Virtual Coaching Activities for Rehabilitation in Elderly

Call: H2020-SC1-2016-2017

Grant Agreement Number: 769807

Deliverable

D6.4 Service Description

Deliverable type:	Report
WP number and title:	WP6: Pathway System – Semantics driven Pathways Development and Execution Services
Dissemination level:	Public
Due date:	Month 33 – May 2020
Lead beneficiary:	TUD
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Document history

Version	Date	Author/Editor	Description
0.1	13.05.2020	Hannes Schlieter, Kai Gand, Martin Burwitz	Initial version, sent to the internal reviewers
0.2	25.05.2020	Patrick Philipp, Lars Böcking, Alvaro Martinez, Alexandru Vulpe	Comments by the internal reviewers
1.0	29.05.2020	Hannes Schlieter	Final version

EXECUTIVE SUMMARY

The deliverable reports on pathway layer's services to exchange pathway information. Therefore, the needed technical provisions are outlined. This information exchange is needed to share the rehabilitation care pathway (template) information after the template have been modelled, altered or selected/assigned with further vCare solution's component that subsequently consume and process this information. The development is part of the services of the overall vCare solution's pathway layer providing the capability to share the pathway information on an aligned technical basis. This also, in turn, provides both the ability for physicians to assign particular pathways to distinct patients and to further monitor the patient and personalise the rehabilitation care with regard to the foreseen procedure by the knowledge layer's reasoning mechanisms. The respective vCare FHIR profile and the FHIR operation interactions/public interfaces that are offered to provide access to the care pathway information are described in order to allow a proper understanding and, therefore, technical accessibility of the pathway layer's component's pathway information. The functions will be initially tested and iteratively refined during the project's lab test phases.

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1 INTRODUCTION

1.1 DOCUMENT SCOPE

The deliverable reports on the pathway layer's services to exchange pathway information. Therefore, the needed technical provisions are outlined. This information exchange is needed to share the rehabilitation care pathway (template) information after the template have been modelled, altered or selected/assigned with further vCare solution's component that further consume and process this information. This especially relates to the professional portal and the knowledge layer. The current deliverable D6.4 is part of WP6's Task 6.1.
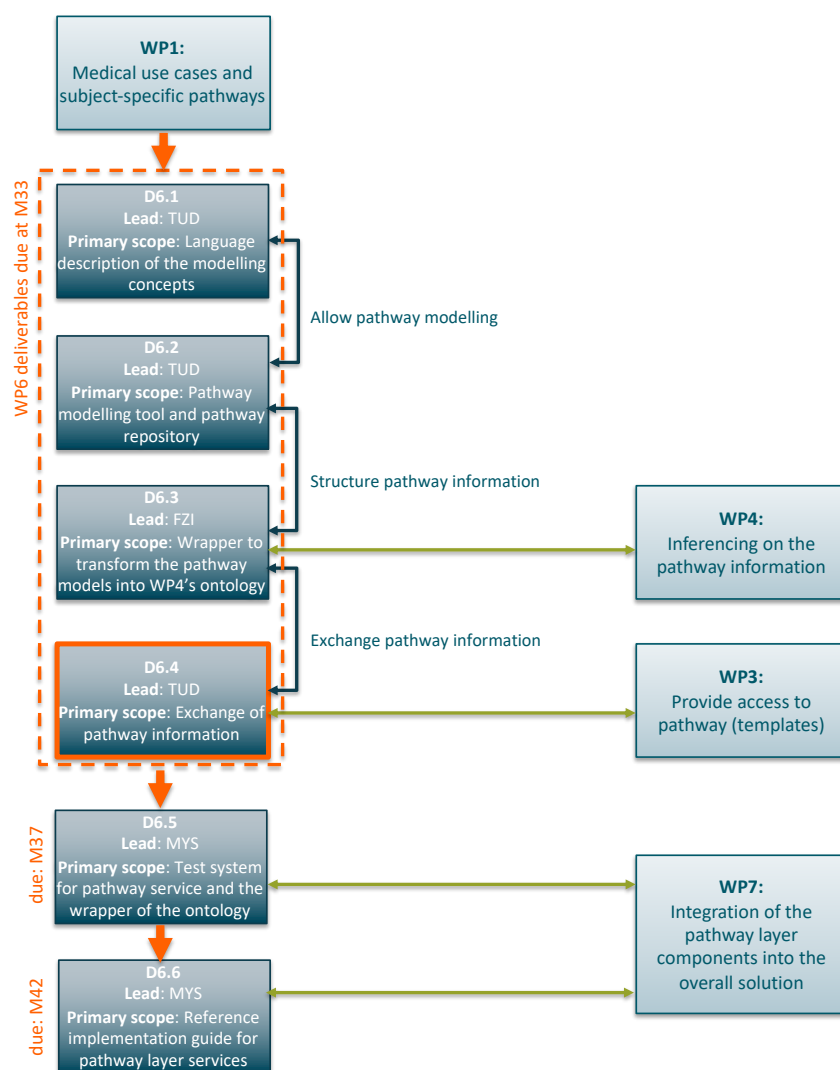
Figure 1: Primary relations of current WP6's deliverables

The primary input-output relations within WP6 and to the most important adjacent deliverables and WPs of D6.4 are outlined in Figure 1. D6.4 is one out of four parallel deliverables in WP6 due in M33 that further specify the pathway layer's components, fill its functionality stack and allow integrating into the overall vCare solution. The main components which interacts with pathway manager are the professional portal (in charge for patient administration) and the

knowledge layer (in charge for pathway adaptation). D6.5 and D6.6 will then describe the test system and the reference implementation guide for the pathway layer's components.

1.2 DOCUMENT STRUCTURE

The document is structured in three primary sections.

Section 1 is introductory and puts the deliverable in the context of WP6 and the vCare project.

In *Section 2*, we provide an overview of the vCare Pathway Layer services particularly looking on the use FHIR's resources profiles as the technical base to store, transfer, instantiate and further process the rehabilitation care pathway information. Secondly, an overview of the FHIR operation interactions/public interfaces that are offered to provide access to the care pathway information is given.

Section 3 discusses the main results that have been achieved as reported in this deliverable and provides an overview of related future work.

2 vCARE PATHWAY LAYER SERVICE SPECIFICATION

2.1 vCARE FHIR PROFILES

Fast Healthcare Interoperability Resources (**FHIR**) is a standard developed by HL7[1]. In general, it aims to exchange data between software systems in the healthcare sector. FHIR describes data formats and elements as so-called "resources" and provides an interface to exchange them. This also combines advantages of the established HL7 standard product lines including CDA[2] and combining with those of current web standards. An easy implementation is the superior aim. Modern web-based API technologies such as the HTTP-based programming paradigms REST[3], HTML[4], TLS[5] and OAUTH2[6] are used within FHIR. Both JSON[7] and XML[8] can be used to represent the data which is advantageous for further processing steps. Furthermore, FHIR provides an alternative to document-centered approaches by allowing direct access to individual information fields as a service.

For the pathway layer, it is fundamental to exchange the information (in the end: the procedure and related elements of the patients' rehabilitation programme in a structured form) regarding the rehabilitation care pathways – both for the patient-independent templates and the patient-specific instances. To adapt this for vCare's rehabilitation context and to concentrate only on

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[1] See: http://hl7.org/fhir/
[2] See: http://www.hl7.org/implement/standards/product_brief.cfm?product_id=7
[3] See: https://www.ics.uci.edu/~fielding/pubs/dissertation/top.htm
[4] See: https://whatwg.org/
[5] See: https://tools.ietf.org/html/rfc8446
[6] See: https://oauth.net/2/, https://tools.ietf.org/html/rfc6749
[7] See: https://www.json.org/json-en.html
[8] See: https://www.w3.org/standards/xml/

the needed elements of the comprehensive FHIR standard, we build a respective FHIR profile[9] to have a concise and easy to ease configuration.

The overall question is then how to represent the medical content in terms of the subject-specific pathways as compiled by the clinical experts (see D1.4 as the clinical core document) given the choice for BPMN as the modelling language for the rehabilitation care pathway templates (as discussed in D6.1). These needs to be mapped/related to FHIR concepts/resources to finally allow the pathway modelling or to make its results technically usable and exchangeable for the vCare's technical components and not only for the human model users (see Figure 2).
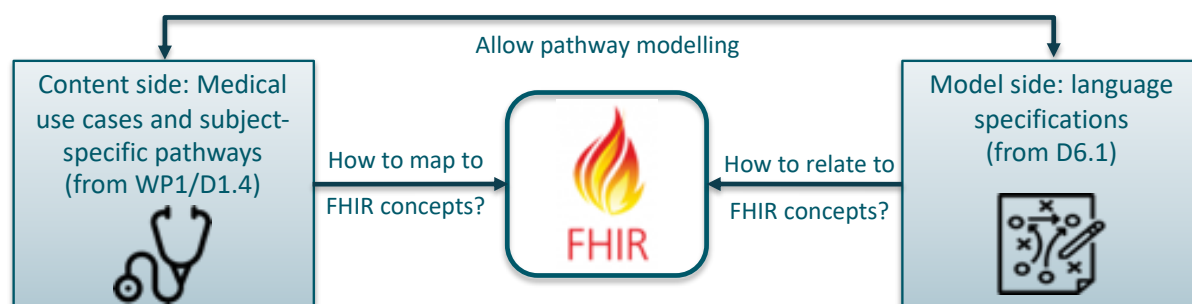
Figure 2: Allow pathway modelling by using FHIR resources

Further on, particular FHIR resources are needed to represent the care pathway information. After analysing the available FHIR resources, PlanDefinition[10] and CarePlan[11] have been chosen (see Figure 3 for an overview of their relation in the project context). The PlanDefinition resource is used to represent the patient-independent rehabilitation care pathway template on the Pathway Layer's side. For this, the Pathway Layer's Pathways editor and Template management (as described in D6.2) uses a HL7 FHIR-based repository[12]. The PlanDefinition resource is then mapped to the CarePlan resources after the physician has assigned a rehabilitation care pathway template to a particular patient. By doing so, a patient-specific instance of the template is generated. This is further used within the professional portal to overview the patient and to allocate particular coaching services. This, in turn, also allows to access the pathway templates both for the professional's portal (WP3) and to allow inference activities of the knowledge layer and a standardised way to access this for a wrapper of clinical pathways (see D6.3 and WP4).

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[9] See: https://www.hl7.org/fhir/profiling.html
[10] See: http://hl7.org/fhir/r4/plandefinition.html
[11] See: https://www.hl7.org/fhir/careplan.html
[12] See: https://hapifhir.io

Figure 3: Relation of FHIR's PlanDefinition and CarePlan for vCare's purposes

The following two sub-sections further specify the PlanDefinition and CarePlan as the two resources used in the vCare FHIR profile. The annex contains an exemplary implementation of these elements to illustrate how this looks like.
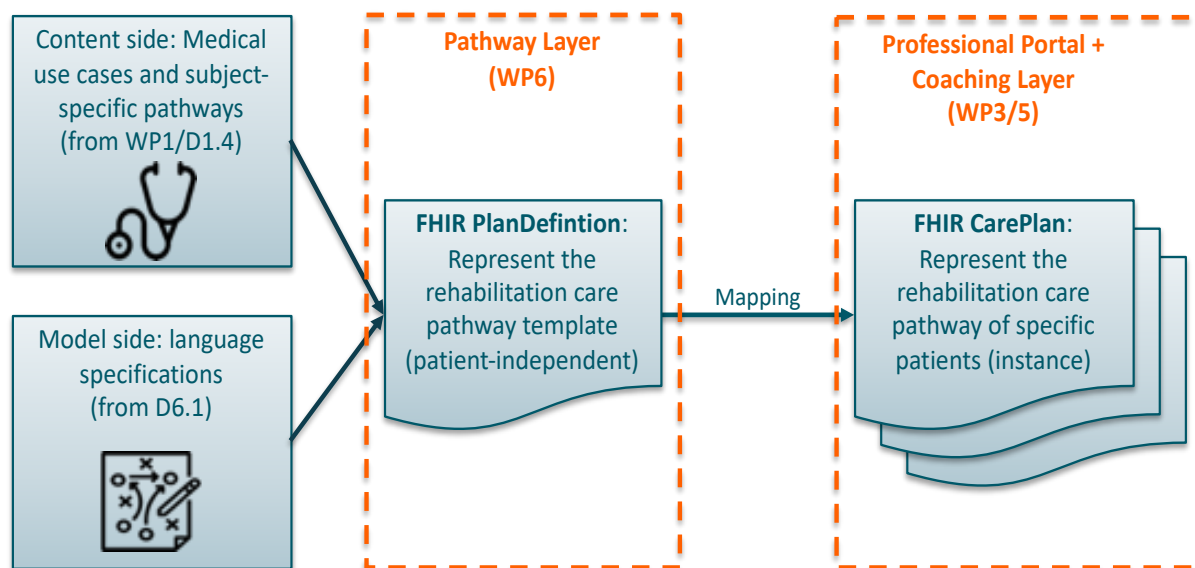
2.1.1 PlanDefinition

To allow the vCare solution's pathway layer (namely the Pathways editor and Template management tool as described in D6.2) to provide the pathway information in a standardised way we use the widely acknowledged HL7 FHIR standard's *PlanDefinition* resource[13].

In order to reflect the specifics of the home-based rehabilitation scenarios in the course of the project, we built a respective profile of the standard PlanDefinition named *ModeledPlanDefinition[14]*. These specifics are outlined in the following. For this, we only emphasise on the elements that have been adapted compared to the standard (see Table 1). Thus, only these elements are used here. The remaining elements' description can be accessed in the standard (even if not in use for now in the course of the project).

Overall, a PlanDefinition is a pre-defined group of actions to be taken in particular circumstances flexible enough to be used to represent a variety of workflows, as well as clinical decision support. This fits well to vCare's rehabilitation care setting. In general, PlanDefinitions hierarchically structure groups of action definitions (activities to be performed), and each group defines additional behaviour, relationships, and applicable conditions between the actions in the overall definition. Moreover, it is not only possible to describe what care procedures should take place but also when and whether/under what conditions this should be done. This again fits well to the conditional and time-related elements as identified in the clinical pathways and as model-sided defined in D6.1. Also according to the FHIR documentation, the subsequent

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[13] See: http://hl7.org/fhir/r4/plandefinition.html
[14] See for an overview: https://simplifier.net/helict/ModeledPlanDefinition

process of applying a PlanDefinition to a particular context typically produces request resources representing the actions that should be performed, relating to a grouping within a CarePlan to capture relationships between the resulting request resources[15].

Table 1: vCare's PlanDefinition profile elements (ModeledPlanDefinition)

PlanDefinition element	Description
extension	Additional content defined by implementations
extension:bpmnXml	This is to have the possibility to record a BPMN model that represents the plan definition content (output as XML file). Only this data is used by the model editor. Extension URL: http://www.helict.de/fhir/StructureDefinition/Extension/BpmnXml
extension:bpmnSvg	This is to have the possibility to record a BPMN model that represents the plan definition content (output as SVG file). Only this data is used by the model editor. Extension URL: http://www.helict.de/fhir/StructureDefinition/Extension/BpmnSvg
PlanDefinition.name	This provides the name for the vCare rehabilitation care plan definition (in machine friendly form/uniquely referenceable).
PlanDefinition.title	This provides the name for the vCare rehabilitation care plan definition (in human readable form).
PlanDefinition.status	This relates to the status of the plan definition. It enables tracking the life-cycle of the content. Standardly, the following status are available: • draft • active • retired • unknown This is especially relevant for the Lab phases of the project in order to see whether a care pathway template is already approved or just newly suggested or outdated (and possibly replaced by a better/more accepted version – according to the test results).
PlanDefinition.date	The date last changed can be stored. This is especially relevant to allow the replicability of pathway modification (e.g., after an overall clinical assessment leading to a change of the pathway template when the templates fit has been reconsidered from the medical point of view).
PlanDefinition.description	This is the natural language description of the plan definition in human readable form so that especially the choice of the

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	physician for a particular care pathway template (appropriate for the respective patient condition) is eased.
PlanDefinition.useContext	This is to outline that the content was developed with a focus and intent of supporting the plan definition's contexts that are listed (e.g. diagnosis, indication, etc.). This is also to assist with indexing and searching for appropriate plan definition instances. As a primary selector, this firstly relates to the four pathologies as relevant in the project context (Stroke, PD, HF, IHD). For this, the ICD11[16] codes classifying the diseases can be used to allow a clearer selection and assignment of care pathway templates to particular patients.
PlanDefinition.jurisdiction	Due to underlying possibly regionally differing medical guidelines or common practice, the legal or geographic region in which the plan definition is intended to be used, is named. For the project context, this relates to: OSA, Basque Country/Spain; CCP, Lombardy region/Italy; HEV, Midtjylland region/Denmark; UMFCD, Bucharest region/Romania. This does, however, in principle not exclude the transferability of care pathway templates to other jurisdictions.
PlanDefinition.usage	This describes the clinical usage of the plan definition in detail in terms of the care pathway template's usage from a clinical perspective.
PlanDefinition.topic	This is to further specify the categorization of diseases (stages, severity, etc.) and need-related topics like physical therapy, cognitive training or risk factor modification in order better assign care pathway templates.
PlanDefinition.author	For transparency reasons, this is to store and show who authored the content (person, organization) of the care pathway template.
PlanDefinition.relatedArtifact	Additional documentation, citations, definitions, related artifacts such as additional documentation, justification, bibliographic references or clinical assessment reports can be referred to. This is to provide clearer evidence for the care pathway template's rationale. Also, this is useful to provide enough information for clinical users of the pathway (and/or interventions or results implicated) to be able to determine and understand the justification for and evidence in support of the pathway.
PlanDefinition.goal	Goal definitions that are relevant within the plan definition. This relates to global/overall goals (e.g., "Rebuild physical performance and regain confidence in the body"). Local and adaptable goals are, however, also needed that could be adapted and checked within a particular activity (e.g., the heartrate while doing a physical exercise; see PlanDefinition.action.condition).
PlanDefinition.goal.description	Human-readable description of a specific desired objective of the rehabilitation care pathway, such as "reach target heartrate".

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[16] See: https://www.who.int/classifications/icd/en/

PlanDefinition.goal.target	Indicates what should be done and within what timeframe. This is the target outcome for the goal definition, e.g. to reach a particular heartrate value (or not exceed it).
PlanDefinition.goal.target.meas ure	This relates to the parameter whose value is to be tracked (observation feature).
PlanDefinition.goal.target.detail [x]	This relates to the target value that is to be achieved according to the care pathway's/the physician's precepts.
PlanDefinition.action	Set of actions defined by the plan, e.g. playing particular rehabilitation games. This suit well with "activity" as defined in the vCare ontology (see D4.2).
PlanDefinition.action.title	Human-readable title of the action.
PlanDefinition.action.descriptio n	Human-readable description of the action.
PlanDefinition.action.code	Code representing the meaning of the action or sub-actions. Type is for example training, questionnaire, assessment, etc. This is to allow the coaching layer (WP5) to easily allocate particular coaching services for the actions (e.g., the questionnaire service CS-7 as defined in D5.1 when the care pathway foresees a Borg assessment).
PlanDefinition.action.goalId	Goals this action is associated with.
PlanDefinition.action.condition	Expresses whether or not the action is applicable concerning defined local goals, i.e. start/stop conditions for the action. The conditions are defined in terms of an expression that describes applicability criteria linked to a goal. For example, a goal as set by the care pathway is reached, e.g. number of steps, or in case the action has to be stopped extraordinarily, e.g. due to a too high heartrate.
PlanDefinition.action.condition. expression.language	Fixed value: text/fhirpath This defines the used language of a condition expression. This is limited to FHIR-Path expressions.
PlanDefinition.action.condition. expression.expression	This is to store the expression in the defined language itself. The FHIR-Path expression specifies the route to one or more goals that should be reached to start/stop the action.
PlanDefinition.action.relatedAct ion	Relationship to another action, implementing sequences in the care pathway.
PlanDefinition.action.relatedAct ion.actionId	ID of the action, this action is related to.
PlanDefinition.action.relatedAct ion.relationship	Defines the relationship of this action to the related action. Standardly, one of the following sequence relations can be chosen: • before-start • before • before-end • concurrent-with-start • concurrent • concurrent-with-end • after-start • after • after-end

PlanDefinition.action.relatedAction.offset[x]	Time offset for the relationship, if there is one.
PlanDefinition.action.timing[x]	A value describing when the action as part of the care pathway should be performed[17]. This suit well with "scheduled activity" as defined in the vCare ontology (see D4.2).
PlanDefinition.action.selectionBehavior	Defines the selection behaviour for the action and its children. This can be used to choose what to do when there only is a group of sub-actions (not a sub-Plan, without sequences).
PlanDefinition.action.requiredBehavior	Defines the required behaviour for the action in terms of whether particular restrictions for the care pathway execution exist (e.g., mandatory range of exercise repetitions, options in the rehabilitation care pathway to choose from). Standardly, the following can be chosen: • must • could • must-unless-documented
PlanDefinition.action.definition[x]	Can be a PlanDefinition, used for sub-processes that are refined in the model.
PlanDefinition.action.dynamicValue	Dynamic aspects of the definition. This can be used for an individualization when creating a CarePlan instance. I.e., this is to highlight that there is the need to be changeable in the instance (values that can be overwritten or that change during the execution of the rehabilitation measures).
PlanDefinition.action.action	A set of sub-actions (sub-actions that are contained within the action). This can be use instead of a sub-PlanDefinition, when we only have a group of actions (without sequences, events, etc.), where we can choose what to do (e.g., see aerobic training in the stroke case). The behaviour of this action determines the functionality of the sub-actions. For example, a selection behaviour of at-most-one indicates that of the sub-actions, at most one may be chosen as part of realizing the action definition.

2.1.2 CarePlan

Based on a PlanDefinition, a specific CarePlan can be generated for a patient. During this transformation step each element is processed and dynamic patient-specific parameters can be set. Furthermore, optional elements of the PlanDefinition can be selected. Again, we only emphasise on the elements that have been adapted compared to the standard (see Table 2).

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[17] Also see the reflections on time-related aspects when modelling clinical pathways as outlined in D6.1.

Table 2: vCare's CarePlan profile elements

CarePlan element	Description
CarePlan.title	This provides the title for the vCare rehabilitation care plan (in human readable form). Can be taken from PlanDefinition.title.
CarePlan.description	Natural language description in a human readable form. Can be taken from PlanDefinition.description.
CarePlan.instantiatesCanonical	Link to the PlanDefinition from that this CarePlan is derived from. It includes the version of the PlanDefiniton to ensure traceability.
CarePlan.status	Current status of the plan. It can be set to: • draft • active • suspended • completed • entered-in-error • cancelled • unknown
CarePlan.intent	Code for the intent. In this case it is "plan".
CarePlan.subject	Reference to the patient the plan is issued. This element is mandatory.
CarePlan.category	Type of the CarePlan (machine friendly). It is used to search or filter specific plans and identifies the kind of a plan. Can be taken from PlanDefinition.name.
CarePlan.period	Start-date and end-date of the plan.
CarePlan.created	Date when the CarePlan was created in the system.
CarePlan.author	User who is the author of the CarePlan.
CarePlan.goal	The goal of the CarePlan is pursuing. This can be taken from PlanDefiniton.goal.
CarePlan.activity	List of the planned actions. They could either be defined as activity.detail or as references to other FHIR-resources like a RequestGroup [18]. The activities are transformed from PlanDefinition.action. They include a detailed description of the action to be performed like the order (which action can be started after another action), timing, patient specific values like the target heartrate etc. A description of the transformation process will be presented in Deliverable D3.3.

2.2 RESOURCES AND WEB-SERVICES – INTERFACE DESCRIPTION

To allow a convenient and duly unimpeded access to the care pathway information the (publicly) available interfaces to access these needs to be disclosed and should follow a standard format. For this, we follow the Representational State Transfer (**REST**)[19] paradigm.

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[18] See: https://www.hl7.org/fhir/requestgroup.html
[19] See: https://www.ics.uci.edu/~fielding/pubs/dissertation/top.htm

The term "Representational State Transfer" is intended to illustrate the transition from the current state to the next state of an application. This state transition is effected by the transfer of the data representing the next state.[20] Web services that conform to the REST architectural style, called **RESTful** Web services, provide interoperability between computer systems. REST is an abstraction of the structure and behaviour of the World Wide Web aiming to create an architecture that better represents the requirements of the modern Web and distributed systems at all. REST is a simple alternative to similar procedures such as SOAP[21] and WSDL[22] and the related procedure RPC[23]. Unlike many related architectures, REST does not encode method information into the Uniform Resource Identifier (URI), because the URI specifies the location and name of the resource, but not the functionality that the Web service provides for the resource. The advantage of REST is that a large part of the infrastructure required for REST (e.g., Web and application servers, HTTP-enabled clients) is already available on the WWW, and many Web services are REST-compliant per se.

In particular, FHIR is a "RESTful" specification in terms the common use as outlined above[24]. Furthermore, FHIR relies on the standardization of resource structures and interfaces. This may be considered a violation of REST principles but is key to ensuring consistent interoperability across diverse systems. Transactions are performed directly on the server resource using an HTTP request/response.

For vCare's pathway layer, Table 3 provides an overview of the FHIR operation interactions/public interfaces that are offered to provide access to the care pathway information/PlanDefinition details (especially relevant for the professional portal and the knowledge layer components; prospectively also thinkable for further external services). In principle, this follows the FHIR RESTful API specifications[25].

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[20] See: https://www.ics.uci.edu/~fielding/pubs/dissertation/evaluation.htm
[21] See: http://www.w3.org/TR/SOAP/
[22] See: http://www.w3.org/TR/wsdl20/
[23] See: http://www.xmlrpc.com/
[24] See: https://www.hl7.org/fhir/http.html
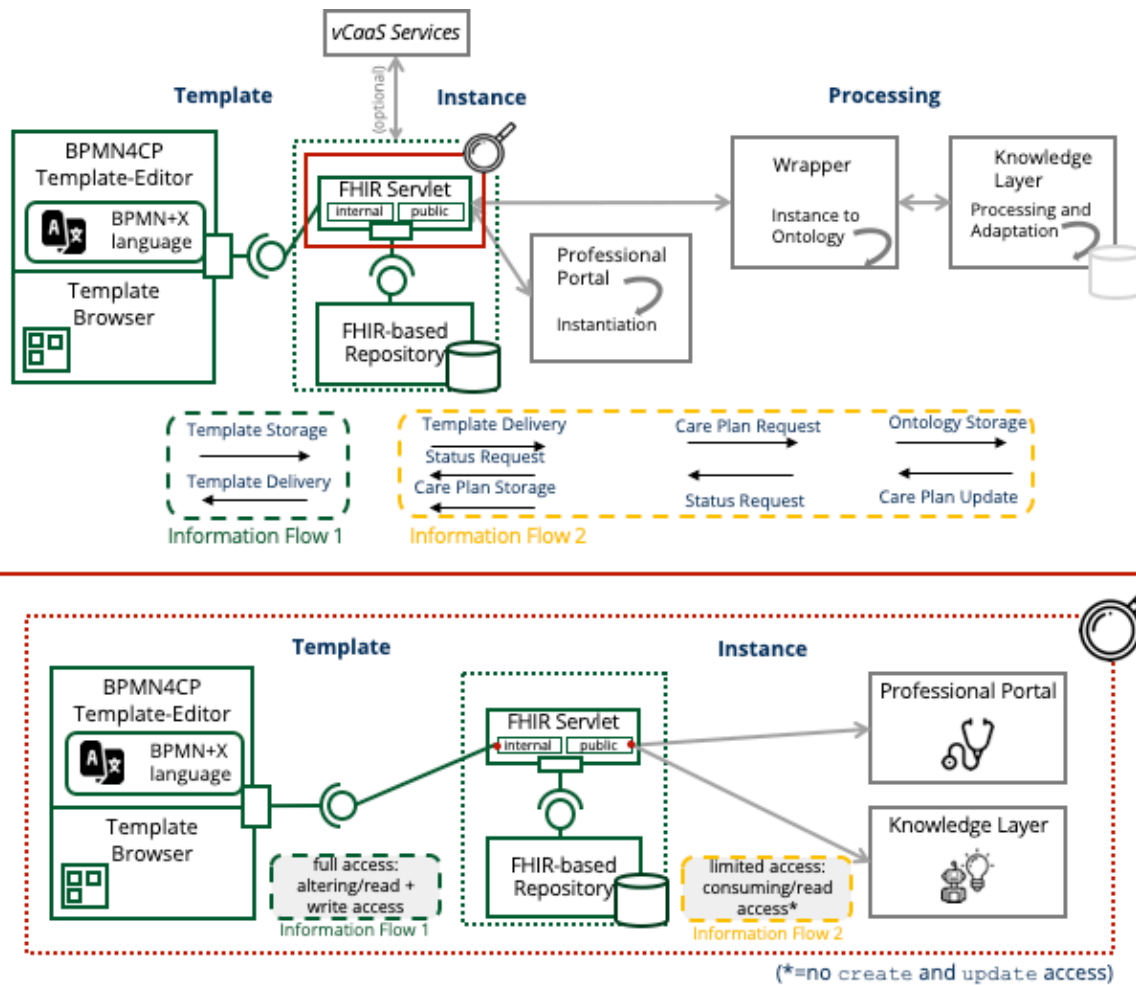[25] See: https://www.hl7.org/fhir/http.html#general

Figure 4: Core Components for the application of the Clinical Pathways in the vCare-Ecosystem (elements of the Pathway Layer in green, elements of the other layers of the vCare system in grey) – revisited and extended architectural view

To allow clearer insight in the service's functioning, we somehow revisit and extend the architectural overview as presented in D6.2 (see Figure 4). Two primary information flow scenarios can be distinguished in addition:

- Information flow 1 (IF1; marked green in Figure 4): This primarily relates to the altering access to the rehabilitation care pathway template by means of the Pathways editor and Template management tool (see D6.2). Thus, the "internal" servlet is also able to use further FHIR operation interactions (also write access). This is to implement the changeability of the pathway templates for users with respective authorisation (i.e., the physician that re-assesses the rehabilitation care pathway template's appropriateness). All operation interactions as outlined in Table 3 are usable.
- Information flow 2 (IF2; marked yellow in Figure 4): This relates to the flow of pathway information to system components external to the pathway layer. This particularly relates to the professional portal and the knowledge layer where a further processing of the rehabilitation care pathway information takes place. Optionally, further external services (following the vCare-as-a-Service (vCaaS) concept) could be connected as well. Here, only a consuming access (no create and update access) is foreseen. Thus, the non-publicly available operation interactions as outlined in Table 2 are not usable.

Exceptions could be made to access the operations when leveraging the complex authentication and authorization framework offered by Keycloak and thus have no risk of unduly compromising the pathway information.

Table 3: FHIR operation interactions the vCare pathway layer offers to retrieve/alter PlanDefinition details as the representation for the rehabilitation care pathway templates

Repository's RESTful base	
`http://pathwayrepository.vcare-project.eu/api` This is the pathway template repository's base URL of the RESTful API. All of the following endpoints are available at this base.	
Interaction	**Description**
read[26] **(IF1 + IF2)**	**Overview** Instance Level Interaction: The `read` interaction accesses the current contents of a single PlanDefinition resource.

	Endpoint
	`GET /PlanDefinition/{id}[/_history/{vId}]`
	Parameters
	`{id}` – Required. The logical id of the PlanDefinition (Pathway) you want to look up. The possible values for the id are described in the id type[27].
	`{vId}` – Optional. The specific version number of the PlanDefinition (Pathway) you want to look up.
	Query string parameters
	`_format` – Optional. `{json|xml}`. Default: `json`
	This can be used to request a specific mime-type format of the result.
	`_pretty` – Optional. `{true|false}`. Default: `true`
	This specifies the pretty-print (line indentation) of the result.
	Response
	`HTTP 200` – Response body contains the requested PlanDefinition resource.
	`HTTP 404` – Returned, if the PlanDefinition resource with the specified id does not exist in the repository. An OperationOutcome[28] identifying the issue is provided.
	`HTTP 410` – Returned, if the PlanDefinition resource with the specified id existed but has been deleted.
	Sample request
	`curl -I -X GET "http://pathwayrepository.vcare-project.eu/bpmn4cp-hapifhir/api/PlanDefinition/1234?_format=json&_pretty=true"`
	Sample response
	`HTTP 200 OK`
	`{`
	`  "resourceType": "PlanDefinition",`
	`  "id": "1234",`
	`  "meta": {`
	`    "versionId": "2",`

---

[26] See: https://www.hl7.org/fhir/http.html#read
[27] See: https://www.hl7.org/fhir/datatypes.html#id
[28] See: https://www.hl7.org/fhir/operationoutcome.html

<table>
<tr><td></td><td>

```
      "lastUpdated": "2020-05-13T21:06:15.906+00:00",
      "profile": [
        "http://www.helict.de/StructureDefinition/plandefinition"
      ]
    },
    ...   further content of the PlanDefinition
}
```

</td></tr>
<tr><td>

search[29]

(IF1 + IF2)

</td><td>

Overview:

Type Level Interaction: Search across all existing PlanDefinition resources based on some filter criteria. This is to find the template that fits best to the instance's context or to support the choice of the pathway template when instantiating (assigning it to a particular patient).

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Endpoint

`GET /PlanDefinition{?[parameters]}`

This searches all PlanDefinition resources using the criteria represented in the parameters, that are a series of `name=value` pairs encoded in the URL.

Query string parameters

`icd11code` – This is one of the ICD11 codes, that are assigned to the PlanDefinition. Supports partial matches.

`icd11title` – This is one of the ICD11 titles, that are assigned to the PlanDefinition. Supports partial matches.

`topic` – This is one of the PlanDefinition's topics - Supports partial matches

The `server also supports filtering for the default parameters specified in the FHIR PlanDefinition spec`[30].

Response

`HTTP 200` – The response body contains a Bundle[31] with type[32] = `searchset` containing the results of the search as a collection of zero or more PlanDefinition resources in a defined order.

If the search fails (cannot be executed, not that there are no matches), the return value will be a status code 4xx or 5xx with an OperationOutcome[33].

`HTTP 400` – The search could not be processed or failed basic FHIR validation rules.

`HTTP 401` – Authorization is required or failed for the interaction that was attempted.

Sample request

```
curl -I -X GET "http://pathwayrepository.vcare-
project.eu/bpmn4cp-
hapifhir/api/PlanDefinition/?icd11title=Stroke
```

Sample response

```
HTTP 200 OK
{
  "resourceType": "Bundle",
  "type": "history",
  "total": 3,
  "entry": [
```

</td></tr>
</table>

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[29] See: https://www.hl7.org/fhir/http.html#search
[30] See: https://www.hl7.org/fhir/plandefinition.html#search
[31] See: https://www.hl7.org/fhir/bundle.html
[32] See: https://www.hl7.org/fhir/bundle-definitions.html#Bundle.type
[33] See: https://www.hl7.org/fhir/operationoutcome.html

	``
	     ... all PlanDefinitions, that have 'Stroke' in the title of
	one of their assigned ICD11s
	   ]
	}
	``

history[34] **(IF1 + IF2)**	**Overview**: Instance Level Interaction: Retrieve the change history for a particular PlanDefinition resource. Additional Notes about maintaining a history of resources: - The history is a record version history on a per-resource basis. It is not intended to support concurrent versions, or multi-branch version history. - Accordingly, there is no way to update or delete past versions of the record, except that the metadata can be modified [35] (mainly for access control purposes). - All past versions of a resource are considered to be superseded, and no longer active, but retained for audit/integrity purposes.

	Endpoint
	`GET /PlanDefinition/{id}/_history`
	Query string parameters
	`_format` – Optional. `{json|xml}`. Default: `json`
	        This can be used to request a specific mime-type format of the result.
	`_pretty` – Optional. `{true|false}`. Default: `true`
	        This specifies the pretty-print (line indentation) of the result.
	Response
	`HTTP 200` – The response body contains a Bundle[36] with type[37] set to `history` containing the specified version history, sorted with oldest versions last, and including deleted resources. Each bundle entry contains a `resource` which holds the PlanDefinition as it is at the conclusion of the interaction, a `request` with `entry.request.method`. The `request` provides information about the result of the interaction that led to this new version.
	`HTTP 404` – Returned, if the PlanDefinition resource with the specified id does not exist in the repository.
	Sample request
	`curl -I -X GET "http://pathwayrepository.vcare-project.eu/bpmn4cp-hapifhir/api/PlanDefinition/1234/_history`
	Sample response
	``
	HTTP 200 OK
	{
	  "resourceType": "Bundle",
	  "type": "history",
	  "total": 2,
	  "entry": [
	    {
	      "resource": {
	        "resourceType": "PlanDefinition",
	        "id": "1234",
	``

```
        "meta": {
          "versionId": "2",
          ...
        }
        ... further content of version 2
      },
      "request": {
        "method": "PUT"
      },
      "response": {
        "status": "200 OK"
      }
    },
    {
      "resource": {
        "resourceType": "PlanDefinition",
        "id": "1234",
        "meta": {
          "versionId": "1",
          ...
        }
        ... further content of version 1
      },
      "request": {
        "method": "POST"
      },
      "response": {
        "status": "201 CREATED"
      }
    }
  ]
}
```

create[38] (IF1 only/ not publicly available)	**Overview** Instance Level Interaction: The `create` interaction creates a new resource in a server-assigned location. If the client wishes to have control over the id of a newly submitted resource, it should use the update interaction instead. This operation is not publicly available but only from inside the modeler tool to avoid unwanted/unauthorised changes of the PlanDefinitions/care pathway templates.

	Endpoint
	`POST /PlanDefinition`
	Request Header
	`Content-Type: application/fhir+{json|xml}`
	        Defines the format of the request body, either xml or json.
	Request body:
	The request body shall be a valid PlanDefinition.
	Query string parameters
	`_format` – Optional. `{json|xml}`. Default: `json`
	            This can be used to request a specific mime-type format of the result.
	`_pretty` – Optional. `{true|false}`. Default: `true`
	            This specifies the pretty-print (line indentation) of the result.

---

[38] See: https://www.hl7.org/fhir/http.html#create

	Response
	`HTTP 201` – The response body contains the created PlanDefinition resource as it would be requested by a read.
	`HTTP 400` – Returned, if the PlanDefinition resource could not be parsed or failed basic FHIR validation rules.
	`HTTP 422` – Returned, if the proposed resource violated the applicable FHIR profile or server business rules.
	Sample request
	`curl -X POST -H "Content-Type: application/json" -d '{"resourceType": "PlanDefinition",...}' "http://pathwayrepository.vcare-project.eu/bpmn4cp-hapifhir/api/PlanDefinition"`
	Sample response
	<pre>HTTP 201 CREATED
	{
	  "resourceType": "PlanDefinition",
	  "id": "1235",
	  "meta": {
	    "versionId": "1",
	    "lastUpdated": "2020-05-14T21:07:15.906+00:00",
	    "profile": [
	      "http://www.helict.de/StructureDefinition/plandefinition"
	    ]
	  },
	  ... further content of the created PlanDefinition
	}</pre>

update[39] **(IF1 only/ not publicly available)**	**Overview** Instance Level Interaction: The `update` interaction creates a new current version for an existing resource or creates an initial version if no resource already exists for the given id. This operation is not publicly available but only from inside the modeler tool to avoid unwanted/unauthorised changes of the PlanDefinitions/care pathway templates.

	Endpoint
	`PUT /PlanDefinition/{id}`
	Parameters:
	`{id}` – The logical id of the PlanDefinition (Pathway) you want to update. The possible values for the id are described in the id type[40].
	Request Header
	`Content-Type: application/fhir+{json|xml}`
	Defines the format of the request body, either xml or json.
	Request body:
	The request body shall be a PlanDefinition with an `id` element that has an identical value to the `{id}` in the URL.
	Query string parameters
	`_format` – Optional. `{json|xml}`. Default: `json`
	This can be used to request a specific mime-type format of the result.

---

[39] See: https://www.hl7.org/fhir/http.html#update
[40] See: https://www.hl7.org/fhir/datatypes.html#id

	_pretty – Optional. {true|false}. Default: true This specifies the pretty-print (line indentation) of the result. **Response** HTTP 200/201 – The response body contains the updated PlanDefinition resource as it would be requested by a read. HTTP 400 – Returned, if no id element is provided, or the id disagrees with the id in the URL. An OperationOutcome[28] identifying the issue is provided. **Sample request** ```curl -X PUT -H "Content-Type: application/json" -d '{"resourceType": "PlanDefinition", "id": "1234",...}' "http://pathwayrepository.vcare-project.eu/bpmn4cp-hapifhir/api/PlanDefinition/1234"``` **Sample response** ```HTTP 200 OK { "resourceType": "PlanDefinition", "id": "1234", "meta": { "versionId": "5", "lastUpdated": "2020-05-14T21:06:15.906+00:00", "profile": ["http://www.helict.de/StructureDefinition/plandefinition"] }, ... further updated content of the PlanDefinition }```
delete[41] **(IF1 only/ not publicly available)**	**Overview** Instance Level Interaction: The delete interaction removes a template/PlanDefinition. A deleted PlanDefinition can still be found using history operation. This operation is not publicly available but only from inside the modeler tool to avoid unwanted/unauthorised changes of the PlanDefinitions/care pathway templates.
	Endpoint ```DELETE /PlanDefinition/{id}``` **Parameters**: {id} – The logical id of the PlanDefinition (Pathway) you want to delete. **Response** HTTP 200 – The response body contains an OperationOutcome[28] reporting the successful deletion. HTTP 404 – Returned, if the PlanDefinition resource with the specified id does not exist in the repository. An OperationOutcome[42] identifying the issue is provided. **Sample request** ```curl -I -X DELETE "http://pathwayrepository.vcare-project.eu/bpmn4cp-hapifhir/api/PlanDefinition/1234"``` **Sample response** ```HTTP 200 OK```

---

[41] See: https://www.hl7.org/fhir/http.html#delete
[42] See: https://www.hl7.org/fhir/operationoutcome.html

```
{
    "resourceType": "OperationOutcome",
    "id": "1234",
    "meta": {
        "versionId": "2"
    },
    "issue": [
        {
            "severity": "information",
            "code": "informational",
            "diagnostics": "Successfully deleted 1 resource(s)
in 50ms"
        }
    ]
}
```

3 CONCLUSION AND NEXT STEPS

This document reported on how we used the well-acknowledged FHIR stack to store and exchange rehabilitation care pathway information on a technically aligned basis. Here, the vCare FHIR profile and the FHIR operation interactions/public interfaces that are offered to provide access to the care pathway information are described in order to allow a proper understanding and, therefore, technical accessibility of the pathway information. This is to put into connection and integrate the pathway layer especially with the professional portal and the knowledge layer within the overall vCare solution that further display and process the pathway information.

The deliverable represents and covers the preliminary state at almost the end of the TechLab phase before having the chance to be tested with real patients. Further developments, integration works and iterative improvements are also likely to happen in the course of the testing activities as foreseen during the project's lab phases. Thus, when we observe the necessity to change the respective rehabilitation care pathway templates (in case it should turn out that attributes have not been considered from a technical or content-related/medical point of view), we will revise and adapt these in the course of the lab phases.

As upcoming steps in WP6, the test system (D6.5) and the reference implementation guide (D6.6) for the pathway layer's components will be derived.

4 ANNEX: EXEMPLARY IMPLEMENTATION OF THE VCARE FHIR PROFILE

Here, we exemplary illustrate how the PlanDefintion (care pathway template) and the subsequent CarePlan (care pathway instance) look like (in JSON code). The basis to derive the PlanDefinition (see section 4.1) is a graphically modelled example pathway template for the Heart Failure case (following the modelling approach as defined in D6.1 and created by using the vCare modeler as described in D6.2; see Figure 5). That is, in turn, the basis for the respective CarePlan instance (see section 4.2; in particular this is twofold: the CarePlan itself that includes/invokes a RequestGroup[43]).
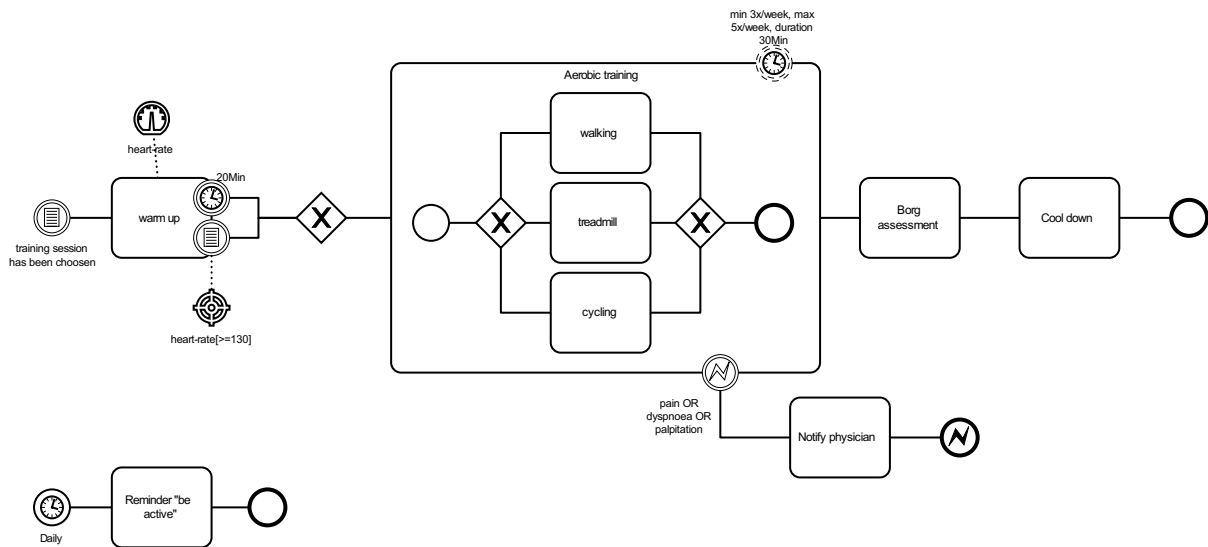
Figure 5: Exemplary care pathway template

4.1 EXEMPLARY PLANDEFINITION

```
{
  "resourceType": "PlanDefinition",
  "id": "a3f7747c-a1b6-4ca5-8ee6-e7c304630ff7",
  "meta": {
    "versionId": "5",
    "lastUpdated": "2020-03-27T14:36:02.669+01:00",
    "source": "#EfFb9Bjv8W5cxp3G",
    "profile": [
      "http://www.helict.de/StructureDefinition/plandefinition"
    ]
  },
  "extension": [
    {
      "url":
"http://www.helict.de/StructureDefinition/plandefinition#bpmn4cp",
      "valueAttachment": {
        "contentType": "application/xml",
```

---

[43] As indicated under CarePlan.activity in Table 2; see: https://www.hl7.org/fhir/requestgroup.html

```
      "data": "<attachment bytecode omitted here for brevity
reasons>"
      }
    },
    {
      "url":
"http://www.helict.de/StructureDefinition/plandefinition#bpmnSvg",
      "valueAttachment": {
        "contentType": "image/svg+xml",
        "data": ""<attachment bytecode omitted here for brevity
reasons>"
      }
    }
  ],
  "name": "heart-failure",
  "title": "Heart failure",
  "description": "This is a demo pathway, shared between TUD, AIT
and FZI.",
  "useContext": [
    {
      "code": {
        "system": "http://terminology.hl7.org/CodeSystem/usage-
context-type",
        "code": "focus"
      },
      "valueCodeableConcept": {
        "coding": [
          {
            "system": "http://hl7.org/fhir/sid/icd-10",
            "code": "I50.9",
            "display": "Heart failure, unspecified"
          }
        ]
      }
    }
  ],
  "topic": [
    {
      "text": "physical therapy"
    }
  ],
  "action": [
    {
      "id": "3d8a1146-8521-4577-88c3-6cf0067d8c55",
      "title": "Daily Reminder",
      "description": "This is a daily reminder activity. Every day,
the virtual coach reminds the patient to be active.",
      "code": [
        {
          "text": "reminder"
        }
      ],
      "timingTiming": {
        "repeat": {
          "period": 1,
```

```
              "periodUnit": "d"
            }
          }
        },
        {
          "id": "ac1334c7-8e7d-4119-bd57-07d96207001e",
          "title": "Warm up",
          "description": "This is the warm up activity before starting a
physical training. The warm up ends, if the patient's heart rate
reaches a certain value, or at least after 10 minutes.",
          "condition": [
            {
              "kind": "start",
              "expression": {
                "name": "training-session-chosen",
                "language": "text/cql",
                "expression": "training-session-has-been-chosen = true"
              }
            },
            {
              "id": "8c5e10d6-d9ba-4943-9328-288b6f8c0ddc",
              "kind": "stop",
              "expression": {
                "description": "Defines the actual expression => heart
rate >= 130, see dynamic value",
                "language": "text/cql"
              }
            }
          ],
          "timingDuration": {
            "value": 10,
            "unit": "min"
          },
          "dynamicValue": [
            {
              "path": "%resource.action[id=ac1334c7-8e7d-4119-bd57-
07d96207001e].condition[id=8c5e10d6-d9ba-4943-9328-
288b6f8c0ddc].expression",
              "expression": {
                "description": "This expression indicates, that the
actual value of the defined stop condition (heart rate) is
dynamically set when instantiating a CarePlan, but has a default
value (>= 130).",
                "language": "text/cql",
                "expression": "codesystem \"SNOMED:2014\":
'http://snomed.info/sct \ncode \"Heart Rate\":\n  '364075005' from
\"SNOMED:2014\" display ' Heart rate (observable entity)' \n\"Heart
Rate\" >= 130"
              }
            }
          ]
        },
        {
          "id": "d03fd024-71e5-4f8c-9e01-4cc17bd04369",
          "title": "Aerobic training",
```

```
    "description": "This is the actual training activity. Within
one week, it should be done at least 3 times, at most 5 times, with
30 minutes duration each execution. It is a complex activity having
a subset of simple actions, where we have to choose the actual
physical training activity (walking, treadmill, cycling) for each
training.",
    "code": [
      {
        "text": "physical training"
      }
    ],
    "condition": [
      {
        "kind": "stop",
        "expression": {
          "name": "notification-required",
          "language": "text/cql",
          "expression": "pain OR dyspnoea OR palpitation"
        }
      }
    ],
    "relatedAction": [
      {
        "actionId": "ac1334c7-8e7d-4119-bd57-07d96207001e",
        "relationship": "after-end"
      }
    ],
    "timingTiming": {
      "repeat": {
        "duration": 30,
        "durationUnit": "min",
        "frequency": 3,
        "frequencyMax": 5,
        "period": 1,
        "periodUnit": "wk"
      }
    },
    "groupingBehavior": "logical-group",
    "selectionBehavior": "exactly-one",
    "action": [
      {
        "title": "Walking",
        "description": "Walking is one alternative of physical
training."
      },
      {
        "title": "Treadmill",
        "description": "Treadmill is a second alternative of
physical training."
      },
      {
        "title": "Cycling",
        "description": "Cycling is one alternative of physical
training."
      }
```

```
    ]
  },
  {
    "id": "bdd21558-cb22-49cf-8fb7-2519bc19f5b1",
    "title": "Borg assessment",
    "description": "This is the Borg assessment, a specific
questionnaire.",
    "code": [
      {
        "text": "questionnaire"
      }
    ],
    "relatedAction": [
      {
        "actionId": "d03fd024-71e5-4f8c-9e01-4cc17bd04369",
        "relationship": "after-end"
      }
    ]
  },
  {
    "id": "dce673f8-66ae-42bf-916b-0a8a795e19e5",
    "title": "Cool down",
    "description": "This is the cool down activity after training
session",
    "code": [
      {
        "text": "physical training"
      }
    ],
    "relatedAction": [
      {
        "actionId": "bdd21558-cb22-49cf-8fb7-2519bc19f5b1",
        "relationship": "after-end"
      }
    ]
  },
  {
    "id": "df486397-0b97-4abd-83a8-89b7986e6ba0",
    "title": "Notify physician",
    "description": "If there is any issue of pain, dyspnoea or
palpitation (during training) -> condition, notify the doctor.",
    "code": [
      {
        "text": "notification"
      }
    ],
    "condition": [
      {
        "kind": "start",
        "expression": {
          "name": "notification-required",
          "language": "text/cql",
          "expression": "pain OR dyspnoea OR palpitation"
        }
      }
```

```
      ]
    }
  ]
}
```

4.2 EXEMPLARY CAREPLAN

4.2.1 CarePlan itself

```json
{
  "resourceType": "CarePlan",
  "title": "Heart failure",
  "description": "This is a demo pathway, shared between TUD, AIT
and FZI.",
  "instantiatesCanonical": [
    "https://pathwayrepository.vcare-
project.eu/api/PlanDefinition/a3f7747c-a1b6-4ca5-8ee6-
e7c304630ff7|5"
  ],
  "status": "active",
  "intent": "plan",
  "category": [
    {
      "text": "heart-failure"
    }
  ],
  "subject": {
    "reference": "CWfVYXbzWeBs7sF3LWFDXg"
  },
  "period": {
    "start": "2020-05-28",
    "end": "2020-11-28"
  },
  "created": "2020-05-28",
  "author": {
    "reference": "WeBs7sF3LWFDXgCWfVYXbz",
    "display": "Dr. Demo"
  },
  "activity": [
    {
      "reference": {
        "reference": "RequestGroup/ed09bf58-a0c8-11ea-bb37-
0242ac130002"
      }
    }
  ]
}
```

4.2.2 RequestGroup related to the CarePlan

```
{
```

```
  "resourceType": "RequestGroup",
  "id": "ed09bf58-a0c8-11ea-bb37-0242ac130002",
  "instantiatesCanonical": [
    "https://pathwayrepository.vcare-
project.eu/api/PlanDefinition/a3f7747c-a1b6-4ca5-8ee6-
e7c304630ff7|5"
  ],
  "status": "active",
  "intent": "plan",
  "subject": {
    "reference": "CWfVYXbzWeBs7sF3LWFDXg"
  },
  "action": [
    {
      "id": "3d8a1146-8521-4577-88c3-6cf0067d8c55",
      "title": "Daily Reminder",
      "description": "This is a daily reminder activity. Every day,
the virtual coach reminds the patient to be active.",
      "code": [
        {
          "text": "reminder"
        }
      ],
      "timingTiming": {
        "repeat": {
          "period": 1,
          "periodUnit": "d"
        }
      }
    },
    {
      "id": "ac1334c7-8e7d-4119-bd57-07d96207001e",
      "title": "Warm up",
      "description": "This is the warm up activity before starting a
physical training. The warm up ends, if the patients heart rate
reaches a certain value, or at least after 10 minutes.",
      "condition": [
        {
          "kind": "start",
          "expression": {
            "name": "training-session-chosen",
            "language": "text/cql",
            "expression": "training-session-has-been-chosen = true"
          }
        },
        {
          "id": "8c5e10d6-d9ba-4943-9328-288b6f8c0ddc",
          "kind": "stop",
          "expression": {
            "description": "NOTE: in this condition the dynamic
value is already the real value! Defines the actual expression =>
heart rate >= 130.",
            "language": "text/cql",
            "expression": "codesystem \"SNOMED:2014\":
'http://snomed.info/sct \ncode \"Heart Rate\":\n  '364075005' from
```

```
\"SNOMED:2014\" display ' Heart rate (observable entity)' \n\"Heart
Rate\" >= 130"
          }
        }
      ],
      "timingDuration": {
        "value": 10,
        "unit": "min"
      }
    },
    {
      "id": "d03fd024-71e5-4f8c-9e01-4cc17bd04369",
      "title": "Aerobic training",
      "description": "This is the actual training activity. Within
one week, it should be done at least 3 times, at most 5 times, with
30 minutes duration each execution. It is a complex activity having
a subset of simple actions, where we have to choose the actual
physical training activity (walking, treadmill, cycling) for each
training.",
      "code": [
        {
          "text": "physical training"
        }
      ],
      "condition": [
        {
          "kind": "stop",
          "expression": {
            "name": "notification-required",
            "language": "text/cql",
            "expression": "pain OR dyspnoea OR palpitation"
          }
        }
      ],
      "relatedAction": [
        {
          "actionId": "ac1334c7-8e7d-4119-bd57-07d96207001e",
          "relationship": "after-end"
        }
      ],
      "timingTiming": {
        "repeat": {
          "duration": 30,
          "durationUnit": "min",
          "frequency": 3,
          "frequencyMax": 5,
          "period": 1,
          "periodUnit": "wk"
        }
      },
      "groupingBehavior": "logical-group",
      "selectionBehavior": "exactly-one",
      "action": [
        {
          "title": "Walking",
```

```
          "description": "Walking is one alternative of physical
training."
        },
        {
          "title": "Treadmill",
          "description": "Treadmill is a second alternative of
physical training."
        },
        {
          "title": "Cycling",
          "description": "Cycling is one alternative of physical
training."
        }
      ]
    },
    {
      "id": "bdd21558-cb22-49cf-8fb7-2519bc19f5b1",
      "title": "Borg assessment",
      "description": "This is the Borg assessment, a specific
questionnaire.",
      "code": [
        {
          "text": "questionnnaire"
        }
      ],
      "relatedAction": [
        {
          "actionId": "d03fd024-71e5-4f8c-9e01-4cc17bd04369",
          "relationship": "after-end"
        }
      ]
    },
    {
      "id": "dce673f8-66ae-42bf-916b-0a8a795e19e5",
      "title": "Cool down",
      "description": "This is the cool down activity after training
session",
      "code": [
        {
          "text": "training"
        }
      ],
      "relatedAction": [
        {
          "actionId": "bdd21558-cb22-49cf-8fb7-2519bc19f5b1",
          "relationship": "after-end"
        }
      ]
    },
    {
      "id": "df486397-0b97-4abd-83a8-89b7986e6ba0",
      "title": "Notify physician",
      "description": "If there is any issue of pain, dyspnoea or
palpitation (during training) -> condition, notify the doctor.",
      "code": [
```

```
        {
          "text": "notification"
        }
      ],
      "condition": [
        {
          "kind": "start",
          "expression": {
            "name": "notification-required",
            "language": "text/cql",
            "expression": "pain OR dyspnoea OR palpitation"
          }
        }
      ]
    }
  ]
}
```