EU-JAPAN VIRTUAL COACH FOR SMART AGEING

D4.9 - Interoperability and standards guidelines for EU/Japan - (Final Version)

Deliverable D4.9	
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Executive Summary

This document represents the final version (D4.9) of the deliverable "Interoperability and standards guidelines". The scope of this deliverable is to describe the role of interoperability and international standards in the e-VITA project in which are involved heterogenous technologies and devices that have to interact in a seamless and integrated way to provide the e-VITA coaching system functionalities.

Chapter 1 covers existing the standards used in e-VITA and their role in the platform. This section includes descriptions and references to the interoperability standards already adopted in the current implementation of the platform and the ones that are planned to be integrated in the next releases.

Chapter 2 defines a set of interoperability guidelines for the external stakeholders to integrate new devices or interact with the platform based on a standard approach.

Chapter 3 is an update about the standardisation activities of e-VITA project across Europe and Japan.

This version includes the content of the previous versions of the deliverable adding specific updates related to the outcomes achieved in the last part of the e-VITA project.

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Disclaimer

E-VITA – European-Japanese Virtual Coach for Smart Ageing

E-VITA (EU PROJECT NUMBER 101016453)

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Acronyms and Abbreviations

Acronym/Abbreviation	Explanation
AAL	Active Assisted Living
AHA	Active and Healthy Aging
APPI	Act on the Protection of Personal Information
AWS S3	Amazon Simple Storage Service
CD	Committee Draft
CDG	Continua Design Guidelines
CDV	Committee Draft for Vote
CRLF	Carriage Return and Line Feed
CSV	Comma-Separated Values
DIS	Draft International Standard
ETSI	European Telecommunications Standards Institute
FDIS	Final Draft International Standard
FHIR	Fast Healthcare Interoperability Resources
GDPR	General Data Protection Regulation
GPII	Global Public Inclusive Infrastructure
HIS	Health Information Services
HL7	Health Level Seven International
HTTP	Hypertext Transfer Protocol
HTTPS	HTTP Secure
IBM	International Business Machines
IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
IoT	Internet of Things
ISO	International Organization for Standardization
JSA	Japanese Standardization Association
JSON	JavaScript Object Notation
JSON-LD	JavaScript Object Notation for Linked Data
JWE	JSON Web Encryption
JWT	JSON Web Token
MAC	Message Authentication Code
MIME	Multipurpose Internet Mail Extensions
MQTT	Message Queuing Telemetry Transport
NGSI	Next Generation Service Interfaces
NGSI-LD	NGSI - Linked Data
NP	New Work Item Proposal
OAS	OpenAPI Specification
OASIS	Organization for the Advancement of Structured Information Standards
OS	Open Cities
PCHA	Personal Connected Health Alliance
REST API	REpresentational State Transfer Application Programming Interface
RFC	Request for Comments
RIFF	Resource Interchange File Format
STOMP	Simple Text Oriented Message Protocol

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TC	Technical Committee
TCP	Transmission Control Protocol
TQG	Telehealth Quality Group
TS	Technical Specifications
UNICODE	Unique, Universal, and Uniform character enCoding
URI	Universal Resource Identifier
URL	Universal Resource Locator
WAV/WAVE	Waveform Audio File Format
XML	eXtensible Markup Language

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Introduction

This document represents the final version (D4.9) of the deliverable "Interoperability and standards guidelines". The scope of this deliverable is to describe the role of interoperability and international standards in the e-VITA project in which are involved heterogenous technologies and devices that have to interact in a seamless and integrated way to provide the e-VITA coaching system functionalities.

In the context of the project the role of standards is crucial: the whole e-VITA platform has been designed paying attention to the adoption of wide used international standards that can simplify the interoperability among different technologies, the future extension of the platform and, at the same time, providing secure and standard way to access to data and functionalities from external systems and applications. Moreover, the presence of European and Japanese partners in the project and respective experimental pilots requires the adoption of international recognised standards and wide used technologies to reach a high degree of interoperability and reusability across the different countries.

This document is an update of the previous version in terms of content from the point of view of the completeness and accuracy of the standards and interoperability approaches adopted by the current implementation of e-VITA platform.

Chapter 1 covers the specific interoperability aspects describing the standards used in e-VITA and their role in the platform. This section includes descriptions and references to the interoperability standards already adopted in the final implementation of the platform and the ones that could be adopted in a further improvement of the platform beyond the project duration. Considering that the previous version of this document reflected the standard and interoperability aspect of the e-VITA platform in his stable release, the information remains still valid also in this final version of the deliverable. Nevertheless, some updates have been performed including:

- the connection details of the final list of the devices integrated in e-VITA,
- updated information about data fusion and its relation with the Context Broker
- information about the event processing rule based on Perseo (FIWARE, 2024).

The Chapter 2 defines a set of interoperability guidelines for the external stakeholders to integrate new devices or interact with the platform based on a standard approach. In this final version have been added more technical details about devices' connection and data categories accessible by a third party application, in relation to the final version of the platform.

Chapter 3 in an update about the standardisation activities of e-VITA project across Europe and Japan: the chapter was updated including the description of the last activities performed by European and Japanese partners.

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1 Interoperability in the e-VITA project

The following section reports the interoperability standards supported by the e-VITA Platform. Starting from the consideration described in D4.1 (e-VITA, 2021), which provides the list of candidate standard technologies to be used in the platform, this document reports the chosen one and approaches to provide interoperability within the current implementation of the platform. Please refer to the technical deliverables D7.1 (e-VITA, 2021), D7.2 (e-VITA, 2022), D7.7 (e-VITA, 2022), and D6.12 (e-VITA, 2022) that provide the rationale behind each chosen approach.

This section focuses on different level of interoperability, in particular:

- interoperability related to devices and their interconnection (named “”
- interoperability related to data formats and semantics
- interoperability related to data and functionalities access from external systems and applications. (named application interoperability)

Figure 1 gives an overview of the different standards and technologies used within the e-VITA platform.

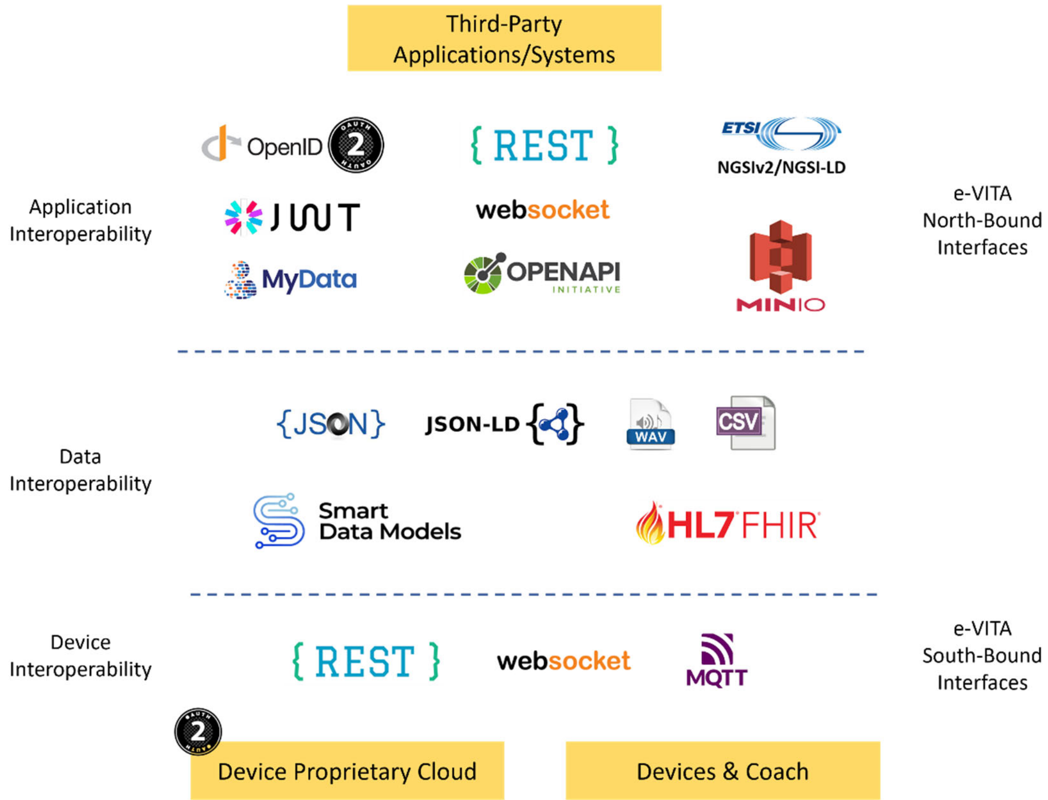

Figure 1: e-VITA Interoperability Approaches

It is important to underline that the technologies reported under the data interoperability and application interoperability part of the figure can be used for the communication among the internal components of the e-VITA platform and, also, for the communication with external application/services that wants to exploit e-VITA capabilities. The main difference is related to the fact that external interactions are subject to specific security, privacy and personal data access controls. The following sections will detail these three interoperability layers describing the specific standards adopted and their purpose in the platform.

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1.1 Device interoperability

This section covers the chosen approaches and technologies that enable the communication among the devices and the e-VITA platform. Starting from the candidate technologies reported in D4.1 (e-VITA, 2021), the following sections report the implemented approaches that allow the devices interact with the platform. In e-VITA the main way in which the devices interact with the platform is via REST APIs and Websocket. The device management and interaction using specific low level IoT protocols (see Annex) is generally delegated to proprietary/dedicated gateways/edge components provided by the device producers that are in charge of interacting with e-VITA platform via REST API. It is important to underline that anyway other IoT communication protocols (e.g. MQTT) and standards can directly be supported by the e-VITA platform, through the Digital Enabler (Engineering Ingegneria Informatica S.p.a., 2022) capabilities, the backbone system of e-VITA platform.

1.1.1 e-VITA Device APIs

The e-VITA platform mainly relies on **REST APIs** (e-VITA, 2022) communication between a client and the server. Representative State Transfer (REST) is a client-server architectural style that uses the HTTP protocol (RFC - Official Internet Protocol Standards, 2022) in a simple and effective way and specifically RESTful interfaces use the HTTP methods - GET, POST, PUT, DELETE: a REST API is an application programming interface that conforms to specific architectural constraints, like stateless communication and cacheable data. In order to guarantee secured transmission of the data, the interactions are preformed through **HTTPS** (RFC - Official Internet Protocol Standards, 2022).
The **e-VITA platform** provides a set of REST APIs that encompass the functionality of the platform.
A primary advantage of REST over HTTP is that it uses Open Standards and does not bind the implementation of the API or the client applications to any specific implementation. A REST web service could be written in a specific programming language, and Client applications can use any language or toolset that can generate HTTP requests and parse HTTP responses. Following are briefly described some e-VITA APIs to be used by devices to send/receive data.

1.1.1.1 Send Data API

e-VITA system provides a REST API to allow Devices to send data to the platform. The data that Devices can send, varies according to its type:

- Smart home sensors or wearable devices can send measurements detected by their sensors to the platform.
- Coaching devices (robots) can send text messages to the platform to allow them to flow to the Dialogue System in order to be analyzed and to produce a response toward the User.

This specific API does not require Authorization to be invoked (the request does not require a Bearer Token obtainable through the OAuth2 User Authentication flow described in the paragraph 1.3.2.1), but it needs the following information:

- Input parameters: *e-VITA Device Id* and *e-VITA Device Token* related to the Device that sends the data. These two fields are assigned to the Device when it is registered within the e-VITA platform.
- Body of the request: the measurement must be inserted inside the body of the request; the payload fields are the attributes of the Device that change according to its specific typology.

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Body request and responses are in JSON format (see paragraph **Fehler! Verweisquelle konnte nicht gefunden werden.**) and whether the HTTPS request has been successfully completed, returns *200 HTTP* response code (otherwise *4xx Client error* or *5xx Server error* status code). Figure 2 shows an example of using the send data API. Further details about this topic are included in D7.2 (e-VITA, 2022).

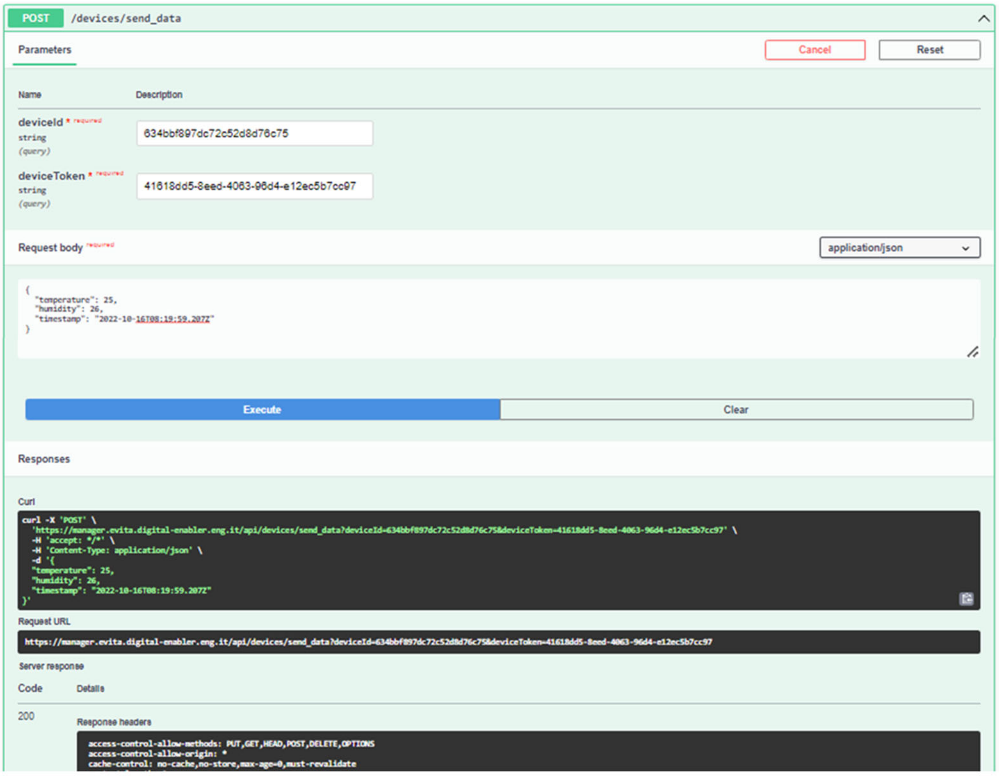

Figure 2 - e-VITA API to send data

1.1.1.2 Send File API

e-VITA system provides a REST API to allow Devices to send file to the platform. The file type that can be sent through this request is an audio file in *WAVE* format (described in paragraph 1.2.1.3).
This specific API does not require Authorization to be invoked (the request does not require a Bearer Token obtainable through the OAuth2 User Authentication flow described in the paragraph 1.3.2.1), but it needs the following information:

- Input parameters: *e-VITA Device Id* and *e-VITA Device Token* related to the Device that sends the file. These two fields are assigned to the Device when it is registered within the e-VITA platform.
- Body of the request: the file must be attached within the body of the request. The request only accepts files in the specified audio formats.

Coaching devices (e.g. robots) are the only type of Devices that are allowed to send audio files.

Whether the HTTPS request has been successfully completed, returns an *2xx* HTTP response code (otherwise *4xx Client error* or *5xx Server error* status code). In this case, the file is stored within the MinIO Object storage (MINIO, 2022) for later processing. Figure 3 shows an example of using the send file API. More details about it can be found in D7.2 (e-VITA, 2022).

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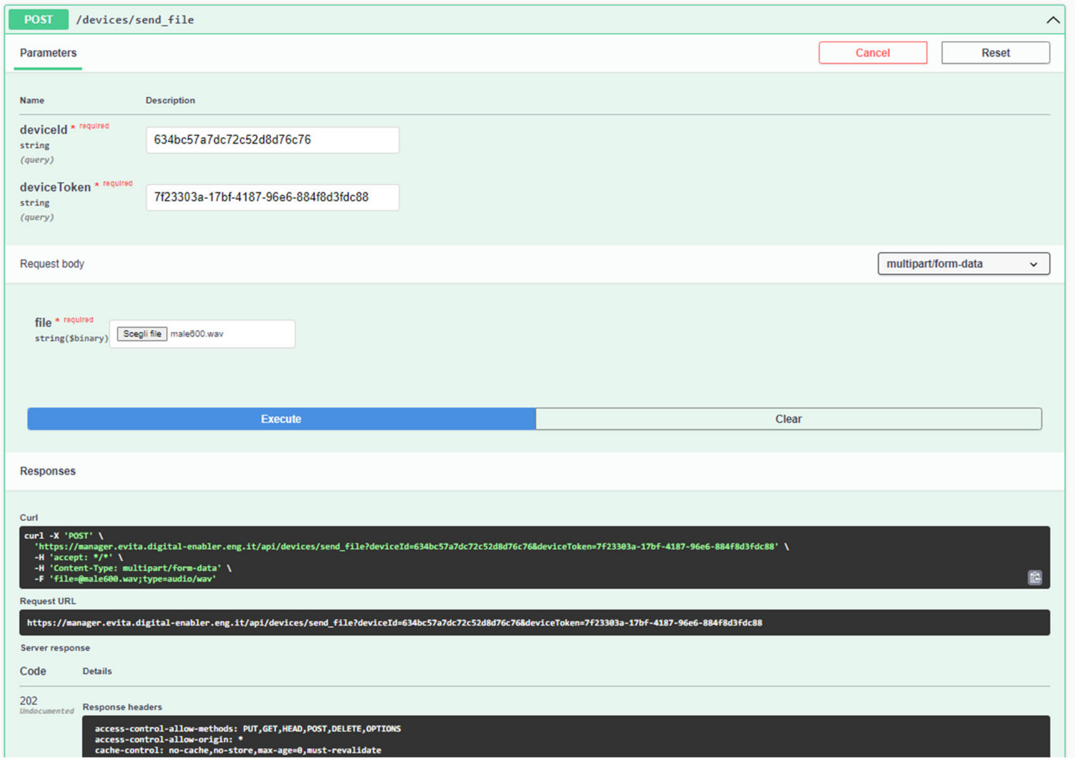

Figure 3 - e-VITA API to send file

1.1.2 WebSocket

The **WebSocket Protocol** (RFC - Official Internet Protocol Standards, 2011) enables two-way communication between a client running untrusted code in a controlled environment - to a remote host that has opted-in to communications from that code. The security model used for this is the origin-based security model commonly used by web browsers. The protocol consists of an opening handshake followed by basic message framing, layered over TCP. The goal of this technology is to provide a mechanism for browser-based applications that need two-way communication with servers that does not rely on opening multiple HTTP connections.

A WebSocket is a bidirectional, full-duplex, persistent connection between a Client and a Server. Once a WebSocket connection is established, the connection is open until the client or server decides to close this connection.

Within the e-VITA platform the WebSocket message handling is enabled, backed by a message broker, which has been appropriately configured.
The configurations designate the *"/app"* prefix to filter destinations and registers the *"/send_data_socket"* endpoint, enabling the support to the STOMP interoperable protocol (STOMP, 2022).
Additionally, an in-memory message broker to carry the messages back to the client on destinations prefixed with *"/ topic"* has been enabled.
This means that all subscribers to the *"/topic/messages"* destination will receive the message.

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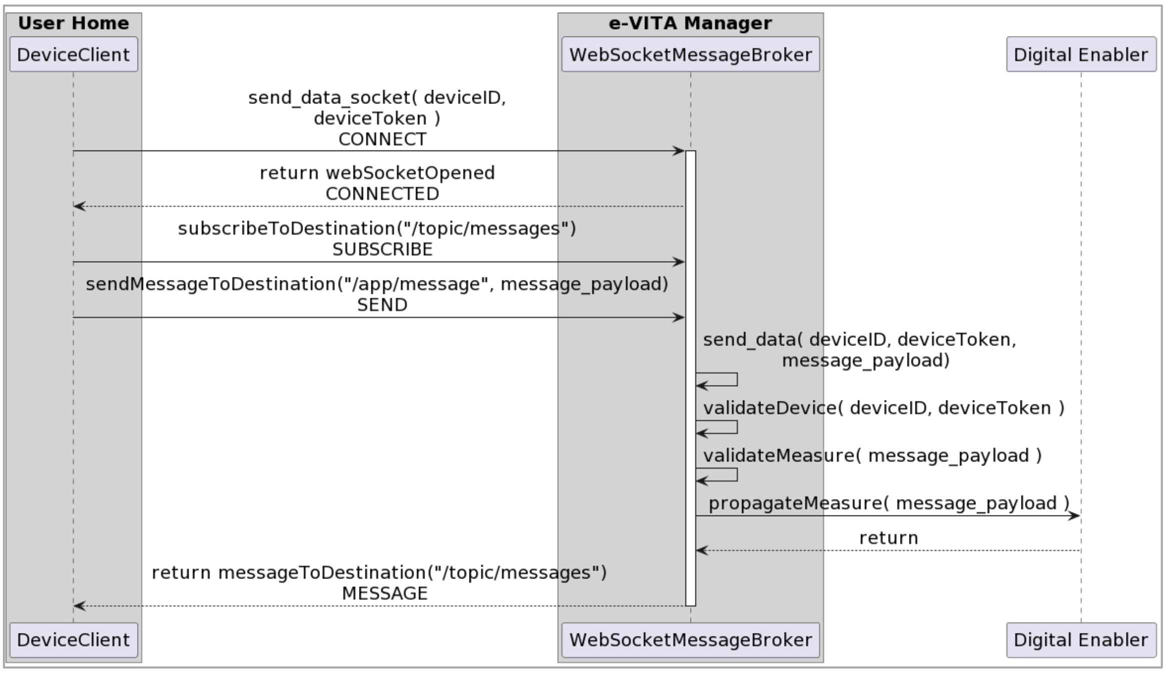

Figure 4 - WebSocket flow

1.1.3 MQTT: The Standard for IoT Messaging

MQTT (OASIS, 2019) is a standard messaging protocol for the Internet of Things (IoT). It is designed as an extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices with a small code footprint and minimal network bandwidth. MQTT is used in a wide variety of industries in particular in automotive, transportation and telecommunication domain (MQTT, 2022).

At the core of MQTT is the MQTT broker and the MQTT clients. The broker is responsible for dispatching messages between the sender and the rightful receivers. An MQTT client publishes a message to a broker and other clients can subscribe to the broker to receive messages. Each MQTT message includes a topic. A client publishes a message to a specific topic and MQTT clients subscribe to the topics they want to receive. The MQTT broker uses the topics and the subscriber list to dispatch messages to appropriate clients.
An MQTT broker is able to buffer messages that can't be dispatched to MQTT clients that are not connected. This becomes very useful for situations where network connections are unreliable. To support reliable message delivery, the protocol supports 3 different types of quality of services messages: 0 - *at most once*, 1 - *at least once*, and 2 - *exactly once* (MQTT, 2022).

Within the e-VITA platform, the adopted MQTT broker is RabbitMQ (RabbitMQ, 2022). It is one of the most popular open-source message brokers, it is an intermediary for messaging. It gives the applications a common platform to send and receive messages, and the messages a safe place to live until received. RabbitMQ is lightweight and easy to deploy on premises and in the cloud and it supports multiple messaging protocols.

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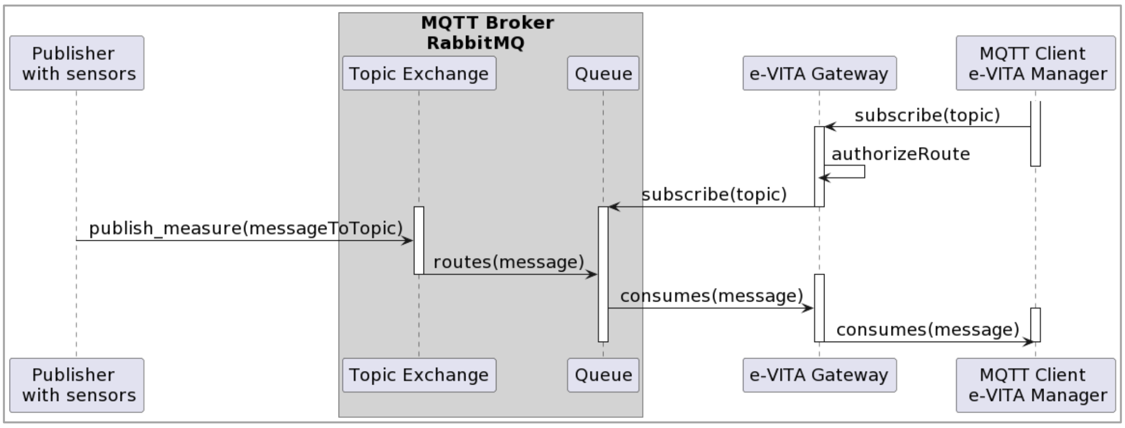

Figure 5 - MQTT flow

1.1.4 e-VITA Devices

The Table 1 includes the final list of devices that has been integrated within the e-VITA platform and their integration mechanism. This information is contained in the table field " Integration type " and can take two different values:

- e-VITA platform API: with this integration mode, the device communicates with e-VITA platform directly using the APIs made available by the platform, particularly the one described in section 1.1.1.1, by which the devices send the measurements detected to the platform. Concerning security and authentication aspects, in this case the communication is secured using a pair of parameters associated with the device during registration phase: *deviceToken* and *deviceId*. They are variables generated using UUIDs (IETF, 2005) and associated uniquely with each device. To send the measurements, the values of these two parameters must therefore be specified. In case they are not the correct ones, the sending of the measurement from the device to the e-VITA platform will not be successful.
- Cloud proprietary API: with this integration mode, the device communicates with the platform indirectly, as they are first connected to a proprietary cloud service. In this case, the device measurements are retrieved by the e-VITA platform from the proprietary cloud related to each device and are not sent from the device to the e-VITA platform as in the first case. Concerning security and authentication aspects, the e-VITA platform in this case in charge of accessing the device data from the cloud vendor's platform of the device. It is therefore necessary to authorize the e-VITA platform to access the data of the specific device. This is done by taking advantage of OAuth2 protocol, described more deeply in paragraph 1.3.2.1.

Device Type	Device Category	Integration type
ANDROID_ROBOT	**Coaching Devices**	e-VITA platform API
CELESTE		e-VITA platform API
DARUMA		e-VITA platform API
GATEBOX		e-VITA platform API
NAO_ROBOT		e-VITA platform API
NETATMO_AIR_QUALITY		Cloud proprietary API

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ENOCEAN_DOOR_SENSOR	**Smart home Sensors**	e-VITA platform API
ENOCEAN_MOTION_SENSOR		e-VITA platform API
ENOCEAN_TEMPERATURE_SENSOR		e-VITA platform API
DELTADORE_INTRUSION_SENSOR		e-VITA platform API
DELTADORE_MOTION_SENSOR		e-VITA platform API
NEU_BRAIN	**Wearable Devices**	Cloud proprietary API
NEU_TRAINING		Cloud proprietary API
OURARING_ACTIVITY		Cloud proprietary API
OURARING_READINESS		Cloud proprietary API
OURARING_SLEEP		Cloud proprietary API
HUAWEI_ACTIVITY		Cloud proprietary API
HUAWEI_SPORT		Cloud proprietary API
HUAWEI_HEALTH		Cloud proprietary API
HUAWEI_SLEEP		Cloud proprietary API

Table 1: final devices integrated in e-VITA platform

1.2 Data interoperability

This section reports the specific technologies and standards related to the data interoperability that are used within the platform. In particular, it is aimed at providing the information about the data formats (section 1.2.1), ontologies and data models (section 1.2.2) used within the e-VITA platform.

1.2.1 Data Formats

Within the e-VITA platform, to guarantee the communication among the different components that are part of the framework, the adopted data formats are JSON/JSON-LD, CSV and WAV/WAVE formats, for audio files. Other data formats will be supported in the future releases of e-VITA platform.

1.2.1.1 JSON/JSON-LD

JSON (RFC - Official Internet Protocol Standards, 2017) (JavaScript Object Notation) is a text format for storing and transporting data. It is a lightweight data-interchange format, "self-describing" and easy to understand. JSON is easy for humans to read and write and for machines to parse and generate. It is based on a subset of the JavaScript Programming Language Standard. JSON is a text format that is completely language independent, and these properties make JSON an ideal data-interchange language (JSON.org, 2022).

The set of REST APIs provided by the e-VITA platform accepts JSON for request payload and also send responses to JSON. JSON is the standard for transferring data. Almost every networked technology can use it and server-side technologies have libraries that can easily decode JSON.

JSON-LD is a lightweight Linked Data format. It is easy for humans to read and write. It is based on the already successful JSON format and provides a way to help JSON data interoperate at Web-scale. JSON-LD is an ideal data format for programming environments, REST Web services, and unstructured databases (JSON-LD, 2014).

NGSI-LD is an extended subset of JSON-LD for use with context management systems. Its payloads are encoded as linked data using JSON. To promote interoperability of data exchange, NGSI-LD context brokers offers data in one of three formats between JSON, JSON-LD (or even GeoJSON/GeoJSON-LD).

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They explicitly expose a JSON-LD @context file to define the data held within the context entities. This defines a unique URI for every entity type and every attribute. More details about this aspect in 1.2.2.1.

1.2.1.2 CSV

The comma separated values format CSV (RFC - Official Internet Protocol Standards, 2005) has been used for exchanging and converting data between various spreadsheet programs. The standard documents the format of comma separated values (CSV) files and formally registers the "text/csv" MIME type for CSV. In CSV files, each record is located on a separate line, delimited by a line break (CRLF); the last record in the file may or may not have an ending line break and there may be an optional header line appearing as the first line of the file with the same format as normal record lines. This header will contain names corresponding to the fields in the file and should contain the same number of fields as the records in the rest of the file.

Within e-VITA platform, this file format is adopted for storing historical data i.e., measurements taken from devices registered on the platform by a user. Files in this format are stored within the Object Storage MinIO (MINIO, 2022). In addition, a user can request the download of such data from the e-VITA dashboard of the platform and the file in this format can then be obtained directly by the user.

1.2.1.3 Waveform Audio File Format (WAV/WAVE)

WAVE is a digital audio file format standard developed by Microsoft and IBM, used to store audio bitstreams. It is the primary format used on Microsoft Windows systems for raw, uncompressed audio. The WAV is a variant of the RIFF (Resource Interchange File Format) format specifications which were first developed by IBM and Microsoft to store data in "chunks" (Microsoft, 2021). The WAV file is an instance of the RIFF container format, which acts as a wrapper for various audio encoding formats. A RIFF file starts out with a file header followed by a sequence of data chunks. A WAVE file is often just a RIFF file with a single "WAVE" chunk which consists of two sub-chunks: one specifying the data format and a "data" chunk containing the actual sample data (Stanford.edu, 2003).
The Internet media types associated with this audio file format is *audio/wav, audio/wave, audio/x-wav*.

Within the e-VITA platform, this file format is the one accepted by a specific e-VITA service that takes as input an audio file related to a particular device and stores it in the MinIO object storage (MINIO, 2022). Upon request, another service of the e-VITA platform allows to communicate with the emotional detection external component and thus extrapolate the emotions associated with the audio file, obtaining a JSON file that reports the emotions detected.

1.2.2 Ontologies and data models

e-VITA platform provides semantic interoperability capabilities by adopting the NGSI information model proposed by FIWARE, leveraging also on the FIWARE Smart Data Model initiative to harmonize the different data representation managed within the platform. Moreover, HL7 information model is described due to the analysis reported in D6.12 (e-VITA, 2022).

1.2.2.1 NGSIv2 and NGSI-LD information model

NGSI Information model

The FIWARE NGSI version 2 API discussed in section 1.3.1.1 defines:

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- a **data model** for context information, based on a simple information model using the notion of context entities
- a **context data interface** for exchanging information by means of query, subscription, and update operations
- a **context availability interface** for exchanging information on how to obtain context information (whether to separate the two interfaces is currently under discussion) (FIWARE, 2018).

The main elements in the NGSI data model, already presented in D4.1 (e-VITA, 2021), are context entities, attributes, and metadata. Each **entity** is defined by an id and a type (the type of thing represented by the entity) and can have one or more properties called context **attributes**, defined by a name, a type and a specific value. Finally, each attribute can have one or more context **metadata**, also defined by a name, type and a value.
Entities, Attributes and Metadata are represented by JSON Objects and therefore the API response payloads in this specification are in JSON format.
In this data model, there are many Special Attribute Types, types used to convey a special meaning, such as `DateTime` used to define the timestamp attribute and also `geo:point`, `geo:line`, `geo:box`, `geo:polygon` and `geo:json` which have special semantics related with entity location. More details in the definition of the data model (FIWARE, 2018).

NGSI-LD Information model

The **NGSI-LD API** standard (ETSI, 2022) defines the following Data Representation:

- NGSI-LD Entity Representation
- NGSI-LD Property Representations
- NGSI-LD Relationship Representations

All NGSI-LD elements are represented in JSON-LD, already defined in 1.2.1.1. For the use with the API, the compacted JSON-LD representation is used, i.e., short terms are used, which are expanded by the component implementing the NGSI-LD API using a JSON-LD @context, typically provided as part of the request.

The JSON-LD **Entity** object shall contain at least an *id* whose value shall be a URI that identifies the Entity, a specific *type* whose value shall be equal to the Entity Type Name, a *scope* whose value shall be a Scope, a *@context*, one member for each Property and one member for each Relationship.

The JSON-LD **Property** object shall be represented by a member whose key is the Property Name (a term) and whose value is a JSON-LD object including the "type" field with "Property" as value and "value" field with the Property Value. In addition to these two, other non-mandatory fields can be defined.

The JSON-LD **Relationship** object shall be represented by a member whose key is the Relationship Name (a term) and whose value is a JSON-LD object including the "type" field with "Relationship" as value and "object" field with the Relationship's object represented by a URI as value. More details are widely described in the standard (ETSI, 2022).

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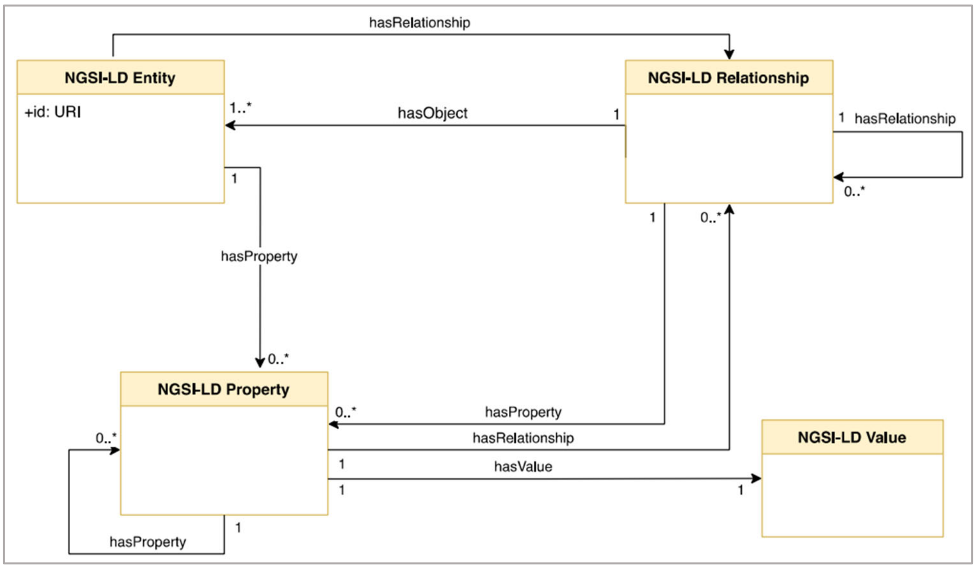

Figure 6 - NGSI-LD Information Model (ETSI, 2022)

1.2.2.2 FIWARE Smart Data Models and Device smart data model

FIWARE is enabling a new generation of smarter applications which exploit large scale, real-time 'context information'. Particularly, the NGSI version 2 API is aimed at making developer's life easier, by providing simpler but powerful RESTful interfaces. Markedly, the combination of NGSI version 2 and harmonized data models enables the creation of portability at the data layer. As a result, a myriad of end-user applications can seamlessly work and interoperate in different scenarios, namely smart cities. The FIWARE Smart Data Models are common data models that underpin a digital market of interoperable and replicable smart solutions in multiple sectors, starting with Smart Cities. A smart data model includes three elements: The schema, or technical representation of the model defining the technical data types and structure, the specification of a written document for human readers, and the examples of the payloads for NGSIv2 and NGSI-LD versions (FIWARE, 2022). All the smart data models thus defined, reusable and free for all are collected in the "Smart Data Models" GitHub organization (FIWARE, 2022).

Within e-VITA platform architecture, two FIWARE components are adopted: FIWARE Orion Context Broker (FIWARE, 2022) and FIWARE IoT Agent-JSON (FIWARE, 2019). The Orion Context Broker receives requests using NGSI-LD from consuming application, any application/service that needs to access to context data for further processing. It is used to manage context information collected from devices or sensors. The IoT Agent JSON is designed to be a bridge between JSON and the NGSI interface of a context broker. The flow expects the FIWARE Orion Context Broker to receive requests using NGSI, the FIWARE IoT Agent for JSON will receive these requests using NGSI and convert them to JSON commands for the devices. More details about their functionalities and roles within the e-VITA platform in deliverables D7.1 (e-VITA, 2021) and D6.12 (e-VITA, 2022).

Device smart data model

The IoT Agent is placed in an intermediate position between the Context Broker and an IoT Device. From the point of view of the data model used to represent the entities, when a new device is registered

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within the e-VITA platform, a new Entity with "Device" as type is added within the IoT Agent-JSON component. Information about all the attributes associated with this device is then stored in the "attributes" field. This list of attributes changes according to the type of device (i.e., humidity and temperature for a smart home device or activity and training information for a wearable device). An example of a Device entity registered in the IoT Agent is shown in Figure 7.


```
{
    "count": 1,
    "devices": [
        {
            "device_id": "62d50ae7e50c9d08f994fba4",
            "service": "7d658e7c_057f_4aa5_96f6_3864fd1e6b98",
            "service_path": "/7d658e7c_057f_4aa5_96f6_3864fd1e6b98",
            "entity_name": "62d50ae7e50c9d08f994fba4",
            "entity_type": "Device",
            "transport": "HTTP",
            "attributes": [
                {
                    "object_id": "temperature",
                    "name": "temperature",
                    "type": "decimal"
                },
                {
                    "object_id": "humidity",
                    "name": "humidity",
                    "type": "decimal"
                },
                {
                    "object_id": "timestamp",
                    "name": "timestamp",
                    "type": "datetime"
                }
            ],
            "lazy": [],
            "commands": [],
            "static_attributes": [],
            "protocol": "JSON"
        }
    ]
}
```


Figure 7 - Example of a smart home Device Entity defined within the e-VITA IotAgent-JSON

Since part of the Entities present in the Orion Context Broker represents specific devices registered within the platform (which can be a coaching device, a smart home sensor or a wearable device), the smart data model chosen for the representation of them is the Smart-sensoring Device data model (FIWARE, 2022). This data model allows to represent devices of different nature (IoT, mobile, wearable, etc.).

The Device Entity within the model, is defined as an apparatus (hardware + software + firmware) intended to accomplish a particular task (sensing the environment, actuating, etc.).

The Device object is then defined by a set of attributes which are specific information fields of the device measurements (i.e., temperature, humidity, noise, etc.) that were previously associated with the Device at the time of its registration within the IoT Agent-JSON. An example of a Device entity registered in the Orion Context Broker is shown in Figure 8.

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```
{
    "id": "62d50ae7e50c9d08f994fba4",
    "type": "Device",
    "TimeInstant": {
        "type": "ISO8601",
        "value": "2022-07-21T12:15:49.00Z",
        "metadata": {}
    },
    "humidity": {
        "type": "decimal",
        "value": "26",
        "metadata": {
            "TimeInstant": {
                "type": "ISO8601",
                "value": "2022-07-21T12:15:49.850Z"
            }
        }
    },
    "temperature": {
        "type": "decimal",
        "value": "25",
        "metadata": {
            "TimeInstant": {
                "type": "ISO8601",
                "value": "2022-07-21T12:15:49.850Z"
            }
        }
    },
    "timestamp": {
        "type": "datetime",
        "value": "2022-07-21T12:12:39.204Z",
        "metadata": {
            "TimeInstant": {
                "type": "ISO8601",
                "value": "2022-07-21T12:15:49.850Z"
            }
        }
    }
}
```


Figure 8 - Example of a smart home Device Entity defined within the e-VITA Context Broker

1.2.2.3 HL7 FHIR

The Continua Design Guidelines (CDG) (Continua Design Guidelines, 2019) are a product of the Personal Connected Health Alliance (PCHA, 2022) which is an international not-for-profit industry organization enabling end-to-end (E2E), plug-and-play connectivity of devices and services for personal health management and healthcare delivery. The Continua Design Guidelines have defined the **FHIR data model** (HL7, 2022) as a set of Continua Certified Capability Classes to represent and standardize the uploading of the devices' measurements through the Services Interface, which is associated with communication between personal health gateways (hardware/software that manage the direct communication with the devices) and health and fitness services. The FHIR specification describes a set of base resources, frameworks and APIs that are used in many different contexts in healthcare.

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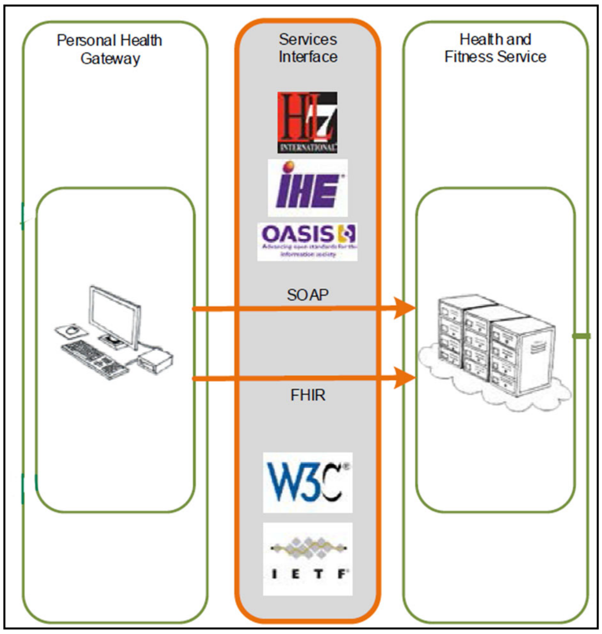

Figure 9 - FHIR usage within the Continua Architecture

The e-VITA platform aims at supporting part of the PCH Alliance specifications in order to interoperate with the compliant devices and systems, but also having the capability to share data with Healthcare Information Systems. In the Continua Design guidelines framework e-VITA platform can be defined as a "Health & Fitness Service" providing, in the cloud, specific coaching capabilities through the collection and processing of data coming from various devices. The relevant interfaces to take in consideration from the point of view of the interoperability with Continua Design Guidelines are the "Service Interface" in relation to the communication with "Personal Health Gateway" and the "HIS Interface" to interact with Healthcare Information Systems. Regarding the Services Interface of the architecture, security is achieved through consent management, consent enforcement, auditing, confidentiality, integrity and service authentication, and entity authentication (using OAuth); the most of these capabilities are already provided by the e-VITA APIs. Regarding the HIS interface (which aims to enable the transfer of patient information between two Health and Fitness Services), the e-VITA platform, in a future perspective, could cover and support the functionalities of this interface.
More details about the interoperability aspects between Continua Design Guidelines and e-VITA platform and technical approaches to implement them in the next phase of e-VITA project, in D6.12 (e-VITA, 2022).

1.2.3 Data fusion

Data fusion is needing data pre-formatting and pre-processing to get them harmonized and synchronized (also refer to deliverable D7.1 (e-VITA, 2021)). To our knowledge there is no standardized Data fusion algorithms for interoperability as generally standards do not apply to computational algorithms, however data as input are generally in specific formats, according to either manufacturer norm (proprietary or standard), or open format data or signal produced in this case by laboratory devices or prototypes and it exists some interoperability process like xAAL allowing then to operate harmonized Data Fusion. Indeed, it might be interesting in the scope of the project to investigate normative activities relative to Data Fusion algorithms themselves and eventually to propose potential inputs to standardization organization acting in the domain of the smart home applications. This potential new interoperable Data Fusion standard could be based on the open format of FIWARE planned to embed the Data fusion stage of the e-VITA prototype.

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The Orion Context Broker contains not only Device type entities but also other types of entities. In particular, it contains output information from the Data Fusion platform. The Data fusion platform is an external system integrated with the e-VITA platform. The platform stores the data produced by the Data fusion component and also saves it within the Orion Context Broker to enable further analysis. The Data fusion com platform provides specific user's situation labels produced through the analysis of data collected from the user's devices. More information about the Data Fusion platform can be found in D5.2 Data fusion situation assessment and context catching (e-VITA, 2023).
No common data model has been adopted for the representation of these entities, but a custom one has been created for this purpose. An example of a data fusion label entity registered in the Orion Context Broker is shown in Figure 10.


```
[
    {
        "id": "650a8375a2293e2e7506cc7d",
        "type": "HomeActivity",
        "label": {
            "type": "StructuredValue",
            "value": {
                "home_activity": {
                    "aggregated_period": 1800,
                    "Enter_Home": 0,
                    "Leave_Home": 0,
                    "Bed_Toilet_Transition": 0,
                    "Toileting_Activity": 0,
                    "Cook": 0,
                    "Eat": 0,
                    "Resting_Activity": 0,
                    "Other_Activity": 1
                }
            },
            "metadata": {}
        },
        "userId": {
            "type": "Text",
            "value": "e5d28d3b-fd34-4d9e-ab60-418f7d7c6754",
            "metadata": {}
        }
    }
]
```


Figure 10: Example of a Data Fusion label Entity defined within the e-VITA Context Broker

1.2.4 Dialogue Models

As discussed in detail in Deliverable D2.4 "Detailed specifications of existing coaching and NLP solutions" (e-VITA, 2021), Chapter 3 "Dialogue Modelling and Natural Language Processing", dialogue technology has matured over the past decade from academic research to commercial deployment, with functionalities ranging from elaborated question-answering to chatbots, covering both text and speech interfaces.

Dialogue modelling and NLP are not standardized, however, in the sense of some other processing units such as speech coders or audio coding systems, but there are many frameworks for developing dialogue systems. For instance, the well-known examples of conversational agents also come with their own development frameworks such as Google's Dialogflow, Amazon's Alexa Skills Kit, Microsoft's Bot Framework, and IBM's Watson Assistant. They provide solutions to dialogue system development, with

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the NLU component using machine learning or neural network-based approaches to interpret the user input with respect to a predefined set of user intents, but the dialogue management and response generation components are hand-crafted. End-to-end dialogue modelling has recently also become under intensive research and development, using big data and neural models.

In the e-VITA project, dialogue management is based on the RASA Open-source Framework which is selected because of its flexibility to enable cutting-edge conversational AI dialogue modelling and also rule-based actions to take care of more complex interaction and knowledge base actions. Moreover, the framework is open-source and allows experimentation with various processing components (commonly used standard ones as well as tailor-made ones built for the project needs) by specification of the configuration file with respect to the NLU (natural language processing) pipeline and the Rasa core dialogue policies.

The Rasa NLU pipeline is responsible for the basic data analysis and the open-source NLP tools (Stanza, CoreNLP, NLTK and Spacy) as well as open-source libraries for training vector representations and fine-tuning neural language models (Hugging Face, FastText, Gensim, LASER) will be experimented and used in order to reach successful solutions for the e-VITA coach (see more in Deliverable D2.4 (e-VITA, 2021)).

Integration of the Rasa dialogue model with the rest of coach architecture is compliant with knowledgebase actions that can be used in the Rasa dialogue model to query json and neo4j knowledge-bases. Suitable speech technology components that convert speech signal to a text-based input, which is required by the main Rasa components, are also possible to integrate with the Rasa dialogue model, thus enabling speech-based interaction between the user and the coach system. Moreover, Rasa is compliant with ROS. However, there are no standards and open-source components for robot dialogue and speech (Jokinen, 2021). On the other hand, there are working groups or organizations like MPAI (MPAI Community, s.d.) and OMG (Object Management Group, 2021). MPAI aims to unify or homogenize AI tools and interfaces between modules, to give recommendations on use cases and functional requirements (MPAI Community, s.d.) .

In particular, MPAI is calling for technologies applicable to "Conversations with Emotions". MPAI Standard is described in more detail in Deliverable D5.5 "Multimodal Annotation Schema and Tools" (e-VITA, 2021).

OMG, on the other hand, focuses on technology standards in the area of distributed object computing, covering a wide range of technologies and a wide range of industries. The international membership covers end-users, vendors, government agencies, universities and research institutions. For instance, within the Robotics Domain Task Force, the Robotics Service Ontology Working Group aims at developing a set of basic ontologies that provide a semantic model of robotic services and related components that can support communications and interoperability between robotic services.

Deliverable D5.5 "Multimodal Annotation Schema and Tools" (e-VITA, 2021) describes the e-VITA project aims concerning multimodal annotation schema and its application for the annotation of multimodal dialogues with RASA-X, as well as data types and principles of data integration of heterogeneous data sources and their use by the dialogue system. Deliverable D5.5 provides a starting point for the general standardization and interoperability issues in dialogue intent design and intent libraries. This is based on the early co-creation of the coach interaction with the real users, to allow generalization and reusability of the models in a variety of use cases, input configurations and user needs.

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1.2.5 Knowledge Graphs

Knowledge Graphs (KG) have evolved as a significant repository for storing facts about the world in interlaced and connected data architecture. Providing robots with the capacity to explore Knowledge Graphs and answer natural language inquiries over them has been a hot topic of research in recent years (Dubey, 2021). The Resource Description Framework (RDF) serves as the perfect data model to implement the concepts envisioned of Knowledge Graphs. RDF is a data format used to describe data that is highly linked. Each RDF statement is a three-part structure made up of resources, each of which is identifiable by a unique URI. AI systems can quickly identify, disambiguate, and link information when it is represented in RDF (OntoText, 2021).

On and off the Web, semantic interoperability refers to the capacity for various agents, services, and applications to communicate information, data, and knowledge in a meaningful way. To allow semantic interoperability, agents, services, and applications must share a common language or establish correspondence or mappings between their various vocabularies. One of the primary goals of RDF and OWL is to offer such semantic interoperability based on mappings.

1.2.6 Translation and Multilingual Services

The e-VITA coach aims to communicate effectively with its user; thus, communicating to the user in their native language is essential. A Japanese user would not prefer the coach to speak English; it will offer a poor experience. On the other hand, the several data and services used by the coach might not all be available in all the languages covered within the e-VITA platform. Thus, we need to use translation services at several stages in the project and overall develop multilingual machine learning models.

From an architectural point of view, we will require to utilize translation services in different ways. The e-VITA system will have an audio interface for the user, the voice inputs are then converted to text, and then the core modules will operate over the text data. Given the way we process the input/output data in the e-VITA architecture, the translation services have several settings, as indicated in the following figure. Say the core system relies on the English language, in such a scenario; we could have the translation service which translates at the input/output text, and the core system is not affected. The second scenario is to have separate system pipelines for a different language. In such settings, we will require to translate our datasets in all the languages within the scope of the e-VITA project, and we will also need to retrain our machine learning module in all the languages separately. To achieve a true level of multilingualism, we need to move towards language-independent algorithms to work on several languages within the same machine learning model.

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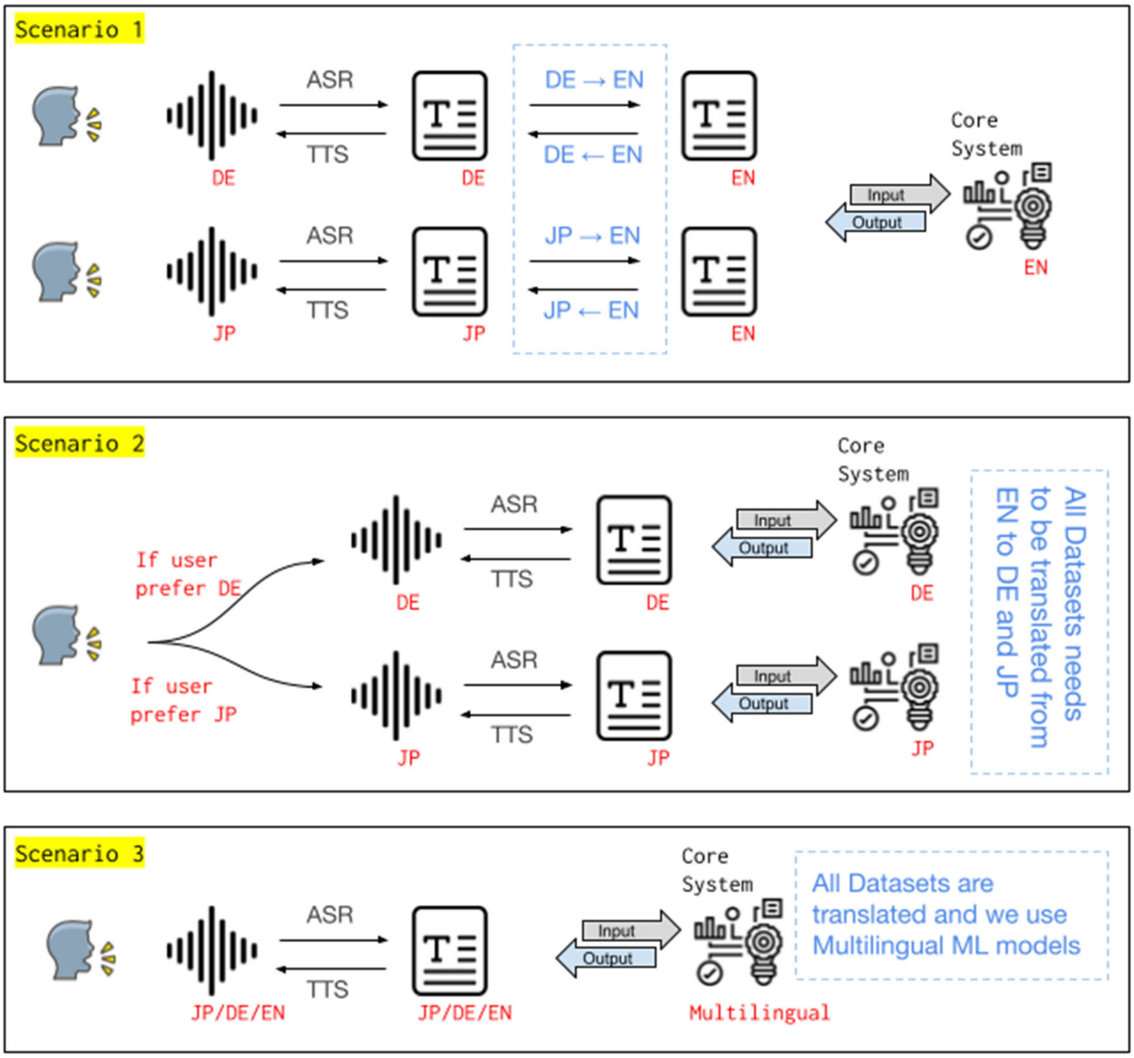

Figure 11: Translation and Multilingual Services

1.3 Application interoperability

This section describes the provided interfaces that a third-party service needs to support to be able to interact with the e-VITA platform. It is important to underline that such interfaces are also used internally by the different components of the platform but to be exploited by external and third-party services the APIs are subject to security and privacy considerations.

1.3.1 Interoperable API for external applications

1.3.1.1 NGSI/NGSI-LD API

NGSI-LD API

NGSI-LD APIs are defined in the ETSI NGSI-LD standard (ETSI, 2022) for Context Information Management. NGSI-LD is a formally structured extended subset of JSON-LD (already described in this document in paragraph 1.2.1.1). Whilst interacting directly with NGSI-LD interface of the Context

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Broker the additional NGSI-LD rules must be respected. However, after the data has been extracted it is possible to loosen this requirement and pass the results to third parties as JSON-LD. NGSI-LD APIs can return data in two main different data formats: *normalized* and *key-value-pairs*. Data returned in the normalized format respects the NGSI-LD rules and may be used directly by another context broker (or any other component offering an NGSI-LD interface). Data returned in the key-value-pairs format is by definition not NGSI-LD (FIWARE, 2022). The NGSI-LD API is structured in terms of HTTP verbs, request and response payload bodies. All resource URIs of this API shall have the following root: *{apiRoot}/{apiName}/{apiVersion}/*. The *apiRoot* includes the scheme ("http" or "https"), host and optional port, and an optional prefix string. The API shall support HTTP over TLS (HTTPS). The *apiName* shall be set to "ngsi-ld" and the *apiVersion* shall be set to "v1". The structure of the resources under the root URI is shown in Figure 12 and the corresponding methods are defined on them (ETSI, 2022).

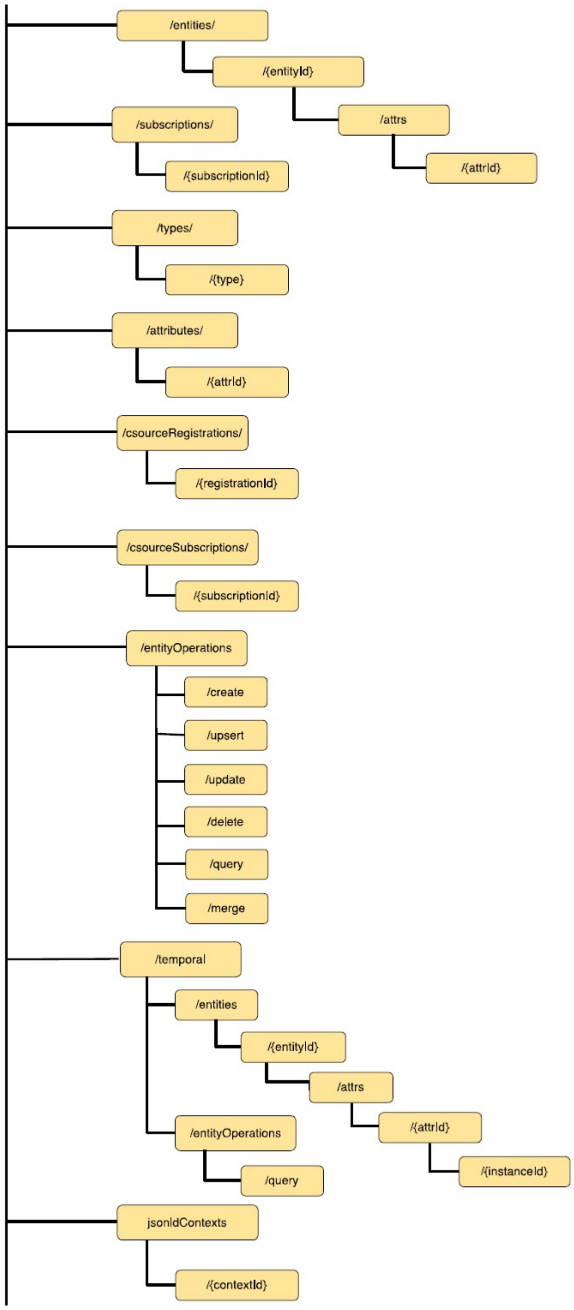

Figure 12 - Structure of the NGSI-LD API resources (ETSI, 2022)

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NGSIv2 API

This specification defines the **FIWARE-NGSI version 2 API** (FIWARE, 2018). FIWARE NGSI is the API exported by a FIWARE Context Broker, used for the integration of platform components within a “Powered by FIWARE” platform and by applications to update or consume context information. Use the FIWARE's Orion Context Broker (FIWARE, 2022), with proper context data flowing through it, is sufficient for an application to qualify as "Powered by FIWARE" (FIWARE, 2022). FIWARE NGSI API specifications have evolved over time, initially matching NGSI-v2 specifications, now aligning with the ETSI NGSI-LD standard (ETSI, 2022).
The FIWARE NGSIv2 API is structured in terms of HTTP verbs, request and response payload bodies.
All resource URIs of this API shall have the following root: *{apiRoot}/{apiVersion}/*
The *apiRoot* includes the scheme ("http" or "https"), host and optional port, and an optional prefix string. The API shall support HTTP over TLS (HTTPS).
The *apiVersion* shall be set to "v2".
The services exposed by FIWARE-NGSI v2 Specification can be directly accessed through the Swagger (FIWARE, 2020), shown in Figure 13.

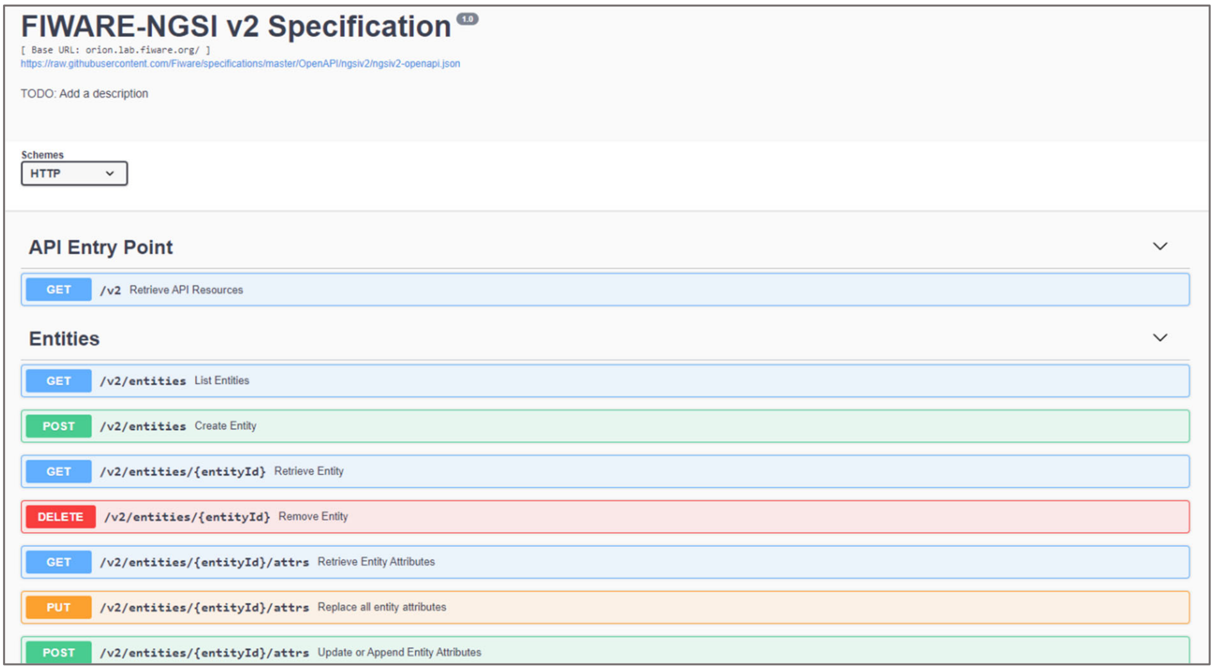

Figure 13 - FIWARE-NGSI v2 Specification (Swagger)

The Orion Context Broker uses NGSI APIs to manage context information and its availability within the e-VITA project, including updates, queries, registrations, and subscriptions. Specifically, within the e-VITA platform, the Context Broker is used to provide the harmonized raw data coming from the devices via publish-subscribe APIs (e-VITA, 2022).
The FIWARE Orion Context Broker receives requests using NGSI-v2 and FIWARE-NGSI v2 is intended to manage the entire lifecycle of context information, including updates, queries, registrations, and subscriptions.

The sequence diagram in Figure 14 shows an example of use of the NGSI API, in particular the request to retrieve the last measurement detected by a specific device, within Orion Context Broker, using the

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retrieveEntity NGSI operation. The measurement can be obtained starting from the device identifier and the user's *'fiware-service'* parameter (in the header of the request) which must necessarily be specified to obtain the measurement, as Orion Context Broker supports hierarchical scopes and allows to perform hierarchical searches (FIWARE, 2022).

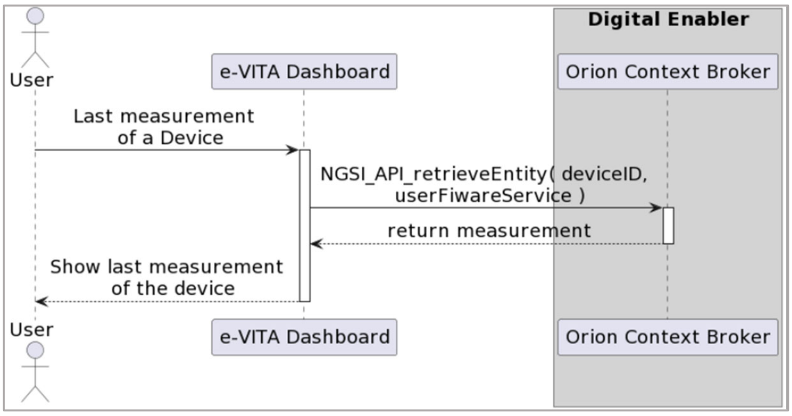

Figure 14 - NGSI flow in retrieving a device measurement

Another example of use of the NGSI API is found in the usage of Perseo (FIWARE, 2024). Perseo is an Event Processing Rule based component used in the e-VITA system. It is a FIWARE component designed to be fully NGSI-v2 compliant. The Context broker tested with it and officially supported is Orion Context Broker. Perseo is an Esper-based Complex Event Processing (CEP) software that uses NGSI-v2 as the communication protocol for events.

Perseo, as schematically shown in Figure 15, is used within the e-VITA platform in combination with the Orion Context Broker of the platform. By exploiting the notifications mechanism of the Context Broker, the platform acts as a client that instructs the Orion CB to notify Perseo of the changes in the entities of interest. Rules to the CORE Rule Engine are easily managed by specific technical users of e-VITA by using the Perseo's Rule API via the e-VITA dashboard web interface. These rules will identify patterns that will trigger actions with Orion to create or update entities.

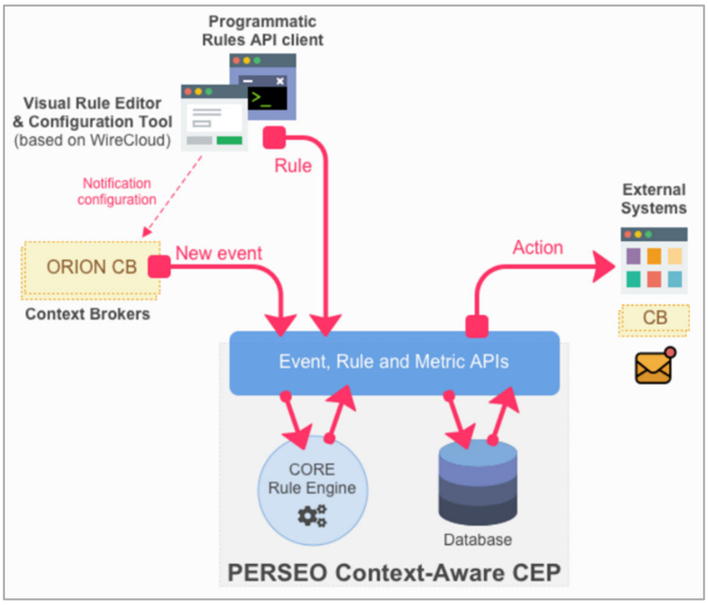

Figure 15: Interaction of Perseo with the Orion CB through Rules and Events

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1.3.1.2 Open API

The Swagger Specification, which was renamed to the **OpenAPI Specification (OAS)** (Swagger, 2020), after the Swagger team joined SmartBear and the specification was donated to the OpenAPI Initiative in 2015, has become the de factor standard for defining RESTful APIs.

The OpenAPI Specification (OAS) defines a standard, language-agnostic interface to RESTful APIs which allows both humans and computers to discover and understand the capabilities of the service without access to source code, documentation, or through network traffic inspection. When properly defined, a consumer can understand and interact with the remote service with a minimal amount of implementation logic. An OpenAPI definition can then be used by documentation generation tools to display the API, code generation tools to generate servers and clients in various programming languages, testing tools, and many other use cases (Swagger, 2020).

Figure 16 shows the Swagger of all the platform's REST APIs: the resource, available and reachable online (e-VITA, 2022), lists all the APIs available with their detailed description, all the operations supported, the input parameters of each API and the returned value. The resource notifies if the APIs needs an authorization and even terms, contact information and license to use the APIs.

In the e-VITA platform, the Open API specification has become the reference for documenting the e-VITA APIs available. This tool facilitates interoperability between stakeholders and allows that the parties involved are aware of the services provided. Furthermore, the specification adopted allows to directly test and use all the e-VITA RESTful web services, by freely entering the input parameters. Specifically, the platform supports the latest version of the specification (OpenAPI 3.0). For more details on the possible inputs of each API and an example of output that can be obtained, refer directly to the Swagger of the platform and to the D7.2 (e-VITA, 2022).

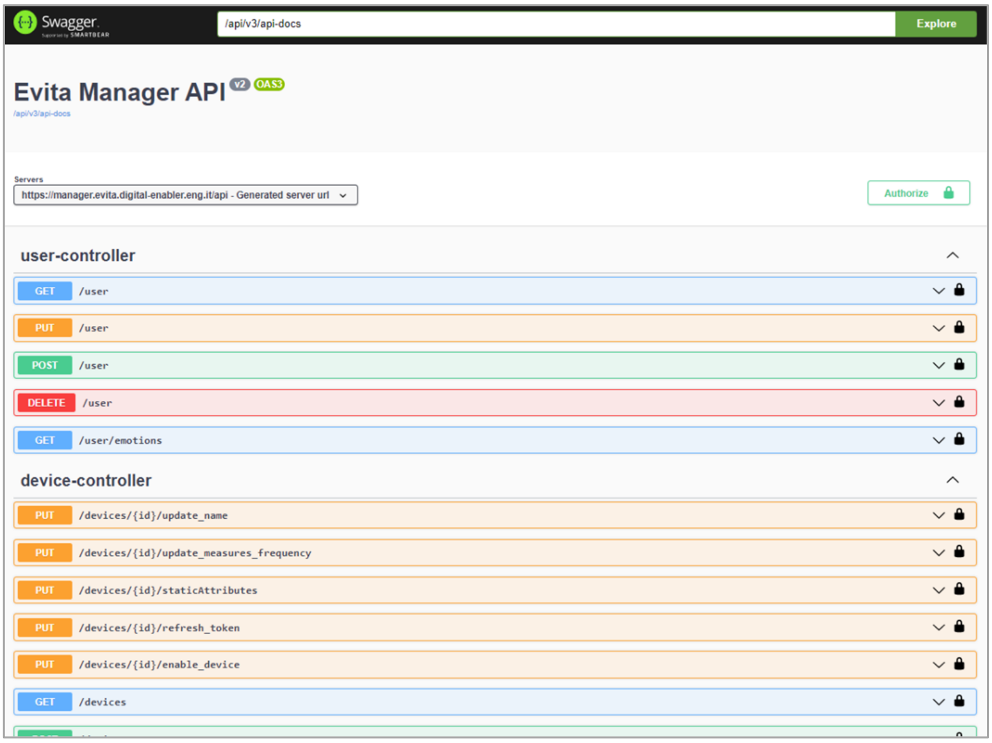

Figure 16 - e-VITA platform Swagger developed with OpenAPI Specification

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1.3.1.3 AWS S3 - MinIO

MinIO established itself as the standard for **AWS S3** compatibility from its inception (AWS, 2006). One of the earliest adopters of the S3 API (both V2 and V4) and one of the only storage companies to focus exclusively on S3, MinIO's massive community ensures that no other AWS alternative is more compatible (MinIO, 2022).

The S3 API is the de facto standard in the cloud and, as a result, alternatives to AWS must speak the API fluently to function and interoperate across diverse environments - public cloud, private cloud, datacenter, multi-cloud, hybrid cloud and at the edge. MinIO is unique in its ability to support its claim of S3 compatibility. With tens of thousands of customers and open-source users, the MinIO S3 API compatibility is the most widely tested and implemented in the world - covering millions of combinations of hardware, software and applications. MinIO releases software weekly and any shortcoming to the S3 API is immediately reported by the community and rectified by MinIO (MinIO, 2022).
The most comprehensive support for the S3 API means that applications can leverage data stored in MinIO on any hardware, at any location and on any cloud. Developers are free to innovate and iterate, safe in the knowledge that MinIO will never break a release (MinIO, 2022).

The MinIO Object Storage is a component that, within the e-VITA platform provides the means to securely store data belonging to a user. At the time this document is written, the tool is mainly used to store and query historical data related to sensor and devices. The Figure 17 shows the bucket creation flow for a user registered within the platform. In the platform, each user is associated with a bucket, an object in the Object Storage that stores the data sent by the devices associated with the user.

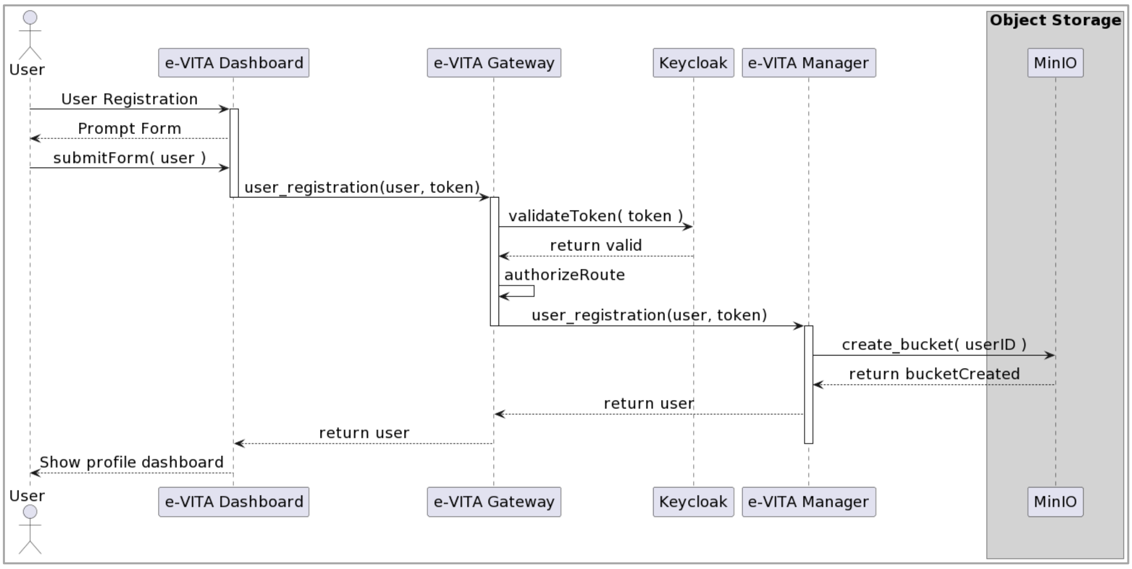

Figure 17 - MinIO: User bucket creation flow

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1.3.2 Security and Privacy

1.3.2.1 OAuth2

OAuth 2.0 (RFC - Official Internet Protocol Standards, 2012) is the industry-standard protocol for authorization. OAuth 2.0 focuses on client developer simplicity while providing specific authorization flows for web applications, desktop applications, mobile phones, and living room devices. This specification and its extensions are being developed within the IETF OAuth Working Group (OAuth.net, 2022).
Within the e-VITA platform, **Keycloak** (Red Hat, 2022), an Open-Source Identity and Access Management platform that, allows to register, authenticate, and authorize users.
After a first phase of redirection to the configured Keycloak authorization endpoint, the user must provide his credentials within a login form. If them are valid, Keycloak returns an access token; it is an **JWT token** (discussed in paragraph 1.3.2.3) and, after being decoded, contains the information of the user. Once the process of user's authentication is completed, the token can be used to authorize the user in any subsequent request to the e-VITA Platform REST APIs.

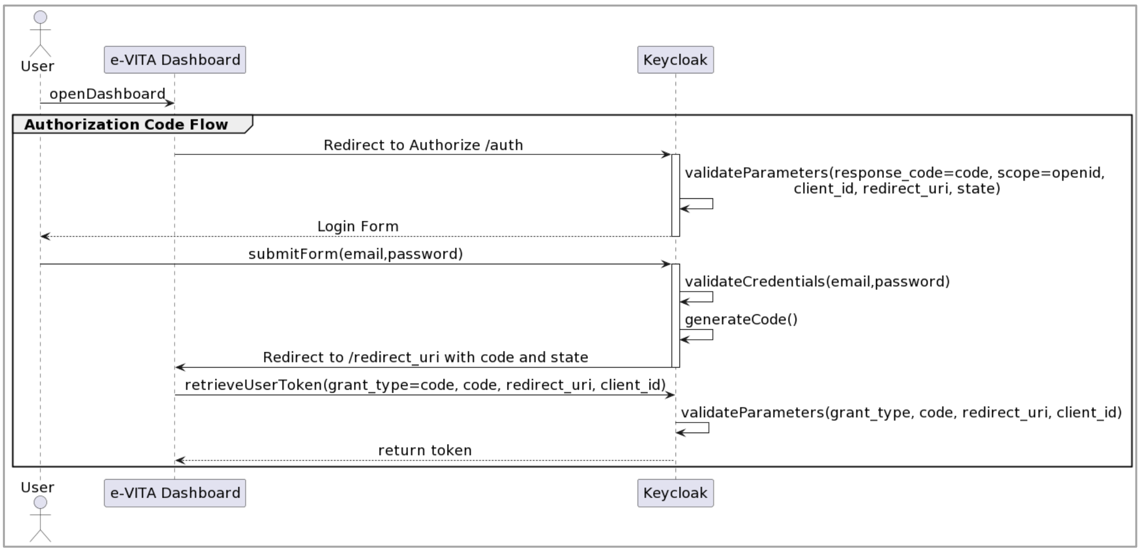

Figure 18 - User Authentication flow

The OAuth2 Client Credentials Grant, allows machine to machine communication providing a token related to a service and not to a single user. Within e-VITA, each service is registered as a client application in Keycloak that assigns a *client_id* and *client_secret* to be used as service credentials. As shown in Figure 19, the token obtained then allows to access, for example, the information of a specific user starting from his identifier, using the specific e-VITA REST API.

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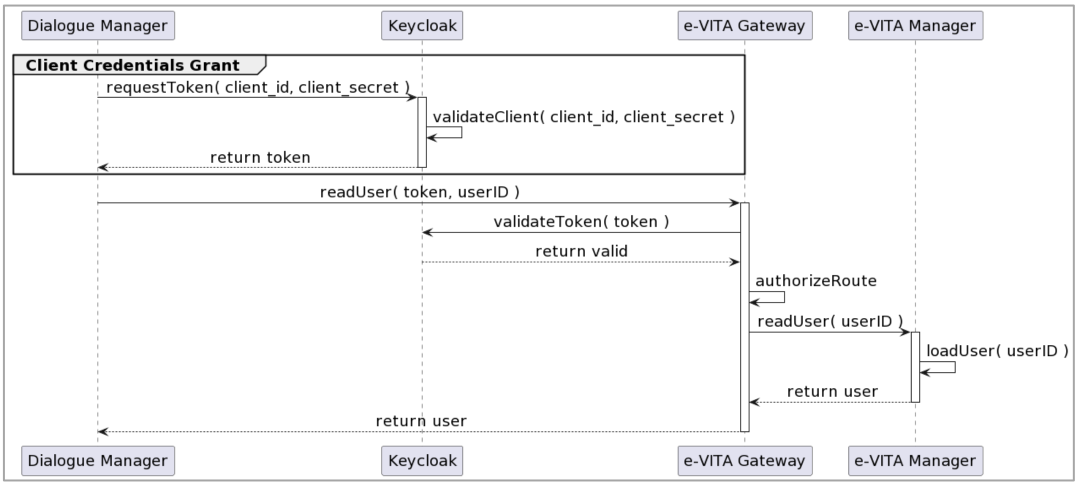

Figure 19 - Client Credentials Grant flow

Figure 20 shows the OAuth2 Authorization Code Flow: it allows a user to authorize the e-VITA platform to read the external vendors' data accessing the REST APIs on his/her behalf. In order to enable this flow, e-VITA is needed to be registered as a client application within each vendors' clod system.
After a first phase of redirection to the specific vendor's authorization endpoint, the user must provide his credentials within a login form. If them are valid, the user is then asked to authorize the client application (e-VITA) to read his / her vendor's data. More details in D7.7 (e-VITA, 2022).

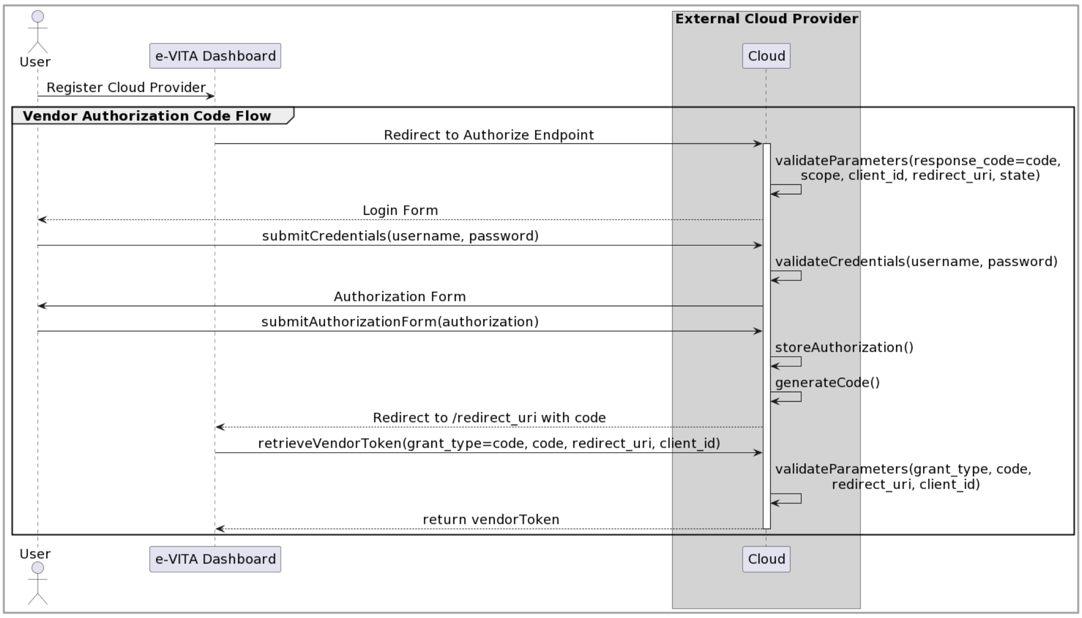

Figure 20 - Third Party System Authorization flow

1.3.2.2 OpenID Connect

OpenID Connect 1.0 (OpenID, 2014) is a simple identity layer on top of the OAuth 2.0 protocol. It allows Clients to verify the identity of the End-User based on the authentication performed by an Authorization

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Server, as well as to obtain basic profile information about the End-User in an interoperable and REST-like manner.
OpenID Connect allows clients of all types, including Web-based and mobile clients, to request and receive information about authenticated sessions and end-users. The specification suite is extensible, allowing participants to use optional features such as encryption of identity data, discovery of OpenID Providers, and logout, when it makes sense for them (OpenID, 2014). OpenID Connect implements authentication as an extension to the **OAuth 2.0 authorization process**. Use of this extension is requested by Clients by including the *openid* scope value in the Authorization Request. Information about the authentication performed is returned in a JSON Web Token (JWT) (described in section 1.3.2.31.3.2.3) called an ID Token. OAuth 2.0 Authentication Servers implementing OpenID Connect are also referred to as OpenID Providers (OPs). OAuth 2.0 Clients using OpenID Connect are also referred to as Relying Parties (RPs) (OpenID, 2014). Within e-VITA platform, OpenID connect allows third-party applications to verify the identity of the end-user and to obtain basic user profile information; it uses JSON web tokens (JWT), obtained using flows conforming to the OAuth 2.0 specifications.

1.3.2.3 JSON Web Token (JWT)

JWT (RFC - Official Internet Protocol Standards, 2015) is an open, industry standard method for representing claims securely between two parties. It is a compact and URL-safe means of representing claims; the claims in a JWT are encoded as a JSON object that is used as the payload of a **JSON Web Signature (JWS)** (RFC - Official Internet Protocol Standards, 2015) structure or as the plaintext of a **JSON Web Encryption (JWE)** (RFC - Official Internet Protocol Standards, 2015) structure, enabling the claims to be digitally signed or integrity protected with a Message Authentication Code (MAC) and/or encrypted. JWT.IO (JWT.IO, 2022) allows to decode, verify and generate JWT. It is important to underline that JWTs are credentials, which can grant access to resources. It's important to be careful where they are inserted; JWT.IO do not record tokens, all validation and debugging is done on the client side.
Within e-VITA platform, JWTs are used as **OAuth 2.0 Bearer Tokens** within OAuth 2.0 process authorization (already descripted in 1.3.2.1) to encode all relevant parts of an access token into the access token itself instead of having to store them in a database. A JWT contains all the required information about an entity to avoid querying a database more than once. The recipient of a JWT also does not need to call a server to validate the token. In the Authorization phase, once a user is successfully logged in, the application requires to access routes, services, or resources (e.g., APIs) on behalf of that user. To do so, in certain requests, it must pass an Access Token, which is in the form of a JWT. In the sequence diagrams shown in the paragraph 1.3.2.1, the access token obtained at the end of the authentication process is a JSON web token.

1.3.2.4 Semantic and technical interoperability for personal data management

The potential presence of personal data suggests following a user-centric approach of data sharing, which also involves aspects of compliancy, from a legislative point of view, and other aspects about technological and semantic interoperability and the use of standards, important to:

- Enabling fine granularity and machine readable in consent management and privacy preferences
- Supporting data usage enforcement based also on the privacy preferences included in the consent given by Data Subject
- Providing transparency tools for individuals

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- Single point of access of privacy preferences always updated

To this end, e-VITA platform has followed user centric approach of personal data sharing also in line with the European Data Strategy (European Commission, 2022) driving towards the introduction of data intermediaries as enablers of a trustworthy organization of data sharing. These enablers should be supported by technological tools and services for automated compliance in data processing and user-centered data protection and transparency. These enablers should extend existing solution in order to complement existing data spaces to support data sharing and sovereignty. In particular data intermediary has the goals to support the entire ecosystem of entities involved in data sharing, by including in particular the individual in the loop. The European Strategy for Data has endorsed MyData initiative (MyData, 2022) as example how to empower individuals to exercise their rights and to decide at a granular level what is done with their data. MyData principles are also followed in Japan (MyData Japan, 2022) to promote an individual-centered approach to personal data and to empower individuals in order to realize a fair and sustainable society. MyData principles are ones also referred on Minimal interoperability Mechanism (MIM 4) capabilities for Personal Data Management (OASC, 2022) To be in line with the above principles and initiatives e-VITA Platform service descriptions includes a personal data vocabulary application profile based on Data Privacy Vocabulary (DPV) from W3C (W3C, 2022) in order to model in a standard manner the legal basis for the processing of personal data (i.e., purpose, processing, type of data and so on) and to assure interoperability and a fine grained and machine-readable format to be processed in a user centric data usage enforcement. In e-VITA the MyData principles are implemented through the use of CaPe suite for personal data management (Engineering Ingegneria Informatica S.p.a., 2022) (refer to D7.7 (e-VITA, 2022) for further details)

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2 Interoperability recommendations in e-VITA

Starting from the consideration reported in D4.1 (e-VITA, 2021), this section details the main interoperability recommendations that should be followed in order to interact with the e-VITA platform. The provided guidelines are meant to be used, mainly, in a dual manner:

1. To integrate a new device within the platform
2. To allow third-party applications or systems to access the e-VITA users or devices data

Moreover, this section reports the main aspects about security and privacy features that needs to be supported by the devices and/or by the third-party applications that wants to exploit e-VITA capabilities.

2.1 Integration of new Devices

This section details the necessary steps needed to integrate a new device within the platform. It is important to underline that the process of adding a new device within the e-VITA ecosystem implies that:

- from the e-VITA platform point of view, the detail of the device needs to be registered. Such characteristics mainly refer to the type and the attributes of the device. Each attribute represents a field name with its type (e.g. datetime, text, number, etc.) that is included in the payload sent by the device or retrieved through the cloud services exposed by the device's vendor. Moreover, if the device measurements are retrieved from the vendor's cloud system, a specific connector needs to be implemented within the e-VITA platform.
- from the device point of view, if the device sends the data directly or through a gateway, the connection with the platform needs to be implemented at device level providing a payload compliant with the attributes defined within the platform. As defined in section 1.1, such connection can be performed by using the e-VITA APIs or, alternatively, by using MQTT or WebSocket solutions. If the device data are accessible from a cloud system, the platform, through the aforementioned connector, will be able to periodically download the measurements.

Concerning security and privacy of the device, in the context of the interactions with the e-VITA platform, as already detailed in D7.7 (e-VITA, 2022), they are related to the nature of the device. On one hand, if the device itself (or through a gateway) sends the measures to the platform the communication is secured using the so-called parameters *deviceToken* and *deviceId* that are variables generated using UUIDs (IETF, 2005), moreover it is performed through HTTPS. On the other hand, if the e-VITA platform is in charge of accessing the device data from its cloud vendor's platform, the user (e.g. taking advantage of OAuth2) needs to authorize the platform to access the data of the personal device.

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This section details the necessary steps needed to integrate a new device within the platform. These aspects are described in the following table.

Step needed	e-VITA platform requirements
Device characteristics to be provided	• Device name • Device type, or the category in which the device can be placed, such as: - Environmental device - Wearable device - Robot/coaching device • Device measurement attributes set with and their type, i.e. the attributes that characterizes the measurement provided by the device and the value type. For instance, for an environmental device they could be: - Temperatures (number) - Humidity (number) - Pressure (number) - Status (text) Timestamp (datetime)
Define the device sending measurements method	The way in which the device sends its detected measurements can be of two types: • The device sends the data directly or through a gateway **(A)** • The device sends the data to the vendor's cloud system **(B)**
Identify the e-VITA device measurements retrieving method	The e-VITA device measurements retrieving method depends on the device sending measurements method: • In case (A) the device can be configured in such a way as to send its data to the endpoint exposed by the e-VITA platform in order to receive the measurements of the devices. More details regarding this endpoint in in paragraph 1.1.1.1 of this document and in more detail in paragraph 2.1.3.1. of the deliverable D7.4 e-VITA Platform Architecture – Final Version (e-VITA, 2022). In addition to the e-VITA API, the device can send its measurements by using the WebSocket solution. • In case (B) a specific connector needs to be implemented within the e-VITA platform. The connector must be implemented through a set of methods, each of which performs a request to a

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	REST API exposed by the external cloud vendor. Such methods include for example: - the request made to the API exposed by the cloud vendor which produces an access token using the OAuth2 protocol described in paragraph 1.3.2.1, needed to access the device data and to be attached to the other REST APIs. - the request made to the API that refreshes the access token when that expires - the request made to the API exposed by the cloud vendor to read the specific characteristics of the device, such as the unique identification number (MAC) or the installation date of the device - the request made to the API exposed by the cloud vendor to read the measurements provided by the device The e-VITA platform, through the connector, will be able to periodically download the measurements.
Cover the e-VITA security and privacy aspects	The e-VITA security and privacy aspects depend on the device sending measurements method: • In case (A) if the device itself, or through a gateway, sends the measures to the platform using the e-VITA API, the communication is secured using the so-called parameters *deviceToken* and *deviceId* that are variables generated using UUIDs (IETF, 2005) and performed through HTTPS. • In case (B), the e-VITA platform is in charge of accessing the device data from its cloud vendor's platform, the user (e.g. taking advantage of OAuth2 protocol) needs to authorize the platform to access the data of the personal device. Details about this step are described in the paragraph 2.1.3.3. of the deliverable D7.4 e-VITA Platform Architecture – Final Version (e-VITA, 2022).

Table 2 - Device integration requirements

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2.2 Third-party applications/system integration

This section of the document intends to give an overview of the steps needed to allow a third-party application or system to access the data managed by the e-VITA platform.

2.2.1 Third-party application access mode to e-VITA platform data

For a third-party application or an external system to be integrated within the e-VITA platform in order to communicate with it and obtain information, two main steps must be finalized:

1. Registration of the external application: the application must be registered as an external client within the Authorization and Authentication manager component of the platform, implemented using Keycloak. For the registration process to be successful, the application must follow the security standards and capabilities listed in section 1.3.2 of this document.
2. Obtaining a valid JWT token: once the third-party application or system is registered, it is necessary to differentiate among the possible OAuth2 flows to be used, namely Authorization Code flow or Client Credential grant. In particular:
   - Using the Authorization Code flow, the user is able to login the application, by providing valid credentials, and the returned JWT token can be used by the application to interact with the different services exposed by e-VITA platform on his/her behalf.
   - Using the Client Credential grant, the application or service that wants to access the data needs to be registered within CaPe giving information, among others, about which specific data is needed for which purposes. Once the service is registered within CaPe, the user needs explicitly to give his/her consent to the service to access the data. Once the consent is provided, the application or service with its client JWT token can access to the requested information.

   Having a valid JWT token, provided by the Authorization and Authentication manager, allows the third-party application or system to exploit the different capabilities of the platform interacting with the different interfaces listed in section 1.3.1 using the data formats and ontologies listed in section 1.2.

   Please refer to paragraph 2.4 of the deliverable D7.4 e-VITA Platform Architecture – Final Version (e-VITA, 2022) for further details about security and privacy aspects.

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2.2.2 e-VITA platform data categories

The table describes the e-VITA platform data categories that an external application can access, using the JWT token obtained in the previous step.

e-VITA platform data category	Description
User personal data	An external application can access a user's personal data such as the user country and city, language, and so on. It is important to underline that for the external system, in order to access such information, it must be aware of the user's identifier within the platform.
User's devices data	An external application can access information about devices registered by a user such as the name and type of devices, the date of their registration and so on. It is important to underline that for the external system in order to access such information, it must be aware of the user's identifier within the platform.
User's detected emotions	An external application can access the detected emotions related to a user. In particular, since a detected emotion is related to an audio file associated with a device, it can know which device is associated with the emotion, the name of the audio file, the date of detection and so on. It is important to underline that for the external system in order to access such information, it must be aware of the user's identifier within the platform.
User's reminders	An external application can access user-created reminders related to events such as the date on which the user wants to receive an alert to remind a doctor's appointment, the time he want to receive the alert, how often and so on . It is important to underline that for the external system in order to access such information, it must be aware of the user's identifier within the platform.
Historical data of a user's devices	An external application can access the measurements of a user's devices, stored in the e-VITA platform. By selecting the timeslot in which the measurements were stored and the identifier of a user's device, the application can obtain the measurements. It is important to underline that for the external system in order to access such information, it must be aware of the user's and device's identifiers within the platform.
Leaderboards	An external application can access the user rankings of the e-VITA platform users, based on the daily number of steps achieved.

Table 3 - Data Categories

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3 Relevant technical standardizations in Europe & Japan: considerations, open issues and future plans

3.1 Recap of the previous standardization activities in the e-VITA project

There are two activities related to standardization in e-VITA project.

1. to build a virtual coaching system using existing standards
2. to identify targets for standardization from the contents of research and development in the project, and promote them to standardization proposals, including the related parties.

The first point has been covered by Chapter 1, showing the roles of the standards in the interoperability aspects.

To achieve the second point, it was planned to take the approach of extracting standardized items from the results of the project. There are several possible directions for this approach:

- Standardization of interoperability technologies (related to point 1): standardization activities related to these have already progressed to a certain extent, and it was considered difficult to identify the seeds that will lead to a new proposal within the project period.
- Focusing on the functional aspects and effects of the virtual coaching system we are developing, we established it as a use case: this approach was adopted for the e-VITA project.

As a first step, it was decided to work with the goal of adding use cases to IEC TS 63134 (Active assisted living (AAL) use cases) and started contact with the Japan delegates of IEC SyC AAL, which established this TS.

Several use case proposals were set up and examined regarding application fields where the results of the e-VITA project are expected to be utilized. For more information about the analysed use cases and the previous preparatory standardisation activity please refer to the intermediate version of this document, Deliverable D4.2.

Another possible approach for standardization was to organize and abstract a series of activities for the implementation of POC studies in the e-VITA project, such as the training of human coaches, collaboration with local governments, and recruitment of subjects, the approach was examined form the perspective of health management, but it was decided to give priority to use case proposals.

3.2 Current status of the standardization activities

As of the end of March 2023, the leader of the T4.1 on the Japan side was replaced by AIST from JQA. With the transfer of leadership on the Japan side, the use case proposals were reviewed.

When reviewing the proposals, the characteristics of the e-VITA system were defined as "a system in which AI and humans collaborate to provide lifestyle guidance for the older adults."

As a result of studying "a system in which AI and humans collaborate to provide lifestyle guidance for the older adults," the following possible standardization issues were identified.

- Knowledge Structure inside AI
- Handling of personal information

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- Reliability of advice
- Safety of interface
- Information security
- Requirements for service providers

"A system in which AI and humans collaborate to provide lifestyle guidance for the older adults," can be regarded as an application of AI in the AAL context. Therefore T4.1 members on the Japan side have decided to work toward standardization of methods for analysing ethical and moral aspects in such a system.

In the meanwhile, T4.1 members on the European side decided to explore the possibility of standardizing criteria for the protection of personal information based on the findings of the personal information management system used in the e-VITA system.

The immediate goal has been set to review the use case proposals as a basis for task and issue analysis on both Japan side and European side, and propose them to the IEC SyC AAL. We contacted and shared information with the key members of SyC AAL Japan delegates and received their support.

At the IEC SyC AAL Seoul Meeting in September 2023, we proposed a use case and made a presentation on the standardization activities planned to be carried out on the European side. The proposed use case has been accepted for inclusion in IEC TS 63134.

Outline of the proposed use case

The proposed use case is regarding a system in which AI and humans collaborate to generate guidance for the older adults on their daily lives.

A researcher has developed a coaching system in which AI and humans collaborate. He developed the system after reviewing it in the light of the guidelines 'Ethical Considerations in the Application of Artificial Intelligence (AI) in Active Assisted Living (AAL) Contexts'. He analysed the ethical and moral aspects of his coaching system against the guideline. He found that his system has cleared many ethical and moral issues. He also found that there are matters that are missing in the development.

An older adult who lives alone used the coaching system developed by him. Conversations with the coaching system made her more positive. She started to do exercises provided by the care staff based on the information delivered by the coaching system.

Next figure illustrates the use case.

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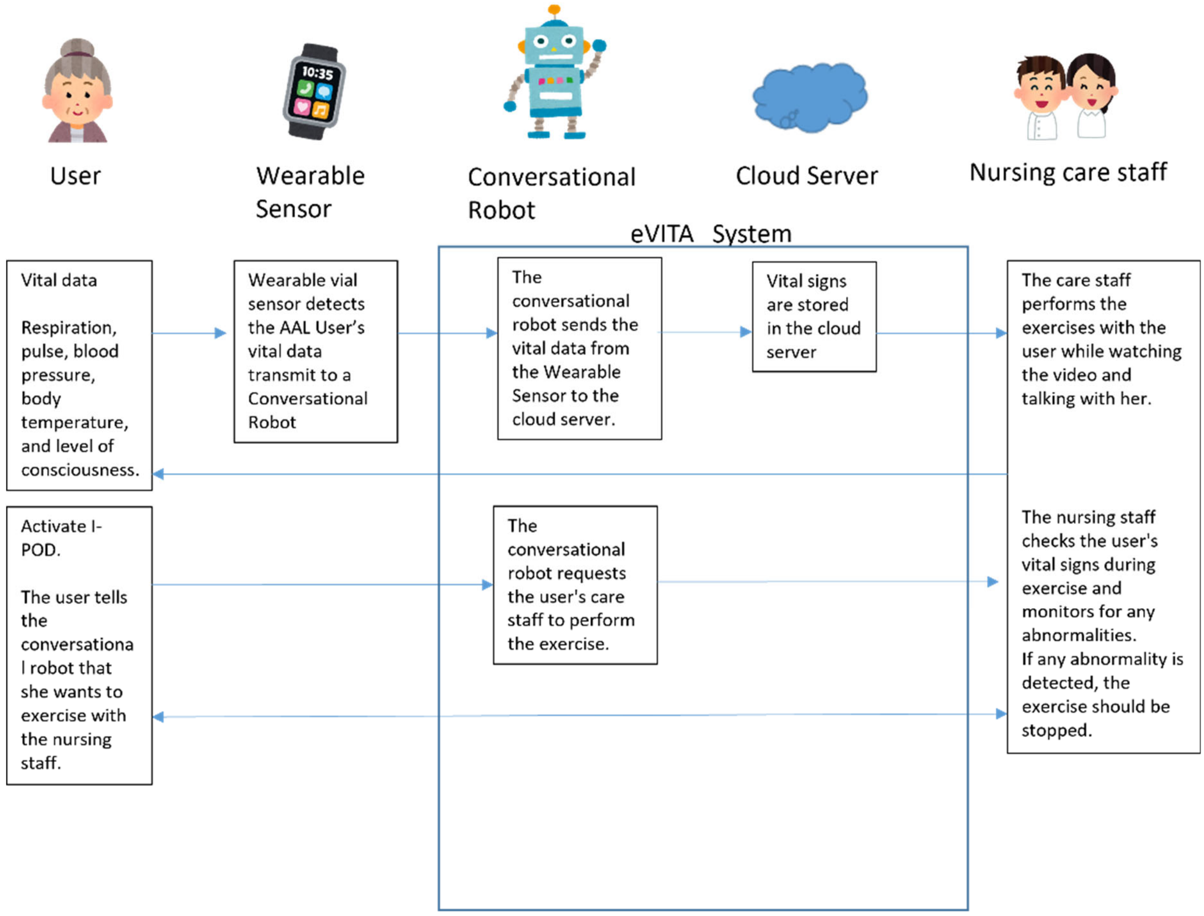

Figure 21 - Use Case of the system in which AI and humans work together to provide lifestyle guidance for the older adults (taken and modified from Figure 20 in D4.2 - Interoperability and standards guidelines for EU/Japan (e-VITA, 2022))

Beside this activity managed by Japanese partners, from European side it was presented a Proposal for IEC SyC AAL standardisation topic related to the Personal Data privacy approach for Active Assisted Living digital services. In particular the proposal was to integrate/reuse in a general architecture for AAL the approach we used in e-VITA for personal data privacy management based on CaPe and the MyData Architecture Framework (https://www.mydata.org/). CaPe is a consent-based and user-centric open source platform targeted at organizations acting as Data Processors, in the private or public sector. It enables them to take advantage of the value of personal data in compliance with GDPR while providing data subjects the natural need to detain both the use and the protection on their own data. CaPe acts as an intermediary and creates a communication channel between Data Subjects and Data Controllers. More details about CaPe and, in general, the privacy approach followed in e-VITA can be found in D7.7 (e-VITA, 2022)

3.3 Future activities and challenges

We are planning to continue the activities for standardization as follows.

Japan side

Using IEC SRD 63416 ("Ethical considerations of artificial intelligence (AI) when applied in the active assisted living (AAL) context") as a norm, a trial assessment will be carried out. In the trial assessment, the ethical and moral aspects of the e-VITA system will be assessed based on the requirements

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described in IEC SRD 63416. The plan is to use the results to create a new proposal for standardization in the future.

European side

A member of the IEC SyC AAL German delegate expressed interest in the presentation at the Seoul meeting, and discussions were held with the European members of the e-VITA project. A discussion inside the consortium has been established to identify and establish a team of people able to follow standardization activities after the end of the project.

Remark

Standardization activities cannot be carried out by the organizations participating in a project alone. Therefore, the cooperation of related organizations is essential. We should continue current cooperation with the related persons in standardization and continue efforts to extract the standardization seeds from the results of the project.

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Conclusion and Outlook

This final version (D4.9) of the "Interoperability and standards guidelines" deliverable marks a significant milestone in the e-VITA project. Throughout this document, we have emphasized the critical role that interoperability and international standards play in ensuring the seamless integration of heterogeneous technologies and devices within the e-VITA coaching system. By adhering to widely recognized international standards, we have not only facilitated interoperability among different technologies but have also laid a foundation for future platform extensions and collaborations with external systems and applications in a secure and standardized manner.

The updates made in this version further enhance the completeness and accuracy of the standards and interoperability approaches adopted in the current implementation of the e-VITA platform. Chapter 1 provided a comprehensive overview of the interoperability aspects, detailing the standards already integrated into the platform and those planned for future enhancements. The inclusion of updated information on device integration, data fusion, and event processing rules reflects our commitment to staying abreast of evolving technological landscapes.

Moreover, Chapter 2 outlined interoperability guidelines, offering external stakeholders a standardized approach to integrate new devices and interact with the platform effectively. The addition of technical details regarding device connections and accessible data categories enhances clarity and accessibility for third-party applications.

Furthermore, Chapter 3 highlights the ongoing standardization activities within the e-VITA project across Europe and Japan, showcasing the collaborative efforts of our international partners in promoting interoperability and reusability across diverse geographical regions. In particular, the standardization activities conducted in e-VITA, demonstrated the potential of e-VITA outcomes as contribution to standardisation groups confirmed by the acceptance of an e-VITA use case into IEC TS 63134 ("Active assisted living (AAL) use cases").

In essence, this document serves as a comprehensive guide, ensuring that interoperability remains at the forefront of the e-VITA project's objectives. By embracing international standards and fostering collaboration among stakeholders, we are not only advancing the capabilities of the e-VITA platform but also contributing to the broader landscape of digital health and well-being solutions.

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