Tailored IoT & BigData Sandboxes and Testbeds for Smart, Autonomous and Personalized Services in the European Finance and Insurance Services Ecosystem

D4.3 – Semantic Models and Ontologies III

Revision Number	3.0
Task Reference	T4.1
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Partners	NOVA, NUIG, BOI
Deliverable Type	Report (R)
Dissemination Level	PU
Due Date	2022-03-31
Delivered Date	2022-03-31
Internal Reviewers	HPE, GRAD
Quality Assurance	CCA
Acceptance	WP Leader Accepted and/or coordinator Accepted
EC Project Officer	Beatrice Plazzotta
Programme	HORIZON 2020 - ICT-11-2018
	This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no 856632

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Revision History

Version	Date	Partner(s)	Description
2.1	2021-09-01	NOVA	Draft ToC
2.2	2021-09-20	NOVA	Review of the global outcomes of T4.1 in light of the current research and development activities
2.3	2022-01-05	NOVA	Adding 2nd Scenario description
2.4	2022-01-12	NOVA	Updating 2nd exemplary Scenario
2.5	2022-01-15	NOVA	Adding 3rd exemplary scenario
2.6	2022-01-28	NUIG	Adding PRIBE ontology to Graph Model Tool in Section 3 and Section 5
2.7	2022-02-5	NOVA, LXC	Adding Section 6 with contributions from LXC
2.8	2022-02-10	NUIG	Reviewing formatting rules
2.9	2022-03-01	NOVA	Pre-Final Version for Internal Review
2.95	2022-03-15	NOVA, GRAD, HPE CCA	Version with Quality Assurance
3.0	2022-03-31	NOVA	Submission Version

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[2] Can be left void

Executive Summary

The purpose of this deliverable, *D4.3 – Semantic Models and Ontologies III*, is to provide the final guidelines and procedures on how to apply the methodology derived and presented in former deliverables (D4.1 – *Semantic Models and Ontologies I [1]* & D4.2 – *Semantic Models and Ontologies II [2])* for building Financial Industry Business Ontology (FIBO), Financial Instrument Global Identifier (FIGI) and Legal Knowledge Interchange Format (LKIF) aligned linked-graphs from available datasets, typically in the form of comma-separated value (CSV).

Reference to the INFINITECH Graph Data Model Online Tool is maintained in this version of the document. This Online Tool supports the creation of semantic data models and knowledge graphs, as well as the data interoperability for Fintech's and Financial Sector. Specific ontologies created by using the semantic alignment methodology are incorporated in this tool, and provide the integration between tasks T4.1 and T4.2.

This deliverable also maintains the references to the semantic layer presented in D4.2, which have a fundamental role in linking pilot-specific data to other components developed within Work Package 4 especially the components developed in task 4.2 – *Massive Distributed Processing of Semantically Linked Streams*.

Since the methodology has already been well established in previous deliverables, in this version the focus has changed from Proof of Concept to execution and validation of the proposed methodology. For this, exemplary scenarios constructed under these same guidelines have been added, in which are presented the outcomes included in the INFINITECH Graph Model Online Tool, and also the functional example of usage of the methodology applied to real-time data streams.

Finally, an overview of the specifications and a viable solution that can be possibly used for demonstrating the integration between Work Packages 3, 4 and 5 is presented, where the adoption of the developed real-time data stream scenario under the guidelines from WP3 will be potentially further built.

This is the 3rd and final version of the document, where the models are finally consolidated and will provide the reference manual with a set of guidelines to enrich pilots' datasets with semantics, and connectivity to other components that can potentially use the semantically created data.

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Abbreviations/Acronyms

Abbreviation	Definition
AI	Artificial Intelligence
CSV	Comma-Separated Values
DILIGENT	The methodology for distributed, loosely-controlled and evolving engineering of ontologies
ETL	Extract, Transform and Load
FIBO	Financial Industry Business Ontology
FIGI	Financial Instrument Global Indentifier
ICT	Information and Communication Technology
IoT	Internet of Things
JDBC	Java DataBase Connectivity
JSON	JavaScript Object Notation
JSON-LD	JavaScript Object Notation for Linked Data
LKIF	Legal Knowledge Interchange Format
MiFID	Markets in Financial Instruments Directive
MiFIR	Markets in Financial Instruments and Amending Regulation
NDA	Non-Disclosure Agreement
NIS	Network and Information Systems
OES	Operators of Essential Services
OLAP	On-Line Analytical Processing
OLTP	On-Line Transaction Processing
OWL	Web Ontology Language
PAN	Primary Account Number
PaaS	Platform as a Service
PCI DSS	Payment Card Industry Data Security Standard
PIA	Privacy Impact Assessment
PSD2	Payment Service Directive 2
PSP	Payment Service Provider
PSU	Payment Service User

P2PP	Peer-to-Peer Payment
RDF	Resource Description Framework
SaaS	Software as a Service
SAMOD	Simplified Agile Methodology for Ontology Development
SAMPLE-FIN	Semantic Annotator-Middleware Pre-Processing Layer for Fintech`s
SAWSDL	Semantic Annotations for Web Service Description Language
SQL	Structured Query language
SotA	State of the Art
SVG	Scalable Vector Graphics
TAG-Tool	Translators Automatic Generation Tool
TTL	Turtle - Terse RDF Triple Language
UPON-Lite	Lightweight Unified Process for Ontology building
WSDL	Web Service Description Language
WWW	World Wide Web
XML	Extensible Markup Language
XSD	XML Schema Definition

1 Introduction

1.1 INFINITECH Scope

Most of the data collected and possessed by financial organizations resides in a wide array of "siloed" (i.e. fragmented) systems and databases, including operational systems and On-Line Transaction Processing (OLTP) databases, On-line Analytical Processing (OLAP) databases and data warehouses, data lakes and others. In this fragmented landscape, heavy analytical queries are usually performed over OLAP systems, which leads financial organizations to transfer data from OLTP, data lakes and other systems to OLAP systems based on intrusive and expensive Extract-Transform-Load (ETL) processes. In several cases, ETLs consume 75%-80% of the budget allocated to data analytics, while being a setup to seamless interoperability across different data systems using up-to-date data. Beyond the lack of integrated OLTP & OLAP processes, financial/insurance organizations have no unified way of accessing & querying vast amounts of structured, unstructured and semi-structured data, which increases the effort and cost that is associated with the development of BigData analytics and Artificial Intelligence (AI) systems. Beyond data fragmentation, there is also a lack of interoperability across diverse datasets that refer to the same data entities with similar semantics. This is a main obstacle to datasets sharing across different stakeholders and to enabling more connected applications and services that span multiple systems across the financial supply chain.

1.2 Work Package 4 Overview

The Work Package 4 (WP4) – *Interoperable Data Exchange and Semantic Interoperability* focuses on establishing the foundation for common, shared meaning across the several data sources and message and event feeds within the INFINITECH platform while facilitating the technical implementation of the INFINITECH principles. In this landscape, WP4 sets the following objectives:

1. Defined shared semantics (ontologies) for semantic interoperability of BigData and IoT streams in the finance/insurance sectors;
2. Provide the means for scalable the massive analytics over linked semantic streams;
3. Provide a permissioned blockchain solution for exchange data across different organizations in the finance and insurance supply chains;
4. Enhance the permissioned blockchain of the project with tokenization functionalities, as means of enabling digital assets trading; and
5. Implement techniques for secure querying of encrypted personal data over a blockchain.

Taking into account the overall objectives, the following set of tasks have been envisioned for WP4:

- **Task 4.1 - Shared Semantic for BigData and IoT Streams**: This task will specify models and ontologies for semantic interoperability of diverse applications in the finance and insurance sectors. It will extend and integrate ontologies such as Financial Industry Business Ontology (FIBO)/Financial Instrument Global Identifier (FIGI) with additional concepts associated with INFINITECH applications and testbeds. The task will produce the project's ontology for semantic interoperability, which will provide the concepts needed for annotating and linking diverse data streams.

- **Task 4.2 - Massive Distributed Processing of Semantically Linked Streams**: This task will provide a prototype implementation of the Super Stream Collider (SSC) engine, that will enable analytics for semantically linked streams (linked data). The engine will be scalable and suitable for massive parallelization in cloud environments. It will be implemented on top of NUIG's SSC component, which

will be customized in order to support linked data in-line with the shared semantics specified in Task 4.1.

- **Task 4.3 - Distributed Ledger Technologies for Decentralized Data Sharing**: This task will implement permissioned blockchain infrastructures based on Corda R3 and/or the open source Hyperledger Fabric project. These blockchains will be customized in order to support the requirements of the financial sector, including data models, authentication and authorization mechanisms, as well as APIs for implementing Ledger Clients for financial/insurance sector applications. The infrastructure will be integrated to existing BigData/ IoT platforms in the testbeds, based on appropriate ledger clients.

- **Task 4.4 - Tokenization and Smart Contracts Finance and Insurance Services**: This task will enhance the permissioned blockchain with cryptographic tokenization features, as a means of enabling assets trading. Likewise, the task will specify and implement Smart Contracts for adding and retrieving information on the tokenized blockchain for all the essential data exchange use cases of the project's pilots. The applications will provide the means for trading access to data and information through the permissioned blockchain. The task will specify and implement ledger protocols for the financial/insurance applications at hand, including trading protocols.

- **Task 4.5 - Secure and Encrypted Queries over Blockchain Data**: This task will implement and provide a framework for querying encrypted data over the project's permissioned blockchain infrastructure. It will exploit and customize algorithms from the OPAL project, based on Multi-Party Computation (MPC) and Linear Secret Sharing (LSS) schemes (i.e. homographic encryption). The mechanisms to be implemented will resemble Enigma's (enigma.io) Personal Data Management infrastructure, through the integration of consent mechanisms that will enable consumers/customers to provide consent for access to their data through the blockchain. In conjunction with the trading and tokenization functionalities of the blockchain, this task will create a foundation for creating a personal data market where customers will be able to trade their data in exchange for tokens on other assets.

- **Task 4.6 - Situation Awareness Front-End over Aggregated Information**: This task will provide a web-based framework for the visualization of the aggregated results of analytic algorithms developed in the scope of the project, and more generally of all information of relevance. The framework will be based on the community edition of Knowage, an OS solution for BI, which is part of the OW2 community. The Knowage suite will be extended and customized in order to support specific data models (Task 4.1) and persistence technologies (Task 4.2 & Task 4.3). The visualization functionality will allow users to assemble personalized dashboards for situation awareness, wiring together related information from different sources. Special emphasis will be paid to visualizing information from distributed ledgers.

Table 1-1 – WP4 Deliverable List

No.	Deliverable	Task	Responsible Partner	Contributors
4.1	Semantic Models and Ontologies - I	4.1	NUIG	NOVA, BOI
4.2	Semantic Models and Ontologies - II	4.1	NOVA	NUIG, BOI

4.3	Semantic Models and Ontologies - III	4.1	NOVA	NUIG, BOI
4.4	Semantic Streams Analytics Engine - I	4.1, 4.2	NUIG	NOVA
4.5	Semantic Streams Analytics Engine - II	4.1, 4.2	NUIG	NOVA
4.6	Semantic Streams Analytics Engine - III	4.1, 4.2	NUIG	NOVA
4.7	Permissioned Blockchain for Finance and Insurance - I	4.3	UBI	GFT, HPE, ENG, SIA, INNOV, UNIC
4.8	Permissioned Blockchain for Finance and Insurance - II	4.3	UBI	GFT, HPE, ENG, SIA, INNOV, UNIC
4.9	Permissioned Blockchain for Finance and Insurance - III	4.3	UBI	GFT, HPE, ENG, SIA, INNOV, UNIC
4.10	Blockchain Tokenization and Smart Contracts - I	4.4	IBM	HPE, ENG, BOUN
4.11	Blockchain Tokenization and Smart Contracts - II	4.4	IBM	HPE, ENG, BOUN
4.12	Blockchain Tokenization and Smart Contracts - III	4.4	IBM	HPE, ENG, BOUN
4.13	Encrypted Data Querying and Personal Data Market - I	4.4, 4.5	FBK	HBE, INNOV, UNIC
4.14	Encrypted Data Querying and Personal Data Market - II	4.4, 4.5	FBK	HBE, INNOV, UNIC
4.15	Encrypted Data Querying and Personal Data Market - III	4.4, 4.5	FBK	HBE, INNOV, UNIC
4.16	Visualization Front-End for Aggregated Information - I	4.1, 4.2, 4.3 4.6	ENG	
4.17	Visualization Front-End for Aggregated Information - II	4.1, 4.2, 4.3 4.6	ENG	

1.3 Objective of the Deliverable

INFINITECH testbeds & pilots are characterized by a very large number of heterogeneous and geographically distributed data sources such as Internet-of-Things (IoT) devices and sensors, other software applications, infrastructure components and services, as well as remote data storage and processing locations. In this landscape, interoperability arises different concerns and challenges that need to be properly handled.

The purpose of the deliverable D4.1 - *Semantic Models and Ontologies - I* is to deeply analyse the main problem of interoperability in the financial and insurance application context. The document is intended to augment and complete the INFINITECH Reference Architecture (INFINITECH-RA) – presented in the deliverable D2.13 – with an interoperability perspective i.e. to extend the INFINITECH-RA with specifications, guidelines and best practices for designing semantic models for diverse applications and testbeds to support the design and development of interoperable services in line with the INFINITECH service platform. To do so an **interoperability framework** is conceived. As a central element of this framework a **methodology** for rapid ontology engineering and building will be proposed to help experts to systematically describe and explore their own business to enable the usage of all the features and capabilities of the INFINITECH platform.

Interoperability is a critical issue in all the applications that need communication, cooperation and collaboration of humans, numerous distributed heterogeneous devices, components and/or services within Information and Communication Technology (ICT) systems. It plays a fundamental role whenever the designed system/platform will be part of a large ecosystem with different stakeholders.

The analysis carried out in this document delivers:

1. how-to description for testbed & pilot owners aligns, integrate and feed the INFINTECH platform with their own data;
2. how-to description for experiments owners aligns and use data stored and generated within the INFINITECH platform within their services and/or applications; and
3. how-to external applications can access multiple ontologies seamlessly.

In the 2nd version (preceding the 3rd, i.e. current, edition) of this document, the fundamental foundation for guidance and guidelines on how to enable testbeds and pilots to align their data to INFINITECH semantic model and ontology was provided, by the adoption of a proposed methodology and supporting technologies. In this 3rd and final version, the focus is on the validation of the methodology by means of its application to different scenarios, and also considering integration with different tasks and Work Packages within INFINITECH.

1.4 Structure

The current document is structured as follow:

- Section 1. *Introduction* details the document context, purpose and intended audience, as well as the overall strategy applied in the WP4 while underlining the role played by this document with respect to the whole project;

- Section 2. *Background: Relevant Inputs from Deliverable version 2* summarizes the main outcomes fully documented in the former version of the current document. These outcomes are then analysed in light of the current status of the research and developments in the Task 4.2;

- Section 3. *INFINITECH graph-data-model Online Tool* introduces the INFINITECH Project Online Ontology Mapping Framework and Toolkit, it includes the Graph Data Model, the Data Sharing Files and Ontology Files provided for the intended use in the INFINITECH project pilots, this tool together with the semantic alignment methodology and supporting technologies comprise the tools that facilitates semantic interoperability. INFINITECH Graph Data Model tool is accessible at (http://graph-data-model.infinitech-h2020.eu/).

- Section 4. *Characterizing the Semantic layer* describes the *Semantic Layer* that represents the main component for enabling semantic interoperability within the INFINITECH platform. This section describes the functionality of the component, presents its architecture and role within the platform as well as its capabilities;

- Section 5. *Exemplary Application Scenarios* provides an extensive scenario for providing guidance and guidelines on how-to apply the INFINITECH Methodology for building semantic models and ontologies in line with the INFINITECH platform. On the other hand, other scenarios are included which aim to visualize usage of exemplary data to build domain specific ontologies aligned with top-level reference ontologies, and also to present a practical use case of the methodology applicability with real-time data streams. The section is the continuation of the section 5 in deliverable D4.2 – *Semantic Models and Ontologies - II* and is related to some pilots that are part of the project;

- Section 6. *WP3/WP4/WP5 integration specification* provides an overview of the current work related to the integration between work packages. Considering the specification inputs of WP3, an architecture is defined to serve as a guideline for building a demonstrator encompassing components/features of the different involved work packages.

- Section 6. *Conclusions* extracts the main conclusion and final remarks;

- *Appendix A*: Preliminary Analysis of pilot's specifications used for semantic alignment

- *Appendix B*: dataworld.com (auxiliary tool) API documentation

- Appendix C: GraphDB / Ontotext (auxiliary tool) APIs documentation

2 Background: relevant Inputs from previous versions

This section is intended to present the main outcomes of the work carried out and reported since the beginning of the Task 4.1. The proposed INFINITECH Semantic Interoperability Framework is presented together with the proposed approach and methodology to include semantic in application specific data. The end of the section is focused on highlighting the connection of this work with the other relevant tasks within the WP4, especially with task 4.2 – Massive Distributed Processing of Semantically Linked Streams.

2.1 INFINITECH Semantic Interoperability Framework

The INFINITECH Semantic Interoperability Framework can be defined as follow:

The INFINITECH Semantic Interoperability Framework is a commonly agreed approach to enable semantic interoperability between applications and services within the INFINITECH platform while defining basic interoperability guidelines in the form of common principles, models and recommendations. Furthermore, as part of the framework, ontology mapping processes are also considered to establish a common platform to deal with multiple ontologies.

In this document, exemplary scenarios are presented to support and demonstrate how developers can describe their dataset to be integrated and ingested by the INFINITECH platform. This framework comprises both manual and (semi)automatic software functionalities and technologies to enable the data transformation and integration while paving the way to newer and deeper usage of analytics.

2.1.1 Proposed Approach for Interoperability

The proposed approach for generating INFINITECH Semantic models and Ontologies combines top-down and bottom-up approaches (see Figure 2-1). The latter - also called Pilot Characterization - is aimed to describe the specific application domain for each one of the testbeds and pilot within the project. The main objective here is the identification, definition and the clear description of the context of application in terms of domain terminologies, glossaries and taxonomies. The former - also called State of the Art (SotA) analysis - is aimed to identify reference ontologies for considered domains (finance and insurance), these ontologies are not linked to a specific application domain. The main objective here is the identification of a common and above all generic set of core concepts and relationships between them that can be used as top ontology i.e. the glue between diverse specific domain ontologies for the same context of application.

In both cases, the combination of the results of the Pilot Characterization and SotA analysis are used as inputs of the INFINITECH Methodology for Semantic Models and Ontologies and used for generating the INFINITECH models, as well as serving as a baseline for the development of transformers that need to be used to exploit all the features and full potentiality of the INFINITECH platform.

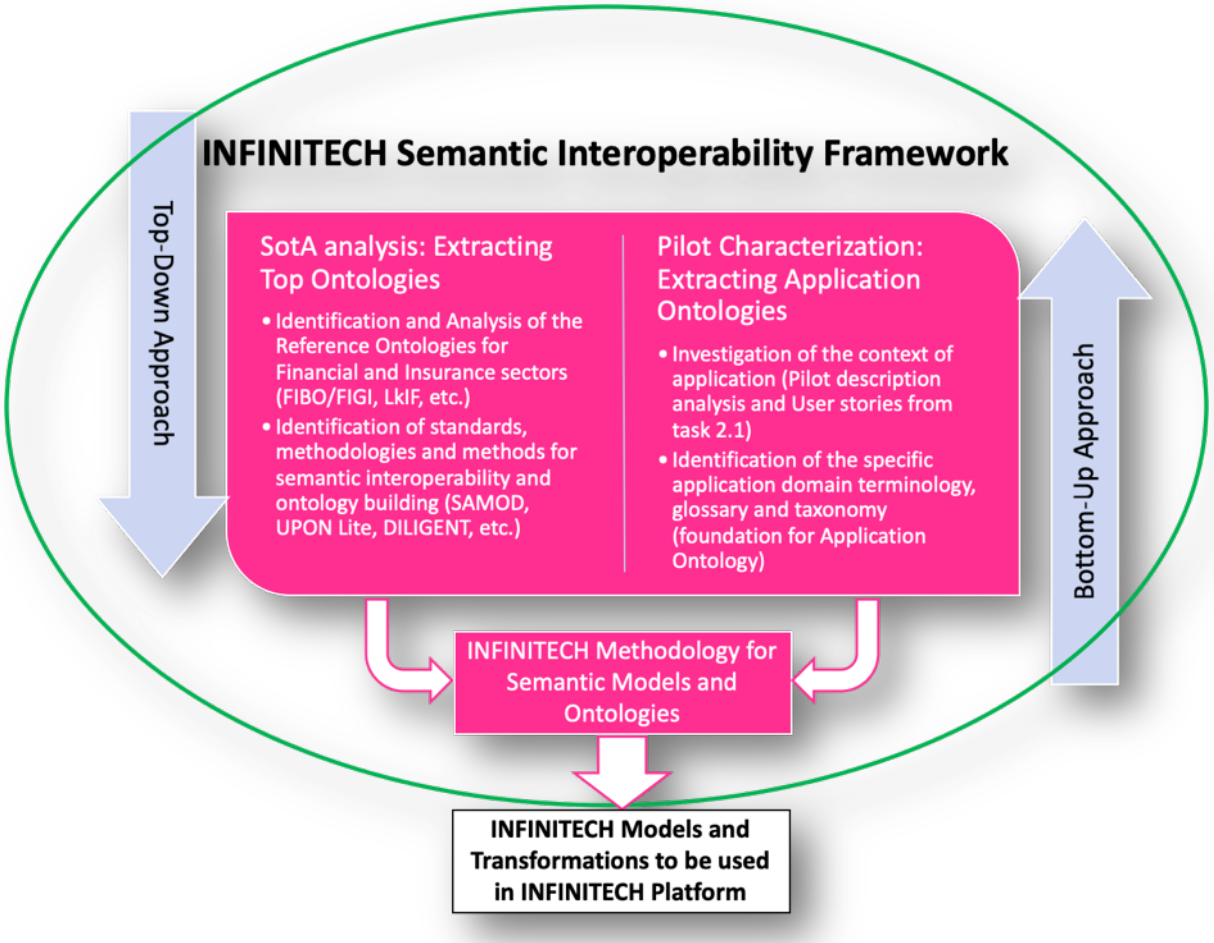

Figure 2-1 – Proposed Approach for Interoperability in INFINITECH

The development of data transformers takes time and is a long process that includes the overall enterprise and/or financial organizations strategy. This means that data management is a struggling activity that requires a new approach. To do that high-impact, small and targeted use cases need to be selected (as also explained in [3]).

2.1.2 Methodology for Semantic Models, Ontologies Engineering and Prototyping

Ontologies are the baseline for developing Semantic applications. Ontologies are conceptual models - constituted by interlinked concepts related to a specific domain - of an observed reality. An ontology is a conceptual model of (a fragment of) an observed reality. Since ontologies play a fundamental role in INFINITECH by means of providing the necessary mechanisms for describing testbeds and pilot application domain then a systematic engineering approach is needed to facilitate the design and development of high-quality and, above all, pilot-aligned ontologies to reference top-level ontologies for the domain.

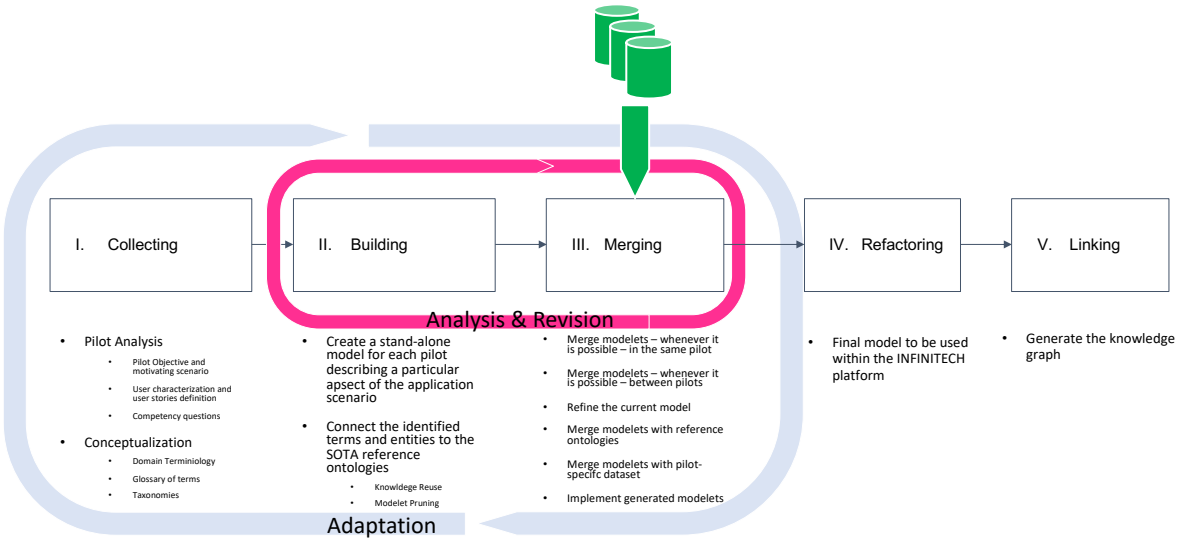

Figure 2-2 – INFINITECH Methodology for Ontology Engineering

As shown in Figure 2-2, the INFINITECH Methodology for Ontology Engineering shares terminology, definitions, and activities and/or steps with the Simplified Agile Methodology for Ontology Development (SAMOD)[4]. It is an iterative process that is aimed at building semantic models and ontologies by applying four steps. It is organized as a sequence of four sequential steps, namely:

1. *Collecting*: gathers all the information about the application domain. It involves the following tasks and/or activities:
    a. Pilot Analysis: write down the motivating scenario, identify user expectation by writing down *user stories* and clarifying everything by using a set of competency questions (User characterization); and
    b. Conceptualization: write down domain terminology, glossary of terms and taxonomies of concepts.
2. *Building*: generates a new Interoperability test case (*aka Modelet*). The *Modelet* is a stand-alone model describing the application domain for the considered pilot and/or testbed. The step involves the following tasks and/or activities:
    a. Creation of a stand-alone model for the pilot or testbed describing the relevant aspects of the application domain;
    b. Connection with the top reference ontology(ies). This activity is aimed to reuse as much as possible already-defined concepts, relations and properties while pruning all the elements that are superfluous.
3. *Merging*: refines the generated *Modelet* with concepts and relations extracted from reference ontologies for the domain to determine more generic domain ontologies. The step involves the following tasks and/or activities:
    a. Merge *Modelets* in the same pilot/testbed;
    b. Merge *Modelets* between different pilots/testbeds within the same application domain;
    c. Refinement of the current Modelet;
    d. Merge *Modelets* with reference ontologies;
    e. Merge *Modelets* with pilot-specific dataset schema; and
    f. Implement generated *Modelets*.

4. *Refactoring*: This step provides the final ontology and semantic model as conceptual schema to be used within INFINITECH. This model delivers the complete description and characterization of the application domain aligned with reference ontologies while enabling any user of the INFINITECH application to seamlessly access diverse ontologies and thus concrete data.
5. *Linking*: maps the refactored models to real data while generating the so-called linked knowledge graph.

Two iteration cycles (Analysis & Revision and Adaptation) are part of the methodology. The Analysis & Revision iteration (executed essentially during the *Building* step) is aimed at analysing and reviewing the building process to guarantee the alignment with the domain expert's expectations and requirements. The result of this step and related iterations is a preliminary model also called *Modelet*. The Adaptation iteration includes the steps *Collecting*, *Defining* and *Merging* and is aimed to refine the generated *Modelets* to cope with new knowledge and or any change in user characterization, user needs, application domain or, more in general, any change that directly could have impact on the way domain experts describe their own business and - thus - application domain.

Generated *Modelets* are very specific and targeted conceptual models that need to be filled and populated with dynamic data from typically heterogeneous and distributed resources. Here is where the semantic graphs and/or knowledge graphs play a fundamental role.

2.1.2.1 Modelling Method

The main result of the application of the INFINITECH methodology for Semantic Models and Ontologies Engineering and Prototyping is an evolving conceptual schema (e.g. ontology) and linked knowledge graph that empowers the INFINITECH platform with the ability to access, query, use and process/analyse data and/or information from heterogeneous and distributed sources.

The conceptual schema is determined by using an evolving prototyping (foundation of agile software methodologies like DevOps) approach, where it grows up by layers while continuously delivering software prototypes. In particular the conceptual model is the combination of three layers, according to [5]:

- Top-level Ontology: describes in a very high-level concepts of interest for the domain;
- Domain Ontology: describes specific concepts typically related to sub-domains of the top-level model; and
- Application Ontology: describes very specific concepts related to the particular application and scenario.

The layered model allows easy adaptation and extension while enabling for knowledge reuse, i.e. to reuse as much as possible currently available ontologies and models. As a matter of fact, this model facilitates the adaptation to various applications as well as new domains.

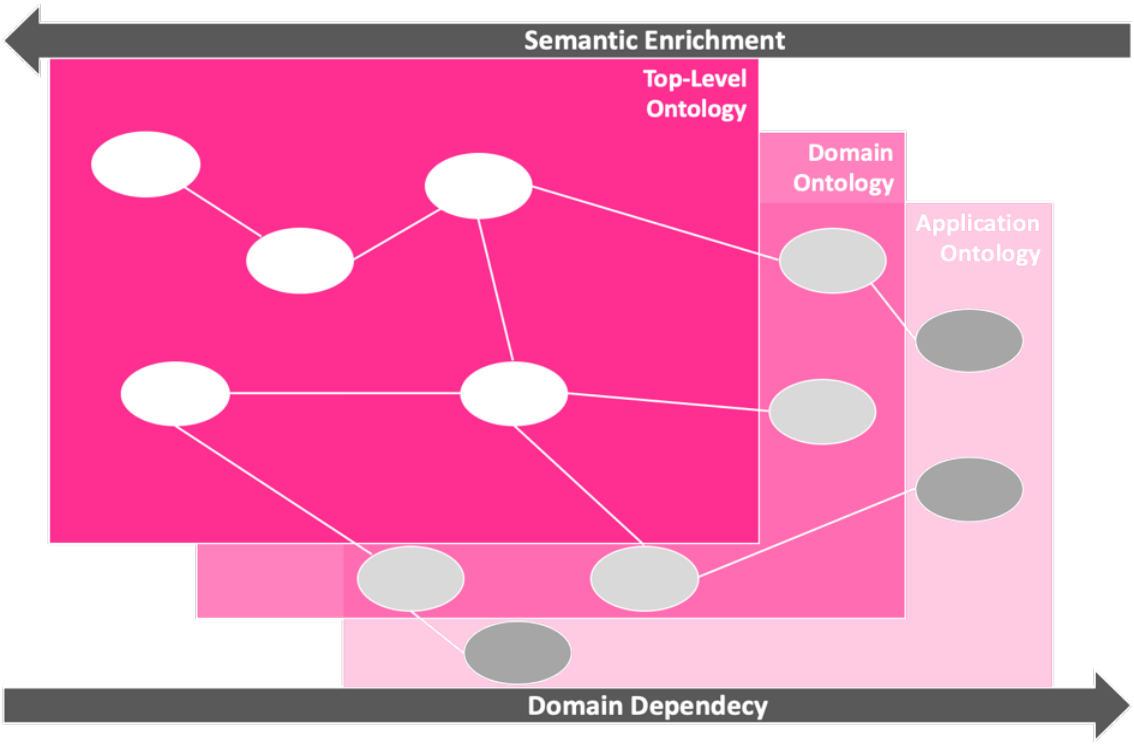

Figure 2-3 – INFINITECH Semantic Model and Ontology Example

2.1.2.2 Rules and Functions in Semantic Models, Ontologies Engineering and Prototyping

Several actors are typically involved in the process of defining, specifying and developing semantic models and ontologies. In particular the ontology engineering process is a collaborative process among several stakeholders. Since the main objective of the INFINITECH methodology for Semantic Models and Ontology Engineering is to provide a stakeholder-centric approach, it is necessary to identify the main roles and functions of the distinct actors of the process. The engineering process starts by having a small group composed of the following stakeholders: domain experts, end-users, knowledge and ontology engineers.

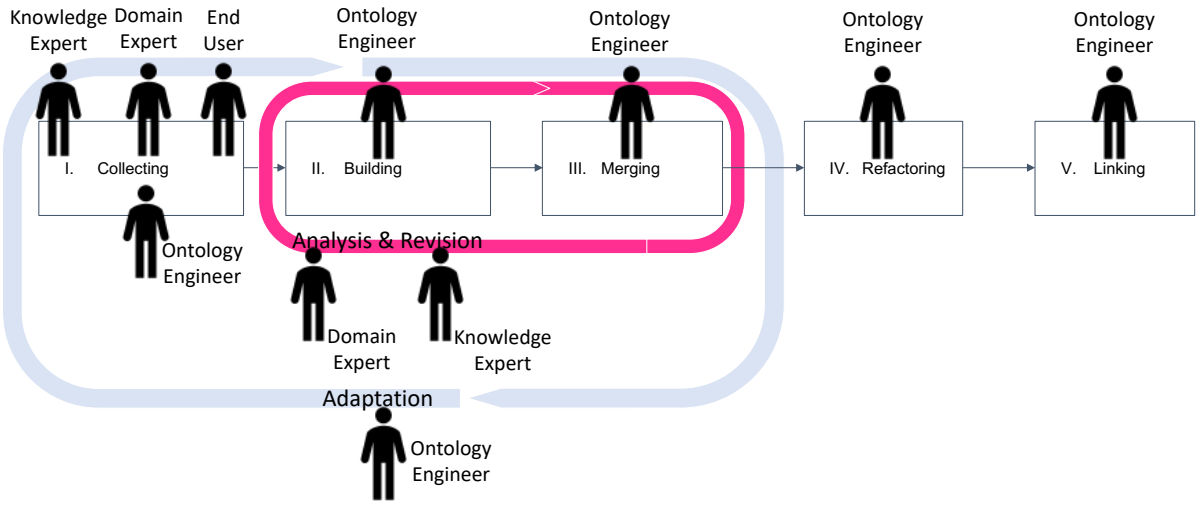

Figure 2-4 – Roles and Functions in INFINITECH Semantic Models and Ontologies Engineering and Prototyping

2.2 INFINITECH Core Models and Data Pack

This section is aimed to introduce the progress on the INFINITECH Data Modelling work and the Semantic Alignments as a first approach on using the Semantic Interoperability Framework.

The INFINITECH Data Modelling is a continuous activity that relies on the identification of the vocabularies and terms used in the different financial domains (sectors) involved in the INFINITECH project. The Semantic alignments provide semantic interoperability between applications and services within the INFINITECH platform while defining basic interoperability guidelines in the form of common principles, models and recommendations. Furthermore, as part of the framework, ontology mapping processes are also considered to establish a common platform to deal with multiple ontologies.

In the first version D4.1 [1] of the present document a preliminary analysis of the reference models was carried out. This analysis, also called Semantic Model Design, has been focused on the reference ontologies like FIBO, Lkif and FIGI to extrapolate common concepts and relations while avoiding repetitions and overlapping. The main objective is the design and development of the *Data Pack,* i.e. a set of files, schemas and metadata model diagrams that represent the way INFINITECH core is organized and structured.

The INFINITECH core model and data pack define a *lingua franca* necessary to minimize the shortcomings of fragmented data from distinct data silos while harmonizing the data organization and knowledge representation within enterprises. In particular, the financial sector is covered by using FIBO as reference model while insurance sector is covered by LKIF. Furthermore, data pack ontologies and models for Internet-of-Things (IoT) derived from FIESTA-IoT or OpenIoT, are also considered, in order to take into account one of the technologies that is driving the digital transformation where data are provided by ubiquitous devices.

3 INFINITECH Graph Data Model Online Tool

The online tool presented in the INFINITECH graph-data-model sub-domain[3] refers to the INFINITECH Project Online Ontology Mapping Framework and Toolkit, it includes the Graph Data Model, the Data Sharing Files and Ontology Files provided for the intended use in the INFINITECH project pilots.

3.1 Data Interoperability for Fintech's and Financial Sector

The INFINITECH Graph data modelling is the process in which a user describes an arbitrary domain as a connected graph of nodes and relationships with properties and labels. This activity uses a reference graph data model to establish the most relevant relationships, connecting with Task 4.2 – Massive Distributed Processing of Semantically linked Datastreams.

The INFINITECH Data Pack is the set of files, schemas and metadata model diagrams (Graphs) that represent the way the INFINITECH data is organised and structured. It contains the metadata in Terse RDF Triple Language - *Turtle (TTL)* in addition to metadata in two different formats, *JSON for Linking-Data (JSON-LD)* and *Web Ontology Language (OWL)* to ensure the Data Pack is accessible to different communities.

The INFINITECH Graph Data Model is the documentation that describes in detail all the taxonomies and vocabularies from INFINITECH Core, FIBO, FIGI and LKIF domains used in INFINITECH. It describes and represents all the relationships between them to build the Data Representation of the INFINITECH Graph Data Model.

The Ontologies section contains the online machine-readable files in TTL, OWL and JSON-LD format for online accessibility. These files are maintained and updated regularly to keep the latest version of the ontology files up to date.

The Support Section presents some tools that are provided to facilitate the data sharing and data exchange, and to introduce the basic process for understanding and adopting the interoperability requirements in the INFINITECH project. In this section the mechanism for how the data model is maintained is included.

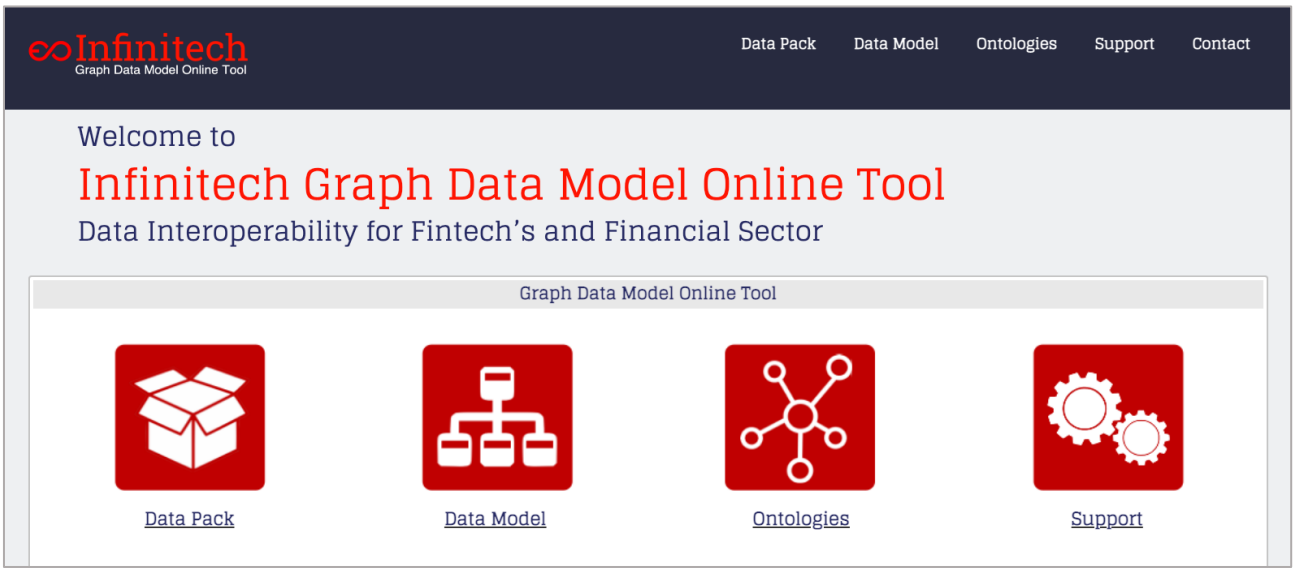

Figure 3-1 – INFINITECH Graph Data Model Online Tool Sections

[3] http://graph-data-model.infinitech-h2020.eu/

3.1.1 Data Pack

The Data Pack is the set of files, schemas and metadata model diagrams (Graphs) that represent the way the INFINITECH data is organised and structured, and as stated in the former section, it contains the metadata in standard formats such as .ttl, .json-ld and .owl, to ensure the Data Pack is accessible to different communities. The current complete Data Pack can be found in the Figure 3-2 below.

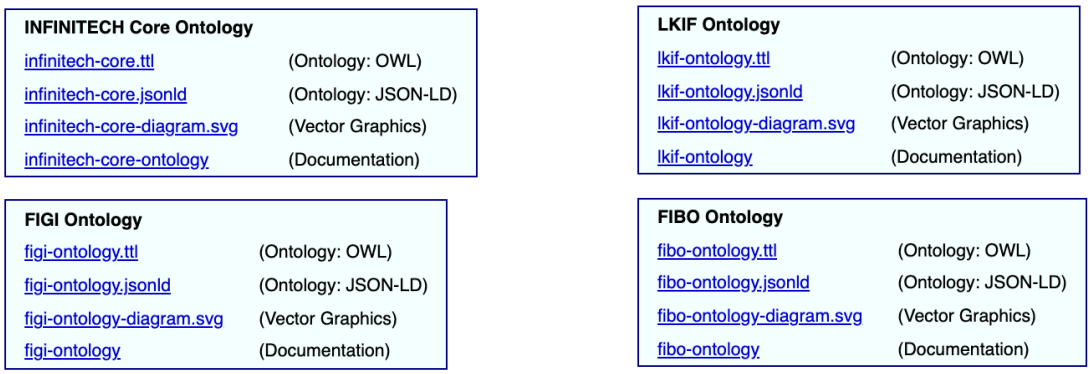

Figure 3-2 – INFINITECH Graph Data Pack

3.1.2 Data Model

The Graph Data Model is the documentation that describes in detail all the taxonomies and vocabularies from INFINITECH Core, FIBO, FIGI and LKIF domains used in INFINITECH and that describes and represent all the relationships between them to build the Data Representation of the INFINITECH Graph Data Model, as depicted in Figure 3-3

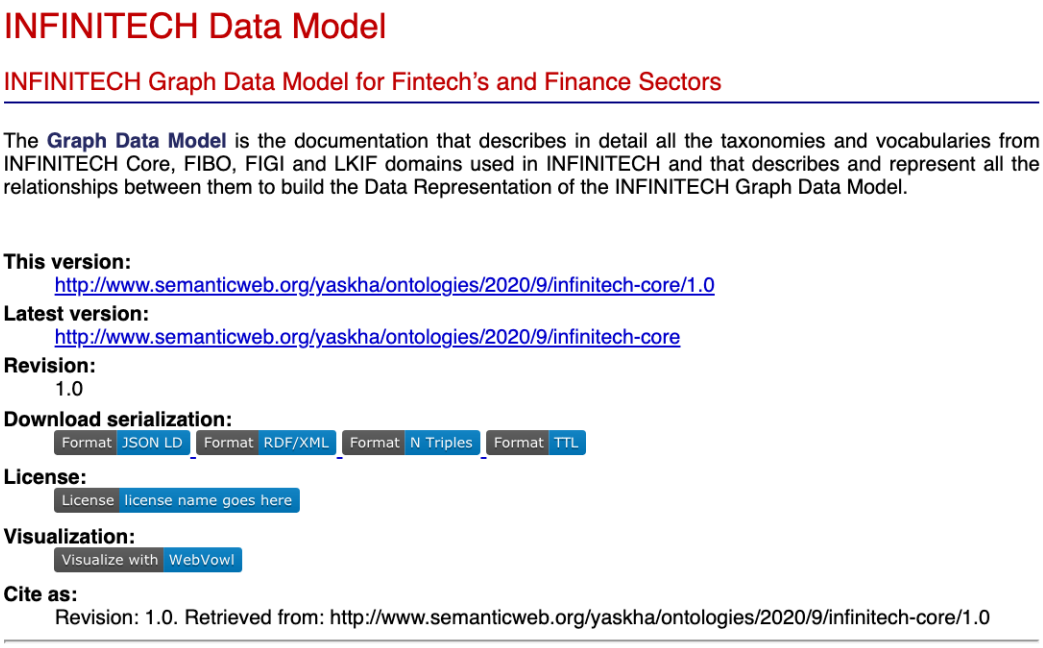

Figure 3-3 – INFINITECH Graph Data Model Online Tool Sections

3.1.3 Ontologies

The INFINITECH Ontologies is the section at the online repository dedicated to store the ontologies that are relevant to the project as shown in Figure 3-4. The ontologies are machine readable files and in INFINITECH the TTL and JSON-LD formats are supported. The online repository also contains the graphic representation in Scalable Vector Graphics (SVG) format.

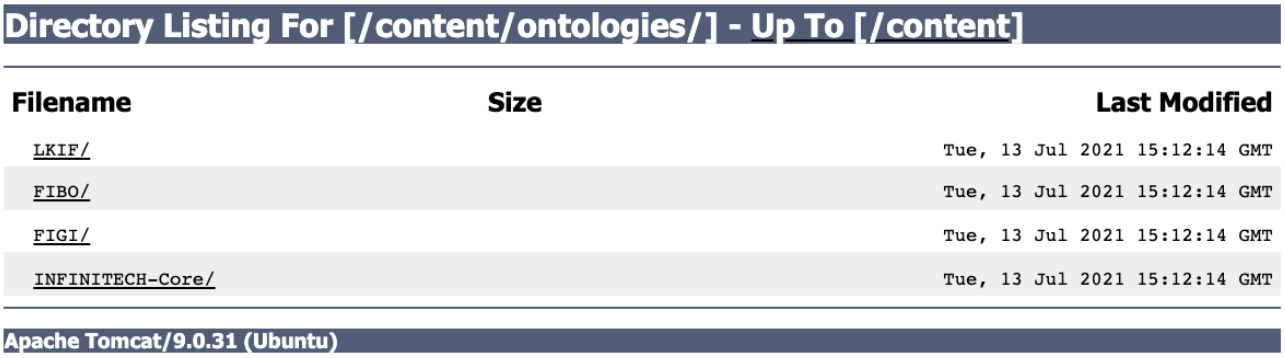

Figure 3-4 – INFINITECH Graph Data Model Online Tool Sections

3.1.4 Support

Figure 3-5 shows the INFINITECH Support, support section in the online repository. It provides tools and methods that facilitate the INFINITECH Core and other Ontologies understanding and adoption, it also provides guidance and support for experts and non-experts in the activity of data modelling.

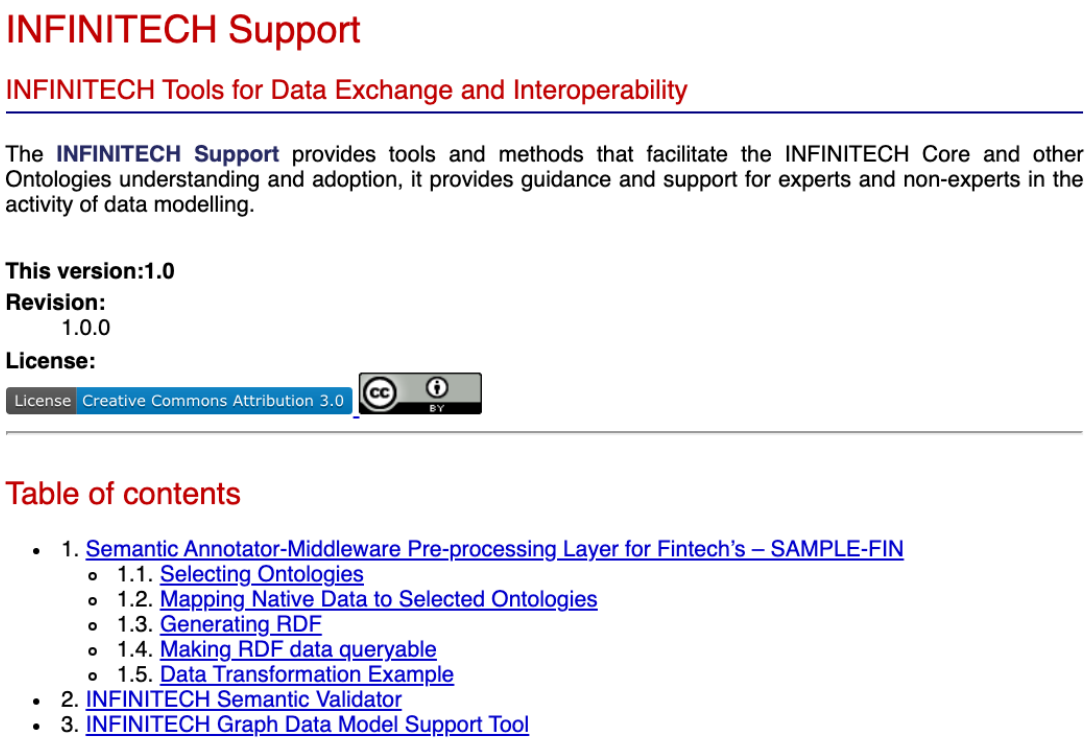

Figure 3-5 – INFINITECH Data Model Online Support Tools

3.1.4.1 Semantic Annotator-Middleware Pre-Processing Layer for Fintech`s (SAMPLE-FIN)

The SAMPLE-FIN helps to transform your data to RDF format. First the user needs to find an ontology which can be used to model its native data in RDF format. In the case of the INFINITECH project, there are several ontologies available in the INFINITECH Data Pack, as was visible in Figure 3-2. The outcome of this task is the transformation of data in a native format (like .csv) into RDF format.

Each step of SAMPLE-FIN is explained in detail in the Deliverable D4.5 – *Semantic Streams Analytics Engine – II* [6], which is a core process tool for the data sets and stream processing semantic Engine (SeSA-ME) also listed as a set of tools which can be used to perform semantic interoperability in the context of task 4.2.

3.1.4.2 INFINITECH Semantic Validator

The semantic validator (see Figure 3-6) allows INFINITECH developers to validate their data against the most used financial vocabularies and their related ontologies. Users can upload their data from a file or directly add the data in the provided textbox. The semantic validator service will compare the data provided against the selected ontology and the result of the validation gives a validation report that provides inconsistencies with the data.

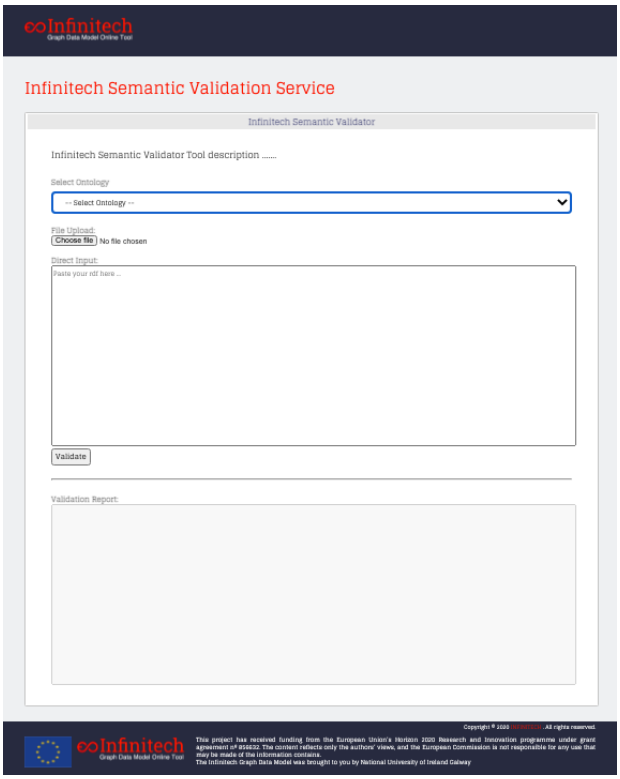

Figure 3-6 – INFINITECH Semantic Validator Online Tool

3.1.4.3 INFINITECH Graph Data Model Support Tool.

The INFINITECH Graph Data Model Support tool project is under development: it will be the mechanism to maintain the data model in INFINITECH is maintained. A graph data model is a continuous process where vocabularies and taxonomies are included and revised on a periodic basis.

4 Characterizing the Semantic Layer

This section is aimed to describe the steps performed towards the design and implementation of an effective technology architecture capable of:

- being incorporated, easily and seamlessly, within already existing heterogeneous, distributed and fragmented data environments; and
- to harmonize and align data to be successfully exploited within the INFINITECH platform.

Nowadays the implementation of a unique and global architecture to support comprehensive enterprise-wide data initiatives is almost impossible to build due to a set of challenges imposed by heterogeneity in both technology solutions and implementations that rely on very different systems, architectures, architectural model, data format, protocol and representation (see {Citation}).

As confirmed by Thomas Siebel in his book *Digital Transformation [7]*:

"Today, organizations capture and store data using all manner of techniques to augment existing enterprise systems. […] Enterprises face a multitude of systems, data sources, data formats, and potential use cases. Generating value requires […] to understand all these data, comprehend the IT infrastructure used to support these data, and then relate the data sets to business use cases and value drivers. […] The only tractable way to approach this problem is through a combination of the right tools, computational techniques, and organizational processes."

These widely-accepted opinions (evidences) have driven our research and development within the Task 4.1 - *Shared Semantics for BigData and IoT Streams*, as described in the following section.

4.1 Overall Picture: connection with Task 4.2 – Massive Distributed Processing of Semantically linked Datastream

In Task 4.1 a new approach is proposed for enterprise data management. This approach relies on semantic and graph technology to ensure data integration, transformation, ingestion and representation to facilitate the development of applications for data analysis while establishing semantic and graph technology a strategic action for any leading financial organization.

The Figure 4-1, shows the proposed architecture for the semantic interoperability framework.

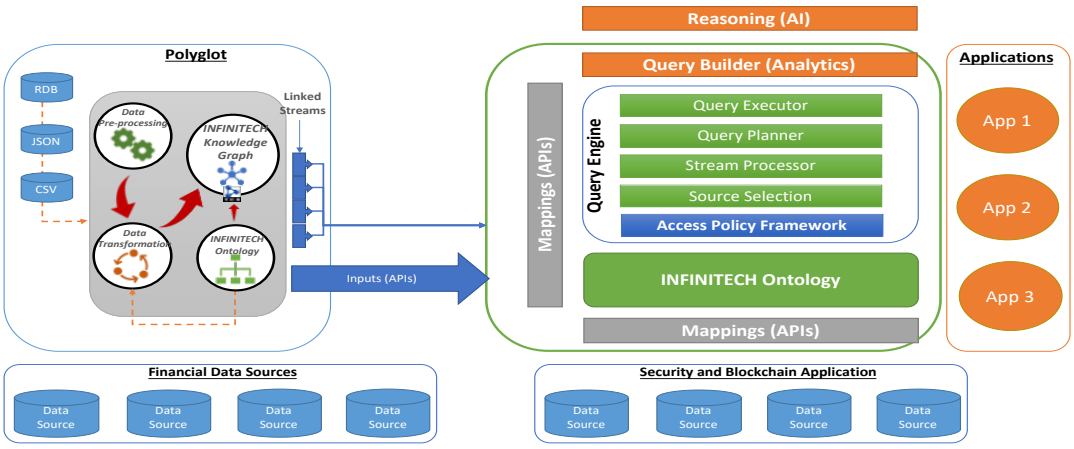

Figure 4-1 – Proposed architecture and Integration plan for Semantic Interoperability Framework

The model is a joint effort – within WP4 – between Task 4.1 and Task 4.2. In particular, the *Semantic Layer* is the focus of this document and of the Task 4.1 in general. The semantic interoperability pipeline is presented in Figure 4-2, where the main activities performed by the *Polyglot* are:

- *Data Ingestion*: is the first stage for semantic interoperability and is related with the activity by which data is gathered from heterogeneous data sources – typically located within enterprise – and moved to the INFINITECH platform;
- *Data Management*: is related with all the necessary tasks performed on enterprise asset data to create harmonized datasets, aligned with a common shared semantic, ready for business consumption.

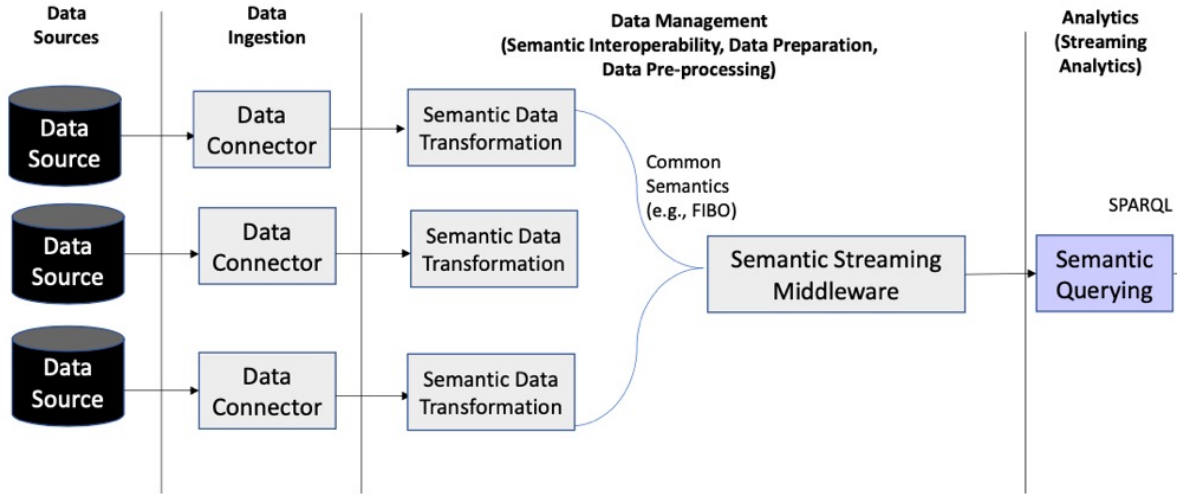

Figure 4-2 – Semantic interoperability pipeline

The *Polyglot* (see Figure 4-3) is responsible for harmonizing disparate unstructured and structured enterprise data assets (aka enterprise data lake) for the sake of enhancing business consumption by different stakeholders and transforming enterprise capability to manage, utilize and monetize their data.

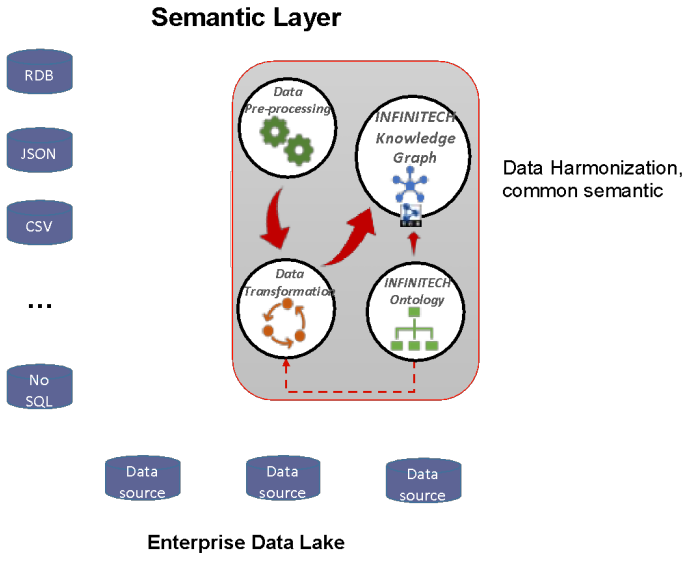

Figure 4-3 – Semantic Layer overview

4.2 Envisioned Capabilities

There are several characteristics and desirable capabilities the *Semantic Layer* should provide to facilitate its integration and adoption by different organizations. These characteristics and capabilities can be listed as follow (see Figure 4-4):

- ***Data Integration***: to provide simple tools and mechanisms to allow organization to easily and quickly import their data-asset across many sources;
- ***Data Transformation***: to provide simple tools and mechanisms for data filtering, cleansing, merging, mapping, etc;
- ***Data Storage***: to provide mechanisms to enable both internal (in-memory) and external (using cloud storage platform such as Google Drive, AWS, MS SharePoint, etc.) data storage;
- ***Data Sharing Services***: to provide endpoints to allow any external application to extract and retrieve the data;
- ***Semantic Engine***: to support the creation of a single semantic layer for enterprise's data-assets, to objective of the engine is to tie together high-value enterprise's data lakes to facilitate data to be consumed by business;
- ***Standardization***: to provide a set of tools built on relevant standards; and
- ***Data Security***: to provide support to user authorization and user authentication.

Data Integration and ***Data Transformation*** are especially critical and intricate tasks. As a matter of fact, big enterprise IT systems to support operations are typically sourced from distinct leading equipment and IT vendors. In an enterprise there are several IT systems (such as for asset management, workforce management, payroll processing, etc.). that are not designed to interoperate while making hard any effort of integrating data. Moreover, the effort is further complicated due to the heterogeneity of the data in terms of data formats, duplication, mismatched references between data sources, etc. As stated in [7], often enterprises try to create a logical description of the data, i.e. identification of the main concepts and of the relations between them in an object-oriented model and/or entity relationship diagram. However, taking into account the great amount of data and data sources, the creation of such a unified model is an onerous task. Taking into account this, the main question is:

How do we realize a semantic layer that can really improve and boost the deployment of AI applications to extract value from disparate data sets?

The above question implies a set of challenges that need to be properly met:

- **Data-to-Business modelling**: how to align heterogenous data from distributed and disparate data sources to the INFINITECH core model?
- **Data Exploration**: once data has been modelled how to support the exploration of the generated knowledge graphs by distinct stakeholders?
- **Data sharing:** how to provide data to external AI applications?

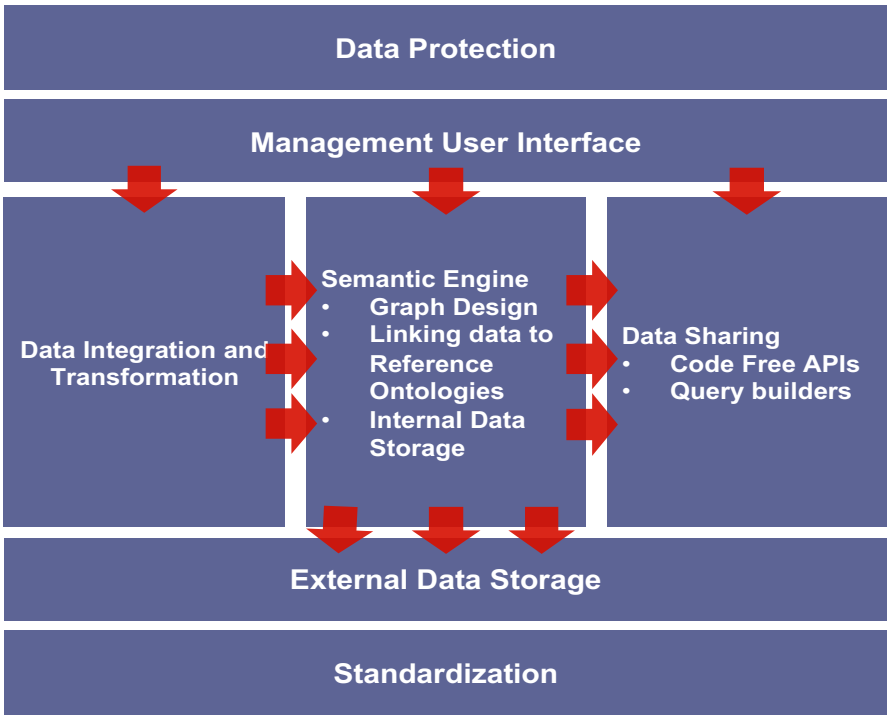

Figure 4-4 – Polyglot platform capabilities

4.3 Supporting Technology

According to [3], nowadays forward-thinking organizations are betting more and more on semantic Knowledge Graphs. In the scope of this research, we do not want to "reinvent the wheel" i.e., we are not designing and developing radically-new technologies. On the contrary, we want to (re-)use already existing enterprise class platforms for operational knowledge graphs. Taking into account the number of solutions available on the market, we decided to extract a small array of graph/triplestore solutions and use them to develop small and high-impact use cases to demonstrate how semantic technologies can bring added value to the financial enterprises.

4.3.1 Semantic Graph Database – Ontotext GraphDB[4]

GraphDB is an enterprise ready Semantic Graph Database, compliant with W3C Standards. Semantic graph databases (also called RDF triplestores) provide the core infrastructure for solutions where modelling agility, data integration, relationship exploration and cross-enterprise data publishing and consumption are important.

GraphDB streamlines the load and makes use of linked data cloud datasets, as well as your own resources. For easy use and compatibility with the industry standards, GraphDB implements the RDF4J framework interfaces, the W3C SPARQL Protocol specification, and supports all RDF serialization formats. The database is the preferred choice of both small independent developers and big enterprise organizations

[4] https://graphdb.ontotext.com

because of its community and commercial support, as well as excellent enterprise features such as cluster support and integration with external high-performance search applications - Lucene, Solr, and Elasticsearch.

GraphDB is one of the few triplestores that can perform semantic inferencing at scale, allowing users to derive new semantic facts from existing facts. It handles massive loads, queries, and inferencing in real time.

Ontotext offers three editions of GraphDB: Free, Standard, and Enterprise.

- GraphDB Free - commercial, file-based, sameAs & query optimizations, scales to tens of billions of RDF statements on a single server with a limit of two concurrent queries.
- GraphDB Standard Edition (SE) - commercial, file-based, sameAs & query optimizations, scales to tens of billions of RDF statements on a single server and an unlimited number of concurrent queries.
- GraphDB Enterprise Edition (EE) - high-availability cluster with worker and master database implementation for resilience and high-performance parallel query answering.

In the context of this document the free server version of the GraphDB has been used.

4.3.2 Data.World[5]

Data.world is a fully managed service, born in the cloud, and optimized for modern data architectures. It delivers powerful data management capabilities including virtualized access, cross-platform federated query, self-service analytics, and collaboration to empower your entire workforce with high-quality data.

The configuration and set up is fast and simple with a large and growing ecosystem of pre-built integrations including all of the major cloud data warehouses. Data.world main capabilities can be listed as follows:

- Cloud-native Software as a Service (SaaS) - Fast deployment. Frequent improvements. Scale to thousands of users.
- Metadata management - Catalog and understand the meaning of all your data and metadata.
- Agile governance - Keep track of all data, metadata, and glossary terms. Request access to critical datasets.
- Clean, intuitive UX - A powerful enterprise platform that acts like a consumer-grade application.
- Data virtualization - Connect to any source without copying and moving your data.
- Cross-platform query - Dig deeper into your data by federating queries across multiple sources and file types.

In the context of this document the free community version of the Data.world platform has been used.

[5] https://data.world/resources/product-overview/

5 Exemplary Application Scenarios

5.1 Applying the Methodology

INFINITECH pilots typically have their own very specific data with different formats, data structure and are differently organized. In order to establish the foundation for interoperability between those pilots, in the same application domain, ontologies are needed. However, most of them do not have a well-defined and well-established conceptual model of their own application domain (e.g. application ontology). Furthermore, the usage of reference ontologies becomes practically impossible due to the lack of a connection with the application domain (i.e. the application ontology). Therefore, it is peremptory to provide pilots with application ontologies.

This section is aimed to show the application of the proposed methodology for semantic models and ontologies engineering and prototyping by using exemplary data from the considered pilots and selected supporting technologies.

It is important to observe that the current document is the last version of three and documents the final description of the work performed within the task 4.1. The *Collecting* activity and the first part of the *Building* activity have been performed and described and consolidated within deliverables D4.1 and D4.2 respectively, and reported in these document as appendices.

As explained in Section 2.1.2, the methodology is an iterative process that aims at providing very specific and targeted models to be used by advanced analytics applications (typically outside to the INFITECH platform). *Figure 5-1* shows the main output of the methodology starting from the pilot characterization and how it is connected to the INFINITECH platform.

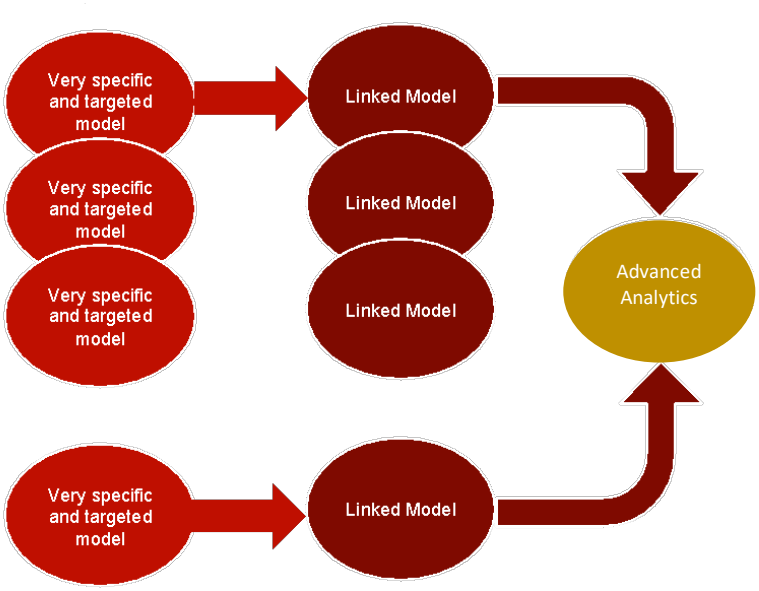

Figure 5-1 – Connection between semantic models and INFINITECH Platform

5.1.1 Step #4 & #5: Refactoring Modelets and linking with application specific dataset

The first scenario presented in Section 5.1.1.1 is part of the 2nd version of the document once necessary data for applying and testing the methodology was available from pilot#2. In this sense, this reporting section is unchanged, since it already provides an example of the work done over the methodology developed in T4.1. However, in section 5.1.1.2 another scenario with different conditions is presented, serving as validation of the same methodology.

Moreover, in Section 5.1.2, the same scenario was adopted and worked over in order to demonstrate the application of the methodology to Real-time data streams to apply the semantic transformation.

5.1.1.1 Cluster #1: Smart, Reliable and Credit Risk Assessment Pilots

5.1.1.1.1 Pilot #2: Real-time Risk Assessment in Investment Banking - Use Case Introduction

Context: In pilot 2 the Value-at-Risk (VaR) for a Forex (FX) portfolio is calculated starting with a trading position (in a CSB file or stored in LeanXcale SQL Database with JDBC driver) and calculating what part of this position/portfolio is at risk within a given interval.

Scenario: The target is to Calculate the VaR for one or more FX portfolios of an institutional investor. We assume that the institutional investor (e.g., a large bank in Portugal) invests in FX trades through different brokers (e.g., HSBC, Interactive Brokers, JP Morgan, e-Toro etc.). The different brokers provide their trades in different semantics & formats (S1, S2, ..., SN). The pilot calculates the VaR for a portfolio that combines assets from the various brokers. To do so, it maps S1, S2, ..., SN to FIBO.

5.1.1.1.2 Use Case Major Steps in Implementation

The following main steps have been performed during the implementation of the Pilot #2 scenario:

1. **Analyse** the outcomes of the D4.1 – Semantic Models and Ontologies V1 (Taxonomy, Glossary and Domain terminology) and align with the specific pilot #2 dataset used for calculating the VaR;
2. **Creation** of pilot-specific linked knowledge graph;
3. **Map** the data from step 1 to FIBO ontology models;
4. **Produce** the graph knowledge that models the data by using concepts from FIBO; and
5. **Query** the data using a single common model.

5.1.1.1.2.1 Analyse

Two comma-separated values files – containing the pilot specific data – have been made available, namely:

1. *Tick Data*: refers to the change in price of a security from one trade to another one (in this case currency since we are in the Forex market). An example of *tick data* is shown in Table 5-1; and
2. *Trades Data:* refers to the quantity of currency exchanged in a specific point in time. An example of *trades data* is shown in
3. Table 5-2.

Table 5-1 – Tick Data example

Id	Tik_close	Datetime	product
2	1.5706	2020-08-17T00:00:00	EURCAD
3	1.0767	2020-08-17T00:00:00	EURCHF
4	1.0766	2020-08-17T00:00:00	EURCHF
5	1.1843	2020-08-17T00:00:00	EURUSD
6	1.3102	2020-08-17T00:00:00	GBPUSD
7	1.3102	2020-08-17T00:00:00	GBPUSD
8	1.5704	2020-08-17T00:00:01	EURCAD
9	1.0767	2020-08-17T00:00:01	EURCHF
10	1.3102	2020-08-17T00:00:01	GBPUSD

Table 5-2 – Trades Data example

symbolid	timestamp	quantity
EURCAD	2020-08-06T00:00:00	-1000000
EURCHF	2020-08-10T00:00:00	2000000
EURCAD	2020-08-10T00:00:00	1000000
EURCHF	2020-08-16T00:00:00	-2000000
GBPUSD	2020-08-17T00:00:00	750000
EURCAD	2020-08-26T00:00:00	1000000
EURUSD	2020-09-01T00:00:00	-500000
EURCHF	2020-09-05T00:00:00	2000000
EURCHF	2020-09-11T00:00:00	500000
GBPUSD	2020-09-15T00:00:00	-500000
EURUSD	2020-09-16T00:00:00	1250000
GBPUSD	2020-09-17T00:00:00	250000
EURCHF	2020-09-18T00:00:00	-1000000

5.1.1.1.2.2 Creation

Applying a semantic approach means to focus on the meaning of the data, the identification of the main concept and of the relationships between them. The connected knowledge graph of the pilot #2's data assets are thus presented in Figure 5-2.

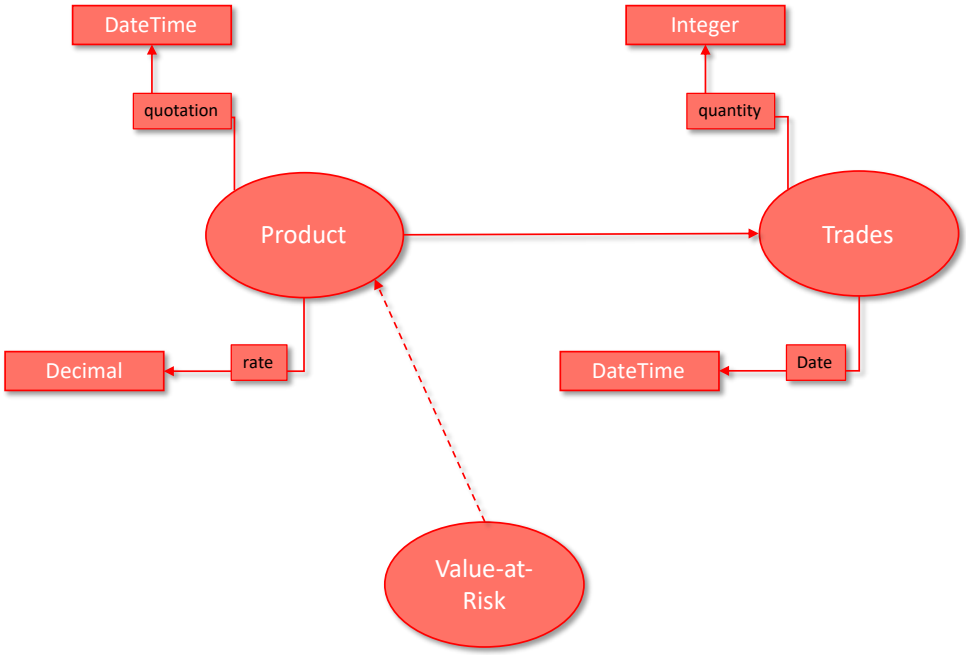

Figure 5-2 – Pilot #2 Knowledge graph

This connected knowledge graph is the first step towards harmonization and standardization of data-assets. As a matter of fact, the knowledge graph needs to be further analyzed and refined to be connected with FIBO ontology.

5.1.1.1.2.3 Mapping

The generated pilot-specific knowledge graph (aka *Modelet*) is – during this stage – further refined and aligned to reference ontologies. Taking into account the domain of application the FIBO ontology has been chosen as reference ontology. At this stage, both pilot-specific and FIBO models have been analyzed to identify a) common concepts; and b) connections and relations between the two models.

The final knowledge graph is shown in Figure 5-3.

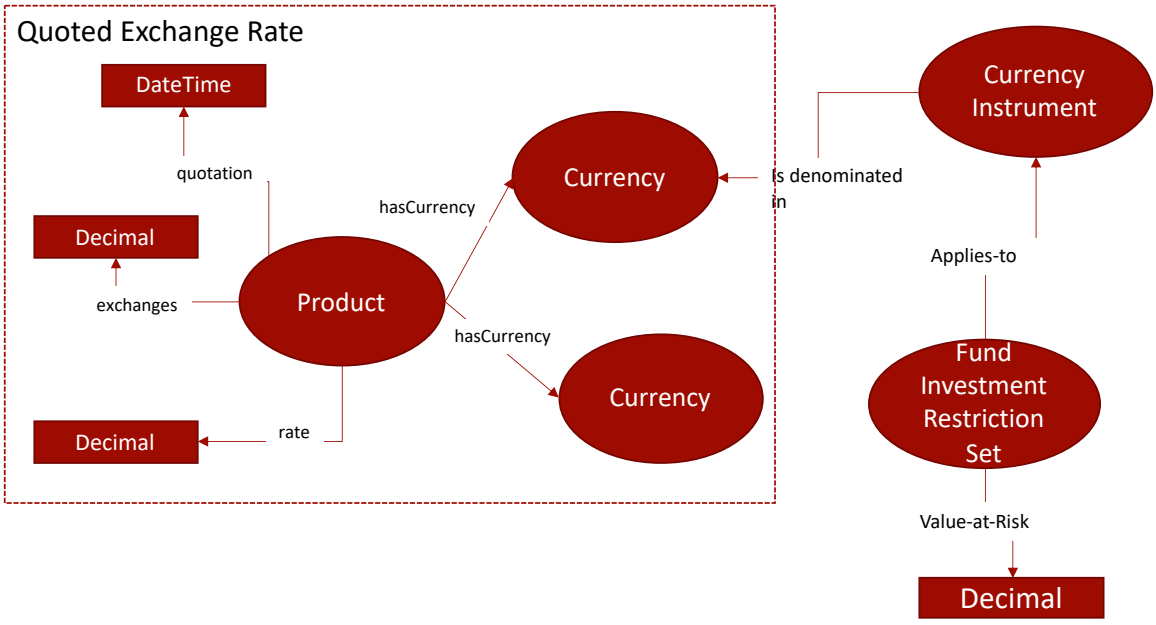

Figure 5-3 – Pilot #2 Knowledge graph aligned to FIBO

The following FIBO concepts have been used for modelling the final pilot #2 knowledge-graph:

- **Currency:** medium of exchange value, defined by reference to the geographical location of the monetary authorities responsible for it.
- **Quoted Exchange Rate:** an exchange rate quoted at a specific point in time, for a given block amount of currency as quoted against another (base) currency. An exchange rate of R represents a rate of R units of the quoted currency to 1 unit of the base currency.
- **Value-at-Risk:** measures and quantifies the level of financial risk within a firm, portfolio or position over a specific time frame.
- **Fund Investment Restriction Set:** Limitations that apply to the fund as a whole, such as risk factors. These are used to determine whether the fund is appropriate for a given type of investor to invest in.
- **Currency Instrument:** financial instrument used for the purposes of currency trading.

The result of this activity is a connected graph – aligned with FIBO ontology – capable of spanning organizational concepts that are relevant for the selected application scenario and use-case.

5.1.1.1.2.4 Producing

The *Producing* stage is aimed at the concrete development and implementation of the knowledge-graph produced after the *Mapping* stage. Therefore, it is mainly focused on the selection of the concrete technology and to show how to apply the technology to create a semantic interoperability framework where data are harmonized according to FIBO and shared to any external application that needs to use them. In this stage, two technologies have been selected to show the repeatability of the process regardless of the specific environment deployed within the pilot.

5.1.1.1.2.4.1 Datasources

In pilot#2, the datasource of the raw data (Tickdata and Trades) is originally being stored in a Structured Query language (SQL) compliant database (LeanXcale) which by its turn, supplies the Java Database Connectivity (JDBC) drivers and other connectors which enable to access the data via several application languages (Java, node.js, python, …).

The original dataset has been replicated into another SQL Database (Postgres) and also extracted and stored as CSV files and made available both locally and remotely (ex: GoogleDrive URL), passing from 1 to 3 different data sources. This has been done in order to complement the testing ground for the adopted technologies.

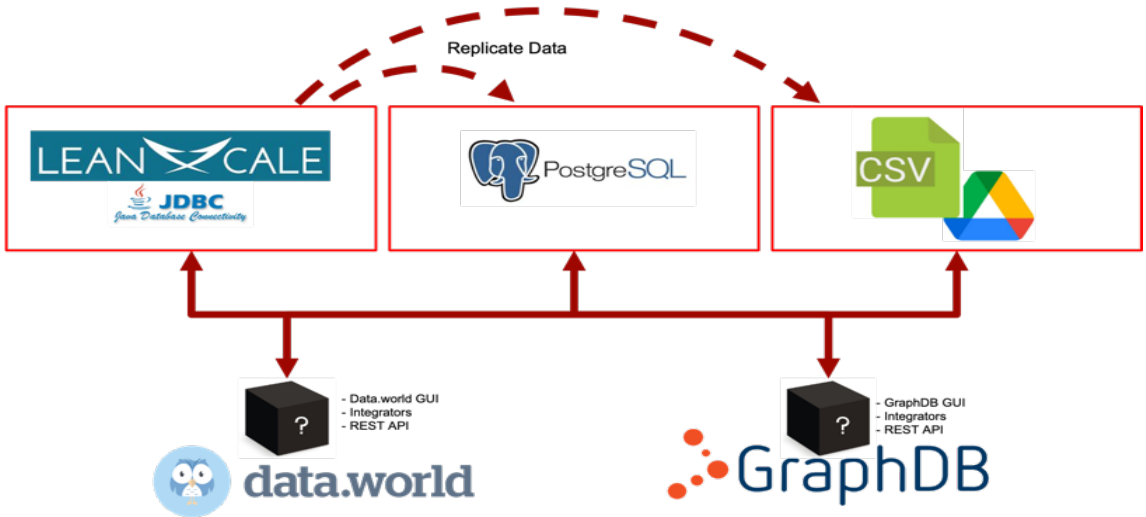

Figure 5-4 - Adopted Data Sources for pilot#2

5.1.1.1.2.4.2 Adopted Technology #1 – Data.world

5.1.1.1.2.4.2.1 Tabular Data Ingestion

In Data.world, data can be injected (and also accessed and supplied) by either importing files (with support for csv, tsv, xls, xlsx and other tabular structured files such as JSON) or through the usage of the available integrators (see Figure 5-5). These Integrators (connectors) act between the data.world platform and a panoply of applications, with the purpose of easing the automation of data connectivity (collecting and supply). Also, there is the possibility to create and include other application specific customized integrators.

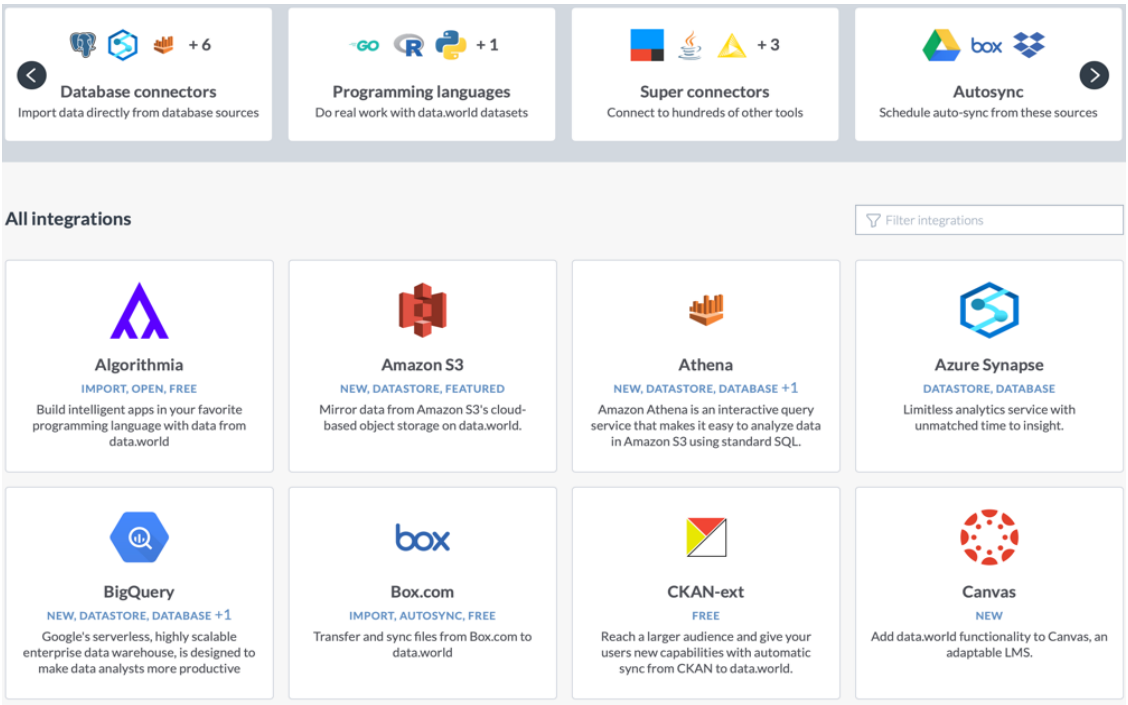

Figure 5-5 - Snapshot of some of the available Data.world Integrations

In **Error! Reference source not found.** is depicted how to perform the data import into a given dataset through the data.world platform GUI. In this example, the user can opt from loading directly the file(s) (local or by public URL), or on the other hand, by using one of the activated integrator relevant for the specific case – GoogleDrive file or postgresQL Database, which cover two of the available data sources.

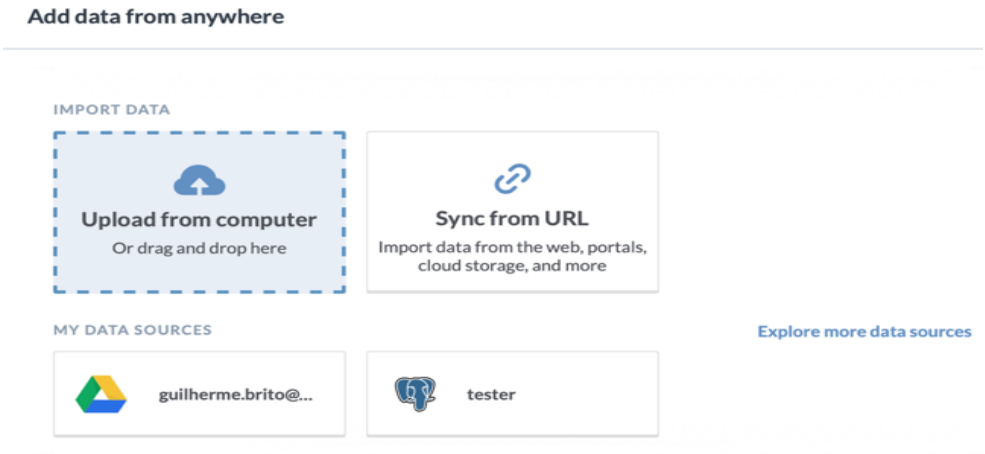

Figure 5-6 - Data.world GUI import frame

In relation to the LeanXcale+JDBC original datasource, the choice was to make use of the data.world REST API, which supports the creation, management and import of data into data.world datasets and projects.

Regardless of the chosen methodology, the user will end up with the imported tabular data as presented in Figure 5-7. In addition, the figure shows the direct association between the injected data and the original data represented in Table 5-1 and

Table 5-2, for TickData and TradesData respectively.

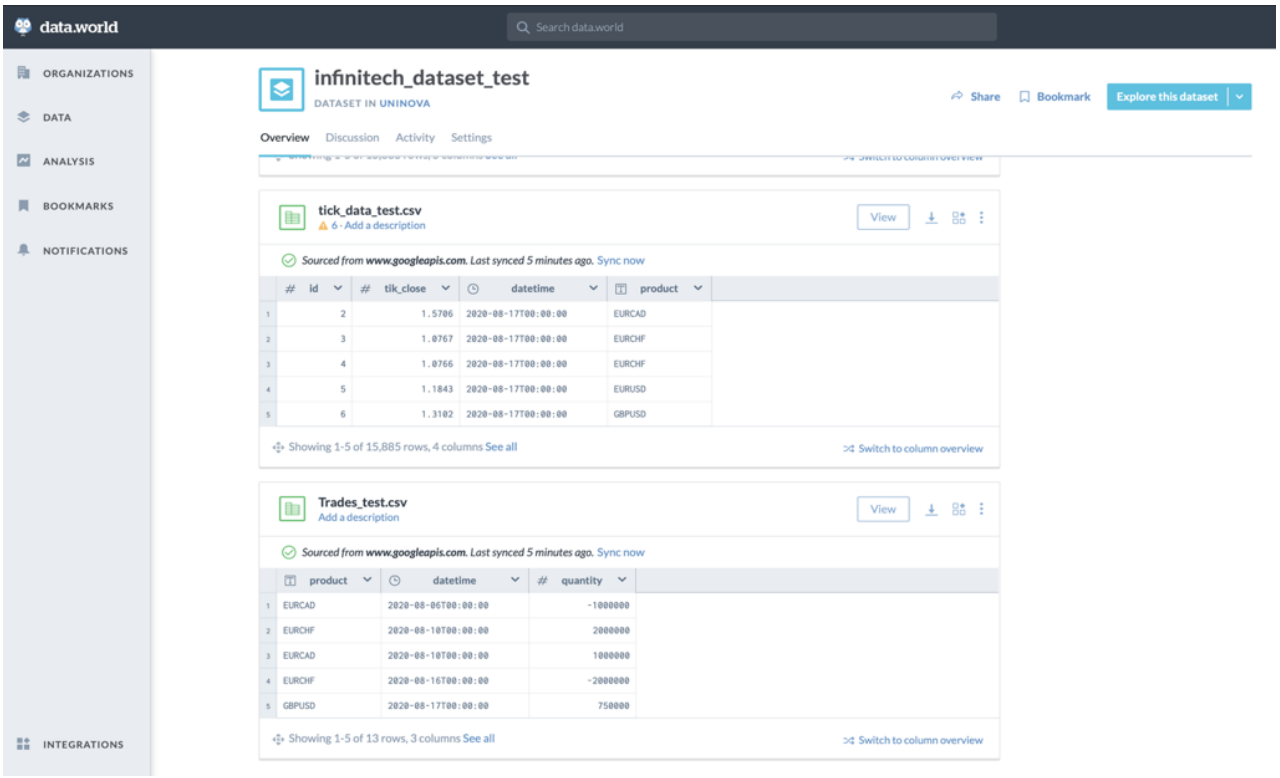

Figure 5-7 - Imported Dataset (from CSV files)

For all the data injection options, excluding local files, data.world offers the possibility to automatically synchronize the tables hourly, daily or weekly. However, users are able to trigger the synchronization at any time by using GUI directly or throughout the REST API.

5.1.1.1.2.4.2.2 Pre-Processing

The internal engine of data.world does not allow users to manipulate (include or modify) the imported data, but on the other hand, this tabular data can be queried by introducing SQL queries. Moreover, it is possible to associate the results of an SQL query with a new tabular data, which can capture updates made to the tables with the imported data, that is to say, that the newly table created by association with the SQL query, can be synchronized (automatically or on demand) in accordance with the latest versions of imported data tables.

For this specific case, Figure 5-8 shows an SQL query (*INNER_JOIN_query*) that takes data from both *Tick_data_test* and *Trades_test* tables and stores the results in the *INNER_JOIN_sync_table* table.

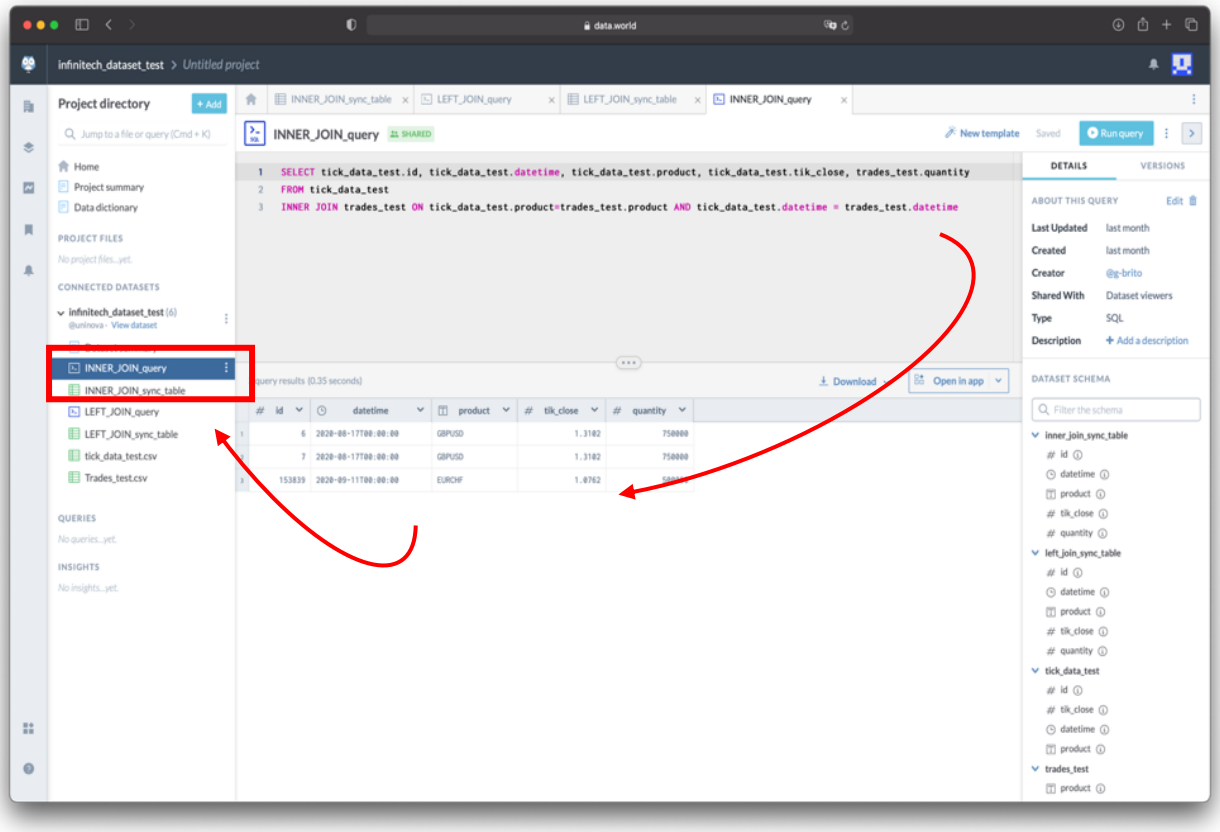

Figure 5-8 - Tabular data process in data.world using SQL query and table links

5.1.1.1.2.4.2.3 Semantic Transformation

First, it must be noticed that data.world engine automatically generates a graph (RDF representation) from the tabular entries of imported data. This means that each dataset and project data is attributed with a named graph (and sub-graphs) with specific namespaces, while the data rows and columns are associated with an RDF representation beneath these graphs. As example, for the *Infinitech_data_Test* dataset, *INNER_JOIN_sync_table* table, column *product*, there are RDF triples automatically generated by the data.world engine, which create associations with the following names:

- *Infinitech_data_Test:* https://uninova.linked.data.world/d/infinitechdatasettest/ (ns1)
- *INNER_JOIN_sync_table*: ns1:tbl-inner_join_sync_table
- Column *product*: ns1: col-inner_join_sync_table-product

Therefore, once inserted in data.world, the tabular data is automatically enabled as RDF, which is the base for providing the semantic transformation as well as for enabling Linked-data between connected datasets. In Figure 5-9 - Metadata file of the imported dataset, including the associated data.world internal RDF, a snapshot of some of the metadata associated to the dataset is presented:

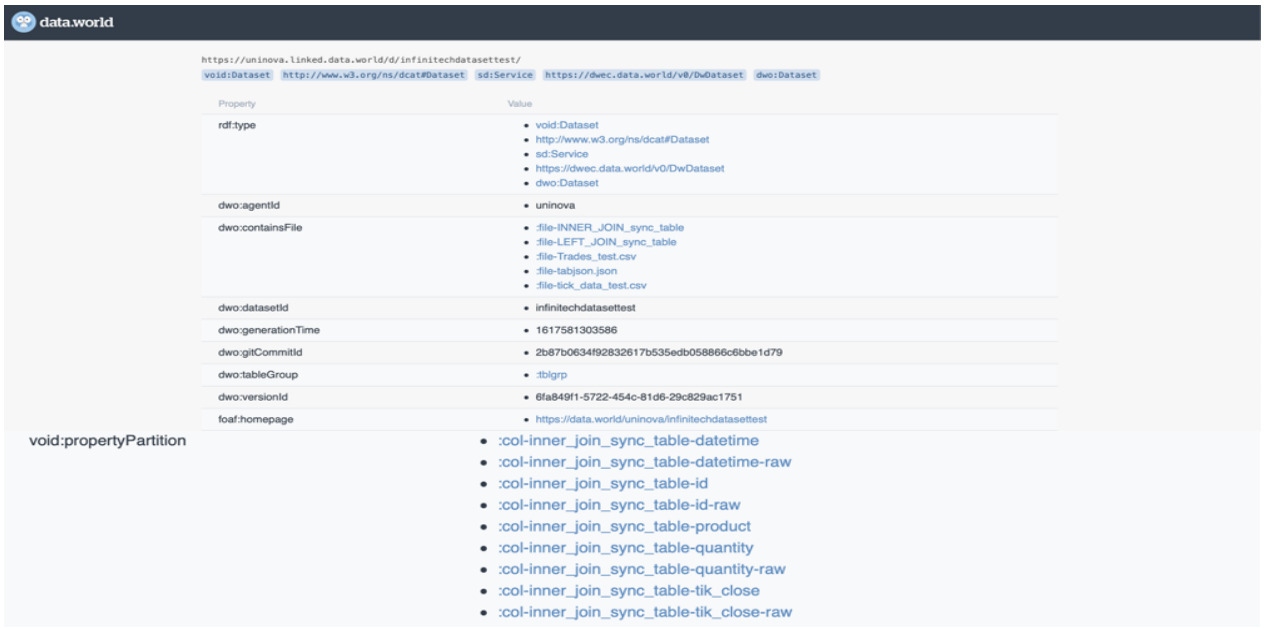

Figure 5-9 - Metadata file of the imported dataset, including the associated data.world internal RDF

Considering the previous self-conversion to RDF representation, it is now possible to apply the methodology that enables users to reach out to the final semantic transformation: creating a knowledge graph which represents the tabular data with the semantic in accordance with the specified FIBO constraint (as projected in Figure 5-3).

By using SPARQL queries instead of SQL, and similarly to what has been performed in section 5.1.1.1.2.4.2.2, the user can specify semantic queries (as seen in Figure 5-10 - Example of a SPARQL query used in the tabular data to RDF transformation process)against the tabular data and use the RDF representation of these tables to associate them with the FIBO concepts, thus creating the semantic object accordingly.

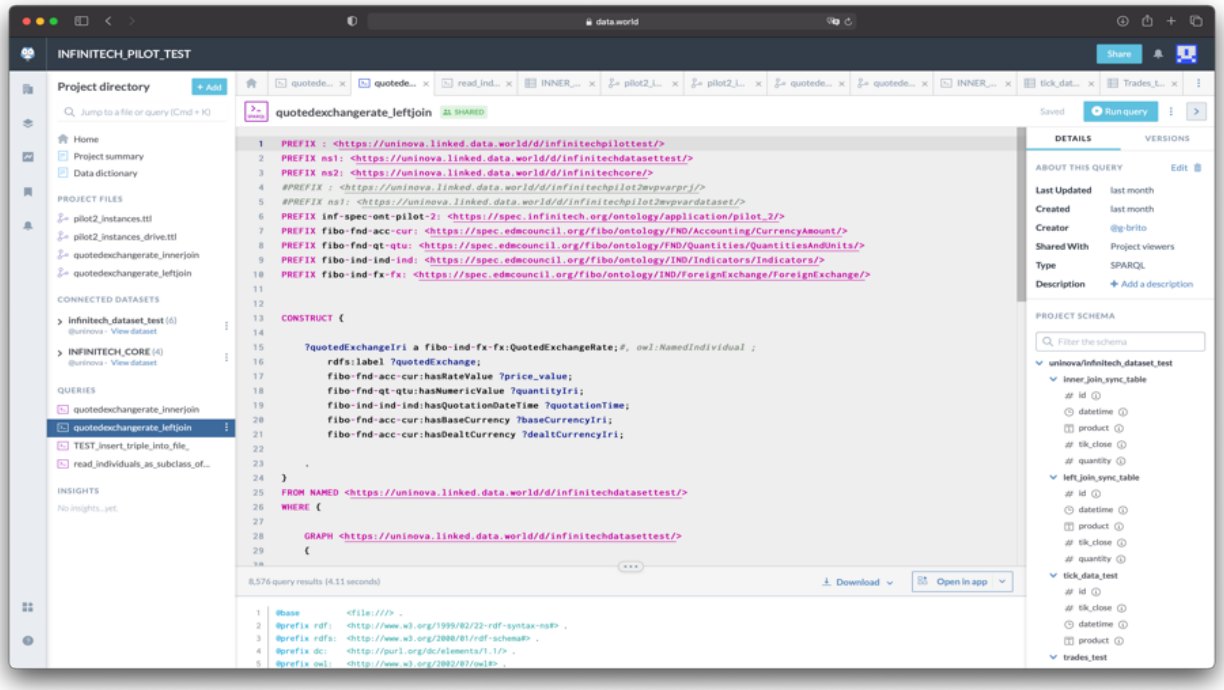

Figure 5-10 - Example of a SPARQL query used in the tabular data to RDF transformation process

Furthermore, the results can also be associated to the auto-generated Graph (in Turtle/RDF syntax) in the triplestore of the data.world project in use, and be kept in synchronization with the tabular tables, by associating the SPARQL query with the results RDF file, as indicated in Figure 5-11 - Snippet of Named Graph (as a Turtle/RDF file), resultant of the transformation SPARQL query:

Figure 5-11 - Snippet of Named Graph (as a Turtle/RDF file), resultant of the transformation SPARQL query

5.1.1.1.2.4.2.4 Access to the RDF data

The provisioned Graphs of the project can then be accessed through SPARQL queries through the platform GUI or the REST-API. These queries can either by pre-established inside the own project - as the example given in Figure 5-12 - Snippet of a pre-saved SPARQL query and results, against the created Pilot#2 Named Graph - and posteriorly invoked, or in case of using the REST-API, they can also be streamed within the call, while results can be specified to be retrieved in several formats (JSON, RDF-Turtle, XML, …).

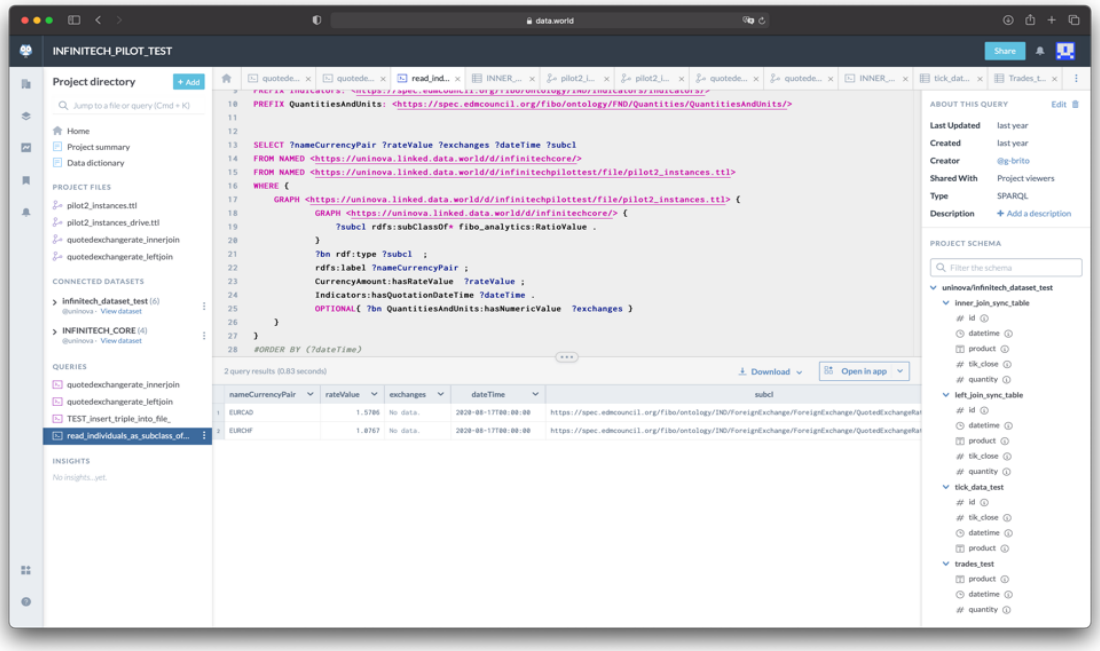

Figure 5-12 - Snippet of a pre-saved SPARQL query and results, against the created Pilot#2 Named Graph

5.1.1.1.2.4.3 Adopted Technology #2 – GraphDB

5.1.1.1.2.4.3.1 Tabular Data Ingestion

GraphDB offers direct import through OntoRefine, which is built on OpenRefine[6] software – a tool that serves, like others, to manipulate, transform, convert data into several formats and extend with external data. Also, OntoRefine offers a complete set of endpoints for external access, where OpenRefine API can be used at full extent, while being complemented with inner GraphDB APIs (REST, RDF4J and RDF-mapper APIs).

By using Ontorefine (see Figure 5-13), users are allowed to import local files, files on the web (URLs) or from a set of SQL databases (although not fully tested at the time). Concerning the file types, CSV, TSV, XLS, XLSX and structured JSON files are accepted. On Figure 5-14, an example of an imported CSV data file is presented, where it can also be depicted that on GraphDB, the user is also offered the feature to convert the data into other types or even to create an associated SQL query that can be used to move data back to a SQL database.

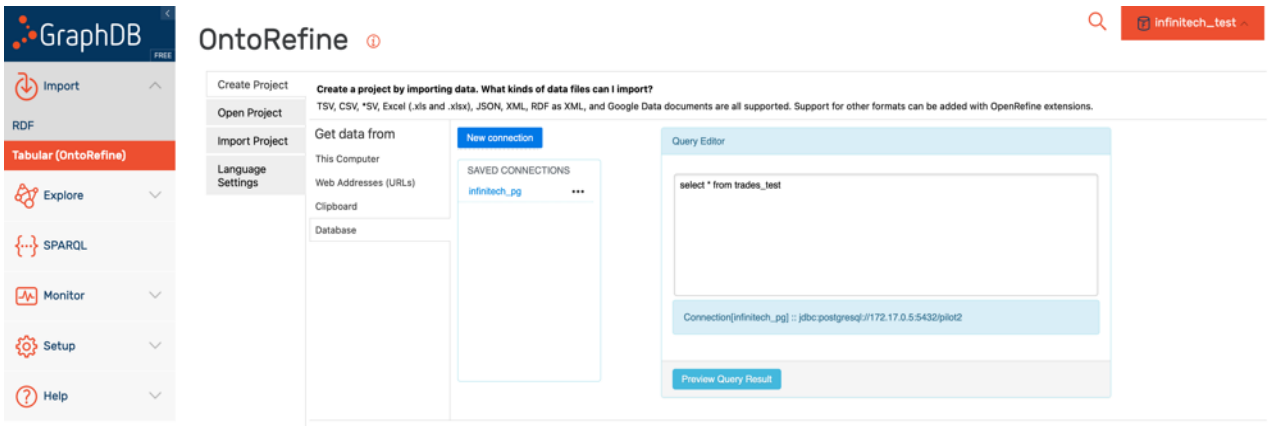

Figure 5-13 - GraphDB/Ontorefine GUI tabular data import frame

[6] https://openrefine.org

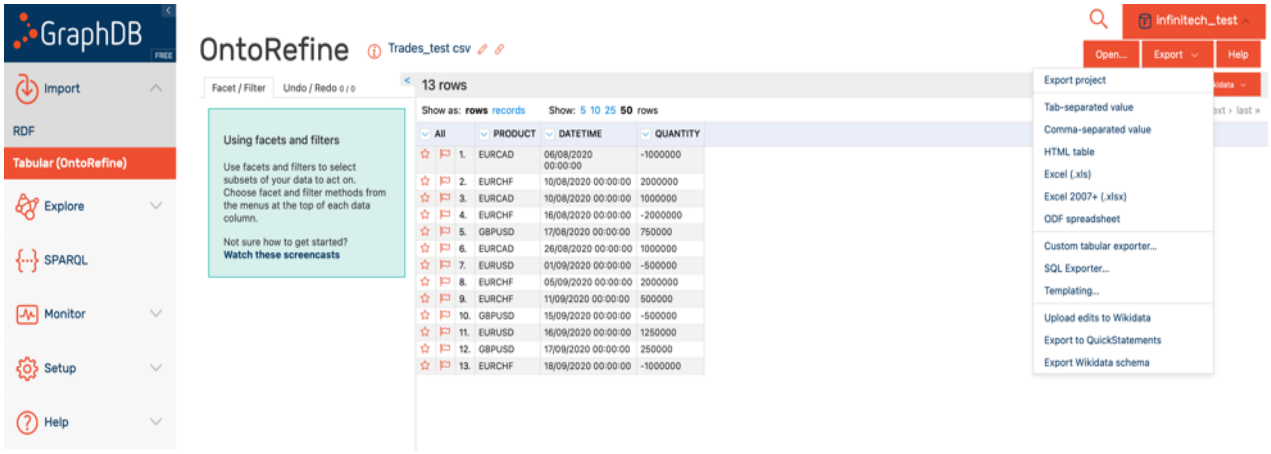

Figure 5-14 - Pilot#2 subset of imported data from a CSV file

5.1.1.1.2.4.3.2 Pre-Processing

Inside OntoRefine projects, the users are able to manipulate the imported data in several ways: applying filters and facets to select subsets; transform data types (e.g. convert date value from string to Timestamp); or creating new columns based on other columns values and/or by applying GREL (General Refine Expression Language) rules. With this, the users may refine the datasets (as depicted in Figure 5-15 - Imported data filtering example) in order to work over them as tabular data, or on the other hand, to be more suitable for the transformation process into RDF data.

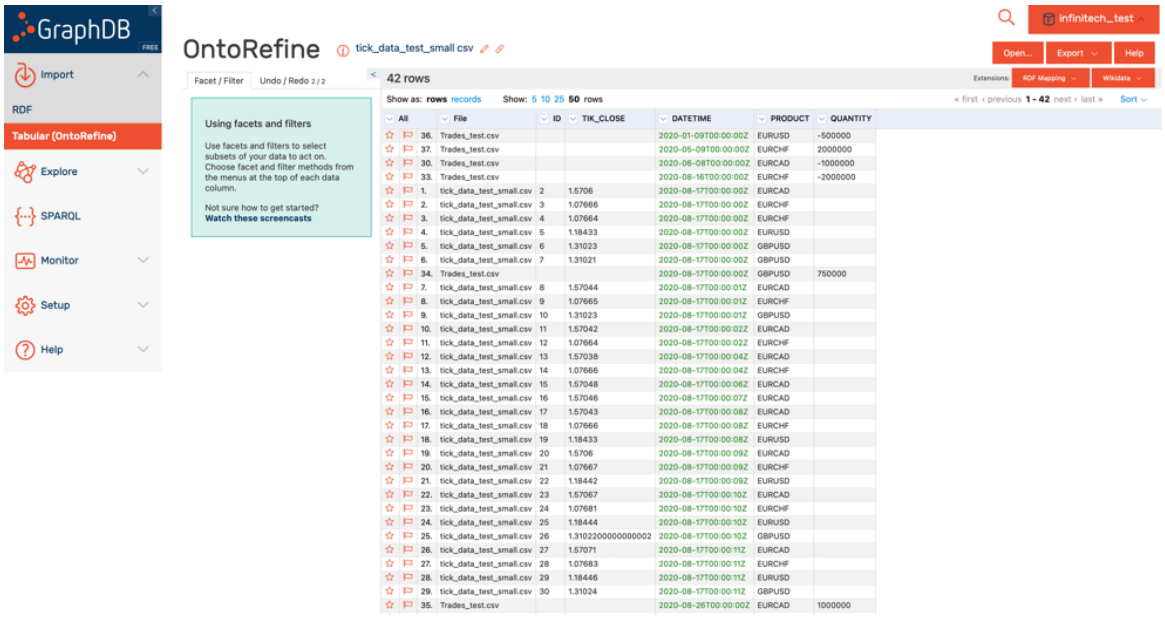

Figure 5-15 - Imported data filtering example

5.1.1.1.2.4.3.3 Semantic Transformation (JSON mapping)

The process for transforming tabular data into RDF consists of specifying a mapping schema, which OntoRefine provides in its toolbox, where the users can create the associations between the column values and the RDF triples (Figure 5-16 - Ontorefine GUI for mapping tabular data to RDF). For this, inside the toolbox, the user has access to several elements necessary, like for example, the namespaces from ontology files stored in GraphDB triplestore.

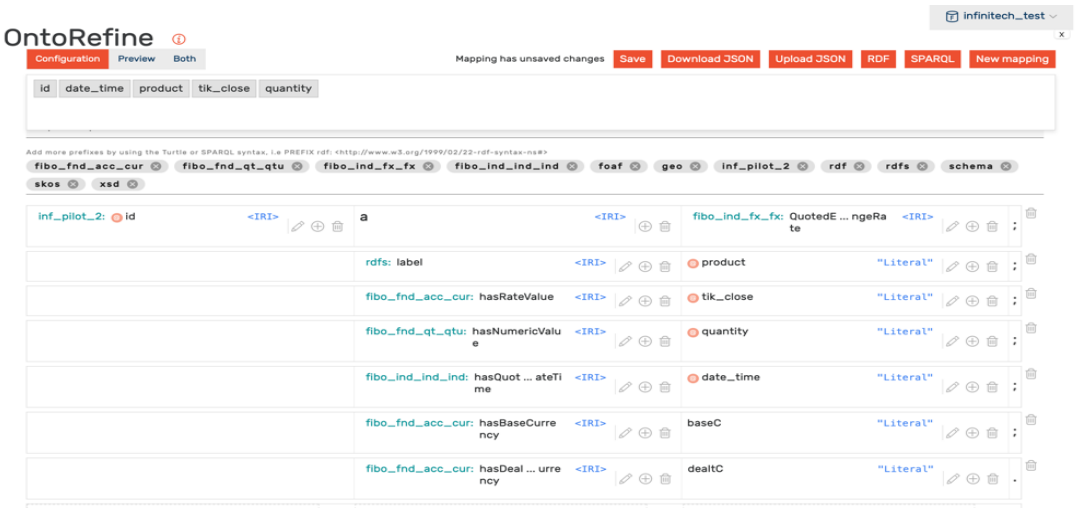

Figure 5-16 - Ontorefine GUI for mapping tabular data to RDF

By using this mapping schema, the RDF results can be downloaded and later imported into the RDF triplestore. Also, the mapping is defined in an independent JSON file, which is associated with the project. However, it can be downloaded and reused in other datasets with the same structure. This, combined with the *Mapper-streaming REST-API*, allows data to be converted into RDF without needing to import it, by performing the following procedure: creation of mapping definition (JSON file) by using an empty/dummy dataset; using the relevant REST-API endpoint, which accepts both the mapping file and well as the dataset by streaming them in the call; collect the RDF results in the response.

In either case, the RDF results can be afterwards imported into the GraphDB, by simply placing the file in the import directory and using the RDF4J/REST-API (or the platform GUI) to conclude the process. In this current implementation, it has been made use of NODE-RED[7] as middleware to apply the necessary external logic (file management, HTTP calls, etc…), as shown in Figure 5-17:

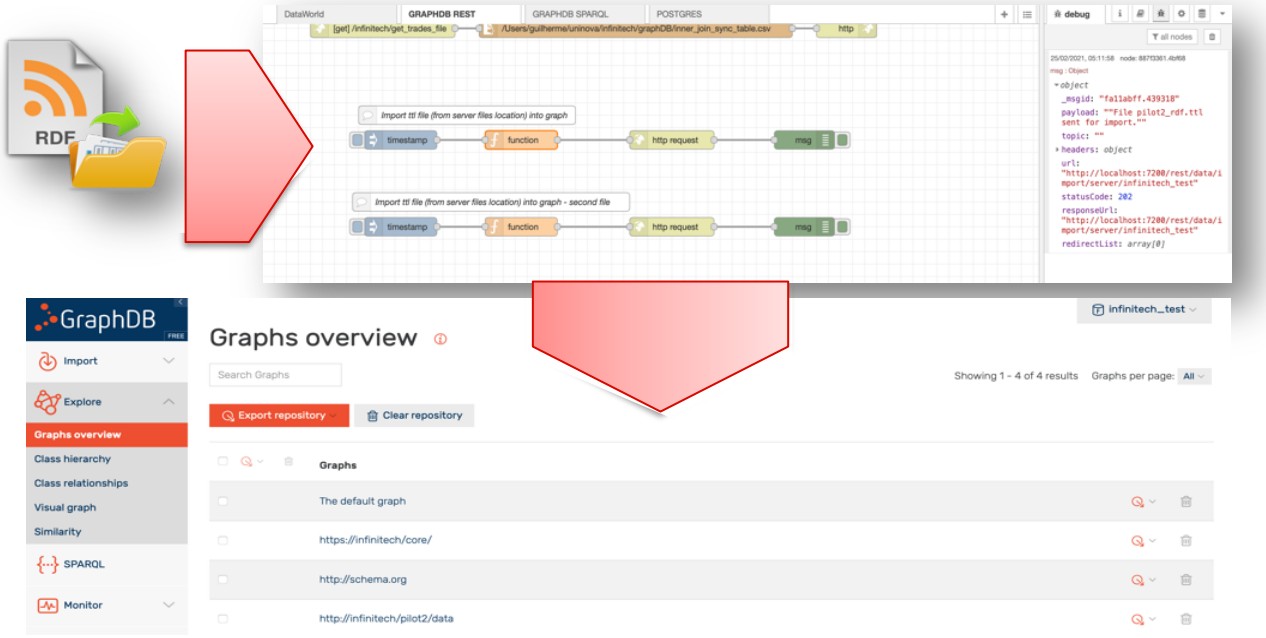

Figure 5-17 - Workflow for importing RDF data (from JSON mapping methodology) into GraphDB triplestore, by means of the RDF4J/REST-API

[7] https://nodered.org

5.1.1.1.2.4.3.4 Semantic Transformation (SPARQL)

With GraphDB, there is also another path to achieve the transformation of tabular data into RDF graphs, by means of SPARQL queries. It differs from the previous case in the sense that it can only operate with imported data – that is, the streaming option is unavailable for this – but on the other hand, it allows users to access and combine data from different datasets/projects all in one step. This is possible due to the existing tabular data projects and respective dataset values, once imported, being attributed with RDF namespaces and values respectively, and which can be invoked inside the SPARQL queries. Besides this, pro-efficient users of SPARQL are able to define more advanced logic for the desired transformation, as data can be also filtered and manipulated.

Another advantage of using SPARQL for the transformation process is that it allows a direct insertion of the RDF results into the GraphDB triplestore, without needing to download and place the result files in the import directory. However, the SPARQL queries used for mapping can also be reused, in other datasets, as long as the respective internal mapping entry points are changed accordingly.

Moreover, the SPARQL queries can be pre-established and stored on GraphDB or, in alternative, they can be sent inside the calls to the RDF4J/REST-API.

Figure 5-18 shows a snippet of a SPARQL query, with the respective results used in tabular data to RDF transformation process. On the left side, it shows a portion of a query which is used for Pilot#2, while on the right side it can be seen the RDF results, as well as the download options for several possible RDF formats.

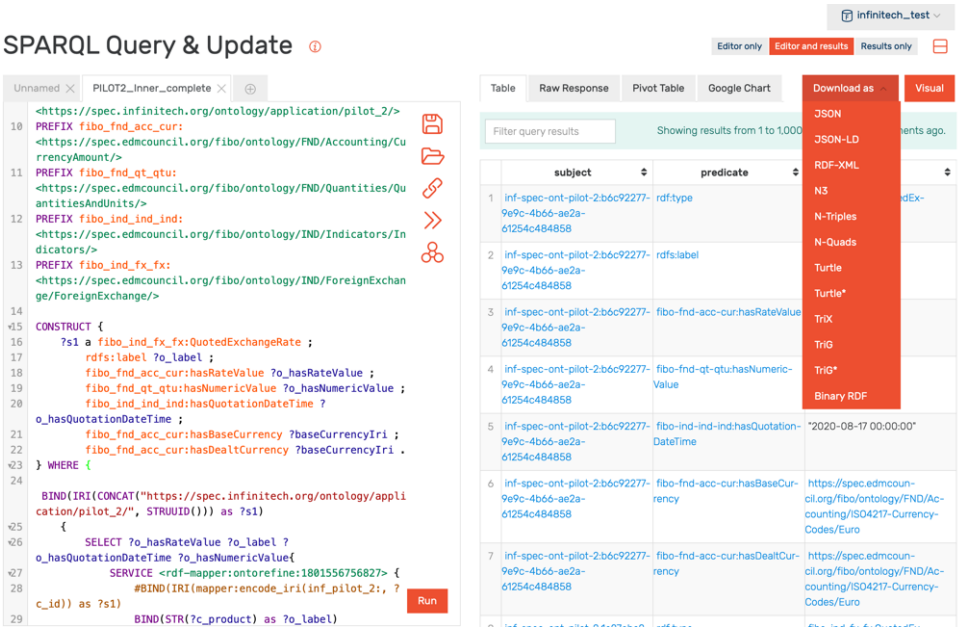

Figure 5-18 - Snippet of SPARQL query and respective results used in tabular data to RDF transformation process

5.1.1.1.2.4.3.5 Access to the RDF data / Other features

RDF data available on the triplestore (as well as repositories and other information) can be consulted/extracted by using the RDF4J/REST API, which includes also the ability to use SPARQL queries for manipulating data (this includes adding, modifying and selecting triples and Graphs). On Figure 5-19 - Visualization a named graph entries through the GraphDB GUI, a snippet of the INFINITECH-core graph is visualized through the GraphDB Workbench:

Figure 5-19 - Visualization a named graph entries through the GraphDB GUI

Finally, it is also important to point out that by using the GraphDB Workbench, users are also capable of accessing other useful features. For example, Figure 5-20 shows a relational graph of Class relationships from the RDF default graph.

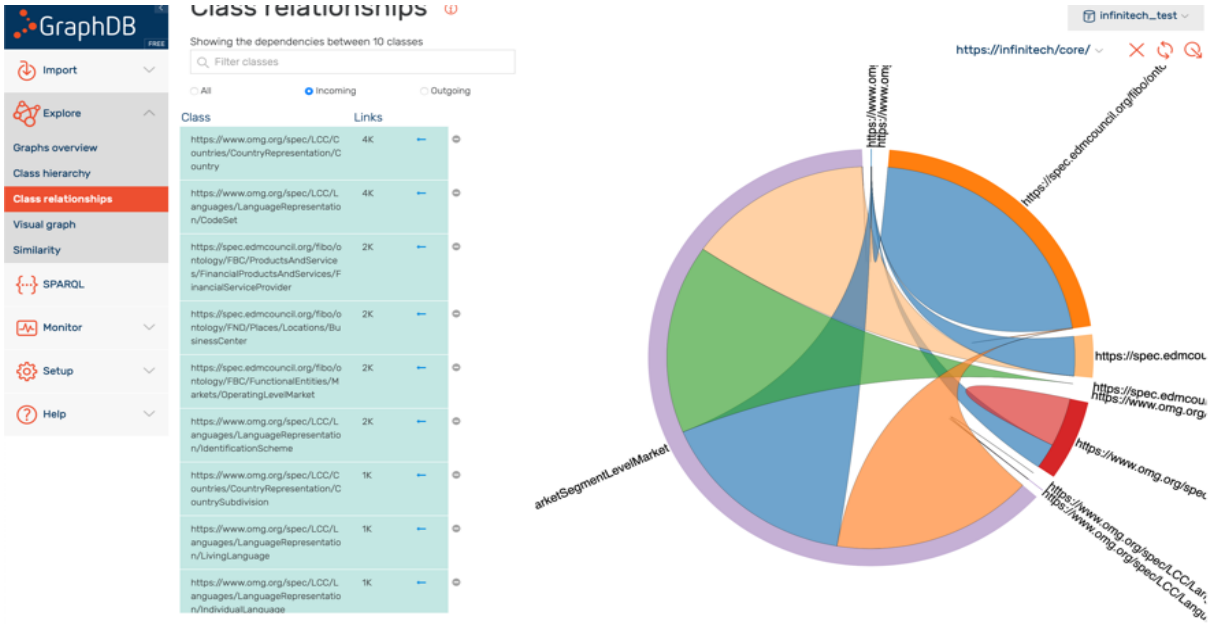

Figure 5-20 - Class relationships graphic - extra feature of the GraphDB platform

5.1.1.1.2.4.4 Comparision data.world/GraphDB

In this section it is presented in Table 5-3 a small comparison between the two tested technologies, so that interested users can more wisely choose between.

Table 5-3 Table of characteristics for Data.world and GraphDB

	data.world	GraphDB
PLATFORM CHARACTERISTICS	- WEB-based: requires WAN connectivity - Needs more security regarding sensitive data - Offers mechanisms for repositories and datasets organization (personal / Organization) and controlled access - Several Integrations for inbound and/or outbound traffic are available (connectors to databases and applications, such as some SQL DBs or visualization tools) - Free accounts are limited to 100MB datasets and few integrations - Community based: Datasets can be exposed to others. Users can contribute with integrations	- Can be setup to only local networks, or used in VPN - can be used in *Docker* - Early stage of development of some features (integrations with Drive or SQL databases are still not operational) - Faster graph search engine - Large limit of data - Some features/documentation regarding REST services are not yet well established on the official Docs: however, they can be consulted on OpenRefine and RDF4j docs (the support frameworks that beneath GraphDB)
DATA INTEGRATION	- Accepts several type of files for tabular data: XLS(X), CSV, structured JSON, … - Import data through REST API - Working connectors to SQL databases (but data not eligible to RDF transformation unless imported)	- Accepts several types of files for tabular data: XLS, CSV, structured JSON, … - Import data through REST API
DATA MANIPULATION	- Create other datasets (from SQL and SPARQL) based on the imported datasets - Links between main and sub datasets which enable synchronization - Stream datasets available (to be tested)	- Allows conversion between files (including SQL query export of the data) – based on *OpenRefine* - Columns can be added in function of others - Rows may be added to the imported data through an URL stream (to be tested)
DATA MAPPING	- Tabular data is directly attributed and RDF value (based on the dataset ID and column name) - SPARQL queries are defined to create the mapped/linked data - RDF triples results can only be inserted by adding a new triple file (although it can be established the sync link between the query and the results file)	- Tabular data is imported into a service, and mapping is defined into a json mapping file - By reusing the json mapping file and the **mapper-stream API**, data can be converted to RDF on a stream - Data is available as RDF in SPARQL (as a SERVICE with an ID and column name), enabling more complex mappings
RDF DATA	- REST API for access and management of Projects, Datasets and queries	- GraphDB allows RDF data manipulation: Create/Add/Delete from desired graphs; use of INSERT and DELETE on SPARQL - Local directory for automatic RDF files import - REST/RDF4J API for management of repositories and queries

5.1.1.1.2.4.5 Client application

As mentioned in 5.1.1.1.2.4.2.4 and 5.1.1.1.2.4.3.5, for Data.world and GraphDB respectively, both technologies offer REST-APIs access so that RDF data (and tabular data also) graphs can be consulted by executing or running pre-saved SPARQL queries. By doing so, data can be retrieved by any external application which deploys HTTP(S) protocol clients. Furthermore, this also implies that the client should comply with RDF (Turtle, RDF to JSON mapping, JSON-LD, …) in order to be able to interpret and evaluate the extracted data.

With this in mind, a simple client application which fulfils these requirements has been developed, and following the described procedure, a pre-saved SPARQL query is executed against the created Pilot#2 knowledge graph to extract a set of data, parse it and finally execute a simple analytic task, as presented in Figure 5-21.

Figure 5-21 - Visualization of data analytics over the pilot#2 RDF data extracted through the data.world REST-API, using a Node.js based client application

5.1.1.2 Cluster #2: Personalized Retails and Investment Banking Services

Two pilot's data model (*Pilot#5 and Pilot#6*) were found available for analysis, where very similar concepts and structures were identified, which in its turn, allowed us to formulate a scenario focused on creating a unified semantic that can be commonly applied and used. Therefore, in the scope of T4.1, and particularly for building this scenario, the most important requirement is to have data models which can be analysed in depth for constructing the semantic alignments, and not so much the pilot's own requirements and objectives. Still, for contextualization, a brief description of the pilots is given in the following section.

5.1.1.2.1 Pilots Introduction

Context: In pilot 5, retail and banking customers have a need for unification of their banking data for an unprecedented number of transactions based on interactions with their bank (e.g. payment of bills and clients, investments, tax obligations, etc..) aiming at a complete data processing of large datasets for more personalized and automated services for leveraging customer's satisfaction and cost reduction. The target is to build a personal pocket assistant based on an AI-enabled personal financial management (PFM) based on

the customer's accounts portfolio, to identify trading patterns, cashflow issues or personalized recommendations.

In Pilot #6, the target is to use BigData & AI analytics applied to retail's personalized portfolio management and customers behaviour for creating, improving or and automating investment recommendations oriented to Enhanced Productivity, Improved Investment Advisory, or Increased Trading Volumes. The main objective of the pilot is to provide these recommendations by performing Client Research and Profiling, Prospects identification ad Portfolio Management,

Scenario: Both studied pilots work over the same type of concepts such as: Customer, Account, Transactions, Portfolio, etc., thus it makes sense to enable the ability for them, (or any other that revolves around the same category) to have a common ground so that different financial institutions are able to semantically treat this type of data, by means of a unified semantic alignment that complies with the both the financial semantic standards and the personal data models in use by each of the pilots.

5.1.1.2.2 Use Case Major Steps in Implementation

The following main steps have been performed during the implementation of the Cluster#2 scenario:

1. **Analyse** the outcomes of the D4.1 – Semantic Models and Ontologies V1 (Taxonomy, Glossary and Domain terminology) and discover the main common concepts used for both pilots;
2. **Semantic alignment** of the common concepts with FIBO;
3. **Ontology development** creating a usable ontology defined by the semantic alignment from step 2;
4. **Map** formulate the data mappings from steps 1-3;
5. **Integration** integration of the resultant ontology in INFINITECH as part of integration between T4.1 and T4.2.

5.1.1.2.3 Analyse

Data structures were obtained and analysed from tables configuration files of LeanXcale (see **Error! Reference source not found.**), thus extracting some of the data concepts in regard to the pilot's description were defined:

1. *Customer*: the retail or banking customers who are possible candidates to service provisioning. It is described by a unique *CIF identifier* and other elements are the *registration Date*, the economic activity code *NACE code*, the location, between others
2. *Account*: described by and *unique account key*, and incorporates a relation to the account holder (through the *Customer CIF*)
3. *Transaction*: possesses a unique *TransactionID*, and several other elements that describes the *type, date,* relation to the *Originator* and *Beneficiary CIFs* and accounts, between other
4. *Cashflow*: relates to a given *Customer CIF* and describes the timed values of the *Customer Cashflow*

```
43  CREATE TABLE SME_ACCOUNTS (
44      skCIF    VARCHAR,
45      SKAcctkey VARCHAR,
46      PRIMARY KEY(SKAcctkey)
47  );
48
49  CREATE TABLE CUSTOMERS (
50      skCIF    VARCHAR,
51      NACECode VARCHAR,
52      NumberofEmployees INTEGER,
53      RegistrationDate DATE,
54      District VARCHAR,
55      PRIMARY KEY(skCIF)
56  );
```

```
CREATE TABLE CASHFLOW_EXP (
    skAcctKey VARCHAR,
    W_1 DOUBLE,
    W_2 DOUBLE,
    W_3 DOUBLE,
    W_4 DOUBLE,
    W_5 DOUBLE,
    W_6 DOUBLE,
    W_7 DOUBLE,
    W_8 DOUBLE,
    W_9 DOUBLE,
    W_10 DOUBLE,
    W_11 DOUBLE,
    W_12 DOUBLE,
    PRIMARY KEY(skAcctKey)
);
```

```
58  CREATE TABLE TXN_BOC (
59      skAcctKey VARCHAR,
60      TransactionID INTEGER,
61      Transactioncode VARCHAR,
62      TransactionDate DATE,
63      OriginatorBankCode VARCHAR,
64      BeneficiaryBankCode VARCHAR,
65      TransactionTypeCode VARCHAR,
66  --    CardNumber VARCHAR,
67      OriginalAmount DOUBLE,
68      CurrencyCode VARCHAR,
69      Amount DOUBLE,
70  --    TransactionDescription VARCHAR,
71  ----    skTransferAcctKey INTEGER,
72      skTransferAcctKey VARCHAR,
```

Figure 5-22 - data structures of cluster 3 obtained from table configurations of LeanXcale

Based on these files, the knowledge graph *Modelet* (depicted in Figure 5-23) was created to encompass these common concepts, in order to be further used in the application of the semantic alignment methodology of T4.1:

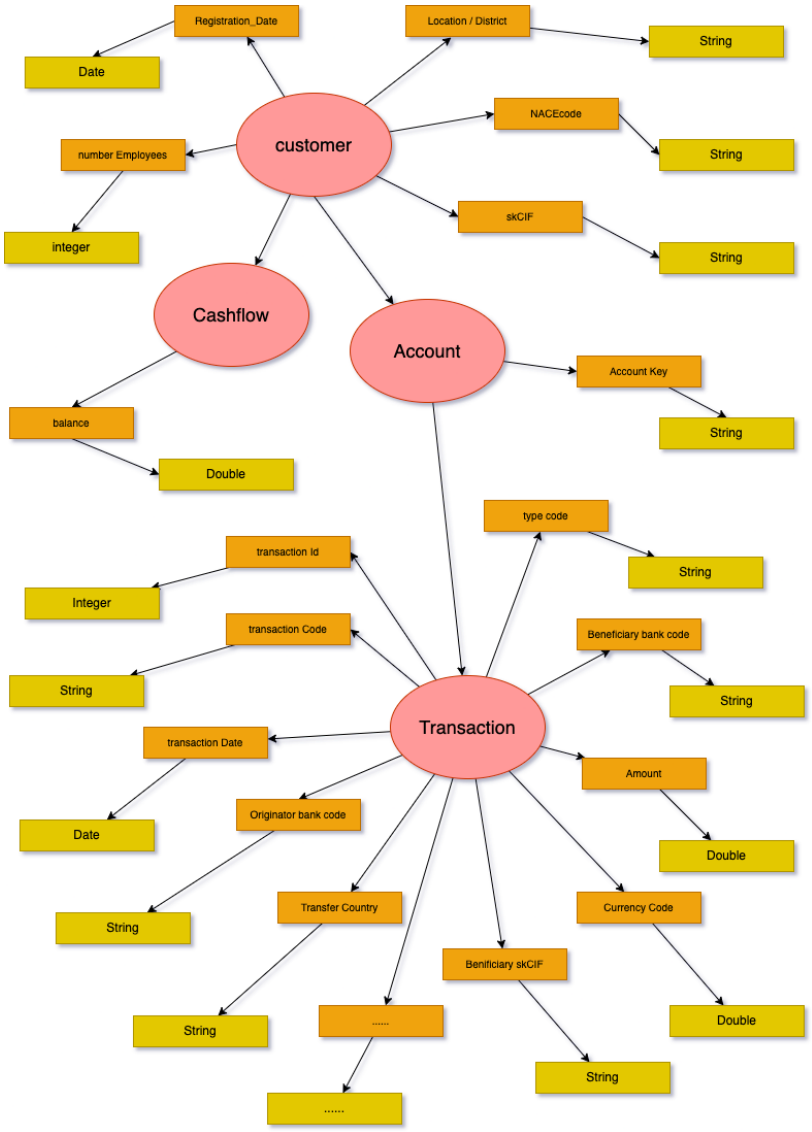

Figure 5-23 Cluster#3 knowledge graph *Modelet*

5.1.1.2.4 Semantic Alignment

By using the knowledge graph *Modelet* developed in the previous step, it was further refined and aligned to the reference ontologies (where once again FIBO was taken as reference for the domain of the application), resulting in the aligned knowledge graph (Figure 5-24):

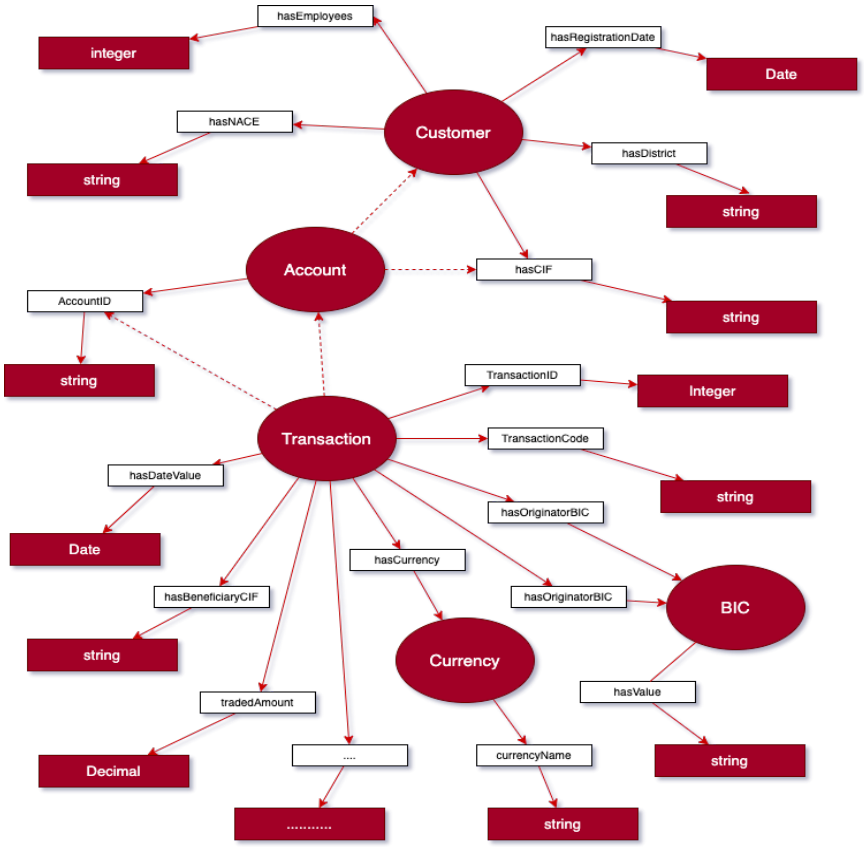

Figure 5-24 - Cluster#3 Knowledge Graph aligned with FIBO

The following concepts of FIBO, either with a direct or indirect relation to concepts of the modelet, have been used:

- **Customer:** the retail or banking customer of the financial institution that can be potentially provided with the services
- **Account:** The account(s) which of which Customer are Account holders, and of which transactions are related to
- **Transaction:** directly related to the concept of the Modelet, represents one's account transactions and incorporating the inherent sub-concepts
- **Currency:** the used currency identifier used in the exchange
- **BIC (Business Identifier Code):** represents the standard identifier of the Banks involved in the transactions

It is important to highlight that some concepts may not be either present in the FIBO reference ontology or, on the other hand, might have a different semantic structure of the practical use each pilot, therefore, this reinforced the need of the creation of an extended ontology for the domain of the Cluster, in which the align is made possible. As examples, consider the following:

- The BIC class in use on the *Modelet* is directly casted into a primitive value, where in FIBO, the same BIC is structured in a different (and more complex) schema, since the BIC can be representative of businesses other than banks, and therefore may involve the usage of other schemas.
- Another case is the Account, where in the *Modelet*, it has a direct relation to the Customer, whereas in FIBO, the Account identifies an AccountHolder which by its turn semantically relates to a Customer or Client.
- Finally, the case of the NACE code, which is not present in FIBO

The provided semantic alignment intends to, besides offering the capability of data transformation into RDF data, to give remedy for these issues by filling in or simplifying the alignment, as part of the methodology.

5.1.1.2.5 Ontology development

Moving on in the development stage, the semantic alignment is implemented using a viable software technology – Protégé[8] – for the purpose, where all the principals previously describer are put in practice, as depicted in Figure 5-25:

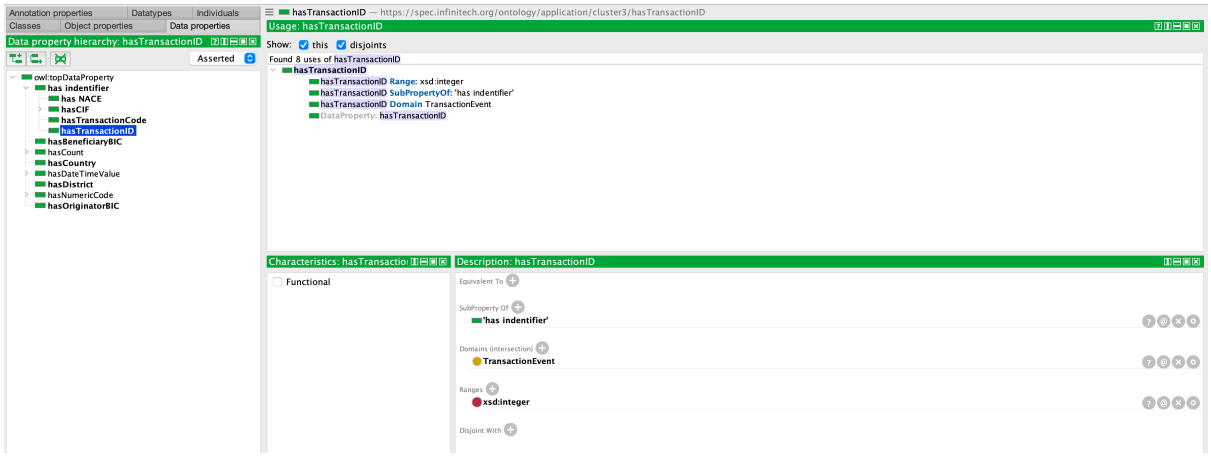

Figure 5-25 - development of the Cluster#3 Ontology from the semantic alignment Knowledge Graph

By concluding the development of the ontology, it is finally exported into a RDF file. In the case of the present scenario the result is the **INFINTECH PRIBE ontology**, where **PRIBE** stands for *Personalized Retail and Investment Banking Vocabulary Extension*. In Figure 5-26, a snippet of the resultant RDF graph of PRIBE can be seen:

```
@prefix : <https://spec.infinitech.org/ontology/application/cluster3/> .
@prefix owl: <http://www.w3.org/2002/07/owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xml: <http://www.w3.org/XML/1998/namespace> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@base <https://spec.infinitech.org/ontology/application/cluster3/> .

<https://spec.infinitech.org/ontology/application/cluster3/> rdf:type owl:Ontology ;
                                                              owl:versionIRI
                                                              <https://spec.infinitech.org
                                                              /ontology/application/cluste
                                                              r3/0.9> ;
                                                              owl:imports
                                                              <https://spec.edmcouncil.org
                                                              /fibo/ontology/quick/> .

#################################################################
#    Data properties
#################################################################

###  https://spec.infinitech.org/ontology/application/cluster3/hasBeneficiaryBIC
:hasBeneficiaryBIC rdf:type owl:DatatypeProperty ;
                   rdfs:domain
                   <https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/Finan
                   cialServicesEntities/BusinessIdentifierCode> ;
                   rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasBeneficiaryCIF
:hasBeneficiaryCIF rdf:type owl:DatatypeProperty ;
                   rdfs:subPropertyOf :hasCIF ;
                   rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasCIF
:hasCIF rdf:type owl:DatatypeProperty ;
        rdfs:subPropertyOf :hasIdentifier ;
        rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasCountry
:hasCountry rdf:type owl:DatatypeProperty ;
            rdfs:domain
            <https://www.omg.org/spec/LCC/Countries/CountryRepresentation/Country> ;
            rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasCurrencyCode
:hasCurrencyCode rdf:type owl:DatatypeProperty ;
                 rdfs:subPropertyOf
                 <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/
                 hasNumericCode> ;
                 rdfs:domain
                 <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/
                 Currency> ;
                 rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasDistrict
:hasDistrict rdf:type owl:DatatypeProperty ;
             rdfs:range xsd:string .


###  https://spec.infinitech.org/ontology/application/cluster3/hasIdentifier
:hasIdentifier rdf:type owl:DatatypeProperty ;
               rdfs:label "has indentifier" .
```

Figure 5-26 - snippet of INFINITECH PRIBE ontology (INFINITECH Cluster#3 ontology)

[8] https://protege.stanford.edu/

5.1.1.2.6 Mapping

Similarly to the previous scenario, and by using the INFINITECH PRIBE Ontology, pilots have now the ability to perform the mappings of the data into semantic data, by either adopting the presented technologies for the purpose (GraphDB, Dataworld, etc.) or any other.

As example, in figures Figure 5-27 and Figure 5-28 mapping examples for the Customer and Transactions are presented, respectively:

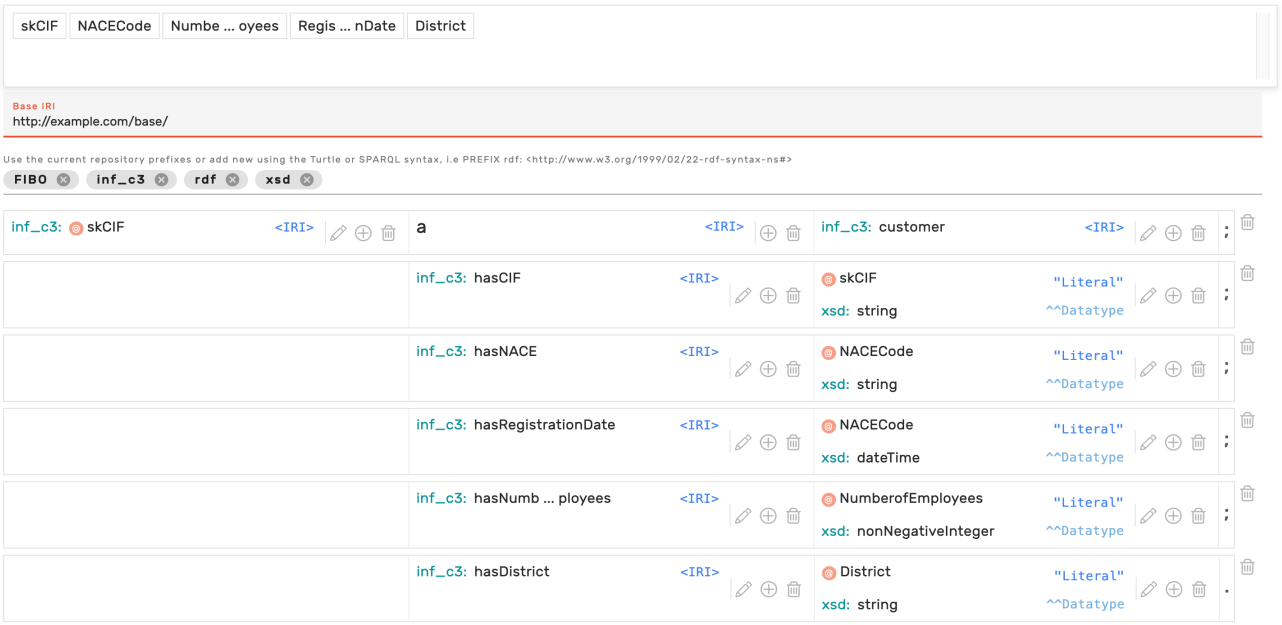

Figure 5-27 - Customer entity mapping with INFINITECH PRIBE ontology (GraphDB Ontorefine)

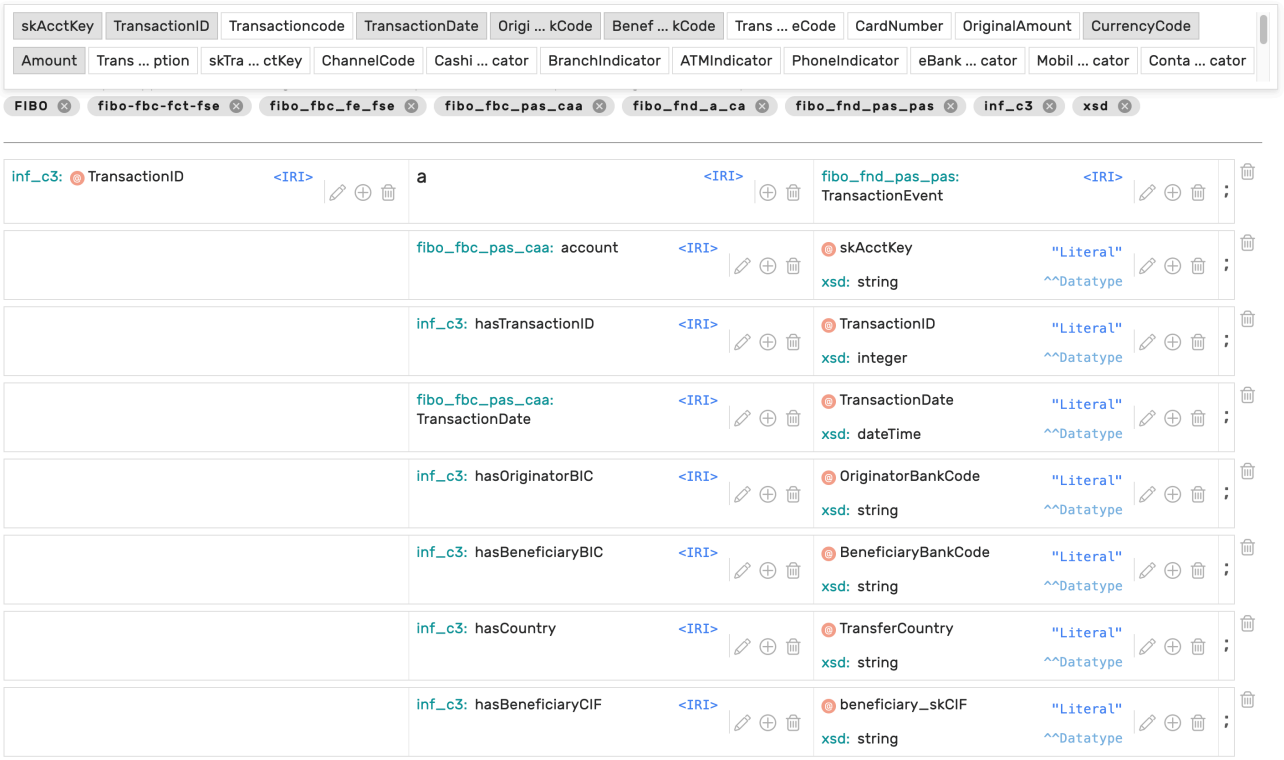

Figure 5-28 - Transaction entity mapping with INFINITECH PRIBE ontology (GraphDB Ontorefine)

5.1.1.2.7 Integration

The INFINITECH PRIBE ontology will be included in the INFINITECH Graph Data Model Online Tool in order to be available for usage and improvement by the developed components of Task 4.2, thus concluding the integration process between T4.1 and T4.2.

5.1.1.3 Data transformation of Real-time data Stream

This section presents how the proposed methodology for semantic alignment and transformation is applicable to in real-time data streams from data sources.

5.1.1.3.1 Scenario description

In this scenario, the principal is the same as the one presented in section 5.1.1.1 – Pilot#2 scenario – where the injected data on which was built the methodology for the semantic transformation and mapping was data-at-rest being stored in a LeanXcale instance.

Therefore, in this scenario, it was possible to re-use the semantic alignment and mappings that were developed through the methodology. The same goes for the technologies in use, where the developed client application was adjusted to conduct the workflow by reproducing the following steps:

1. Connect and receive the source data
2. Send the data into Ontorefine stream API for transformation (using the pre-existing mappings produced accordingly to the alignment model)
3. Store the data in an RDF GraphDB triple store, thus making it available

5.1.1.3.2 Architecture

In order to present a scenario which uses real-time data stream, the architecture of the Pilot#2 scenario was changed accordingly. For this, a simple modification of the source, from LeanXcale into a Broker/Trading Platform stream API was defined in the architecture. Whereas the data is now being received directly from the source in real-time, the workflow of the scenario remained the same, as depicted in Figure 5-29:

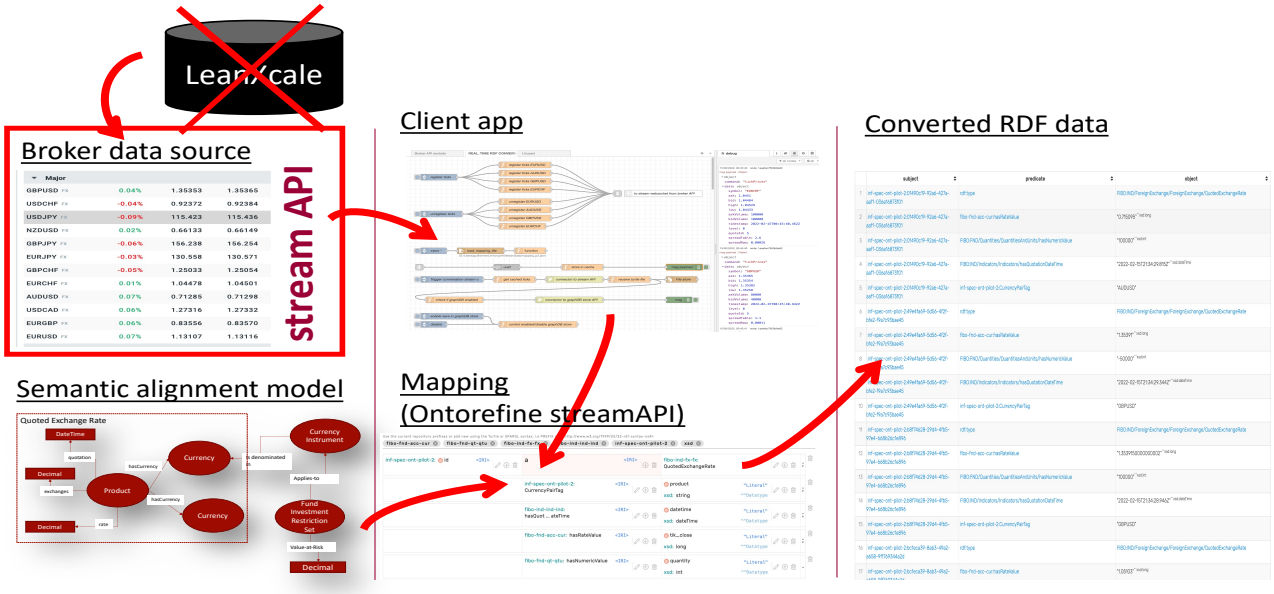

Figure 5-29 - Real-time data Stream semantic transformation workflow

A demonstrator video was made presenting the current scenario in execution, which can accessed in the following link:

https://drive.google.com/file/d/1tMERMCFyFETiXRfL6HdAIx5Hcif5GNjj/view?usp=sharing

6 WP3/WP4/WP5 integration specification

As WP3 addressed the tasks related to Data management and Governance, LeanXcale has been the adopted solution for the injection and management of INFINITECH pilot's data, thus, it makes sense to outline the terms in which raw data can be injected for semantic context of WP4 coming from LeanXcale, by following the specifications and requirements that come out from WP3.

Thus, LeanXcale provides a connector which works under the publish/subscribe messaging paradigm – used with Kafka software - , that enables to forward the incoming data stream in the following terms:

- Kafka subscription topics are created for given data sources/datasets
- The data is streamed from data sources into LeanXcale instance
- The injected data if out-streamed forward through the respective registered Kafka topic

In order to be able to acquire this out-streamed data, a Kafka connector needs to be included on the side of the application, making it possible to subscribe to the desired topics and therefore receive the streamed data for further usage on the process of semantic transformation.

The envisioned architecture for an integrated solution can be depicted in Figure 6-1:

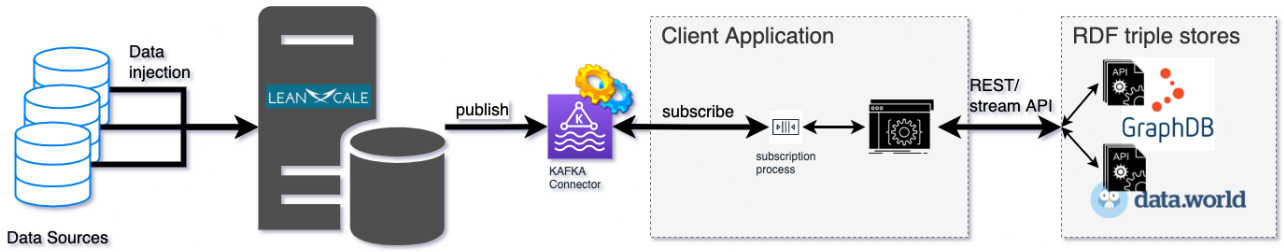

Figure 6-1 - Architecture for data stream adopting the LenXcale Kafka connector

Considering the architecture provided, where data will be streamed directly from LeanXcale component in a close to real-time data stream, it is now possible to re-adopt the Pilot#2 based scenario (Section 5.1.1.3).

7 Conclusions

This deliverable is the third and final version of the T4.1 - Semantic Models and Ontologies and introduces the final methodology for semantic alignment, including exemplary Scenarios for demonstrating the functional behaviour capabilities. The set of recipes, and technologies provide semantic interoperability within the INIFINITECH platform by delivering the necessary mechanisms to automatically extract data from heterogeneous data sources, transform the data according to the designed knowledge graph, connect the graph to the reference ontologies and provide the data to the outside world following FIBO reference models, as part of a defined methodology.

In this deliverable, the focus is on the validation of the proposed methodology presented in the previous versions, which supports the creation of semantic data models enabling data interoperability for Fintech's and Financial Sector. The scenarios presented demonstrate the validity of the methodology encompassing the analyses, the creations of the knowledge graphs and respective semantic alignment graphs and, finally, the development of mappings on which applications were able to use and execute data transformation in both data-at-rest and real-time data-streams.

Moreover, as part of the process of semantic alignment, an extended ontology dedicated to pilot's Cluster#2 was developed and provided as input to task 4.2 – Massive Distributed Processing of Semantically Linked Streams component, where its inclusion on the INFINITECH Graph Model Online Tool have a vital role so that pilots specific data can be linked and used by other semantically aware components.

Finally, the document also addresses the integration between WP3/WP4/WP5, by presenting the specifications and also an architectural overview of how the integration will be achieved, and possibly demonstrated by adoption of the real-time data stream exemplary scenario.

Table 7-1 – (map TASK KPI with Deliverable achievements)

KPI	Description	Comment
KPI 1	Semantic Interoperability Solution to be developed >=1.	The document provides the definition of the Semantic Layer (the one that is responsible for semantic interoperability within the INFINITECH platform). The semantic layer is the result of the application of the methodology developed within Task 4.1 which defines the process for gathering data from heterogeneous data sources and harmonize them according to reference ontologies, through the semantic alignment. The document also provides exemplary scenarios (pilot #2, and cluster #2), where the methodology is applied, deployed to access pilot specific streamed and at-rest data, and providing FIBO-aligned data through a REST endpoint from a triple-store database. The KPI is fully achieved since the full interoperability solution is completely functional and reproducible when using different datasets.
KPI 2	Financial & Insurance Sector Ontologies to be covered >= 3.	The document presents how pilot specific dataset can be harmonized by performing the proposed methodology for semantic alignment to the reference ontologies such as FIBO. The KPI is fully achieved.

References

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[2] "INFINITECH-D4.2 – Semantic Models and Ontologies II.pdf." 2021.

[3] "Leveraging Semantic and Graph Technology to Tame the Enterprise Data Storm." https://info.cambridgesemantics.com/hubfs/whitepapers/Perfect%20Storm%20Fin%20Svcs%20Whitepaper.pdf (accessed Mar. 26, 2022).

[4] S. Peroni, "SAMOD: an agile methodology for the development of ontologies," 2016, pp. 1–14.

[5] N. Guarino, *Formal ontology in information systems: Proceedings of the first international conference (FOIS'98), June 6-8, Trento, Italy*, vol. 46. IOS press, 1998.

[6] "INFINITECH-D4.5 – Semantics Streams Analytics Engine II.pdf." 2021.

[7] T. M. Siebel, *Digital transformation: survive and thrive in an era of mass extinction*. RosettaBooks, 2019.

Appendix A: Pilot Clusters' Analysis from deliverable's first and second versions

Step #1: Collecting

Cluster #1: Smart, Reliable and Credible Risk Assessment Pilots

Conceptualization of the Application Domain by using word clouds

Figure 7-1 – Cluster #1: Similarity from Natural Language analysis with Word Clouds

Deliverable #1: Domain Terminology

Table 7-2 – Domain Terminology Cluster #1

Terminology
Accuracy
Assessment
Asset
Asset Management
Asset Manager
Bank
Business
Client
Cost
Credit
Credit Report
Credit Reporting Service
Credit Risk
Credit Risk Score
Document
Expected Shortfall
Financial Organization
Financial Product
Financial Regulator
Financial Service
Index
Invoice
Lead
Manager
Market
Market Risk
Notarial Service
Notary
Notary Rate
Policy
Portfolio
Process
Processing System
Product
Regulatory Authority
Report
Risk
Risk Assessment
Risk Assessment Score
Risk Manager
Risk Metrics
Rules
Sales Manager
Score
Service
Service Cost
Supervisory Authority

Sustainability
Sustainability Index
Sustainability Score
Sustainable Business
Trade
Trade Analysis
Trader
Value-at-Risk

Deliverable #2: Glossary of Terms

Table 7-3 – Glossary of Terms Cluster #1

Glossary			
Term	**Synonym**	**Kind (OPAL semantic)**	**Description**
Accuracy	Correctness, Preciseness	Property	The quality or state of being correct or precise
Assessment	Determination, Rating, Estimation, Valuation	Process	The process of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made
Asset	Resource, property	Object	An asset is a resource with economic value that an individual, corporation, or country owns or controls with the expectation that it will provide a future benefit.
Asset Management	Investment management, portfolio management, wealth management	Process	Refers to the active management of an investor's portfolio by a financial services company (usually an investment bank)
Asset Manager	Investment manager, portfolio manager, wealth manager	Actor	A person that determines what investments to make, or avoid, that will grow a client's portfolio
Bank	Investment Firm, Trust Company	Actor	is a type of financial institution that accepts deposits, offers checking account services, makes various loans, and offers basic financial products like certificates of deposit (CDs) and savings accounts to individuals and small businesses. A commercial bank is where most people do their banking, as opposed to an investment bank
Business	Affair, Trade, Transaction, Contract	Process	The activity/process of buying and selling goods and services
Client	Costumer	Actor	A person or organization who engages or use the services of a lawyer or other professional person or company
Cost	Expense, expenditure, score	Property	An outlay or expenditure of money, time, effort, labour, trouble to acquire, produce, accomplish or maintain anything
Credit	Loan	Object	The ability and/or contractual agreement in which a customer obtains goods or services before payment, based on the trust that payment will be made in the future
Credit Report	Credit review, credit rating	Complex Property	Detailed breakdown of an individual's credit history prepared by a credit bureau and/or agency
Credit Reporting Service	Credit reporting	Process	A service that provides detailed breakdown of an individual's credit history prepared by a credit bureau and/or agency
Credit Risk	Risk of failure, risk of non-repayment, risk of insolvency	Property	The possibility of a loss resulting from a borrower's failure to repay a loan or meet contractual obligations
Credit Risk Score	Credit Risk rating, credit worthiness	Property	The number used by lenders that provides a snapshot of your credit risk picture at a particular point in time
Document	Certificate, record, form, report	Object	Paper or a set of papers with written or printed information, especially of an official type
Expected Shortfall	ES, CVaR, Expected Tail loss	Property	is a risk assessment measure used in the field of financial risk measurement to evaluate the market risk or credit risk of a portfolio. It is the expected return on the portfolio if the worst-case threshold is ever crossed

Financial Organization	Financial Institution, Trust Company, Bank	Actor	It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets
Financial Product	Financial instruments, financial tools	Object	A financial product is a product (typically in the form of a contract) provided to consumers and businesses or other organizations (municipalities or sovereigns) by financial institutions such as banks, insurance companies, brokerage firms, consumer finance companies, and investment companies all of which comprise the financial services industry
Financial Regulator	Financial supervisor, financial authority	Actor	A financial regulator is an institution that supervises and controls a financial system and related financial services. Their objective is to guarantee fair and efficient markets and financial stability
Financial Service	Banking, business services, financial affairs	Process	Service provided by the finance industry involving the investment, lending, and management of money and assets
Index	indicator, indication	Property	System of numbers used for comparing values of things that change according to each other or a fixed standard
Invoice	Bill	Object	Itemized list of goods shipped, usually specifying the price and terms of sale
Lead	Potential customer, potential client, interested customer, interested client	Actor	is an individual or organization with an interest in what you are selling
Manager	Administrator, director	Actor	is a person who manages or is in charge of something
Market	Retail, exchange, marketplace	Object	is a place where two parties can gather to facilitate the exchange of goods and services. The parties involved are usually buyers and sellers
Market Risk	Systematic risk	Property	is the possibility of an investor experiencing losses due to factors that affect the overall performance of the financial markets in which he or she is involved
Notarial Service	Notarize, notarizations	Process	Notary Services are services rendered by a state commissioned notary public
Notary	Notary public, public official, certifier	Actor	A person who has been licensed/authorized by a state to perform certain legal functions, especially to draw up or certify contracts, deeds, and other documents
Notary Rate	Notary fees	Property	The fee that a notary charges for their notary services
Policy	Plan, strategy	Object	a course or principle of action adopted or proposed by an organization or individual
Portfolio	Collection of investments	Object	is a grouping of financial assets such as stocks, bonds, commodities, currencies and cash equivalents, as well as their fund counterparts, including mutual, exchange-traded and closed funds
Process	Procedure, transaction	Process	A series of actions or steps taken in order to achieve a particular end
Processing System	Information processing, data processing, DP	Process	The combination of machines, people, and processes that for a set of inputs produces a defined set of outputs
Product	Commodity, output, solution	Object	It is an object or system made available for consumer use; it is anything that can be offered to a market to satisfy the desire or need of a customer
Regulatory Authority	Regulatory agency, regulatory institution	Actor	A regulatory authority is an autonomous authority or agency established by a federal, state or provincial government

Report	Account, story, chronicle,record	Object	an account, statement or document describing in detail an event, situation, or the like, usually as the result of observation, inquiry, etc.
Risk	Hazzard, pitfall, threat, trouble	Property	Risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return. Risk includes the possibility of losing some or all of an original investment.
Risk Assessment	Risk evaluation, risk analysis	Process	The systematic process of evaluating the potential risks and/or to determine the likelihood of loss on an asset, loan, or investment
Risk Assessment Score	Risk rating score, risk scoring	Property	It is a calculated number (score) that reflects the severity of a risk due to some factors
Risk Manager	Risk supervisor, director risk	Actor	an individual responsible for managing an organization's risks and minimizing the adverse impact of losses on the achievement of the organization's objectives
Risk Metrics	Risk measures	Property	The attribute of a risk that is being measured. Risk metrics are the statistical features used in risk measure calculations
Rules	Law, regulation	Complex Property	an accepted principle or instruction that states the way things are or should be done, and tells you what you are allowed or are not allowed to do
Sales Manager	Sales supervisor, sales leader	Actor	a manager in charge of the sales department and responsible for its performance, organization and planning
Score	Amount, number, amount, final count	Property	It is a number that expresses facts about an actual situation
Service	Assistance, support, utility	Object	the organized system of apparatus, appliances, employees, etc., for supplying some accommodation required by the public
Service Cost	Service charge, additional charge	Property	The expense associated with having another person perform a valuable task for which specialized expertise may be required
Supervisory Authority	SA, DPA	Actor	is an independent public authority that supervises, through investigative and corrective powers, the application of European data protection law
Sustainability	Maintainable, supportable	Property	The ability to be maintained at a certain rate or level
Sustainability Index	Performance indicator	Property	Instrument to measure the responsibility of a certain company in social, environmental and economic development. It can be used to predict a debtor’s financial performance and improve the predictive validity of the credit rating process
Sustainability Score	Sustainability rating	Property	It allows for a quick assessment of how well a company is run
Sustainable Business	Green business	Object	Is an enterprise to be that has minimal negative impact on the global or local environment, community, society, or economy
Trade	Exchange, transaction	Process	The action of buying and selling goods and services with compensation paid by a buyer to a seller, or the exchange of goods or services between parties
Trade Analysis	Technical analysis	Process	a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume

Trader	dealer, buyer, seller	Actor	an individual who engages in the buying and selling of financial assets in any financial market, either for himself or on behalf of another person or institution
Value-at-Risk	VaR	Property	is a statistic that measures and quantifies the level of financial risk within a firm, portfolio or position over a specific time frame

Deliverable #3: Taxonomy

Table 7-4 – Preliminary Taxonomy of Concepts for Cluster #1

Taxonomy			
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**
Document	Legal Document	Rule	
	Business Document	Credit Report	
		Invoice	
Service	Financial Service	Credit Reporting Service	
	Notary Service		
Customer	Lead		
Product	Financial Product	Portfolio	
		Asset	Physical Asset
			Intangible Asset
Score	Credit Risk Score		
	Sustainability Score		
	Risk Assessment Score	Expected Shortfall	
		VaR	
		Risk Metrics	
Index	Sustainability Index		
	Accuracy		
Process	Processing System		
	Assessment	Risk Assessment	
	Asset Management		
	Trade		
	Trade Analysis		
Cost	Service Cost		
	Notary Rate		
Business	Sustainable Business		
Institution	Financial Institution	Bank	

	Market Risk	
Risk	Credit Risk	
Employee	Manager	Asset Manager
		Risk Manager
		Sales Manager
Trader		
Market		
Authority	Supervisory Authority	
	Regulatory Authority	
	Financial Regulator	

Cluster #2: Personalized Retails and Investment Banking Services

Conceptualization of the Application Domain by using word clouds

Figure 7-2 – Cluster #2: Similarity from Natural Language Analysis with Word Clouds

Deliverable #1: Domain Terminology

Table 7-5 – Domain Terminology Cluster #2

Terminology
Advisor
Artificial Intelligence
Anti-Money Laundering
Assessment
Bank
Big-Data
Business
Client
Cost
Credit
Credit Risk
Credit Risk Score
Customer Data
Customer Profile
Customer Service
Data
Data Anonymization
Data Custodian Service
Digital Service
Financial Data
Financial Organization
Financial Product
Financial Regulator
Financial Service
Investment
Investment Advice
Investment Profile
Investor
Investor Profile
Know-Your-Client
Fund
Loyalty
Market
Open-Data
Optimization
Portfolio
Process
Processing System
Product
Regulatory Authority
Relationship Manager

Retail Customer
Risk
Risk Assessment
Risk Assessment Score
Risk Profiling
Score
Service
Service Cost
Service Provider
Trade
Trade Analysis
Wealth-Management

Deliverable #2: Glossary of Terms

Table 7-6 – Glossary of Terms Cluster #2

Glossary			
Term	**Synonym**	**Kind (OPAL semantic)**	**Description**
Advisor	Consultant	Actor	a person who gives advice in a particular field
Artificial Intelligence	AI, machine intelligence, machine learning, ML	Process	refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions
Anti-Money Laundering	AML	Process	Anti-money laundering refers to a set of laws, regulations, and procedures intended to prevent criminals from disguising illegally obtained funds as legitimate income.
Assessment	Determination, Rating, Estimation, Valuation	Process	The process of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made
Bank	Investment Firm, Trust Company	Actor	is a type of financial institution that accepts deposits, offers checking account services, makes various loans, and offers basic financial products like certificates of deposit (CDs) and savings accounts to individuals and small businesses. A commercial bank is where most people do their banking, as opposed to an investment bank
Big Data	Massive data, BDA	Process	is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software
Business	Affair, Trade, Transaction, Contract	Process	The activity/process of buying and selling goods and services
Client	Costumer	Actor	A person or organization who engages or use the services of a lawyer or other professional person or company
Cost	Expense, expenditure, score	Property	An outlay or expenditure of money, time, effort, labour, trouble to acquire, produce, accomplish or maintain anything
Credit	Loan	Object	The ability and/or contractual agreement in wich a customer obtains goods or services before payment, based on the trust that payment will be made in the future
Credit Risk	Risk of failure, risk of non-repayment, risk of insolvency	Property	The possibility of a loss resulting from a borrower's failure to repay a loan or meet contractual obligations
Credit Risk Score	Credit Risk rating, credit worthiness	Property	The number used by lenders that provides a snapshot of your credit risk picture at a particular point in time

Customer Data	Consumer Data, customer dataset	Object	Refers to all personal, behavioural, and demographic data that is collected by marketing companies and departments from their customer base.
Customer Profile	Client Profile, client profiling	Process	is a summary of a specific customer type that is based primarily on available statistical information, such as demographics, income (or company revenue if B2B), gender, age, location, etc.
Customer Service	Client service	Process	is the direct one-on-one interaction between a consumer making a purchase and a representative of the company that is selling it
Data	Info, facts	Object	facts and statistics collected together for reference or analysis
Data Anonymization	Data de-identification, data privacy, data obfuscation, data masking	Process	is the process of removing sensitive information from a document or other message whose intent is privacy protection
Data Custodian Service	Data custody service	Process	is responsible for the safe custody, transport, storage of the data and implementation of business rules
Digital Service	Electronic service, computer service	Process	Refers to the electronic delivery of information including data and content across multiple platforms and devices like web or mobile
Financial Data	Financial statements	Object	Financial data consists of pieces or sets of information related to the financial health of a business
Financial Organization	Financial Institution, Trust Company, Bank	Actor	It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets
Financial Product	Financial instruments, financial tools	Object	A financial product is a product (typically in the form of a contract) provided to consumers and businesses or other organizations (municipalities or sovereigns) by financial institutions such as banks, insurance companies, brokerage firms, consumer finance companies, and investment companies all of which comprise the financial services industry
Financial Regulator	Financial supervisor, financial authority	Actor	A financial regulator is an institution that supervises and controls a financial system and related financial services. Their objective is to guarantee fair and efficient markets and financial stability
Financial Service	Banking, business services, financial affairs	Process	Service provided by the finance industry involving the investment, lending, and management of money and assets
Investment	Transaction, expenditure, funding	Process	is the purchase of goods that are not consumed today but are used in the future to create wealth
Investment Advice	Investment recommendation	Process	is any recommendation or guidance that attempts to educate, inform, or guide an investor regarding a particular investment product or series of products.
Investment profile	investment profiling	Process	brings together a group of investments with a similar level of risk. It is made up of key data relating to investments or financial assets

Investor	shareholder, stockholder	Actor	is any person or other entity (such as a firm or mutual fund) who commits capital with the expectation of receiving financial returns
Investor profile	Investment style	Process	defines an individual's preferences in investment decisions
Know Your Client	KYC	Process	is a standard in the investment industry that ensures investment advisors know detailed information about their clients' risk tolerance, investment knowledge, and financial position
Fund	Capital, endowment, foundation	Object	is a pool of money that is allocated for a specific purpose
Loyalty	Allegiance, devotion	Property	In general use, loyalty, is a devotion and faithfulness to a nation, cause, philosophy, country, group, or person
Market	Retail, exchange, marketplace	Object	is a place where two parties can gather to facilitate the exchange of goods and services. The parties involved are usually buyers and sellers
Open Data	Free data, free accessible data	Object	Open data is the idea that some data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control
Optimization	Enhancement, improvement	Process	the action of making the best or most effective use of a situation or resource
Portfolio	Collection of investments	Object	is a grouping of financial assets such as stocks, bonds, commodities, currencies and cash equivalents, as well as their fund counterparts, including mutual, exchange-traded and closed funds
Process	Procedure, transaction, faithfulness	Process	A series of actions or steps taken in order to achieve a particular end
Processing System	Information processing, data processing, DP	Process	The combination of machines, people, and processes that for a set of inputs produces a defined set of outputs
Product	Commodity, output, solution	Object	It is an object or system made available for consumer use; it is anything that can be offered to a market to satisfy the desire or need of a customer
Regulatory Authority	Regulatory agency, regulatory institution	Actor	A regulatory authority is an autonomous authority or agency established by a federal, state or provincial government
Relationship Manager	Account manager, account executive	Actor	Relationship managers work to improve business relationships with partner firms and clients. Relationship management is generally divided into two fields: client relationship management and business relationship management
Retail Customer	Retail client	Actor	is customer who is going to buy in small quantity and the product usage would be by him or by his family or friends
Risk	Hazzard, pitfall, threat, trouble	Property	Risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return. Risk includes the possibility of losing some or all of an original investment.

Risk Assessment	Risk evaluation, risk analysis	Process	The systematic process of evaluating the potential risks and/or to determine the likelihood of loss on an asset, loan, or investment
Risk Assessment Score	Risk rating score, risk scoring	Property	It is a calculated number (score) that reflects the severity of a risk due to some factors
Risk profiling	Risk-profile	Process	evaluation of an individual's willingness and ability to take risks
Score	Amount, number, amount, final count	Property	It is a number that expresses facts about an actual situation
Service	Assistance, support, utility	Object	the organized system of apparatus, appliances, employees, etc., for supplying some accommodation required by the public
Service Cost	Service charge, additional charge	Property	The expense associated with having another person perform a valuable task for which specialized expertise may be required
Service Provider	SP, service bureau	Actor	Organization, business or individual which offers service to others in exchange for payment
Trade	Exchange, transaction, financial transaction	Process	The action of buying and selling goods and services with compensation paid by a buyer to a seller, or the exchange of goods or services between parties
Trade Analysis	Technical analysis	Process	a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume
Wealth-Management	Customer relationship management, CRM	Process	is an investment advisory service that combines other financial services to address the needs of affluent clients. It is a consultative process whereby the advisor gleans information about the client's wants and tailors a bespoke strategy utilizing appropriate financial products and services

Deliverable #3: Taxonomy

Table 7-7 – Preliminary Taxonomy of Concepts for Cluster #2

Taxonomy			
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**
Authority	Regulatory Authority		
	Financial Regulator		
Business			
Customer	Investor		
	Retail Customer		
Cost	Service Cost		
Process	Processing System	Data anonymization	
		Anti-Money Laundering	
		Artificial Intelligence	Big Data, Optimization
	Assessment	Risk Assessment	Risk Profiling
			KYC
Product	Financial Product	Portfolio	
		Asset	Physical Asset
			Intangible Asset
Profile	Risk Profile		
	Customer Profile		
	Investor Profile		
	Investment Profile		
Fund			
Market			
Risk	Credit Risk		
Employee	Manager	Relationship Manager	
	Advisor	Financial Advisor	
Score	Credit Risk Score		
	Risk Assessment Score		
Service	Financial Service	Digital Service	
		Data Custodian Service	
		Wealth-Management	
	Customer Service		
Data	Financial Data	Open Data Banking	

	Customer Data	
Event	Alert	
	Investment Advice	
Institution	Financial Institution	Bank
Service Provider		
Loyalty	Customer Loyalty	

Cluster #3: Financial Crime and Fraud Detection

Conceptualization of the Application Domain by using word clouds

Figure 7-3 – Cluster #3: Similarity from Natural language Analysis with Word Clouds

Deliverable #1: Domain Terminology

Table 7-8 – Domain Terminology Cluster #3

Terminology
Alert
Ancillary Service
Artificial Intelligence
Anti-Money Laundering
Assessment
Asset
Asset Management
Bank
Big Data
Client
Cyber-attack
Cyber Security
Customer Data
Customer Profile
Customer Service
Data
Data stream
Digital Service
Exchange Company
Financial Crime
Financial Crime Risk
Financial Data
Financial Organization
Financial Product
Financial Regulator
Financial Service
Forensics Analyst
Fraud
Fund
Investment
Open-banking
Know Your Client
Process
Processing System
Product
Regulatory Authority
Report
Retail Customer
Risk
Risk Assessment
Risk Assessment Score

Risk-based Supervision
Risk profiling
Score
Service
Terrorist Financing
Trade

Table 7-9 – Glossary of Terms Cluster #3

Glossary			
Term	**Synonym**	**Kind (OPAL semantic)**	**Description**
Alert	Warning, notice, notification	Property	an announcement, notice, or signal warning of potential dangerous situations and/or circumstances
Anti-Money Laundering	AML	Process	Anti-money laundering refers to a set of laws, regulations, and procedures intended to prevent criminals from disguising illegally obtained funds as legitimate income.
Artificial Intelligence	AI, machine intelligence, machine learning, ML	Process	refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions
Assessment	Determination, Rating, Estimation, Valuation	Process	The process of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made
Asset	Resource, porperty	Object	An asset is a resource with economic value that an individual, corporation, or country owns or controls with the expectation that it will provide a future benefit.
Asset Management	Investment management, portfolio management, wealth management	Process	Refers to the active management of an investor's portfolio by a financial services company (usually an investment bank)
Bank	Investment Firm, Trust Company	Actor	is a type of financial institution that accepts deposits, offers checking account services, makes various loans, and offers basic financial products like certificates of deposit (CDs) and savings accounts to individuals and small businesses. A commercial bank is where most people do their banking, as opposed to an investment bank
Big Data	Massive data, BDA	Process	is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software
Client	Costumer	Actor	A person or organization who engages or use the services of a lawyer or other professional person or company
Customer Data	Consumer Data, customer dataset	Object	Refers to all personal, behavioural, and demographic data that is collected by marketing companies and departments from their customer base.
Customer Profile	Client Profile, client profiling	Process	is a summary of a specific customer type that is based primarily on available statistical information, such as demographics, income (or company revenue if B2B), gender, age, location, etc.

Customer Service	Client service	Process	is the direct one-on-one interaction between a consumer making a purchase and a representative of the company that is selling it
Data	Info, facts	Object	facts and statistics collected together for reference or analysis
Digital Service	Electronic service, computer service	Process	Refers to the electronic delivery of information including data and content across multiple platforms and devices like web or mobile
Exchange Company	Exchange broker	Actor	is a company that offers currency exchange and international payments to private individuals and companies
Financial Crime	Financial infraction, financial misconduct, financial transgression	Process	is crime committed against property, involving the unlawful conversion of the ownership of property (belonging to one person) to one's own personal use and benefit
Financial Crime Risk	Financial infraction risk, financial misconduct risk, financial transgression risk	Property	is the risk of an organization to become victim of a financial crime
Financial Data	Financial statements	Object	Financial data consists of pieces or sets of information related to the financial health of a business
Financial Organization	Financial Institution, FI, Trust Compnay, Bank	Actor	It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets
Financial Product	Financial instruments, financial tools	Object	A financial product is a product (typically in the form of a contract) provided to consumers and businesses or other organizations (municipalities or sovereigns) by financial institutions such as banks, insurance companies, brokerage firms, consumer finance companies, and investment companies all of which comprise the financial services industry
Financial Regulator	Financial supervisor, financial authority	Actor	A financial regulator is an institution that supervises and controls a financial system and related financial services. Their objective is to guarantee fair and efficient markets and financial stability
Financial Service	Banking, business services, financial affairs	Process	Service provided by the finance industry involving the investment, lending, and management of money and assets
Forensics Analyst	Financial Forensics	Actor	may help with risk management and risk reduction through customized design of accounting and auditing systems and procedures. As a function of due diligence and investment analysis, they will advise on a wide variety of financial transactions
Fraud	Fraudulence, criminal deception	Process	is an intentionally deceptive action designed to provide the perpetrator with an unlawful gain or to deny a right to a victim. Fraud can occur in finance, real estate, investment, and insurance

Fund	Capital, endowment, foundation	Object	is a pool of money that is allocated for a specific purpose
Investment	Transaction, expenditure, funding	Process	is the purchase of goods that are not consumed today but are used in the future to create wealth
Process	Procedure, transaction, faithfulness	Process	A series of actions or steps taken in order to achieve a particular end
Processing System	Information processing, data processing, DP	Process	The combination of machines, people, and processes that for a set of inputs produces a defined set of outputs
Product	Commodity, output, solution	Object	It is an object or system made available for consumer use; it is anything that can be offered to a market to satisfy the desire or need of a customer
Regulatory Authority	Regulatory agency, regulatory institution	Actor	A regulatory authority is an autonomous authority or agency established by a federal, state or provincial government
Report	Account, story, chronicle, record	Object	an account, statement or document describing in detail an event, situation, or the like, usually as the result of observation, inquiry, etc.
Retail Customer	Retail client	Actor	is customer who is going to buy in small quantity and the product usage would be by him or by his family or friends
Risk	Hazzard, pitfall, threat, trouble	Property	Risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return. Risk includes the possibility of losing some or all of an original investment.
Risk Assessment	Risk evaluation, risk analysis	Process	The systematic process of evaluating the potential risks and/or to determine the likelihood of loss on an asset, loan, or investment
Risk Assessment Score	Risk rating score, risk scoring	Property	It is a calculated number (score) that reflects the severity of a risk due to some factors
Risk-based Supervision	RBS	Process	t is a comprehensive, formally structured system that assesses risks within the financial system, giving priority to the resolution of those risks
Risk profiling	Risk-profile	Process	evaluation of an individual's willingness and ability to take risks
Score	Amount, number, amount, final count	Property	It is a number that expresses facts about an actual situation
Service	Assistance, support, utility	Object	the organized system of apparatus, appliances, employees, etc., for supplying some accommodation required by the public
Terrorist Financing	TF	Process	is the provision of funds or providing financial support to individual terrorists or non-state actors
Trade	Exchange,	Process	The action of buying and selling goods and services with compensation paid by a buyer to a seller, or

	transaction, financial transaction	the exchange of goods or services between parties

Deliverable #3: Taxonomy

Table 7-10 – Preliminary Taxonomy of Concepts for Cluster #3

Taxonomy			
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**
Employee	Advisor	Financial Advisor	
	Forensic Analyst		
Authority	Regulatory Authority		
	Financial Regulator		
Customer	Investor		
	Retail Customer		
Crime	Financial Crime	Money Laundering	
		Terrorist Financing	
		Fraud	
Data	Financial Data	Open Data Banking	
	Customer Data		
Document	Legal Document		
	Business Document	Report	
Event	Alert		
	Investment Advice		
	Cyber Attack		
Institution	Financial Institution	Bank	
		Exchange Company	
Product	Financial Product	Portfolio	
		Asset	Physical Asset
			Intangible Asset (Investment)
Profile	Risk Profile		
	Customer Profile		
	Investor Profile		

	Investment Profile		
Process	Processing System	Artificial Intelligence	Big Data, Optimization, event streaming, data streaming
		Anti-Money Laundering	
		Anti-Terrorist Financing	
		Cyber Security	
	Assessment	Risk Assessment	Risk Profiling
			KYC
			RBS
	Trade		
	Trade Analysis		
	Asset Management		
Market			
Risk	Credit Risk		
	Financial Crime Risk		
Service	Financial Service	Digital Service	
		Wealth-Management	
		Ancillary Services	
	Customer Service		
Score	Credit Risk Score		
	Risk Assessment Score		
Loyalty	Customer Loyalty		
Service Provider			
Fund			

Cluster #4: Personalized Usage-based Insurance Products

Conceptualization of the Application Domain by using word clouds

Figure 7-4 – Cluster #4: Similarity from Natural Language Analysis with Word Clouds

Deliverable #1: Domain Terminology

Table 7-11 – Domain Terminology Cluster #4

Terminology
Accident
Alert
Artificial Intelligence
Assessment
Big Data
Bill
Car owner
Client
Customer Data
Customer Profile
Customer Service
Data
Data stream
Data vehicle
Device
Digital Service
Driver's behaviour Monitoring
Financial Organization
Financial Product
Fraud
Fraud detection
Health Insurance
Health Risk Assessment
Insurance
Insurance Company
Insurance premium
Insurance Product
Insured
Internet of Things

License
Location Data
Manufacturer Maintenance Program
Medical Device
Ministry database
Ministry of Transport
Process
Processing System
Product
Regulatory Authority
Report
Risk
Risk Assessment
Risk Assessment Score
Score
Sensor
Service
Usage-based Insurance
Vehicle
Vehicle identification number
Vehicle Inspection
Vehicle insurance

Table 7-12 – Glossary of Terms Cluster #4

Glossary			
Term	**Synonym**	**Kind (OPAL semantic)**	**Description**
Accident	Collision, crush	Process	an unfortunate incident that happens unexpectedly and unintentionally, typically resulting in damage or injury
Alert	Warning, notice, notification	Property	an announcement, notice, or signal warning of potential dangerous situations and/or circumstances
Artificial Intelligence	AI, machine intelligence, machine learning, ML	Process	refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions
Assessment	Determination, Rating, Estimation, Valuation	Process	The process of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made
Big Data	Massive data, BDA	Process	is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software
Bill	Invoice	Object	a statement of money owed for goods or services supplied
Car owner	Registered owner	Actor	is usually used in instances of title of a vehicle (such as an automobile) to refer to the person who has right of possession of the vehicle
Client	Costumer	Actor	A person or organization who engages or use the services of a lawyer or other professional person or company
Customer Data	Consumer Data, customer dataset	Object	Refers to all personal, behavioural, and demographic data that is collected by marketing companies and departments from their customer base.
Customer Profile	Client Profile, client profiling	Process	is a summary of a specific customer type that is based primarily on available statistical information, such as demographics, income (or company revenue if B2B), gender, age, location, etc.
Customer Service	Client service	Process	is the direct one-on-one interaction between a consumer making a purchase and a representative of the company that is selling it
Data	Info, facts	Object	facts and statistics collected together for reference or analysis
Data stream	data transmission, data flow	Process	a set of digital signals used for different kinds of content transmission
Data vehicle	Vehicle telemetry, car data, car telemetry	Object	Live data collected from the vehicle
Device	Appliance, instrument	Object	a thing made or adapted for a particular purpose, especially a piece of mechanical or electronic equipment
Digital Service	Electronic service, computer service	Process	Refers to the electronic delivery of information including data and content across multiple platforms and devices like web or mobile
Driver's behaviour Monitoring	Driver behaviour estimation, driver behaviour service	Process	is the process that allows to gain valuable insights into driving behavior and vehicle usage patterns from collected vehicle data
Financial Organization	Financial Institution, Trust Company, Bank	Actor	It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets

Financial Product	Financial instruments, financial tools, insurance	Object	A financial product is a product (typically in the form of a contract) provided to consumers and businesses or other organizations (municipalities or sovereigns) by financial institutions such as banks, insurance companies, brokerage firms, consumer finance companies, and investment companies all of which comprise the financial services industry
Fraud	Fraudulence, criminal deception, theft	Process	is an intentionally deceptive action designed to provide the perpetrator with an unlawful gain or to deny a right to a victim. Fraud can occur in finance, real estate, investment, and insurance
Fraud detection	Fraud prevention, fraudulent activities detection	Process	is a set of activities undertaken to prevent money or property from being obtained through false pretenses
Health Insurance	Medicare, medical insurance, health plan	Object	is a type of insurance coverage that pays for medical, surgical, and sometimes dental expenses incurred by the insured
Health Risk Assessment	HRA, health risk appraisal, health & well-being assessment	Process	is a health questionnaire, used to provide individuals with an evaluation of their health risks and quality of life
Insurance	Assurance, protection	Object	Insurance is a contract, represented by a policy, in which an individual or entity receives financial protection or reimbursement against losses from an insurance company
Insurance Company	Insurance firm, insurer	Actor	A business that provides coverage, in the form of compensation resulting from loss, damages, injury, treatment or hardship in exchange for premium payments
Insurance premium	Insurance price, tariffs	Property	is the amount of money an individual or business pays for an insurance policy. Insurance premiums are paid for policies that cover healthcare, auto, home, life, and others
Insurance Product	Insurance contract, insurance service	Object	Insurance products are common financial arrangements in which an insurance provider states its guarantee to pay on covered claims. In return, the buyer agrees to pay a monthly premium cost.
Insured	Protected, covered, assured	Actor	covered by insurance
Internet of Things	IoT	Object	is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction
License	Drive license	Object	is an official document, permitting a specific individual to operate one or more types of motorized vehicles, such as a motorcycle, car, truck, or bus on a public road
Location Data	Vehicle Location Data	Object	is the big data collection of vehicle locations, including automatic vehicle location data
Manufacturer Maintenance Program	Servicing program, car care program, car care service	Object	is a document containing the maintenance scheduled servicing, inspections, and vehicle repairs that needs to be carried out to prevent potential problems and maximize vehicle availability
Medical device	Medical appliance, medical instrument	Object	any instrument, apparatus, implement, machine, appliance, implant, reagent for in vitro use, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings, for one or more of the specific medical purpose(s)
Ministry database	Ministry db	Object	A set of structured data about driver and vehicle information that is available to the public

Ministry of Transport	Ministry of Transportation	Actor	ministry responsible for transportation within a country
Process	Procedure, transaction, faithfulness	Process	A series of actions or steps taken in order to achieve a particular end
Processing System	Information processing, data processing, DP	Process	The combination of machines, people, and processes that for a set of inputs produces a defined set of outputs
Product	Commodity, output, solution	Object	It is an object or system made available for consumer use; it is anything that can be offered to a market to satisfy the desire or need of a customer
Regulatory Authority	Regulatory agency, regulatory institution	Actor	A regulatory authority is an autonomous authority or agency established by a federal, state or provincial government
Report	Account, story, chronicle, record	Object	an account, statement or document describing in detail an event, situation, or the like, usually as the result of observation, inquiry, etc.
Risk	Hazzard, pitfall, threat, trouble	Property	Risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return. Risk includes the possibility of losing some or all of an original investment.
Risk Assessment	Risk evaluation, risk analysis	Process	The systematic process of evaluating the potential risks and/or to determine the likelihood of loss on an asset, loan, or investment
Risk Assessment Score	Risk rating score, risk scoring	Property	It is a calculated number (score) that reflects the severity of a risk due to some factors
Score	Amount, number, amount, final count	Property	It is a number that expresses facts about an actual situation
Sensor	Detector, sensing device, transducer	Object	a device which detects or measures a physical property and records, indicates, or otherwise responds to it
Service	Assistance, support, utility	Object	the organized system of apparatus, appliances, employees, etc., for supplying some accommodation required by the public
Usage-based Insurance	UBI, PAYD, PHYD, mile-based auto insurance	Object	is a type of vehicle insurance whereby the costs are dependent upon type of vehicle used, measured against time, distance, behavior and place
Vehicle	Car, automobile	Object	a road vehicle, typically with four wheels, powered by an internal combustion engine and able to carry a small number of people
Vehicle identification number	VIN, car identification number	Property	is the identifying code for a specific automobile
Vehicle Inspection	Technical Inspection	Object	Vehicle inspection is a procedure mandated by national or subnational governments in many countries, in which a vehicle is inspected to ensure that it conforms to regulations governing safety, emissions, or both
Vehicle insurance	Auto insurance, car insurance, motor insurance	Object	is insurance for cars, trucks, motorcycles, and other road vehicles

Deliverable #3: Taxonomy

Table 7-13 – Preliminary Taxonomy of Concepts for Cluster #4

Taxonomy			
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**
Authority	Regulatory Authority		
	Financial Regulator		
	Ministry of Transport		
Car Owner			
Customer	Insured		
Crime	Financial Crime	Fraud	
Cost	Insurance Premium		
Data	Financial Data		
	Vehicle Data	VIN	
	Geographical Data	Location Data	
	Customer Data		
Document	Legal Document	Insurance	Vehicle Insurance, Usage-based Insurance
		License	
	Business Document	Report	
		Invoice	
Device	Measurement Device	Vehicle Sensor	IoT Device
		Medical Device	
Event	Alert		
	Accident		
Institution	Financial Institution	Insurance Company	
Product	Financial Product	Insurance	Health Insurance
Profile	Customer Profile		
Process	Processing System	Artificial Intelligence	Big Data, Optimization, event streaming, data streaming
		Driver's behaviour	
		Vehicle Inspection	
		Fraud Detection	
	Assessment	Risk Assessment	Risk Profiling
Risk	Credit Risk		
	Financial Crime Risk		
Service	Financial Service	Digital Service	

	Customer Service	Manufacturer Maintenance Program
Score	Credit Risk Score	
	Risk Assessment Score	
Vehicle		
Fund		

Cluster #5: Configurable and Personalized Insurance Product

Conceptualization of the Application Domain by using word clouds

Figure 7-5 – Cluster #5: Similarity from Natural Language Analysis with Word Clouds

Deliverable #1: Domain Terminology

Table 7-14 – Domain Terminology Cluster #5

Terminology
Actuary
Agent
Agricultural Insurance
Agroclimatic advisories
Agroclimatic Indicator
Artificial Intelligence
Assessment
Big Data
Client
climate risk management
Client Portfolio
Cold Spell Indicator
Cost
Crop
Customer Data
Customer Profile
Customer Service
Damage Assessment
Data
Data Anonymization
Data Protection
Data stream
Digital Service
Disaster Risk Management
Evotranspiration
Financial Organization
Financial Product
Geographical Data
Hail Storm Indicator
Heat stress
Index
Insurance
Insurance Broker
Insurance Company
Insurance premium
Insurance Product
Insured
Insurer
Land Use
Late frost Indicator
Loss adjuster

Normalized Difference Vegetation Index
Pest Impact Indicator
Pesticide
Phenological Indicator
Portfolio
Precipitation
Process
Processing System
Product
Regulatory Authority
Remote Sensing
Report
Risk
Risk Assessment
Risk Assessment Score
Risk profiling
Sales Agent
Score
Service
Small and Medium Enterprise
Soil Map
Sowing date shifting Indicator
Supervised Learning
Temperature
Topography
Underwriter
Underwriting
Unsupervised Learning
Warm Spell Duration Index
Water stress
Weather data
Weather index
Weather-index Insurance
Wind Storm indicator

Deliverable #2: Glossary of Terms

Table 7-15 – Glossary of Terms Cluster #5

Glossary			
Term	**Synonym**	**Kind (OPAL semantic)**	**Description**
Actuary	Statistician	Actor	a person who compiles and analyses statistics and uses them to calculate insurance risks and premiums
Agent	Broker	Actor	is a person who has been legally empowered to act on behalf of another person or an entity
Agricultural Insurance	AgI, Crops Insurance	Object	is a valuable business risk management tool that provides farmers with financial protection against production losses (loss or damage to crops) caused by natural perils, such as drought, excessive moisture, hail, frost, wind and wildlife
Agroclimatic advisories	Agroclimatic advisory services	Object	Agrometeorological advisory involves research and applied work aimed at communicating weather information and agricultural advice to farmers, based on weather monitoring and forecasting
Agroclimatic Indicator	Agroclimatic index	Property	A measure or indicator of an aspect of the climate that has specific agricultural significance
Artificial Intelligence	AI, machine intelligence, machine learning, ML	Process	refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions
Assessment	Determination, Rating, Estimation, Valuation	Process	The process of judging or deciding the amount, value, quality, or importance of something, or the judgment or decision that is made
Big Data	Massive data, BDA	Process	is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software
Client	Costumer	Actor	A person or organization who engages or use the services of a lawyer or other professional person or company
climate risk management		Process	is the systematic approach to and practice of considering climate-related trends and events in development decision-making to minimize potential harm (UNDP BCPR 2013)
Client Portfolio	Customer base, customer wallet, client base	Object	is a segmented list of the various groups that do business with you
Cold Spell Indicator	Cold spell duration index, CSDI	Property	it measures the number of days with a minimum daily temperature below its climatological 10th percentile for at least 6 consecutive days
Cost	Expense, expenditure, score	Property	An outlay or expenditure of money, time, effort, labour, trouble to acquire, produce, accomplish or maintain anything
Crop	Selection, Batch, lot, collection	Object	is a plant or animal product that can be grown and harvested extensively for profit or subsistence
Customer Data	Consumer Data, customer dataset	Object	Refers to all personal, behavioural, and demographic data that is collected by marketing companies and departments from their customer base.
Customer Profile	Client Profile, client profiling	Process	is a summary of a specific customer type that is based primarily on available statistical information, such as demographics, income (or company revenue if B2B), gender, age, location, etc.

Customer Service	Client service	Process	is the direct one-on-one interaction between a consumer making a purchase and a representative of the company that is selling it
Damage Assessment		Process	Preliminary but fairly accurate onsite evaluation of damage or loss caused by an accident or natural event before filing a formal claim or disaster declaration. Damage assessment records the extent of damage, what can be replaced, restored, or salvaged, and time required for their execution
Data	Info, facts	Object	facts and statistics collected together for reference or analysis
Data Anonymization	Data de-indentification, data privacy	Process	is the process of removing sensitive information from a document or other message whose intent is privacy protection
Data protection	Data privacy	Process	is the process of protecting data and involves the relationship between the collection and dissemination of data and technology, the public perception and expectation of privacy and the political and legal underpinnings surrounding that data
Data stream	data transmission, data flow	Process	a set of digital signals used for different kinds of content transmission
Digital Service	Electronic service, computer service	Process	Refers to the electronic delivery of information including data and content across multiple platforms and devices like web or mobile
Disaster Risk Management	DRM	Process	The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster
Evotranspiration	ET	Property	It is the sum of evaporation and plant transpiration. It is the water lost from an area through the combined effects of evaporation from the ground surface and transpiration from the vegetation
Financial Organization	Financial Institution, Trust Company, Bank	Actor	It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets
Financial Product	Financial instruments, financial tools, insurance	Object	A financial product is a product (typically in the form of a contract) provided to consumers and businesses or other organizations (municipalities or sovereigns) by financial institutions such as banks, insurance companies, brokerage firms, consumer finance companies, and investment companies all of which comprise the financial services industry
Geographical Data	Spatial data	Property	data that contains information about the spatial location (position) and the attribute being monitored (yield, seed population, etc.)
Hail Storm Indicator	Potential Hail Indicator, Potential Hail Index, PHI	Property	It quantifies the atmospheric potential for hailstorms and can be derived from atmospheric numerical models
Heat stress		Property	Temperatures above the optimum for growth can be deleterious, causing injury or irreversible damage, which is generally called 'heat stress' (Wahid et al. 2007)
Index	indicator, indication, measure	Property	System of numbers used for comparing values of things that change according to each other or a fixed standard
Insurance	Assurance, protection	Object	Insurance is a contract, represented by a policy, in which an individual or entity receives financial protection or reimbursement against losses from an insurance company

Insurance Broker	Broker	Actor	An individual or firm who represents buyers of insurance and deals with insurance companies or their agents in arranging for insurance coverage for the buyer
Insurance Company	Insurance firm, insurer	Actor	A business that provides coverage, in the form of compensation resulting from loss, damages, injury, treatment or hardship in exchange for premium payments
Insurance premium	Insurance price, tariffs	Property	is the amount of money an individual or business pays for an insurance policy. Insurance premiums are paid for policies that cover healthcare, auto, home, life, and others
Insurance Product	Insurance contract, insurance service	Object	Insurance products are common financial arrangements in which an insurance provider states its guarantee to pay on covered claims. In return, the buyer agrees to pay a monthly premium cost.
Insured	Protected, covered, assured	Actor	covered by insurance
Insurer	Underwriter, insurance underwriter	Actor	a person or company that underwrites an insurance risk; the party in an insurance contract undertaking to pay compensation
Land Use		Process	Human activities, which are directly related to the land, making use of its resources, or having an impact upon it. A given land use may take place on one or more than one piece of land, and several land uses may occur on the same piece of land
Late frost Indicator		Property	It provides a prediction of the last late frost of the season
Loss adjuster	Claims adjuster	Actor	an insurance agent who assesses the amount of compensation that should be paid after a person has claimed on their insurance policy
Normalized Difference Vegetation Index	NDVI	Property	is a simple graphical indicator that can be used to analyze remote sensing measurements, often from a space platform, assessing whether or not the target being observed contains live green vegetation
Pest Impact Indicator	Assessement Indicator of Damage	Property	It measures the pest and/or disease damage
Pesticide	Insecticide, fungicide	Object	substances intended to repel, mitigate, control or destroy diseases and pests in plants or animals and to prevent any harm to agricultural commodity during production, storage, transport, processing and marketing etc.
Phenological Indicator	Crop Phenology Indicator	Property	It is an indicator s associated to the periodic events in the life cycle of living species, used to manage crop activities
Portfolio	Collection of investments	Object	is a grouping of financial assets such as stocks, bonds, commodities, currencies and cash equivalents, as well as their fund counterparts, including mutual, exchange-traded and closed funds
Precipitation	Rainfall, hail, hailstorm, snow	Property	The quantity of such water falling in a specific area within a specific period
Process	Procedure, transaction, faithfullness	Process	A series of actions or steps taken in order to achieve a particular end
Processing System	Information processing, data processing, DP	Process	The combination of machines, people, and processes that for a set of inputs produces a defined set of outputs
Product	Commodity, output, solution	Object	It is an object or system made available for consumer use; it is anything that can be offered to a market to satisfy the desire or need of a customer
Regulatory	Regulatory	Actor	A regulatory authority is an autonomous authority or agency

Authority	agency, regulatory institution		established by a federal, state or provincial government
Remote Sensing	Remote-sensing, remote monitoring	Process	he act of detection and/or identification of an object, series of objects, or landscape without having the sensor in direct contact with the object. The most common forms include color and color infrared aerial photography, satellite imaging and radar sensing
Report	Account, story, chronicle,record	Object	an account, statement or document describing in detail an event, situation, or the like, usually as the result of observation, inquiry, etc.
Risk	Hazzard, pitfall, threat, trouble	Property	Risk is defined in financial terms as the chance that an outcome or investment's actual gains will differ from an expected outcome or return. Risk includes the possibility of losing some or all of an original investment.
Risk Assessment	Risk evaluation, risk analysis	Process	The systematic process of evaluating the potential risks and/or to determine the likelihood of loss on an asset, loan, or investment
Risk Assessment Score	Risk rating score, risk scoring	Property	It is a calculated number (score) that reflects the severity of a risk due to some factors
Risk profiling	Risk-profile	Process	evaluation of an individual's willingness and ability to take risks
Sales Agent	Insurance agent	Actor	helps insurance companies generate new business by contacting potential customers and selling one or more types of insurance. Insurance sales agents explain various insurance policies and help clients choose plans that suit them
Score	Amount, number, amount, final count	Property	It is a number that expresses facts about an actual situation
Service	Assistance, support, utility	Object	the organized system of apparatus, appliances, employees, etc., for supplying some accommodation required by the public
Soil Map	Soil features, earth features	Object	a map that indicates differences in soil properties (texture, fertility, organic matter, pH, etc.) within a field
Sowing date shifting Indicator	Planting date shfiting indicator	Property	It measures the optimal planting time
Supervised Learning	Classification	Process	is the machine learning task of learning a function that maps an input to an output based on example input-output pairs
Temperature	TI, Thermal reading	Property	the degree or intensity of heat present in a substance or object, especially as expressed according to a comparative scale and shown by a thermometer or perceived by touch
Topography	Chorography, geomorphology	Process	a detailed description or representation on a map of the physical features of an area
Underwriter	Guarantor, risk-taker, insurance underwriter	Actor	is any party that evaluates and assumes another party's risk for a fee.
Underwriting	Insure, subscription	Process	Underwriting is the process through which an individual or institution takes on financial risk for a fee
Unsupervised Learning	Clustering	Process	is a type of machine learning that looks for previously undetected patterns in a data set with no pre-existing labels and with a minimum of human supervision
Warm Spell Duration Index	WSDI	Property	It defines periods of excessive warmth, cold, wetness or dryness. WSDI is defined as the annual count of days with at least 6 consecutive days when the daily maximum temperature is exceeding the threshold T90
Water stress		Property	occurs when water demand exceeds water supply. Increased drought occurrence will lead to increased crop water stress in areas where irrigation infrastructure is lacking, or plants are

			unable access groundwater (Lobell and Gourdji 2012)
Weather data	Weather indication, climatological data	Property	Information about precipitation, wind, temperature, and other climate conditions
Weather index		Property	is based on specific weather parameters measured over a pre-specified period of time at a particular weather station (World Bank 2011)
Weather-index Insurance		Object	A class of insurance products that can allow weather-related risk to be insured in developing countries where traditional agricultural insurance may not always be feasible, thereby helping to increase farmers' ability (and willingness) to invest in measures that might increase their productivity
Wind Storm indicator	Wind Storm Index	Property	It measures the changes in wind speed

Deliverable #3: Taxonomy

Table 7-16 – Preliminary Taxonomy of Concepts for Cluster #5

Taxonomy			
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**
Authority	Regulatory Authority		
	Financial Regulator		
Customer	Company	Small and Medium Enterprise (Insured)	
	Client Portfolio		
Crime	Financial Crime	Fraud	
Cost	Insurance Premium		
Data	Financial Data		
	Customer Data		
	Geographical Data	Location Data	
	Weather Data		
Document	Legal Document		
	Business Document	Report	
		Invoice	
Device	Agricultural Device	Sensor	IoT Device
Employee	Agent	Sales Agent	
	Actuary		
	Insurance Broker		
	Loss Adjuster		
Institution	Financial Institution	Insurance Company (Insurer)	Underwriter
Index	Agroclimatic indicator	Cold Spell indicator	
		Evotranspiration	
		Hail Storm indicator	
		Heat Stress	
		Land Use	
		Late frost Indicator	
		Normalized Difference Vegetation Index	
		Pest Impact Indicator	
		Phenological Indicator	
		Soil Map	
		Sowing date shifting indicator	
		Temperature	

		Warm Spell duration Index	
		Water Stress	
		Weather Index	
		Wind Storm Indicator	
Product	Financial Product	Insurance	Agricultural Insurance, Weather-index Insurance
		Portfolio	
Profile	Customer Profile		
Process	Processing System	Artificial Intelligence	Big Data, Optimization, event streaming, data streaming, Supervised Learning, Unsupervised Learning
		Underwriting	
		Remote Sensing	
	Assessment	Risk Assessment	Climatic Risk Assessment, Risk profiling
		Damage Assessment	
Risk	Credit Risk		
	Climatic Risk		
Service	Financial Service	Digital Service	
		Climatic Risk Management	
		Disaster Risk Management	
	Customer Service		
	Agroclimatic Advisory Service		
Score	Credit Risk Score		
	Risk Assessment Score		
Vehicle			
Fund			

Step #2: Building modelets from Terminology, Glossary and Taxonomies

Cluster #1: Smart, Reliable and Credible Risk Assessment Pilots Table 7-17 – Cluster #1: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

Taxonomy				
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**	**Fourth-Level Specialization**
rdfs: subClassOf				
INFINITECH: Document owl:equivalentClass **FIBO: Document** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-expr: Document**	**INFINITECH: LegalDocument owl:equivalentClass** **FIBO: Legal Document** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-norm: Legal Document**			
	INFINITECH:Report owl:equivalentClass **FIBO: Report** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Reporting/)	FIBO:Assessment Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/AssessmentReport)	FIBO:Rating Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/RatingReport)	**INFINITECH:Credit Report owl:equivalentClass** **FIBO:CreditReport** (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditReport)
	INFINITECH: Invoice			
INFINITECH:Service owl:equivalentClass **FIBO: Service** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	Fro-fin-ref: Professional Service	**INFINITECH: Customer Service owl:equivalentClass** **FIBO: Financial Service** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialService)	**INFINITECH:Credit Reporting Service**	
		INFINITECH:Notary Service		
		INFINITECH: Digital Service		
FIBO: Agent in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	FIBO: Party in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH:Client owl:equivalentClass** **FIBO: Client** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)		
		FIBO: Buyer (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH:Customer owl:equivalentClass** **FIBO: Customer** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	
			INFINITECH: Asset Manager	

		FIBO: Responsible Party (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/ClientsAndAccounts/	**INFINITECH: Sales Manager** **INFINITECH: Risk Manager**	
		INFINITECH: Supervisory Authority		
INFINITECH:Product owl:equivalentClass FIBO:Product (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product)	**INFINITECH:Financial Product owl:equivalentClass FIBO:Financial Product** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct)			
INFINITECH:Asset owl:equivalentClass FIBO: Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/Asset)	FIBO: Tangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/TangibleAsset)			
	FIBO: Intangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/IntangibleAsset)			
INFINITECH: Portfolio o wl:equivalentClass FIBO: Portfolio (https://spec.edmcouncil.org/fibo/ontology/SEC/Securities/SecurityAssets/Portfolio)				
FIBO: Rating (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/Rating)	FIBO: Credit Rating (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditRating)			
INFINITECH: Score owl:equivalentClass FIBO: Rating Score (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)	**INFINITECH: Credit Risk Score**			
	INFINITECH: Sustainability Score			
	INFINITECH: Risk Assessment Score	**INFINITECH: Expected Shortfall**		
		INFINITECH: VaR		
		INFINITECH: Risk Metrics		
FIBO: Reference Index (https://spec.edmcouncil.org/fibo/ontology/IND/MarketIndices/BasketIndices/ReferenceIndex)	**INFINTECH: Sustainability Index**			
	INFINITECH: Accuracy			
	FIBO: Credit Index (https://spec.edmcouncil.org/fibo/ontology/IND/MarketIndices/BasketIndices/CreditIndex)	**INFINITECH: Credit Risk**		
	INFINITECH: Market Risk			
FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/on	**INFINITECH: Assessment owl:equivalentClass FIBO: Assessment Activity**	**INFINITECH: Risk Assessment Activity**	**INFINITECH: Risk Assessment owl:equivalentClass FIBO: Credit Risk Assessment**	

tology/FND/DatesAndTimes/Occurrences/)	(https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/)		(https://spec.edmcouncil.org/fibo/ontology/LOAN/LoanContracts/LoanCore/CreditRiskAssessment)	
	INFINITECH: Data Processing Activity			
	FIBO: Transaction Event (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/TransactionEvent)	**INFINITECH: Trade owl:equivalentClass** **FIBO: Trade** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/Trade)		
	INFINITECH: Trade Analysis Activity			
	INFINITECH: Asset Management Activity			
INFINITECH: Cost	**INFINITECH: Service Cost**			
	INFINITECH: Notary Rate			
INFINITECH: Business owl:equivalentClass **FIBO: Business** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/)	**INFINITECH: Sustainable Business**			
FIBO: Service provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/)	**INFINITECH: Trader owl:equivalentClass** **FIBO: Trader** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/)			
	INFINITECH: Regulatory Authority INFINITECH: Financial Regulator owl:equivalentClass **FIBO: Regulatory Agency** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency) **Fr-fin-reg: Regulatory Authority**			
	FIBO: Financial Service Provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialServiceProvider)	**INFINITECH: Financial Organization owl:equivalentClass** **FIBO: Financial Institution** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/FinancialInstitution)	FIBO. Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/DepositoryInstitution)	**INFINITECH: Bank owl:equivalnetClass** **FIBO: Bank** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/Bank)
INFINITECH: Market owl:equivalentClass **FIBO: Exchange** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/Markets/Exchange)				

Cluster #2: Personalized Retails and Investment Banking Services

Table 7-18 – Cluster #2: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

Taxonomy				
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**	**Fourth-Level Specialization**
rdfs: subClassOf				
INFINITECH: Business owl:equivalentClass FIBO: Business (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/)				
FIBO: Agent in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	FIBO: Party in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Client owl:equivalentClass FIBO: Client** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)		
		FIBO: Buyer (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Customer owl:equivalentClass FIBO: Customer** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Retail Customer**
		FIBO:Owner (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)	FIBO: Entity Owner (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)	**INFINITECH: Investor owl:equivalentClass FIBO: Investor** (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)
		FIBO: Responsible Party (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/ClientsAndAccounts/	**INFINITECH: Relationship Manager owl:equivalentClass FIBO: Relationship Manager** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/ClientsAndAccounts/RelationshipManager)	
		FIBO: Funds Processing Party (https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/FundsProcessingParty)	**INFINITECH: Advisor owl:equivalent Class FIBO: Investment Advisor** (https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/InvestmentAdvisor)	
INFINITECH: Cost	**INFINITECH: Service Cost**			
INFINITECH: Document owl:equivalentClass	**INFINITECH:Report owl:equivalentClass FIBO: Report**	FIBO:Assessment Report (https://spec.edmcouncil.org/fibo/ontolo	FIBO:Rating Report (https://spec.edmcouncil.org/fibo/ontolog	**INFINITECH:Credit Report owl:equivalentClass FIBO:CreditReport**

FIBO: Document (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-expr: Document**	(https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Reporting/)	gy/FND/Arrangements/Assessments/AssessmentReport)	y/FND/Arrangements/Ratings/RatingReport)	(https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditReport) **INFINITECH: Risk Profile** **INFINITECH: Investment Profile** **INFINITECH: Investor Profile** **INFINITECH: Customer Profile**
FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/)	**INFINITECH: Assessment** **owl:equivalentClass** **FIBO: Assessment Activity** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/)	**INFINITECH: Risk Assessment Activity**	**INFINITECH: Risk Assessment** **owl:equivalentClass** **FIBO: Credit Risk Assessment** (https://spec.edmcouncil.org/fibo/ontology/LOAN/LoanContracts/LoanCore/CreditRiskAssessment)	**INFINITECH: Risk Profiling**
		INFINITECH: Optimization Activity		
	INFINITECH: Data Processing Activity	**INFINITECH: Data anonymization**		
		INFINITECH: Anti-Money Laundering		
	FIBO: Transaction Event (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/TransactionEvent)	**INFINITECH: Trade** **owl:equivalentClass** **FIBO: Trade** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/Trade)		
	INFINITECH: Trade Analysis Activity			
	INFINITECH: Investment Advice **owl:equivalentClass** **fr-fin-ref: Investment Advice**			
FIBO: Analytics	FIBO: statistical program			
	INFINTECH: Artificial Intelligence	**INFINITECH: BigData**		
		INFINITECH: Optimization		
INFINITECH: Product **owl:equivalentClass** **FIBO:Product** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product)	**INFINITECH: Financial Product** **owl:equivalentClass** **FIBO:Financial Product** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct)			
INFINITECH:Asset **owl:equivalentClass** **FIBO: Asset** (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/Asset)	FIBO: Tangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/TangibleAsset)			
	FIBO: Intangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/IntangibleAsset)			
INFINITECH: Portfolio **owl:equivalentClass** **FIBO: Portfolio**				

https://spec.edmcouncil.org/fibo/ontology/SEC/Securities/SecurityAssets/Portf				
FIBO: Reference Index (https://spec.edmcouncil.org/fibo/ontology/IND/MarketIndices/BasketIndices/ReferenceIndex)	FIBO: Credit Index (https://spec.edmcouncil.org/fibo/ontology/IND/MarketIndices/BasketIndices/CreditIndex)	**INFINITECH: Credit Risk**		
FIBO: Rating (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/Rating)	FIBO: Credit Rating (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditRating)			
INFINITECH: Score owl:equivalentClass **FIBO: Rating Score** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)	**INFINITECH: Credit Risk Score** **INFINITECH: Risk Assessment Score**			
INFINITECH: Service owl:equivalentClass **FIBO: Service** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	Fro-fin-ref: Professional Service	**INFINITECH: Customer Service owl:equivalentClass** **FIBO: FinacialService** (Data Custodian Service)	**INFINITECH: Data Custodian Service** **INFINITECH: Wealth-Management Service**	
INFINITECH: Data	**FIBO: Published Financial Information** (https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/PublishedFinancialInformation) **INFINITECH: Customer Data**	**INFINITECH: Financial Data**	**INFINITECH: Open Data Banking**	
FIBO: Service Provider (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/ServiceProvider)	**INFINITECH: Regulatory Authority owl:equivalentClass** **FIBO: Regulatory Agency** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency) (Regulatory Authority, Finacial Regulator) **Fr-fin-reg: Regulatory Authority**			
	FIBO: Financial Service Provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialServiceProvider)	**INFINITECH: Financial Organization owl:equivalentClass** **FIBO: Financial Institution** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/FinancialInstitution)	FIBO. Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/DepositoryInstitution)	**INFINITECH: Bank owl:equivalnetClass** **FIBO: Bank** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/Bank)
INFINITECH: Fund owl:equivalentClass **FIBO: Fund** (https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/Fund)				
INFINITECH: Loyalty	**INFINITECH: Customer Loyalty**			

Cluster #3: Financial Crime and Fraud Detection

Table 7-19 – Cluster #3: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

Taxonomy				
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**	**Fourth-Level Specialization**
rdfs: subClassOf				
FIBO: Service Provider (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/ServiceProvider)	**INFINITECH: Regulatory Authority owl:equivalentClass** **FIBO: Regulatory Agency** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency) **fro-leg-ref: Regulatory Authority** (Regulatory Authority, Financial Regulator)			
	FIBO: Financial Service Provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialServiceProvider)	**INFINITECH: Financial Organization owl:equivalentClass** **FIBO: Financial Institution** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/FinancialInstitution)	FIBO. Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/DepositoryInstitution)	**INFINITECH: Bank owl:equivalnetClass** **FIBO: Bank** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/Bank)
			FIBO. Non-Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/NonDepositoryInstitution)	**INFINITECH: Exchnge Company**
FIBO: Agent in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	FIBO: Party in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Client owl:equivalentClass** **FIBO: Client** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)		
		FIBO: Buyer (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Customer owl:equivalentClass** **FIBO: Customer** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Retail Customer**
		FIBO:Owner (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)	FIBO: Entity Owner (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)	**INFINITECH: Investor owl:equivalentClass** **FIBO: Investor** (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/)
		FIBO: Funds Processing Party (https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/FundsProcessingParty)	**INFINITECH: Financial Advisor owl:equivalentClass** **FIBO: Investment Advisor**	

			(https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/InvestmentAdvisor)	
		INFINITECH: Forsenic Analyst		
INFINITECH: Crime	INFINITECH: Financial Crime	INFINITECH: Money Laundering		
		INFINITECH: Terrorist Financing		
		INFINITECH: Fraud		
INFINITECH: Data	FIBO: Published Financial Information (https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/PublishedFinancialInformation)	INFINITECH: Financial Data	INFINITECH: Open Data Banking	
	INFINITECH: Customer Data			
INFINITECH: Event owl:equivalentClass FIBO: Occurence (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/Occurrence)	INFINITECH: Cyber attack			
INFINITECH:Product owl:equivalentClass FIBO:Product (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product)	INFINITECH:Financial Product owl:equivalentClass FIBO:Financial Product (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct)			
INFINITECH:Asset owl:equivalentClass FIBO: Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/Asset)	FIBO: Tangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/TangibleAsset)			
	FIBO: Intangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/IntangibleAsset)			
INFINITECH: Portfolio owl:equivalentClass FIBO: Portfolio (https://spec.edmcouncil.org/fibo/ontology/SEC/Securities/SecurityAssets/Portfolio)				
INFINITECH: Market owl:equivalentClass FIBO: Exchange (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/Markets/Exchange)				
INFINITECH: Document owl:equivalentClass	INFINITECH: LegalDocument owl:equivalentClass			

FIBO:Document (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-expr: Document**	**FIBO: Legal Document** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-norm: Legal Document**			
	INFINITECH:Report owl:equivalentClass FIBO:Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Reporting/)	FIBO:Assessment Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/AssessmentReport)	FIBO:Rating Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/RatingReport)	**INFINITECH:Credit Report owl:equivalentClass FIBO:CreditReport** (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditReport) **INFINITECH: Risk Profile** **INFINITECH: Customer Profile** **INFINITECH:Investor Profile** **INFINITECH: Investment Profile**
FIBO: Analytics	FIBO: statistical program			
	INFINITECH: Artificial Intelligence	**INFINITECH: Big Data**		
FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/)	**INFINITECH: Assessment owl:equivalentClass FIBO: Assessment Activity** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/)	**INFINITECH: Risk Assessment Activity**	**INFINITECH: Risk Profiling** **INFINITECH: KYC** **INFINITECH: RBS**	
		INFINITECH: Optimization Activity		
	INFINITECH: Data Processing Activity	**INFINITECH: Anti-Terrorist Financing Activity**		
		INFINITECH: Anti-Money Laundering Activity		
	INFINITECH: Cyber Security Activity			
	FIBO: Transaction Event (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/TransactionEvent)	**INFINITECH: Trade owl:equivalentClass FIBO: Trade** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/Trade)		
	Trade Analysis Activity			
	INFINITECH: Investment Advice owl:equivalentClass fr-fin-ref: Investment Advice (Investment Advice)			
INFINITECH: Risk	**INFINITECH: Credit Risk**			
	INFINITECH: Financial Crime Risk			
INFINITECH:Service owl:equivalentClass FIBO: Service (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	fro-fin-ref: Professional Service	**INFINITECH: Customer Service owl:equivalentClass FIBO: FinacialService** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialService) (Customer Service)	**INFINITECH: Ancillary Services**	

		INFINITECH: Digital Service		
FIBO: Rating (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)	FIBO: Credit Rating (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/CreditRatings/CreditRating)			
INFINITECH: Score owl:equivalentClass FIBO: Rating Score (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)	**INFINITECH: Credit Risk Score** **INFINITECH: Risk Assessment Score**			
INFINITECH: Fund owl:equivalentClass FIBO: Fund (https://spec.edmcouncil.org/fibo/ontology/CIV/Funds/CIV/Fund)				

Cluster #4: Personalized Usage-based Insurance Products

Table 7-20 – Cluster #4: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

Taxonomy				
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**	**Fourth-Level Specialization**
rdfs: subClassOf				
FIBO: Service provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/)	**INFINITECH: Regulatory Authority owl:equivalentClass** **FIBO: Regulatory Agency** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency) **fro-leg-ref: Regulatory Authority** (Regulatory Authority, Financial Regulator)			
	FIBO: Financial Service Provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialServiceProvider)	**INFINITECH: Financial Organization owl:equivalentClass** **FIBO: Financial Institution** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/FinancialInstitution)	FIBO. Non-Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/NoNDepositoryInstitution)	**INFINITECH: Insurance Company owl:equivalenteClass** **FIBO: Insurance Company** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/InsuranceCompany)
FIBO: Government Agency (https://spec.edmcouncil.org/fibo/ontology/BE/GovernmentEntities/GovernmentEntities/GovernmentAgency)	**INFINITECH: Ministry of Transport**			
FIBO: Agent in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	FIBO: Party in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Client owl:equivalentClass** **FIBO: Client** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)		
		FIBO: Buyer (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	**INFINITECH: Customer owl:equivalentClass** **FIBO: Customer** (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	
		FIBO: Owner (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/Owner)	**INFINITECH: Car Owner**	
INFINITECH: Crime	**INFINITECH: Financial Crime**	**INFINITEC: Fraud**		
INFINITECH: Cost	**INFINITECH: Insurance Premium**			

INFINITECH: Data	FIBO: Published financial Information (https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/PublishedFinancialInformation)	**INFINITECH: Financial Data**		
	INFINITECH: Vehicle Data	**INFINITECH: VIN**		
	INFINITECH: Geographical Data	**INFINITECH: Location Data**		
	INFINITECH: Customer Data			
INFINITECH: Document owl:equivalentClass FIBO:Document (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) Lkif-expr: Document	**INFINITECH: Legal Document owl:equivalentClass FIBO: Legal Document** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) **Lkif-norm: Legal Document**	FIBO: Contract Document (https://spec.edmcouncil.org/fibo/ontology/FND/Agreements/Contracts/ContractDocument)		
		FIBO: Identity document (https://spec.edmcouncil.org/fibo/ontology/FND/AgentsAndPeople/People/)	**INFINITECH: License owl:equivalentClass FIBO: driver's license** (https://spec.edmcouncil.org/fibo/ontology/FND/AgentsAndPeople/People/)	
	INFINITECH:Report owl:equivalentClass FIBO:Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Reporting/)	FIBO:Assessment Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/AssessmentReport)	FIBO:Rating Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/RatingReport)	**INFINITECH: Customer Profile**
	INFINTECH: Invoice			
INFINITECH: Device	**INFINITECH: IoT Device**	**INFINITECH: Vehicle Device**		
		INFINITECH: Medical Device		
INFINITECH:Product owl:equivalentClass FIBO:Product (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product)	**INFINITECH:Financial Product owl:equivalentClass FIBO:Financial Product** (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct)			
INFINITECH:Asset owl:equivalentClass FIBO: Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/Asset)	FIBO: Tangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/TangibleAsset)			
	FIBO: Intangible Asset (https://spec.edmcouncil.org/fibo/ontology/FND/OwnershipAndControl/Ownership/IntangibleAsset)			
FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/)	**INFINITECH: Assessment owl:equivalentClass FIBO: Assessment Activity** (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/)	**INFINITECH: Risk Assessment Activity**	**INFINITECH: Risk Profiling**	
			INFINTECH: Health Risk Assessment	
		INFINITECH: Optimization Activity		
		INFINITECH: Accident Assessment Activity		
	INFINITECH: Data Processing Activity	**INFINITECH: Driver's behaviour**		
		INFINITECH: Fraud Detection		
	INFINITECH: Vehicle Inspection			

INFINITECH: Risk	**INFINITECH: Financial Crime Risk**			
FIBO: Service (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	fro-fin-ref: Professional Service	**INFINITECH: Manufacturing maintenance program**		
		INFINITECH: Customer Service owl:equivalentClass FIBO: FinacialService (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialService) (Customer Service)	**INFINITECH: Insurance owl:equivalentClass FIBO: Insurance Service (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/InsuranceService)**	**INFINITECH: Vehicle Insurance** **INFINTECH: Usage-based Insurance** **INFINITECH: Health Insurnce**
		INFINITECH: Digital Service		
INFINITECH: Score owl:equivalentClass FIBO: Rating Score (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)	**INFINITECH: Risk Assessment Score**			
INFINITECH: Vehicle				

Cluster #5: Configurable and Personalized Insurance Products

Table 7-21 - Cluster #5: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

Taxonomy				
Top Level Concept	**First-Level Specialization**	**Second-Level Specialization**	**Third-Level Specialization**	**Fourth-Level Specialization**
rdfs: subClassOf				
FIBO: Service Provider (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/ServiceProvider)	INFINITECH: Regulatory Authority owl:equivalentClass FIBO: Regulatory Agency (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency) fro-leg-ref: Regulatory Authority (Regulatory Authority, Financial Regulator)			
	FIBO: Financial Service Provider (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialServiceProvider)	INFINITECH: Financial Organization owl:equivalentClass FIBO: Financial Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/FinancialInstitution)	FIBO: Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/DepositoryInstitution)	INFINITECH: Bank owl:equivalentClass FIBO: Bank (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/Bank)
			FIBO: non-Depository Institution (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/NonDepositoryInstitution)	INFINITECH: Insurance Company owl:equivalenteClass FIBO: Insurance Company (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/InsuranceCompany)
		INFINITECH: Insurer owl:equivalentClass FIBO: Insurer (https://spec.edmcouncil.org/fibo/ontology/FBC/DebtAndEquities/Guaranty/Insurer)		
FIBO: Agent in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	FIBO: Party in role (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	INFINITECH: Client owl:equivalentClass FIBO: Client (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)		
		FIBO: Buyer (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	INFINITECH: Customer owl:equivalentClass FIBO: Customer	INFINITECH: SME owl:equivalentClass FIBO: Formal Organization

			(https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	(https://spec.edmcouncil.org/fibo/ontology/FND/Organizations/FormalOrganizations/)
		FIBO: Contract Third Party (https://spec.edmcouncil.org/fibo/ontology/FND/Agreements/Contracts/ContractThirdParty)	INFINITECH: Broker owl:equivalentClass FIBO: Broker (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/Broker)	INFINITECH: Insurance Broker
			INFINITECH: Loss Adjuster	
			INFINITECH: Actuary	
			INFINITECH: Sales Agent	
INFINITECH: Cost	INFINITECH: Insurance Premium			
INFINITECH: Data	FIBO: Published financial Information (https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/PublishedFinancialInformation)	INFINITECH: Financial Data		
	INFINITECH: Customer Data			
	INFINITECH: Geographical Data	INFINITECH:Location Data		
	INFINITECH: Weather Data			
INFINITECH: Document owl:equivalentClass FIBO:Document (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) Lkif-expr: Document	INFINITECH: Legal Document owl:equivalentClass FIBO: Legal Document (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/) Lkif-norm: Legal Document	INFINITECH: Contract Owl:equivalentClass FIBO: Contract Document (https://spec.edmcouncil.org/fibo/ontology/FND/Agreements/Contracts/ContractDocument)		
	INFINITECH:Report owl:equivalentClass FIBO:Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Reporting/)	FIBO: Assessment Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/AssessmentReport)	FIBO: Rating Report (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/RatingReport)	INFINITECH: Customer Profiule
	INFINITECH: Invoice			
INFINITECH: Agent Owl:equivalentClass FIBO: Issuance Agent (https://spec.edmcouncil.org/fibo/ontology/BP/SecuritiesIssuance/MuniIssuance/IssuanceAgent)				
INFINITECH: Device	INFINITECH: IoT Device	INFINITECH: Agricoltural Device		
FIBO: Index (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/IdentifiersAndIndices/Index)	INFINITECH: Agroclimatic indicator	INFINITECH: old Spell indicator		
		INFINITECH: Evotranspiration		
		INFINITECH: Hail Storm indicator		
		INFINITECH: Heat Stress		
		INFINITECH: Land Use		
		INFINITECH: Late frost Indicator		

		INFINITECH: Normalized Difference Vegetation Index		
		INFINITECH: Pest Impact Indicator		
		INFINITECH: Phenological Indicator		
		INFINITECH: Soil Map		
		INFINITECH: Sowing date shifting indicator		
		INFINITECH: Temperature		
		INFINITECH: Warm Spell duration Index		
		INFINITECH: Water Stress		
		INFINITECH: Weather Index		
		INFINITECH: Wind Sorm Indicator		
INFINITECH:Product owl:equivalentClass FIBO:Product (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product)	INFINITECH:Financial Product owl:equivalentClass FIBO:Financial Product (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct)			
FIBO: Portfolio (https://spec.edmcouncil.org/fibo/ontology/SEC/Securities/SecurityAssets/Portfolio)	INFINITECH: Client Portfolio			
FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/)	INFINITECH: Assessment owl:equivalentClass FIBO: Assessment Activity (https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/)	INFINITECH: Risk Assessment Activity	INFINITECH: Climatic Risk Assessment	
			INFINITECH: Risk Profiling	
		INFINITECH: Damage Assessment Activity		
		INFINITECH: Optimization Activity		
	INFINITECH: Data Processing Activity	INFINITECH: Fraud Detection		
		INFINITECH: Data Anonymization Activity		
		INFINITECH: Data Protection activity		
	INFINITECH: Issuance process Activity	INFINITECH: Underwriting Activity		
	INFINITECH: Monitoring Activity	INFINITECH: Remote Sensing		
INFINITECH: Risk	INFINITECH: Climatic Risk			
INFINITECH: Score owl:equivalentClass FIBO: Rating Score **(https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Ratings/)**	INFIINTECH: Credit Rating Score			
	INFIINTECH: Risk Assessment Score			
FIBO: Service (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/)	fro-fin-ref: Professional Service	INFINITECH: Customer Service owl:equivalentClass FIBO: FinacialService (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialService	INFINITECH: Insurance owl:equivalentClass FIBO: Insurance Service (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/FinancialServicesEntities/InsuranceService)	INFINITECH: Agricoltural insurance, Weather-index insurance
			INFINITECH: Climatic Risk Management Service	

			INFINITECH: Disaster Risk Management Service	
		INFINITECH: Agroclimatic Advisory Service		
		INFINITECH: Digital Service		

Appendix B: Data.World API documentation

data.world API Reference

INFINITECH - Pilot 2

Introduction

This document provides the guidelines for accessing the ***data.world*** **REST API**, using INFINITECH Pilot 2 Scenario as example. *Data.world* is a web-oriented collaborative platform which enables data sharing, analysis and integration with multiple applications.

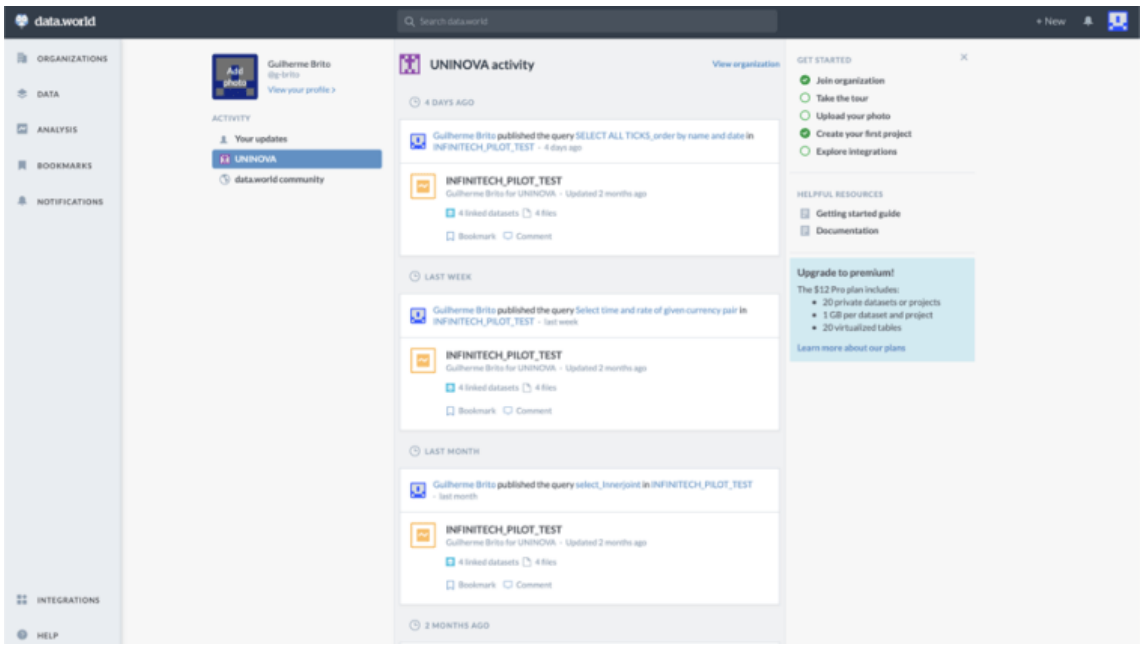
Data.world has been selected for the current development of Task 4.1, supported by pilot 2, in order to present a minimum viable product for the mentioned work. However, other software solutions have also been adopted.

First, we present how *data.world* has been setup with all the necessary components, while highlighting the most relevant architectural aspects of the platform in regard to INFINITECH. Then, we will focus on how to access the *data.world* REST API, starting by describing the authorization and authentication, and finally providing the most relevant endpoints for the given use case.

data.world in a glance

User / Organizations

The participation in *data.world* environment is performed through account registration associated to an e-mail.



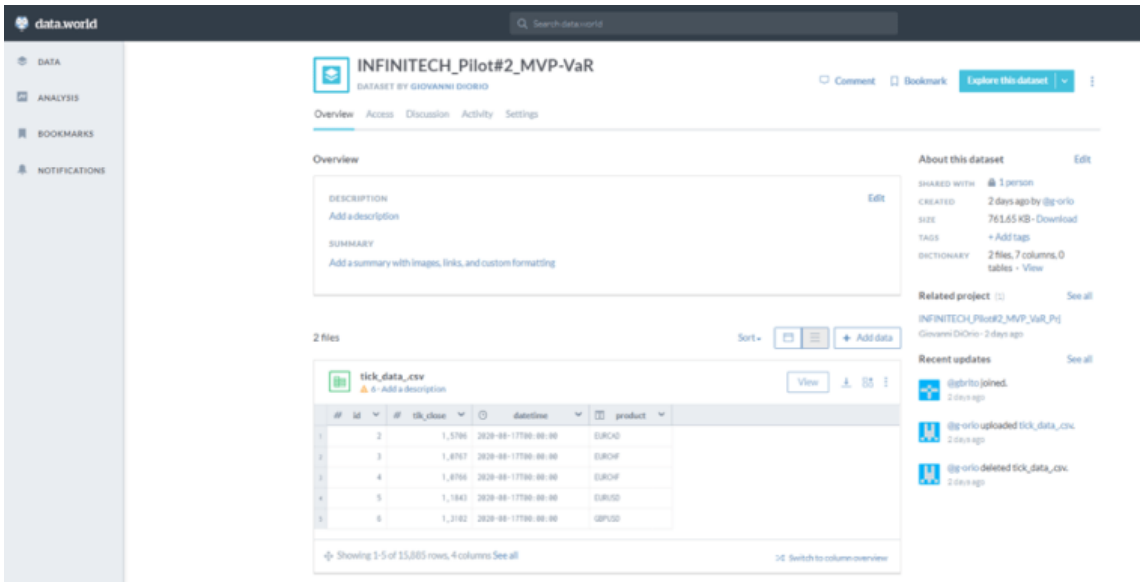
Once registered, users may start to work in *data.world*, by creating or accessing datasets and projects from other users/organizations, with free or authorization based access.

Organization is a type of user that allows to define and manage a workspace of several users, such as select which users may view/edit/manage projects or datasets, which are settled as internal to the organization itself.

Datasets

Datasets are the building blocks of Projects. They are composed of files that contain data and/or metadata, focusing on RDF graphs and tabular data (although other types of files can also be included), which are therefore available for users to be managed, transformed, queried or analyzed.

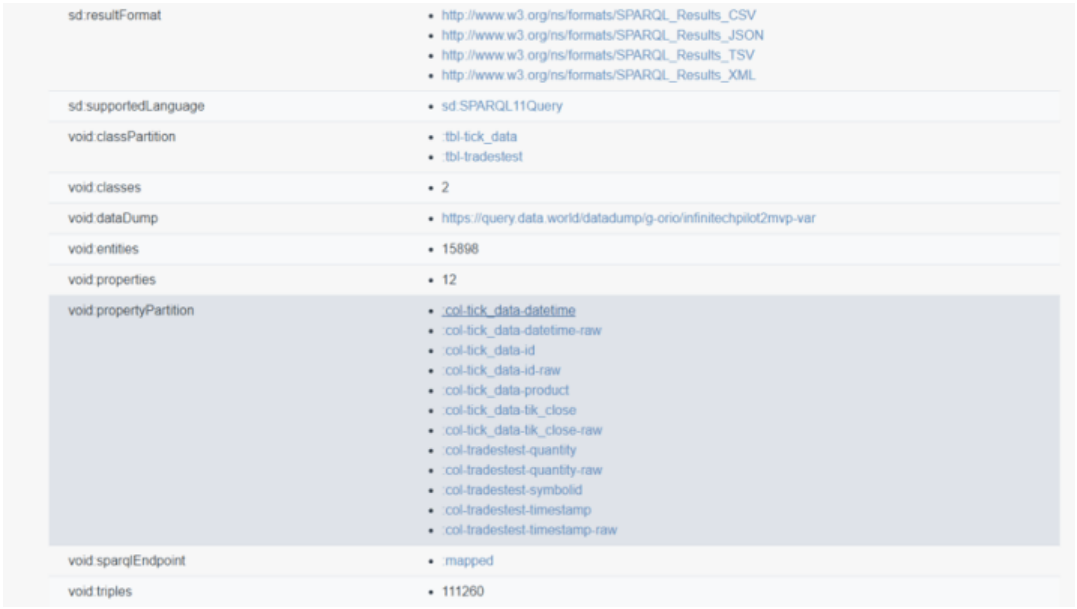
However, datasets exist as independent source which can be linked to one or more independent Projects, even if they belong to a different User (either individual or Organization), as long as it has been given access authorization or published as free of access.



Datasets accept a wide spectrum of file types, focusing more on tabular data (csv, xlxs, …), RDF data (rdf, owl, ttl, jsonl, etc.) and structured files (e.g. structured json). However, also other file types such as compressed files, images, source files or documents are accepted.

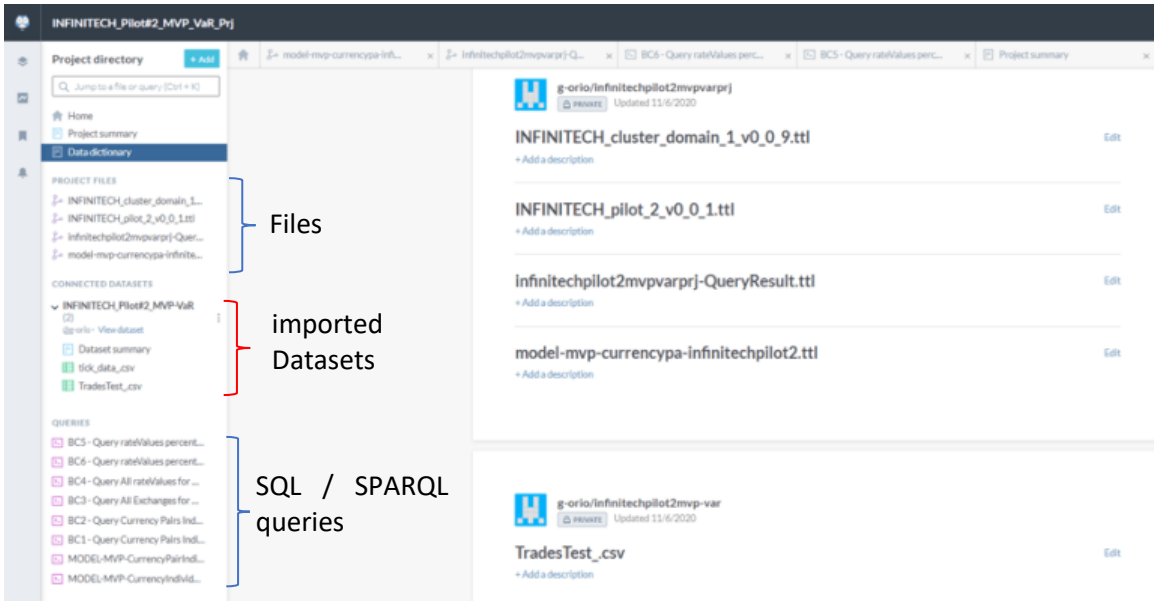
In case of tabular data or structured files, an auto-generation of correspondent RDF triples from each imported data is performed and made available internally, so that it can eventually be accessed not only with SQL queries, but also with SPARQL queries. In this case, for the imported data from *tick_data.csv*, a named graph will be created, while structuring the respective triples with the following names:

{:col-tick_data-datetime, :col-tick_data-id, :col-tick_data-tik_close, :col-tick_data-product}



Projects

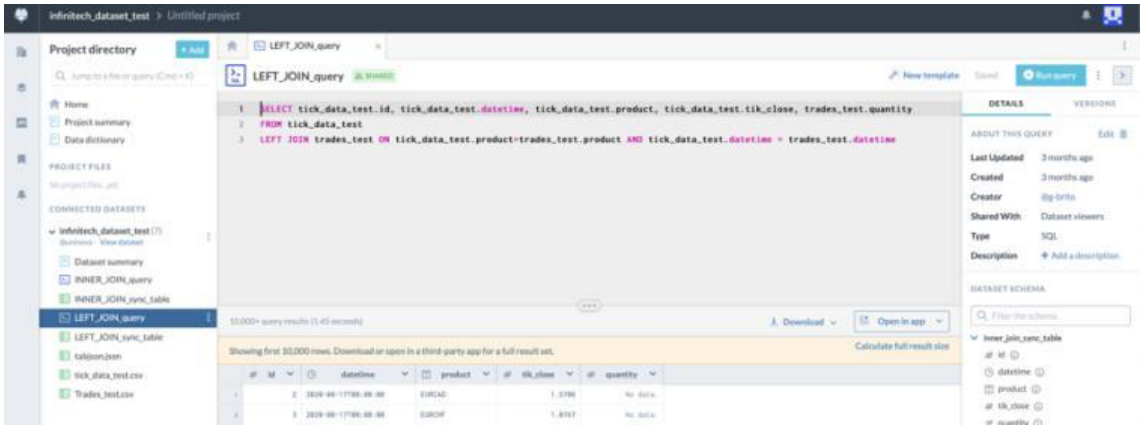
Projects are the working environment where documentation and analysis to the linked datasets can be applied. They differ from datasets, in the sense that Projects are allowed to incorporate one or more datasets inside, but cannot be included or linked into other projects or datasets. That is to say that Projects provide a unique workspace, where files and queries which belong to the project are only available to the users who have been granted access rights.



On the other hand, it must be noted that the linked datasets are still available to be accessed and used for analytics inside the project, but their access points (Ids, namespaces, etc.) will suffer no change.

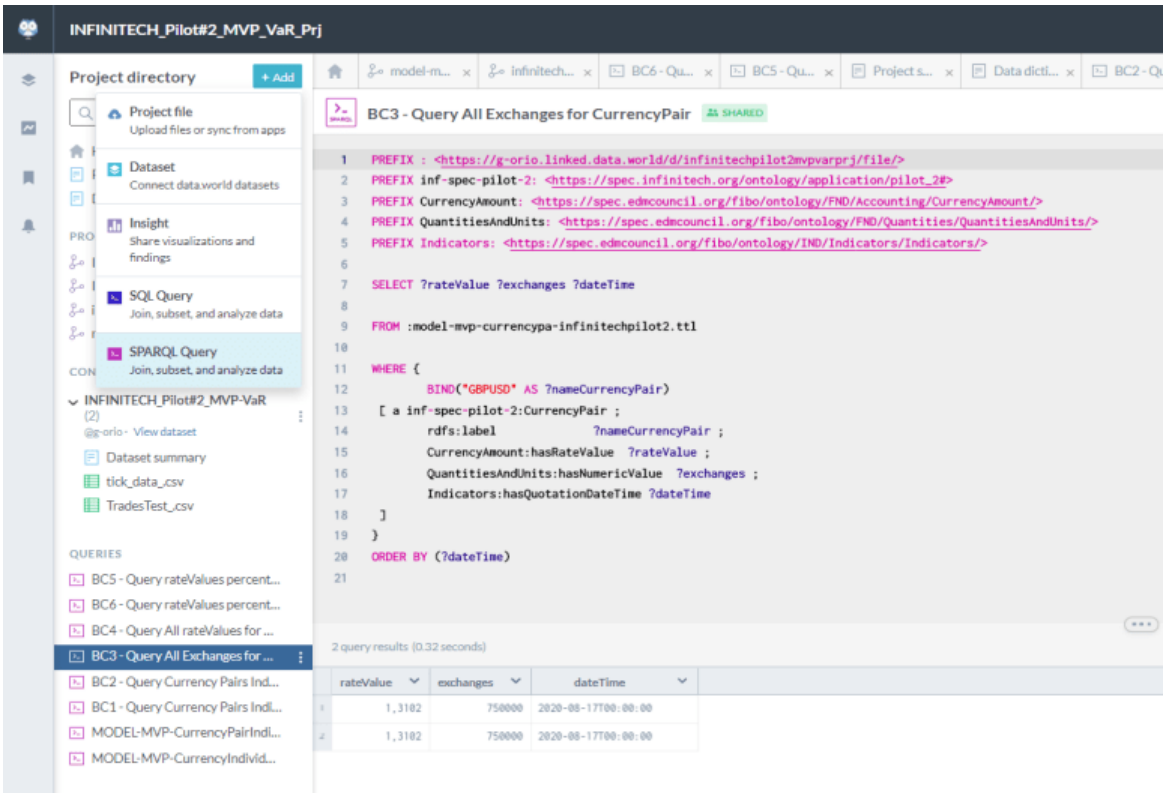
SQL

SQL queries can be used to consult the existing tabular data for extraction or to create new datasets. In the latest, an SQL query can be saved into the dataset/project and create a link between the existent table(s) and the resultant table.



SPARQL

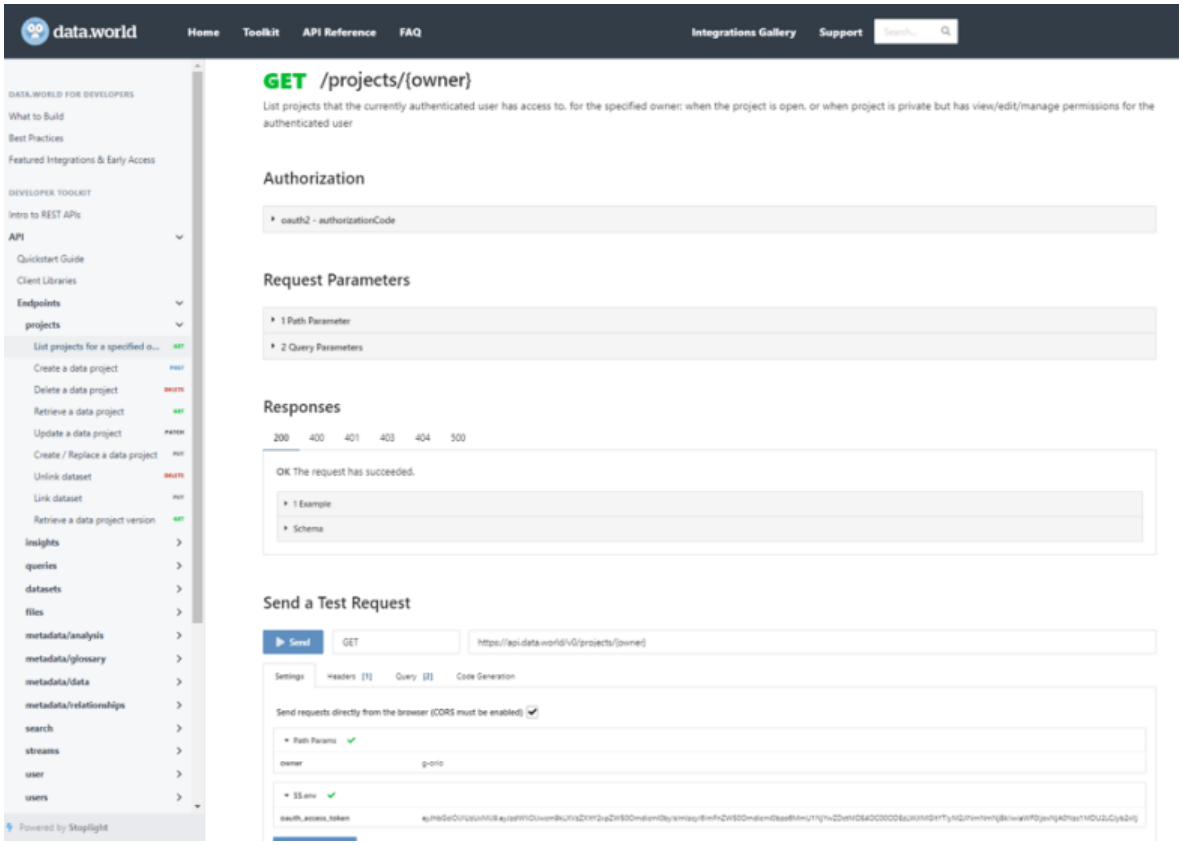
As previously mentioned, Datasets/Projects are able to incorporate SPARQL queries. In the given example, the data is queried in order to retrieve the details from all trades made with the *CurrrencyPair "GBPUSD"*.



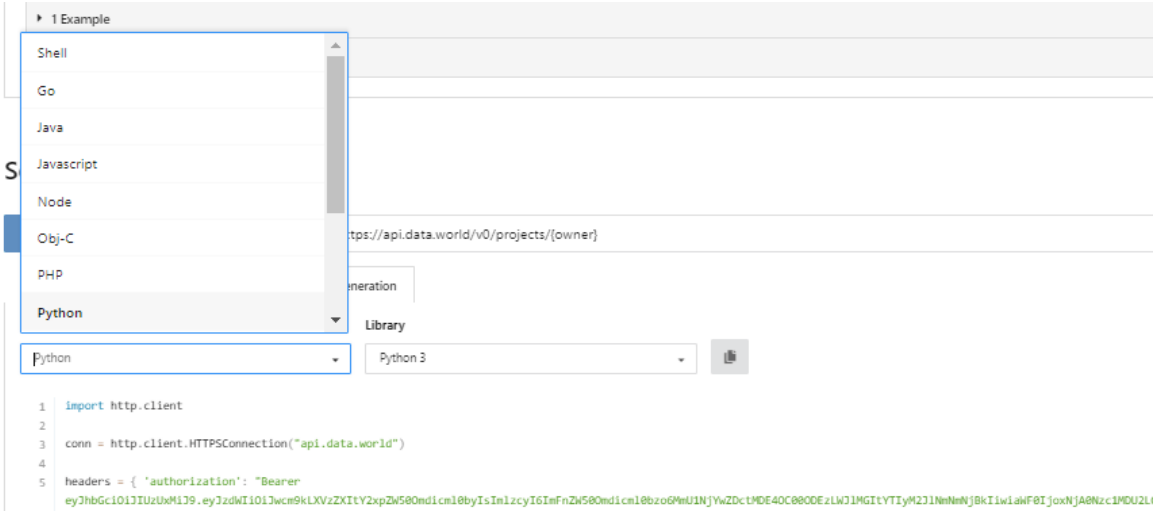
Also, SPARQL queries can be saved in the project/dataset, or they can be sent inside the REST-API call in order to extract RDF data.

REST API

Moving from working inside data.world platform into connecting from external applications, one of the adopted methodologies is to pass through the REST-API. By visiting https://apidocs.data.world/toolkit/api , the extensive description of all endpoints is provided, as well as the ability to test them directly from the browser:



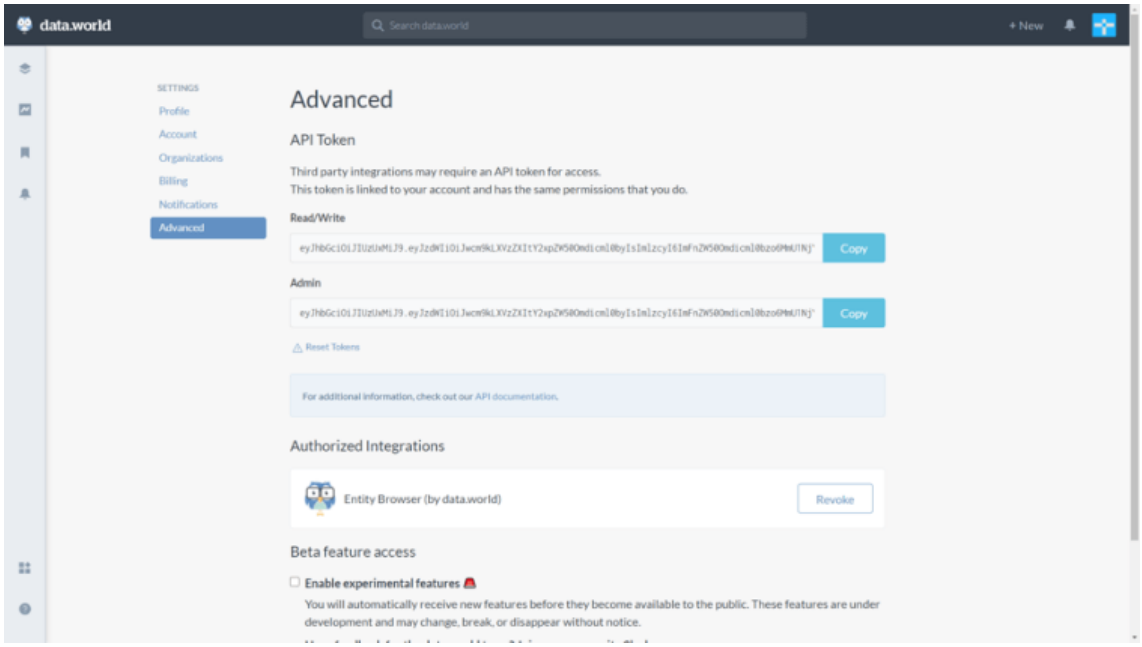
Moreover, for supporting the development of API clients, it is possible to generate the code for each endpoint, in diverse languages:



Authentication and Authorization

In data.world works, there are two possible authorization schemas to access the REST API – *Bearer Token* and *OAuth2*. For the sake of easiness of developing, we only cover the Bearer authorization option for now.

Each user account from data.world is granted with API tokens, which can be found in the "Advanced" tab of the account settings.



This also means that there are two ways to use these tokens for authorization:

1. Another user from data.world is invited to collaborate in the Projects and/or Datasets by the owner(s) (which can grant different levels of access – view, read/write or admin). In this case, the invited user can use their personal token(s) on the REST API.
2. The owners of projects and/or datasets in data.world can supply their token(s) and username, which grants authorization through the REST API, even for someone who does not possess an account.

Bearer Authorization usage

Once a token is obtained, it must be used in every request made to the REST API. Bearer token is included in the "headers" of the HTTP(s) request, as showed in the example:

```
curl --request GET \
  --url https://api.data.world/v0/datasets/jonloyens/an-intro-to-dataworld-dataset \
  --header 'authorization: Bearer [YOUR API TOKEN]'
```

For security reasons, it is advised that tokens are sent over a *secure connection*, between clients of the REST API.

Users and Project/Datasets namespaces

This section describes some relevant information, such as Users/Organizations and Projects/Datasets Identifiers, namespaces or fixed paths used in the current implementation of Infinitech, and which serve as valid context for presenting and testing the REST-API endpoints.

Organization / Users

Organization Identifier (OrgId): uninova

Usernames (user Ids) which belong (b) or have been granted access (a) to the Organization project/datasets):

- g-brito (b)
- g-orio (b)
- nuig (a)
- …

Project

Project identifier (and also the name of the default Graph): infinitechpilottest

Project internal data namespaces (in this case these are the Named Graphs generated from tabular data transformation):

quotedexchangerate_innerjoin

quotedexchangerate_leftjoin

Linked Dataset identifiers (name and identifier):

- name: INFINITECH-CORE
  - Id: infinitechcore
- name: infinitech_dataset_test
  - Id: infinitechdatasettest
- name: postgres_conn
  - Id: postgresconn
- name: postgres_live
  - Id: postgres_live

Project Saved SPARQL Queries (name and identifier):

- name: quotedexchangerate_innerjoin
  - Id: 66e34cef-6dc2-4a25-9828-279c918ccdc4
  - Description: Construct RDF results from tabular data (table INNERJOIN_sync_table). It is used as the sync query for the correspondent Named Graph (quotedexchangerate_innerjoin)
- name: quotedexchangerate_leftjoin
  - Id: 791c7c08-519f-4795-9282-c82984f5a1c8

    - Description: Construct RDF results from tabular data (table *LEFTJOIN_sync_table*). It is used as the sync query for the correspondent Named Graph *(quotedexchangerate_leftjoin*)
- name: read_individuals_as_subclass_of_FIBO_class
  - Id: 518697cb-296e-41bb-a444-5201cd03ebb0
  - Description: select individuals from graph (*pilot2_instances* file), which are subclass of the *FIBO RatioValue* class
- name: select_Innerjoin
  - Id: a4016a98-b2f1-49ea-a32b-5b568a7488f6
  - Description: select individuals from *quotedexchangerate_Innerjoint* graph, as subclass of *FIBO RatioValue* class
- name: select time and rate of a given currency pair
  - Id: fd958c26-772a-422f-8c01-3ce586678e1b
  - Description: select timestamp and rateValue of individuals from *quotedexchangerate_leftjoint* graph, as subclass of *FIBO RatioValue* class
- name: select_all_ticks_order_by_name_and_date
  - Id: fd958c26-772a-422f-8c01-3ce586678e1b
  - Description: select individuals from *quotedexchangerate_leftjoint* graph, as subclass of *FIBO RatioValue* class, ordered by currencypair value and date

From alternative project **MVP-pilot#2** (id = infinitechpilot2mvpvarprj)

- name: BC1 - Query Currency Pairs Individuals
  - Id: cc2b39a2-aa42-4f9b-84ce-c5ae6ad4698c
- name: BC2 - Query Currency Pairs Individuals with Exchanges
  - Id: 43c6b982-e313-4035-bca6-f7d546d9be1a
- name: BC3 - Query All Exchanges for CurrencyPair
  - Id: e83cc558-6a0d-41af-ac46-5a489594323e
- name: BC4 - Query All rateValues for CurrencyPair
  - Id: 6679b90c-8485-45dd-9475-0b85588a3e4f
- name: BC5 - Query rateValues percentage variation for CurrencyPair
  - Id: 72b52268-9cc1-4b63-a24e-726869a2dfe0
- name: BC6 - Query rateValues percentage variation for CurrencyPair
  - Id: c7e96b9d-ad02-49bd-95b8-7269173222be
- name: BC7 – Get FIBO:RatioValue subclasses individuals from dataset
  - Id: 5f6adb04-95fb-4cfa-80e8-ff2f388be78e

Datasets

INFINITECH-CORE (*infinitechcore*)**:**

Data (files):

infinitech-core-v1.0.ttl

FIBO.ttl

FIGI_ontology.ttl

LKIF_ontology.ttl

infinitech_dataset_test *(infinitechdatatest)***:**

data:

Trades_test.csv

tick_data_test.csv

LEFT_JOIN_sync_table

INNER_JOIN_sync_table

Linked queries:

- name: LEFT_JOIN_query
  Id: bb938948-fbd0-46e0-9b03-b066a87e2606
- name: BC1 - Query Currency Pairs Individuals
  Id: 02653a03-562a-45a4-a99f-709e64b57a41

Project endpoints

The endpoints presented in this section have a closer relation to the work being performed in INFINITECH. For a complete view of the data.world REST-API documentation and testing, please access to https://apidocs.data.world/toolkit/api .

REST-API base URL:

https://api.data.world/v0

GET /projects/{owner}

List projects for a specific owner

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	username of the project owner (creator)

RESPONSE

STATUS CODE – 200: List of projects of the owner

Response Body: application/json

portion of model:

INFINITECH Pilot 2 example

```
curl --request GET \
  --url https://api.data.world/v0/projects/uninova \
  --header 'authorization: Bearer [USER API TOKEN]'
```

GET /projects/{owner}/{id}

Retrieves a project's definition data (not associated data)

REQUEST

PATH PARAMETERS

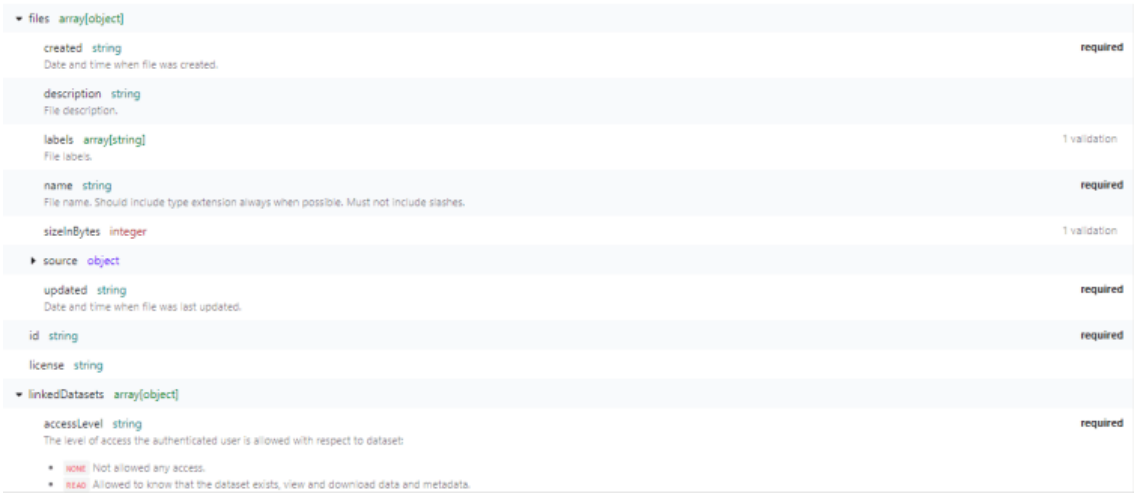
NAME	TYPE	DESCRIPTION
*owner	string	username of the project owner (creator)
*id	String	unique identifier of the project

RESPONSE

STATUS CODE – 200: Project definition data is retrieved

Response Body: application/json

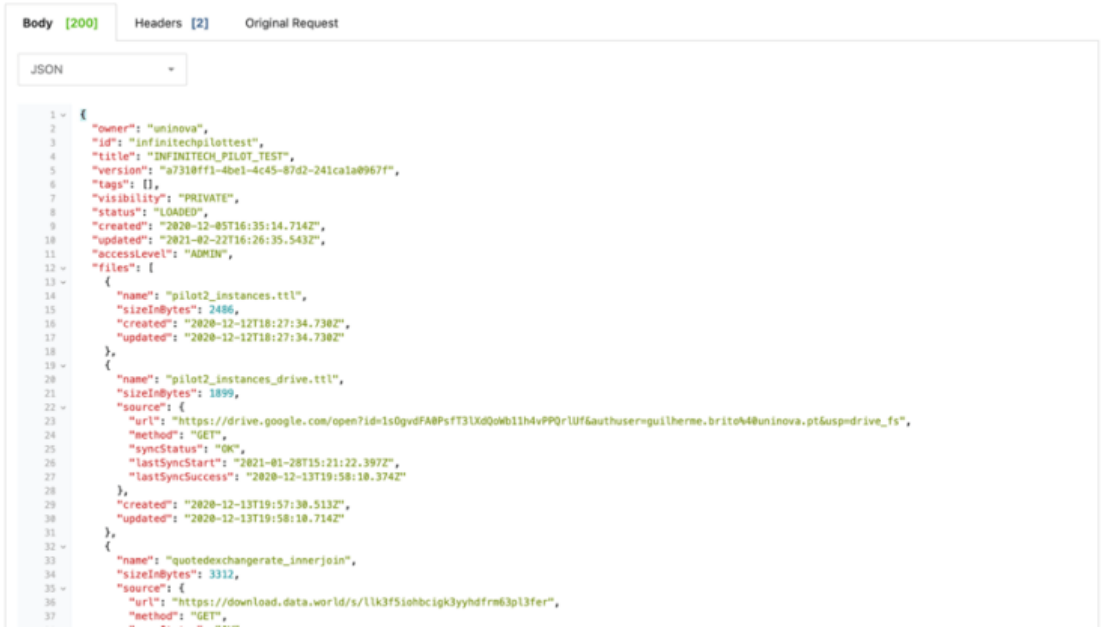
portion of model:



INFINITECH Pilot 2 example

```
curl --request GET \
  --url https://api.data.world/v0/projects/uninova/infinitechpilottest \
  --header 'authorization: Bearer [USER API TOKEN]'
```

Response body:



PUT /projects/{owner}/{id}/linkedDatasets/{linkedDatasetowner}/{linkedDatasetId}

Add a linked Dataset to a project

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the project owner (creator)
*id	string	unique identifier of the project
*linkedDatasetOwner	String	Username/unique identifier of the linked dataset owner (creator)
*linkedDatasetId	String	unique identifier of the linked dataset

RESPONSE

STATUS CODE – 200: dataset is linked to the project

Response Body: application/json

message string

Output example

```
{
  "message": "Dataset successfully linked to project."
}
```

DELETE /projects/{owner}/{id}/linkedDatasets/{linkedDatasetowner}/{linkedDatasetId}

Remove a linked Dataset from the project

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the project owner (creator)
*id	string	unique identifier of the project
*linkedDatasetOwner	String	Username/unique identifier of the linked dataset owner (creator)
*linkedDatasetId	String	unique identifier of the linked dataset

RESPONSE

STATUS CODE – 200: the linked dataset is removed to the project

Response Body: application/json

message string

Output example

```
{
  "message": "Successfully removed linked dataset from project."
}
```

Dataset endpoints

The following endpoints are related to data.world datasets

GET /user/datasets/own

List datasets that the currently authenticated user is the owner

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
-	-	-

RESPONSE

STATUS CODE – 200: array of datasets and their sub items is received

Response Body: application/json

- records array[object] **required**
  - accessLevel string **required**
    The level of access the authenticated user is allowed with respect to dataset:
    - NONE Not allowed any access.
    - READ Allowed to know that the dataset exists, view and download data and metadata.
    - WRITE Allowed to update data and metadata, in addition to what READ allows.
    - ADMIN Allowed to delete dataset, in addition to what WRITE allows.
  - created string **required**
    Date and time when the dataset was created.
  - description string
    Short dataset description.
  - dois array[object]
  - files array[object] 1 validation
    Initial set of files. At dataset creation time, file uploads are not supported. However, this property can be used to add files via URL.
  - id string **required**
    Unique identifier of dataset.
  - isProject boolean **required**
    Every data project on data.world comes with a default dataset linked to it. This flag indicates if the dataset is a project's default dataset.
  - license string
    Dataset license. Find additional info for allowed values here.
  - owner string **required**
    User name and unique identifier of the creator of the dataset.

Output example (authenticated user: g-brito)

```
curl --request GET \
  --url https://api.data.world/v0/user/datasets/own \
  --header 'authorization: Bearer [g-brito token]
```

Response body:

```
{
  "count": 1,
  "records": [
    {
      "owner": "gbrito",
      "id": "mytest",
      "title": "myTest",
      "version": "86a2ec99-ee81-4e8d-a2f7-09c4eb77e5e9",
      "tags": [],
      "visibility": "PRIVATE",
      "files": [
        {
          "name": "INFINITECH_cluster_domain_1_v0_0_9.ttl",
          "sizeInBytes": 9494,
          "created": "2020-11-01T18:57:37.053Z",
          "updated": "2020-11-01T18:57:37.053Z"
        },
        {
          "name": "INFINITECH_pilot_2_v0_0_2.ttl",
          "sizeInBytes": 9430,
          "created": "2020-11-01T18:57:37.053Z",
          "updated": "2020-11-01T22:05:58.154Z"
        },
        {
          "name": "core_merged.ttl",
          "sizeInBytes": 24102119,
          "created": "2020-11-01T18:53:08.954Z",
          "updated": "2020-11-01T18:53:08.954Z"
        }
      ],
      "status": "LOADED",
      "created": "2020-10-23T14:38:39.482Z",
      "updated": "2020-11-08T15:49:18.342Z",
      "accessLevel": "ADMIN",
      "versionDois": [],
      "isProject": true
    }
  ]
}
```


GET /user/datasets/{owner}

List datasets owned that the currently authenticated user has access to, from the specified owner

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the dataset owner (creator)

RESPONSE

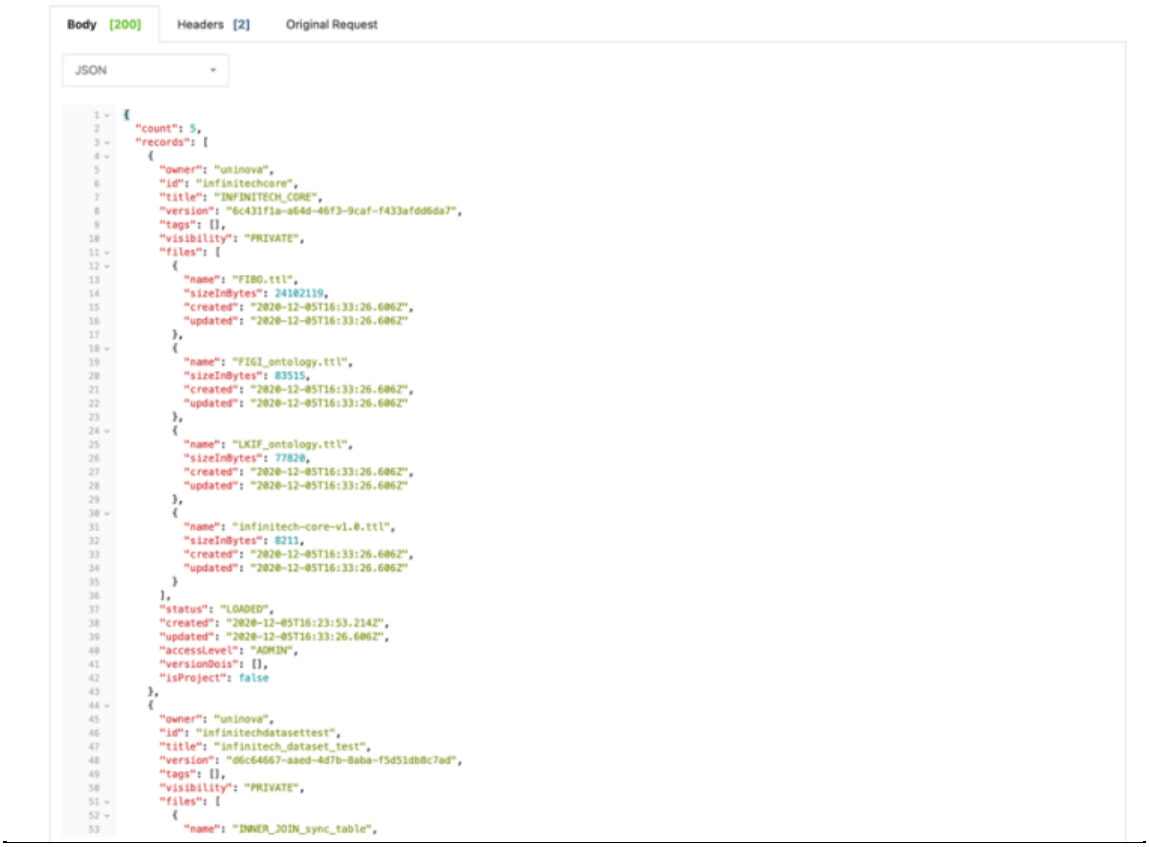
STATUS CODE – 200: array of datasets and their sub items is received

Response Body: application/json

- records array[object] — required
  - accessLevel string — required
    The level of access the authenticated user is allowed with respect to dataset:
    - NONE Not allowed any access.
    - READ Allowed to know that the dataset exists, view and download data and metadata.
    - WRITE Allowed to update data and metadata, in addition to what READ allows.
    - ADMIN Allowed to delete dataset, in addition to what WRITE allows.
  - created string — required
    Date and time when the dataset was created.
  - description string
    Short dataset description.
  - dois array[object]
  - files array[object] — 1 validation
    Initial set of files. At dataset creation time, file uploads are not supported. However, this property can be used to add files via URL.
  - id string — required
    Unique identifier of dataset.
  - isProject boolean — required
    Every data project on data.world comes with a default dataset linked to it. This flag indicates if the dataset is a project's default dataset.
  - license string
    Dataset license. Find additional info for allowed values here.
  - owner string — required
    User name and unique identifier of the creator of the dataset.

```
curl --request GET \
  --url https://api.data.world/v0/datasets/uninova \
  --header 'authorization: Bearer [USER API TOKEN]'
```

Response body:



GET /user/datasets/{owner}/{id}

Retrieves the specified dataset definition data (not associated data)

REQUEST

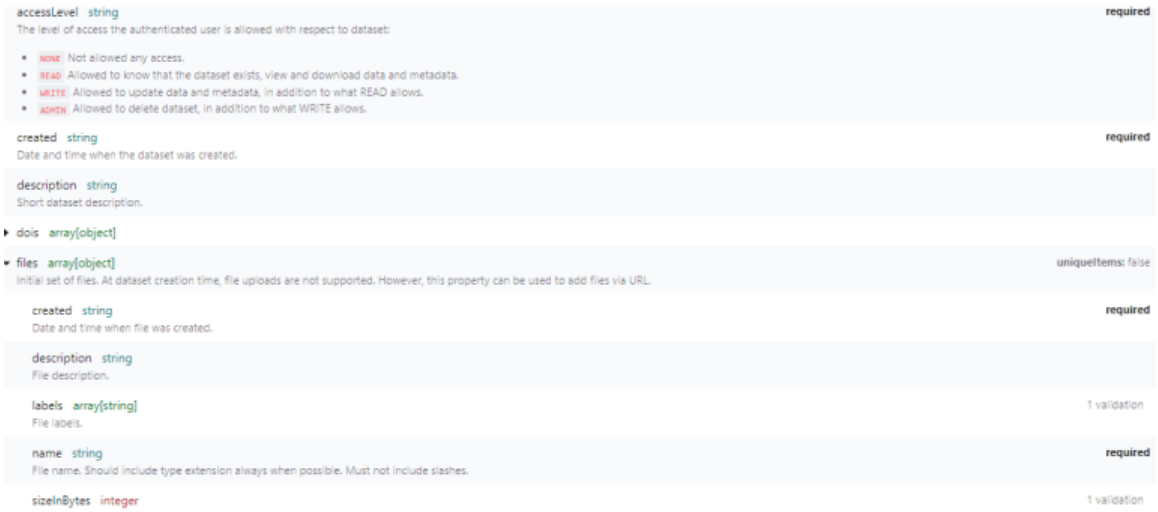
PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the dataset owner (creator)
*id	String	unique identifier of the dataset

RESPONSE

STATUS CODE – 200: dataset definition data is retrieved

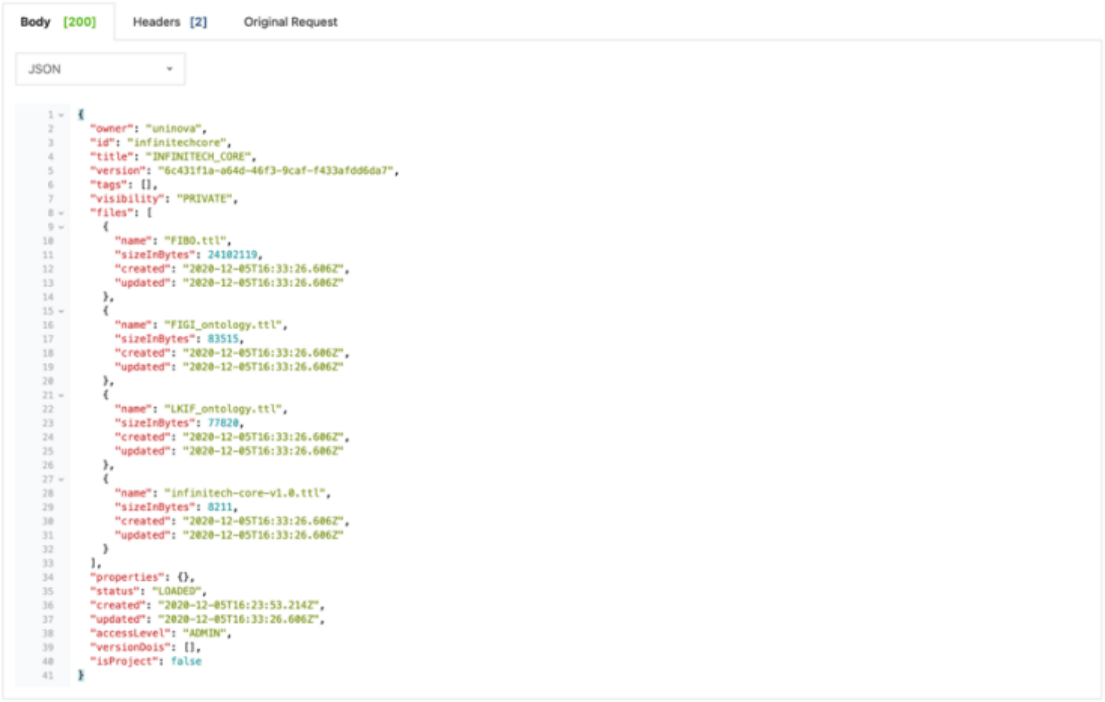
Response Body: application/json



INFINITECH Pilot 2 example (infinitechcore dataset)

```
curl --request GET \
 --url https://api.data.world/v0/datasets/uninova/infinitechcore \
 --header 'authorization: Bearer [g-brito token]'
```

Response body:



SPARQL Queries

The following endpoints are related to SPARQL queries

GET /queries/{id}/

Retrieves the specified saved query definitions (not the results)

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*id	String	unique identifier of the saved query

RESPONSE

STATUS CODE – 200: the saved query definitio0ns is retrieved

Response Body: application/json

body string
Query body.

created string
Date and time when the query was created.

id string
query unique identifier

language string
Type of language in which this query is written. Can be either 'SPARQL' or 'SQL'.

name string
Query name.

owner string
User name and unique identifier of the creator of the dataset.

updated string
Date and time when the query was updated.

version string
Query version id.

parameters object
Parameters declared in the query body

INFINITECH Pilot 2 example (query id: 68c4eb84-7a2d-459f-8b30-5500172b46fd)

```
curl --request GET \
  --url https://api.data.world/v0/queries/68c4eb84-7a2d-459f-8b30-5500172b46fd \
  --header 'authorization: Bearer [USER API TOKEN]'
```

Response body:

GET /queries/{id}/results

Execute a saved result

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*id	String	unique identifier of the saved query

HEADER PARAMETERS

By default, application/sparql-results+json will be returned.

Set the Accept header to one of the following values in accordance with your preference:

- application/sparql-results+xml
- application/sparql-results+json
- application/rdf+json
- application/rdf+xml
- text/csv
- text/tab-separated-values
- text/turtle
-

RESPONSE

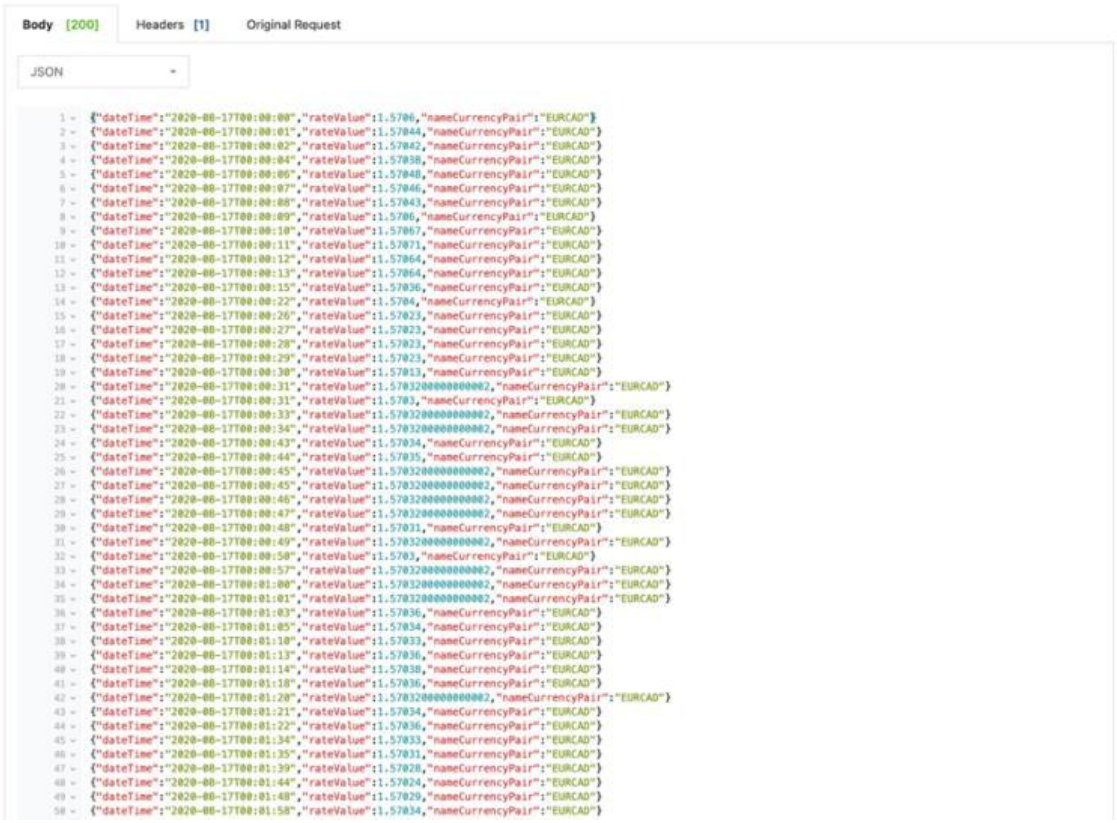
STATUS CODE – 200: the query was performed

Response Body: Set by request accept header (pre-defined as application/json)

INFINITECH Pilot 2 example (query id: 68c4eb84-7a2d-459f-8b30-5500172b46fd)

```
curl --request GET \
  --url                  https://api.data.world/v0/queries/68c4eb84-7a2d-459f-8b30-5500172b46fd/results \
  --header 'authorization: Bearer [USER API TOKEN]'
```

Response body:




```
{"dateTime":"2020-08-17T00:00:00","rateValue":1.5706,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:01","rateValue":1.57044,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:02","rateValue":1.57042,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:04","rateValue":1.57038,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:06","rateValue":1.57048,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:07","rateValue":1.57046,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:08","rateValue":1.57043,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:09","rateValue":1.5706,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:10","rateValue":1.57067,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:11","rateValue":1.57071,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:12","rateValue":1.57064,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:13","rateValue":1.57064,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:15","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:22","rateValue":1.5704,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:26","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:27","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:28","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:29","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:30","rateValue":1.57013,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:31","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:31","rateValue":1.5703,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:33","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:34","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:43","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:44","rateValue":1.57035,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:45","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:45","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:46","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:47","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:48","rateValue":1.57031,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:49","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:50","rateValue":1.5703,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:57","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:00:00","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:01","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:03","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:05","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:10","rateValue":1.57033,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:13","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:14","rateValue":1.57038,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:18","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:20","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:21","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:22","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:34","rateValue":1.57033,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:35","rateValue":1.57031,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:39","rateValue":1.57028,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:44","rateValue":1.57024,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:48","rateValue":1.57029,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T01:01:58","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
```


POST/queries/{id}/results

Execute a saved result

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*id	String	unique identifier of the saved query

HEADER PARAMETERS

By default, application/sparql-results+json will be returned.

Set the Accept header to one of the following values in accordance with your preference:

- application/sparql-results+xml
- application/sparql-results+json
- application/rdf+json
- application/rdf+xml
- text/csv
- text/tab-separated-values
- text/turtle
-

RESPONSE

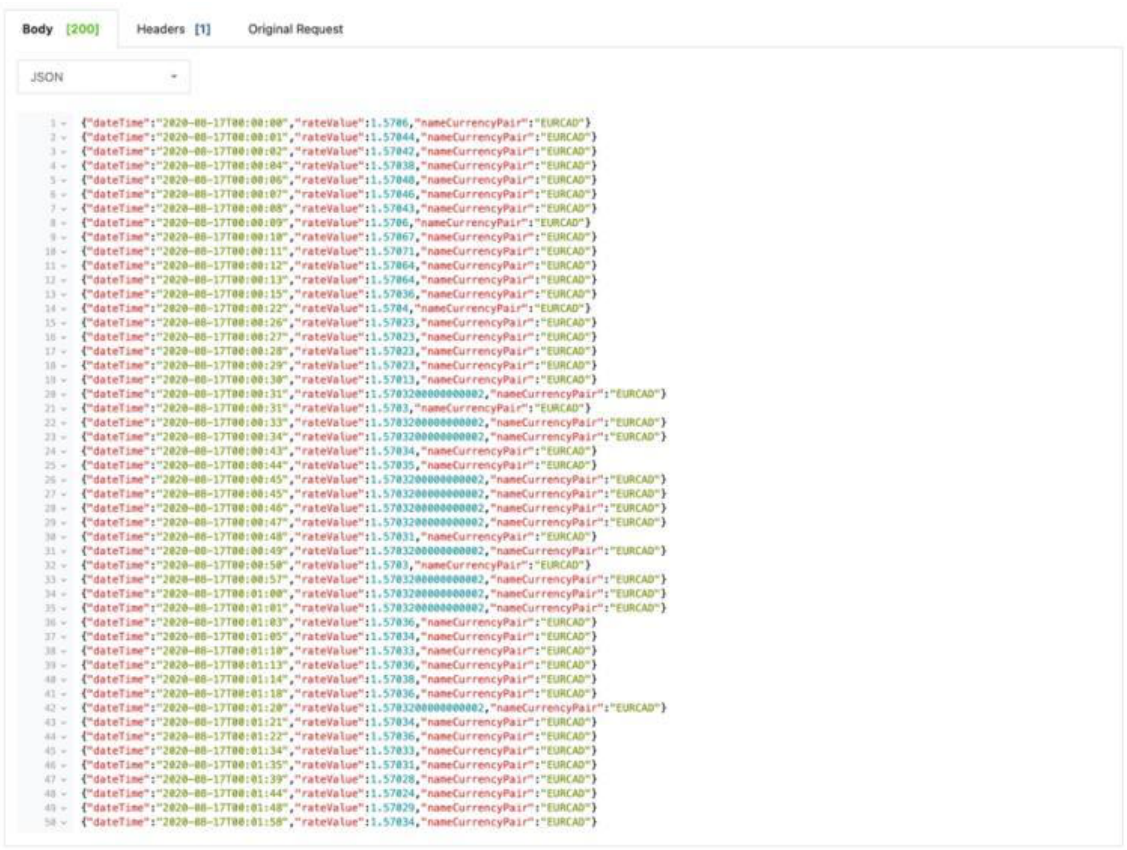
STATUS CODE – 200: the query was performed

Response Body: Set by request accept header (pre-defined as application/json)

INFINITECH Pilot 2 example (query id: 68c4eb84-7a2d-459f-8b30-5500172b46fd)

```
curl --request POST \
  --url                    https://api.data.world/v0/queries/68c4eb84-7a2d-459f-8b30-5500172b46fd/results \
  --header 'authorization: Bearer [USER API TOKEN]' \
  --header 'content-type: application/json' \
  --data '{"parameters":{},"includeTableSchema":false,"maxRows":50}'
```

Response body:



{"dateTime":"2020-08-17T00:00:00","rateValue":1.5706,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:01","rateValue":1.57044,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:02","rateValue":1.57042,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:04","rateValue":1.57038,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:06","rateValue":1.57040,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:07","rateValue":1.57046,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:08","rateValue":1.57043,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:09","rateValue":1.5706,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:10","rateValue":1.57067,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:11","rateValue":1.57071,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:12","rateValue":1.57064,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:13","rateValue":1.57064,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:15","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:22","rateValue":1.5704,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:26","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:27","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:28","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:29","rateValue":1.57023,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:30","rateValue":1.57013,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:31","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:31","rateValue":1.5703,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:33","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:34","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:43","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:44","rateValue":1.57035,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:45","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:45","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:46","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:47","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:48","rateValue":1.57031,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:49","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:50","rateValue":1.5703,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:00:57","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:00","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:01","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:03","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:05","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:10","rateValue":1.57033,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:13","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:14","rateValue":1.57038,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:18","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:20","rateValue":1.5703200000000002,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:21","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:22","rateValue":1.57036,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:34","rateValue":1.57033,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:35","rateValue":1.57031,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:39","rateValue":1.57028,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:44","rateValue":1.57024,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:48","rateValue":1.57029,"nameCurrencyPair":"EURCAD"}
{"dateTime":"2020-08-17T00:01:58","rateValue":1.57034,"nameCurrencyPair":"EURCAD"}

GET /sparql/{owner}/{id}

Attempts to perform the sent query against the specified data project or dataset

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the dataset or data project owner (creator)
*id	string	unique identifier of the saved query

QUERY PARAMETER

query string
Form parameter used to submit the body of a SPARQL or SQL query.

HEADER PARAMETERS

By default, application/sparql-results+json will be returned.

Set the Accept header to one of the following values in accordance with your preference:

- application/sparql-results+xml
- application/sparql-results+json
- application/rdf+json
- application/rdf+xml
- text/csv
- text/tab-separated-values
- text/turtle
-

RESPONSE

STATUS CODE – 200: the query was performed

Response Body: Set by request accept header (pre-defined as application/json)

INFINITECH Pilot 2 example (query against data project)

```
curl --request GET \
  --url
'https://api.data.world/v0/sparql/uninova/infinitechpilottest?query=PREFIX%20%3A%20
%3Chttps%3A%2F%2Funinova.linked.data.world%2Fd%2Finfinitechpilottest%2F%3E%0APREFIX
%20ns1%3A%20%3Chttps%3A%2F%2Funinova.linked.data.world%2Fd%2Fpostgresconn%2F%3E%0AP
REFIX%20ns2%3A%20%3Chttps%3A%2F%2Funinova.linked.data.world%2Fd%2Finfinitechcor...'
\
  --header 'authorization: Bearer [USER API TOKEN]'
```

Response body:

POST /sparql/{owner}/{id}

Attempts to perform the sent query against the specified data project or dataset

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
*owner	string	Username / unique identifier of the dataset or data project owner (creator)
*id	String	unique identifier of the saved query

REQUEST BODY (x-www-form-urlencoded)

query string
Form parameter used to submit the body of a SPARQL or SQL query.

HEADER PARAMETERS

By default, application/sparql-results+json will be returned.

Set the Accept header to one of the following values in accordance with your preference:

- application/sparql-results+xml
- application/sparql-results+json
- application/rdf+json
- application/rdf+xml
- text/csv
- text/tab-separated-values
- text/turtle
-

RESPONSE

STATUS CODE – 200: the query was performed

Response Body: Set by request accept header (pre-defined as application/json)

INFINITECH Pilot 2 example (query against data project)

cURL request:

```
curl --request POST \
  --url https://api.data.world/v0/sparql/uninova/infinitechpilottest \
  --header 'accept: application/sparql-results+json' \
  --header 'authorization: Bearer [USER API TOKEN]' \
  --header 'content-type: application/x-www-form-urlencoded' \
  --data query=PREFIX%20%3A%20%3Chttps%3A...
```

Response body:

Appendix C: GraphDB API documentation

GraphDB APIs Reference

INFINITECH - Pilot 2

Introduction

This document provides the guidelines for accessing the ***GraphDB* APIs**, using INFINITECH Pilot 2 Scenario as example. *GraphDB* is an RDF database for Knowledge Graphs, which allows diverse data linking, semantic indexing and enrichment. Furthermore, it enables fast integration of new information sources by parsing structured data (CSV, xml, structured JSON, …) which is used in INFINITECH as a means to perform the transformation from this type of data into RDF Knowledge Graphs and providing its availability afterwards.

GraphDB encompasses separated APIs with different aims regarding the offered functionalities, which can be aligned with the methodology proposed as an outcome of Task 4.1 of Infinitech. Ontorefine - the GraphDB module which allows importing and management of tabular data – provides an API which extends the *OpenRefine HTTP API*. The *RDF-mapper REST-API* can be used for applying and retrieving the transformation results as Knowledge Graphs. The *GraphDB REST API* and *RDF4J API* for operating all the Knowledge Graph and SPARQL interactions of GraphDB database (repositories management, Inserting/extracting RDF data with statements or SPARQL queries, etc.).

As such, using these 4 APIs it is possible to follow the proposed INFINITECH methodology for the semantic transformation and provision of data, which is divided into the following steps:

1) Importing structured data;
2) transformation process (mapping and conversion to knowledge graph - RDF);
3) knowledge graph storage, and;
4) data consumption by external actor (client applications).

OntoRefine HTTP API

Base URL: **http://<host>:<port>/orefine**

Obtain CRSF token

Get /command/core/get-csrf-token

Request for a CRSF token to be used on following requests

Example:

curl -X GET \

--url http://localhost:7200/orefine/command/core/get-csrf-token

Response:

{"token":"ZMNAkhoTNBcNuJy9mqjQf0O3brY1zG6Y"}

Create project (by importing local files)

POST /command/core/create-project-from-upload

Create a new project by importing the specified tabular data

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
crsf_token	String	The crsf session token previously requested

BODY: Form data (application/x-www-form-urlencoded)

NAME	TYPE	DESCRIPTION
Project-file	string	File contents (or file: @path/to/file)
Project-name	String	Project name
Format (optional)	String	Format of the data (e.g. 'text/line-based/*sv', 'text/json')
Options	Json object	containing options relevant to the file format (e.g. 'csv separator')

Example:

curl -X POST \

--url http://localhost:7200/orefine/command/core/create-project-from-upload?csrf_token=ZMNAkhoTNBcNuJy9mqjQf0O3brY1zG6Y \

-F project-file=@Trades.csv \

```
-F project-name=pilot2_trades \
-F format=text/line-based/csv \
-F options='{"separator":","}' \
-Ls -w %{url_effective} -o /dev/null
```

Response:

-

NOTE:

If Project is successfully created, the project identifier can be captured from the query parameter <project> of the redirected url:

http://localhost:7200/project?project=1628195961675

Get Project Model

Get /command/core/get-models?

Recovers the models for the specified project

REQUEST

PATH PARAMETERS

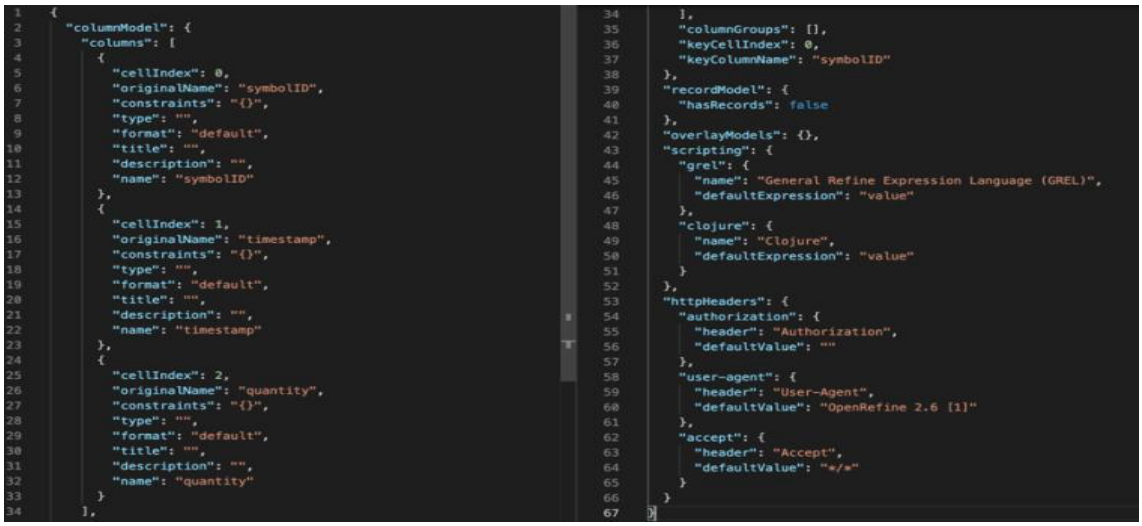
NAME	TYPE	DESCRIPTION
Project	String	Project identifier

Example:

curl -X GET \

--url http://localhost:7200/orefine/command/core/get-models?project=1628195961675

Response:



Get all Projects meta-data

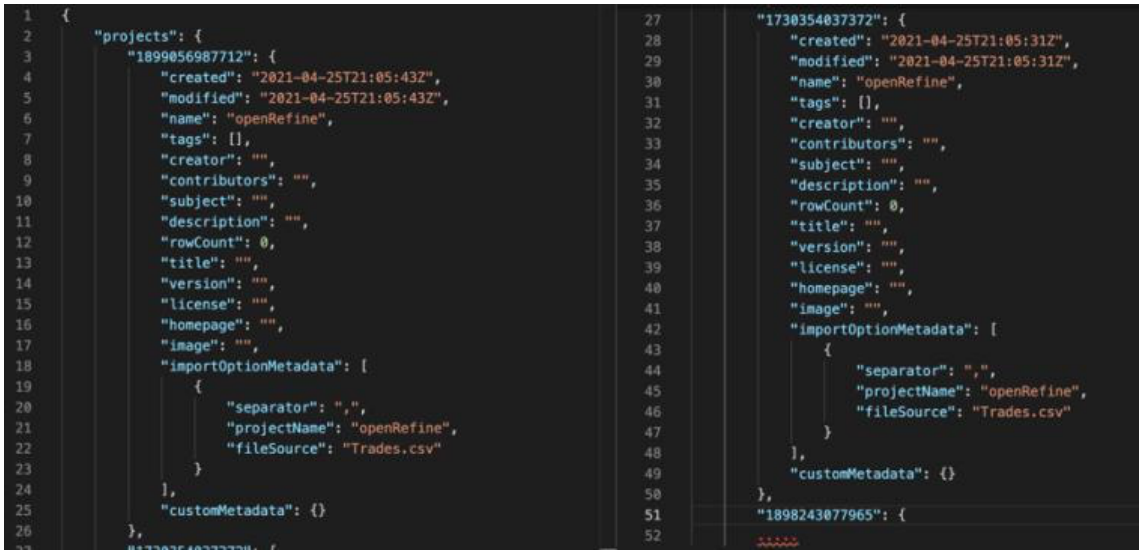
Get /command/core/get-all-project-metadata

Recovers all existing projects meta-data (ids, names, time of creation…)

Example:

curl -X GET --url http://localhost:7200/orefine/command/core/get-all-project-metadata

Response:



Get all Projects meta-data

POST /command/core/delete-project

Deletes the specified project

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
crsf_token	String	The crsf session token previously requested
Project	String	Project identifier

Example:

curl -X POST \

--url http://localhost:7200/orefine/command/core/delete-project?project=2435979223170&csrf_token=jPbHZlmJ5DmWci62qSywSxYaSJz6mVA2

Response:

{"code" : "ok" }

RDF-mapper REST API

Base URL: **http://<host>:<port>/rest/rdf-mapper**

Stream transformation

POST /rdf/stream:<filetype>:{<options>}

Get transformed knowledge graph, with streamed data

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
filetype	String	The crsf session token previously requested
options	String	Related options defined by pairs (key=value) – e.g {separator=;}

BODY: Form data (application/x-www-form-urlencoded)

NAME	TYPE	DESCRIPTION
mapping	Json	Json Mapping data (or file: @path/to/file)
data	{fileType}	Data to be transformed (if from file: @path/to/file)

Headers

NAME	TYPE	DESCRIPTION
Accept	Json	MIME type of the result ('text/turtle')

Example:

```
curl -X POST -sL \
    --url "http://localhost:7200/rest/rdf-mapper/rdf/stream:csv:separator=%2C"\
    -F mapping=@mapping-2.json \
    -F data=@inner_join_sync_table.csv \
    -H 'accept: text/turtle' \
    -o stream_file.ttl
```

Response:

```
@base <http://example.com/base/> .
@prefix fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/> .
@prefix fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/> .
@prefix fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/> .
@prefix fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/> .
@prefix inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

inf-spec-ont-pilot-2:2 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCAD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.5706"^^xsd:long .

inf-spec-ont-pilot-2:3 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCHF";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.07666"^^xsd:long .

inf-spec-ont-pilot-2:4 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCHF";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.07664"^^xsd:long .

inf-spec-ont-pilot-2:5 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURUSD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.18433"^^xsd:long .

inf-spec-ont-pilot-2:6 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "GBPUSD";
```

Get associated SPARQL query

POST /sparql/ontorefine:<projectId>

Get the transformative SPARQL query from an imported dataset and a specified mapping file

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
projectID	String	The project identifier

Headers

NAME	TYPE	DESCRIPTION
Accept	Json	MIME type of the result (e.g. 'text/plain')
Content-type	Json	MIME type of the request body (application/Json)

BODY: raw data

NAME	TYPE	DESCRIPTION
-	Json	Json Mapping data (or file: @path/to/file)

Example:

```
curl -X POST \
  --url 'http://localhost:7200/rest/rdf-mapper/sparql/ontorefine:2341737408163' \
  -H 'Accept: application/json, text/plain, */*' \
  -H 'Content-Type: application/json' \
```

--data-raw '{"baseIRI":"http://example.com/base/","namespaces":{"fibo-fnd-acc-cur":"https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/","fibo-fnd-qt-qtu":"https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/","fibo-ind-ind-ind":"https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/","fibo-ind-fx-fx":"https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/","inf-spec-ont-pilot-2":"https://spec.infinitech.org/ontology/application/pilot_2/","xsd":"http://www.w3.org/2001/XMLSchema#"},"subjectMappings":[{"propertyMappings":[{"property":{"transformation":{"expression":"inf-spec-ont-pilot-2","language":"prefix"},"valueSource":{"source":"constant","constant":"CurrencyPairTag"}},"values":[{"valueSource":{"columnName":"product","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"string"}}}}]},{"property":{"transformation":{"expression":"fibo-ind-ind-ind","language":"prefix"},"valueSource":{"source":"constant","constant":"hasQuotationDateTime"}},"values":[{"valueSource":{"columnName":"datetime","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"dateTime"}}}}]},{"property":{"transformation":{"expression":"fibo-fnd-acc-cur","language":"prefix"},"valueSource":{"source":"constant","constant":"hasRateValue"}},"values":[{"valueSource":{"columnName":"tik_close","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"long"}}}}]},{"property":{"transformation":{"expression":"fibo-fnd-qt-qtu","language":"prefix"},"valueSource":{"source":"constant","constant":"hasNumericValue"}},"values":[{"valueSource":{"columnName":"quantity","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"int"}}}}]}],"subject":{"transformation":{"expression":"inf-spec-ont-pilot-2","language":"prefix"},"valueSource":{"columnName":"id","source":"column"}},"typeMappings":[{"transformation":{"expression":"fibo-ind-fx-fx","language":"prefix"},"valueSource":{"source":"constant","constant":"QuotedExchangeRate"}}]}]}'

Response:

```
BASE <http://example.com/base/>
PREFIX mapper: <http://www.ontotext.com/mapper/>
PREFIX fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/>
PREFIX fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/>
PREFIX fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/>
PREFIX fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/>
PREFIX inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

CONSTRUCT {
    ?s1 a fibo-ind-fx-fx:QuotedExchangeRate ;
        inf-spec-ont-pilot-2:CurrencyPairTag ?o_CurrencyPairTag ;
        fibo-ind-ind-ind:hasQuotationDateTime ?o_hasQuotationDateTime ;
        fibo-fnd-acc-cur:hasRateValue ?o_hasRateValue ;
        fibo-fnd-qt-qtu:hasNumericValue ?o_hasNumericValue .
} WHERE {
    SERVICE <rdf-mapper:ontorefine:2341737408163> {
        # Columns as variables:
        #   ?c_id, ?c_datetime, ?c_product, ?c_tik_close, ?c_quantity
        # Metadata as variables:
        #   ?row_index, ?record_id
        BIND(IRI(mapper:encode_iri(inf-spec-ont-pilot-2:, ?c_id)) as ?s1)
        BIND(STRDT(?c_product, xsd:string) as ?o_CurrencyPairTag)
        BIND(STRDT(?c_datetime, xsd:dateTime) as ?o_hasQuotationDateTime)
        BIND(STRDT(?c_tik_close, xsd:long) as ?o_hasRateValue)
        BIND(STRDT(?c_quantity, xsd:int) as ?o_hasNumericValue)
    }
}
```

Run associated SPARQL query

POST /rdf/ontorefine:<projectId>

Execute the transformative SPARQL query from an imported dataset and a specified mapping file

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
projectID	String	The project identifier

Headers

NAME	TYPE	DESCRIPTION
Accept	Json	MIME type of the result (e.g. 'text/turtle')
Content-type	Json	MIME type of the request body (application/Json)

BODY: raw data

NAME	TYPE	DESCRIPTION
-	Json	Json Mapping data (or file: @path/to/file)

Example:

```
curl -X POST \
  --url 'http://localhost:7200/rest/rdf-mapper/rdf/ontorefine:2341737408163' \
  -H 'Accept: text/turtle,' \
  -H 'Content-Type: application/json' \
  --data-raw '{"baseIRI":"http://example.com/base/","namespaces":{"fibo-fnd-acc-cur":"https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/","fibo-fnd-qt-qtu":"https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/","fibo-ind-ind-ind":"https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/","fibo-ind-fx-fx":"https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/","inf-spec-ont-pilot-2":"https://spec.infinitech.org/ontology/application/pilot_2/","xsd":"http://www.w3.org/2001/XMLSchema#"},"subjectMappings":[{"propertyMappings":[{"property":{"transformation":{"expression":"inf-spec-ont-pilot-2","language":"prefix"},"valueSource":{"source":"constant","constant":"CurrencyPairTag"}},"values":[{"valueSource":{"columnName":"product","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"string"}}}}]},{"property":{"transformation":{"expression":"fibo-ind-ind-ind","language":"prefix"},"valueSource":{"source":"constant","constant":"hasQuotationDateTime"}},"values":[{"valueSource":{"columnName":"datetime","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"dateTime"}}}}]},{"property":{"transformation":{"expression":"fibo-fnd-acc-cur","language":"prefix"},"valueSource":{"source":"constant","constant":"hasRateValue"}},"values":[{"valueSource":{"columnName":"tik_close","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"long"}}}}]},{"property":{"transformation":{"expression":"fibo-fnd-qt-qtu","language":"prefix"},"valueSource":{"source":"constant","constant":"hasNumericValue"}},"values":[{"val
```

ueSource":{"columnName":"quantity","source":"column"},"valueType":{"type":"datatype_literal","datatype":{"transformation":{"expression":"xsd","language":"prefix"},"valueSource":{"source":"constant","constant":"int"}}}}]},"subject":{"transformation":{"expression":"inf-spec-ont-pilot-2","language":"prefix"},"valueSource":{"columnName":"id","source":"column"}},"typeMappings":[{"transformation":{"expression":"fibo-ind-fx-fx","language":"prefix"},"valueSource":{"source":"constant","constant":"QuotedExchangeRate"}}]}]}'

Response:

```
@base <http://example.com/base/> .
@prefix fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/> .
@prefix fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/> .
@prefix fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/> .
@prefix fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/> .
@prefix inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

inf-spec-ont-pilot-2:2 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCAD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.5706"^^xsd:long .

inf-spec-ont-pilot-2:3 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCHF";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.07666"^^xsd:long .

inf-spec-ont-pilot-2:4 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCHF";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.07664"^^xsd:long .

inf-spec-ont-pilot-2:5 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURUSD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.18433"^^xsd:long .

inf-spec-ont-pilot-2:6 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "GBPUSD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.31023"^^xsd:long;
  fibo-fnd-qt-qtu:hasNumericValue "750000"^^xsd:int .

inf-spec-ont-pilot-2:7 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "GBPUSD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.31021"^^xsd:long;
  fibo-fnd-qt-qtu:hasNumericValue "750000"^^xsd:int .

inf-spec-ont-pilot-2:8 a fibo-ind-fx-fx:QuotedExchangeRate;
  inf-spec-ont-pilot-2:CurrencyPairTag "EURCAD";
  fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:01"^^xsd:dateTime;
  fibo-fnd-acc-cur:hasRateValue "1.57044"^^xsd:long .
```

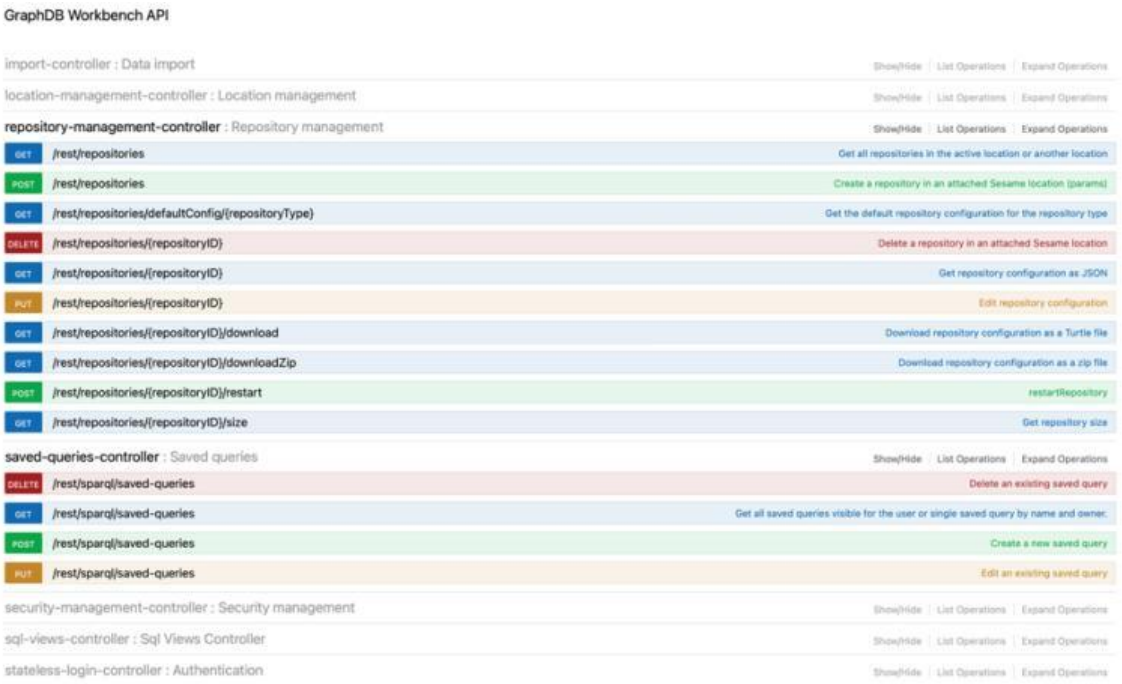
GraphDB Workbench REST API

Base URL: **http://<host>:<port>/rest**

This REST-API offers access to the GraphDB RDF database functionalities, such as importing and adding knowledge graphs from local or URL files, repository management or saved SPARQL queries.

Also, by accessing the GraphDB Workbench (GUI), a Swagger is available in order to allow users to experiment and test the available endpoints.

In the context of INFINITECH, using pre-established SPARQL queries can be a very useful feature, so in this section it is presented the saved-queries-controller routes if the REST API.



Save a SPARQL query

POST /sparql/saved-queries

Saves a SPARQL query into GraphDB

REQUEST

Headers

NAME	TYPE	DESCRIPTION
Content-type	Json	MIME type of the request body (application/Json)

BODY

NAME	TYPE	Model
query	Json	

Example:

```
curl -X POST \
    --url 'http://localhost:7200/rest/sparql/saved-queries' \
    --header 'Content-Type: application/json' \
    -d '{"name":"saved_by_rest",
        "shared":"true",
        "body":"BASE <http://example.com/base/>\nPREFIX mapper: <http://www.ontotext.com/mapper/>\nPREFIX fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/>\nPREFIX fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/>\nPREFIX fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/>\nPREFIX fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/>\nPREFIX inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/>\nPREFIX xsd: <http://www.w3.org/2001/XMLSchema#>\n\nCONSTRUCT {\n ?s1 a fibo-ind-fx-fx:QuotedExchangeRate ;\n inf-spec-ont-pilot-2:CurrencyPairTag ?o_CurrencyPairTag ;\n fibo-ind-ind-ind:hasQuotationDateTime ?o_hasQuotationDateTime ;\n fibo-fnd-acc-cur:hasRateValue ?o_hasRateValue ;\n fibo-fnd-qt-qtu:hasNumericValue ?o_hasNumericValue .\n} WHERE {\n SERVICE <rdf-mapper:ontorefine:2341737408163> {\n # Columns as variables:\n # ?c_id, ?c_datetime, ?c_product, ?c_tik_close, ?c_quantity\n # Metadata as variables:\n # ?row_index, ?record_id\n BIND(IRI(mapper:encode_iri(inf-spec-ont-pilot-2:, ?c_id)) as ?s1)\n BIND(STRDT(?c_product, xsd:string) as ?o_CurrencyPairTag)\n BIND(STRDT(?c_datetime, xsd:dateTime) as ?o_hasQuotationDateTime)\n BIND(STRDT(?c_tik_close, xsd:long) as ?o_hasRateValue)\n BIND(STRDT(?c_quantity, xsd:int) as ?o_hasNumericValue)\n }\n}"
    }'
```

Result (after successful call):


saved_by_rest
BASE <http://example.com/base/>
PREFIX mapper: <http://www.ontotext.com/mapper/>
PREFIX fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/>
PREFIX fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/>
PREFIX fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/>
PREFIX fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/>
PREFIX inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
CONSTRUCT {
?s1 a fibo-ind-fx-fx:QuotedExchangeRate ;
inf-spec-ont-pilot-2:CurrencyPairTag ?o_CurrencyPairTag ;
fibo-ind-ind-ind:hasQuotationDateTime ?o_hasQuotationDateTime ;
fibo-fnd-acc-cur:hasRateValue ?o_hasRateValue ;
fibo-fnd-qt-qtu:hasNumericValue ?o_hasNumericValue .
} WHERE {
SERVICE <rdf-mapper:ontorefine:2341737408163> {
# Columns as variables:
# ?c_id, ?c_datetime, ?c_product, ?c_tik_close, ?c_quantity
# Metadata as variables:
# ?row_index, ?record_id
BIND(IRI(mapper:encode_iri(inf-spec-ont-pilot-2:, ?c_id)) as ?s1)
BIND(STRDT(?c_product, xsd:string) as ?o_CurrencyPairTag)
BIND(STRDT(?c_datetime, xsd:dateTime) as ?o_hasQuotationDateTime)
BIND(STRDT(?c_tik_close, xsd:long) as ?o_hasRateValue)
BIND(STRDT(?c_quantity, xsd:int) as ?o_hasNumericValue)
}
}
Add statements
Clear graph
pilot2_Construct
pilot2_INSERT
Remove statements
saved_by_rest
SPARQL Select template
Run
Press Alt+Enter to autocomplete

Change a SPARQL query

PUT /sparql/saved-queries

Updates a saved SPARQL query

REQUEST

Headers

NAME	TYPE	DESCRIPTION
Content-type	Json	MIME type of the request body (application/Json)

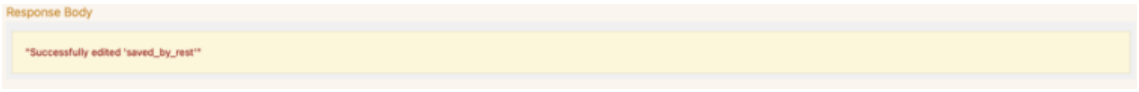
BODY

NAME	TYPE	Model
query	Json	

Example:

```
curl -X PUT \
    --url 'http://localhost:7200/rest/sparql/saved-queries' \
    --header 'Content-Type: application/json' \
    -d '{"name":"saved_by_rest",
        "shared":"true",
        "body":"BASE <http://example.com/base/>\nPREFIX mapper: <http://www.ontotext.com/mapper/>\nPREFIX fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/>\nPREFIX fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/>\nPREFIX fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/>\nPREFIX fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/>\nPREFIX inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/>\nPREFIX xsd: <http://www.w3.org/2001/XMLSchema#>\n\nCONSTRUCT {\n  ?s1 a fibo-ind-fx-fx:QuotedExchangeRate ;\n  inf-spec-ont-pilot-2:CurrencyPairTag ?o_CurrencyPairTag ;\n  fibo-ind-ind-ind:hasQuotationDateTime ?o_hasQuotationDateTime ;\n  fibo-fnd-acc-cur:hasRateValue ?o_hasRateValue ;\n  fibo-fnd-qt-qtu:hasNumericValue ?o_hasNumericValue .\n} WHERE {\n  SERVICE <rdf-mapper:ontorefine:2341737408163> {\n  # Columns as variables:\n  # ?c_id, ?c_datetime, ?c_product, ?c_tik_close, ?c_quantity\n  # Metadata as variables:\n  # ?row_index, ?record_id\n  BIND(IRI(mapper:encode_iri(inf-spec-ont-pilot-2:, ?c_id)) as ?s1)\n  BIND(STRDT(?c_product, xsd:string) as ?o_CurrencyPairTag)\n  BIND(STRDT(?c_datetime, xsd:dateTime) as ?o_hasQuotationDateTime)\n  BIND(STRDT(?c_tik_close, xsd:long) as ?o_hasRateValue)\n  BIND(STRDT(?c_quantity, xsd:int) as ?o_hasNumericValue)\n  }\n}"
    }'
```

Result:



Change a SPARQL query

GET /sparql/saved-queries

Retreives a saved SPARQL query

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
Name	string	Name of the query
Owner	String	Owner of the repository

Headers

NAME	Value	DESCRIPTION
Accept	Application/Json	MIME type of the request body (application/Json)

Example:

```
curl -X GET \
        --header 'Accept: application/json' 'http://localhost:7200/rest/sparql/saved-queries?name=saved_by_rest&owner=admin'
```

Result:

DELETE /sparql/saved-queries

Deletes a saved SPARQL query

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
Name	string	Name of the query

Example:

```
curl -X DELETE --header 'Accept: */*' 'http://localhost:7200/rest/sparql/saved-queries?name=saved_by_rest'
```

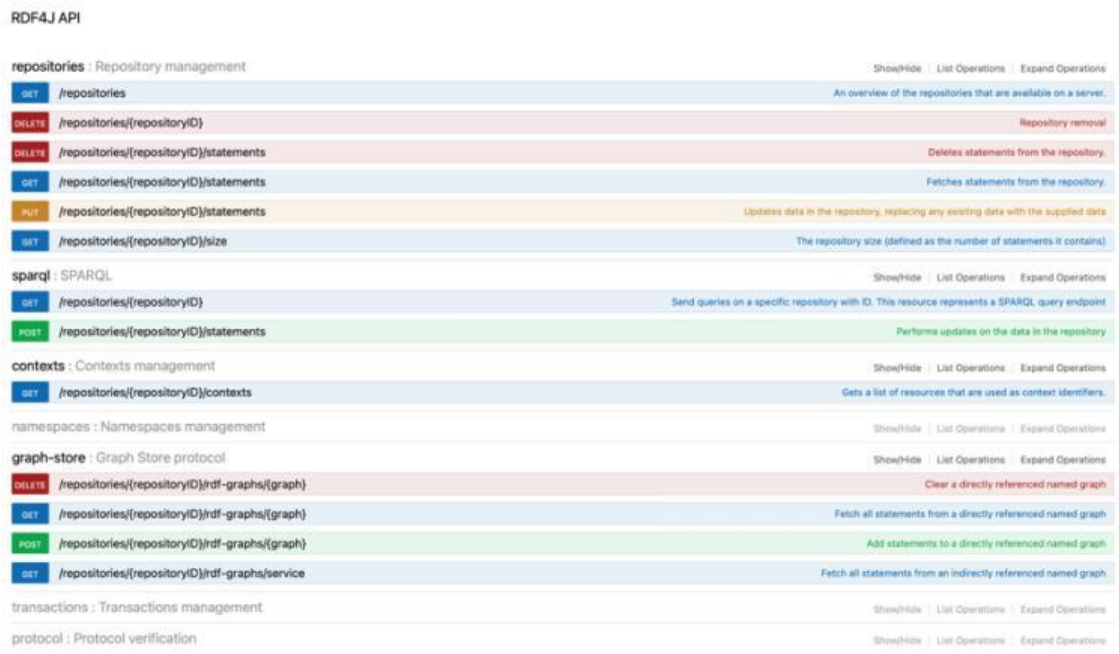
RDF4J API

Base URL: **http://<host>:<port>/**

The RDF4J API complements the access points of GraphDB, and also by accessing the GraphDB Workbench (GUI), a Swagger is available in order to allow users to experiment and test the available endpoints.

More information about RDF4J can be found in https://rdf4j.org/documentation/reference/rest-api/ , although not all endpoints specified by RDF4J have been exposed in GraphDB.

Besides providing the ability to management the repositories, RDF4J API can be mainly used for consuming or inserting RDF data by means of SPARQL queries or by passing RDF statements (RDF files such as turtle or Json-LD).



Execute a Select SPARQL query (consuming)

GET /repositories/{repositoryID}

Passes and runs a Select SPARQL query against the GraphDB triplestore

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
repositoryID	string	The repository identifier
Query	String	the SPARQL query (SELECT)
Limit	Int	Maximum number of results
Offset	Int	Specifies the number of query solutions to skip
$<varname>	String	Specifies variable bindings

Headers

NAME	Value	DESCRIPTION
Accept	application/sparql-results+json application/sparql-results+xml	Response content type

Example:

```
curl -X GET \
    --url 'http://localhost:7200/repositories/infinitech_test? \
    --header 'Accept: application/sparql-results+json' \
  query=BASE%20%3Chttp%3A%2F%2Fexample.com%2Fbase%2F%3E%20PREFIX%20mapper%3A%20%3Chttp%3A%2F%2Fwww.ontotext.com%2Fmapper%2F%3E%20PREFIX%20fibo-fnd-acc-cur%3A%20%3Chttps%3A%2F%2Fspec.edmcouncil.org%2Ffibo%2Fontology%2FFND%2FAccounting%2FCurrencyAmount%2F%3E%20PREFIX%20fibo-fnd-qt-qtu%3A%20%3Chttps%3A%2F%2Fspec.edmcouncil.org%2Ffibo%2Fontology%2FFND%2FQuantities%2FQuantitiesAndUnits%2F%3E%20PREFIX%20fibo-ind-ind-ind%3A%20%3Chttps%3A%2F%2Fspec.edmcouncil.org%2Ffibo%2Fontology%2FIND%2FIndicators%2FIndicators%2F%3E%20PREFIX%20fibo-ind-fx-fx%3A%20%3Chttps%3A%2F%2Fspec.edmcouncil.org%2Ffibo%2Fontology%2FIND%2FForeignExchange%2FForeignExchange%2F%3E%20PREFIX%20inf-spec-ont-pilot-2%3A%20%3Chttps%3A%2F%2Fspec.infinitech.org%2Fontology%2Fapplication%2Fpilot_2%2F%3E%20PREFIX%20xsd%3A%20%3Chttp%3A%2F%2Fwww.w3.org%2F2001%2FXMLSchema%23%3E%20%20PREFIX%20rdfs%3A%20%3Chttp%3A%2F%2Fwww.w3.org%2F2000%2F01%2Frdf-schema%23%3E%20PREFIX%20rdf%3A%20%3Chttp%3A%2F%2Fwww.w3.org%2F1999%2F02%2F22-rdf-syntax-ns%23%3E%20%20SELECT%20%20%3Fid%20%3FCurrencyPair%20%3FdateTime%20%3FrateValue%20%3Fquantity%20FROM%20%3Chttp%3A%2F%2Finfinitech%2Fjson_mapping%2F%3E%20%20WHERE%7B%20%20%20%20%20%3Fid%20rdf%3Atype%20fibo-ind-fx-fx%3AQuotedExchangeRate%3B%20%09%09inf-spec-ont-pilot-2%3ACurrencyPairTag%20%3FCurrencyPair%3B%20%20%20%09%09fibo-ind-ind-ind%3AhasQuotationDateTime%20%3FdateTime%3B%20%20%20%20%20%09fibo-fnd-acc-cur%3AhasRateValue%20%3FrateValue%3B%20%09%09fibo-fnd-qt-qtu%3AhasNumericValue%20%20%3Fquantity%20.%20%7D'
```

Result body (Json and XML):


```
{
  "head" : {
    "vars" : [
      "id",
      "CurrencyPair",
      "dateTime",
      "rateValue",
      "quantity"
    ]
  },
  "results" : {
    "bindings" : [
      {
        "id" : {
          "type" : "uri",
          "value" : "https://spec.infinitech.org/ontology/application/pilot_2/6"
        },
        "CurrencyPair" : {
          "type" : "literal",
          "value" : "GBPUSD"
        },
        "dateTime" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#dateTime",
          "type" : "literal",
          "value" : "2020-08-17T00:00:00"
        },
        "rateValue" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#long",
          "type" : "literal",
          "value" : "1.31023"
        },
        "quantity" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#int",
          "type" : "literal",
          "value" : "750000"
        }
      },
      {
        "id" : {
          "type" : "uri",
          "value" : "https://spec.infinitech.org/ontology/application/pilot_2/7"
        },
        "CurrencyPair" : {
          "type" : "literal",
          "value" : "GBPUSD"
        },
        "dateTime" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#dateTime",
          "type" : "literal",
          "value" : "2020-08-17T00:00:00"
        },
        "rateValue" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#long",
          "type" : "literal",
          "value" : "1.31021"
        },
        "quantity" : {
          "datatype" : "http://www.w3.org/2001/XMLSchema#int",
          "type" : "literal",
          "value" : "750000"
        }
      },
```



```
<?xml version='1.0' encoding='UTF-8'?>
<sparql xmlns='http://www.w3.org/2005/sparql-results#'>
    <head>
        <variable name='id'/>
        <variable name='CurrencyPair'/>
        <variable name='dateTime'/>
        <variable name='rateValue'/>
        <variable name='quantity'/>
    </head>
    <results>
        <result>
            <binding name='id'>
                <uri>https://spec.infinitech.org/ontology/application/pilot_2/6</uri>
            </binding>
            <binding name='CurrencyPair'>
                <literal>GBPUSD</literal>
            </binding>
            <binding name='dateTime'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#dateTime'>2020-08-17T00:00:00</literal>
            </binding>
            <binding name='rateValue'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#long'>1.31023</literal>
            </binding>
            <binding name='quantity'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#int'>750000</literal>
            </binding>
        </result>
        <result>
            <binding name='id'>
                <uri>https://spec.infinitech.org/ontology/application/pilot_2/7</uri>
            </binding>
            <binding name='CurrencyPair'>
                <literal>GBPUSD</literal>
            </binding>
            <binding name='dateTime'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#dateTime'>2020-08-17T00:00:00</literal>
            </binding>
            <binding name='rateValue'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#long'>1.31021</literal>
            </binding>
            <binding name='quantity'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#int'>750000</literal>
            </binding>
        </result>
        <result>
            <binding name='id'>
                <uri>https://spec.infinitech.org/ontology/application/pilot_2/153839</uri>
            </binding>
            <binding name='CurrencyPair'>
                <literal>EURCHF</literal>
            </binding>
            <binding name='dateTime'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#dateTime'>2020-09-11T00:00:00</literal>
            </binding>
            <binding name='rateValue'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#long'>1.0762200000000002</literal>
            </binding>
            <binding name='quantity'>
                <literal datatype='http://www.w3.org/2001/XMLSchema#int'>500000</literal>
            </binding>
        </result>
    </results>
```

Execute a Select SPARQL query (insert/construct)

POST /repositories/{repositoryID}

Passes and runs a Select SPARQL query against the GraphDB triplestore

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
repositoryID	string	The repository identifier
Query	String	the SPARQL query (SELECT)
Limit	Int	Maximum number of results
Offset	Int	Specifies the number of query solutions to skip
$<varname>	String	Specifies variable bindings

BODY

NAME	TYPE	Description
Query	String	The Construct sparql query

Headers

NAME	Value	DESCRIPTION
Content-type	application/sparql-query	Request content type
Accept	Application/rdf+xml	Response content type

Example:

```
curl -X POST \
    --header 'Accept: application/rdf+xml' \
    --url 'http://localhost:7200/repositories/infinitech_test' \
    -d query="BASE <http://example.com/base/> PREFIX mapper: <http://www.ontotext.com/mapper/> PREFIX fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/> PREFIX fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/> PREFIX fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/> PREFIX fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/> PREFIX inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/> PREFIX xsd: <http://www.w3.org/2001/XMLSchema#> CONSTRUCT { ?s1 a fibo-ind-fx-fx:QuotedExchangeRate ; inf-spec-ont-pilot-2:CurrencyPairTag ?o_CurrencyPairTag ; fibo-ind-ind-ind:hasQuotationDateTime ?o_hasQuotationDateTime ; fibo-fnd-acc-cur:hasRateValue ?o_hasRateValue ; fibo-fnd-qt-qtu:hasNumericValue ?o_hasNumericValue . } WHERE { SERVICE <rdf-mapper:ontorefine:2435979223170> { # Columns as variables: # ?c_id, ?c_datetime, ?c_product, ?c_tik_close, ?c_quantity # Metadata as variables: # ?row_index, ?record_id BIND(IRI(mapper:encode_iri(inf-spec-ont-pilot-2:, ?c_id)) as ?s1) BIND(STRDT(?c_product, xsd:string) as ?o_CurrencyPairTag) BIND(STRDT(?c_datetime, xsd:dateTime) as ?o_hasQuotationDateTime) BIND(STRDT(?c_tik_close, xsd:long) as ?o_hasRateValue) BIND(STRDT(?c_quantity, xsd:int) as ?o_hasNumericValue) } }"
```

Add/update statements to a named graph

PUT /repositories/{repositoryID}/rdf-graphs/{graph}

Passes a set of RDF statements and includes them in the specified named graph

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
repositoryId	string	Identifier of the repository
Graph	url	URL of the named graph

BODY

NAME	TYPE	Description
Query	RDF	The RDF statements (turtle, RDF/xml, …)

Headers

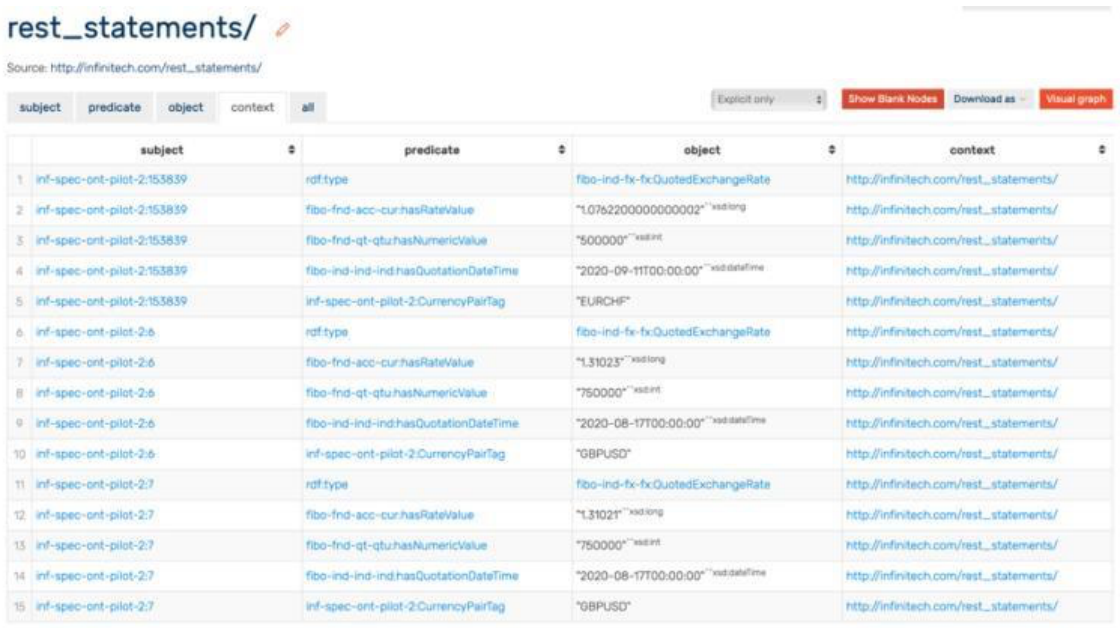
NAME	Value	DESCRIPTION
Content-type	application/sparql-query	Request content type

Example:

```
curl -X PUT \
  --url
"http://172.17.0.4:7200/repositories/infinitech_test/statements?context=<http://infinitech.com/rest_statements/>"
  --header 'Content-type: test/turtle' \
  -d "@base <file:///> . @prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> . @prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> . @prefix dc: <http://purl.org/dc/elements/1.1/> . @prefix owl: <http://www.w3.org/2002/07/owl#> . @prefix xsd: <http://www.w3.org/2001/XMLSchema#> . @prefix foaf: <http://xmlns.com/foaf/0.1/> . @prefix fn: <http://www.w3.org/2005/xpath-functions#> . @prefix : <https://uninova.linked.data.world/d/infinitechpilottest/> . @prefix ns1: <https://uninova.linked.data.world/d/infinitechdatasettest/> . @prefix ns2: <https://uninova.linked.data.world/d/infinitechcore/> . @prefix inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/> . @prefix fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/> . @prefix fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/> . @prefix fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/> . @prefix fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/> . @prefix skos: <http://www.w3.org/2004/02/skos/core#> . @prefix dcterms: <http://purl.org/dc/terms/> . @prefix time: <http://www.w3.org/2006/time#> . @prefix figigii: <http://www.omg.org/spec/FIGI/GlobalInstrumentIdentifiers/> . inf-spec-ont-pilot-2:b24960675dfa4aa7c1f6506690330c1be8b6f1cd rdf:type fibo-ind-fx-fx:QuotedExchangeRate ; rdfs:label "GBPUSD" ; fibo-fnd-acc-cur:hasRateValue 1.31023 ; fibo-fnd-qt-qtu:hasNumericValue 750000 ; fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime ; fibo-fnd-acc-cur:hasBaseCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/PoundSterling> ; fibo-fnd-
```

acc-cur:hasDealtCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/USDollar> . inf-spec-ont-pilot-2:bf1fe3f0ee5357a2a8b64c4988168cd6886c2fda rdf:type fibo-ind-fx-fx:QuotedExchangeRate ; rdfs:label "GBPUSD" ; fibo-fnd-acc-cur:hasRateValue 1.31021 ; fibo-fnd-qt-qtu:hasNumericValue 750000 ; fibo-ind-ind-ind:hasQuotationDateTime "2020-08-17T00:00:00"^^xsd:dateTime ; fibo-fnd-acc-cur:hasBaseCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/PoundSterling> ; fibo-fnd-acc-cur:hasDealtCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/USDollar> . inf-spec-ont-pilot-2:0c2971e4040d354a9dcfcad12a3b0f1f99394cc7 rdf:type fibo-ind-fx-fx:QuotedExchangeRate ; rdfs:label "EURCHF" ; fibo-fnd-acc-cur:hasRateValue 1.0762200000000002 ; fibo-fnd-qt-qtu:hasNumericValue 500000 ; fibo-ind-ind-ind:hasQuotationDateTime "2020-09-11T00:00:00"^^xsd:dateTime ; fibo-fnd-acc-cur:hasBaseCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/Euro> ; fibo-fnd-acc-cur:hasDealtCurrency <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/SwissFranc> ."

Result (if successful, the named graph will be updated/created):



Fecth statements to a named graph

GET /repositories/{repositoryID}/rdf-graphs/service

Passes a set of RDF statements and includes them in the specified named graph

REQUEST

PATH PARAMETERS

NAME	TYPE	DESCRIPTION
repositoryId	string	Identifier of the repository
Graph	url	URL of the named graph

Headers

NAME	Value	DESCRIPTION
Accept	application/rdf+xml text/turtle	Response content type

Example:

curl -X GET \

--header 'Accept: text/turtle' \

--url 'http://localhost:7200/repositories/infinitech_test/rdf-graphs/service?graph=http%3A%2F%2Finfinitech.com%2Frest_statements%2F'

Result (after stored in file):

```
@base          <file:///> .
@prefix rdf:   <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs:  <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dc:    <http://purl.org/dc/elements/1.1/> .
@prefix owl:   <http://www.w3.org/2002/07/owl#> .
@prefix xsd:   <http://www.w3.org/2001/XMLSchema#> .
@prefix foaf:  <http://xmlns.com/foaf/0.1/> .
@prefix fn:    <http://www.w3.org/2005/xpath-functions#> .
@prefix :      <https://uninova.linked.data.world/d/infinitechpilottest/> .
@prefix ns1:   <https://uninova.linked.data.world/d/infinitechdatasettest/> .
@prefix ns2:   <https://uninova.linked.data.world/d/infinitechcore/> .
@prefix inf-spec-ont-pilot-2: <https://spec.infinitech.org/ontology/application/pilot_2/> .
@prefix fibo-fnd-acc-cur: <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/CurrencyAmount/> .
@prefix fibo-fnd-qt-qtu: <https://spec.edmcouncil.org/fibo/ontology/FND/Quantities/QuantitiesAndUnits/> .
@prefix fibo-ind-ind-ind: <https://spec.edmcouncil.org/fibo/ontology/IND/Indicators/Indicators/> .
@prefix fibo-ind-fx-fx: <https://spec.edmcouncil.org/fibo/ontology/IND/ForeignExchange/ForeignExchange/> .
@prefix skos:  <http://www.w3.org/2004/02/skos/core#> .
@prefix dcterms: <http://purl.org/dc/terms/> .
@prefix time:  <http://www.w3.org/2006/time#> .
@prefix figigi: <http://www.omg.org/spec/FIGI/GlobalInstrumentIdentifiers/> .

inf-spec-ont-pilot-2:b24960675dfa4aa7c1f6506690330c1be8b6f1cd
        rdf:type                        fibo-ind-fx-fx:QuotedExchangeRate ;
        rdfs:label                      "GBPUSD" ;
        fibo-fnd-acc-cur:hasRateValue   1.31023 ;
        fibo-fnd-qt-qtu:hasNumericValue  750000 ;
        fibo-ind-ind-ind:hasQuotationDateTime  "2020-08-17T00:00:00"^^xsd:dateTime ;
        fibo-fnd-acc-cur:hasBaseCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/PoundSterling> ;
        fibo-fnd-acc-cur:hasDealtCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/USDollar> .

inf-spec-ont-pilot-2:bf1fe3f0ee5357a2a8b64c4988168cd6886c2fda
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        fibo-fnd-qt-qtu:hasNumericValue  750000 ;
        fibo-ind-ind-ind:hasQuotationDateTime  "2020-08-17T00:00:00"^^xsd:dateTime ;
        fibo-fnd-acc-cur:hasBaseCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/PoundSterling> ;
        fibo-fnd-acc-cur:hasDealtCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/USDollar> .

inf-spec-ont-pilot-2:0c2971e4040d354a9dcfcad12a3b0f1f99394cc7
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        fibo-fnd-qt-qtu:hasNumericValue  500000 ;
        fibo-ind-ind-ind:hasQuotationDateTime  "2020-09-11T00:00:00"^^xsd:dateTime ;
        fibo-fnd-acc-cur:hasBaseCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/Euro> ;
        fibo-fnd-acc-cur:hasDealtCurrency  <https://spec.edmcouncil.org/fibo/ontology/FND/Accounting/ISO4217-CurrencyCodes/SwissFranc> .
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