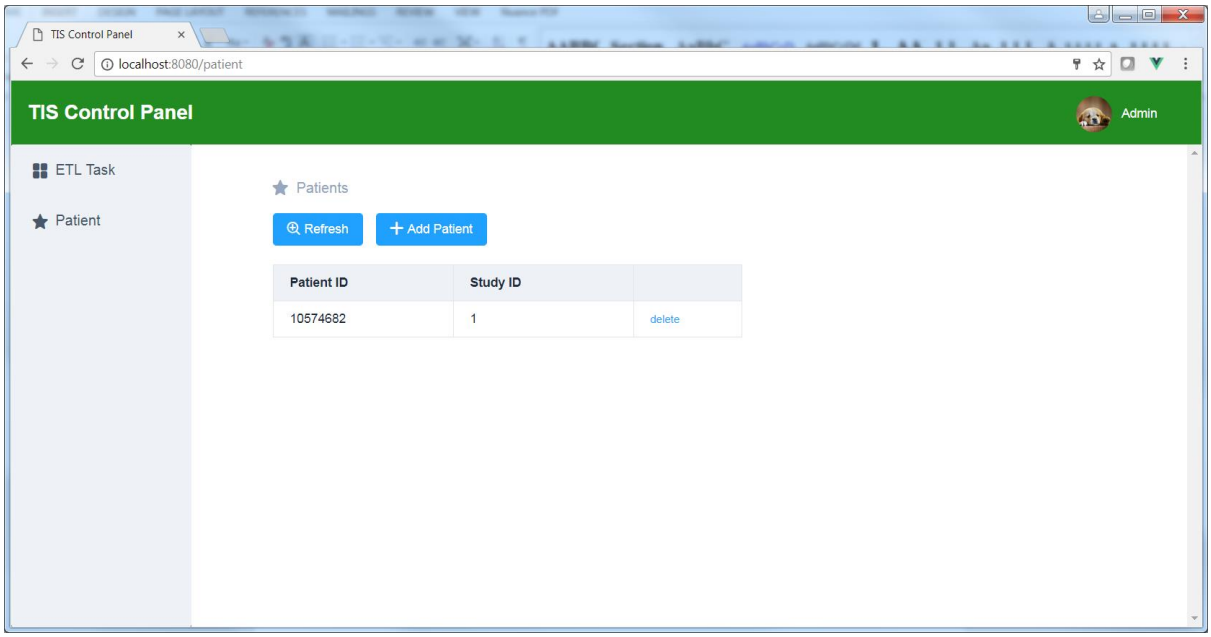

Figure 12 Patient Added

- Now we can run the task by going back to the "ETL Task" page and click the "schedule" button. The system allows to schedule the task in many different ways, e.g. as one time execution, repeating every 5 minutes for 1 hour, running daily, weekly or monthly. Choose "Now" and click OK will execute the task immediately.

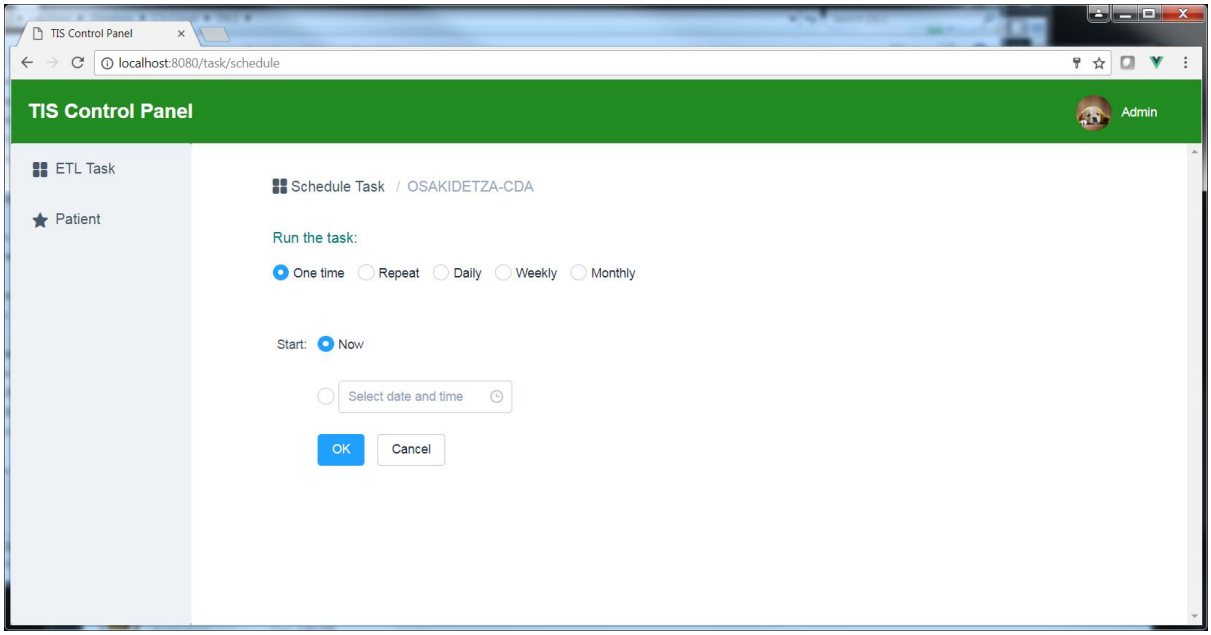

Figure 13 Schedule Task

- The task is running as indicated by the task status.

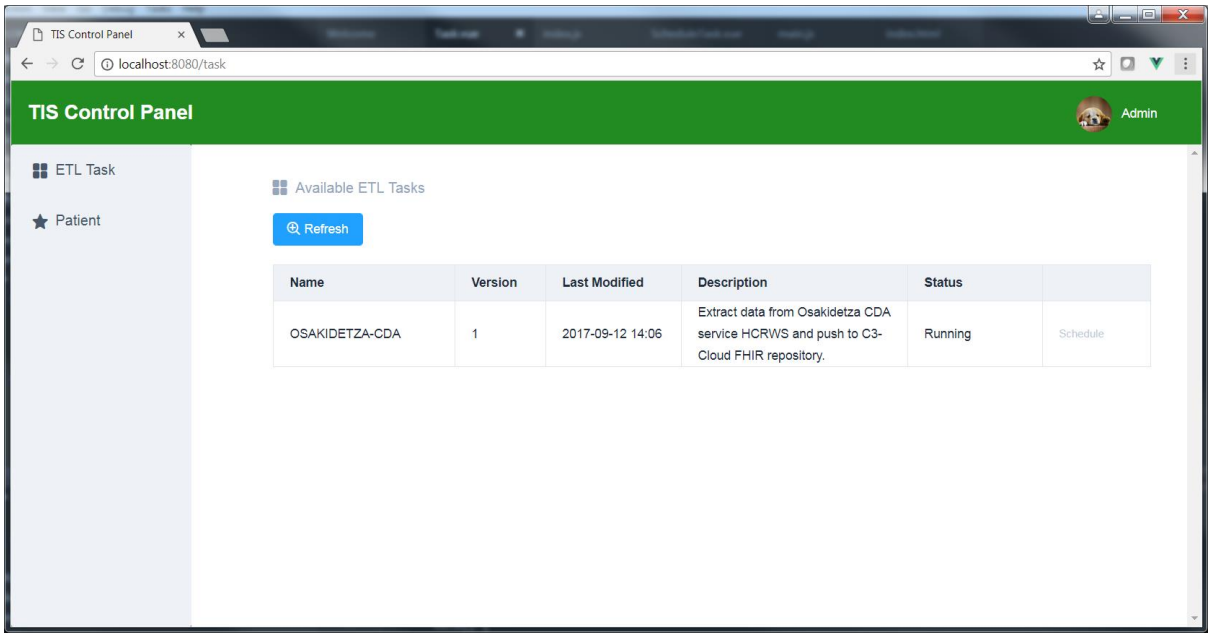

Figure 14 Task is Running

- Click “Refresh” to update the task status. When the task is completed, the patient data is now available from the FHIR repository for C3DP to consume.

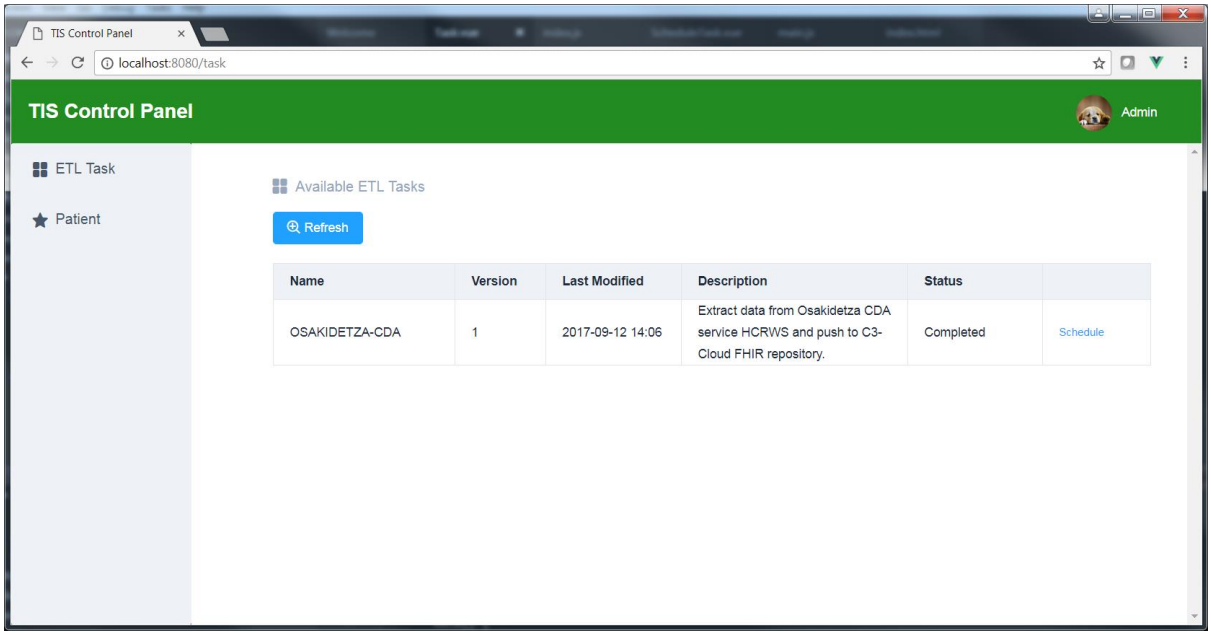

Figure 15 Task Completed

- Open the C3DP system and see the data update in the patient's medical summary page. Figure 16 shows the C3DP medical summary screenshot of an example patient. The actual data received in the software demonstration depends on the patient id input in the step of "Add Patient".

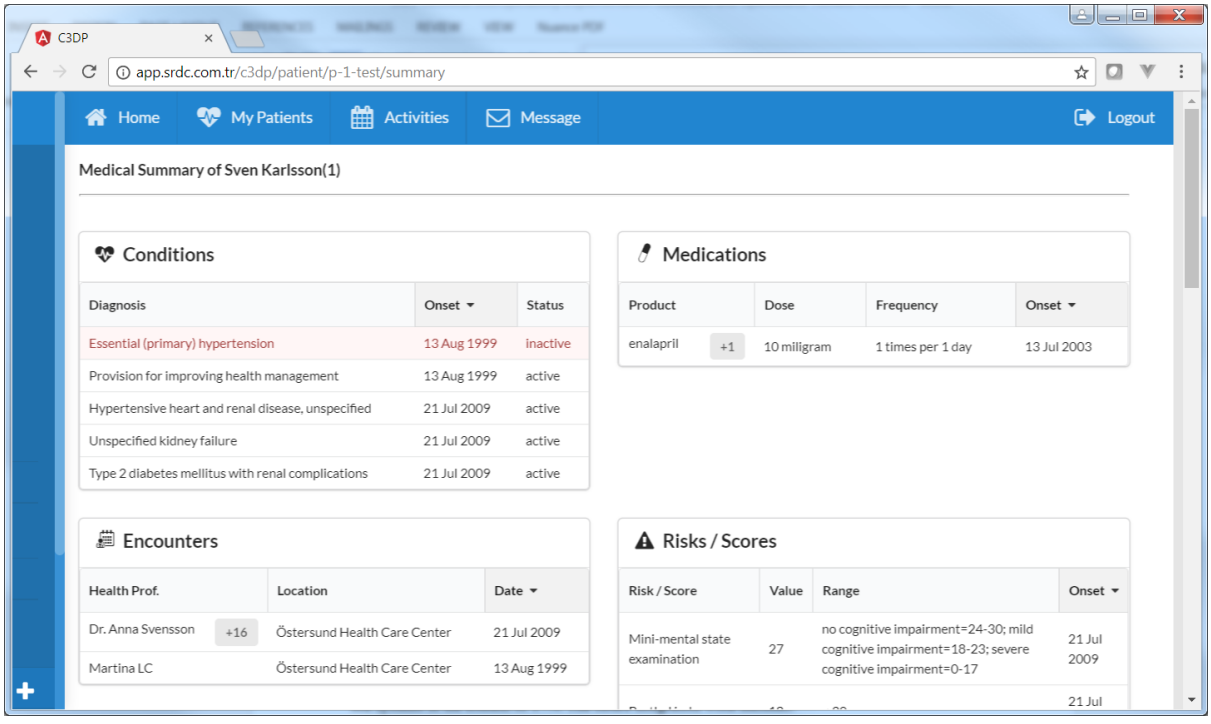

Figure 16 C3DP Medical Summary Example

5. FUTURE PLANS

WP6 ends at the end of October 2017 (Month 18). During the period of WP6, we have investigated patient data sources in C3-Cloud pilot sites, designed C3-Cloud FHIR profiles, developed an extensible data integration framework, and achieved initial integration with the pilot site EHR systems in T6.1. The future development of TIS will focus on full integration with other C3-Cloud components and pilot site systems in the context of T7.4. The future integration work includes:

- Full integration with SIS structural mapping and terminology mapping services for all three sites to enable data exchange with unambiguous, shared meaning.
- Full integration with SPS to participate in C3-Cloud single sign-on framework, and protect communication channels with local care system EHRs and C3-Cloud FHIR repository to ensure confidentiality of patient information in transit.
- Full integration with C3DP to ensure the C3-Cloud care plan management platform has flexible and timely access to patient data sources.

Besides this, one pilot site (OSAKI) plans to upgrade their system to support the use case of sharing care plan from C3-Cloud to local care system EHR. The care plan exported from C3-Cloud will be FHIR CarePlan resources. A new care plan function is under development at the OSAKI site to import and store FHIR resources in the internal system.