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

D7.4 C3-Cloud Coordinated Care and Cure Delivery Platform

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EXECUTIVE SUMMARY

WP7 is responsible for developing ICT platforms (Personalised Care Plan Development Platform & Coordinated Care and Cure Delivery Platform) and supporting Clinical Decision Support Modules, in order to enable multidisciplinary team of health and social care givers to collaboratively create, execute and monitor personalised care plans, through reconciliation of clinical guidelines for individual diseases.

Task 7.4 concerns two main strands of work: i) implementation of the Coordinated Care and Cure Delivery Platform (C3DP), which acts as a workflow engine to facilitate organisation, planning, and monitoring of integrated care activities, and to enable flagging of unperformed activities and unmet goals for later follow up within the scope of a personalised care plan, and ii) integration of all C3-Cloud software components that have been developed in work packages 5, 6 and 7, and local Electronic Health Record (EHR) and Identity Provider (IdP) systems of the pilot sites.

The deliverable D7.4 focuses on the second strand of work, by presenting the integration activities that have been realised to achieve the end-to-end (E2E) integrated C3-Cloud software system, which will be deployed to three different pilot sites for long term operation and evaluation. The first strand has already been presented in detail in D7.3, due Month 22 of the project. This deliverable has been reserved for integration activities. This document first presents the initial conceptual software design and the final realised software architecture. Then, the objectives and major features of the C3-Cloud software components are presented, and when necessary by referring to the dedicated deliverables, explaining the components in detail. After recapping on the software components and their objectives, it presents in detail how integration is achieved between different pairs of C3-Cloud components and pilot site EHR and IdP systems. Ten main combinations of integration activities are presented.

Task 7.4 started in month 9 (1st January 2017) and will end in month 26 (30 June 2018).

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1. DOCUMENT OVERVIEW

1.1. Purpose

The purpose of this deliverable is to describe the end-to-end (E2E) integrated C3-Cloud software system for integrated and personalised care plan management of multi-morbid elderly patients with the involvement of a multi-disciplinary care team who are supported with Clinical Decision Support services, implementing evidence based clinical guidelines, and communicating with the patients and their informal care givers. The E2E integrated C3-Cloud system is the final merged outcome of the technical work packages 5, 6 and 7 of the C3-Cloud project.

1.2. Outline of the deliverable

The report on the C3-Cloud Personalised Care Plan Development Platform (PCPDP) demonstrator is organized as follows:

- Section 2 presents the objectives and major features of the C3-Cloud software components, and when necessary by referring to the dedicated deliverables explaining the components in detail.
- Section 3 presents in detail how integration is achieved between different pairs of C3-Cloud components and pilot site Electronic Health Record (EHR) and Identity Provider (IdP) systems. Ten main combinations of integration activities are presented.
- Section 4 concludes the main document, by referring to the future plans for remaining integration work and deployment.
- Section 5 lists the references.
- Section 6 provides the integration storyboard as an appendix, which has been developed starting from the beginning of the 2nd year of the project, in order to facilitate the development and integration activities within the C3-Cloud consortium.

1.3. Context

In the C3-Cloud architecture, Coordinated Care and Cure Delivery Platform (C3DP) is the digital multi-actor knowledge exchange environment for shared and informed decision making during management of the personalised care plans of the elderly with chronic diseases. In order to achieve the functionality of this platform, existing patient electronic health records received from the local EHR systems via C3-Cloud Technical Interoperability Suite (TIS) and Semantic Interoperability Suite (SIS) and patient reported observations and feedback from the C3-Cloud Patient Empowerment Platform (PEP) are taken into account in care planning. Furthermore, C3-Cloud Clinical Decision Support (CDS) services are utilised for enabling personalised goal recommendations (e.g., blood pressure targets, dietary targets) and intervention recommendations (e.g., medication therapies, guidance on contradicting medications, laboratory test requests, referrals to specialists, scheduling follow-up timings) to the care team members, based on clinical guidelines for individual chronic diseases and reconciliation rules for disease combinations, as defined by the C3-Cloud clinical experts.

In the Description of Action (DoA), there are two closely linked tasks and corresponding deliverables that are involved in personalised care plan management: Task 7.3 - Personalised Care Plan Development Platform (PCPDP); and Task 7.4 - Development of Coordinated Care and Cure Delivery Platform (C3DP) through Integration of C3-Cloud Components. PCPDP handles the creation and editing of a personalised care plan by care team members, while C3DP provides the holistic platform that acts as a workflow engine to facilitate organisation, planning, and monitoring of integrated care activities and flagging of unperformed activities and unmet goals for future follow-up, within the scope of a personalised care plan. Although PCPDP and C3DP are located in separate tasks, this does not mean that there are separate (Web) applications for editing and follow-up of a care plan. In order to prevent confusion among the C3-Cloud partners, it has been agreed to position PCPDP as a sub-component of the C3DP during the architectural design phase. Hence, it should be noted that PCPDP and C3DP can be used interchangeably in the remaining of this document. The name of the Web

application, which is the single-page entry point for the care team members for care plan management, is C3DP.

The details of the C3DP, in this respect, have already been presented in D7.3 [D7.3]. Besides all of these, Task 7.4 has another important role: integration of all C3-Cloud software components that have been developed in work packages 5, 6 and 7, and local EHR and IdP systems of the pilot sites. D7.4 is focused solely on presenting these integration activities that have been realised to achieve the end-to-end (E2E) integrated C3-Cloud software system, which will be deployed to three different pilot sites for long term operation and evaluation.

1.4. Abbreviations and Acronyms

Abbreviation	Definition
ATNA	Audit Trail and Node Authentication
BC	Basque Country
C3DP	Coordinated Care and Cure Delivery Platform
CRUD	Create, Read, Update, Delete
Dp	Depression
E2E	End-to-end
EHR	Electronic Healthcare Records
GP	General Practitioner
FHIR	Fast Healthcare Interoperability Resources
HF	Heart Failure
HL7	Health Level Seven
HTTP	Hypertext Transfer Protocol
HP	Health Professional
IdP	Identity Provider
PCPDP	Personalised Care Plan Development Platform
PEP	Patient Empowerment Platform
PHI	Personal Health Information
RF	Renal Failure
RJH	Region Jämtland Härjedalen
SAML	Security Assertion Markup Language
SIS	Semantic Interoperability Suite
SPS	Security and Privacy Suite
STU	Standard for Trial Use
SWFT	South Warwickshire NHS Foundation Trust
T2D	Type 2 Diabetes Mellitus
TIS	Technical Interoperability Suite
UI	User Interface

2. INTEGRATED C3-CLOUD SYSTEM ARCHITECTURE

2.1. Architectural Design

The component diagram of the overall C3-Cloud integrated solution was depicted as in Figure 1 in the Conceptual Design of the C3-Cloud Architecture at month 8 [D3.3].

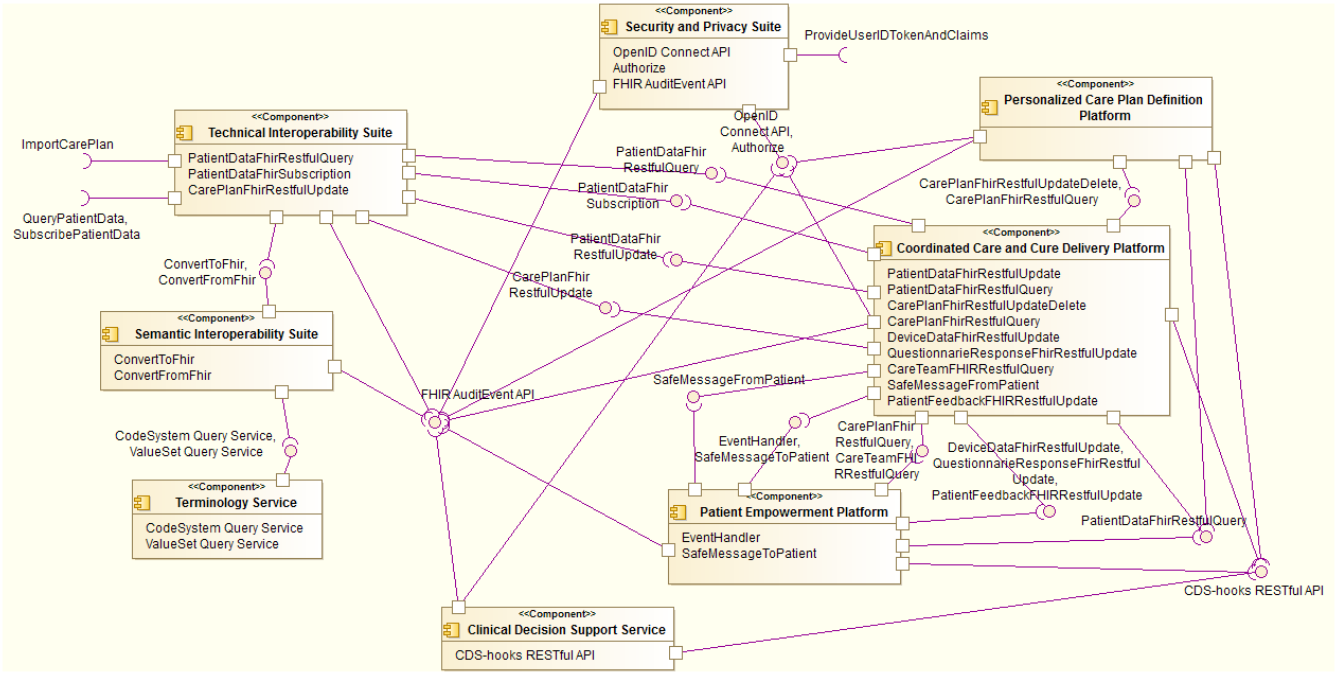


Figure 1 Conceptual Integrated C3-Cloud System Architecture [D3.3]

The final implemented architecture at the end of month 24 of the project is depicted in Figure 2. All the software components in the figure are explained briefly in the next section, and the integration among them are explained in Section 3.

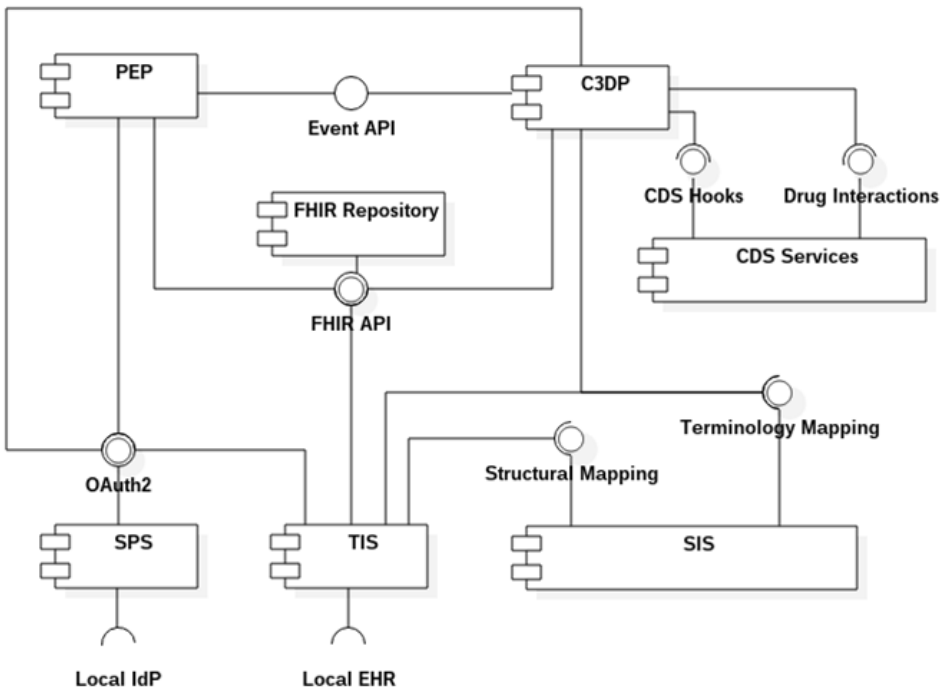


Figure 2 Final Integrated C3-Cloud System Architecture

2.2. C3-Cloud Software Components

2.2.1. Technical Interoperability Suite (TIS)

The Technical Interoperability Suite (TIS) provides interoperability interfaces to enable seamless data exchange with the local care systems. This considers that the data exchange protocols and clinical data models are heterogeneous across C3-Cloud components, while there exist different EHR systems utilized in each local care site. TIS provides a standard-based data exchange protocol to enable information exchange between local care systems and C3-Cloud components, such as C3DP. 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). TIS utilizes the ETL model to pull patient data out of a local EHR system through its native API, convert the data into FHIR with support of the Semantic Interoperability Suite (SIS), and push the transformed FHIR data into the C3-Cloud FHIR repository. The core of TIS is an ETL engine, which is able to schedule and execute ETL tasks. TIS also provides an extensible library of functions, on top of which it is easy to assemble an ETL task for integration with an EHR data source. The technical implementation of TIS is based on Spring Boot and Java 8. The HAPI FHIR library is used for FHIR resource processing. The deliverable D6.1 provides more details of the architecture design and implementation [D6.1].

TIS provides both a web-based user interface for system administrator to execute or schedule an ETL task, and a RESTful service API for other C3-Cloud components, such as C3DP, to trigger an immediate ETL action, so as to get the latest patient data. Figure 3 shows a screenshot of UI for scheduling an ETL task. Figure 4 shows an example of sending a HTTP request to the RESTful API to trigger an instant import of the latest data of a specific patient from OSAKIDETZA. The service simply returns a 202 HTTP response, once the request is processed successfully.

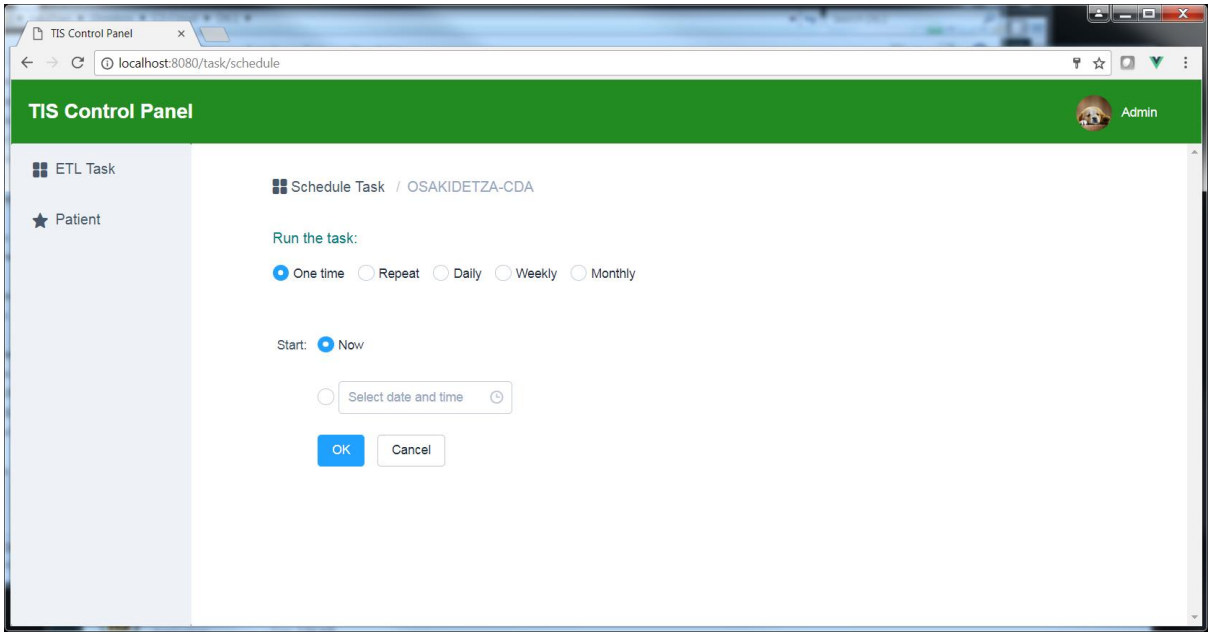


Figure 3 TIS schedules an ETL task

Http Request:

```
POST /api/import HTTP/1.1
Host: localhost
Content-Type: application/json
Cache-Control: no-cache

{
  "patient" : "123456",
  "source" : "osaki"
}
```

Http Response:

```
HTTP/1.1 202 Accepted
Content-Length: 0
```

Figure 4 RESTful API to import the latest data of a patient

2.2.2. Semantic Interoperability Suite (SIS)

The Semantic Interoperability Suite (SIS), handles both structural mappings among different information models and resolves semantic mismatches due to the use of different terminology systems and different compositional aggregations, used to represent the same clinical concept. Due to local implications of terminologies used, the SIS is developed in close relation with the pilot sites.

Two different types of mappings are performed in the semantic interoperability suite: structural mappings and semantic mappings. Structural mappings are involved in the translation between local pilot sites data in local format and FHIR resources data format used in C3-Cloud. Semantic mappings perform the transcoding between coding systems used in local sites and within C3-Cloud components.

The functional requirement specifications for SIS can be summarised as follows:

- SIS maps input data from pilot sites, provided in their local format, to corresponding FHIR resources.
- SIS provides coding values and related coding system used from locally coded pilot site data.

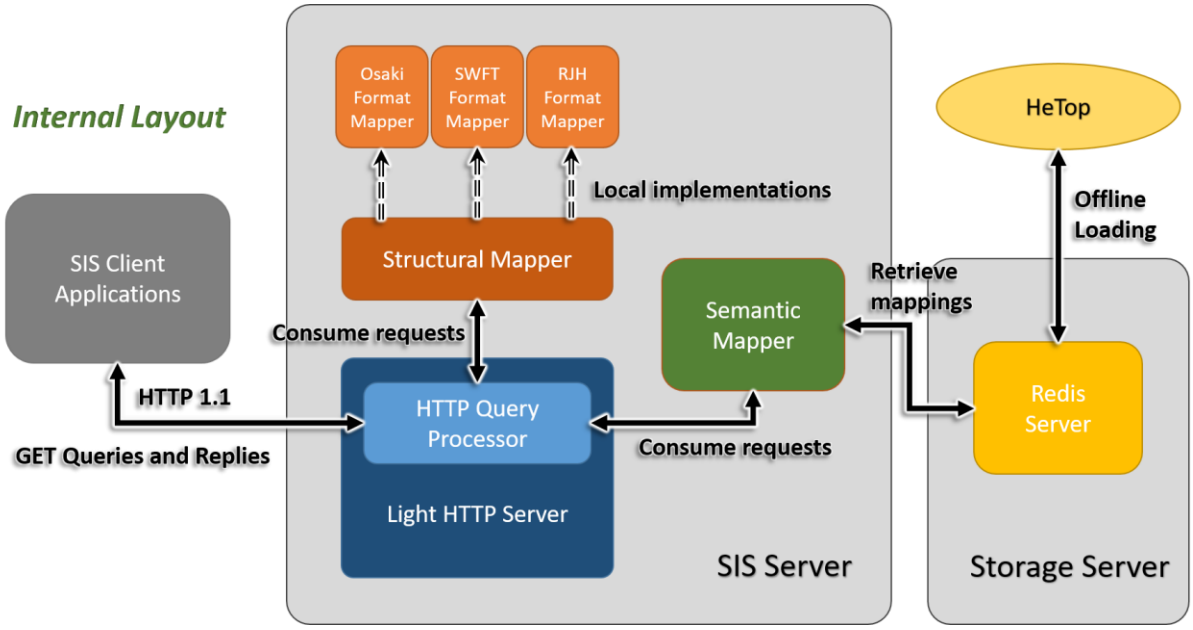


Figure 5 Semantic Interoperability Suite Architecture

The architecture of the SIS is provided in Figure 5. SIS is articulated around two main sub-components: SIS Structural Mapper and SIS Semantic Mapper.

1. **SIS Structural Mapper:** The structural mapper of SIS is the internal SIS sub-component in charge of the generation of FHIR resources, which have to be filled with data provided in pilot site local format by TIS. To achieve its purpose, the structural mapper consists of pilot site dedicated local format mappers. These mappers provide precise mappings to create correspondence to every relevant data exported by the pilot site to its correct interpretation and place in FHIR resource. FHIR resources mapped from pilot site data are defined in the C3-Cloud data dictionary, which is defined in D6.1 - C3-Cloud Technical Interoperability Implementation Guidelines and Open Source Toolkits.
2. **SIS Semantic Mapper:** The semantic mapper of SIS is in charge of transforming, using the HeTOP service [HETOP], the vocabulary used to describe data exported by pilot site into standard codes that will be used in the high-level components of C3-Cloud. A clinical concept mapping sheet is being maintained as the source of truth, which includes all the clinical concepts that are needed by the CDS services, in reference terminologies like SNOMED-CT and WHO ATC, and all the local codes that are used by the pilot sites for these concepts.

The main characteristics of the prototype development are the following:

- C3-Cloud SIS is implemented as a fully deployable exchange suite, running on independent Docker containers.
- It is based on HTTP communication standards, with embedded JSON content.
- It supports FHIR inputs and outputs, and previously mapped local format pilot site inputs.
- SIS is developed using Java 8 Maven.
- Regarding the terminology server, Python 3 is used to develop an application that reads the mappings from use case files and creates an HTTP service (Flask) that is able to achieve the tasks listed in the specifications.
- The C3-Cloud Semantic Interoperability Suite can be easily deployed by running its related Docker image as containers.

The Structural Mapper generates JSON encoded FHIR resources. The semantic mapping is based on a pre-filled registry containing, for each concept, the corresponding code(s) for each site's terminology,

and the code used as reference by C3-Cloud. The registry is continuously updated, via a dedicated service method during the time of the project. Multiple codes can be specified for a single concept if the used terminology has several codes corresponding to the concept (narrower-than relation). Multiple terminologies are used as reference, in order to match each concept exactly.

The semantic mapping service is called in two different scenarios:

- Inside the 6.2 interoperability suite, in order to perform the transcoding of local codes to standard codes.
- By C3DP, in order to match patient data coded in pilot sites' terminologies to the clinical concepts that are needed by the CDS services.

Both the Structural Mapper and Semantic Mapper expose a REST API for integration with other C3-Cloud components, but a simple user interface has been developed for the Semantic Mapper as well. This Web-based UI is available at http://cispro.chu-rouen.fr/c3-cloud/, where it is possible to review the existing mappings, build HTTP GET mapping requests and see the server's response. An example request is provided below:

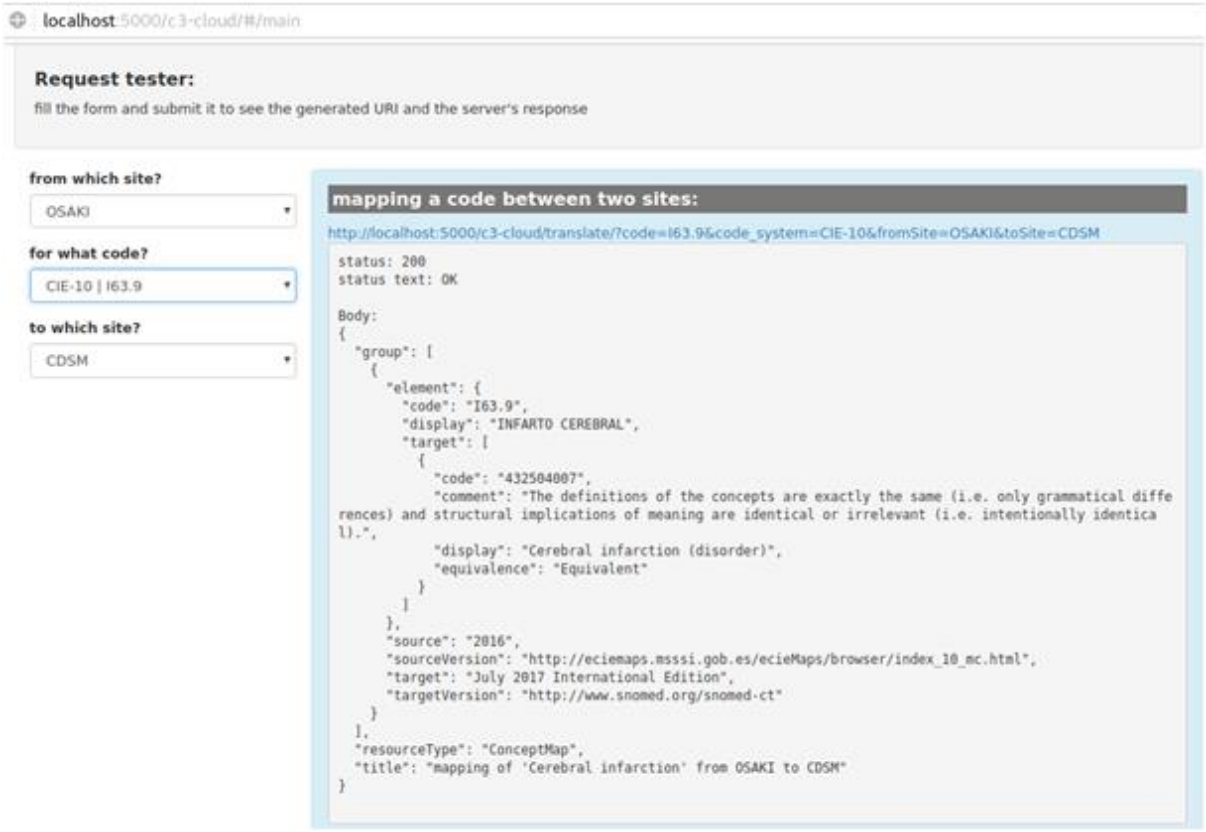


Figure 6 SIS Semantic Mapper Demo UI

In this example, the request is to map I63.9 in CIE-10 code system, which is used by the OSAKIDETZA pilot site, to the reference terminology, which is SNOMED-CT International in this case. A JSON-encoded FHIR ConceptMap resource is provided as a response, describing the URLs of the input and output code systems and their versions (CIE-10 and SNOMED-CT respectively), the input code and the corresponding code in the target system (the SNOMED CT code 432504007 for cerebral infarction). It also shows the type of relation; equivalent in this case, meaning that the two codes are identical.

Example HTTP requests for the SIS Structural Mapper can be done via the Postman collection containing the test patient data resources provided by the pilot sites: https://www.getpostman.com/collections/41b7828a06c57795743a

The details of the Semantic Interoperability Suite are explained in the deliverable D6.2 [D6.2].

2.2.3. Security and Privacy Suite (SPS)

The Security and Privacy Suite (SPS) is responsible for authentication and authorisation of Care Team Members, while they are managing personalised care plans of patients and accessing sensitive personal data; and ensuring that all data exchange within and across C3-Cloud software components is encrypted and properly auditable.

In the C3-Cloud architecture, the patient's electronic health records received from the local EHR systems via the Technical Interoperability Suite (TIS), patient reported observations from the Patient Empowerment Platform (PEP), and the care plan of the patient managed through Coordinated Care and Cure Delivery Platform (C3DP) are all managed in the C3-Cloud FHIR Repository. Hence, each of these client apps, i.e. TIS, PEP and C3DP needs to be authenticated and authorized to access (read, write, update) patient data to C3-Cloud FHIR Repository, via the functionalities provided by the SPS. All such operations need to be logged for ensuring accountability via SPS.

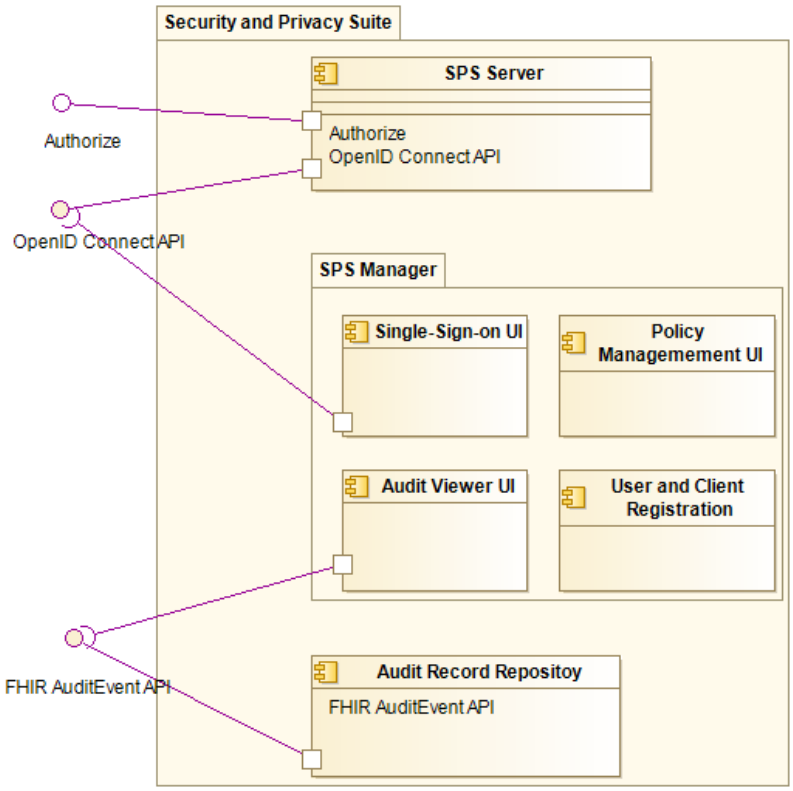


Figure 7 SPS Software Architecture

The SPS has three sub-components, as shown in the architecture diagram in Figure 7:

- **C3-Cloud SPS Server** provides services for user registration, privacy policy management and endpoints defined in **OpenID Connect 1.0** standard [OPENIDCONNECT] to perform authentication and authorization (Authorization Endpoint, Token Endpoint, etc.). By implementing OpenID Connect API, it serves C3-Cloud Identity Provider (IdP), which is the default IdP when the IdP of some users (e.g., social care workers) of the pilot sites cannot be integrated within the scope of the project. The SPS Server also manages the C3-Cloud Access Control Policy Store.
- **C3-Cloud SPS Manager** is a web application for representing the functionalities of C3-Cloud SPS Server with the following user interfaces; single sign on UIs, policy management UI, client registration UI, user registration UI and audit viewer UI.
- **Audit Record Repository** is a FHIR repository that maintains audit trail records implemented as FHIR AuditEvent resource. In C3-Cloud architecture, the C3-Cloud FHIR Repository is used as the Audit Record Repository.

The SPS is based on onAuth security and privacy framework of SRDC, which has been implemented within the scope of not just C3-Cloud but also further international and local projects of SRDC. It is a generic framework to cover the needs of healthcare and other vertical domains. It implements the widely preferred modern authorization specifications, such as OpenID Connect 1.0 and OAuth 2.0. Each user is authenticated with the OAuth 2 flow and authorized for the allowed scopes with a JWT token. This token is exchanged between components to ensure that a user / system is authorized. User / system credentials are stored in MongoDB and Redis databases.

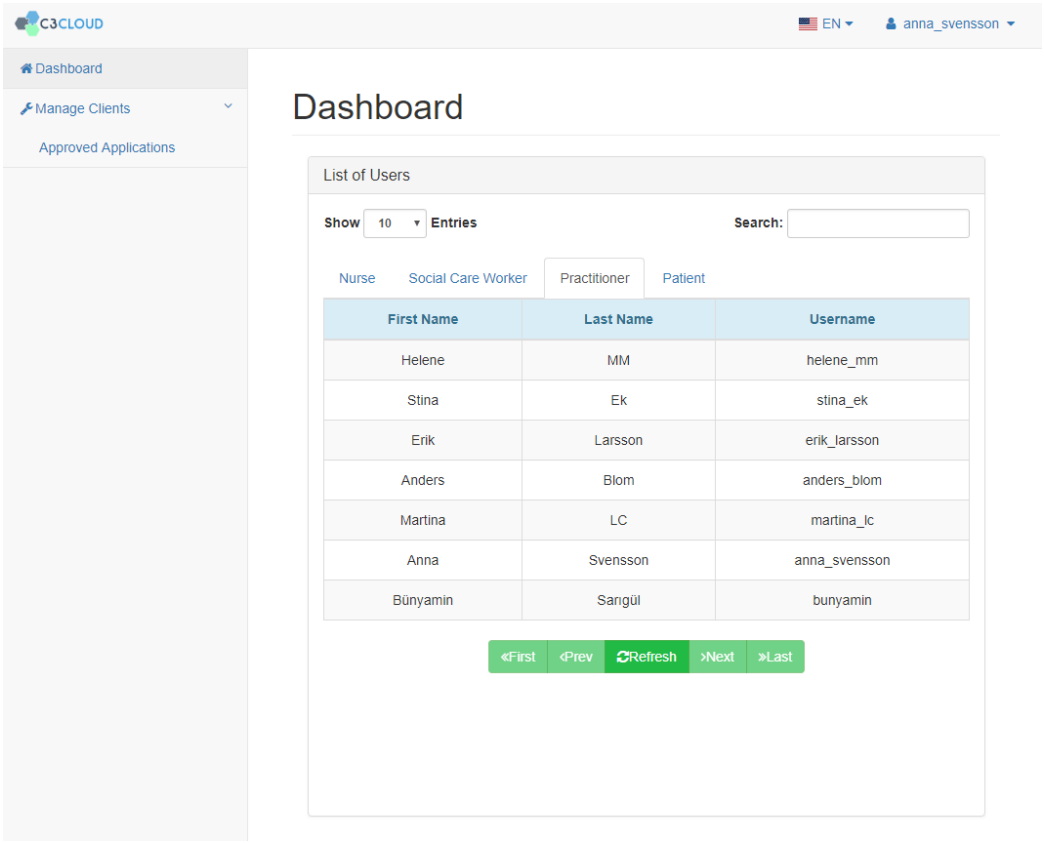


Figure 8 SPS Manager Dashboard

It should be noted that patient authentication into the Patient Empowerment Platform (PEP) is not within the scope of SPS, but managed by the PEP itself.

SPS is explained in detail in D6.3 [D6.3].

2.2.4. Clinical Decision Support (CDS) Services

The Clinical Decision Support Services are supporting modules of C3-Cloud Coordinated Care and Cure Delivery Platform (C3DP). The CDS Modules enable the reconciliation of clinical guidelines for individual diseases, risk stratification, poly-pharmacy management and care plan goal setting and monitoring. As part of C3DP platform, CDS services access patient data from different sources to subsequently fuse and analyse all these data. This is accomplished in order to: perform risk assessment and stratification of candidate elderly people for inclusion in integrated care programmes; reconcile clinical guidelines for individual diseases to develop personalised care plans; detect and propose resolutions for guideline clashes; detect duplicate, unnecessary or contraindicating medications; and monitor and detect deviations from the outcome goals set in a patient's care plan.

In the scope of C3-Cloud, the project focuses on elderly patients who have at least 2 out of 4 chronic diseases:

A. Diabetes Mellitus type 2 (T2D)

B. Renal Failure (RF) (including eGFR/GFR 30-59; excluding eGFR/GFR<30)
C. Heart Failure (HF) (including NYHA I-II; excluding NYHA III-IV)
D. Depression (Dp) (mild/moderate conditions only)

Based on NICE guidelines, CDS services are developed to support care planning for the 4 specific diseases and their combinations, including:

- Blood pressure management
- Lipid management
- QRISK2
- HbA1c targets
- Blood glucose management
- Diabetic foot complication
- Diabetic nephropathy management
- Diet management
- Lifestyle advice
- CKD referral
- CKD eGFR-control frequency
- CKD CVD prevention & treatment
- CHF vaccination
- CHF fluid management
- CHF first line treatment
- CHF second line treatment
- Depression assessment
- Mild to moderate depression treatment
- Antidepressant treatment
- Education materials

These guideline-based services are implemented as FHIR based CDS Hooks services, with decision logic encoded in Guideline Definition Language (GDL) version 2. GDL is a formal language used to express clinical rules and guidelines in a machine-readable format by leveraging semantically interoperable EHR standards. GDLv2 supports FHIR and CDS Hooks. The project uses the GDL Editor software to develop both the CDS guideline definitions and CDS Hooks services. The editor software is developed by Cambio Healthcare Systems, member of project consortium. Figure 9 shows a screenshot of the editor. More details on the CDS modules and their technical implementation are available in deliverable D7.2 [D7.2].

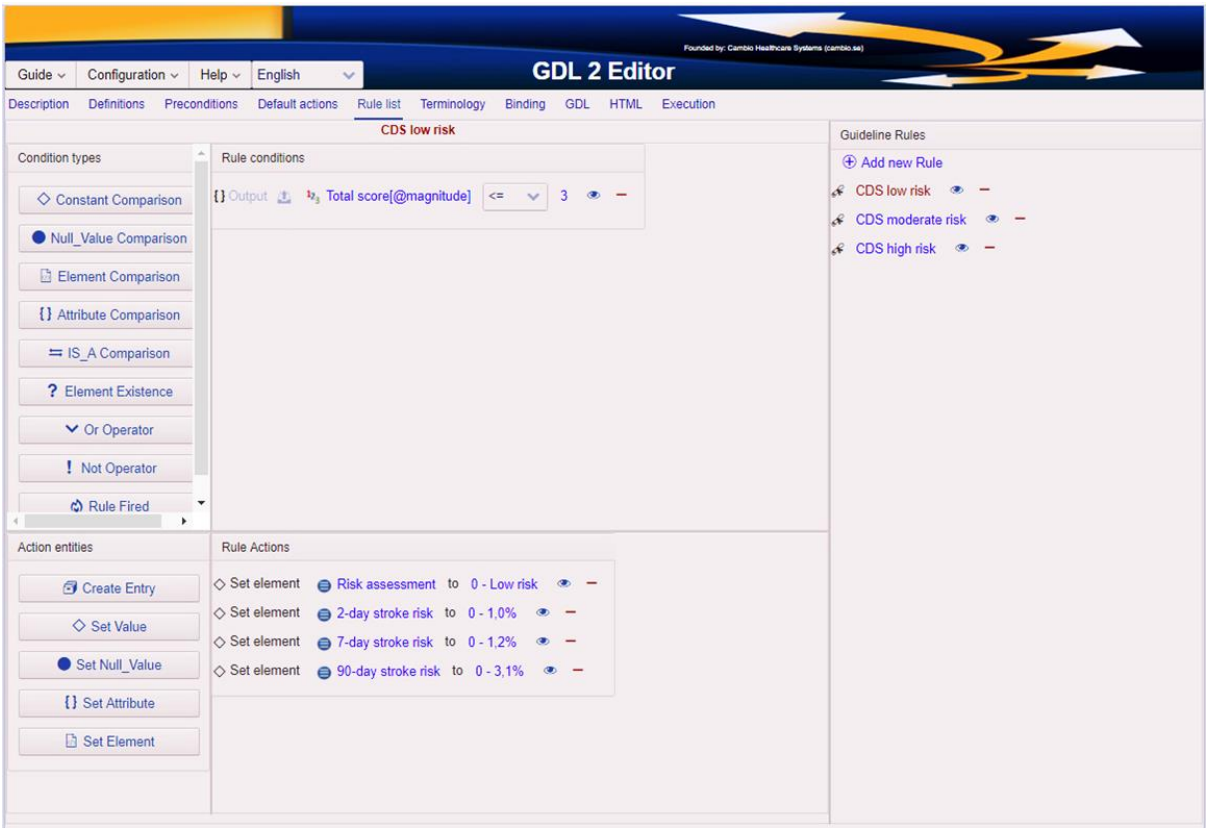


Figure 9 GDL2 Editor

In addition to the guideline-based services, a RESTful service is developed on top of a drug-drug and drug-disease interaction database provided by Pharmaceutical Information Centre Ltd (Lääketietokeskus Oy). The service makes the interaction database accessible through Web API, so C3DP can use it to enhance guideline reconciliation and polypharmacy management.

2.2.5. C3-Cloud FHIR Repository

C3-Cloud FHIR Repository acts as the centralized data repository for existing clinical data of the patients and newly created care planning related data. It stores the data, which arrive from EHR systems via TIS and newly created or updated care plan data from other C3-Cloud components like C3DP and PEP, as HL7 FHIR [FHIR] resources. SRDC provides its FHIR Repository product named onFHIR for free for this purpose [ONFHIR], but any other FHIR STU3 server can be used as well. A public deployment of SRDC onFHIR Repository to be used for testing and development purposes in C3-Cloud is available since April 2017, first at http://app.srdc.com.tr/fhir/stu3 and then at http://app.srdc.com.tr/c3cloud/fhir. onFHIR was tested successfully at the 15th FHIR Connectathon in Madrid on 6-7 May 2017. FHIR specification conformance of onFHIR has been validated by the Crucible and Touchstone FHIR testing tools and onFHIR performs at the top among tens of FHIR servers. onFHIR also outperforms the publicly available FHIR servers both in read and write operations.

Figure 10 onFHIR.io

In addition to the open access version, SRDC provided a secured C3-Cloud FHIR Repository at the beginning of March. This version is integrated with the SPS, which is based on SRDC onAuth security and privacy framework. It is not possible to access any resource in the secured repository without first acquiring a valid access token from the SPS. The authorization flow is fully compliant with the Smart App Authorization specification, which is based on the well-known OAuth 2.0 specification [OAUTH]. The secure version is served at https://app.srdc.com.tr/c3cloud/fhir-secure.

C3-Cloud FHIR Repository is fully compliant with the FHIR STU3 specification. An authorized user or system can use this FHIR STU3 API to manage patient data. Thanks to C3-Cloud FHIR Repository's automatic auditing functionality, audit trail records are kept for each access and manipulation of data as FHIR AuditEvent resources. These audit resources are available from the same API for authorized users with administrator roles as any other FHIR resource. For example, the Audit Viewer interface of the SPS reads the audit records from this API.

C3-Cloud FHIR Repository is also extensible and configurable for adding custom operations over standard FHIR API. An example for such custom functionalities is the CDS Hooks extension, which is implemented specifically for the CDS service interaction needs of the C3-Cloud project. C3DP uses this endpoint to collate all the required patient data needed for calling a CDS service and then doing the actual call to the CDS service.

onFHIR is implemented natively in Scala, and MongoDB is used as the database.

2.2.6. Coordinated Care and Cure Delivery Platform (C3DP)

The C3DP is the Web application for collaborative and personalized care plan management by the members of a multidisciplinary team of care (MDT). All the patient data required for care planning is fetched from the C3-Cloud FHIR Repository, which is continuously fed with existing EHR data of the

pilot sites via TIS and SIS. C3DP visualizes this data and helps the health professionals to easily manage the integrated care coordination process for multi-morbid elderly patients. This process is formalized as a FHIR Care Plan resource, which consists of building blocks like "Goal" and different types of "Activity" resources.

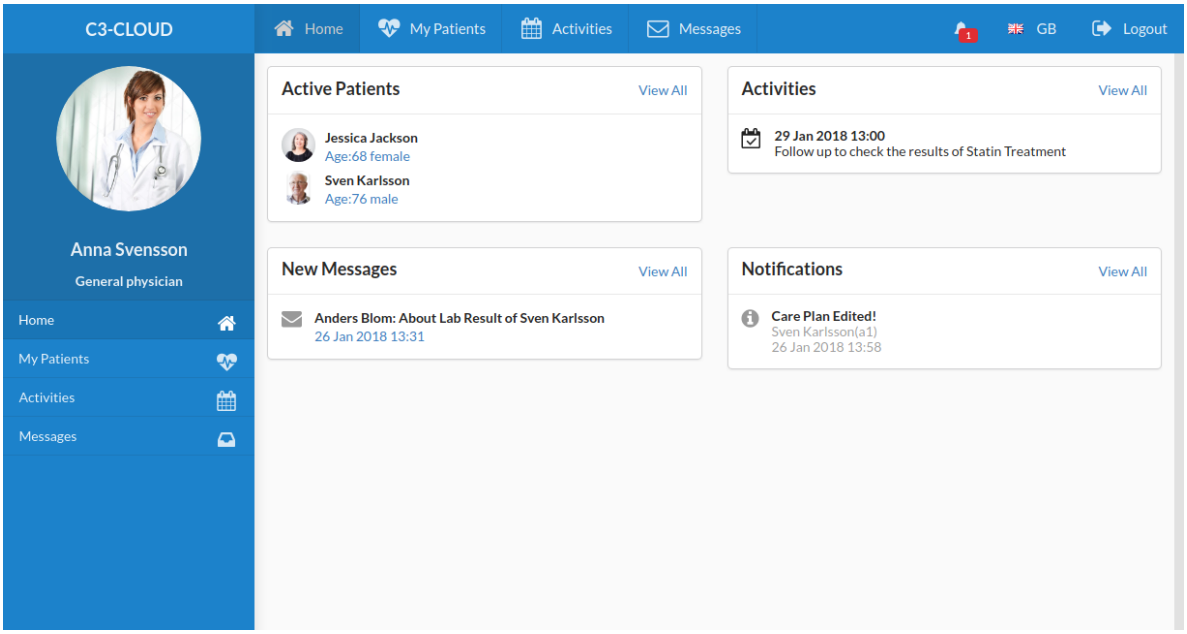


Figure 11 C3DP Home Screen

The major functionalities enabled by the C3DP are:

- **Review of medical summary**: All the patient data that is provided by the local EHR/EMR systems, and also by the patient via Patient Empowerment Platform (PEP), -including conditions, medications, allergies, lab results, vital signs, procedures and social history- are presented to the care team members in a single location. It is not possible to provide any new data via the medical summary view.
- **Cross-check of all patient data that are needed as input by the CDS services**: This is a good example of a requirement that was not discovered during the requirements analysis or conceptual design phase, but only after having a working prototype and performing an early usability analysis with the actual clinical experts, who will use and evaluate the system during pilot studies. C3-Cloud clinical experts indicated that they would like to see and validate all patient data to be sent to CDS services for getting personalised goal and treatment suggestions. Although the C3DP will retrieve all patient data, provided by the local EHR/EMR systems and integrated via the Interoperability Layer (WP6), clinical experts indicated that there can be missing or incomplete data even in these sources, and they can complete them via C3DP user interfaces before calling the CDS services. In order to address this emerging requirement, all clinical concepts that are checked by the CDS services relevant to the health concerns of the patient, for providing personalised goal and activity recommendations, are now presented to the care team members, either in a single holistic list in the "Chronic Disease Profile" view, or in a more context aware manner associated with each high-level goal (e.g., glucose management, blood pressure management). For example, the lipid management CDS service checks the existence of three diseases (and some other parameters like lab results and specific medications) in its decision tree: type 2 diabetes, chronic kidney disease and cardiovascular disease. The patient records retrieved from the local EHR system show that the patient has type 2 diabetes, but there is no information about the existence of chronic kidney disease and cardiovascular disease. The GP of the patient can declare that this patient has also a cardiovascular disease, which was somehow missing in the patient's EHR system records. Such

newly provided patient data, via the C3DP interface, can be provided back to the original EHR/EMR systems.

- **Management of the care plan building blocks; goals, activities and education materials**: In addition to the addressed health concerns and risk factors, an integrated care plan is mainly composed of goals to manage the health concerns and activities (i.e. interventions) to achieve these goals and improve the associated health concerns. In C3-Cloud, education materials for the empowerment of the patients are also part of the care plans, while they are treated separately from the rest of the activities. There are three ways of adding a goal / activity / education material to a care plan, as follows:
    - **Manual entry from scratch**: Care team members can, at any time, create a goal / activity / education material themselves via the C3DP user interface.
    - **Recommendations from the CDS services**: Personalised goal, activity and education material suggestions, provided by the CDS services according to patient data can be directly added to the care plan of a patient by the care team members, or after some modifications.
    - **Transfer from the older care plan**: When provided by the local systems of the pilot sites, it is possible to transfer existing goals and activities from a treatment plan of a patient into an integrated care plan during its initialization.
- **"Execution" of a care plan**: Integrated care planning is a continuous process. Ideally, an integrated care plan lives with the patient and is adjusted to the most recent patient context. It is updated during planned and unplanned encounters of the patient with health professionals and social care workers, and also with patient provided feedback via the Patient Empowerment Platform. All updates can be shared with the local EHR/EMR systems, bilaterally as well. Hence, "execution" of a care plan refers to the continuous follow-up and update of an integrated care plan. This can happen in a number of ways in C3-Cloud:
    - **Updating the progress of goals and activities**: The status of any goal or activity can be updated (e.g., a goal can be set as "achieved" or "on-target") by a care team member. The patient can also provide feedback on their progress.
    - **Re-execution of CDS services during planned and unplanned encounters**: This is akin to the CDS service usage for the first time during initialization of a care plan. Relevant progress in the patient status is reflected in the recommendations of the CDS services.
    - **Display of patient provided data**: Patient and his informal care giver are active participants of the care planning process. Goals and activities are decided with his active involvement, and for an activity that is assigned to themselves, the patient is able to provide update via the Patient Empowerment Platform (PEP). Patient provided data includes questionnaire responses, medical device measurements (e.g., blood glucose, blood pressure), daily meal photographs and more. All patient provided data are matched with the corresponding care plan items and shown to the care team members.
    - **Commenting on the care plan items**: It is also possible to comment on specific goals and activities of a care plan, which are visible to the care team members.
- **Management of the care team**: It is possible to invite new care team members to a care plan, during initialization or at any time. An invitation is subject to the confirmation of the invited care team member, who is informed via a notification in the system and an email depending on the preference of the pilot sites. The Care Team Manager, who is always the GP of the patient in all 3 pilot sites of C3-Cloud, can also remove a professional from a care team, or a member may want to leave a care team. It is also possible for a health professional or social care worker to request joining an existing care team for a specific patient. Different roles can have different rights in the care team; for example, a nurse assistant or a social care worker can see a care plan but not modify it.

- **Communication among care team members and with the patient / informal care giver**:
    - **Asynchronous messaging**: C3DP has its own messaging module that enables safe messaging among all care team members, and also with the patients due to the integration between C3DP and PEP. HL7 FHIR Communication resource is used for messaging.
    - **Organization of tele/video conferences**: It will be possible to organize a tele/video conference session among the care team members (e.g., for a virtual case review meeting) and also bilaterally between a care team member and the patient. Among all the functionalities listed in this section, only this one is still in progress as it has strong dependency on the existing teleconferencing solutions of the pilot sites and integration work is ongoing. The setup in each pilot site is different for this purpose. This activity will continue in Task 7.4.
- **Dashboard view**: Dashboard view enables a signed in care team member to quickly go over the important updates in the care plans of all her patients since the previous login, such as new messages received, awaiting appointments, new system notifications.
- **Patient provided data screen**: Recently a new screen that collates all the patient provided data such as vital sign measurements, meal photos, feedback on the care plan and messages to the care team members has been implemented.
- **Activity calendar**: It enables view and update of scheduled activities of a care team member on a calendar.
- **Real-time system notifications**: Real-time system notifications are implemented for several events (e.g., for care plan update, new patient feedback, new message, invitation to a care team, etc.). When the user is already logged in to the system, such notifications are displayed in real time. It is also possible to access care team members via email for offline scenarios. SMS option was dropped by the pilot sites for real-time clinical notifications.

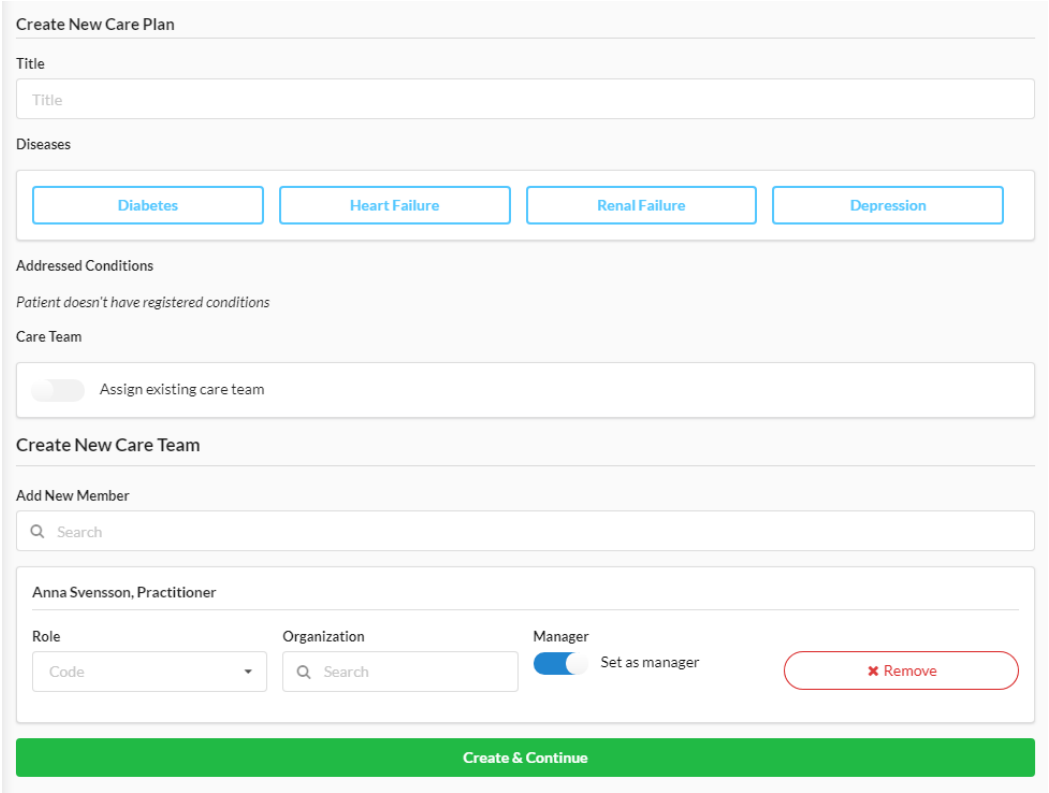


Figure 12 Care Plan Initiation Screen

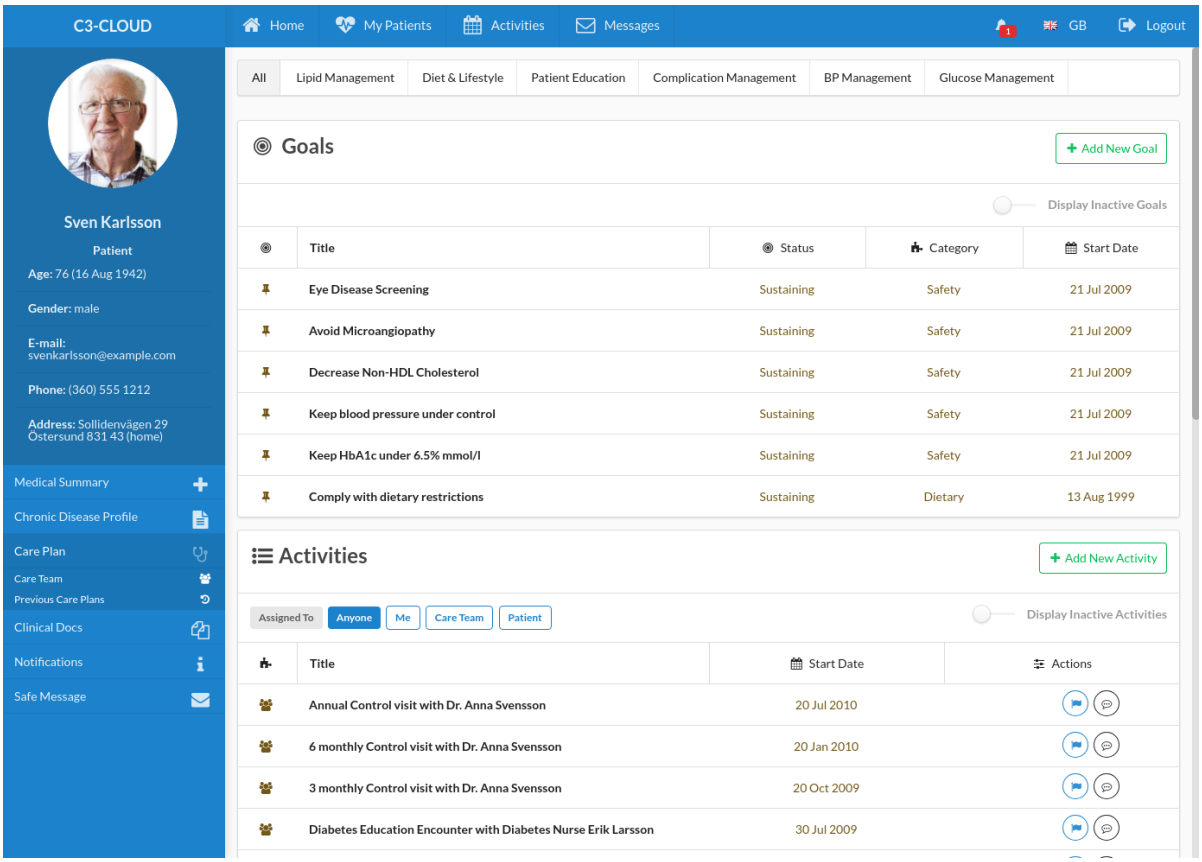


Figure 13 Care Plan Screen

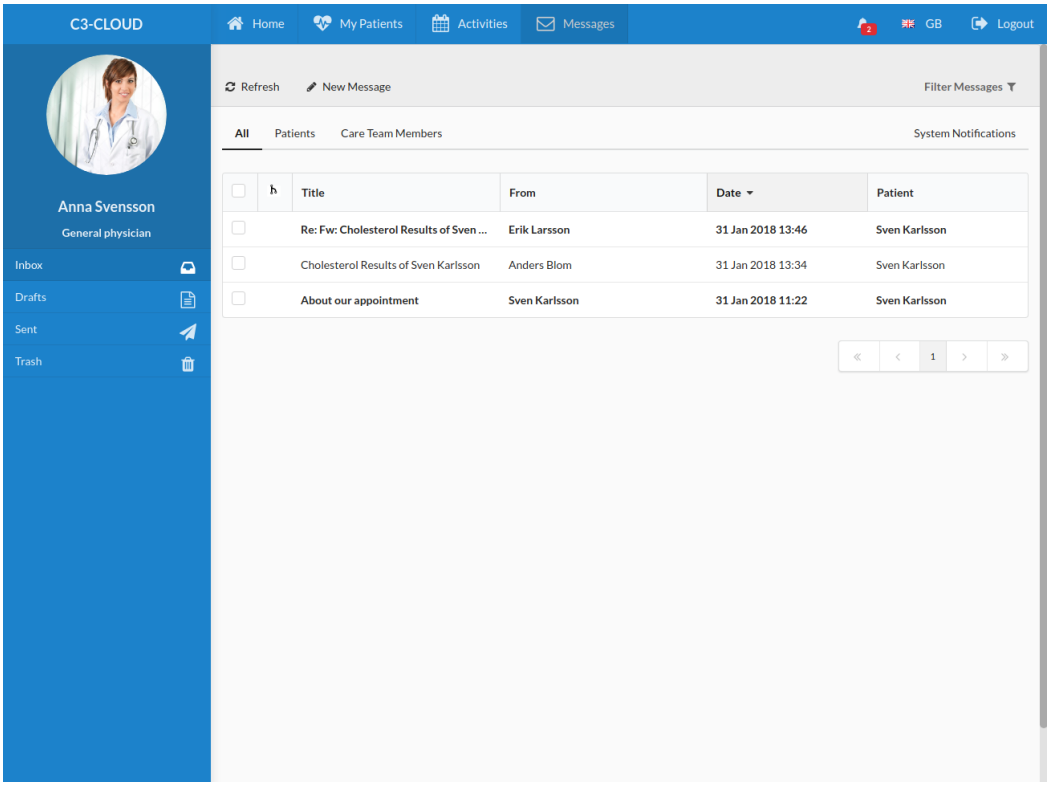


Figure 14 C3DP Messaging Screen

C3DP is implemented using Angular framework and interacts with other components via web APIs. It uses several NPM libraries like "fhir.js" which is the FHIR API library for JavaScript.

All the care plan management functionalities of C3DP are explained in detail in D7.3.

2.2.7. Patient Empowerment Platform (PEP)

The objective of the Patient Empowerment Platform (PEP) is to provide access for a patient to the published care plan and its information and thus increase patient and informal caregiver participation in decision making. PEP aims to provide computerized means to improve the interaction between patients and health professionals and provide computerized means to collect relevant data and information to enable monitoring of care plan related activity status and progress. It directly interacts with C3DP to be informed about new care plans and updated care plans, and to send back patient reported observations. It also directly communicates with the supported set of sensor devices to record patient measurements.

The core user functionalities and features provided to PEP Users are:

- Make published care plans available to the users.
- Send reminders to patients to help them comply and stay on track with the interventions and activities included in the care plan.
- Allow patients to actively collect data related to the care plan activities.
- Allow health professionals and patients to communicate with each other using either messages or video appointments.
- Provide patients with access to relevant self-management material.
- Provide all PEP users with secure access to this information and functionality.

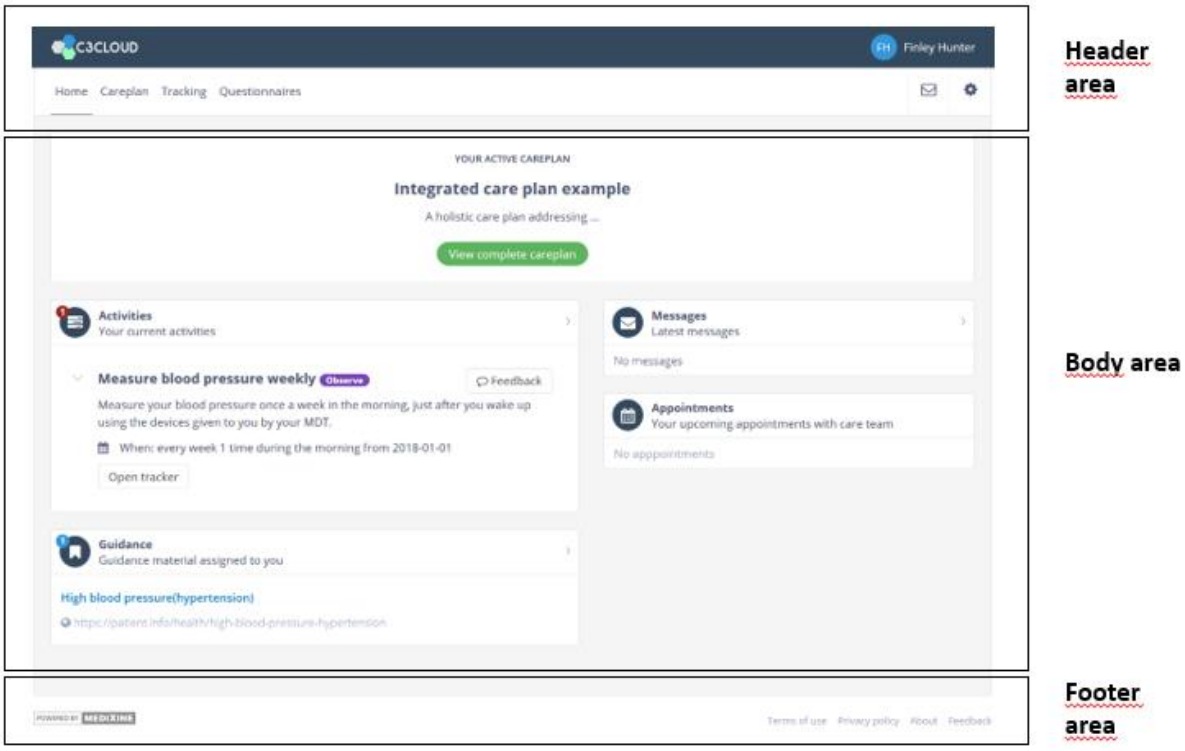


Figure 15 PEP User Interface

The PEP user application is a modern web application, which allows PEP Users (patients and their informal caregivers) to access all the functionality to meet the objectives of the Patient Empowerment Platform. PEP is built on the Medixine Suite product. The Medixine Suite technology stack follows traditional logic for web-based services and consists of OS (Microsoft Windows Server), Data storage (Microsoft SQL Server), Web Server (IIS) and Programming platform (.NET). The database layer contains some supporting functionalities, but the actual business logic is built into the application layer. Configurations for Windows, SQL Server and IIS follow standard conventions, which means that Medixine Suite can be hosted in practically every environment capable of hosting Microsoft technologies (Azure, AWS, Google Cloud, private clouds, traditional hosted servers, etc.). The application logic is based on modern resource-based thinking and is exposed through a REST API that is structured around those resources. The core logic includes role-based access configuration for different operations, full audit trails of operations performed in the system, application ecosystem model, dynamic and extensible data modelling tools, event subscription model for integrations and extensible support for multiple languages and cultures.

See deliverables D5.1, D5.2 and D5.3 for more details [D5.1, D5.2, D5.3].

3. INTEGRATION ACTIVITIES

3.1. TIS – Local EHR Systems Integration

TIS implements the technical layer of interoperability. As explained in Section 2 and D6.1, TIS provides a generic ETL framework independent of any particular EHR data exchange protocol. To integrate a specific EHR data source, an ETL task is built for that data source using the TIS framework. In the scope of C3-Cloud, TIS integrates the three pilot sites through their respective API for patient data access. Table 1 summarises the data exchange mechanisms provided by each pilot site.

Table 1 Pilot sites data exchange API

Pilot Site	*EHR Data Exchange API*	*Description*
OSAKI	CDA Web Service	The web service is a SOAP service, which returns the document of Summarized Clinical History of a patient in HL7 CDA R2 format. The CDA document contains the patient's demographics, conditions, lab tests, vital signs, medications, procedures, allergies, vaccinations, etc.
	Hospital Appointments Web Service	The web service is a SOAP service which returns future appointments in hospital care.
	Primary Care Appointments Web Service	The web service is a SOAP service which returns all appointments in primary care.
RJH	Cambio Open Services - Diagnoses	The REST service returns all diagnoses for a patient. The selection can be filtered with reference to time period.
	Cambio Open Services – Medical notes	The REST service returns all journal entries for a patient. The selection can be filtered with reference to time period.
	Cambio Open Services – Laboratory chemistry	The REST service returns all laboratory response chemistry for a patient. The selection can be filtered with reference to sampling time.
	Cambio Open Services – Drugs list	The REST service returns all pharmaceutical list for a patient. The selection can be filtered with reference to time period.
	Cambio Open Services – Patient	The REST service returns demographic data for a patient.
	Cambio Open Services – attention Signals	The REST service returns all attention signals for a patient. The selection can be filtered with reference to time period.
	Cambio Open Services – Care contacts	The REST service returns all care contacts for a patient. The selection can be filtered with reference to time period.
SWFT	EMIS data extract	The patient data extract is a CSV file generated from EMIS reporting service. EMIS is a GP system in SWFT. The extract contains patient demographics, conditions, lab tests, vital signs, medications, vaccinations, allergies, procedures and encounters. The extract is updated on a daily basis.

	Lorenzo/GAP data extract	The data extract is a CSV file generated from Lorenzo/GAP. Lorenzo is a patient administration system in secondary care and community care. GAP is a community scheduling tool in community care. The extract is updated on a daily basis.

Figure 16 shows an example of OSAKIDETZA CDA SOAP service. In the SOAP request, <tem:Cic/> encodes the patient identifier. The SOAP response returns the CDA xml document of the patient.

Http Request:

```
POST /osakidetza/negocio/asistencial/OsabideGlobal/HCRWS_v1/HCRWS HTTP/1.1
Host: pre.osb.osasunet:80
Content-Type: text/xml
Cache-Control: no-cache

<soapenv:Envelope              xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:tem="http://tempuri.org/">
   <soapenv:Header/>
   <soapenv:Body>
      <tem:getInformeHCRCDA3_V2>
         <tem:Cic>10574682</tem:Cic>
         <tem:IdIdioma>1</tem:IdIdioma>
      </tem:getInformeHCRCDA3_V2>
   </soapenv:Body>
</soapenv:Envelope>
```

Http Response:

```
HTTP/1.1 200 OK
Content-Type: text/xml; charset=utf-8
Content-Encoding: gzip
Connection: Keep-Alive
Keep-Alive: timeout=5, max=1000

<s:Envelope xmlns:s="http://schemas.xmlsoap.org/soap/envelope/">
    <s:Body>
        <getInformeHCRCDA3_V2Response xmlns="http://tempuri.org/">
            <getInformeHCRCDA3_V2Result
xmlns:a="http://schemas.datacontract.org/2004/07/B40_Ibermatica.Humancare.External.Entit
ies" xmlns:i="http://www.w3.org/2001/XMLSchema-instance">
                <a:CIC>10574682</a:CIC>
                <a:HCR_CDA>&lt;?xml version="1.0" encoding="utf-8"?&gt;&#xD;
&lt;?xml-stylesheet type="text/xsl" href="CDA_Profesional.xsl"?&gt;&#xD;
&lt;ClinicalDocument              xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:hl7-org:v3   CDASchema/CDA.xsd"   xmlns:voc="urn:hl7-org:v3/voc"
xmlns="urn:hl7-org:v3"&gt;&#xD;
  &lt;typeId root="2.16.840.1.113883.1.3" extension="POCD_HD000040" /&gt;&#xD;

…
&lt;/ClinicalDocument&gt;</a:HCR_CDA>
</getInformeHCRCDA3_V2Result>
        </getInformeHCRCDA3_V2Response>
    </s:Body>
</s:Envelope>
```

Figure 16 OSAKIDETZA CDA service example

RJH allows to access patient data through Cambio Open Services, which provides OAuth 2 protected API. The client application needs to register with the services and get an API key, client_id, and client_secret. Then, for each API call, the application needs to get an OAuth 2 access token by OAuth 2 client credentials grant, and use the token and API key to access the API. Figure 17 shows an example of acquiring an OAuth 2 access token before accessing Cambio Open Services. Figure 18 shows an example of using the access token to access Cambio Open Services - Patient API in order to retrieve patient demographics data.

Http Request:

```
POST /auth/realms/master/protocol/openid-connect/token HTTP/1.1
Host: authorizer.openservices.cambio.se
Cache-Control: no-cache
Content-Type: application/x-www-form-urlencoded

grant_type=client_credentials&client_id=5a89e2e902717807b8e6ffeb&client_secret=KjEpFCLxB
SEXAbYQTgrpWBLVnmVtE!ke
```

Http Response:

```
HTTP/1.1 200 OK
Content-Type: application/json
content-length: 3609

{
    "access_token": "tNLAVos34OqBR45Ie1ApaUQH_TRvWaYkVXcGUtIPT9dOBuBzVT5yhKBUetha3- …",
    "expires_in": 600,
    "refresh_expires_in": 1800,
    "refresh_token": "eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJEandYQkZRU …",
    "token_type": "bearer",
    "id_token":
"eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJEandYQkZRUDE5THktWlk4SDZPZnJNYl …",
    "not-before-policy": 0,
    "session_state": "902f1f99-e166-4851-9216-7db8abed43fd"
}
```

Figure 17 Acquire access token before accessing Cambio Open Services

Http Request:

```
GET /patients/patient/ HTTP/1.1
Host: api.openservices.cambio.se
Ocp-Apim-Subscription-Key: 77aa2b5043204fb88f333bc2b2bfb73e
patient: 198611062384
Authorization: Bearer eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJEandYQkZRUDE5…
Cache-Control: no-cache
```

Http Response:

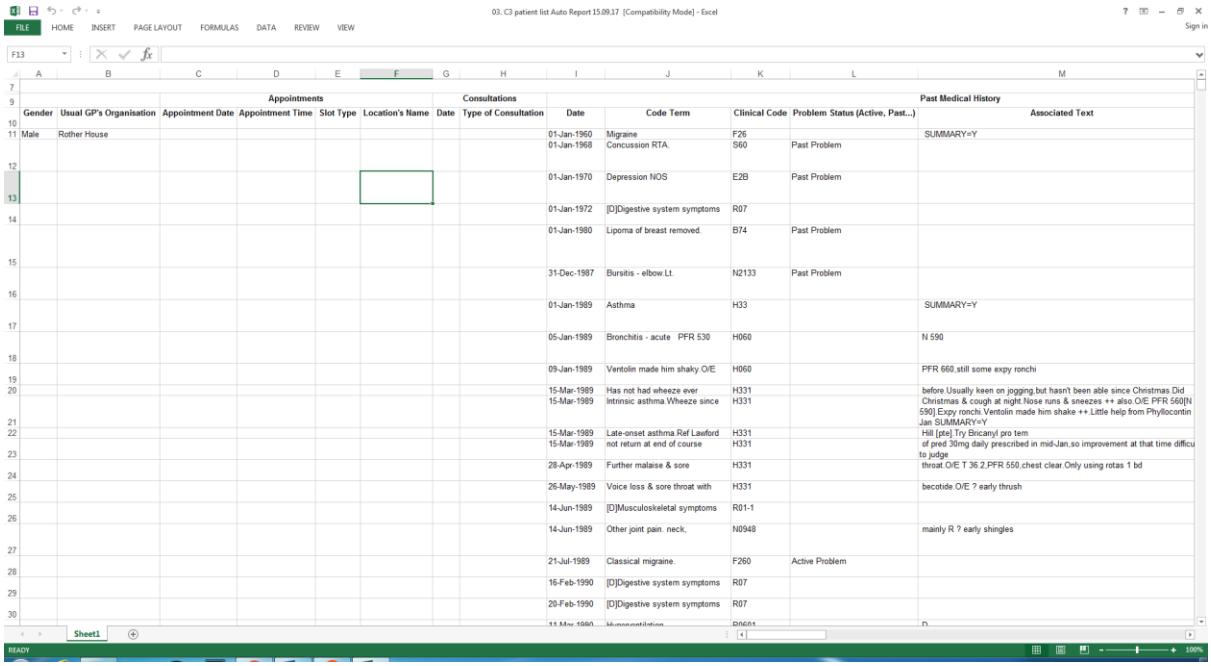
```
HTTP/1.1 200 OK
Content-Length: 3432
Content-Type: application/json;charset=UTF-8
Expires: 0

[
    {
        "XSDVersion": {
            "version": 0.42
        },
        "PatientEHRExtract": [
            {
                "ehr_id": {
                    "extension": "SE162321000024-Cambio_Common_U:EhrId:198611062384",
                    "root": "1.2.752.129.2.1.2.1"
                },
                "ehr_system": {
                    "extension": "SE162321000024-Cambio_Common_U",
                    "root": "1.2.752.129.2.1.2.1"
                },
                "time_created": {
                    "value": "20171108155050"
                },
                "Patient": {
                    "PhoneNumbers": {
                        "Phone": [
                            {
                                "PhoneComment": "Svara enbart på kvällar.",
                                "PhoneType": "Mobil",
                                "PhoneNumber": "089-000001"
                            }
                        ]
                    },
                    "PatientBirthDate": {
                        "value": "19861106"
                    },
                    "PatientDataRegister": {
                        "PatientCounty": "",
                        "PatientCity": "",
                        "PatientDistrict": "",
                        "PatientCountry": "Sverige"
                    },
                    "PatientProtectedId": false,
                    "PatientName":

                …
            }
        ]
    }
]
```

Figure 18 Cambio Open Services -- Patient API example

Figure 19 shows an example of SWFT EMIS data extract in MS Excel. The file exports all patient data fields as columns so the data is in a wide format of table structure, which contains over 100 columns.



	Appointments					Consultations						Past Medical History	
Gender	Usual GP's Organisation	Appointment Date	Appointment Time	Slot Type	Location's Name	Date	Type of Consultation	Date	Code Term	Clinical Code	Problem Status (Active, Past...)	Associated Text
Male	Rother House							01-Jan-1960	Migraine	F26		SUMMARY=Y
								01-Jan-1968	Concussion RTA.	S60	Past Problem	
								01-Jan-1970	Depression NOS	E2B	Past Problem	
								01-Jan-1972	[D]Digestive system symptoms	R07		
								01-Jan-1980	Lipoma of breast removed.	B74	Past Problem	
								31-Dec-1987	Bursitis - elbow.Lt.	N2133	Past Problem	
								01-Jan-1989	Asthma	H33		SUMMARY=Y
								05-Jan-1989	Bronchitis - acute PFR 530	H060		N 590
								09-Jan-1989	Ventolin made him shaky.O/E	H060		PFR 660,still some expy ronchi
								15-Mar-1989	Has not had wheeze ever	H331		before.Usually keen on jogging,but hasn't been able since Christmas.Did Christmas & cough at night.Nose runs & sneezes ++ also.O/E PFR 560[N 590].Expy ronchi.Ventolin made him shake ++ Little help from Phyllocontin Jan.SUMMARY=Y
								15-Mar-1989	Intrinsic asthma.Wheeze since	H331		
								15-Mar-1989	Late-onset asthma.Ref Lawford	H331		Hill [pte].Try Bricanyl pro tem
								15-Mar-1989	not return at end of course	H331		of pred 30mg daily prescribed in mid-Jan,so improvement at that time difficu to judge
								28-Apr-1989	Further malaise & sore	H331		throat.O/E T 36.2,PFR 550,chest clear.Only using rotas 1 bd
								26-May-1989	Voice loss & sore throat with	H331		becotide.O/E ? early thrush
								14-Jun-1989	[D]Musculoskeletal symptoms	R01-1		
								14-Jun-1989	Other joint pain. neck,	N0948		mainly R ? early shingles
								21-Jul-1989	Classical migraine.	F260	Active Problem	
								16-Feb-1990	[D]Digestive system symptoms	R07		
								20-Feb-1990	[D]Digestive system symptoms	R07		

Figure 19 SWFT EMIS extract example

3.2. TIS – SIS Integration

The TIS – SIS integration allows TIS to use the SIS Structural Mapper service to transform patient data in their original format exposed by local EHR systems into FHIR resources. The SIS Structural Mapper service provides a RESTful API. The API is described in Table 2. Figure 20 shows an example of TIS using the SIS Structural Mapper service to transform OSAKI CDA xml into FHIR resources in JSON format. The mapper for other pilot site EHR data works in a similar way.

Table 2 SIS Structural Mapper Service API

	Name	**Description**
URL Path	/transform	The REST service endpoint
Query Parameter	format	Output FHIR resource format. Its value is “json” or “xml”.
Query Parameter	mapperInstance	Indicates which mapping function is requested. Its value takes the form “source:ehr:version”. For example, a value “osaki:cda:0.1” represents a mapping function of version 0.1 for OSAKI CDA data.
Output	The service returns a FHIR resource Bundle in the format specified by the request parameter “format”.	

Http Request:

```
POST /transform?format=json&amp;mapperInstance=osaki:cda:0.1 HTTP/1.1
Host: ubiqore.fr
Content-Type: text/xml
Cache-Control: no-cache

<?xml-stylesheet type="text/xsl" href="CDA_Profesional.xsl"?>
<ClinicalDocument                  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:hl7-org:v3   CDASchema/CDA.xsd"   xmlns:voc="urn:hl7-org:v3/voc"
xmlns="urn:hl7-org:v3">
  <typeId root="2.16.840.1.113883.1.3" extension="POCD_HD000040" />
  <templateId root="2.16.724.4.50.1" />
…
</ClinicalDocument>
```

Http Response:

```
HTTP/1.1 200 OK
Content-Type: application/json;charset=UTF-8
Content-length: 17317

{
    "resourceType": "Bundle",
    "type": "collection",
    "entry": [
        {
            "resource": {
                "resourceType": "Patient",
                "id": "10574682",
                "identifier": [
                    {
                        "system": "urn:oid:2.16.724.4.16.1.100.2.1",
                        "value": "10574682"
                    }
                ],
                "name": [
                    {
                        "family": "FICTICIO ACTIVO",
                        "given": [
                            "CIUDADANO"
                        ]
                    }
                ],
                "telecom": [
                    {
                        "system": "phone",
                        "value": "000000000"
                    }
                ],
                "gender": "male",
                "birthDate": "1977-06-22",
                …
        },
        {
            "resource": {
                "resourceType": "Condition",
                "clinicalStatus": "active",
        …
    ]
}
```

Figure 20 SIS structural mapping service example

3.3. TIS – FHIR Repository Integration

The TIS – FHIR repository enables TIS to push FHIR resources into the C3-Cloud FHIR Repository. As described in the previous section, TIS receives transformed patient data in a FHIR resource bundle from the SIS Structural Mapper service. TIS converts the resource bundle into a transaction bundle, where patient resource is processed by PUT operation while other resources are processed by POST. Then TIS posts the transaction bundle to the repository REST endpoint. After the transaction bundle is processed, the repository returns an HTTP 200 response with a FHIR resource bundle containing all the resources that have been successfully saved. Figure 21 shows an example of HTTP request that TIS sends a transaction bundle to the FHIR repository. Note that the FHIR repository API is protected by OAuth 2.0, so the request carries an OAuth 2.0 access token in the Authorization header. Section 3.7 describes how TIS acquires the access token through TIS – SPS integration. Figure 22 shows the HTTP response to the example request in Figure 21.

Http Request:

```
POST /c3cloud/fhir-secure/ HTTP/1.1
Host: app.srdc.com.tr
Content-Type: application/fhir+json;charset=utf-8
Authorization: Bearer 13d7b8ei8ha71gecih4g5h5e3jhcg71

{
  "resourceType": "Bundle",
  "type": "transaction",
  "entry": [
    {
      "fullUrl": "https://app.srdc.com.tr/c3cloud/fhir-secure/Patient/123456",
      "resource": {
        "resourceType": "Patient",
        "id": "123456",
        "name": [
          {
            "family": "ORUETA LEAL",
            "given": [ "JOSEBA ANTXON" ]
          }
        ],
        "gender": "male",
        "birthDate": "1965-11-23",
        …
      },
      "request": {
        "method": "PUT",
        "url": "Patient/123456"
      }
    },
    {
      "resource": {
        "resourceType": "MedicationStatement",
        "medicationCodeableConcept": {
          "coding": [
            {
              "system": "urn:oid:2.16.724.4.21.5.15",
              "display": "CLOPIDOGREL 75MG 28 COMPRIMIDOS RECUBIERTO"
            }
          ]
        },
        "effectivePeriod": {
          "start": "2017-11-20T00:00:00+00:00",
          "end": "2018-03-19T00:00:00+00:00"
        },
        "subject": {
          "reference": "Patient/123456",
          "display": "[JOSEBA ANTXON] ORUETA LEAL"
        },
        …
      },
      "request": {
        "method": "POST",
        "url": "MedicationStatement"
      }
    },
    …
  ]
}
```

Figure 21 TIS - FHIR repository integration HTTP request example

Http Response:

```
HTTP/1.1 200 OK
Content-Type: application/fhir+json; charset=UTF-8
Access-Control-Allow-Origin: *
Content-Length: 1955

{
    "resourceType": "Bundle",
    "id": "2772affd-6ef8-4f64-b66f-4a56b699e3fa",
    "type": "transaction-response",
    "entry": [
        {
            "resource": {
                "resourceType": "Patient",
                "id": "123456",
                "name": [
                    {
                        "family": "ORUETA LEAL",
                        "given": [ "JOSEBA ANTXON" ]
                    }
                ],
                …
                "meta": {
                    "versionId": "4",
                    "lastUpdated": "2018-04-07T08:10:46Z"
                }
            },
            "fullUrl": "/c3cloud/fhir-secure/Patient/123456/_history/4",
            "response": {
                "status": "200 OK",
                "lastModified": "2018-04-07T08:10:46",
                "location":                    "https://app.srdc.com.tr/c3cloud/fhir-
secure/Patient/123456/_history/4",
                "etag": "W/\"4\""
            }
        },
        {
            "resource": {
                "resourceType": "MedicationStatement",
                …
                "id": "3d452b68-a69a-4de8-aba9-76b312c958ac",
                "meta": {
                    "versionId": "1",
                    "lastUpdated": "2018-04-07T08:10:46Z"
                }
            },
            "fullUrl":     "/c3cloud/fhir-secure/MedicationStatement/3d452b68-a69a-4de8-
aba9-76b312c958ac/_history/1",
            "response": {
                "status": "201 Created",
                "lastModified": "2018-04-07T08:10:46",
                "location":                    "https://app.srdc.com.tr/c3cloud/fhir-
secure/MedicationStatement/3d452b68-a69a-4de8-aba9-76b312c958ac/_history/1",
                "etag": "W/\"1\""
            }
        },
        …
    ]
}
```

Figure 22 TIS - FHIR repository integration HTTP response example

3.4. C3DP – SPS Integration

The C3DP is integrated with the SPS to authorize the care team members and let them view and manipulate the data of the patients and manage the respective care plan. Unauthenticated users are redirected to the SPS Manager for single sign on. After the user is authenticated by SPS, C3DP asks for an access token and user info for the authenticated user. Then, it uses this token to communicate and exchange data with Secure C3-Cloud FHIR Repository and other components.

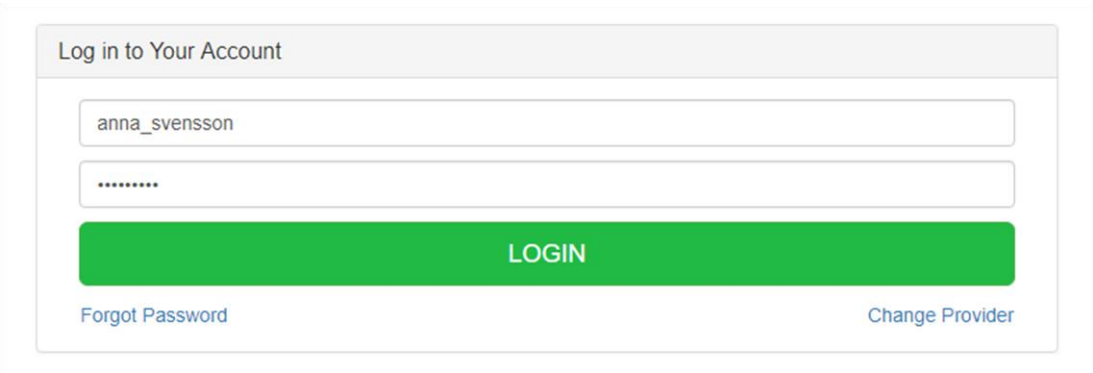


Figure 23 SPS Single Sign-on

SPS implements the OAuth 2 specification for authorization. C3DP is integrated with the SPS using the standard OAuth 2 endpoints. C3DP redirects the care team member user to the SPS single sign-on interface with OAuth 2 compliant query parameters asking for scope, redirect URI and response type:

Redirect to: https://app.srdc.com.tr/c3cloud/onauth/onauth-manager/login?

state=47808031

&scope=profile,openid,user/*.*

&prompt=login

&redirect_uri=https://app.srdc.com.tr/c3dp/home

&client_id=c3dp-client-id

&response_type=code

After the user is logged via the SPS Manager (either to the default C3-Cloud IdP or an IdP of a pilot site), it redirects the browser with an authentication code for this user.

Redirect to: https://app.srdc.com.tr/c3dp/home?

code=**84996171995053431629979719424531834307O**

Then, C3DP uses this code to get a token which will allow it to access the data in the Secure C3-Cloud FHIR Repository in compliance with the user's allowed permissions (i.e. scope) and interact with other C3-Cloud components. These scopes are compliant with the Smart App Authorization specification [SMART-APP-AUTHZ], which is developed specifically to cover the needs of HL7 FHIR based permissions by benefiting from the OAuth 2 standard.

Request URL: https://app.srdc.com.tr/c3cloud/onauth/api/token

Request Method: POST

Form Data:

grant_type: authorization_code

client_id: c3dp-web

redirect_uri: https://app.srdc.com.tr/c3dp/home

code: 84996171995053431629979719424531834307O

The response includes JWT tokens that are the access token, refresh token and id token for the current user.

```
{
    "access_token": "dgfhc44e9e073a2391jbhbi22481f6",
    "token_type": "Bearer",
    "scope": "user/Group.write user/UserInfo.write user/Condition.write offline_access ...",
    "refresh_token": "baf82d1g2126hg8fch6j07150044b4",
    "expires_in": 86400,
    "id_token": "eyJraWQiOiJlYjAwZDg3Yy1mZTZhLTQ4MjctYTQ1Mi1jM2YxMTkyN2M1NT..."
}
```

C3DP decodes the id token to extract the user identity, and uses the access token to access the patient data or interact with other components.

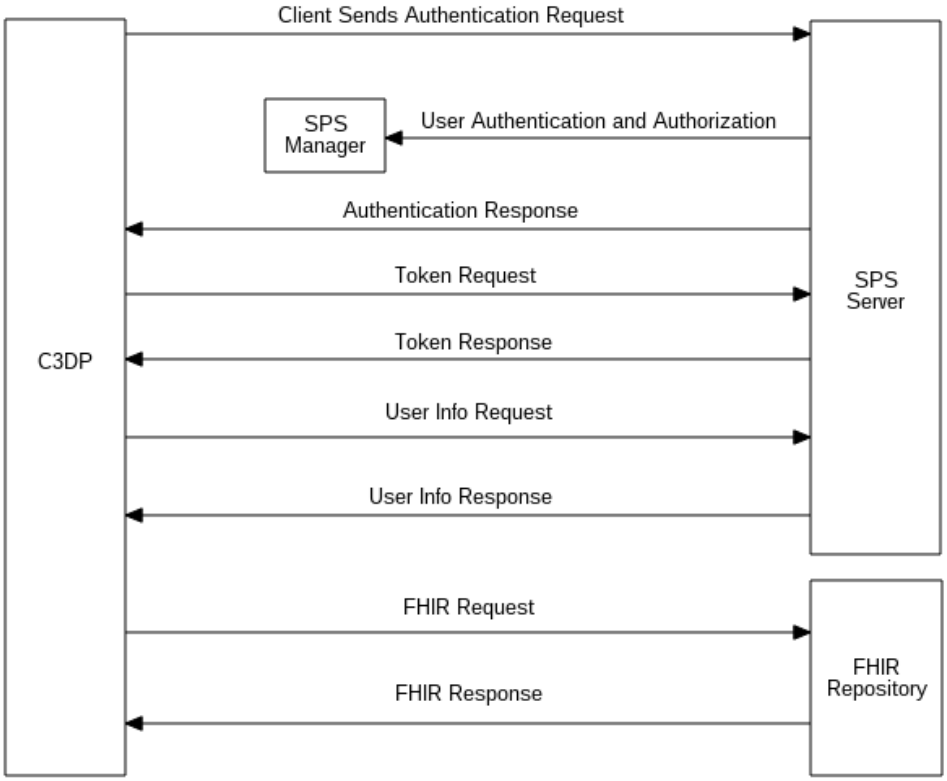


Figure 24 C3DP - SPS Authentication Flow

3.5. C3DP – CDS Services Integration

C3DP is integrated with Clinical Decision Support (CDS) services to provide the care team members with personalised goal and activity (e.g., medication, referral, physical exercise, diet, etc.) recommendations for their multi-morbid elderly patients according to the expert knowledge present in the evidence based clinical guidelines.

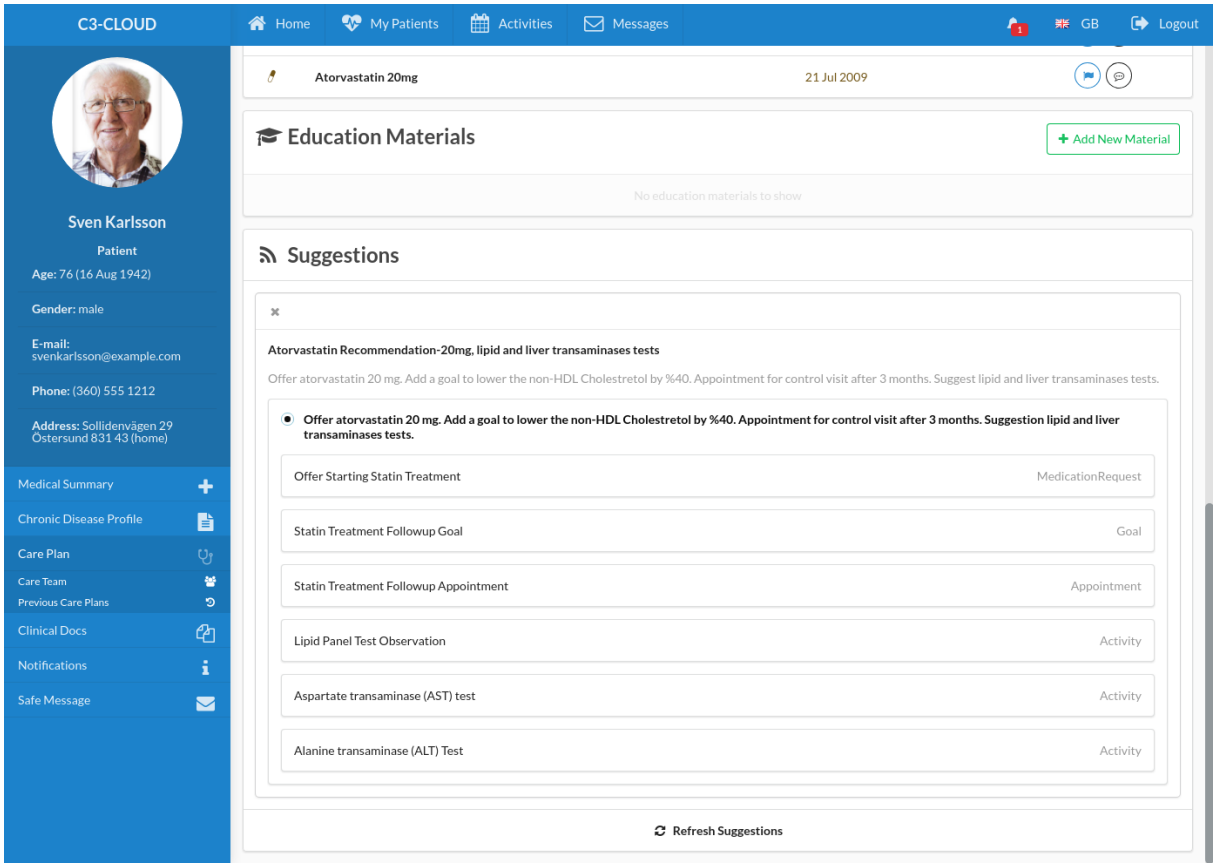


Figure 25 CDS Suggestions in C3DP UI

In the C3-Cloud architecture, all the guideline based CDS services are implemented in compliance with the CDS Hooks specification [CDS-HOOKS]. C3DP is pre-configured with the input data requirements (i.e. prefetch data) of each separate CDS service. CDS prefetch data requirements are provided by the C3-Cloud FHIR Repository via a C3-Cloud specific FHIR operation named **$cds-config** to the C3DP. In the example below, the prefetch data requirements of the diet management and QRISK2 score calculation CDS services are provided:

Request Url: https://app.srdc.com.tr/c3cloud/fhir/Parameters/$cds-config

Response:


```
{
   "resourceType": "Parameters",
   "parameter": [
      {
         "name": "REM_DIET",
         "resource": {
            "prefetch": "conditions[t2d;ckd] lab_results[egfr]",
            "required": ""
         }
      },
      {
         "name": "REM_QRISK2",
         "resource": {
            "prefetch": "conditions[t1d;t2d;ckd;atrial_fibrillation;rheumatoid_arthritis]
medications[antihypertensives;diuretics;beta_blocking_agents;calcium_channel_blockers;renin_angi
otensin] vital_signs[height;weight;bp] lab_results[cholesterol;hdl]
family_history[family_heart_attack;family_angina] social_history[smoking]",
            "required": "vital_signs[height;weight;bp] lab_results[cholesterol;hdl;ldl;egfr]"
         },
          ...
   ]
}
```


C3DP displays these required data to the care team members for cross-check, either in the “Chronic Disease Profile” screen or in each dedicated tab for high-level goals. After the user decides that the data is complete and correct, a CDS Hooks request is created with the collected patient data and sent to the corresponding CDS service to get the personalised goal and activity recommendations for the patient.

Request Url: https://app.srdc.com.tr/c3cloud/fhir-secure/Patient/p-1-demo/$c3dp-cdsm

Request Method: POST

Request Body:

```
{
  "prefectch": {
    "patient": <<Patient Resource>>,
    "conditions": <<Related Conditions as FHIR Bundle>>,
    "medications": <<Related Medications as FHIR Bundle>>,
    ...
  }
}
```

Response:

```
{
  "cards": [{
      "summary": <<Suggestion Summary>>,
      "detail": <<Detailed description>>,
      "source": <<Source of the Suggestion>>,
      "suggestions": [
        {
          "uuid": <<Unique Id of the Suggestion>>,
          "label": <<Label of the Suggestion>>,
          "actions": [{
              "description": <<Description of the Suggested Action>>,
              "type": <<Type of the Suggested Action(e.g. "create")>>,
              "resource": <<The FHIR Resource that the Action will be Applied >>
          }]
        }]
    }]
}
```

C3DP visualizes these suggestions, as shown in Figure 25, and allows user to select and apply suggested actions or read the information cards.

Recently a new CDS service, providing drug-drug and drug-disease interactions, has been implemented, by WARWICK, on top of the test database provided by the Finnish company Lääketietokeskus. Integration with this new service is ongoing. SRDC is trying to optimize the calls to the CDS services and display to the care team members.

3.6. C3DP – PEP Integration

The integration and bidirectional data sharing between C3DP and PEP C3-Cloud components is done via the centralized C3-Cloud FHIR Repository and the Event APIs. When a component changes data in the FHIR repository, the component sends an event to other components to signal to it to fetch and process the new data. When an action is taken on C3DP like assigning a goal/activity to the patient or any care plan update, PEP is notified to inform the patient. The same flow is valid for the opposite direction as well. When patient performs an action like filling a questionnaire, uploading a meal photo

or a device measurement, an event is created by the PEP and sent to the C3DP Event API, which then informs the corresponding care team members via the C3DP user interface in real-time using Socket.io web sockets (see Figure 26).

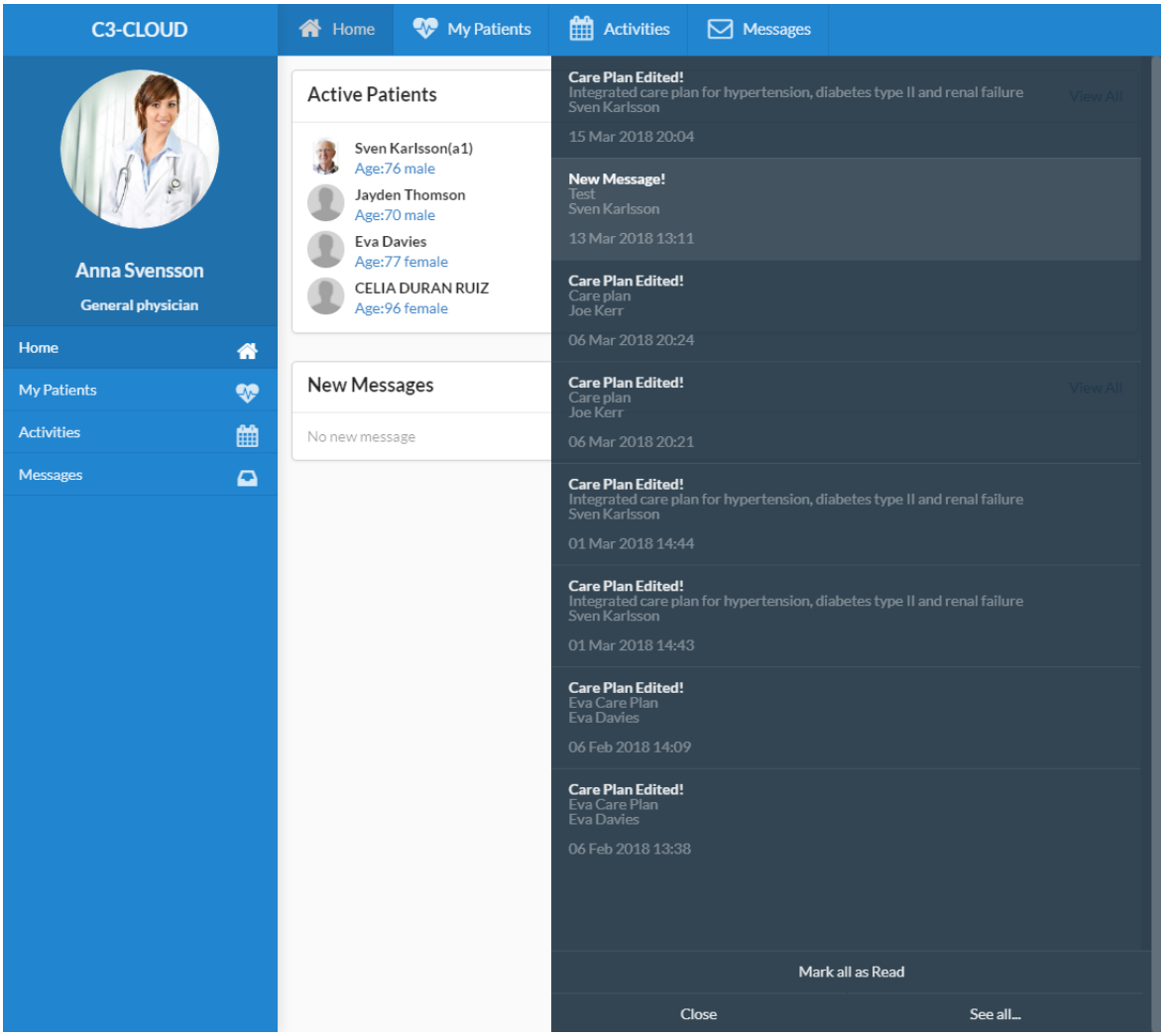


Figure 26 Display of PEP Notifications in C3DP

3.6.1. FHIR Resources

The following FHIR resources are used in the integration with other C3-Cloud components:

Resource	Description
Patient	The core information of the patient enrolled in C3-Cloud
CareTeam	The MDT of a patient.
Practitioner	A health professional, who is a member of patient MDT.
RelatedPerson	An informal caregiver of a patient.
CarePlan	The integrated care plan of a patient.
Goal	The care plan goals set in the care plan.
CarePlan.activity	Questionnaire, observation or a general activity assigned to the patient by the MDT.
DeviceRequest	Measurement activity assigned to patient by the MDT.

MedicationRequest	Medications prescribed to the patient.
Appointment	Patient appointments related to the care plan.
CommunicationRequest	Guidance and training materials assigned to the patient
Communication	Messages between patient and MDT.

3.6.2. Events

C3DP and PEP trigger the other component whenever there is action and/or new data the other component needs to be aware of.

Each event sent to the other component contains:

- Id: A unique identifier for this event.
- Type: A descriptive identifier for the event that helps to process the event correctly.
- Timestamp: Occurrence date/time for the event.
- Related resources: Links to resources that are relevant for processing this event and their relationship with this event. Shall contain at least the target resource, for which the event was triggered.

Optionally the event may contain:

- Subject (if applicable): The entity that has been the target of this operation. Primarily patient if this operation pertains to a patient.
- Performer (if applicable): The entity whose actions have caused this event in the system of origin. Primarily expert or patient.

Request Url: https://app.srdc.com.tr/c3cloud/event/api/c3dp

Request Body:

```
{
  "type": "QuestionnaireResponseCreated",
  "subject": {
    "reference": "Patient/example-patient",
    "display": "Example Patient"
  },
  "performer": {
    "reference": "Patient/example-patient",
    "display": "Example Patient"
  },
  "timestamp": "2018-04-02T11:00:00Z",
  "relatedResources": [{
    "reference": "QuestionnaireResponse/qr-example",
    "relationship": "target"
  }]
}
```

Figure 27 Example of event between C3DP and PEP

The most essential events from C3DP to PEP are:

- CarePlanCreated, CarePlanUpdated: There is a new or updated care plan in the FHIR repository for the specified patient.
- CommunicationCreated: There is a new message to the patient in the FHIR repository.

The most essential events from PEP to C3DP are:

- ObservationCreated: Patient has created new observation data, which has been stored in the FHIR repository.
- QuestionnaireResponseCreated: Patient has completed a patient questionnaire and the response is available in the FHIR repository.
- CarePlanRead: The patient has viewed the care plan.
- CommunicationRead: The patient has viewed the message from a care team member.
- CommunicationCreated: There is a new message from the patient in the FHIR repository.

3.6.3. Message Examples

3.6.3.1. Questionnaire activity (CarePlan.activity)

The assignment of a patient questionnaire in the care plan.


```
"detail": {
    "category": {
        "coding": [{
            "system": "http://hl7.org/fhir/care-plan-activity-category",
            "code": "observation",
            "display": "Observation"
        }]
    },
    "extension": [{
            "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/identifier",
            "valueIdentifier": {
                "value": "a-008"
            }
        },
        {
            "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/introducedBy",
            "valueReference": {
                "reference": "Practitioner/2-000003",
                "display": "Erik Larsson"
            }
        }
    ],
    "description": "Fill in the questionnaire to collect information about your lifestyle",
    "definition": {
        "reference": "Questionnaire/q-001",
        "display": "Lifestyle questionnaire"
    },
    "status": "completed",
    "prohibited": false,
    "scheduledTiming": {
        "repeat": {
            "frequency": 1,
            "period": 1,
            "periodUnit": "wk",
            "duration": 20,
            "durationUnit": "min",
            "boundsPeriod": {
                "start": "2009-07-22",
                "end": "2009-07-29"
```


Figure 28 Extract from Questionnaire CarePlan activity message

3.6.3.2. QuestionnaireResponse

A response to a questionnaire provided by the patient or informal care giver.


```
{
  "resourceType": "QuestionnaireResponse",
  "id": "a71aa3dcd14e44ee99f4f788d02391df",
  "language": "en",
  "questionnaire": {
    "reference": "Questionnaire/173b490102ef4285886239a2e259ce33"
  },
  "status": "completed",
  "subject": {
    "reference": "Patient/1-000001",
    "display": "Sven Karlsson"
  },
  "authored": "2017-08-29T13:40:00+02:00",
  "item": [
    {
      "linkId": "h86ipzc4ue38m9ffcpp11x38f4lwyn46", "text": "About you",
      "item": [
        {
          "linkId": "feeling",
          "item": [
            {
              "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb", "text": "How are you feeling right now?",
              "item": [
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling01", "text": "Energy", "answer": [{"valueDecimal": 15.0}]},
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling02", "text": "Moving", "answer": [{"valueDecimal": 15.0}]},
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling03", "text": "Stress", "answer": [{"valueDecimal": 15.0}]},
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling04", "text": "Sleep", "answer": [{"valueDecimal": 15.0}]},
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling05", "text": "Weight", "answer": [{"valueDecimal": 15.0}]},
                { "linkId": "rffnuq4otjys4ha4jqfdbw27vij944vb-feeling06", "text": "Mood", "answer": [{"valueDecimal": 15.0}]}
              ]
            }
          ]
        }
      ]
    },
    {
      "linkId": "yxuqo77ui94u6dhgorevep77utehod8n", "text": "About you",
      "item": [
        {
          "linkId": "dynbxv2xkyheyvpbqnvzlu032rng4w8k", "text": "What stops you taking care of yourself?",
          "answer": [
```


Figure 29 Extract from QuestionnaireResponse message

3.6.3.3. Measurement CarePlan activity (DeviceRequest)

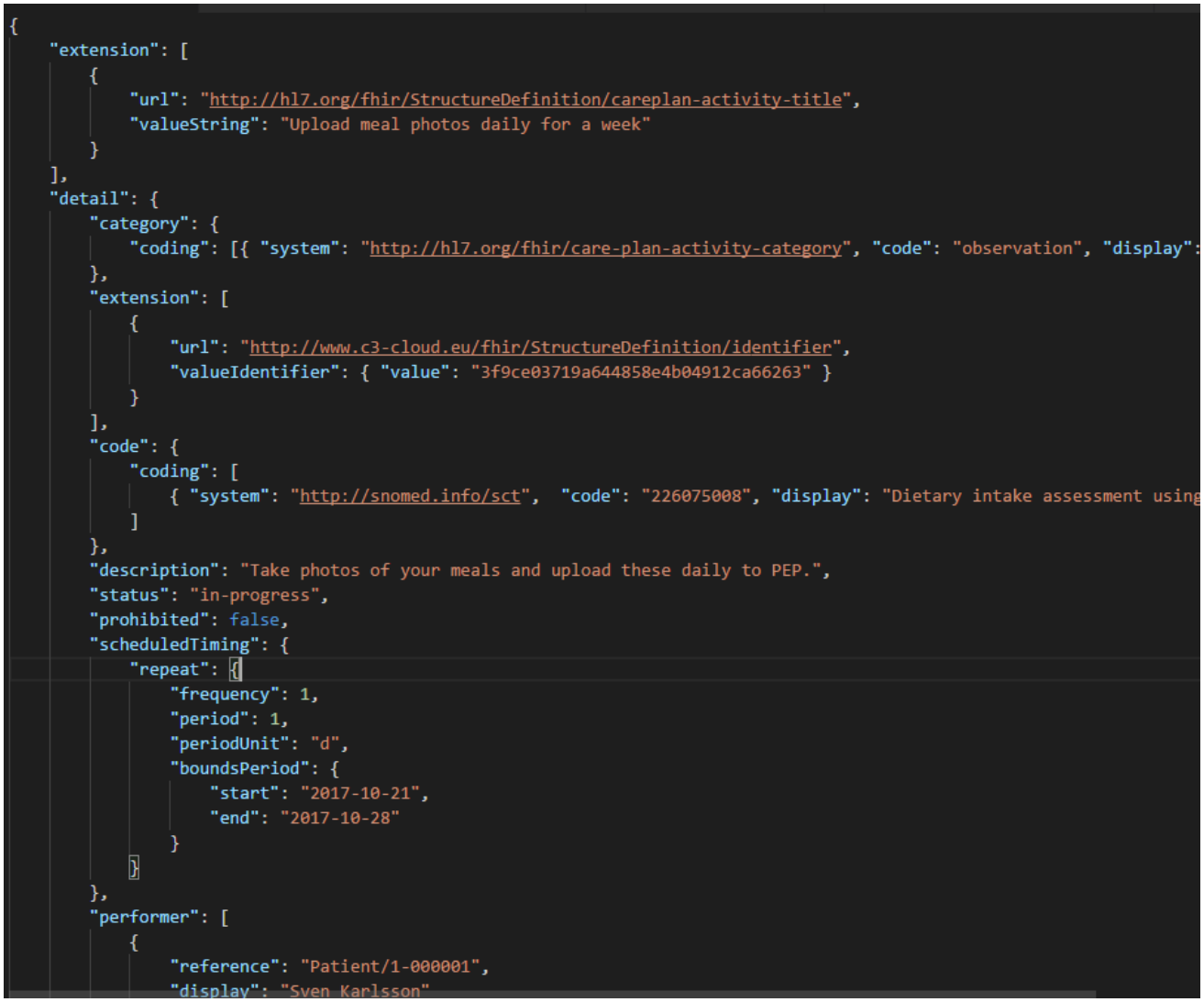
The assignment of medical device usage to a patient within inside the care plan.


```
{
    "resourceType": "DeviceRequest",
    "id": "b4635f0ed75d4f06b1ad199e36631097",
    "extension": [
        {
            "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/title",
            "valueString": "Measure your blood pressure daily in the morning, just after you wake up for two weeks (clinical)"
        },
        {
            "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/description",
            "valueString": "Make sure the measurement is available in your PEP record."
        }
    ],
    "status": "active",
    "intent": {
        "coding": [{"code": "order"}]
    },
    "codeReference": {
        "reference": "Device/3d43bea093734b5e8006d06b2febeb21"
    },
    "subject": {
        "reference": "Patient/1-000001"
    },
    "occurrenceTiming": {
        "repeat": {
            "frequency": 1,
            "period": 1, "periodUnit": "d", "when": "MORN",
            "boundsPeriod": {
                "start": "2017-09-15",
                "end": "2017-09-29"
            }
        }
    },
    "performer": {
        "reference": "Patient/1-000001"
    }
}
```


Figure 30 Measurement activity using provider device (clinical)

3.6.3.4. Observation CarePlan activity (CarePlan.activity)

The assignment of some observations to be performed by the patient within the scope of his care plan.

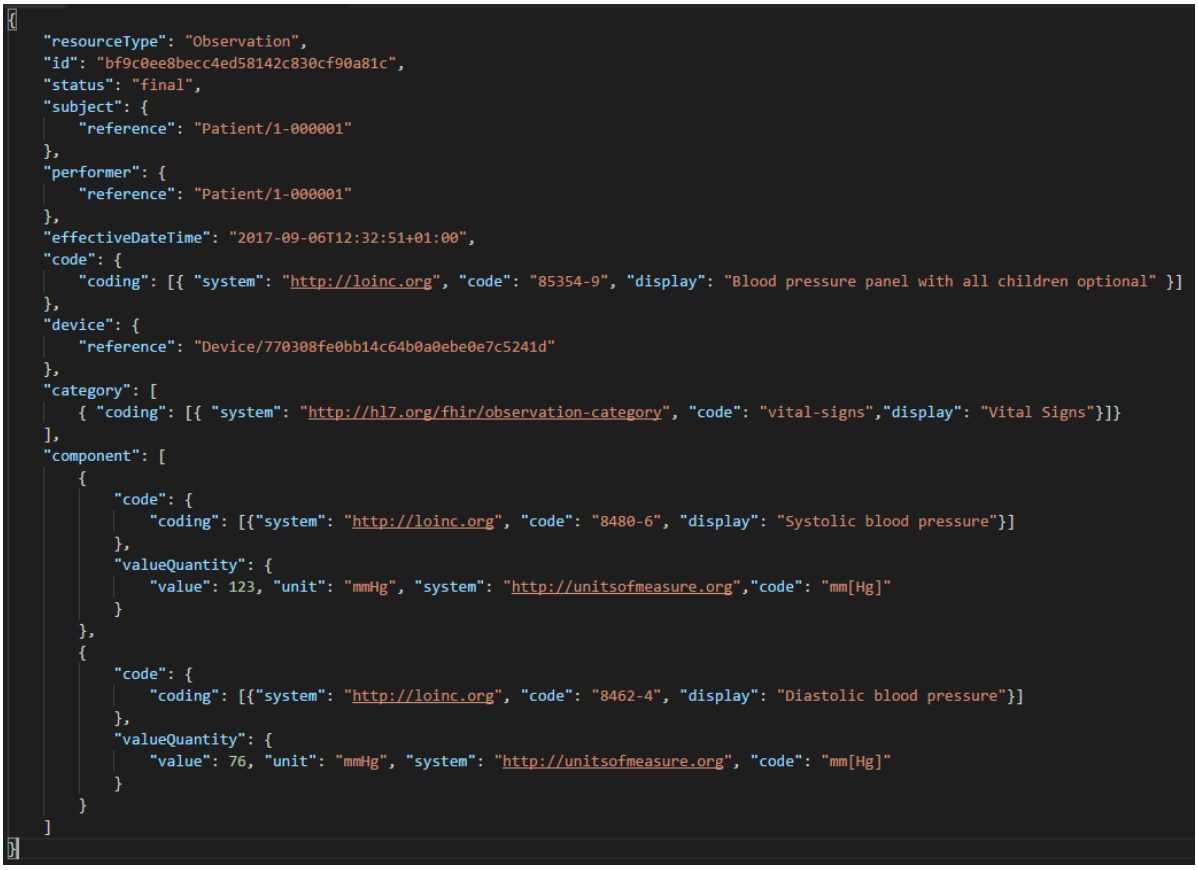



```
{
    "extension": [
        {
            "url": "http://hl7.org/fhir/StructureDefinition/careplan-activity-title",
            "valueString": "Upload meal photos daily for a week"
        }
    ],
    "detail": {
        "category": {
            "coding": [{ "system": "http://hl7.org/fhir/care-plan-activity-category", "code": "observation", "display":
        },
        "extension": [
            {
                "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/identifier",
                "valueIdentifier": { "value": "3f9ce03719a644858e4b04912ca66263" }
            }
        ],
        "code": {
            "coding": [
                { "system": "http://snomed.info/sct",  "code": "226075008", "display": "Dietary intake assessment using
            ]
        },
        "description": "Take photos of your meals and upload these daily to PEP.",
        "status": "in-progress",
        "prohibited": false,
        "scheduledTiming": {
            "repeat": {
                "frequency": 1,
                "period": 1,
                "periodUnit": "d",
                "boundsPeriod": {
                    "start": "2017-10-21",
                    "end": "2017-10-28"
                }
            }
        },
        "performer": [
            {
                "reference": "Patient/1-000001",
                "display": "Sven Karlsson"
```


Figure 31 Extract from observation activity

3.6.3.5. Observations

The results of the performed observations by the patient or informal care giver.



```
{
    "resourceType": "Observation",
    "id": "bf9c0ee8becc4ed58142c830cf90a81c",
    "status": "final",
    "subject": {
        "reference": "Patient/1-000001"
    },
    "performer": {
        "reference": "Patient/1-000001"
    },
    "effectiveDateTime": "2017-09-06T12:32:51+01:00",
    "code": {
        "coding": [{ "system": "http://loinc.org", "code": "85354-9", "display": "Blood pressure panel with all children optional" }]
    },
    "device": {
        "reference": "Device/770308fe0bb14c64b0a0ebe0e7c5241d"
    },
    "category": [
        { "coding": [{ "system": "http://hl7.org/fhir/observation-category", "code": "vital-signs","display": "Vital Signs"}]}
    ],
    "component": [
        {
            "code": {
                "coding": [{"system": "http://loinc.org", "code": "8480-6", "display": "Systolic blood pressure"}]
            },
            "valueQuantity": {
                "value": 123, "unit": "mmHg", "system": "http://unitsofmeasure.org","code": "mm[Hg]"
            }
        },
        {
            "code": {
                "coding": [{"system": "http://loinc.org", "code": "8462-4", "display": "Diastolic blood pressure"}]
            },
            "valueQuantity": {
                "value": 76, "unit": "mmHg", "system": "http://unitsofmeasure.org", "code": "mm[Hg]"
            }
        }
    ]
}
```


Figure 32 Blood pressure Observation message

```
{
    "resourceType": "Observation",
    "id": "9d036340d80943d89ca0b5f39c4e77df",
    "status": "final",
    "subject": {
        "reference": "Patient/1-000001"
    },
    "performer": {
        "reference": "Patient/1-000001"
    },
    "effectiveDateTime": "2017-09-06T12:32:51+01:00",
    "code": {
        "coding": [{ "system": "http://loinc.org", "code": "3141-9", "display": "Body weight Measured" }]
    },
    "category": [
        { "coding": [{ "system": "http://hl7.org/fhir/observation-category", "code": "vital-signs","display": "Vital Signs"}]}
    ],
    "valueQuantity": {
        "value": 83.1,
        "unit": "kg",
        "system": "http://unitsofmeasure.org",
        "code": "kg"
    }
}
```

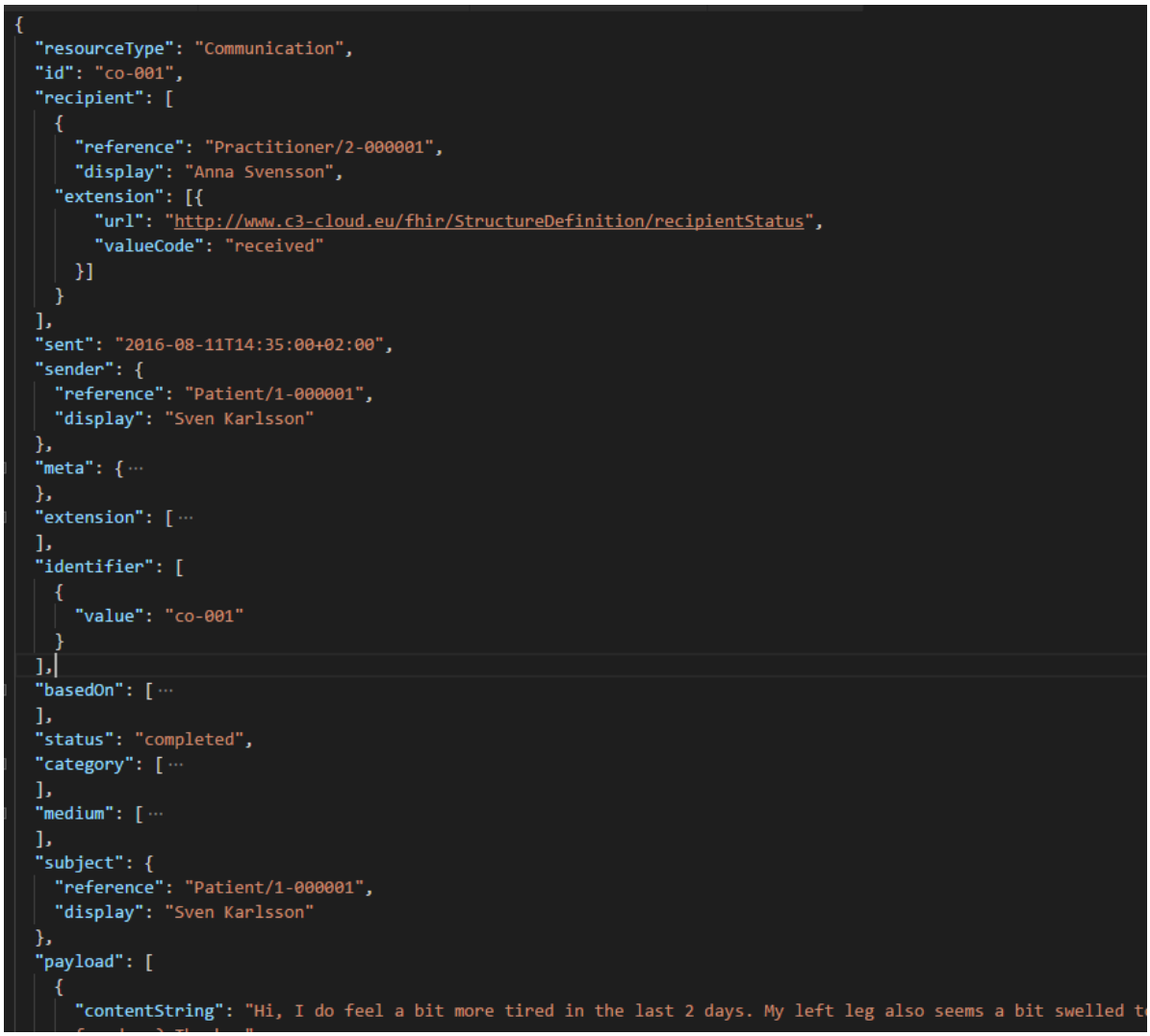

Figure 33 Weight Observation message

```
{
    "resourceType": "Observation",
    "id": "2c4dd758030440f4aefaac46a372cfa2",
    "status": "final",
    "subject": {
        "reference": "Patient/1-000001"
    },
    "performer": {
        "reference": "Patient/1-000001"
    },
    "effectiveDateTime": "2017-09-26T17:05:51+01:00",
    "code": {
        "coding": [{ "system": "http://loinc.org", "code": "226075008", "display": "Dietary intake assessment using food photographs" }]
    },
    "category": [
        { "coding": [{ "system": "http://hl7.org/fhir/observation-category", "code": "imaging"}]}
    ],
    "valueAttachment": {
        "contentType": "image/jpeg",
        "data":
        "/9j/4SzQRXhpZgAASUkqAAgAAAAJAA8BAgAGAAAAegAAABABAgAgAAAAgAAAABIBAwABAAAAAQAAABoBBQABAAAAoAAAABsBBQABAAAAqAAAACgBAwABAAAAAgAAADIBAgAUAAAAsAAAABMCAwABAAA
        AAQAAAGmHBAABAAAAxAAAAMAEAABDYW5vbgBDYW5vbiBQb3dlclNob3QgRzMAAAAAAAAAAAAAAAAAALQAAAABAAAAtAAAAAEAAAAyMDAzOjA0OjA1IDE1OjE3OjEyABQAmoIFAAEAAAC6AQAAnYIFAAE
        AAADCAQAAAJAHAAQAAAAwMjIwA5ACABQAAADKAQAABJACABQAAADeAQAAAZEHAAQAAAABAgMAAZIKAAEAAADyAQAAApIFAAEAAAD6AQAABJIKAAEAAAACAgAACpIFAAEAAAAKAgAAfJIHAGABAAASAgA
        AhpIHAAgBAABAyAwAAAKAHAAQAAAAAwMTAwAaADAAEAAAABAAAAAqADAAEAAAD/AQAA6ADAAEAAACpAgAABaEAAEAAAB6BAAADqIFAAEAAACwBAAAD6IFAAEAAAC4BAAAEKIDAAEAAAACAAAAAAAAAAE
        AAADiBAAAKAAAAAoAAAAyMDAzOjA0OjA1IDE1OjE3OjEyADIwMDM6MDQ6MDUgMTU6MTc6MTIASQEAACAAAACAAAAAIAAAAAAAAAAGAAAAzQEAACAAAAAHAAEAAwAuAAAAbAIAAAIAAwAEAAAAyAIAAAQ
        AAwAhAAAA0AIAAAYAAgAgAAAAEgMAAAcAAgAgAAAAMgMAAAgABAABAAAAfh0VAAkAAgAgAAAAUgMAAAAAABcAAIAAAABgAUAAAAAAAQA/////wAACAAAAAAAAAAAAA8AAwABAAAAAD/////mgPmACA
```


Figure 34 Extract from meal photo Observation message

3.6.3.6. Communication

Exchange of safe messages between the care team and the patient / informal care giver.



```
{
  "resourceType": "Communication",
  "id": "co-001",
  "recipient": [
    {
      "reference": "Practitioner/2-000001",
      "display": "Anna Svensson",
    "extension": [{
        "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/recipientStatus",
        "valueCode": "received"
      }]
    }
  ],
  "sent": "2016-08-11T14:35:00+02:00",
  "sender": {
    "reference": "Patient/1-000001",
    "display": "Sven Karlsson"
  },
  "meta": {···
  },
  "extension": [···
  ],
  "identifier": [
    {
      "value": "co-001"
    }
  ],
  "basedOn": [···
  ],
  "status": "completed",
  "category": [···
  ],
  "medium": [···
  ],
  "subject": {
    "reference": "Patient/1-000001",
    "display": "Sven Karlsson"
  },
  "payload": [
    {
      "contentString": "Hi, I do feel a bit more tired in the last 2 days. My left leg also seems a bit swelled t
```


Figure 35 Extract from message sent by patient to MDT

```
{
  "resourceType": "Communication",
  "id": "co-002",
  "subject": {
    "reference": "Patient/1-000001",
    "display": "Sven Karlsson"
  },
  "recipient": [
    {
      "reference": "Patient/1-000001",
      "display": "Sven Karlsson",
    "extension": [{
        "url": "http://www.c3-cloud.eu/fhir/StructureDefinition/recipientStatus",
        "valueCode": "received"
      }]
    }
  ],
  "sent": "2016-08-12T09:15:00+02:00",
  "sender": {
    "reference": "Practitioner/2-000001",
    "display": "Anna Svensson"
  },
  "meta": {···
  },
  "extension": [···
  ],
  "identifier": [···
  ],
  "basedOn": [···
  ],
  "status": "completed",
  "category": [···
  ],
  "medium": [···
  ],
  "payload": [
    {
      "contentString": "Hi Sven, Please stop doing your physical exercises for 3 days, and then do let me know how you feel.
    }
  ]
}
```


Figure 36 Extract from message sent by MDT to patient

3.7. C3DP – SIS Integration

During the conceptual design phase and even at the beginning of the 2nd year of the project, it was considered that the C3DP would not need semantic code mapping for most of the time, as the patient data will be retrieved from the local EHR systems and displayed to the care team members, who already use the code systems available in the local patient data. Then the CDS services would handle the semantic code mapping to understand clinical concepts coded in different terminologies. This requirement is still valid for the CDS services; however, due to an emerging requirement in the middle of the project by clinical experts, the C3DP now needs to collate and display all the clinical concepts (e.g., cardiovascular disease, type 2 diabetes, angina history in first degree relative, etc.) that are required as input data by the CDS services to the care team members and let them update these patient data via the C3DP before calling any external CDS service. This necessitates the use of semantic code mapping within C3DP, as well.

For the moment, C3DP is benefiting manually from the clinical concepts mapping sheet managed by SIS. Integration activities with the SIS Semantic Mapper Service RESTful API is ongoing to automatically use the required code mappings, e.g., in the Chronic Disease Profile of the patient.

For example, a CDS service requires the presence of “hypertensive disorder” for a patient, and hence C3DP needs to find this data among the full list of diagnoses of the patient, which is coded differently in each pilot site by using a different medical terminology system. C3DP represents this concept in SNOMED-CT terminology system, and asks the Semantic Mapper Service the corresponding code and code systems in the case of OSAKIDETZA, who uses CIE-10 code system as a customized version of the ICD-10 code system. A corresponding HTTP response is provided below:

```
status: 200
status text: OK
Body: {
  "group": [
    {
      "element": {
        "code": "I10",
        "display": "Hipertension Arterial",
        "target": [
          {
            "code": "38341003",
            "comment": "The definitions of the concepts are exactly the same (i.e.
only grammatical differences) and structural implications of meaning are identical
or irrelevant (i.e. intentionally identical).",
            "display": "Hypertensive disorder, systemic arterial (disorder)",
            "equivalence": "Equivalent"
          }
        ]
      },
      "source": "uri:oid:CIE-10_oid",
      "sourceVersion": "unknown",
      "target": "uri:oid:2.16.840.1.113883.6.96",
      "targetVersion": "unknown"
    }
  ],
  "resourceType": "ConceptMap",
  "title": "mapping of 'Hypertension' from OSAKI (CIE-10) to CDSM (SNOMED CT)"
}
```


3.8. TIS – SPS Integration

The TIS – SPS integration integrates TIS into the SPS provided OAuth 2 authorisation framework [OAUTH]. TIS has registered with SPS to get a client_id and client_secret. As the FHIR repository API is protected by OAuth 2, for every FHIR repository access, TIS needs to get an OAuth 2 access token by OAuth 2 client credentials grant, and use that token to access the repository. TIS implements OAuth 2 client credentials grant. Figure 38 shows an example of TIS acquiring an OAuth 2 access token in order to access the FHIR repository.

```
Http Request:

POST /c3cloud/onauth/api/token HTTP/1.1
Host: app.srdc.com.tr
Authorization: Basic YzNjbG91ZC10aXM6NzJkamhuMGYzZmRkZjVyYjU4ZWZlZjc0c2Fkcw==
Cache-Control: no-cache
Content-Type: application/x-www-form-urlencoded

grant_type=client_credentials&scope=user%2F*.*

Http Response:

HTTP/1.1 200 OK
Content-Type: application/json
Content-length: 109
Access-Control-Allow-Origin: *
Access-Control-Allow-Credentials: true
Access-Control-Allow-Headers: Authorization, Content-Type, X-Requested-With

{
    "access_token": "abhc525jbjh6iibb18hdf37965hbjd",
    "token_type": "Bearer",
    "scope": "user/*.*",
    "expires_in": 86400
}
```

Figure 37 TIS acquires an SPS OAuth 2.0 access token example

3.9. PEP – SPS Integration

The exactly same OAuth 2 compliant method is used for integration of PEP with the SPS and then the Secure C3-Cloud FHIR Repository, as explained in the previous section for TIS. Hence, the same procedure is not repeated in this section.

3.10. SPS – Local IdP Systems Integration

One of the main objectives of SPS is to enable authentication of the end users into the C3-Cloud applications, via their already existing accounts (e.g., username-password), provided by the local authorities. Hence, SPS needs to be integrated with the existing Identity Provider (IdP) systems of the pilot sites. No new C3-Cloud specific user account will be created unless there is no integration possibility, as in the case of social care workers who are not directly affiliated with the C3-Cloud healthcare providers.

3.10.1.RJH

SPS has already been integrated with the IdP of RJH. RJH is using Microsoft Active Directory Federation Services (MS ADFS) as their IdP [MS ADFS]. During summer-autumn 2017, RJH updated their IdP to the latest release, i.e. MS ADFS 2016, which supports natively the OpenID Connect 1.0 specification [OPENIDCONNECT]. This has been a great advantage as the SPS has already been implemented in compliance with the OpenID Connect 1.0 specification for user authentication and authorization. The OpenID Connect configuration of RJH ADFS setup including the token endpoints is available at https://idp.regionjh.se/adfs/.well-known/openid-configuration.

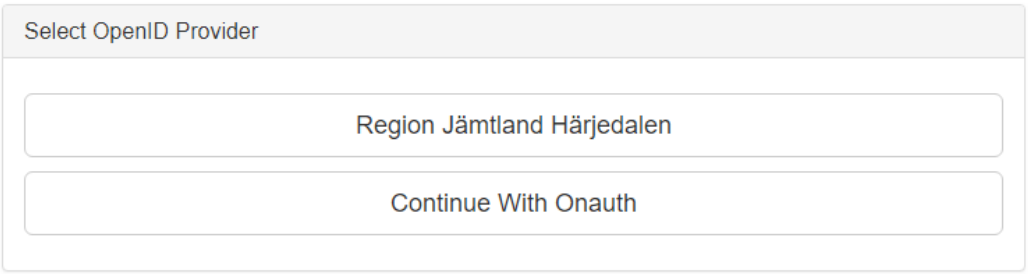


Figure 38 Sign in with RJH Account

When a user opens the C3DP, it is redirected to the login page of the SPS, and there two options are provided to the RJH users: i) login with their existing RJH accounts, or ii) login via default C3-Cloud IdP. RJH health professionals select the first option and then they are redirected to the original RJH login page. When the login is successful, the SPS acquires the id token of the user and provides it to the C3DP along with an access token, just like the case in C3-Cloud IdP authentication. The second option is used only by the social care workers of RJH, who do not have any user accounts maintained by RJH.

An example id token for a demo user is provided below:


```
{
  "aud": "b5532df7-5a21-4507-81d6-2bfa48eb5b69",
  "iss": "https://idp.regionjh.se/adfs",
  "iat": 1522848102,
  "exp": 1522851702,
  "auth_time": 1522848102,
  "nonce": "219945098322415982888586289718099112547",
  "sub": "azJ8hQU7cKZXTrDxSE5XOz/PTd2CNzlfFsA2kcrR4jQ=",
  "upn": "c3cloud@jll.jllad.se",
  "unique_name": "JLL\\c3cloud",
  "pwd_exp": "7176991",
  "sid": "S-1-5-21-1458514816-1055937895-1845911597-48586",
  "email": "c3cloud@dummy.org",
  "role": "Role",
  "family_name": "Surname",
  "given_name": "Givenname",
  "apptype": "Confidential",
  "appid": "b5532df7-5a21-4507-81d6-2bfa48eb5b69",
  "authmethod": "urn:oasis:names:tc:SAML:2.0:ac:classes:PasswordProtectedTransport",
  "ver": "1.0",
  "scp": "allatclaims profile openid"
}
```


3.10.2.OSAKIDETZA

The integration is in progress in the case of OSAKIDETZA. For this case, a proprietary approach will be followed upon the request and restrictions of the OSAKIDETZA pilot site: signed JWT token exchange. No Osakidetza worker will be able to access C3DP directly. They will always first login to

their EHR system Osabide Global, which they do every day for their operational work. Osabide Global will then provide a link to C3DP, which will direct the user to the C3DP when clicked. Thanks to integration via JWT token sharing as explained above, single sign-on will be achieved and the users will not need to be authenticated again in C3DP.

As in the case of RJH, there will also be social care workers involved in C3-Cloud piloting who are not OSAKIDETZA staff. As it is not possible to integrate with social care workers' IdPs, it has been agreed to use the OpenID Connect 1.0 compliant C3-Cloud default IdP.

3.10.3.SWFT

The information security experts of the South Warwickshire NHS Foundation Trust (SWFT) clearly indicated that they cannot attempt integration with their IdP for less than 100 users. It is planned to involve 16 professional users from SWFT in the pilot studies, therefore it is not possible to proceed with authentication integration.

SWFT agreed to use the OpenID Connect 1.0 compliant C3-Cloud default IdP that is provided within the SPS for all professional users.

4. FUTURE PLANS

As presented in detail in the previous sections, the integration among C3-Cloud software components and the pilot site EHR and IdP systems have already been achieved to a great extent. Some more work is needed to either improve the existing integrations or to achieve new integrations (i.e. multiplication of an already established interface for another purpose as in the case of CDS services to be implemented). Planned future work, which will be completed in the remaining months of Task 7.4 and then during the deployment task 8.3, can be summarised as follows:

- Analysis of the real care plan examples to be provided by the Clinical Reference Group (CRG) and revision of system requirements when relevant.
- Update of all C3-Cloud software components according to newly identified or revised requirements derived from CRG input.
- Completion of all remaining integration activities:
    - Switching to the new CAMBIO open service API in TIS – RJH EHR system integration.
    - Integration of C3DP with remaining CDS services for renal failure, heart failure and depression once they are ready.
    - Finalization of SPS integration with the OSAKIDETZA systems via JWT token exchange.
    - Improvement of C3DP – PEP integration, e.g. for care plan feedback mechanism.
- Improvement of the integrated system based on feedback from the component and usability testing activities that are already taking place within the scope of Task 9.2.
- Testing of the overall system with real un-identified data before finalizing the deployment.

5. REFERENCES

[ANGULAR] Angular Framework, https://angular.io/

[ATNA] IHE Audit Trail and Node Authentication integration profile, http://wiki.ihe.net/index.php/Audit_Trail_and_Node_Authentication

[AUDITEVENT] FHIR STU3 AuditEvent Resource, http://hl7.org/fhir/auditevent.html

[CDS-HOOKS] CDS Hooks Specification, https://cds-hooks.org/

[CRUCIBLE] Crucible: Open Source FHIR Testing, https://projectcrucible.org/

[D3.2] C3-Cloud Deliverable 3.2 - Requirements Specification of the C3-Cloud Architecture

[D3.3] C3-Cloud Deliverable 3.3 – Conceptual Design of the C3-Cloud Architecture

[D5.1] C3-Cloud Deliverable 5.1 – Self-Management Training Materials for Increasing Patient Adherence to Care Plans

[D5.2] C3-Cloud Deliverable 5.2 – Data Collection and Feedback Mechanism

[D5.3] C3-Cloud Deliverable 5.3 – Responsive Multi-Channel Patient Empowerment Platform

[D6.1] C3-Cloud Deliverable 6.1 – C3-Cloud Technical Interoperability Implementation Guidelines and Open Source Toolkits

[D6.2] C3-Cloud Deliverable 6.2 – C3-Cloud Semantic Interoperability Platform

[D6.3] C3-Cloud Deliverable 6.3 – Open Source Privacy and Security Toolkits for the C3-Cloud Architecture

[D7.2] C3-Cloud Deliverable 7.2 – Clinical Decision Support Modules for Personalised Care Plan Development and Execution

[D7.3] C3-Cloud Deliverable 7.3 – Personalised Care Plan Development Platform

[D8.1] C3-Cloud Deliverable 8.1 – Use Cases and Requirement Specifications of the Pilot Application

[FHIR] HL7 FHIR STU3 Specification, https://www.hl7.org/fhir

[HETOP] HeTOP Health Terminology / Ontology Portal, https://www.hetop.eu

[MONGODB] MongoDB, https://www.mongodb.com/

[MS ADFS] Microsoft Active Directory Federation Services, https://docs.microsoft.com/en-us/windows-server/identity/ad-fs/overview/ad-fs-scenarios-for-developers

[OAUTH] OAuth 2.0, https://oauth.net/2/

[ONFHIR] onFHIR HL7 FHIR® Based Secure Data Repository, https://onfhir.io/

[OPENIDCONNECT] OpenID Connect Core 1.0, http://openid.net/specs/openid-connect-core-1_0.html

[OPENID-CLIENTREG] OpenID Connect Dynamic Client Registration 1.0, http://openid.net/specs/openid-connect-registration-1_0.html

[SEMANTICUI] Semantic-UI CSS Framework, https://semantic-ui.com/

[SMART-APP-AUTHZ] Smart App Authorization, http://docs.smarthealthit.org/authorization/

[SOCKET-IO] Socket.IO real-time bidirectional event-based communication, https://socket.io/

[TLS] The Transport Layer Security (TLS) Protocol Version 1.2, https://www.ietf.org/rfc/rfc5246.txt

[TOUCHSTONE] Touchstone: Infrastructure as a Service (IaaS) and Testing as a Service (TaaS) Open Access Solution, https://touchstone.aegis.net/touchstone/

6. APPENDIX I – INTEGRATION STORYBOARD

SRDC has initiated the development of a complete and realistic storyboard in order to facilitate development and integration activities among C3-Cloud partners. The early drafts prepared by SRDC were based on the Swedish patient story in D8.1 and the reference care plan example that was prepared in Task 7.3. As only CDS specifications related with diabetes were available at that phase, this storyboard is mostly focused around the diabetes scenario with some minor complications related with hypertension and renal failure. It includes complete patient data represented as FHIR resources, and detailed execution steps to create a personalised care plan and share it with both the care team via C3DP and also the patient via PEP. Till September 2017, it has been reviewed and updated a few times with contributions from several partners, especially MEDIXINE and RJH. It helped and continues to help a lot to integration activities.

It should be noted that it does not reflect the final implementation status of the C3-Cloud software components by April 2018, as it has not been updated after September 2017.

1. Introduction

Sven is a **67-year old** man, married with two sons living in Stockholm 600 km away. The couple lives in a small village with no public transports 20 km from the health center and from shops and 100 km from the town where the county hospital is. His wife Lisa handles the cooking and other household chores inside while Sven takes more responsibility for the garden. Sven's newly retired and feels like Lisa fit. He has been on medication for high blood pressure for 10 years and he uses to control his blood pressure once a year at the health center. His hypertension treatment is managed by his GP, Dr. Anna Svensson who coordinates his Hypertension Treatment Plan, and by Martina LC, the community nurse who assists him to meet his diet and exercise goals.

2. Preliminary Steps - Initial setup for C3-Cloud

2.1. Practitioner Data Registration

In this scenario, we assume that Sven Karlsson has been cared by a care team consisting of Dr. Anna Svensson (GP), Martina LC (Community Nurse), Erik Larsson (Diabetes Nurse), Anders Blom (Nephrologist), Stina Ek (Nutritionist) and Helene MM (Nurse specialist (nephrology)). So, we assume that users are registered into local care systems.

In the initialization step, through the C3-Cloud TIS, and the following resources are stored to C3DP FHIR Repository:

Table 3 Data to be generated in FHIR Repository at Practitioner Registration Phase

Data	C3-Cloud Resource Type	Test Data File
Anna Svensson's profile (GP)	Practitioner	Practitioner 2-0000001 Anna.json
Martina LC's profile (Community Nurse)	Practitioner	Practitioner 2-0000002 Martina.json
Erik Larsson's profile (Diabetes Nurse),	Practitioner	Practitioner 2-0000003 Erik.json
Anders Blom (Nephrologist)	Practitioner	Practitioner 2-0000004 Anders.json
Stina Ek (Nutritionist)	Practitioner	Practitioner 2-0000005 Stina.json
Helene MM (Nurse specialist (nephrology)).	Practitioner	Practitioner 2-0000006 Helene.json

Östersund Health Care Center Organization Profile	Organization	Organization org-001 GP center.json
Östersund Hospital, Dialysis and Nephrology Surgery	Organization	Organization org-002 hospital nephrology.json
Östersund Hospital, Dietitian Clinic	Organization	Organization org-003 hospital diet.json

2.2. Necessary Steps for Authorization & Authentication of Practitioners to C3DP

In this version, we are assuming that there is no integration with the local authentication systems and C3-Cloud users will be created in the C3-Cloud identity provider, and authorization rules will be defined in C3-Cloud authorization server (i.e. the case in SWFT pilot).

2.3. Patient Data Stored in Local Systems

Sven Karlsson's medical summary as of 21/07/2009 before his appointment on 21/07/20019 is recorded in the 'Baseline_PatientSummary' sheet of Appendix A-DataforStoryBoard.xlsx.

Sven Karlsson has an active treatment plan for hypertension. His current treatment plan for hypertension is recorded in the 'Baseline_TreatmentPlan' sheet of Appendix A-DataforStoryBoard.xlsx.

3. Patient registration to C3-Cloud Integrated Care Programme (Appointment A-Primary Care Physician Visit - 21/07/2009)

3.1. Sven visits his GP for the annual checkup for Hypertension. Based on the recent lab results, Dr. Svensson notices that Sven has type 2 diabetes and mild renal impairment. As this complicates his condition, Dr. Svensson proposes Sven to be included in the C3-Cloud Integrated Care Plan programme. His new diagnosis and lab results have been stored to local care system. See 'EncounterA_PatientData' sheet of Appendix A-DataforStoryBoard.xlsx.

3.2. Dr. Svensson provides more explanation about system and Sven accepts registration to C3-Cloud programme and signs the Patient Consent Form.

C3-Cloud C3DP Application

3.3. Dr. Svensson opens the C3-Cloud C3DP Application, logins to the system, and opens the patient registration page.

3.4. Dr. Svensson enters the requested information and creates an account for Sven.

3.5. An email is automatically sent to Sven providing the link to continue and describing next steps for finalizing the registration.

3.6. Dr. Svensson suggests Sven to use the Patient Empowerment Platform as well. Sven accepts. Dr. Svensson helps Sven to register to PEP.

PEP

3.7. Patient Registration via PEP

Alternative 1: Registration with local strong authentication provider

Pre-requisite 0a: Sven has been invited to access PEP and he knows the URL address of PEP.

Step 1. Sven opens the PEP URL in a browser.

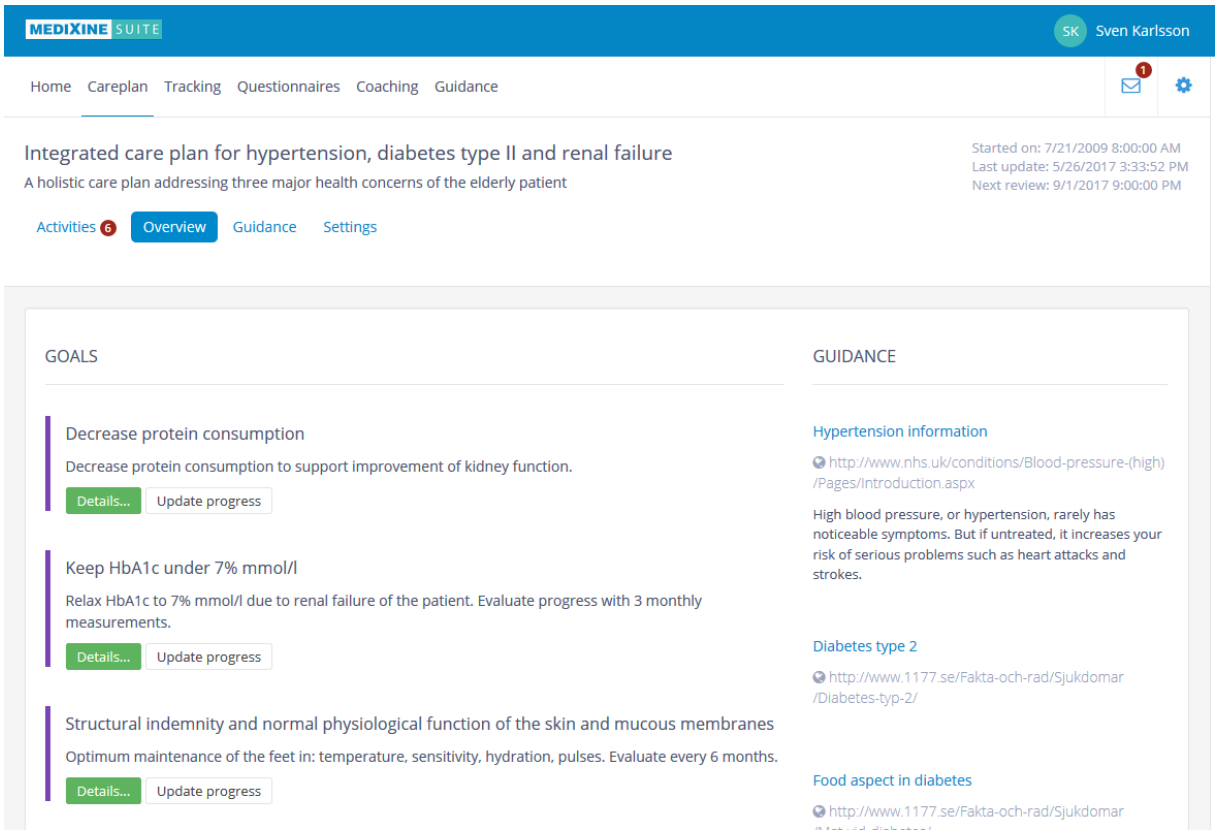
Step 2. Sven authenticates using the local strong authentication provider.

Step 2b [alternative path]. Sven's credentials don't match any valid patient profile and an error message is displayed.

Step 3. Sven completes the registration if he logs in for the first time. At a minimum he checks his contact details and accepts the terms of use. The system links his user account with the matching patient profile.

Step 4: After registration.

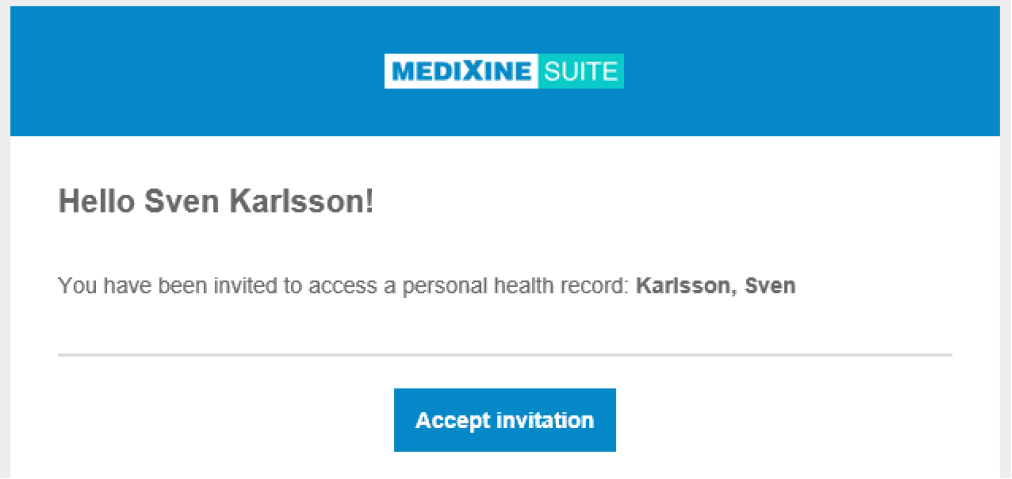
On first use after registration, Sven is shown the care plan overview.



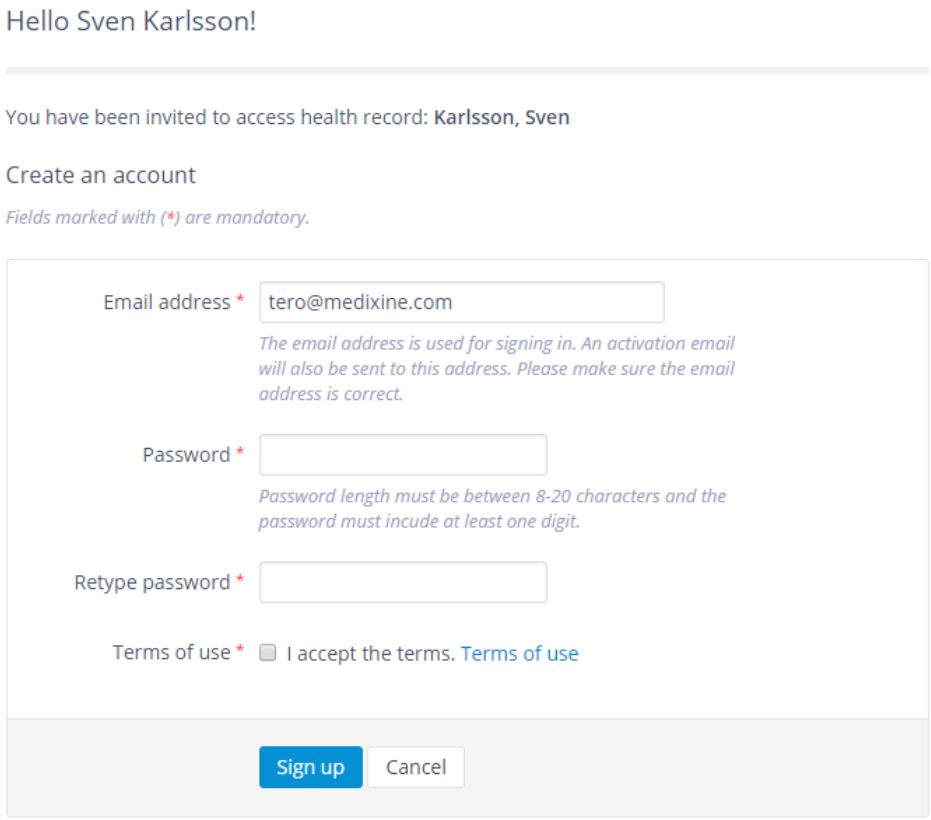
Alternative 2: Registration with other authentication provider
Pre-requisite 0a: Sven is invited to access PEP.

N.B. This can occur automated behind the scenes in PEP Gateway when new patient event from C3DP is processed, if the email address and the mobile phone number of the patient are known in advance. The fully automated mode requires the use of both email and SMS channel to be used. The email channel delivers the invitation message and SMS channel is used to deliver to unique invitation code needed to register to the pilot. If the email address and the mobile phone number are not known, the invitation must be created manually.

Step 1. Sven opens the invitation link in the invitation email in a browser.



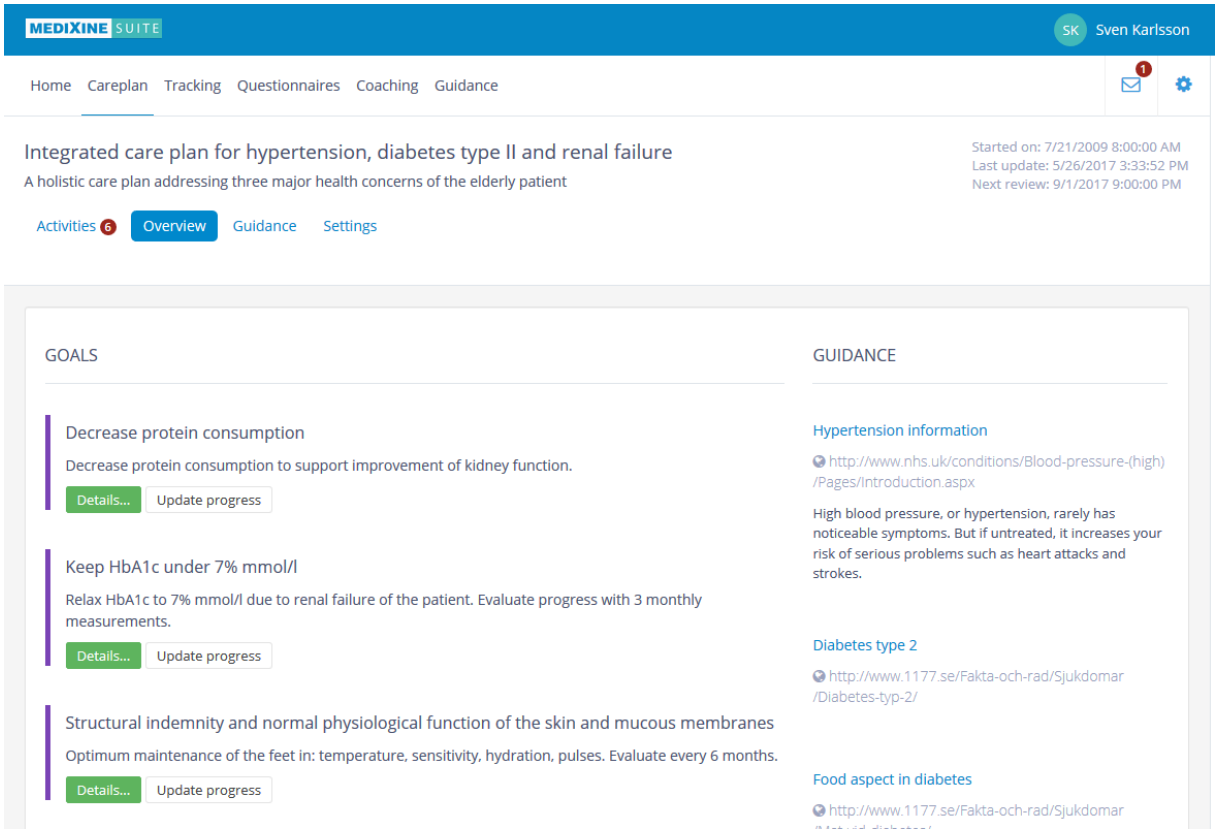
Step 2: Sven registers and signs in to PEP.



N.B. The authentication method for patients and informal caregivers may vary depending on system configuration and affects the authentication details the user must give when registering.

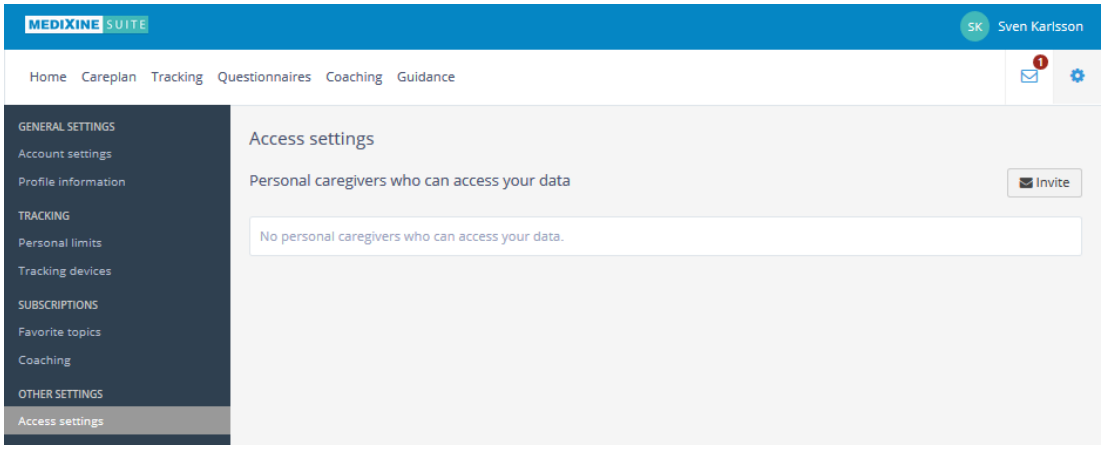
Step 3: After registration

On first use after registration, Sven is shown the care plan overview.

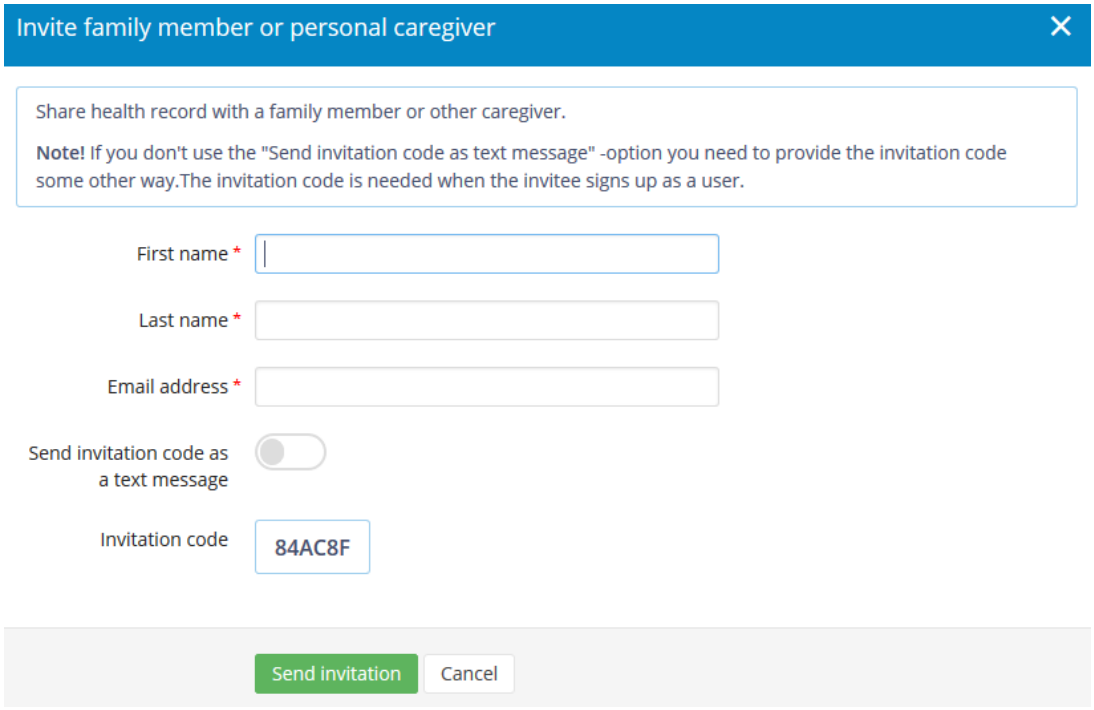


3.8. Patient can give access rights to his wife, Lisa Karlsson

Step 1: Sven opens Settings -> Access settings.



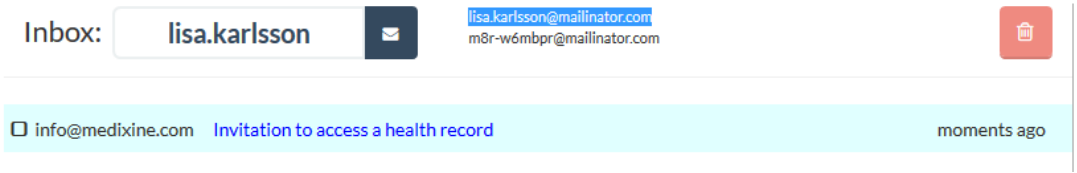
Step 2: Sven chooses in the personal caregiver section Invite.



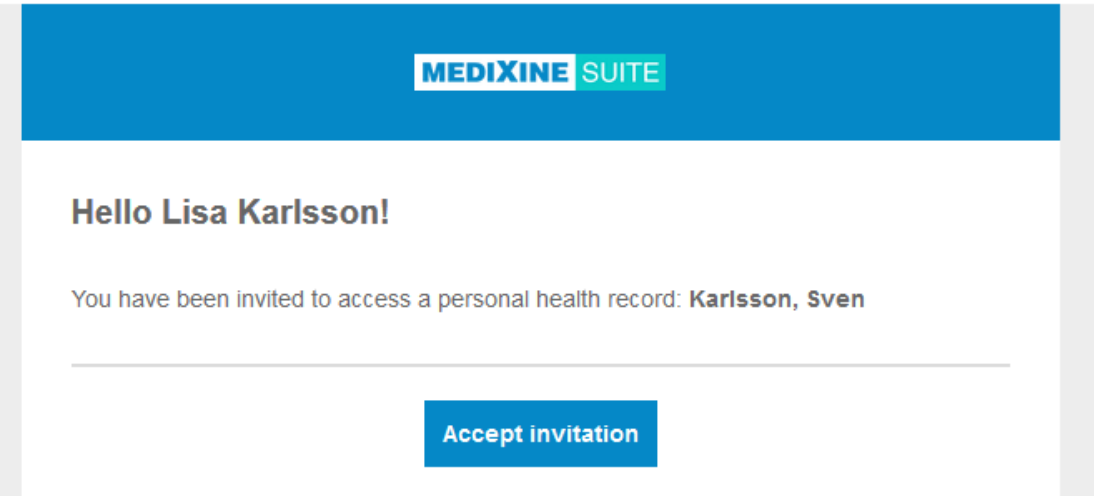
Step 3: Sven fills in the requested information and presses Send invitation.

The system sends now an email invitation to personal caregiver.

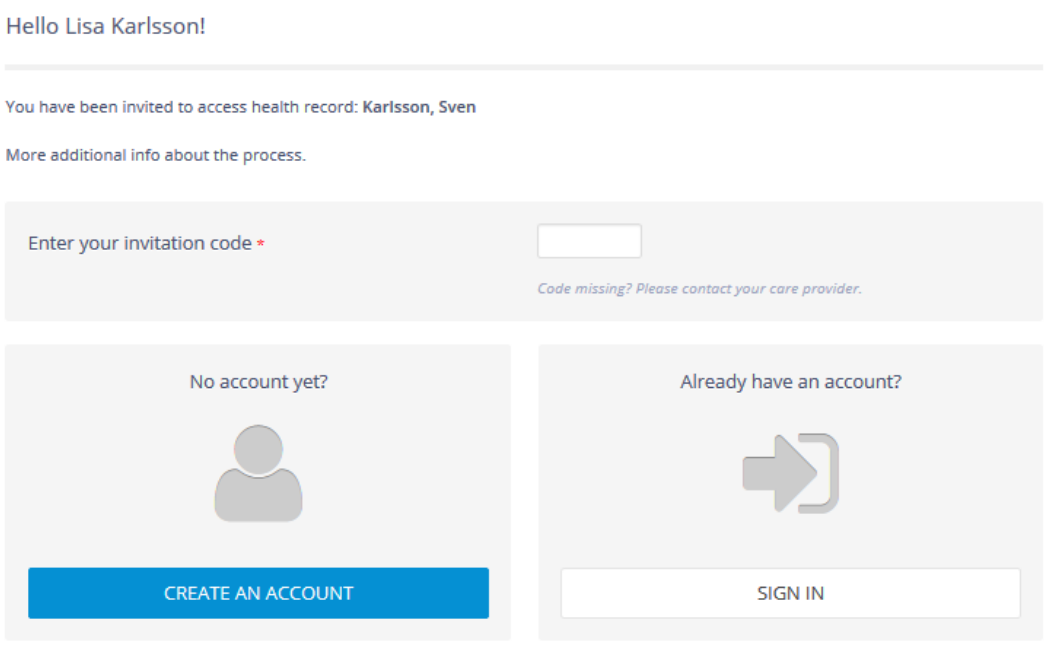
Step 4. Personal caregiver opens the invitation link in a browser.



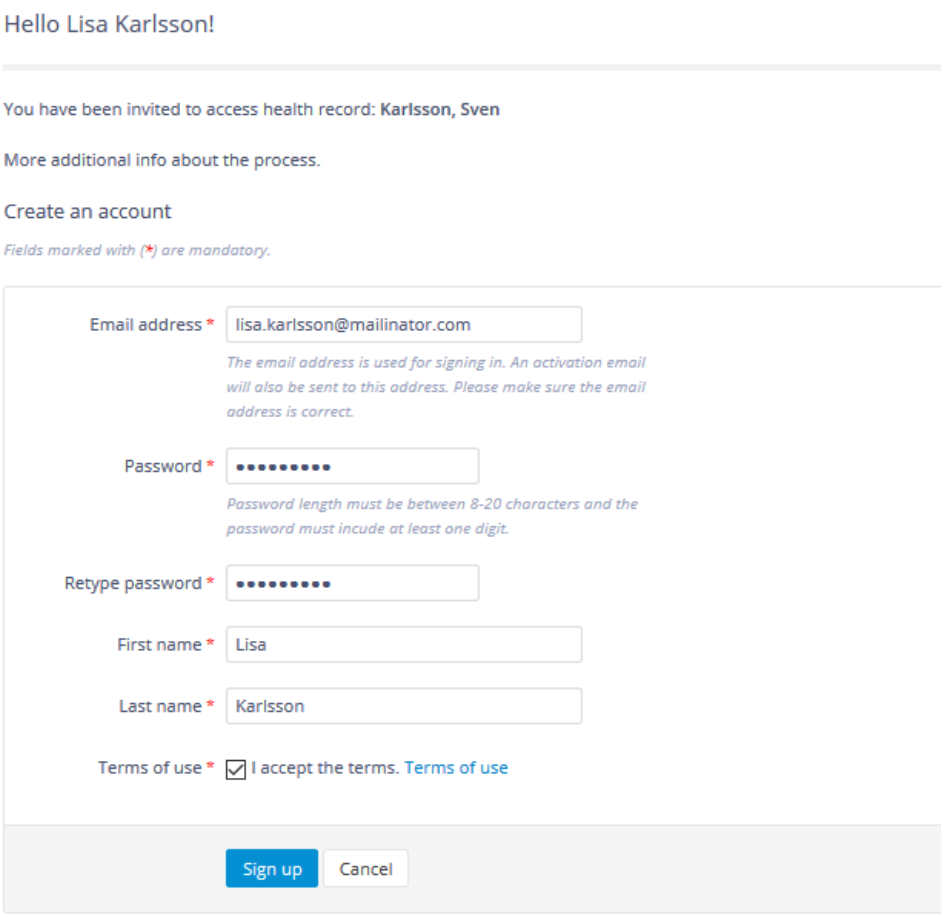
Step 5. Lisa Karlsson sees the invitation page.



Step 6. Lisa Karlsson enters the invitation code.



Step 7. Lisa Karlsson creates an account, registers and signs in to PEP.



Step 8. Lisa Karlsson sees Sven's Care plan and can access the other PEP functionality.

N.B. Same default view for the informal caregiver as the patient has.

C3-Cloud C3DP Application

3.9. Dr. Svensson is added to Sven's Care Team, and assigned as 'Care Coordinator'.

3.10. C3DP registers the patient to TIS, by providing his patient ID to initiate the retrieval of patient's current medical summary, and his current active hypertension treatment plan, and stores them to FHIR Repository.

Technical Interoperability Suite

3.11. **TIS**

The patient summary depicted in 'EncounterA_PatientData' sheet of Appendix A-DataforStoryBoard.xlsx is provided as FHIR resources as indicated in Table 3.

After C3DP registers the patient to TIS, TIS will get in contact with Local systems and SIS and push the data to FHIR repository.

SIS

3.12. To be detailed by INSERM (regarding how the patient summary in local format is processed to create the necessary FHIR resources…

Technical Interoperability Suite

3.13. TIS pushes the data to FHIR Repository

Table 4 Data to be generated in FHIR repository during Patient Registration Phase

Data	C3-Cloud Resource Type	Test Data File	Related Step
Basic patient data for Sven **Given Name: Sven** **Family Name: Karlsson** **Gender**: Male **Age**: 67	Patient	Patient 1-000001 Sven-v01.json	3.4
Care Team for Sven (involving Anna Svensson and Martina LC)	CareTeam	CareTeam ct-001-v01.json	3.6

Table 5 Identity Data for Patient to be generated in Core Services during Patient Registration Phase

Data	Test Data File	Related Step
User account data for Sven	sven_profile.json	3.4

Table 3 Patient Medical Summary Data retrieved from Local Care systems via TIS and stored to C3DP FHIR Repository:

Data	C3-Cloud Resource Type	Test Data File	Related step
Sven Karlsson's profile	Patient	Patient 1-000001 Sven-v02.json	3.7
Lisa Karlsson's profile as an Informal Caregiver	RelatedPerson	RelatedPerson 1-000002 Lisa.json	3.7
Conditions of Sven Karlsson	Condition	Condition c-001 hypertension-v02.json Condition c-002 improving health.json Condition c-003 diabetes.json Condition c-004 hypertension with comp.json Condition c-005 mild renal.json	3.7
Encounters of Sven Karlsson	Encounter	Encounter e-001.json Encounter e-002.json Encounter e-003.json Encounter e-004.json Encounter e-005.json Encounter e-006.json Encounter e-007.json Encounter e-008.json Encounter e-009.json Encounter e-010.json Encounter e-011.json Encounter e-012.json Encounter e-013.json Encounter e-014.json Encounter e-015.json Encounter e-016.json Encounter e-017.json Encounter e-018.json	3.7

Medications of Sven Karlsson	MedicationStatement	Medicationstatement ms-001 enalapril.json Medicationstatement ms-002 enalapril_doseincrease.json	3.7
Lab results of Sven Karlsson	Observation	Lab Result l-001.json Lab Result l-002.json Lab Result l-003.json Lab Result l-004.json Lab Result l-005.json Lab Result l-006.json Lab Result l-007.json Lab Result l-008.json Lab Result l-009.json Lab Result l-010.json Lab Result l-011.json Lab Result l-012.json Lab Result l-013.json Lab Result l-014.json Lab Result l-015.json Lab Result l-016.json Lab Result l-017.json Lab Result l-018.json Lab Result l-019.json Lab Result l-020.json Lab Result l-021.json Lab Result l-022.json Lab Result l-023.json Lab Result l-024.json Lab Result l-025.json Lab Result l-026.json Lab Result l-027.json	3.7
Vital Signs of Sven Karlsson	Observation	Vital Sign vs-001.json Vital Sign vs-002.json Vital Sign vs-003.json Vital Sign vs-004.json Vital Sign vs-005.json Vital Sign vs-006.json Vital Sign vs-007.json Vital Sign vs-008.json Vital Sign vs-009.json Vital Sign vs-010.json Vital Sign vs-011.json Vital Sign vs-012.json Vital Sign vs-013.json Vital Sign vs-014.json Vital Sign vs-015.json Vital Sign vs-016.json Vital Sign vs-017.json Vital Sign vs-018.json Vital Sign vs-019.json	3.7
Other observations	Observation	Observation obs-001 Observation obs-002	3.7
Location of the GP Office	Location	Location l-005 GP office.json	3.7
Lab results of Sven Kalsson	Observation	LabResults lr-001.json LabResults lr-002.json	3.7

Table 4 Patient's Hypertension Treatment Plan retrieved from Local Care systems via TIS and stored to C3DP FHIR Repository:

Data	C3-Cloud Resource Type	Test Data File	Related step
Sven Karlsson's Hypertension Treatment Plan	CarePlan	CarePlan cp-001 hypertension treatment plan.json (including all the referenced resources, such as activities and goals)	3.7

Test Data Files related with Sven Karlsson's Hypertension Treatment Plan are provided in Appendix B- BaselineData.

4. Initial integrated Care Plan Preparation via C3DP (Appointment A- Primary Care Physician Visit - 21/07/2009)

C3DP Application

4.1. Dr. Svensson quickly reviews Sven's medical summary from the Patient Medical Summary Menu.

4.2. Dr. Svensson initiates the process to create an integrated care plan for the patient. At this stage, he has been asked by PCPDP whether he would like to start from any of the existing (imported) care/treatment plan. She chooses to start from his hypertension treatment plan.

4.3. Dr. Svensson finalizes the metadata of this new integrated plan (such as next review date), and selects the 'health concerns' to be targeted by this care plan among the conditions of the patient as 'type 2 diabetes', 'mild renal impairment' and 'hypertension with complications'.

4.4. Dr. Svensson will be able to see the imported goals and activities from the 'Hypertension Treatment Plan' in the PCPDP tool

4.5. PCPDP will open up the "Chronic Disease Profile" panel, where she is requested to check the parameters that are essential in deciding the personalized goals and activities for addressing his new conditions in the light of information provided by the evidence based clinical guidelines. Dr. Svensson reviews them, and updates when necessary. She will be reminded these parameters in a context dependent manner in the relevant steps of the care plan definition process. (For the sake of simplicity, in this story board the updates she will be carrying out in patient's parameters' will be highlighted in the relevant step below).

4.6. Dr. Svensson starts adding new goals and activities for the patient. PCPDP provides guidance to Dr. Svensson by presenting the high-level goals that needs to be attained for a patient being treated for Diabetes in a step by step manner as a wizard.

4.6.1. First of all, by processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggests goals and activities for organizing Diabetes Education Sessions as depicted in Table 5.

Table 5 Goals and Activities Suggested by PCDP based on Care Plan Template at Step 4.6.1:

GOALS

Goal 1:	category	Safety, http://hl7.org/fhir/goal-category
	Description code	311401005, Patient Education, SNOMED International 2017 v1.33.2
	Description text	Offer evidence based structured education to patients and caregivers
ACTIVITIES		
Activity 1: Type II Diabetes Education	Title	Recommend Type 2 Diabetes Education
	Description	Type 2 Diabetes Education Material for patients
	Category	CommunicationRequest
	url	https://patient.info/health/type-2-diabetes
Activity 2: Type II Diabetes Education Appointment	Title	Diabetes Education Review
	Description	Diabetes Education Review (at Diagnosis and with annual reinforcement)
	Specialty	408475000, Diabetic medicine, SNOMED International 2017 v1.33.2
	serviceCategory	13 (Education & Learning)
	serviceType	488 (Diabetes Educator)

Dr. Svensson, agrees with these recommendations, and adds this goal and activity to the care plan by editing the details (like the date of the appointment with Diabetes Nurse, i.e. Erik Larsson for diabetes education.
In addition to these, Dr. Svensson adds an additional Education Material for Hypertension as follows:

Patient Educational Material		
Title	Topic	Link
High blood pressure (hypertension)	I10, Essential (primary) hypertension, ICD-10	https://patient.info/health/high-blood-pressure-hypertension

4.6.1.1. Dr. Svensson adds Diabetes Nurse, Erik Larsson to the Care team. He also adds two new activities (1) for the patient to fill a questionnaire regarding lifestyle habits, preferred type of food and physical activities, and (2) for uploading daily photos of his meals to PEP during the next week, before Sven's appointment with Erik Larsson.

We can use the *"*"How are you? Quiz" by the NHS One You" that Pontus has already prepared.

4.6.1.2. Erik Larsson receives a system notification about the care team member invitation and accepts this invitation to be involved in Sven's care team.

4.6.2. Then, by processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggest a high level goal for “Diet & Lifestyle Management”.

GOALS		
Goal 2:	category	Safety, http://hl7.org/fhir/goal-category
	Description code	-
	Description text	Dietary & Lifestyle Management

This high-level goal will be presented as a separate tab in PCPDP, guiding the healthcare professional about the necessity of a number of goals and activities that can be grouped under the “Diet & Lifestyle Management” title.
In order to suggest personalized goals and activities about Diet & Lifestyle Management, PCPDP makes a call to CDSM service for “Diet Plan Suggestions”. The parameters need to be passed to the “Diet Plan Suggestion” service, i.e. “list of conditions of patient” in our case “Type 2 Diabetes diagnosis, Mild Renal Failure and Hypertension” and “his latest eGFR measurements”, are presented to Dr. Svensson for confirmation, then the call to CDSM is completed.

CDSM Services

4.6.2.1. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 6 Goals and Activities Suggested by “Diet Plan Suggestion” CDSM

GOALS		
Goal 3:	category	Dietary, http://hl7.org/fhir/goal-category"
	Description code	385769008, Encouragement of compliance (regime/therapy), SNOMED International 2017 v1.33.2
	Description text	Comply with the dietary restrictions mild renal failure and diabetes. Evaluate every 6 months.
Activity 3:	Title	Preparation to correctly follow the prescribed diet
	Description	• Encourage Mediterranean diet with reduced sodium level (salt intake)) • Explain the purpose of the diet, report permitted and prohibited foods, provide meal plans in writing. • Provide dietary advice in a form sensitive to the person's needs, culture and beliefs, being sensitive to their willingness to change and the effects on their quality of life.

		• Emphasize advice on healthy balanced eating that is applicable to the general population when providing advice to adults with type 2 diabetes.
	Category	Diet
	Code	5614, Teaching: prescribed diet, Nursing Interventions Classification (NIC)
	performer	HP (Please note that as CDS does not know the identity of individual health professionals, but it indicates whether the activity is targeted for a HP or the PATIENT. Then in PCPDP the necessary assignments are completed by the Care plan editor, i.e. HP).
Activity 4:	Title	Follow the Diet
	Description	Strictly follow the Diet programme (Mediterranean diet with reduced sodium level (salt intake))
	Category	Diet
	Code	385769008, Encouragement of compliance (regime/therapy), SNOMED International 2017 v1.33.2
	performer	PATIENT

C3DP Application

4.6.2.2. Receiving the suggested goals and activities from "Diet Plan Suggestion" service, PCPDP processes them in comparison with the existing goals and activities in the care plan.

- A goal identical to *Goal 3 (coded with the same Snomed CT code)* already exist in the existing care plan, hence PCPDP highlights this factor and suggest Dr. Svensson whether she wishes to keep the existing one or update it with the new suggestion. Dr. Svensson prefers to update it, as it reflects the current condition of the patient (i.e. Diabetes with mild renal failure).
- An activity identical to *Activity 3 (coded with the same Snomed CT code)* already exist in the existing care plan, hence PCPDP highlights this factor and suggest Dr. Svensson whether she wishes to keep the existing one or update it with the new suggestion. Dr. Svensson prefers to update it, as the description now suggests a new diet (Mediterranean diet with reduced sodium level (salt intake)). As the performer of the activity, she chooses "Erik Larsson", i.e. the diabetes nurse, to deliver this education about the diet regime.
- An activity identical to *Activity 4 (coded with the same Snomed CT code)* already exist in the existing care plan, hence PCPDP highlights this factor and suggest Dr. Svensson whether she wishes to keep the existing one or update it with the new suggestion. Dr. Svensson prefers to update it, as the description now suggests a new

diet (Mediterranean diet with reduced sodium level (salt intake)). As the performer of the activity, she chooses the patient, i.e. "Sven Karlsson".

Finally, in the "Dietary Regime Management" tab, PCPDP reminds Dr. Svensson to choose the necessary educational material about the suggested diet.

Table 7 Education Materials selected for Sven about Diet Management:

Patient Educational Material		
Title	Topic	Link
Type 2 Diabetes Diet for Healthy Eating	E11, Type 2 diabetes mellitus, ICD-10	https://patient.info/health/diabetes-healthy-eating-sheet

4.6.3. By processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggests a high level goal for "Blood Pressure Management". This high-level goal will be presented as a separate tab in PCPDP, guiding the healthcare professional about the necessity of a number of goals and activities that can be grouped under the "Blood Pressure Management" title.

In order to suggest personalized goals and activities about Blood Pressure Management, PCPDP makes a call to CDSM service for "Blood Pressure Management Suggestions". The parameters need to be passed to the "Blood Pressure Management Suggestions" service are listed in Table 8.

Table 8 Clinical parameters presented to HP before passing them to Blood Pressure Management Suggestions CDSM:

Prefetch Data for "Blood Pressure Management Suggestions" Service		
	Items to be specifically checked	Sven's Data
Conditions	Hypertension	√ (I13.9-Hypertension with complications)
	Type 2 Diabetes	√ (E11.2-Type 2 diabetes mellitus with renal complications)
	Microvascular Conditions (E11.2, E11.4, G63.2)	√ (E11.2-Type 2 diabetes mellitus with renal complications)
	Macrovascular Conditions (E11.5,I20,I21,I22,I23,I24,I25,I63,I65,I66,I67.2,I70,K55.1)	X
	ACE inhibitor intolerance	X
Medications	ACE Inhibitors (Angiotensin Converting Enzyme Inhibitor)	√ (C09AA02, Enalapril)
	A II Blockers	X
	Calcium Blocker	X
	Diuretic	X
	Alpha Blocker	X
	Beta Blocker	X
	Potassium-sparing diuretic	X

	Raas	√ (C09AA02, Enalapril)
Vital Signs	Blood Pressure	72, 127
Social History Observations	Smoking Status	8517006 - Former Smoker, SNOMED CT
	Alcohol Consumption Status (160573003- Snomed CT) (drink/week)	2
Allergies	Intolerance to ACE inhibitors	X

These are presented to Dr. Svensson for confirmation (as presented in Figure XX). She confirms existing data and completes smoking status and alcohol intake status as presented in Table 8. Then the call to CDSM is completed.

CDSM Services

4.6.3.1. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 9 Goals and Activities Suggested by "Blood Pressure Management Suggestions" CDSM

GOALS		
Goal 4:	category	Safety, http://hl7.org/fhir/goal-category"
	Description code	135840009, Blood pressure monitoring (regime/therapy), SNOMED International 2017 v1.33.2
	Description text	Keep the blood pressure under 130/80 mmHg.
ACTIVITIES		
Activity 5:	Title	Measure Blood Pressure
	Description	Measure BP in every 4-6 months
	Category	Observation
	Code	385846000, Blood pressure taking management (procedure), SNOMED International 2017 v1.33.2
	performer	HP
	Timing	In 6 months
Activity 6: (Appointment)	Title	Appointment for Blood Pressure Management
	Description	Six monthly Blood Pressure Management Appointment
	status	proposed
	start	(Date+6 Months)

	specialty	-
	Performer	HP & PATIENT

C3DP Application

4.6.3.2. Receiving the suggested goals and activities from "Blood Pressure Management Suggestion" service, PCPDP processes them in comparison with the existing goals and activities in the care plan.

- A goal identical to *Goal 4 (coded with the same Snomed CT code)* already exist in the existing care plan, hence PCPDP highlights this factor and suggest Dr. Svensson whether she wishes to keep the existing one or update it with the new suggestion. Dr. Svensson prefers to update it, as it reflects the new Blood Pressure targets for the patient due to the new Diabetes with microvascular complications condition.
- The suggested activities for an appointment within 6 months for blood pressure management and the accompanying BP observation are added to the care plan. Dr. Svensson completes the missing parameters of these activities through PCPDP editing features.
- In addition to this, Dr. Svensson adds an activity for the patient for measuring his BP once a week, and record his measurements to PEP:

Activity 7:	Title	Self-monitoring of Blood Pressure
	Description	Measure your blood pressure once a week in the morning, just after you wake up, and record it to PEP
	kind	Observation
	code	135840009, Blood pressure monitoring (regime/therapy), SNOMED International 2017 v1.33.2
	Timing	Once a week in the morning
	performer	Sven Karlsson

4.6.4. By processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggests a high level goal for "Lipid Management". This high-level goal will be presented as a separate tab in PCPDP, guiding the healthcare professional about the necessity of a number of goals and activities that can be grouped under the "Lipid Management" title.

In order to suggest personalized goals and activities about Lipid Management, PCPDP makes a call to CDSM service for "Lipid Management Suggestions". The parameters need to be passed to the "Lipid Management Suggestions" service are listed in Table 10.

Table 10 Clinical parameters presented to HP before passing them to Lipid Management CDSM:

Prefetch Data for "Lipid Management Suggestions" Service		
	Items to be specifically checked	Sven's Data
Conditions	CKD	X
	Type 2 Diabetes	√ (E11.2-Type 2 diabetes mellitus

		with renal complications)
	Macrovascular Conditions (E11.5,I20,I21,I22,I23,I24,I25,I63,I65,I66,I67.2,I70,K55.1)	X
	Muscle pain	X
Medications	Atorvastatin	X
Lab results	LDL	132
	eGFR	58
	Aspartate transaminase (AST	X
	Alanine transaminase (ALT)	X
Risk Calculations	Cardiovascular Risk (via QRISK2)	NA (Later calculated as 29.1 %)

These are presented to Dr. Svensson for confirmation (as presented in Figure XX). She confirms the existing data. As CVD risk has not been calculated for this patient yet, Dr. Svensson clicks "Calculate CVD Risk" button. The required data (presented in Table 11) to calculate CVD risk via QRISK2 algorithm is presented and Dr. Svensson confirms with the patient that Sven does not have any 1st degree relative who has suffered from Heart attack or Angina before age 60. Then his CVD risk is calculated automatically as 29.1 % by calling the "CVD Risk" calculation services.

Table 11 Clinical parameters presented to HP before passing them to QRISK2 CDSM:

Prefetch Data for "QRISK2" Service		
	Items to be specifically checked	Sven's Data
Conditions	CKD (stage 1-stage 5)	X
	Type 2 Diabetes	√ (E11.2-Type 2 diabetes mellitus with renal complications)
	Type 1 Diabetes	X
	Rheumatoid arthritis (required for QRISK calculation)	X
	Atrial Fibrillation	X
Medications	Antihypertensives	X
	Calcium Blocker	X
	Diuretic	X
	Beta Blocker	X
	Raas	√ (C09AA02, Enalapril)
Vital Signs	Blood Pressure	72, 127
	weight	90
	height	180
Social History Observations	Smoking Status	8517006 - Former Smoker, SNOMED CT
Lab results	LDL	132
	HDL	52
	cholesterol	198
	eGFR	58
Family History	Heart attack in a 1st degree relative < 60, Angina in a 1st degree relative < 60)	NA

Then all these parameters are passed to “Lipid Management Suggestions” service, and the call to CDSM is completed.

CDSM Services

4.6.4.1. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 12 Goals and Activities Suggested by “Lipid Management Suggestions” CDSM

GOALS		
Goal 5:	category	Safety, http://hl7.org/fhir/goal-category"
	Description code	-
	Description text	Decrease Non-HDL Cholesterol by %40
	Target Measure code	312260007 (Non-HDL Cholesterol)
	Targeted range (coded)	High:87.6
	Target Duration	3 months
	Target Date	-
ACTIVITIES		
Activity 8: (Medication Request)	Title	Atorvastatin Recommendation
	Description	Offer Atrorvastatin 20mg
	Medication code	C10AA05, Atorvastatin, ATC
	Dosage text	Atrorvastatin 20mg
	MaxDosePerPeriod	20mg
Activity 9: (Appointment)	Title	Appointment for control visit (lipid management)
	Description	Appointment for lipid control after 3 months
	status	proposed
	start	(Date+3 Months)
	specialty	-
	performer	HP & PATIENT
Activity 10:	Title	Lipid Panel Test
	Description	Have lipid Panel test before 3 monthly lipid control visit

	kind	Observation
	code	24331-1, Lipid 1996 panel - Serum or Plasma, LOINC
	Timing	Date+3 months
	performer	HP & PATIENT
Activity 11:	Title	Aspartate transaminase (AST) Test
	Description	Have Aspartate transaminase (AST) test before 3 monthly lipid control visit
	kind	Observation
	code	1920-8, Aspartate transaminase (AST), LOINC
	Timing	Date+3 months
	performer	HP & PATIENT
Activity 12:	Title	Alanine transaminase (ALT) Test
	Description	Have Alanine transaminase (ALT) test before 3 monthly lipid control visit
	kind	Observation
	code	1742-6, Alanine transaminase (ALT), LOINC
	Timing	Date+3 months
	performer	HP & PATIENT

C3DP Application

4.6.4.2. Receiving the suggested goals and activities from "Lipid Management Suggestion" service, PCPDP processes them in comparison with the existing goals and activities in the care plan. No matching/clashing existing goal or activity are found, all are presented as suggestions to Dr. Svensson, who reviews and adds them all to the care plan by completing the missing details.

4.6.5. By processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggests a high level goal for "Blood Glucose Management". This high-level goal will be presented as a separate tab in PCPDP, guiding the healthcare professional about the necessity of a number of goals and activities that can be grouped under the "Blood Glucose Management" title.

First of all, based on the care plan template, in order to set a personalized HbA1C goal for the patient, PCPDP makes a call to CDSM service for "HbA1C Target Suggestions". The

parameters need to be passed to the "HbA1C Target Suggestions" service are listed in Table 13.

Table 13 Clinical parameters presented to HP before passing them to "HbA1C Target Suggestions" CDSM:

Prefetch Data for "HbA1C Target Suggestions" Service		
	Items to be specifically checked	Sven's Data
Conditions	Type 2 Diabetes	√ (E11.2-Type 2 diabetes mellitus with renal complications)
Medications	Any treatment with risk of hypoglycemia: A10A, A10BB, A10BC01, A10BD01, A10BD02, A10BD04, A10BD06	X
Lab results	eGFR	58
Observations	Frailty Score	Not available in EHR
	Reduced Life Expectancy	No indication in EHR
	Weight	90
Demographics	Age	67

Dr. Svensson indicated that the patient is not "Frail" and does not have "Reduced Life expectancy". Then these parameters are passed to the respective CDS service.

CDSM Services

4.6.5.1. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 14 Goals and Activities Suggested by "HbA1c Target Suggestions" CDSM

GOALS		
Goal 6:	category	Safety, http://hl7.org/fhir/goal-category"
	Description code	51798006 - Decreased glucose level (finding)- Snomed CT
	Description text	Keep HbA1C level below 48 mmol/mol (6.5%)
	Target Measure code	4548-4 (HbA1c)
	Targeted range (coded)	High:48 mmol/mol (6.5%)
	Target Duration	3 months
	Target Date	-
Information Cards		
If the following conditions are observed: • disturbed erythrocyte turnover and/or • abnormal hemoglobin and/or • unexplained discrepancies between HBA1c and glucose measurements then "Estimate trends in blood glucose control using one of the following: quality-controlled plasma glucose profiles, total glycated haemoglobin estimation (if abnormal haemoglobins), fructosamine estimation" & Seek advice from specialists in diabetes and clinical biochemistry		

C3DP Application

4.6.5.2. Then, in order to suggest personalized goals and activities related with “Blood Glucose Management Therapies” PCPDP makes a call to CDSM service for “Blood Glucose Management Therapy Suggestions”. The parameters need to be passed to the “Blood Glucose Management Therapy Suggestions” service are listed in Table 15.

Table 15 Clinical parameters presented to HP before passing them to “Blood Glucose Management Therapy Suggestions” CDSM:

Prefetch Data for “Blood Glucose Management Therapy Suggestions” Service		
	Items to be specifically checked	Sven’s Data
Conditions	Type 2 Diabetes	√ (E11.2-Type 2 diabetes mellitus with renal complications)
	Symptomatic hyperglycemia (E11.0A - E11.1B)	X
	Alcoholism with complications (F10.2A - F10.2X, K70)	X
	Cardiac Failure	X
	Hepatic Impairment	X
	Liver Insufficiency	X
	Diabetic Ketocodosis	X
	Bladder cancer	X
	Uninvestigated macroscopic hematuria	X
	Malnutrition	X
	Arthrosis in hip	X
	Arthrosis in knee	X
	Schizophrenia and other psychosis	X
	Significant risk of hypoglycemia	X
Medications	Bosentan	X
	Canaglifozin	X
	Empaglifozin	X
	Insulins and Analogues	X
	Sulfonylureas	X
	Glymidine	X
	Phenformin and Sulfonylureas	X
	Metformin and Sulfonylureas	X
	Glimepiride and Rosiglitazone	X
	Glimepiride and Pioglitazone	X
	Metformin	X
	DPP-4 inhibitor	X
	Pioglitazone	X
	SGLT-2 inhibitor	X
	GLP-1	X
Lab results	eGFR	58
	HbA1C	6.7
Observations	Weight	90
	Height	180
Demographics	Age	67
Social History	Occupation (Taxi/lorry/bus/train driver, airplane personel, divers)	X
Allergy and Intolerances	Metformin Intolerance	X
	Sulfonylurea Intolerance	X

Dr. Svensson reviews these parameters and confirms them. Then these parameters are passed to the respective CDS service.

CDSM Services

4.6.5.3. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 16 Goals and Activities Suggested by "Blood Glucose Management Therapy Suggestions" CDSM

ACTIVITIES		
Activity 13: (Medication Request)	Title	Metformin Recommendation
	Description	Offer Metformin 500mg twice a day, (gradually increase the dose to reach this dose)
	Medication code	A10BA02, Metformin, ATC
	Dosage text	Metformin 500mg twice a day
	MaxDosePerPeriod	1000mg
Activity 14: (Appointment)	Title	Appointment for control visit (blood glucose management)
	Description	Appointment for control visit (blood glucose management) 6weeks after therapeutic change
	status	proposed
	start	(Date+6 weeks)
	specialty	-
	performer	HP & PATIENT
Activity 15:	Title	HbA1C Test
	Description	Have HbA1c before control visit
	kind	Observation
	code	4548-4, Hemoglobin A1c/Hemoglobin.total in Blood,LOINC
	Timing	Date+6 weeks
	performer	HP & PATIENT
Activity 16:	Title	Fasting Glucose Test

	Description	Have Fasting Glucose Test before control visit
	kind	Observation
	code	1558-6, Fasting glucose [Mass/volume] in Serum or Plasma, LOINC
	Timing	Date+6 weeks
	performer	HP & PATIENT
Activity 17:	Title	eGFR Test
	Description	Have eGFR before control visit
	kind	Observation
	code	33914-3, eGFR Test, LOINC
	Timing	Date+6 weeks
	performer	HP & PATIENT
Information Cards		
Arrange Control visit 6 weeks after therapeutic change, 6 months if no change Order HbA1c and p-glucose labs both for the control visits. Order eGFR for the control visit if the record will be older than 6 months.		

C3DP Application

4.6.5.4. Receiving the suggested goals and activities from "Blood Glucose Management Suggestion" service, PCPDP processes them in comparison with the existing goals and activities in the care plan. No matching/clashing existing goal or activity are found, all are presented as suggestions to Dr. Svensson, who reviews and adds them all except the Activity 17 (eGFR Test) to the care plan by completing the missing details. She omits eGFR test suggestion in the light of the information card, as eGFR test has been recently conducted and it will not be 6 months till the next control visit. She also realizes that there is already an appointment after 3 months (related with lipid control), and decides to conduct the Blood Glucose control in the same visit, and deletes the recently added 6 weekly control.

4.6.6. By processing the Diabetes & Renal Failure care plan template, PCPDP suggests to add a high level goal to monitor complications (microangiopathy complications such as retinopathy, nephropathy, and neuropathy; erectile dysfunction), and an appointment for a yearly control visit to check these complications.

Table 17 Goals and Activities Suggested by Care Plan template for monitoring of complications

GOALS

Goal 7:	category	Safety, http://hl7.org/fhir/goal-category"
	Description code	NOC Code, Avoid microangiopathy,NOC
	Description text	Monitor Diabetes Complications
Activity 18: (Appointment)	Title	Appointment for annual control visit (Monitor complications)
	Description	Appointment for annual control visit (Monitor complications)
	status	proposed
	start	(Date+12 Months)
	specialty	-
	performer	HP & PATIENT

Dr. Svensson reviews these suggestions and agrees to add them to the careplan.

4.6.7. By processing the care plan template prepared for Diabetes & Renal Failure, PCPDP suggests a high level goal for "Diabetic Foot Problem Management". This high-level goal will be presented as a separate tab in PCPDP, guiding the healthcare professional about the necessity of a number of goals and activities that can be grouped under the "Diabetic Foot Problem Management" title.

In order to suggest personalized goals and activities about Diabetic Foot Problem Management, PCPDP makes a call to CDSM service for "Diabetic Foot Problem Management Suggestions". The parameters need to be passed to the "Diabetic Foot Problem Management Suggestions" service are listed in Table 18.

Table 18 Clinical parameters presented to HP before passing them to CDSM:

Prefetch Data for "Diabetic Foot Problem Management Suggestions" Service		
	Items to be specifically checked	Sven's Data
Conditions	Ulceration of limb	X
	Spreading infection in limbs	X
	Critical limb ischemia	X
	Non-Critical limb ischemia	X
	gangrene	X
	Suspicion of an acute arthropathy	X
	neuropathy	X
	Callus of limb	X
	Deformity of limbs	X
Conditions/Procedures/Medications???	Ulceration therapy	X
	Renal replacement therapy	X

These are presented to Dr. Svensson for confirmation, she confirms that non of the conditions exist for Mr. Karlsson.

Then all these parameters are passed to "Diabetic Foot Problem Management Suggestions" service, and the call to CDSM is completed.

CDSM Services

4.6.7.1. Receiving the prefetch data as FHIR Resources, the CDSM service executes the decision logic implemented in GDL2, and returns the suggested goals and activities as summarized in the following table.

Table 19 Goals and Activities Suggested by "Diabetic Foot Problem Management Suggestions" CDSM

Activity 19: (Appointment)	Title	Appointment for annual control visit (Diabetic Foot Problem Management)
	Description	Appointment for annual control visit (Diabetic Foot Problem Management)
	status	proposed
	start	(Date+12 Months)
	specialty	-
	performer	HP & PATIENT

C3DP Application

4.6.7.2. Receiving the suggested goals and activities from "Diabetic Foot Problem Management Suggestion" service, PCPDP processes them in comparison with the existing goals and activities in the care plan. PCPDP discovers that there is already an appointment in the care plan in the same dates, and notifies this to Dr. Svensson. Dr. Svensson reviews the suggestions, and updates the existing appointment's description to include "Diabetic Foot Problem Management" as well without adding a new control visit.

4.6.8. By processing the Diabetes & Renal Failure care plan template, PCPDP suggests to add a goal for "Monitoring Eye Disease", a "Referral for retinography" immediately.

GOALS		
Goal 8:	category	Safety, http://hl7.org/fhir/goal-category"
	Description code	274412005, Eye disorder Screening, Snomed CT
	Description text	Monitoring Eye Disease
Activity 20: (Referral)	Title	Referral for retinography
	Description	Referral for retinography (Monitor eye disease complications)
	status	proposed
	start	Tomorrow
	specialty	Ophtalmologist
	performer	HP & PATIENT

Dr. Svensson reviews these suggestions and agrees to add them to the careplan.

4.7. Dr. Svensson assesses the mental state of Sven Mini-Mental examination. Additionally, he assesses his functional impairment status via Barthel Index and notes the results to the care plan.
4.8. After discussing with Sven, Dr. Svensson adds a care barrier to his care plan indicating that he refuses blood transfusions.

4.9. Dr. Svensson checks the possible contradictions in the draft care plan via the reconciliation feature of PCPDP. Details to be completed after examining the reconciliation services…
4.10. Once the care plan is finalized, C3DP shares the current care plan with all the care team members and also with the Patient and his informal care giver, Lisa Karlsson by sending a notification to PEP.

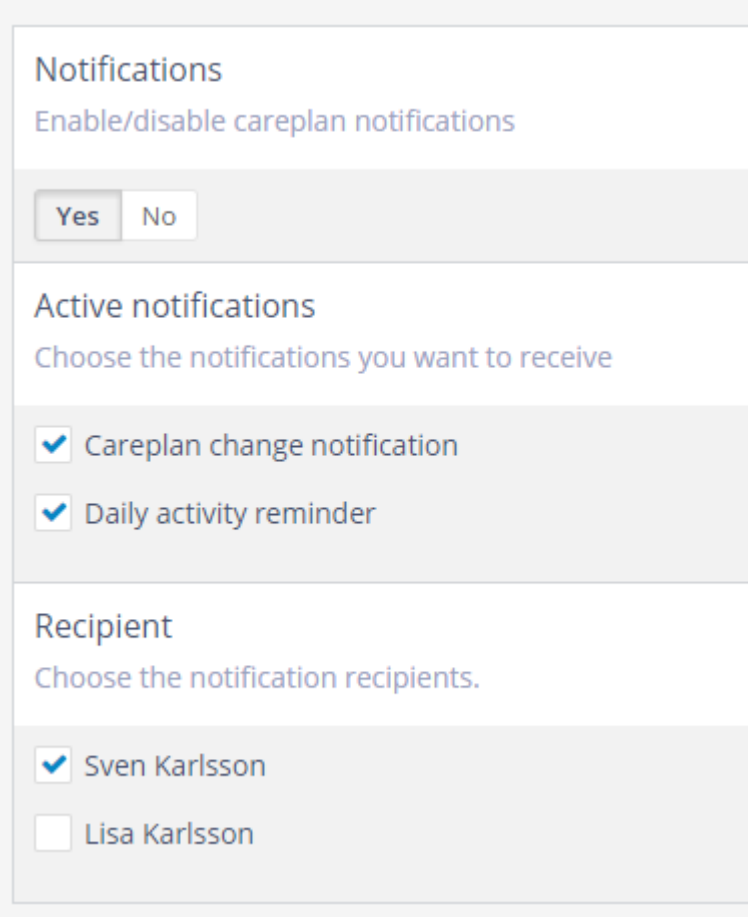
Table 20 Patient's Integrated CarePlan stored in C3DP FHIR Repository and shared with PEP:

Data	C3-Cloud Resource Type	Test Data File	Related step
Sven Karlsson's Integrated Care Plan after Encounter A	CarePlan	CarePlan cp-002.json (including all the referenced resources, such as activities and goals)	4.23

PEP

4.11. Upon receiving the event notification, PEP retrieves the new care plan instance from FHIR Repository

Pre-requisite a [optional]: Sven may optionally choose to review and change his notification settings. By default careplan change notifications are enabled.

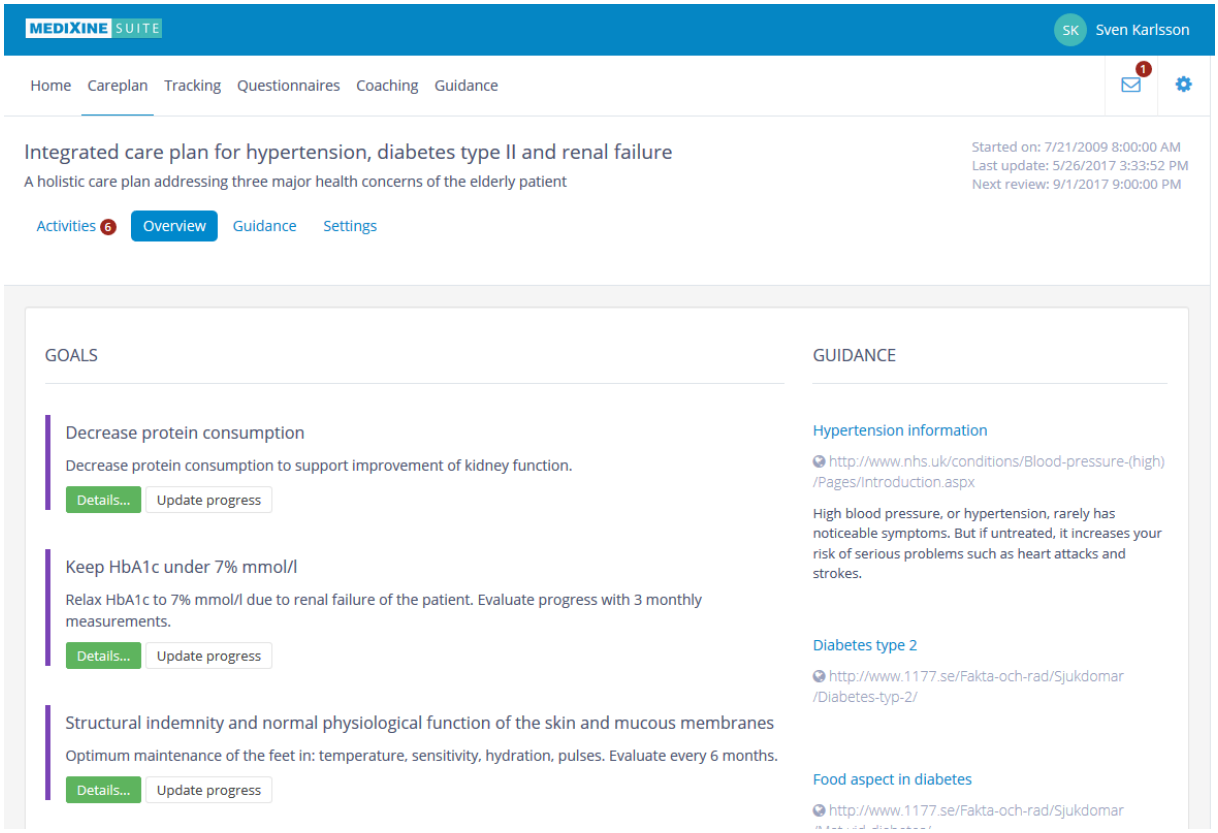


Step 1. Email Notification of new/changed care plan to patient!

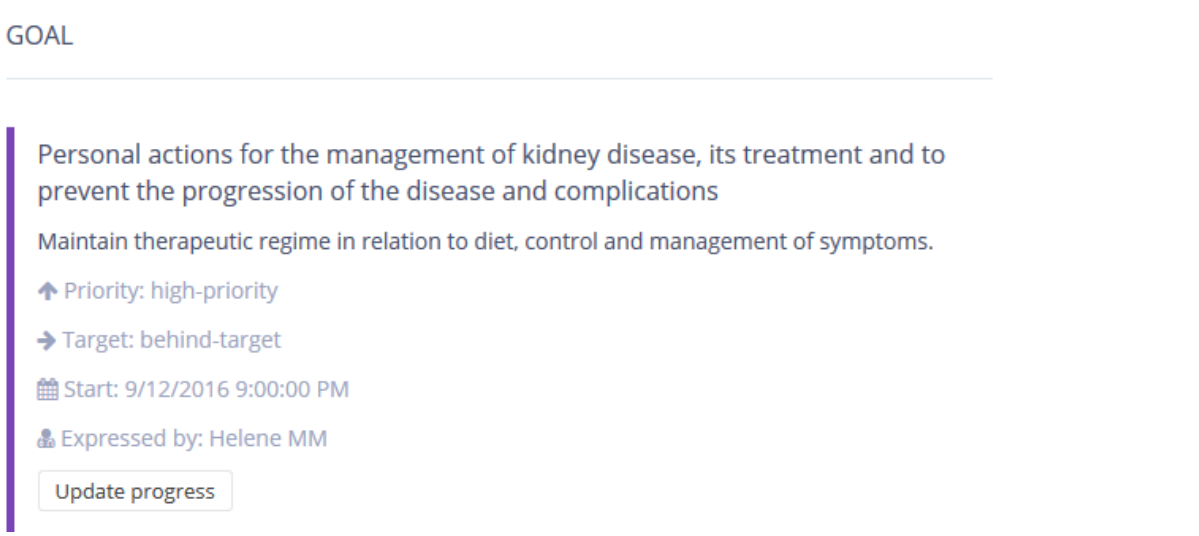
No screenshot for this functionality. Happens automated under the hood in PEP Gateway when the new / changed care plan event is triggered by C3DP to PEP.

4.12. Patient sees care plan

Step 1. Sven views a care plan overview with the goals and associated guidance assets to get to know the care plan.



Details of a general goal:



Details of a goal with target measure:

GOAL

Keep HbA1c under 7% mmol/l

Relax HbA1c to 7% mmol/l due to renal failure of the patient. Evaluate progress with 3 monthly measurements.

Priority: high-priority

Measure: Hemoglobin A1c/Hemoglobin.total in Blood (4548-4)

Limit: less than 7.0 mmol/l

Due date: 2017-02-15

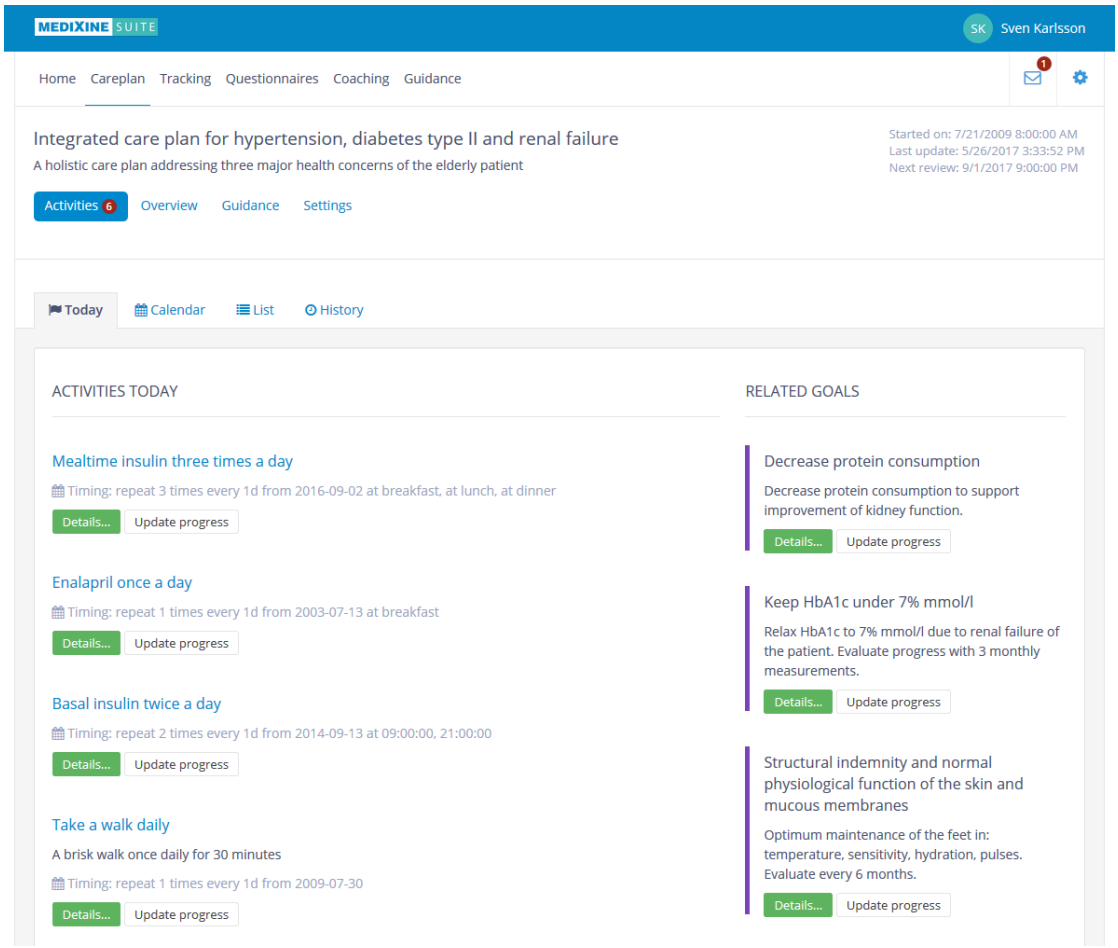
Start: 9/1/2016 9:00:00 PM

Expressed by: Anders Blom

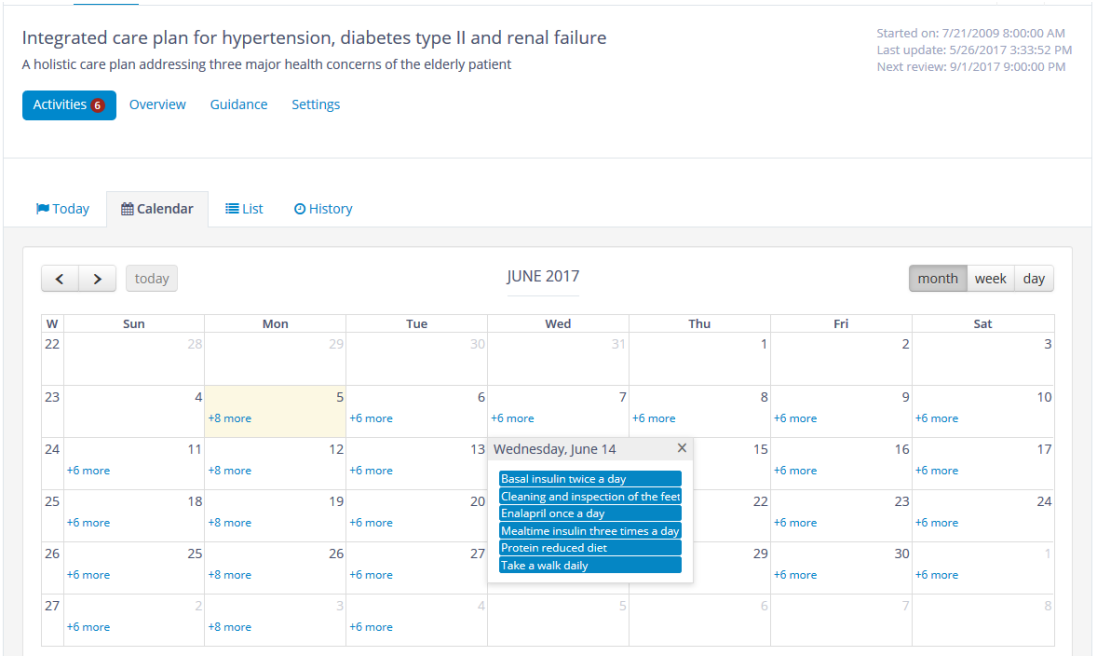
Update progress

Step 2. Sven views the activity views: today, calendar, list, history.

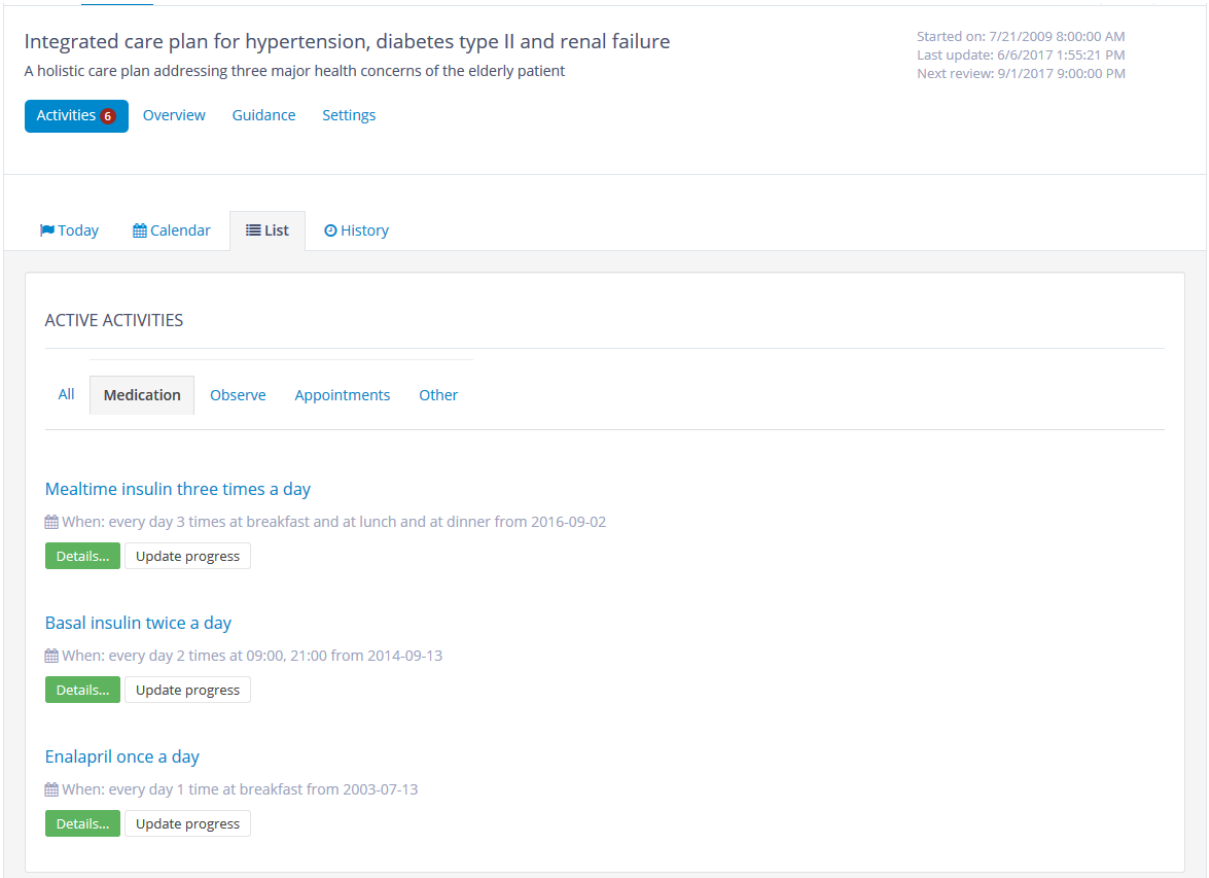
Today view:



Calendar view:



List view:



[[Clinical Partners will provide details of what careplan activity information in the examples to show to patient when patient is viewing how to follow the published care plan.]]

Identified activity/request types:

General activity (none of the more specific types listed below)

MedicationRequest (use medication)

Appointment (meet with someone)

DeviceRequest (measure with device)

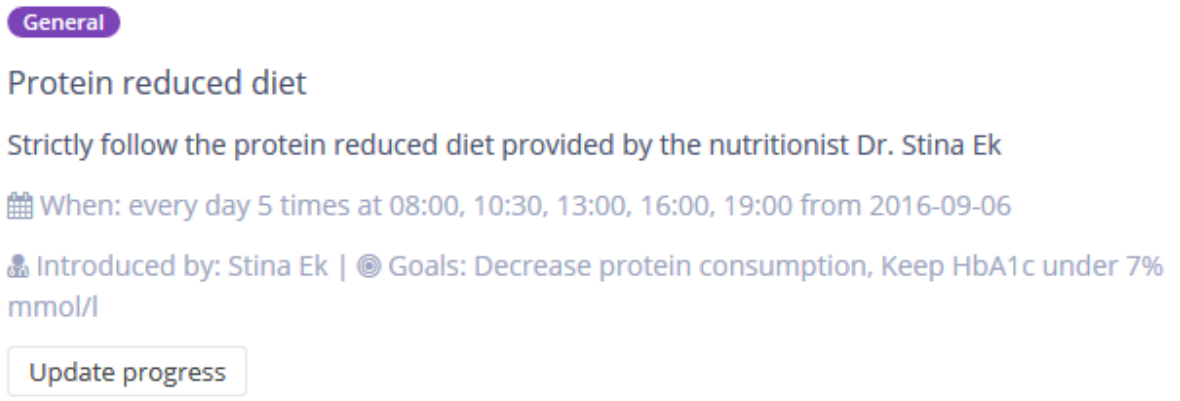
CommunicationRequest (this is guidance information)

The following activites are internal to healthcare provider and not directly displayed to patient

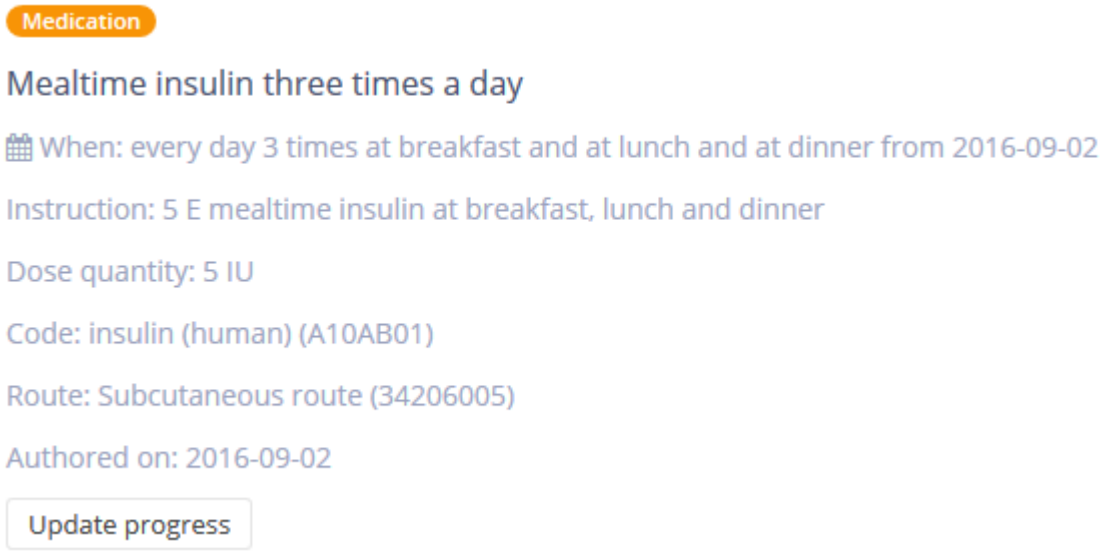
ReferralRequest (hide from patient?; there should always be a related appointment)

ProcedureRequest hide from patient?; there should always be a related appointment)

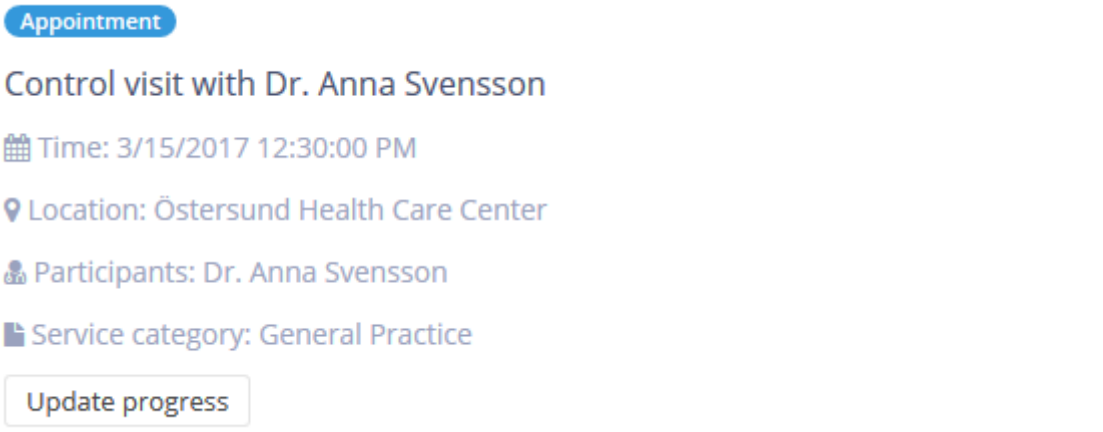
General activity:



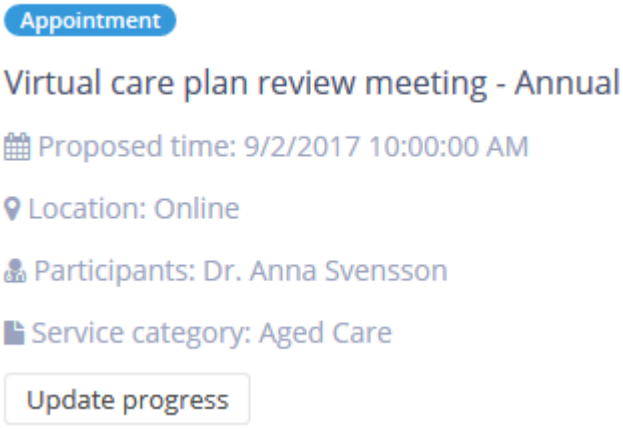
MedicationRequest:



Booked Appointment:



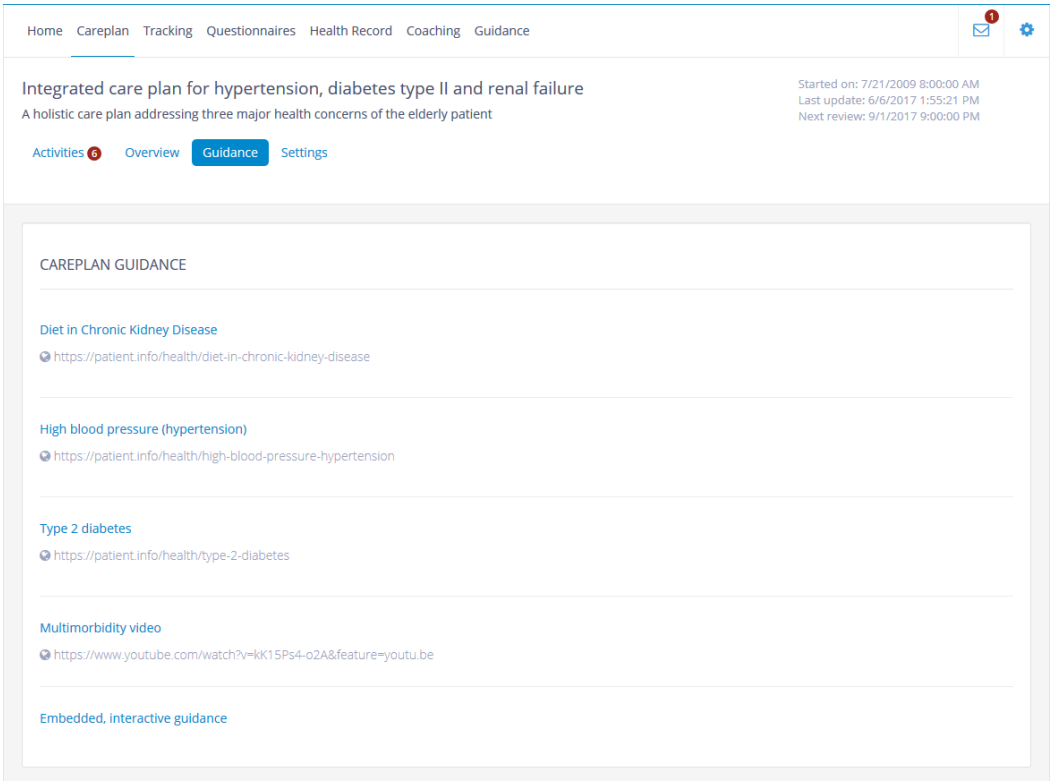
Proposed Appointment:



DeviceRequest:

4.13. Patient sees educational material

Step 1: Sven opens the careplan guidance page and can access guidance assets associated with the care plan.



C3DP Application

4.14. A notification message to all care team members has been sent, informing that the integrated care plan has been defined for Sven Karlsson.

4.15. Upon notification Diabetes Nurse Erik Larsson opens the C3DP and views the current care plan of Sven.
4.16. The integrated care plan instance is exported as a FHIR Care Plan resource shared with the local EHR via TIS.

Technical Interoperability Suite

4.17. **Care plan sharing with local care sites….**

Local Care Site

4.18. Upon receiving the care plan from C3DP via TIS, it is processed, and new MedicationStatement corresponding to the MedicationRequest inside the care plan for Metformin is created in local care systems

Feedback from OSAKIDETZA:

- Drug Prescription: It has to be done from the ePrescription platform, PRESBIDE. PRESBIDE can be called from the PCPDP platform. There would be a link, and given that the Care Plan already has the CIC (Patient Identification Number) and the ID number of the professional, the Presbide screen will be preloaded with the data of the patient and the professional. Specific prescription (drug, dose, etc) should be completed in PRESCRIBE. There has to be some development work to be done in PCPDP to integrate. Nico can send you information on how to carry out the integration.
- Appointments and referrals: This can be done by the Health Care Professional only from the "Working Station", i.e. Osabide Global (or OGP in Primary care). There is a functionality called "Gestor Peticiones" ("Order Entry") in Osabide Global, where it is possible for the professional to make a request for an appointment. The procedure is quite complex (it has to take into account all the organizational structure of Osakidetza). So even if in theory it could be feasible, due to internal nrms and complexity, we think it is out of scope of the Project.

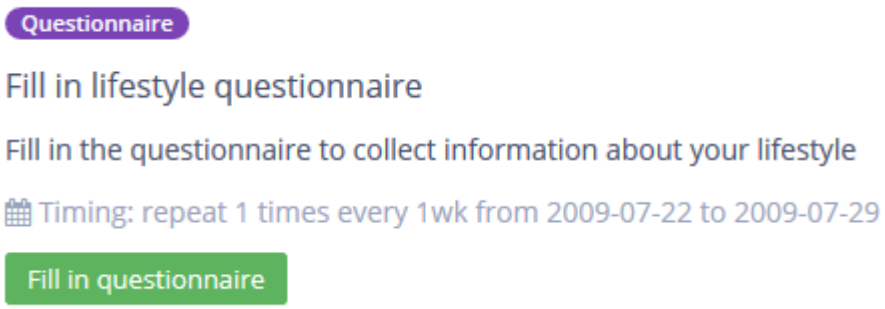
5. Patient Activities over PEP till Diabetes Nurse Visit (22/07/2009 - 30/07/2009)

PEP

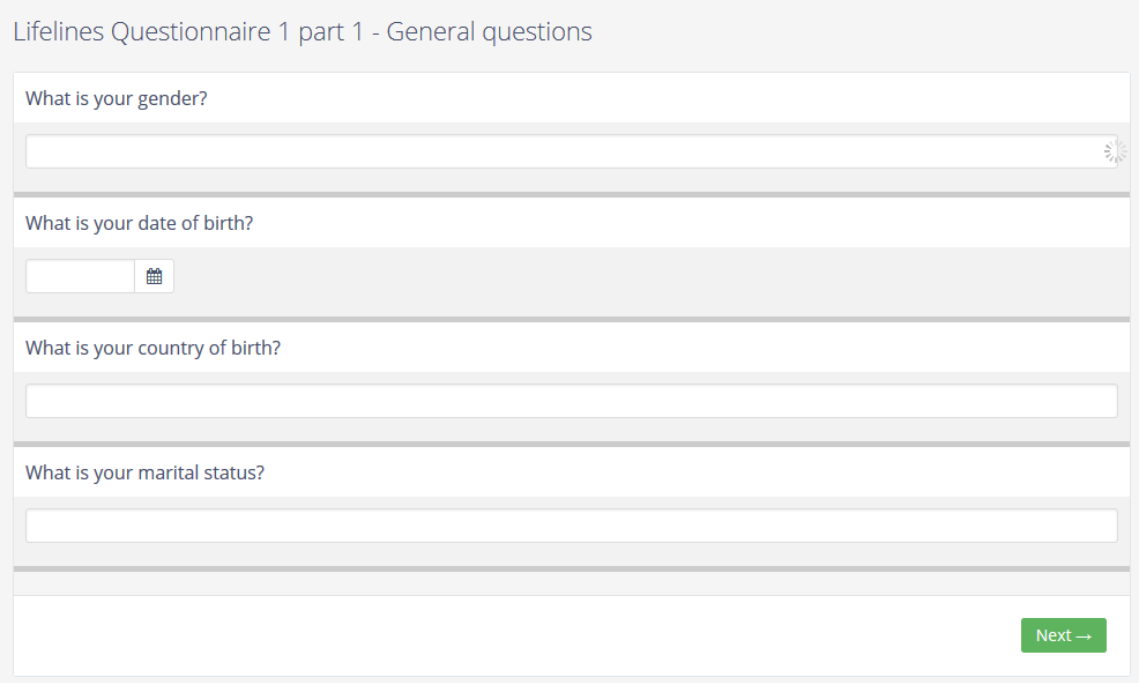
5.1. Sven uses PEP functionalities to fill in the lifestyle questionnaire
Step 1: Sven sees the questionnaire activity in his Today-activities.

TODO: [no active questionnaire Activity at the moment in the FHIR repository. Let's make one for the future use into the FHIR repository. Below the available completed activity is used for screenshots.]

Step 2: Sven clicks on the activity link to answer the questionnaire.



Step 3: Sven answers each page of the questionnaire.



Step 4: Sven completes the questionnaire.

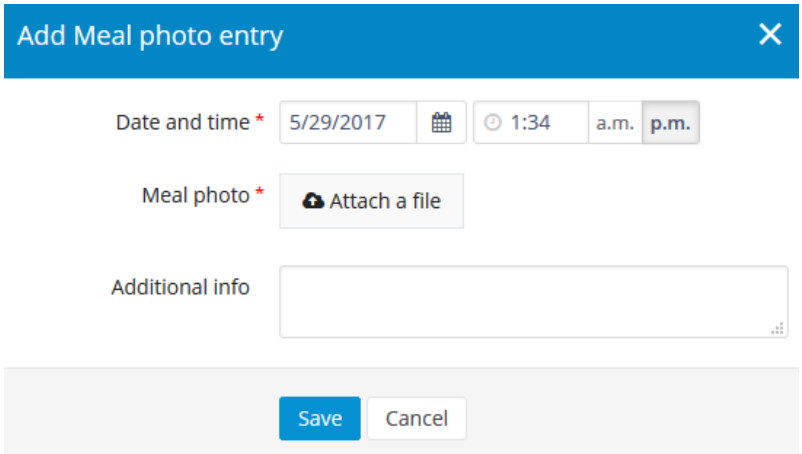
Clinical partners: [What message to patient after completing the example questionnaire. The message can be configured separately for each defined questionnaire. Simple thank you message or a more story/process related message?]

5.2. PEP directly stores the results as a QuestionnaireResponse FHIR resource to C3DP FHIR Repository through the given interface

5.3. Sven uploads the photos of his daily meals to PEP everyday

Step 1: Sven logs in and opens the MealPhoto-tracker.

Step 2: Sven chooses to add a new meal photo. Sven attaches the photo has taken of his meal.



5.4. PEP directly stores these as MealPhoto Observation resources to C3DP FHIR Repository through the given interface

6. Diet and Lifestyle counselling (Appointment B- Diabetes Nurse Visit - 30/07/2009)

C3DP Application

6.1. Erik Larsson opens up PCPDP and sees the highlighted goals and activities that requires his attention. He completes the Patient education task he is assigned to.
6.2. Erik continues with Diet and Lifestyle counselling. He is able to see the questionnaire results, and Sven's meal photos via the C3DP interfaces. He examines them and adds a new exercise goal for increasing physical activity and adds an accompanying activity (daily walk for 30 minutes) to the care plan.
6.3. He continues with "Diabetic Foot Problem Management" high level goal. Erik adds a new health concern to the care plan related with the 'Risk of deterioration of skin integrity", add a new goal for "maintaining tissue integrity", and an activity for "Cleaning and inspection of the feet".
6.4. Care Plan is finalized and saved to FHIR repository and a notification to care team members, and to PEP is sent to inform the updated care plan
6.5. All care team members receive system notifications about the care plan update operation.
6.6. The finalized care plan is also shared with local care sites via TIS.
6.7. Erik has reminded Sven and Lisa to frequently use PEP to find information about their conditions, to record the BP measurements and send questions to him and Dr. Svensson.

PEP

6.8. Upon receiving the event notification, PEP retrieves the new care plan instance from FHIR Repository…..

Technical Interoperability Suite

6.9. **Care plan sharing with local care sites….**

Local Care Site

6.10. Upon receiving the care plan from C3DP via TIS, it is processed, and new health concern corresponding to the "skin deterioration risk" is created in local care systems

7. Patient Activities till Control Visit (31/07/2009 - 20/10/2009)

PEP

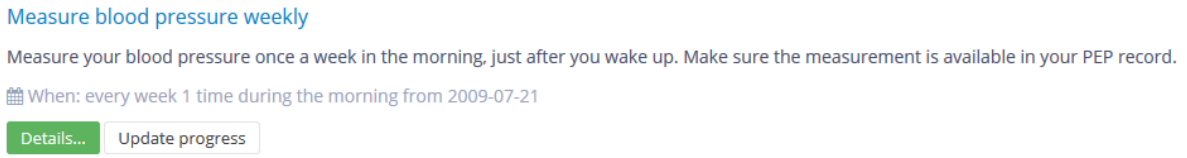
7.1. Sven gets an automatic blood pressure meter and an activity tracking device to follow vital measurements, and links them to PEP Platform

NOTE! Device assignment by care team (blood pressure cuff) for clinical devices. Values uploaded to C3-Cloud automatically.

NOTE! Activity tracker could be a BYOD device, that when a supported one is used, the BYOD device can be connected with PEP and the measured values transferred into C3Cloud.

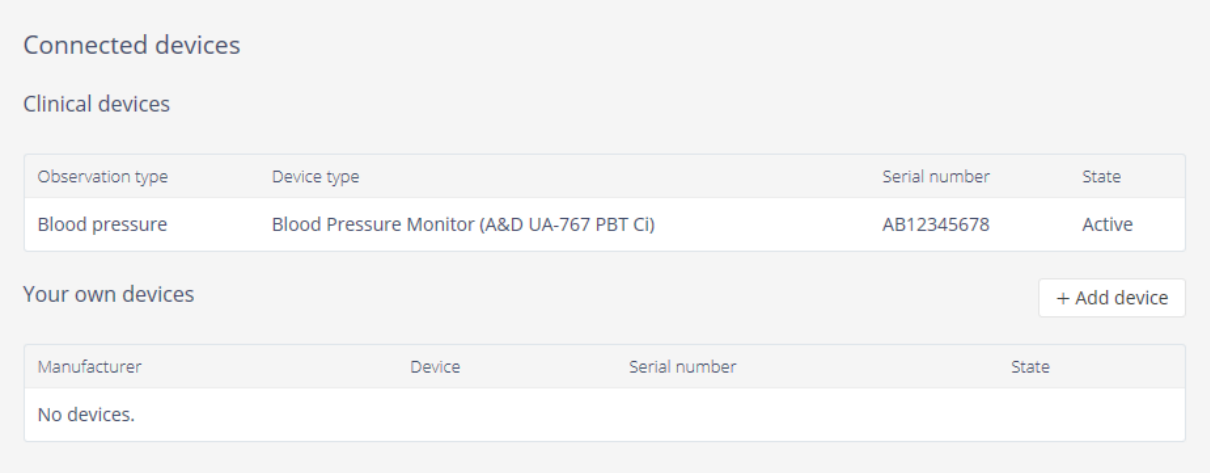
Pre-requisite a [optional]: Sven receives a daily reminder, that he has activities today and they include measurements with connected devices.

Pre-requisite b [optional]: Sven logs in and views his non-completed measurement activity before he starts measuring.



[N.B. current information model activity information does not yet include any information, that would allow linking the activity to relevant tracker, devices etc.]

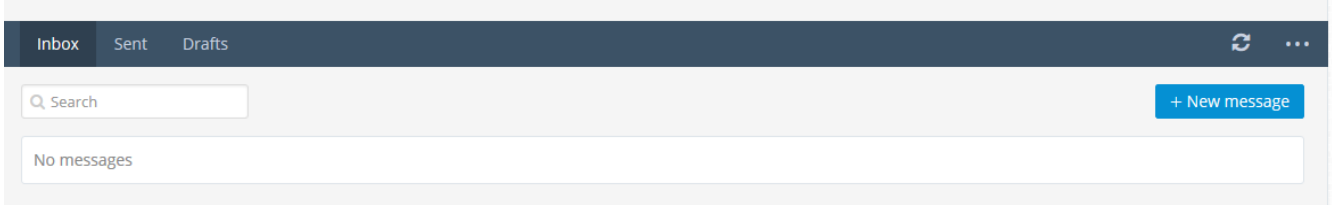
Pre-requisite c [optional]: Sven logs in and checks the info of his assigned devices.



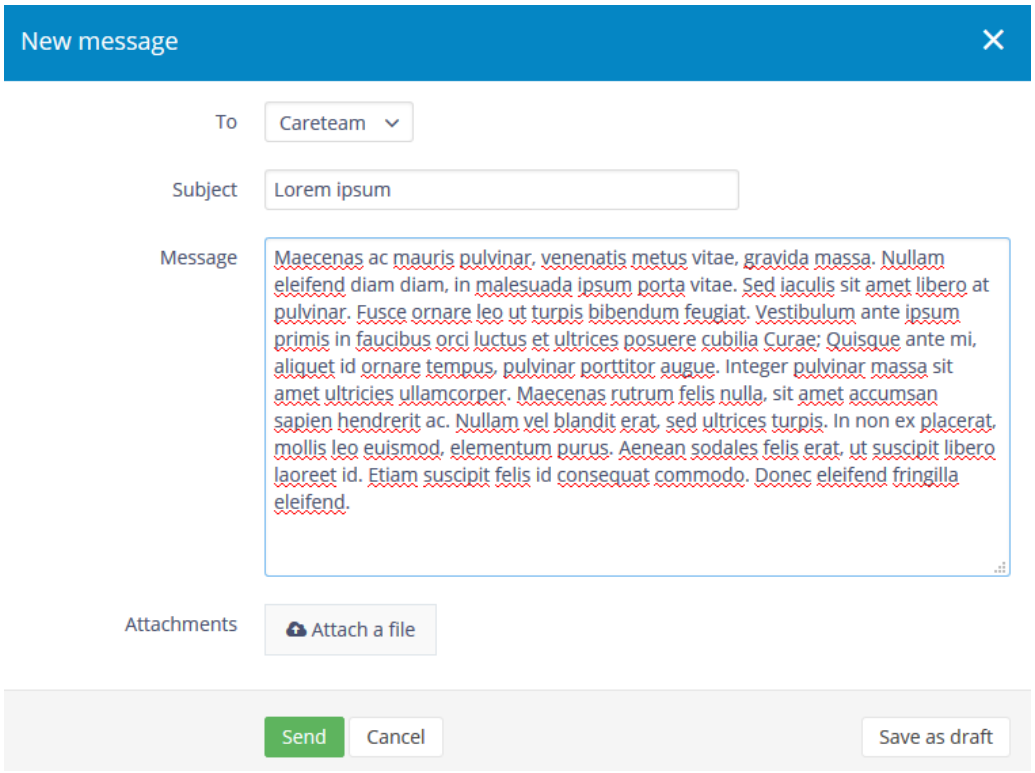
7.2. Sven uses the messaging functionality of PEP to ask about correct usage of blood pressure monitor

Step 1: Sven opens Safe messaging. He has been reminded that for emergency cases, he should not use messaging feature, instead he should directly call the emergency department.

Step 2: Sven clicks on New Message



Step 3: Sven writes the message and sends it to the care team.



Step 4: Sven finds the sent messages in the Sent tab.

7.3. PEP passes this question to C3DP as a FHIR Communication message.

C3DP Application

7.4. C3DP receives patient's message, saves it to FHIR Repository, and a notification is sent to Erik Larsson about the new message received from the patient

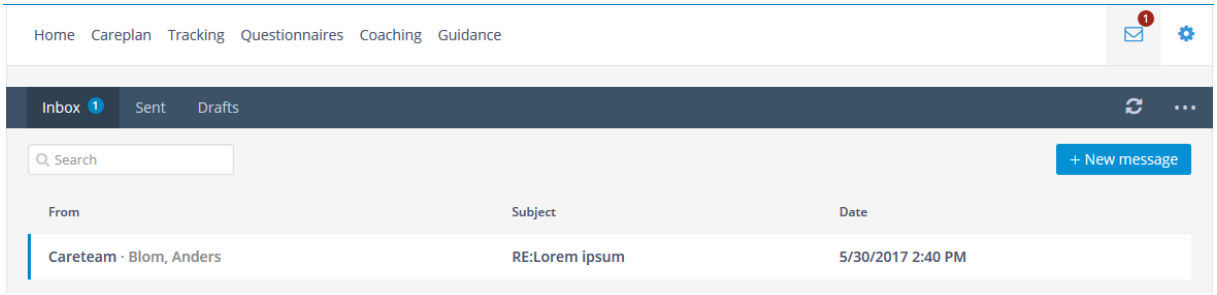
7.5. Erik views and answers the message via C3DP messaging platform. C3DP delivers the response to PEP as a FHIR communication.

PEP

7.6. PEP presents the message response to patient.

Step 1: Sven has received notification of new message and has logged in. Sven notices the new message(s) badge and opens his Safe Messaging inbox.

Step 2: Sven opens his Safe Messaging inbox.



Step 3: Sven opens the response message and reads it.

[N.B: It should be discussed and specified who Sven may be in contact with (initiate new conversations). Only the care team in general (message visible to all team members) or also directly one-on-one with specific health professionals (if yes, which team members). If more specified and controlled access is desired, the management of authorization needs to be specified.]

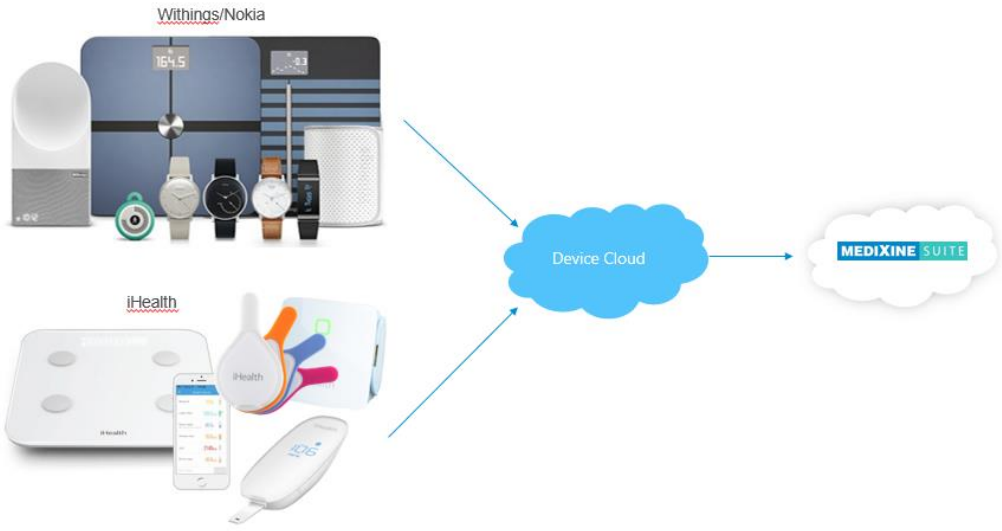
7.7. Patient regularly uses these devices, and the measurements are automatically transferred to PEP

- Patient uses connected device kit assigned and given by care team

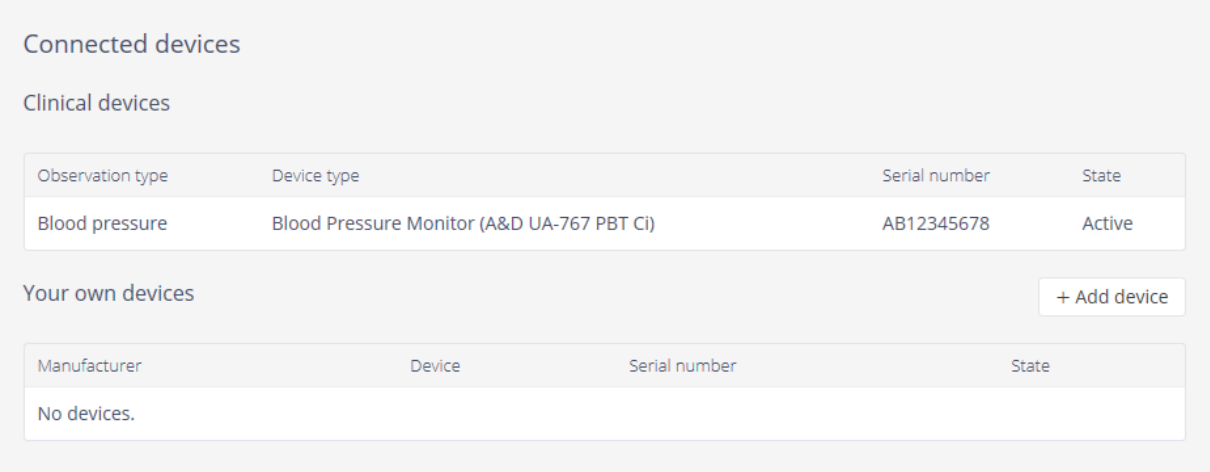
Step 1: Sven uses the assigned clinical device, which automatically uploads the value to the system.

Step 2: Sven receives a notification that measurement has been uploaded successfully.

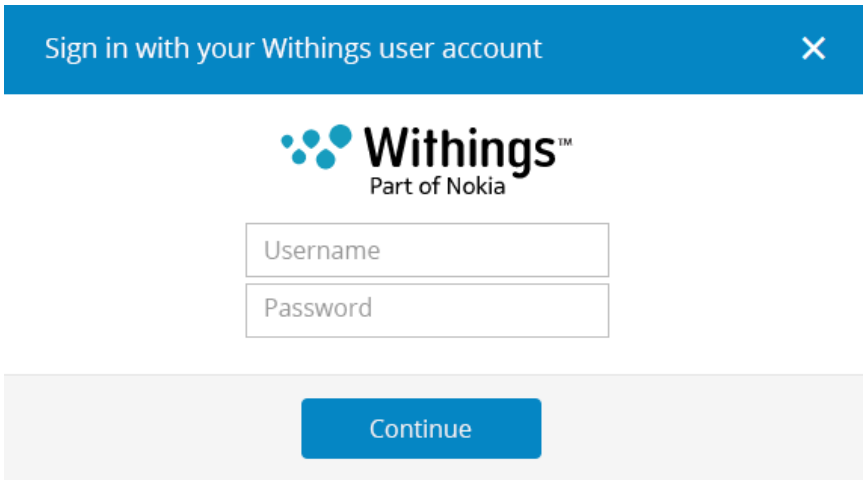
- Sven registers measurement values using BYOD device

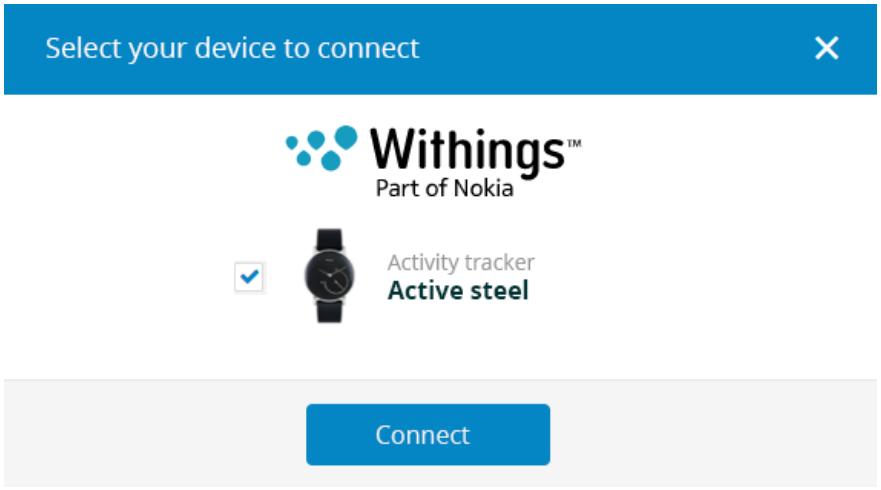


Step 1: Sven logs in and opens Device settings.

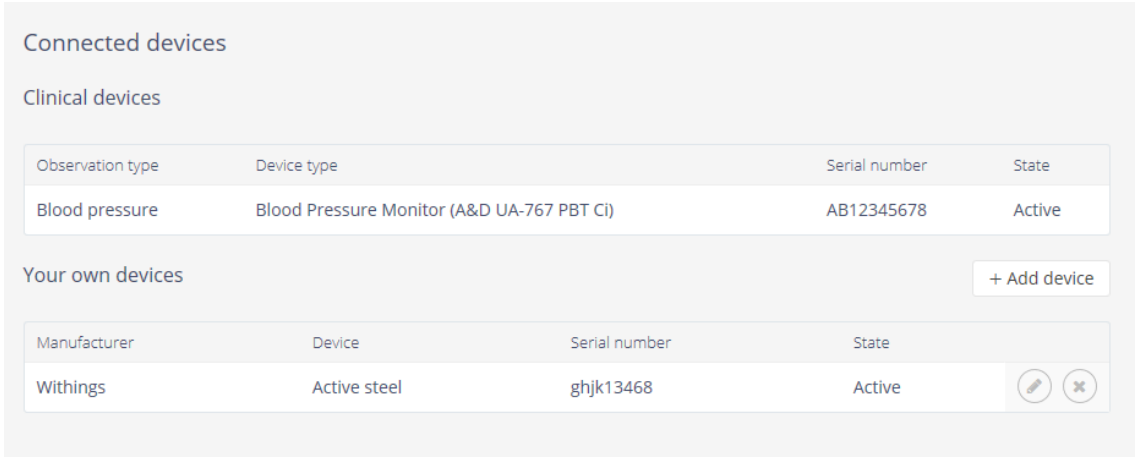


Step 2: Sven registers his BYOD devices.





Step 3: Sven sees his added BYOD device in the device list.

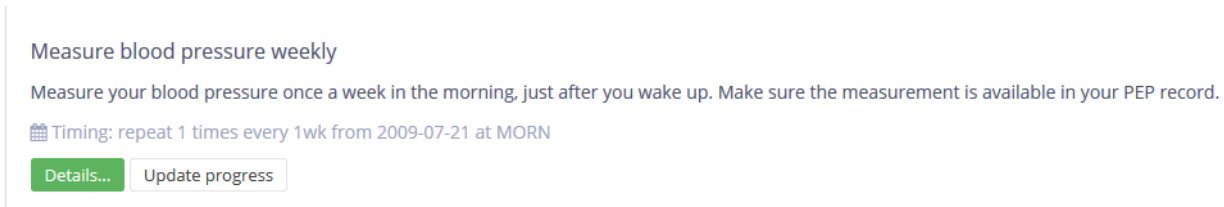


Step 4: Sven uses his BYOD device and the measurements are transferred to the BYOD solution.

Step 5: The values are transferred at regular intervals from the BYOD solution to C3Cloud.

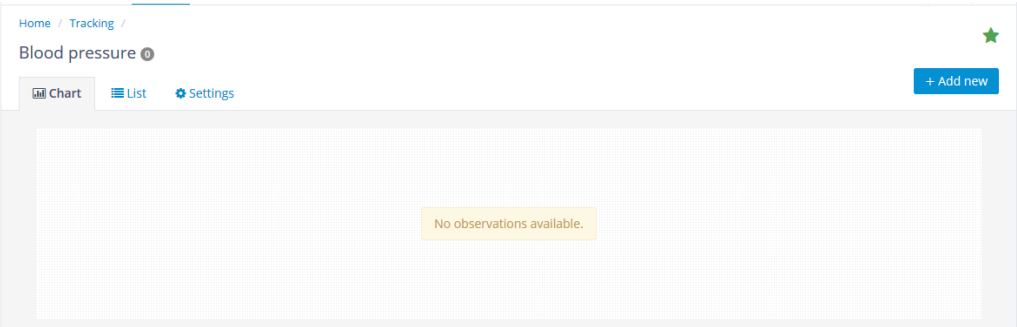
- Sven registers measurement values manually

Step 1: Sven sees his non-completed measurement activity.

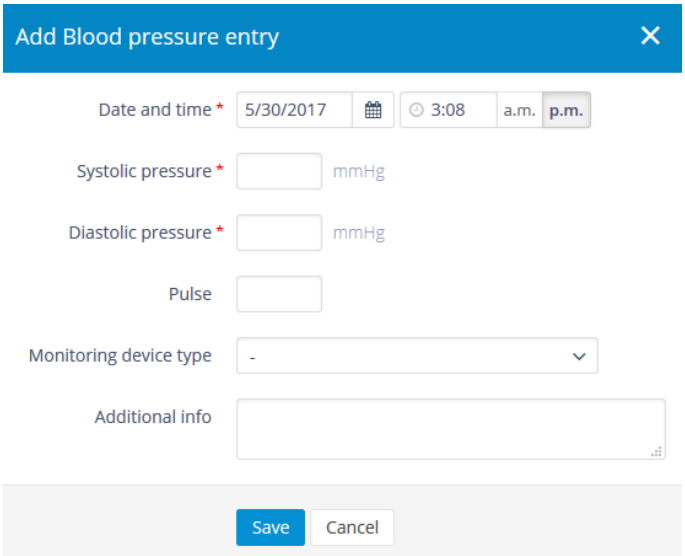


[N.B. current FHIR careplan activity information does not yet include any information, that would allow linking activity to relevant tracker.]

Step 2: Sven opens the relevant tracker.



Step 3: Sven adds a new measurement/observation value

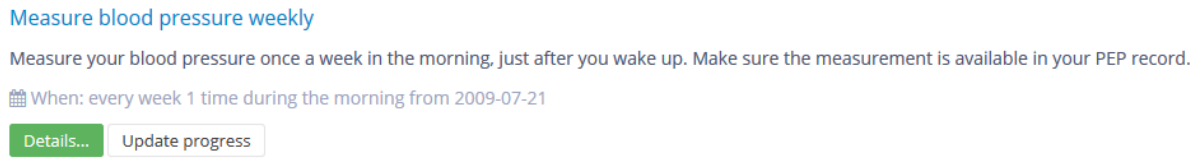


7.8. PEP sends these data to C3DP FHIR Repository through the interfaces provided

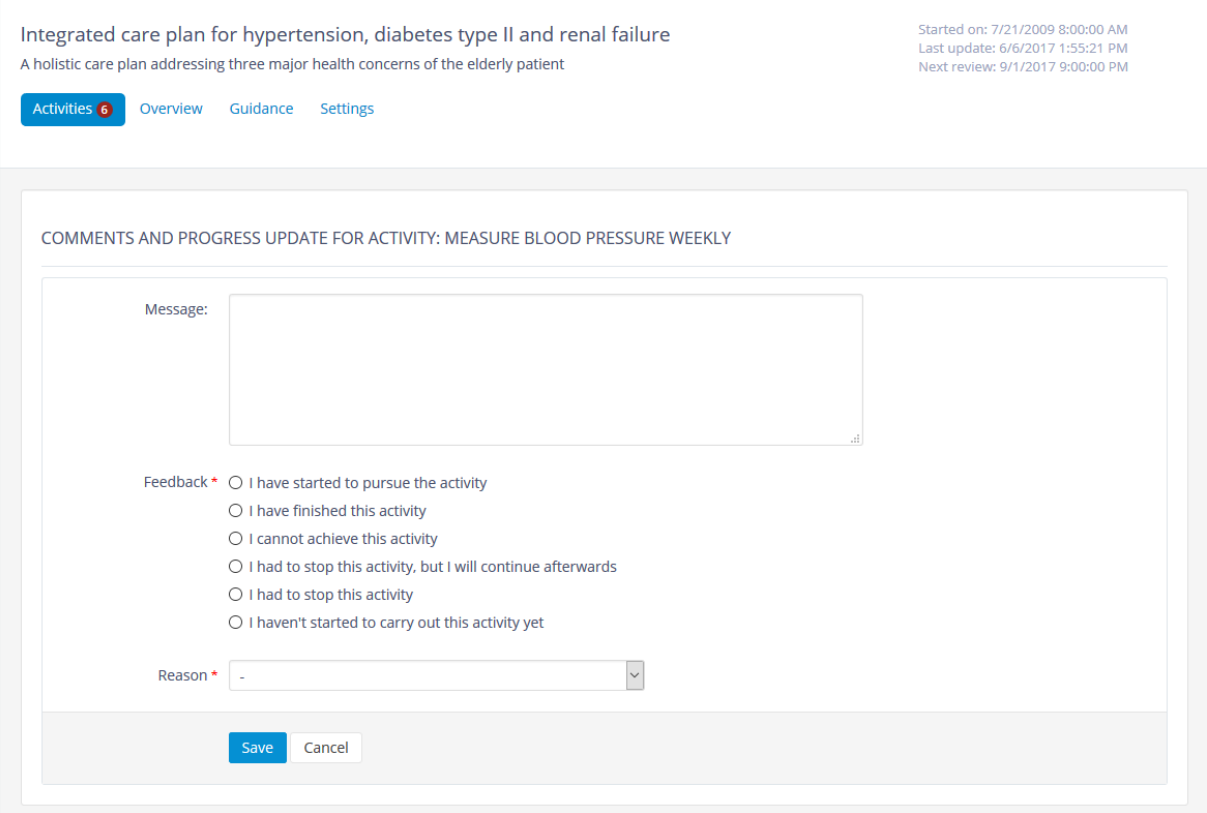
PEP

7.9. On 21/08/2009 Sven provides progress about the "Blood pressure activity" via PEP. He notes that he is using the BP device comfortably now

Step1: Sven opens the related care plan activity and choose Update progress.



Step 2: Sven fills in the progress report fields and saves the progress update.



[N.B: The real-world use of this functionality doesn't yet feel fully clear. It should especially be discussed when the patient will opt to use the messaging functionality and when will it feel natural to use this progress update functionality to contact the care team.]

7.10. PEP sends these comments to C3DP FHIR Repository through the interfaces provided

C3DP Application

7.11. These notes are added to the current active care plan as progress notes of the respective activities.

Local Care Site

7.12. On 18/10/2009 Sven goes to the health center, and completed his HbA1C test. His results are saved to the local system.

Technical Interoperability Suite

7.13. TIS pushes the new lab result to C3DP…

8. New Follow-up Encounter (Appointment AB-Control - Primary Care Physician Visit - 20/10/2009)

C3DP Application

8.1. Dr. Anna Svensson reviews Sven's latest BP measurements received from the devices, and also checks recent lab results.

8.2. Dr. Svensson checks the recent HbA1C measurement, and adds a note to the care plan indicating that "The patient is progressing well with Metformin" (both to g-003 (Keep HbA1c under 6.5%

mmol/l), and to a-005 (Metformin twice a day)). She links the recent HbA1C measurement to this goal as an outcome measurement.

8.3. Erik Larsson also reviews the most recent results, patient's comments and after discussing with the patient he adds notes to the relevant goals and activities, indicating that:

- g-005 (Structural indemnity and normal physiological function of the skin and mucous membranes): The patient maintains the cutaneous integrity of the feet, performs well the care. Monofilament test: 10/10.
- g-006 (Increase physical activity): The patient has increased daily activity level
- a-012 (Cleaning and inspection of the feet in order to achieve a clean and healthy relaxed skin): Choice of appropriate footwear and socks. Maintains good hygiene and condition of skin and toenails

8.4. Dr. Svensson and Erik Larsson encourages the patient to continue his exercises, diet and medications and arranged the next 3 monthly control visit on 02/01/2010

8.5. Care Plan is finalized and saved to FHIR repository and a notification to care team members, and to PEP is sent to inform the updated care plan

8.6. All care team members receive system notifications about the care plan update operation.

8.7. The finalized care plan is also shared with local care sites via TIS.

PEP

8.8. Upon receiving the event notification, PEP retrieves the new care plan instance from FHIR Repository

Technical Interoperability Suite

8.9. **Care plan sharing with local care sites…**

Local Care Site

8.10. Upon receiving the care plan from C3DP via TIS, it is processed.

9. Discussion Points:

1. This version of the storyboard does not include all the functionalities proposed in Requirements Specifications. After first integration attempt, a cross check will be performed and missing features will be added.
    a. PEP related ones:
        - This version of the story does not include the patient to add appointment time of a proposed appointment (a future activity to meet with healthcare provider).
        - This version of the story does not include the use of video-conferencing with the patient. This could for instance be used by the care plan manager to discuss the care plan with the patient (i.e. an online video appointment).
        - This version of the story does not include the use of health coaching. This has been included in the PARs but on the other hand is not strictly necessary (it is an optional method to deliver guidance material to enrolled patients).