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

# ∞Infinitech

# D4.1 – Semantic Models and Ontologies- I

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| 2.5 | 2020-09-30 | RB | Review, minor edits |
| 3.0 | 2020-09-30 | NOVA | Version for Submission |

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[2] Can be left void

# Executive Summary

The purpose of the deliverable *D4.1 – Semantic Models and Ontologies – I* is to describe the overall approach used for specifying the models and ontologies for semantic interoperability of diverse applications in the finance and insurance sectors.

The document provides the necessary theoretical foundation for the design and implementation of the INFINITECH Interoperability Framework. Furthermore, a methodology for semantic models and ontologies engineering is also presented that defines the overall strategy used to design and specify semantic models. In particular the semantic models are organized hierarchically according to the domain and the specific application and linked to reference ontologies such as FIBO/FIGI, Lkif, FinReg, etc. The provided models will establish the cornerstone for semantic interoperability within INFINITECH while enabling the annotation and linking of diverse data streams. Finally, the document provides the preliminary analysis of the distinct domain clusters considered within INFINITECH and the application and execution of the initial steps of the methodology.

**This is a working document as the preliminary models will be further refined and thus, changed to fit emerging requirements as the INFINITECH architecture and the specification of the test beds and experiments are being refined.**

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# Abbreviations/Acronyms

| Abbreviation | Definition |
| --- | --- |
| AI | Artificial Intelligence |
| 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 |
| JSON | JavaScript Object Notation |
| JSON-LD | JavaScript Object Notation for Linked Data |
| 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 |
| SAMOD | Simplified Agile Methodology for Ontology Development |
| SAWSDL | Semantic Annotations for Web Service Description Language |
| SotA | State of the Art |

| | |
|---|---|
| TAG-Tool | Translators Automatic Generation Tool |
| 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 reside 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 in transferring 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 in 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 | NUIG | NOVA, BOI |
| 4.3 | Semantic Models and Ontologies - III | 4.1 | NUIG | NOVA, 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 a main concerning problem and challenge that need to be properly handled.

The purpose of the deliverable D4.1 - Semantic Models and Ontologies 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 that an interoperability framework will be 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.

> **This is the 1ˢᵗ version for the current deliverable, as part of the document the analysis of the state-of-the-art is included that analyses semantic interoperability solutions relevant for the INFINITECH project. Moreover, the INFINITECH Semantic Interoperability Framework is presented to provide an agreed process to enable testbeds and pilots to align their data to the INFINITECH semantic model and ontology as well as to establish a common ground to deal with multiple distinct ontologies.**

## 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 and Related Work*: this section delivers a complete picture for framing the research activities within the task 4.1. In particular the main concepts are presented together with the relevant European Research projects, techniques, methods, methodologies and tools that established the foundation for all the works carried out in this task;
● Section 3. *INFINITECH Semantic Interoperability Framework*: this section describes - from one side - the main approach to interoperability used in INFINITECH and - from the other side - the INFINITECH methodology for Semantic Models and Ontologies Engineering and Prototyping. It represents the core of the activities conducted in Task 4.1.;
● Section 4. *INFINITECH Core Data Model & Semantic Alignments*: this section provides an overview of the relevant reference ontologies for the considered application domain while highlighting the concepts, terms and vocabularies that will be part of the INFINITECH core semantic model and – thus – linked to the specific application semantic models;
● Section 5. *Exemplary Application Scenario*: this section provides guidance and guidelines on how-to apply the INFINITECH Methodology for building semantic models and ontologies in line with INFINITECH platform. It is aimed on using exemplary data to build domain specific ontologies aligned with top-level reference ontologies;
● Section 6. *Conclusion*: this section extracts the main conclusion and final remarks;
● *Appendix A*: provides the literature; and
● *Appendix B*: provides a detailed overview of the European Research Initiatives that have been considered relevant for building the INFINITECH Semantic Interoperability Framework.

# 2 Background and Related Works

This section is intended to frame the research realized under the scope of the Task 4.1 - Shared Semantic for BigData and IoT Streams. It establishes a common ground and a necessary foundation to support the design and definition of the proposed methodology for developing INFINITECH models and ontologies for semantic interoperability while avoiding any misunderstanding regarding INFINITECH main concepts.

## 2.1 Concepts and Definitions

### 2.1.1 Interoperability

There is no unique definition of interoperability in the literature since the concept has different meanings depending on the context. As a matter of fact, according to ISO/IEC 2382-01 [1] interoperability is: "The capability to communicate, execute program, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units". According to Next Generation Networks (NGN) from ETSI's technical committee TISPAN [2], interoperability is: "the ability of equipment from different manufacturers (or different systems) to communicate together on the same infrastructure (same system), or on another". EICTA defines interoperability as [3]: "the ability of two or more networks, systems, devices, applications or components to exchange information between them and to use the information so exchanged". Although the particular definition of interoperability is always about making sure that systems are capable of sharing data between each other and to understand the exchanged data [4]. In this scenario the word "understand" includes the content, the format, as well as, the semantic of the exchanged data [5]. Interoperability ranges over four different levels [6] namely:

  i.   physical/technical interoperability: concerns with the physical connection of hardware and software platforms;
  ii.  Syntactical interoperability: concerns with data format, i.e. it relates on how the data are structured;
  iii. Semantic interoperability: concerns with the meaningful interaction between systems, devices, components and/or applications; and
  iv.  and Organizational interoperability: concerns with the way organizations share data and information.
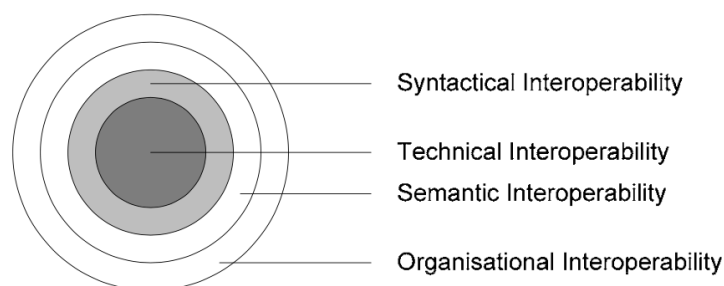


Figure 2-1 – Different Interoperability levels according to [6]

### 2.1.1.1 Interoperability in INFINITECH

The first three interoperability levels are part of the INFINITECH platform and handled in Task 4.1. INFINITECH Semantic models and Ontologies are the final result of an exercise that takes as inputs physical and syntactical interoperability aspects already analysed in WP2 Task 2.1 - User's Stories and Analysis of Stakeholders' Requirements, Task 2.5 - Open Banking APIs, Testbeds and Data Asset Specifications, Task 2.6 - Specification and Design of Integrated Data Models and Task 2.7 - Reference Architecture for BigData, AI and IoT in Financial Services Industry.

As stated in [7], nowadays ICT solutions - in the most desperate context of application from e.g. manufacturing, healthcare, automotive, white goods, logistics, finance, etc. - comprise several distinct elements - e.g. devices, communication infrastructures, services, applications etc. - typically distributed and heterogeneous that need to cooperate and communicate with each other. However, communication between two systems is more than the particular network protocol to be used. Several aspects need to be considered whenever a communication channel between two systems needs to be established. As a matter of fact, the information flow within an ICT system and/or platform ranges from information detection from the data extraction, data transformation, data provisioning, data processing and data usage. In such a context, interoperability represents the enabler and the facilitator for this flow. As shown in Figure 2-2, interoperability can be seen from different perspectives, however Task 4.1 is restricted to discussing the semantic interoperability and thus data models, information models and ontologies.
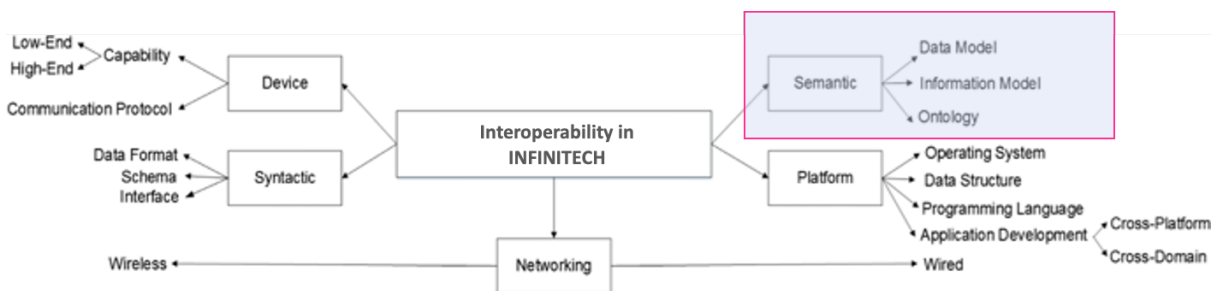


Figure 2-2 – Interoperability in INFINITECH perspectives and Task 4.1 main focus [8]

## 2.1.1.2 Semantic Interoperability

Semantics plays a main role in interoperability for ensuring that exchanged information between counterparts are provided with sense. For Computer Systems, this notion of Semantic Interoperability translates in the ability of two or more systems to exchange data between them, by means of adopting it with precise unambiguous and shared meaning, therefore allowing its readily access and reuse.

Since around the nineties of the past century, the emerging concept of Semantic Web [9], coined by World Wide Web (WWW) founder Tim Berners-Lee, has been conducted by an exhaustive research and industry applicability, turning itself has base fundamentals to Semantic Web Services and the latest Semantic Internet of Things (IoT) concepts [10]–[12]. All of them aim to carry out collaboration across semantically heterogeneous environments, contributing to a connected world of consuming and provisioning devices that can potentially exchange and combine data to potentially offer new or augmented services. However, accomplishing this vision has raised several challenges due to the varied standards, legacy systems constraints, tools, etc. currently in use worldwide.

The Semantic interoperability process can, therefore, focus on different viewpoints of semantic aspects, such as the exchanged data description or the systems interaction terms. As example, the interoperability specification beside defining the meaning of a given sensor, it can also provide information on the units of such value or what protocols to use in order to connect and extract the value from the provider device.

## 2.1.1.3 Semantic Models

The provision of semantic information modelling can be granted with several types, including key-value, mark-up scheme, graphics, object-role, logic-based and ontology-based models [13]. From this set, the key-value type offers the simplest data structure but lacks expressivity and inference.  On the other hand, the ontology-based model provides the best way to express complex concepts and inter-relations, being therefore the main trend model used for elaborating semantic models.

### 2.1.1.4 Ontologies

Since semantic web has started to gain shape, its inherent semantic interoperability has been mostly grounded on the use of ontologies for knowledge-representation basis. In this sense, usually there exists a top-level ontology (or domain ontology), and multiple sub-domain ontologies, each one representative of a more specific domain. With the use of ontologies, the entity is provided with comprehension [14].

### 2.1.1.5 Semantic Annotations

Semantic annotation is the process of attaching additional information to any element of data encompassed in some sort of document. Ontologies on their own are not sufficient to fulfil the semantic interoperability requirements to enable data readability by machines, as there may be differences and inconsistencies. Semantic annotation has been widely used to fill this gap by creating links between the disparate ontologies to the original sources [15].

## 2.2 Relevant European Research Projects and Initiatives

The Table 2-1 provides a list of European funded projects and relevant initiatives that provided some input for the definition of the INFINITECH Semantic Interoperability Framework and the specification of the INFINITECH semantic models and ontologies. The list of projects is the result of the State of the Art (SotA) analysis and is intended to identify the pillars and set the baseline and/or ground for supporting the choices and decisions taken.

Table 2-1 – Relevant European Research Projects and Initiatives for Task 4.1

| Project Name | Project Details | Involved Partner |
|---|---|---|
| MANTIS | Project ID: 662189<br><br>Call for Proposal: ECSEL-2014-1<br><br>Duration: from 2015-05-01 to 2018-04-30 | NOVA |
| ARROWHEAD | Project ID: 332987<br><br>Call for Proposal: ARTEMIS-2012-1<br><br>Duration: from 2013-03-01 to 2017-02-28 | NOVA |
| PRODUCTIVE 4.0 | Project ID: 737459<br><br>Call for Proposal: ECSEL-2016-2<br><br>Duration: from 2017-05-01 to 2020-06-31 | NOVA |
| BigIoT | Project ID: 688038<br><br>Call for Proposal: H2020-ICT-2015<br><br>Duration: from 2016-01-01 to 2018-12-31 | NUIG, ATOS |
| FIESTA-IoT | Project ID: 643943<br><br>Call for Proposal: CNECT-ICT-2015<br><br>Duration: from 2015-02-01 to 2018-01-01 | NUIG |

The Appendix B provides a full description of the identified projects and highlights how these projects have an impact on INFINITECH.

## 2.3 Semantic Annotations Methods & Tools Overview

### 2.3.1 SAWSDL

Semantic Annotations for Web Service Description Language (SAWSDL) [16] is the W3C recommendation for annotating Web Service Description Language (WSDL) and Extensible Markup Language (XML) Schemas. With SAWSDL, each XSD element or attribute can be annotated with ontology concepts. It defines a set of extension attributes for the Web Services Description Language and XML Schema definition language that allows description of additional semantics of WSDL components. The specification defines how semantic annotation is created using references to semantic models (e.g. ontologies). The definition does not specify a language to represents the semantic models. In its place it provides mechanisms by which concepts from the semantic models, typically defined outside the WSDL document, can be referenced in WSDL and XML Schema components using annotations.

*<xs:element type="xs:float"name="indoorTemp"sawsdl:modelReference="/IndoorTemperature"/> (1)*

An example of a semantic annotation using SAWSDL is presented in Equation (1). In the presented annotation example, the XML element "indoorTemp" is annotated with the concept "IndoorTemperature" from the ontology presented in Figure 2-3.
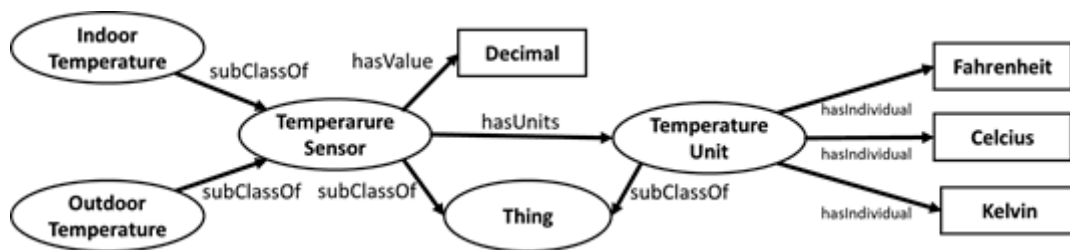


Figure 2-3 – Example of an ontology for temperature sensors

### 2.3.2 Annotation Path

In [17], [18] are proposed annotation paths which extend the SAWSDL. This extension enables the creation of more expressive annotations, like the possibility to annotate XML Schema Definition (XSD) elements with ontology concepts and properties and not only with concepts, as SAWSDL allows. The elements in an XSD Schema are annotated with annotation paths, where each path is a sequence of steps and each step can be a concept or a property defined in the reference ontology. As defined in the annotation path, the odd steps are always ontology concepts and the event steps are always ontology properties like data type or object property (an object property cannot be the final step and a data type property cannot be a middle step). Additionally, concept steps may have restrictions.

In order to better explain the differences, the XSD element annotated in Equation 1 using SAWSDL is annotated in Equation 2 with an annotation path where the first step (an even step) is a concept step and the second step (an odd step and the final one) is a data type property.

*<xs:element type="xs:float" name="indoorTemp" sawsdl:modelReference="/indoorTemperature/hasValue"/> (2)*

In Equation 3 is presented other example of an annotation path. In this example, the first and the third steps are concepts and the second is an object property.

*<xs:element type="xs:string"name="unitsa"sawsdl:modelReference="temperatureSensor/hasUnits/temperatureUnits"/>(3)*

In Figure 2-4 (a) is presented an example of a semantic annotated XSD using annotation paths and in Figure 2-4 (b) is presented an example of an XML message.



(a)  (b)
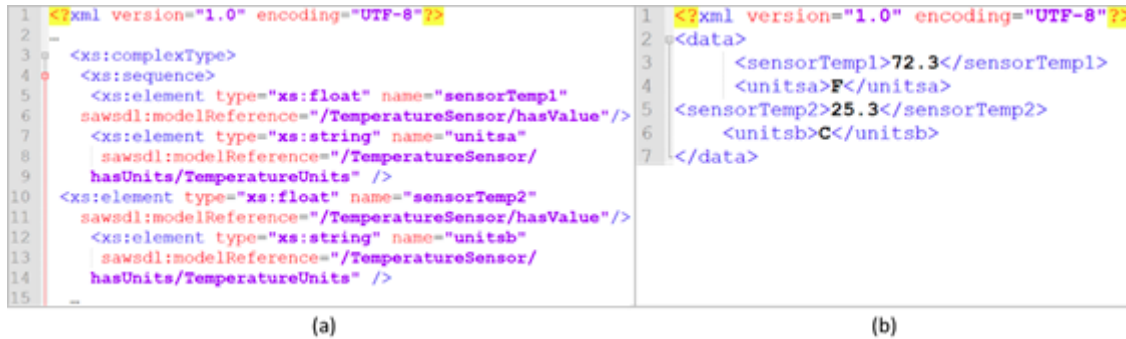
Figure 2-4 – a) XSD with annotation paths referring the ontology in figure 2-3. b) Example of an XML message

The XML elements "sensorTemp1", "sensorTemp2", "unitsa", and "unitsb", contain values and units of temperature sensors. Each one of these elements has an associated semantic annotation, as presented in XSD in Figure 2-4 (a).

## 2.3.3 Grouping Semantic Annotations

Annotation paths with groups were proposed in [19]. This extension allows to group/associate XML elements/attributes.

The annotation paths, presented in [17], [18], give meaning to each XML element or attribute; but they can't associate them, to support the creation of groups of XSD elements. In the presented example (Figure 2-4), which contains two values and two units, it is not possible define an association between one value and its unit.  If it is intended to associate "sensorTemp1" element with the "unitsa" element or the "sensorTemp2" element with the "unitsb" element, the annotation paths, as proposed in [17], [18] are not enough.

An annotation path with groups is an annotation path where each concept step can have a set of group IDs. Group IDs are only valid in each XSD. This means that group IDs in two different XSDs are independent and it can be different.

```xml
1  <?xml version="1.0" encoding="UTF-8"?>
2  ...
3    <xs:complexType>
4     <xs:sequence>
5      <xs:element type="xs:float" name="sensorTemp1"
6      sawsdl:modelReference="/TemperatureSensor{1}/hasValue"/>
7       <xs:element type="xs:string" name="unitsa"
8        sawsdl:modelReference="/TemperatureSensor{1}/
9       hasUnits/TemperatureUnits" />
10    <xs:element type="xs:float" name="sensorTemp2"
11     sawsdl:modelReference="/TemperatureSensor{2}/hasValue"/>
12      <xs:element type="xs:string" name="unitsb"
13       sawsdl:modelReference="/TemperatureSensor{2}/
14      hasUnits/TemperatureUnits" />
15       ...
```

Figure 2-5 – XSD with annotation paths with groups

The extension proposed in [4] defines how to create groups of XSD elements (XML elements/attributes). For instance, if "sensorTemp1" and "unitsa", from Figure 2-5, give information from the same temperature sensor ("1") and "sensorTemp2" and "unitsb", give information from another temperature sensor ("2"), then it must be specified in the XSD, to prevent doubts and translation mismatches. To explain how to annotate with groups, the annotated XSD presented in Figure 2-4 (a) is presented in Figure 2-5 with annotation path with groups. The definition of the groups is highlighted in a red box.

In [20], it is presented a set of rules that define how to correctly annotate using annotation path with groups.

## 2.4 JSON-LD

The JavaScript Object Notation for Linked Data (JSON-LD) emerged as a JavaScript Object Notation (JSON) based language with the purpose of serializing Linked Data. While its syntax allows easy integration with deployed systems based on JSON, it also aims at the usage of Linked Data in Web-based programming, the specification of interoperable Web Services and supporting the storage of JSON-based databases. JSON-LD offers not only a simplified method for expressing Linked Data in JSON. At the same time, JSON-LD is also a serialization format of the W3C standard Resource Description Framework (RDF), which means that it can be used to supply semantics through an ontology-based semantic model, developed in Resource Description Framework Schema (RDFS) or Web Ontology Language (OWL). From this point of view, it is possible to (de-)serialize the JSON-LD document into RDF triples, and therefore enabling the integration of RDF triple stores and consequently their semantic inference by using query technologies, such as SPARQL.

Thus, it is fair to say that JSON-LD files are suitable to work with structured data as well as to support structuring unstructured data, as it can be used as either a data serialization and a messaging format.

### 2.4.1 Annotating/Linking

A JSON-LD file consists of a file that complies with the JSON format, while it provides additional mappings to given ontologies through coercing the values with specific types related to the concepts, properties or data types which belong to such ontologies in use. The annotation method relies on a specified set of syntax keywords, from which "@id", @type" and "@value" are used to perform the desired semantic relations. In short definition, the "@id" tag enables some node to be referenced by another one while the "@type" creates the association between nodes. The "@value" enforces the value inside the annotation structure. Taking as example the following JSON object (see Listing 2-1), which represents an instance of the type "Project_instance":

```
1 {
2   "Project": {
3     "Dates": {
4         "start_date": "01-10-2019",
5         "end_date": "31-01-2023"
6     },
7     "Name": "Infinitech"
8   }
9 }
```

Listing 2-1 – JSON Object for the instance type "Project_instance"

A possible JSON-LD annotation would be defined shown in Listing 2-2, where the top-level object is now linked into a "instance" concept, represented by the *http://example.infinitech/#intance* IRI , while the it has created a link to *http://example.infinitech/project_instance* IRI, which should be included in the vocabularies/ontologies in use.

```
 1 {
 2          "@id": "http://example.infinitech/#instance",
 3          "@type": "http://example.infinitech/#project_instance",
 4          "Project": {
 5                  "@id": "http://example.infinitech/#Project",
 6                  "@type": "http://example.infinitech/#Project",
 7                  "Dates": {
 8                          "@id": "http://example.infinitech/#Dates",
 9                          "@type": "http://example.infinitech/#Dates",
10                          "start_date": {
11                                  "@id": "http://example.infinitech/#start_time",
12                                  "@type": "http://www.w3.org/2001/XMLSchema#dateTime",
13                                  "values": "01-10-2019"
14                          },
15                          "end_date": {
16                                  "@id": "http://example.infinitech/#end_time",
17                                  "@type": "http://www.w3.org/2001/XMLSchema#dateTime",
18                                  "values": "31-01-2023"
19                          }
20                  },
21                  "Name": {
22                          "@id": "http://example.infinitech/#Name",
23                          "@type": "http://www.w3.org/2001/XMLSchema#string",
24                          "values": "Infinitech"
25                  }
26          }
27 }
```

Listing 2-2 – JSON-LD Annotation for "Project_instance" JSON Object

By following this process through all document, we can achieve the semantic annotation of the JSON example.

## 2.4.2 Context

In the previous case, although sometimes there is no necessity for annotating all the attributes, performing this inline method could turn into a sluggish pattern. However, JSON-LD documents can incorporate a context ("@context" field of the JSON-LD Schema), from which usage can bring several benefits, including the annotation method:

- State the vocabularies (like ontologies) that will be used for mapping from the IRIs defined.
- allowing to map short terms to the IRIs or other JSON objects can be mapped into simpler terms (instead of the long URIs), which simplifies the annotation process

- Contexts can be referenced instead of embedded in the file.
-  Other Contexts can be declared when any JSON object is defined

These benefits are provided by several "@context" properties, included in the JSON-LD documents schema, to potentially facilitate the annotation and linking data processes. Considering the previous JSON document, a "@context" was added. Inside, as example, the namespace http://www.w3.org/2001/XMLSchema# was attributed with a short name "xsd" (term definition in JSON-LD terminology). This means that from the point of view of processing this JSON-LD document, this namespace can now be recognized by its short name, as can be depicted on lines 6, 8 and 9 from the Listing 2-3. Another attribute is the "@vocab", which defines a prefix IRI for Subjects or Objects (not forgetting that JSON-LD is also an RDF graph representation). Therefore, the Listing 2-3 presents a semantically equivalent annotation for the annotation presented in Listing 2-2.

```
 1 {
 2   "@context": {
 3     "@vocab": "http://example.infinitech/#",
 4     "xsd": "http://www.w3.org/2001/XMLSchema#",
 5     "Project": { "@id": "Project", "@type": "Project"},
 6     "Name": {"@id": "Name","@type": "xsd:string"},
 7     "Dates": {"@id": "Dates", "@type": "Dates"},
 8     "start_date": { "@id": "start_date","@type": "xsd:dateTime"},
 9     "end_date": {"@id": "end_date","@type": "xsd:dateTime"}
10   },
11   "Project": {
12     "Dates": {
13       "start_date": "01-10-2019",
14       "end_date": "31-01-2023"
15     },
16     "Name": "Infinitech"
17   }
18 }
```

Listing 2-3 – JSON-LD Annotation for "Project_instance" JSON Object using @context tag

JSON-LD documents can be transformed into four different forms: i) Expanded, ii) Compacted, iii) Flattened and iv) Framed. Depending on the resource environments or applications to serve the data, it can be selected which form to apply to the document. Furthermore, the JSON-LD Processing algorithms and API specifications provide the method for translating the documents from one form into another. In more detail:

- Compacted: In this case, the JSON properties and RDF model IRIs are defined inside the "@context" node, as well as the term definitions (shortcuts for IRIs into simple values) when referenced in the graph. This can serve for example to transform a JSON document into a JSON-LD document by adding the "@context" node, while not changing the data element from the JSON. All the semantic is, therefore, provided inside the "@context", while only-JSON aware applications may continue to handle directly the data
- Expanded: In this form, the mappings provided by the "@context" are resolved by expanding the IRIs, types and values. This results on a new JSON-LD which is stripped off of "@context", which is no longer needed.
- Flattened: the properties from each node are collected and rearranged into a single JSON object, and blank nodes are attributed with blank node identifiers, which is more structurally related to an RDF graph. It some applications this may simplify the document parsing.

Framed: The framed form is obtained by combining a pre-defined frame (which can include also the "@context") to a flattened JSON-LD document, resulting in a formatted and object-oriented graph.

## 2.5 TAG-Tool

The Translators Automatic Generation Tool (TAG-Tool) is a tool, developed in Nova School of Science and Technology that automatically generates translators to support the communication between heterogeneous systems/devices.

As presented in Figure 1, it receives three files, as input, two XML Schemas (XSDs) of two systems annotated to a reference ontology and the ontology. The tool verifies if these two systems are semantically compatible, that is, if it is possible to translate from one to the other. In case when they are compatible, the tool returns the translator file in XSLT format.
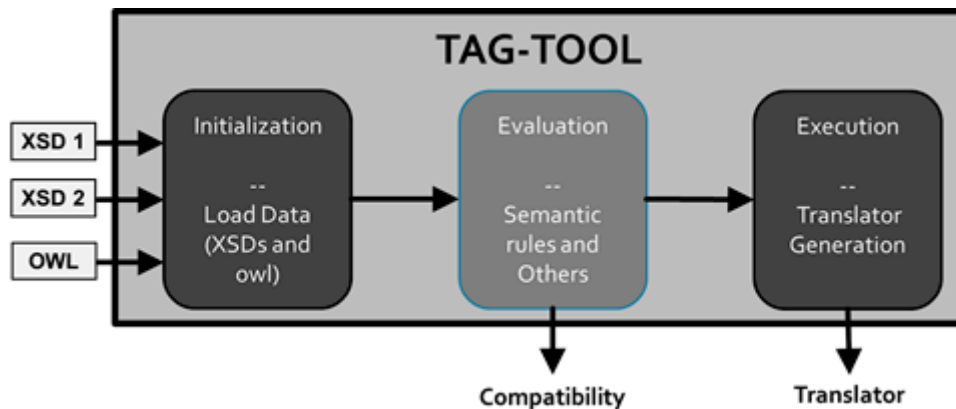


Figure 2-6 – TAG-Tool Interface and Phases

The tool uses both XSDs and the reference ontology to determine, among other things, the matches between the two systems, namely if the provider delivers all the consumer's needs and also, if possible, to generate the translator that will be used in the exchange of messages between the two systems during their communication. That is, the tool does not translate, it generates a translator that makes it available to be used during communication between the two systems/devices (Figure 2).
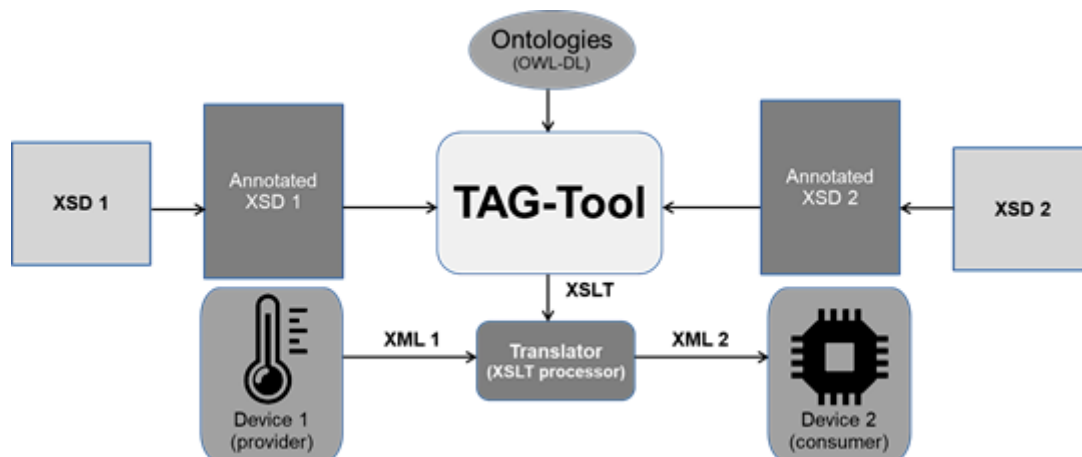


Figure 2-7 – TAG-Tool application scenario

## 2.6 Methodologies for Ontology Engineering This section is aimed to present
relevant methodologies for ontology engineering in the literature that inspired the INFINITECH methodology for Semantic Models and Ontology Engineering and Prototyping.

## 2.6.1 METHONOTOLOGY

METHONTOLOGY has been developed by the Ontological Engineering group at the Universidade Tecnica de Madrid. It is a structured method to build ontologies initially developed in the domain of chemicals [21] The methodology guides the ontology development process throughout the whole ontology life cycle. It consists of the following main development activities:

- *Specification*: concerns with the definition of the objectives of the ontology, the end users and frames the domain;
- *Conceptualization*: concerns with developing an initial conceptual representation/model of a perceived view of the application domain. A set of intermediate representations are here used to organize the concepts to be easily understood by both ontology and domain experts;
- *Formalization*: concerns with the implementation of a semi-computable model from the conceptual model generated in the previous activity;
- *Integration*: concerns with the knowledge reuse, i.e. extracting and integrating definitions and concepts from already built ontologies;
- *Implementation*: concerns with the implementation of fully computational models using various ontology languages; and
- *Maintenance*: concerns with any update to the ontology.

Furthermore, as part of the methodology, several ortogonal supporting activities are also identified to manage and support the development ones. These activities are: the knowledge acquisition, documentation and evaluation.

## 2.6.2 SAMOD

The Simplified Agile Methodology for Ontology Development (SAMOD) [22] focuses on designing and developing well-developed and documented models from significant domain data and/or descriptions. It consists of three simple and small steps that are part of an iterative process aimed to produce preliminary and incremental results. The three steps can be labelled as:

1. *Test case Definition*: write down a motivating scenario, being as close as possible to the language commonly used for talking about the domain;
2. *Merging current Model with modelet*: merge the modelet included in the defined test case with the current model; and

*Refactoring current model*: refactor the current model shared among all the defined tests cases.

## 2.6.3 DILIGENT

The methodology for distributed, loosely-controlled and evolving engineering of ontologies (DILIGENT) [23] is a methodological approach intended to support domain experts in a distributed setting to engineer and evolve ontologies. It is based on Rhetorical Structure Theory, viz. the DILIGENT model of ontology engineering by argumentation. The process comprises five main activities:, namely:

1. *Build*: concerns with the development of ontologies by having different stakeholders, with different needs, purposes and that are typically distributed;
2. *Local Adaptation*: concerns with the usage and adaptation of the developed ontology. By using the ontology many updates can be necessary due for example to new business requirements and/or new arised needs;
3. *Analysis*: concerns with the analysis of any local request for update. As a matter of fact, local ontologies can be updated but the shared ontology will be updated only after the analysis of the update request;
4. *Revision*: concerns with the constant revision of the shared ontology to guarantee the alignment with the local ones; and

5. *Local Update*: concerns with the update of the local ontologies after a new shared ontology is available.

## 2.6.4 UPON-Lite

The Lightweight Unified Process for Ontology building (UPON-Lite) methodology [24] is a simple, agile ontology engineering approach and/or method that is intended to place the end users and domain experts at the center of the overall ontology building process while avoiding the presence of ontology engineers. Therefore, the main pillars of the process are: i) the adoption of a fully user-centered approach; ii) the adoption of a social collaborative approach to collect domain expert knowledge to achieve all the steps in the method; and iii) an ontology building method based on six main activities. The six activities and/or steps of the UPON-Lite method are the following (named and/or labelled according to the produced outcome):

1. *Domain Terminology*: concerns with producing the list of all the fundamental domain terms that characterize the observed domain;
2. *Domain glossary*: provides the definition and possible synonyms of the domain terms;
3. *Taxonomy*: concerns with the organization of the domain terms according to an "ISA" hierarchy;
4. *Predication*: concerns with the identification of those terms that represents properties and/or relations between other terms and/or concepts;
5. *Parthood*: concerns with the analysis of the structure of the identified concepts and/or entities in order to elicit their (de-)composition hierarchies; and

*Ontology*: concerns with the production of the formally encoded ontology.

# 3 INFINITECH Semantic Interoperability Framework

This section is aimed to present the INFINITECH Semantic Interoperability Framework.

> **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.**

## 3.1 Proposed Approach for Interoperability

The proposed approach for generating INFINITECH Semantic models and Ontologies combines top-down and bottom-up approaches (see Figure 3-1). 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 domain (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 INFINITECH models, as well as, baseline for the development of transformers that needs to be used to exploit all the features and full potentiality of the INFINITECH platform.
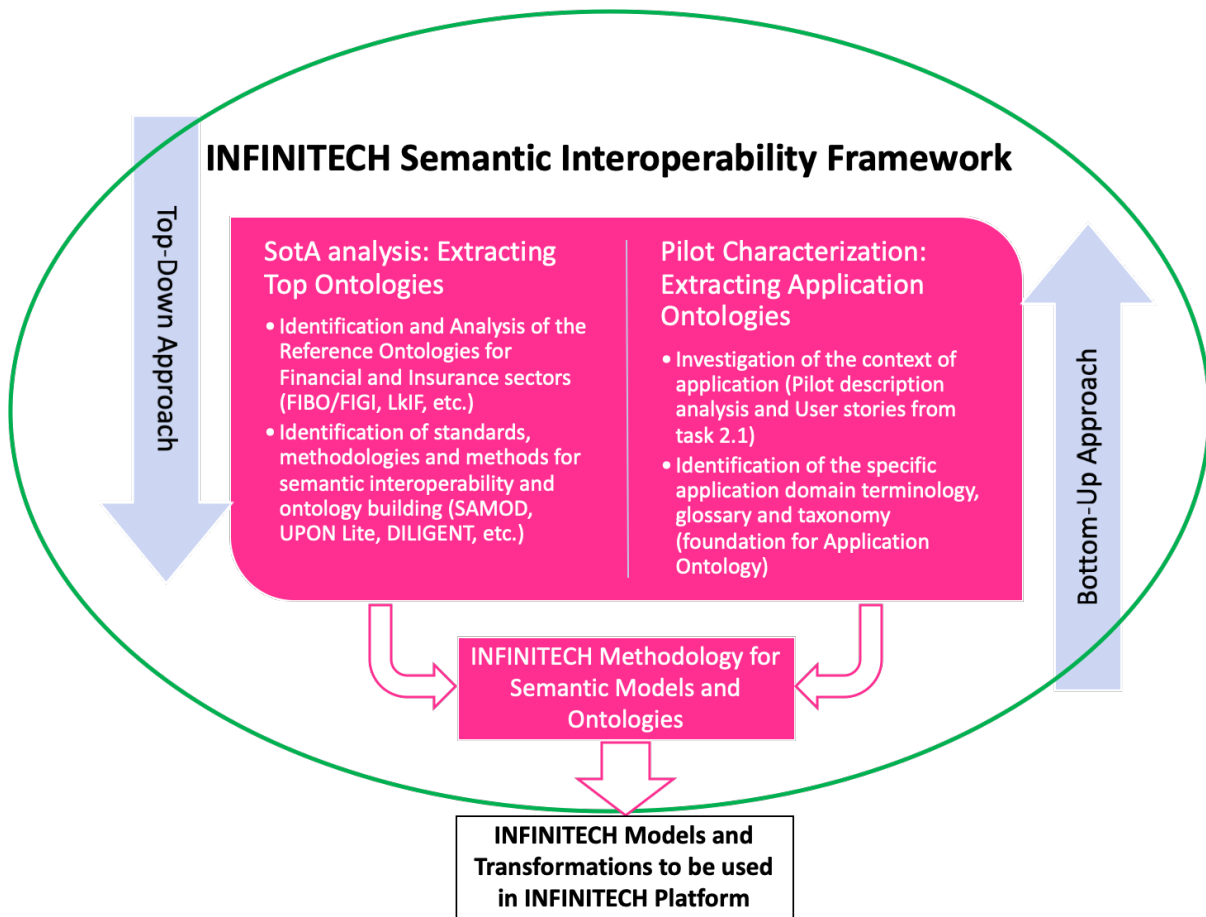
Figure 3-1 – Proposed Approach for Interoperability in INFINITECH

## 3.2 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 while 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.
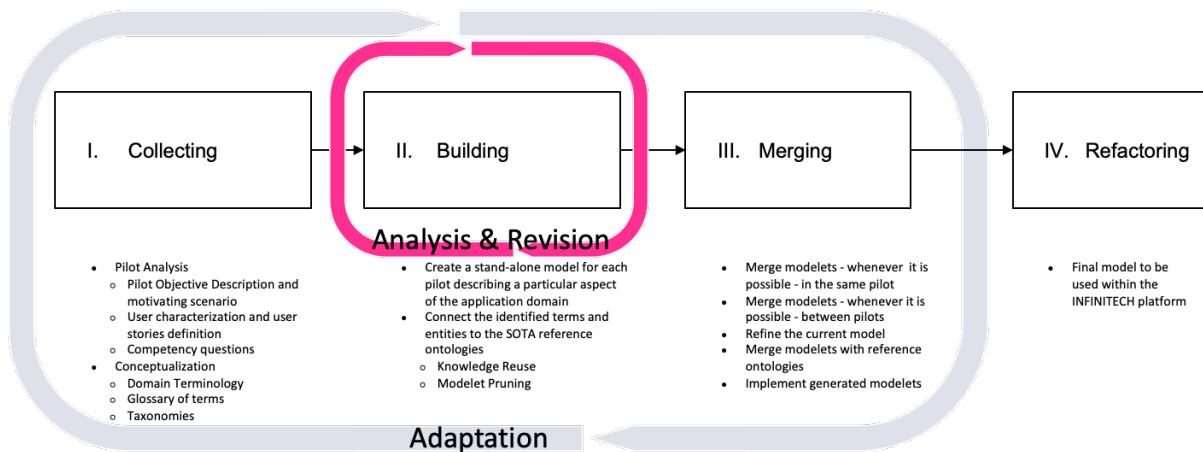
Figure 3-2 – INFINITECH Methodology for Ontology Engineering

As shown in Figure 3-2, the INFINITECH Methodology for Ontology Engineering shares terminology, definitions, and activities and/or steps with the SAMOD methodology. 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*. This step collects 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*. This step builds 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*. This step 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; and
   e. 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.

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 review 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.

## 3.2.1 Modelling Method

> **The main result of the application of the INFINITECH for Semantic Models and Ontologies Engineering and Prototyping is an evolving conceptual schema (e.g. ontology) that the INFINITECH platform needs to know for accessing, querying and processing the data and/or information.**

The conceptual schema is determined by using an evolving prototyping (foundation of agile software methodologies like DevOps) approach, where it grows up by layers but continuously delivering software prototypes. In particular the conceptual model is the combination of three layers, according to [25]:

- 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.
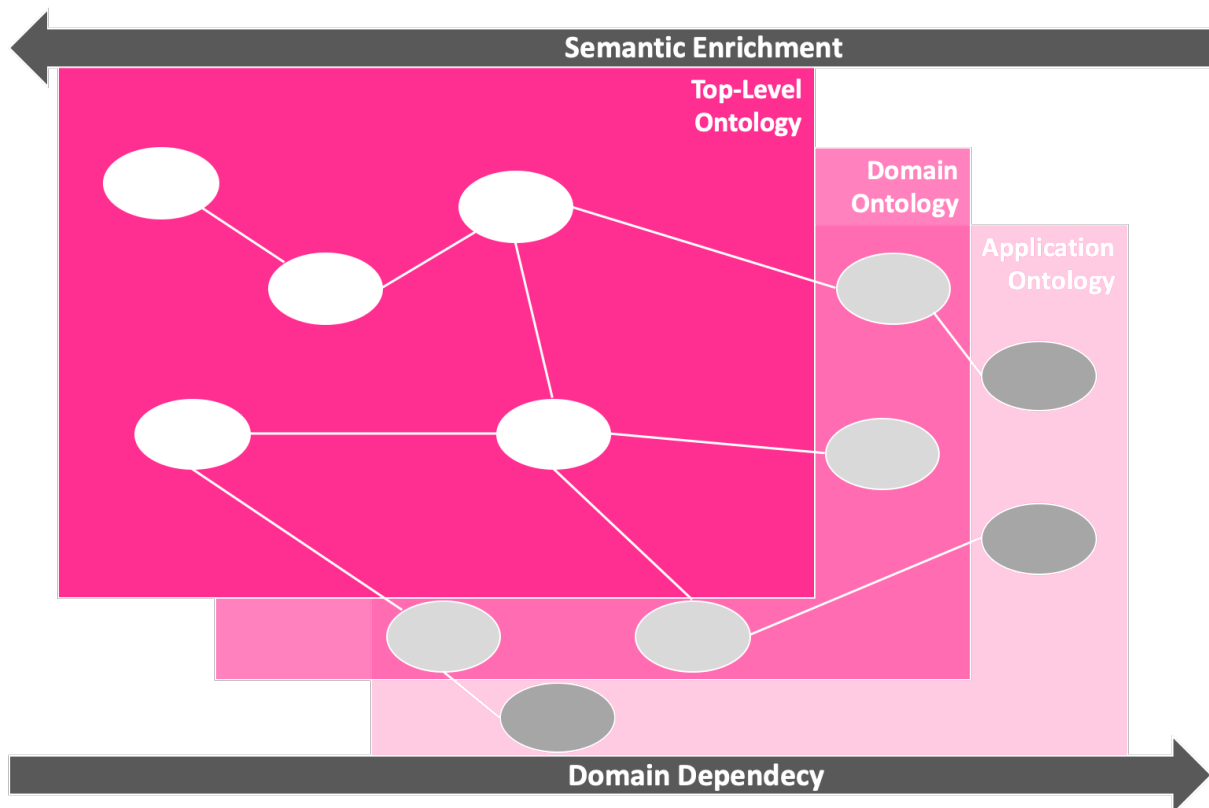


Figure 3-3 – INFINITECH Semantic Model and Ontology Example

## 3.2.2 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 by the following stakeholders: domain experts, end-users, knowledge and ontology engineers.
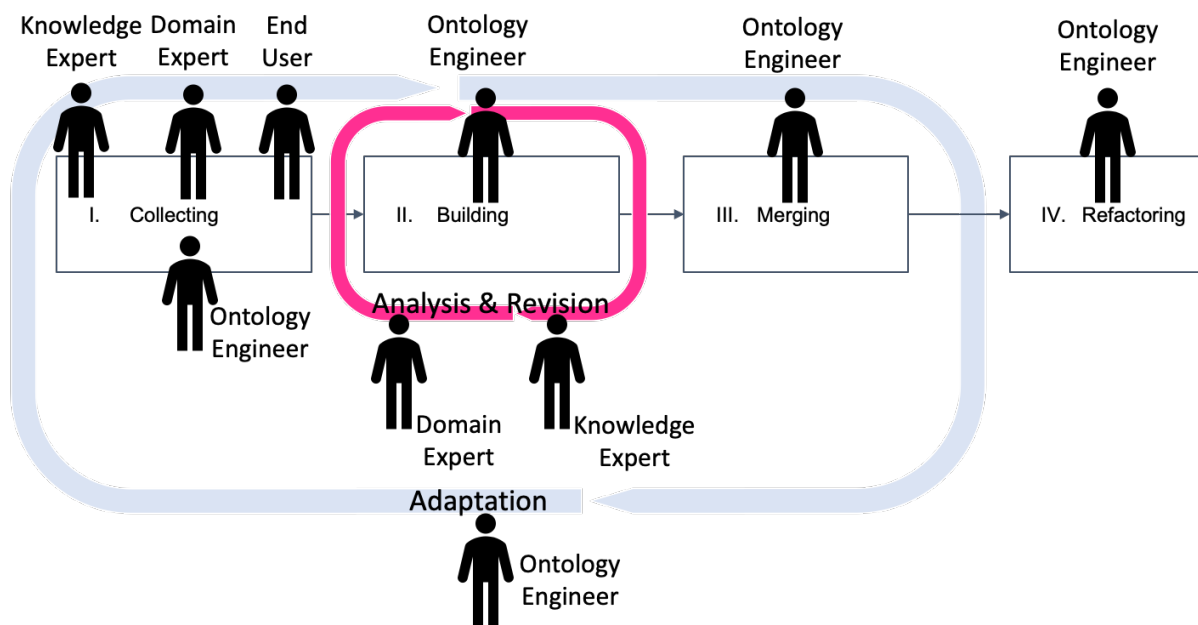


Figure 3-4 – Roles and Functions in INFINITECH Semantic Models and Ontologies Engineering and Prototyping

# 4 INFINITECH Core Data Model & Semantic Alignments

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 continue activity that rely 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.**

## 4.1 FIBO Domains Schema

Figure 4-1 shows the FIBO domains from where the overlapping concepts originate. For example, the overlapping concepts of FIBO comes from only 4 domains of FIBO, i.e. Foundations, Business Entities, Securities, and Financial Business and commerce.
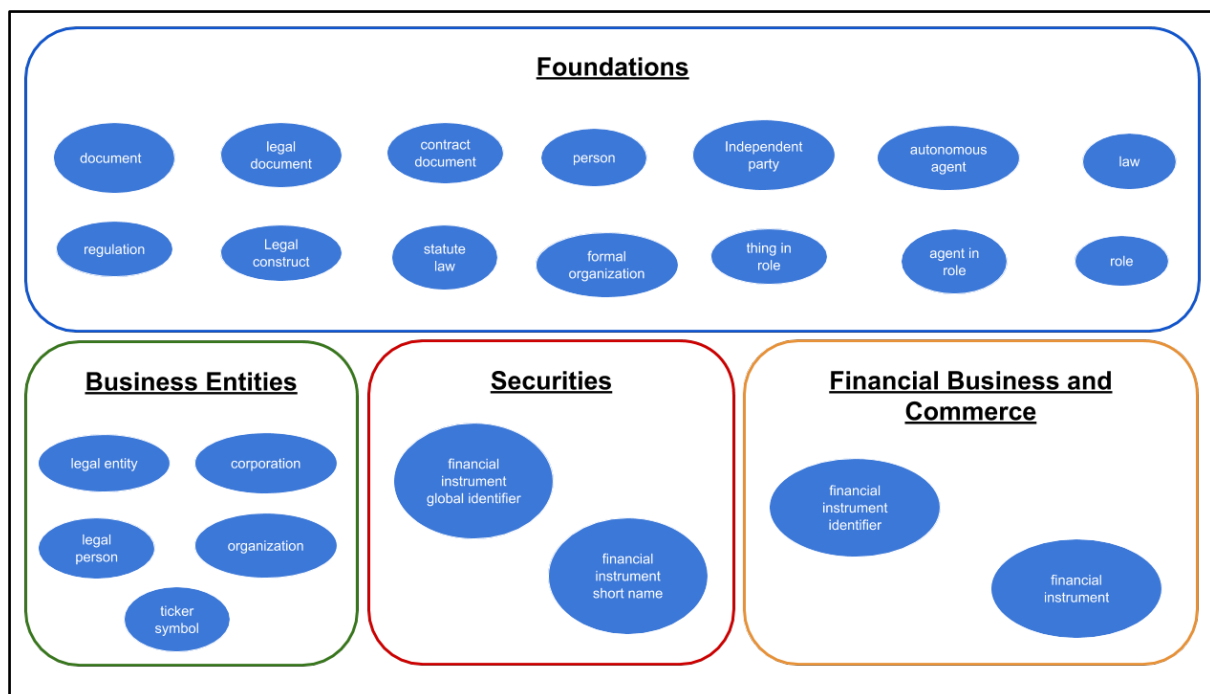


Figure 4-1: FIBO identified domains with Overlapping Concepts

## 4.2 LKIF Domains Schema

Figure 4-2 shows the LKIF domains from where the overlapping concepts originate. These domains include Norm, Action, Expression, Legal Action, Role and Legal Role.
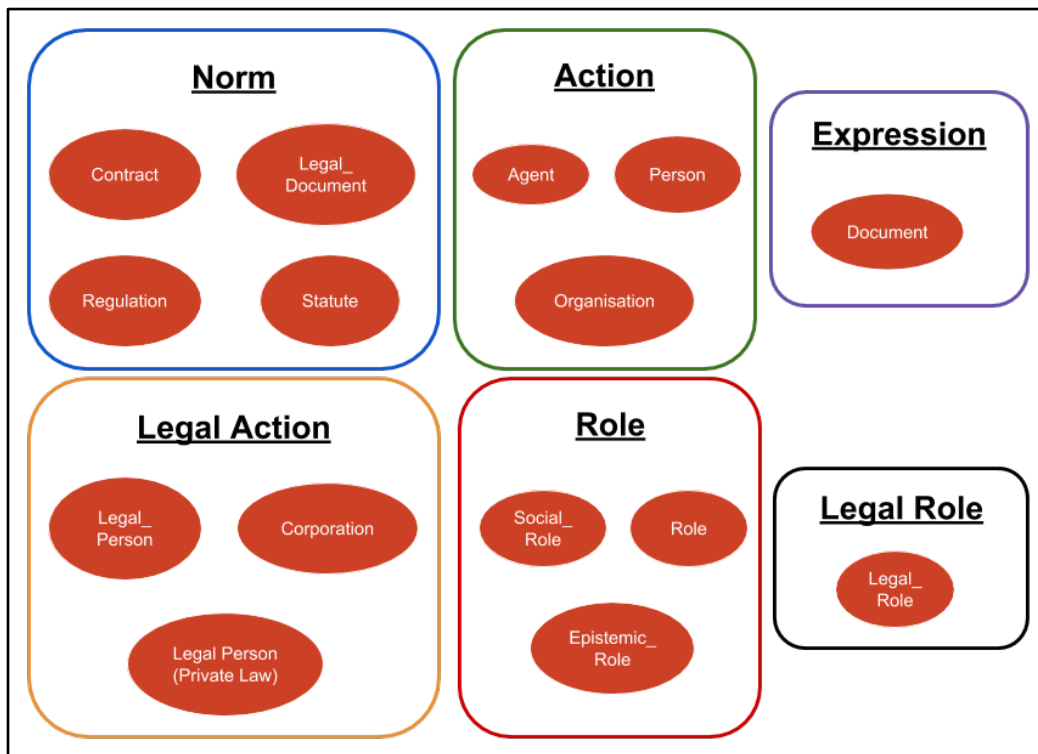
Figure 4-2: LKIF identified domains with Overlapping Concepts

## 4.3 FIGI Domains Schema

Figure 4-3 shows FIGI's overlapping concepts. As FIGI does not have any domains or subdomains further, so all the overlapping concepts directly come under FIGI.
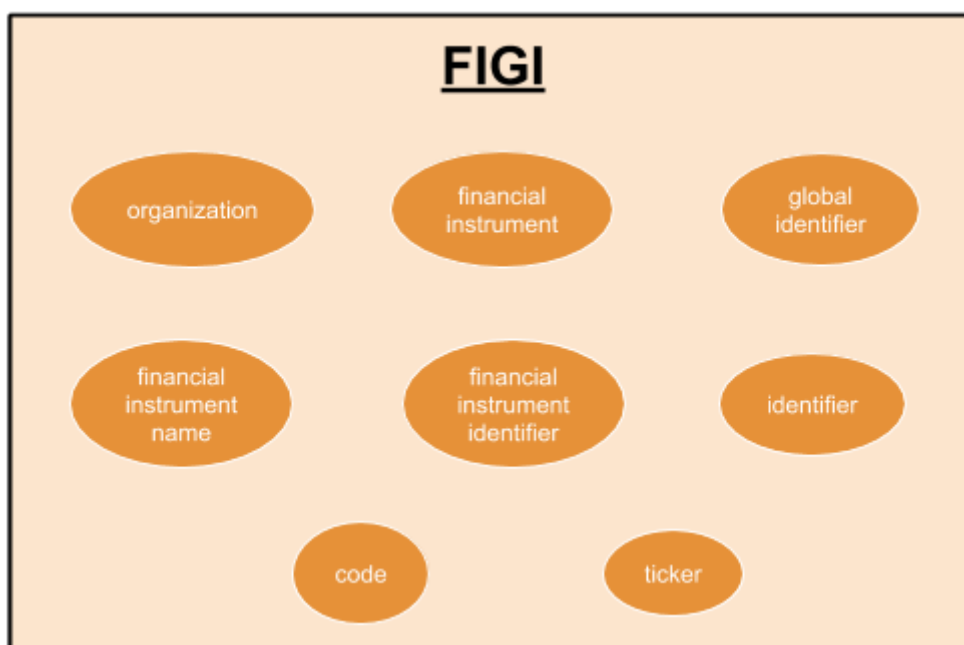


Figure 4-3: FIGI identified domains with Overlapping Concepts

## 4.4 FIBO, LKIF and FIGI Data Schema Alignments

Figure 4-4represents the conceptual alignments between FIBO, LKIF and FIGI. All the three ontologies have common concepts between them. For example, organization concept is defined in all the three ontologies. We have identified the common concepts and defined relationships between the common concepts. In Figure A, you can see that "equivalentClass'' relationship is defined between the concept representing an organization in FIBO, FIGI and LKIF. In the case of document concept, we have defined a "subClassOf'' relationship between document concept from FIBO and Document concept from LKIF. The bottom part of Figure A shows the diagram legend. Classes are represented as oval shapes, while properties (relationships) between classes are represented using solid lines with filled arrowheads on one side of it to show the direction of the relationship. The property (relationship) is shown in the rectangular box attached to these lines. The "subClassOf '' relationship is represented using a dotted line with hollow arrowhead on the side of super class. The color of a relationship represents the origin of the relationship, i.e. green color relationships represent alignments defined by us while black colored relationships come from the respective ontology.
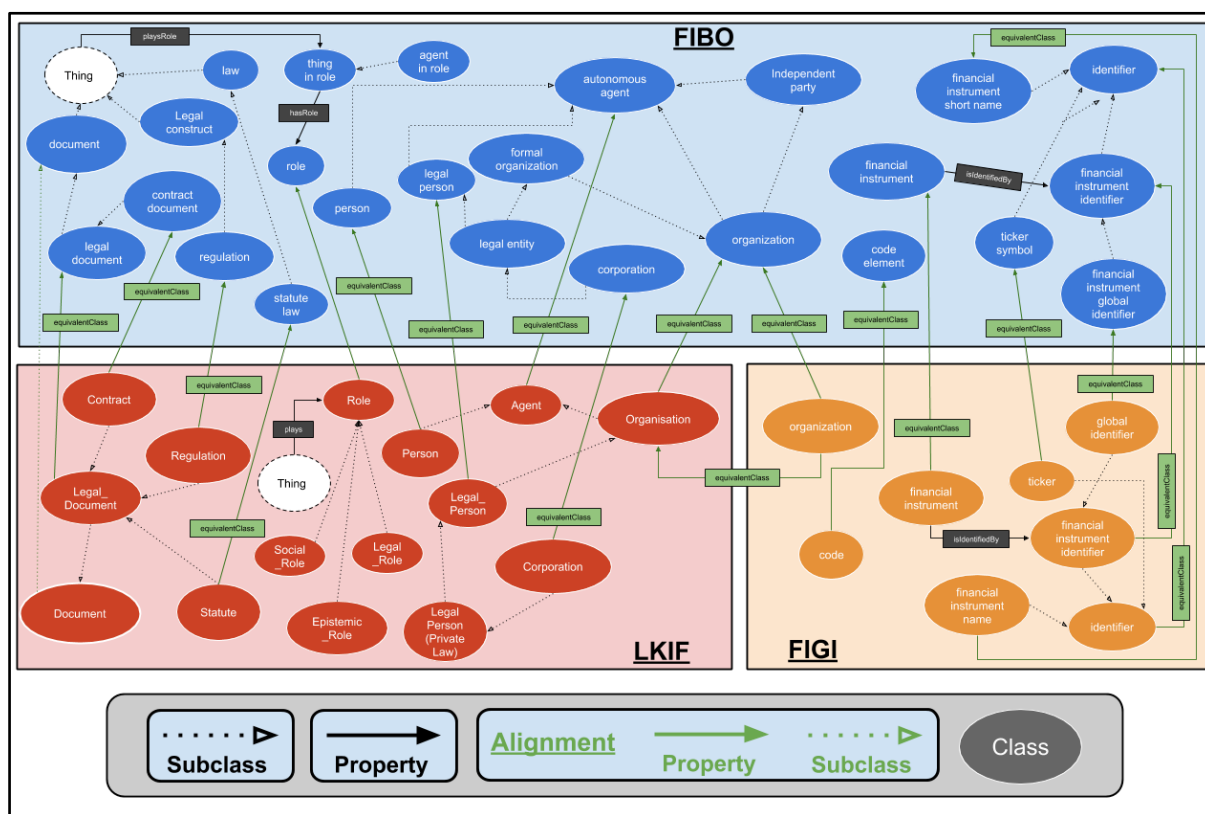


Figure 4-4: FIBO, LKIF and FIGI Alignments

The following sections introduce the descriptions of all the overlapping concepts. The description includes concept names, their definitions and hierarchical context in their respective ontologies.

The structure of the sections has been organized according to the tamplate:

Concept → **Document**

**Definition:**

*"A Document bears some (and only) expression(s) stated by some statement in writing."*

**Context:**

| `rdfs:subClassOf` | ➔ **Medium** |
|---|---|

❏ **Proposition:**

The proposition defines the relationship(s) that exist between the different concepts in between the identified schemas.

## 4.5 FIBO-LKIF Alignments

## 4.5.1 Document

FIBO and LKIF both ontologies have the "**Document**" concept which is shown in Figure 4-5 as hierarchies. FIBO has a more comprehensive and financial domain specific hierarchy of the "**Document**" concept as shown in Figure 4-6. The respective descriptions of both FIBO and LKIF "**Document**" concepts are below:

❑ **FIBO**

**Concept** → **document**

**Definition:**

*"something tangible that records something, such as a recording or a photograph, or a writing that can be used to furnish evidence or information"*

**Context:**

| rdfs:subClassOf | ➔  owl:Thing |
|---|---|

❑ **LKIF**

Concept → **Document**

**Definition:**

*"A Document bears some (and only) expression(s) stated by some statement in writing."*

**Context:**

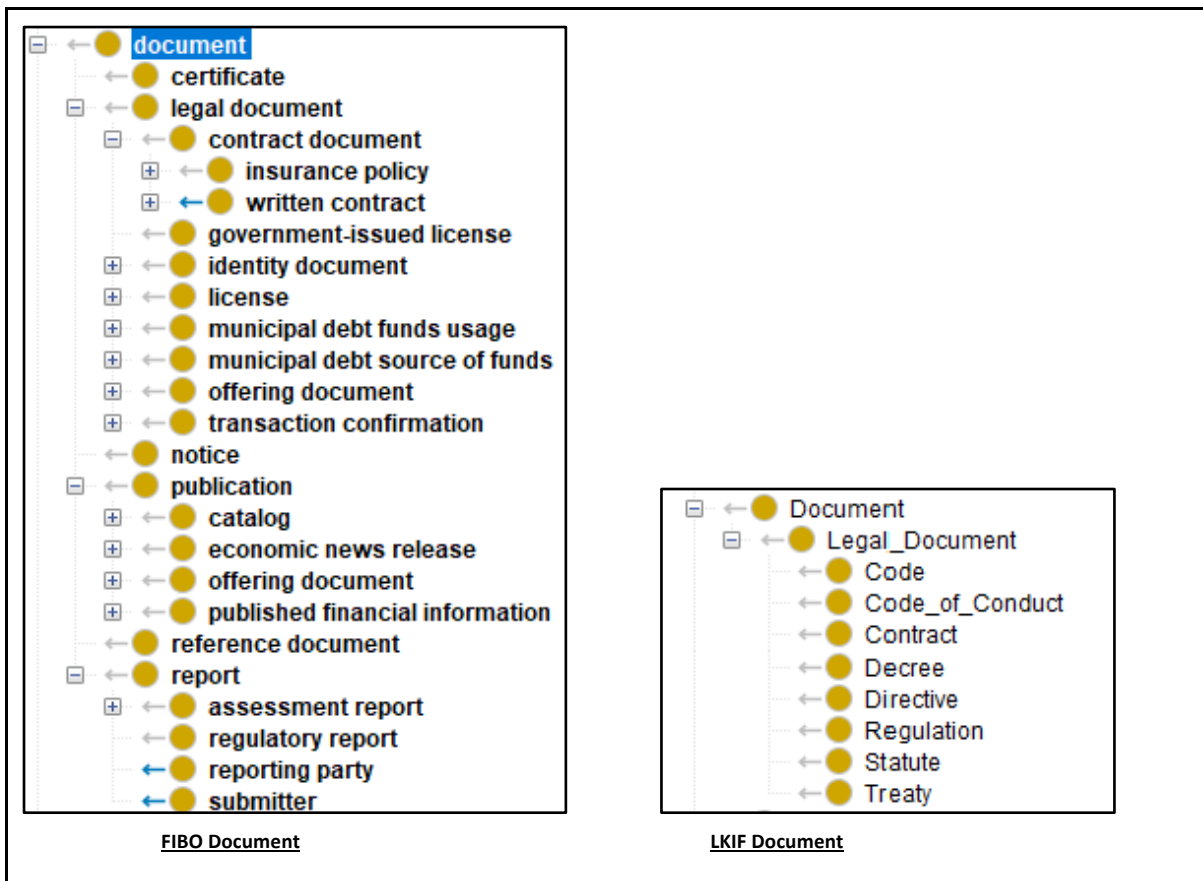| rdfs:subClassOf | ➔  **Medium** |
|---|---|

❑ **Proposition:**
**Subclass**
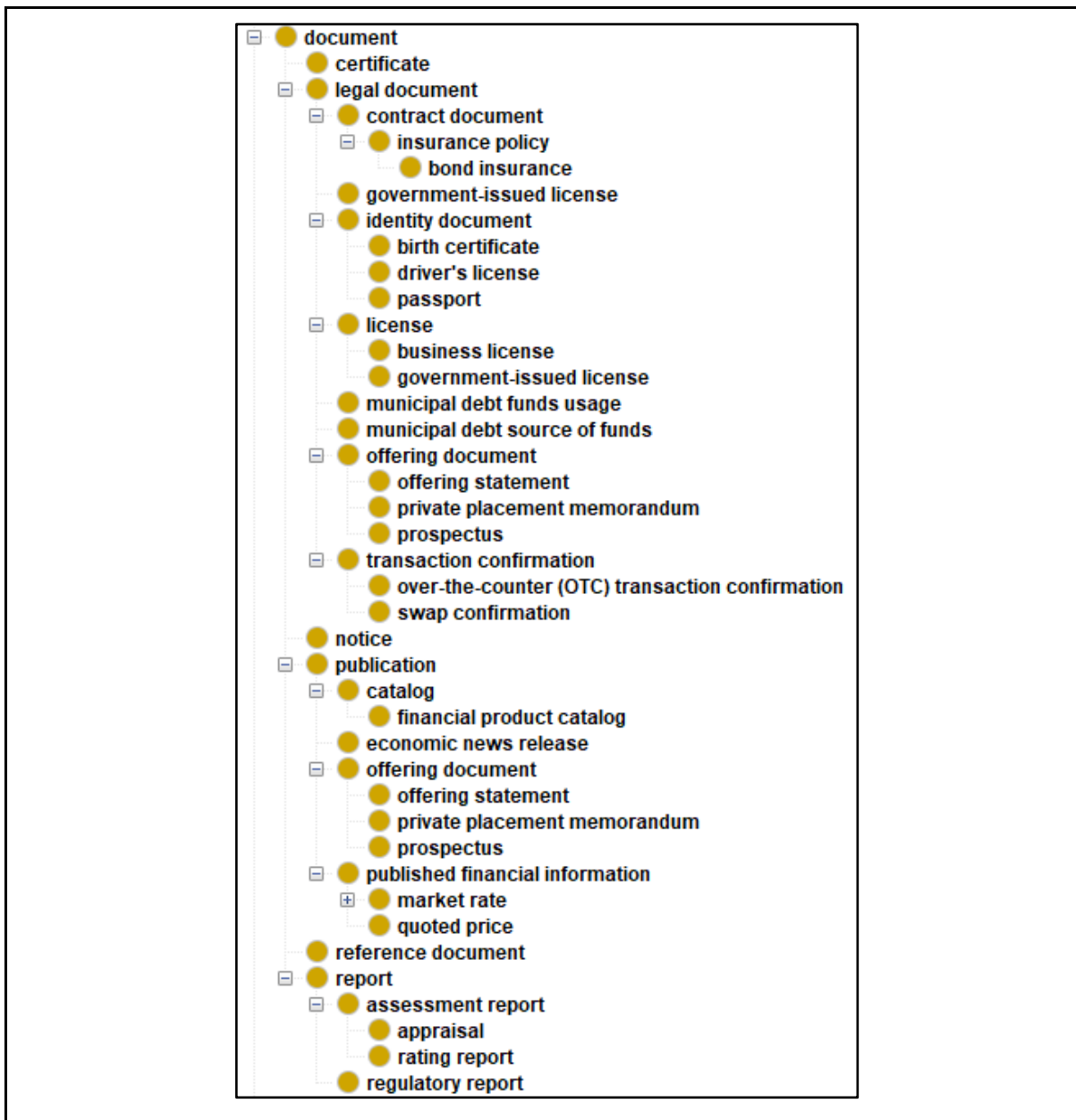
Figure 4-5: FIBO vs LKIF Document Hierarchy

Figure 4-6: FIBO Document Hierarchy in detail

## 4.5.2 Legal Document

Both FIBO and LKIF have the concept "**Legal Document**". Their respective hierarchies are shown in Figure 4-7.

❏ **FIBO**

Concept → **legal document**

**Definition:**

*"a written or printed paper that bears the original, official, or legal form of something and can be used to furnish decisive evidence or information"*

**Context:**

| rdfs:subClassOf | ➔ document |
|---|---|

❏ **LKIF**

Concept → **Legal_Document**

**Definition:**

*"A legal document is a document bearing norms or normative statements. By virtue of this definition the norm-as-propositional-attitude is reified as norm-as proposition. In other words, the norm being expressed through the legal source is an expression of the propositional attitude."*

**Context:**

| rdfs:subClassOf | ➔ Document<br>➔ Legal_Source |
|---|---|

❏ **Proposition:**
**Equivalent Class**
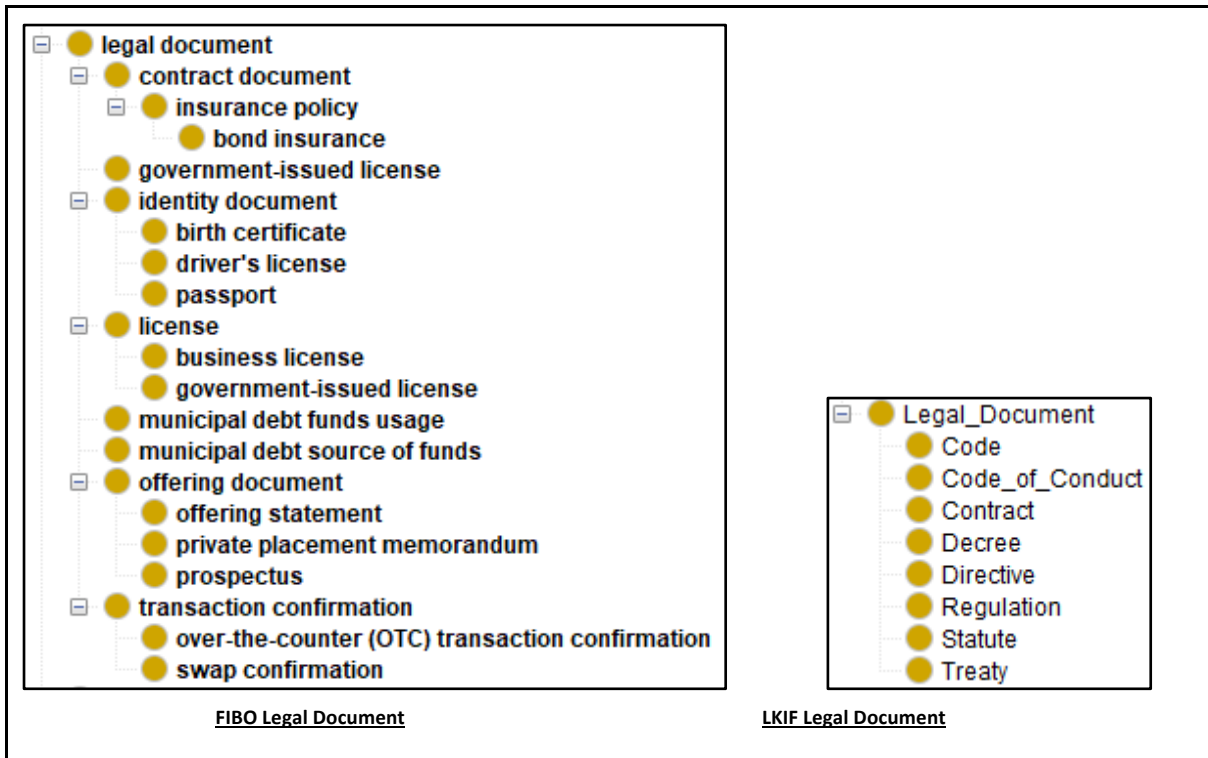
Figure 4-7: FIBO vs LKIF Legal Document Hierarchy

## 4.5.3 Regulation

Both FIBO and LKIF have the concept "**Regulation**". Figure 4-8 shows hierarchy of "**Regulation**" concept defined in FIBO while LKIF hierarchy can be found in Figure 4-7.

❏ **FIBO**

**Concept** → **regulation**

**Definition:**

*"a rule used to carry out a law"*

**Context:**

| rdfs:subClassOf | ➔ legal construct |
|---|---|

❏ **LKIF**

Concept → **Regulation**

**Definition:**

*"A regulation bears one or more norms, all of which are uttered by some legislative body. It cannot bear expressions which are not uttered by a legislative body."*

**Context:**

| rdfs:subClassOf | ➔ Legal_Document |
|---|---|

❏ **Proposition:**
**Equivalent Class**
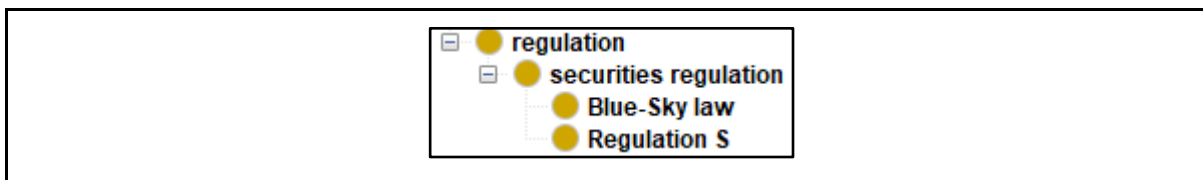


Figure 4-8: FIBO hierarchy of regulation concept

## 4.5.4 Statute

FIBO has the concept "**Statute Law**", while LKIF has the concept "**Statute**". Figure 4-9 shows hierarchy of "**Statute Law**" concept defined in FIBO while LKIF hierarchy can be found in Figure 4-7.

❏  **FIBO**

**Concept** → **statute law**

**Definition:**

*"written law (as opposed to oral or customary law) set down by a legislature or by a legislator (in the case of an absolute monarchy)"*

**Context:**

| **rdfs:subClassOf** | ➔  **law** |
|---|---|

❏  **LKIF**

Concept → **Statute**

**Definition:**

*"A statute bears one or more norms, all of which are uttered by some legal person. It cannot bear expressions which are uttered by a different kind of agent."*

**Context:**

| **rdfs:subClassOf** | ➔  **Legal_Document** |
|---|---|

❏  **Proposition:**
**Subclass** OR **Equivalent Class** OR **any other relationship**
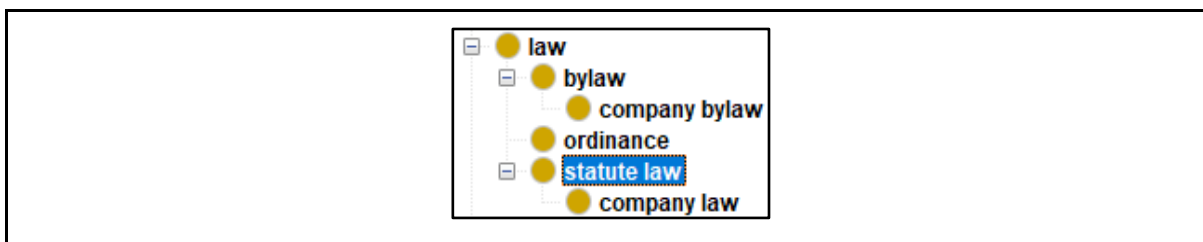


Figure 4-9: FIBO hierarchy of statute law concept

## 4.5.5 Contract

FIBO has the concepts "**Contract Document**" and "**Contract**" and LKIF has the concept "**Contract**". Figure 4-10 shows hierarchy of "**Contract**" concept defined in FIBO while LKIF hierarchy can be found in Figure 4-7. As depicted in Figure 4-10, FIBO has defined a very detailed hierarchy of the "**Contract**" concept while in LKIF it has no further subclasses.

❏ **FIBO**

Concept → **contract, contract document**

**Definition:**

contract → *"voluntary, deliberate agreement between two or more competent parties to which those parties agree to be legally bound, and to which the parties must have provided valuable consideration"*

contract document → *"legal document that records the formal terms and conditions of some contract"*

**Context:**

*contract*

| **rdfs:subClassOf** | ➔ **agreement** |
|---|---|

*contract document*

| **rdfs:subClassOf** | ➔ **legal document** |
|---|---|

❏ **LKIF**

Concept → **Contract**

**Definition:**

*"A contract bears one or more norms, all of which are uttered by some natural person or legal person. It cannot bear expressions which are uttered by a different kind of agent."*

**Context:**

| **rdfs:subClassOf** | ➔ **Legal_Document** |
|---|---|

❏ **Proposition:**
**Equivalent Class**
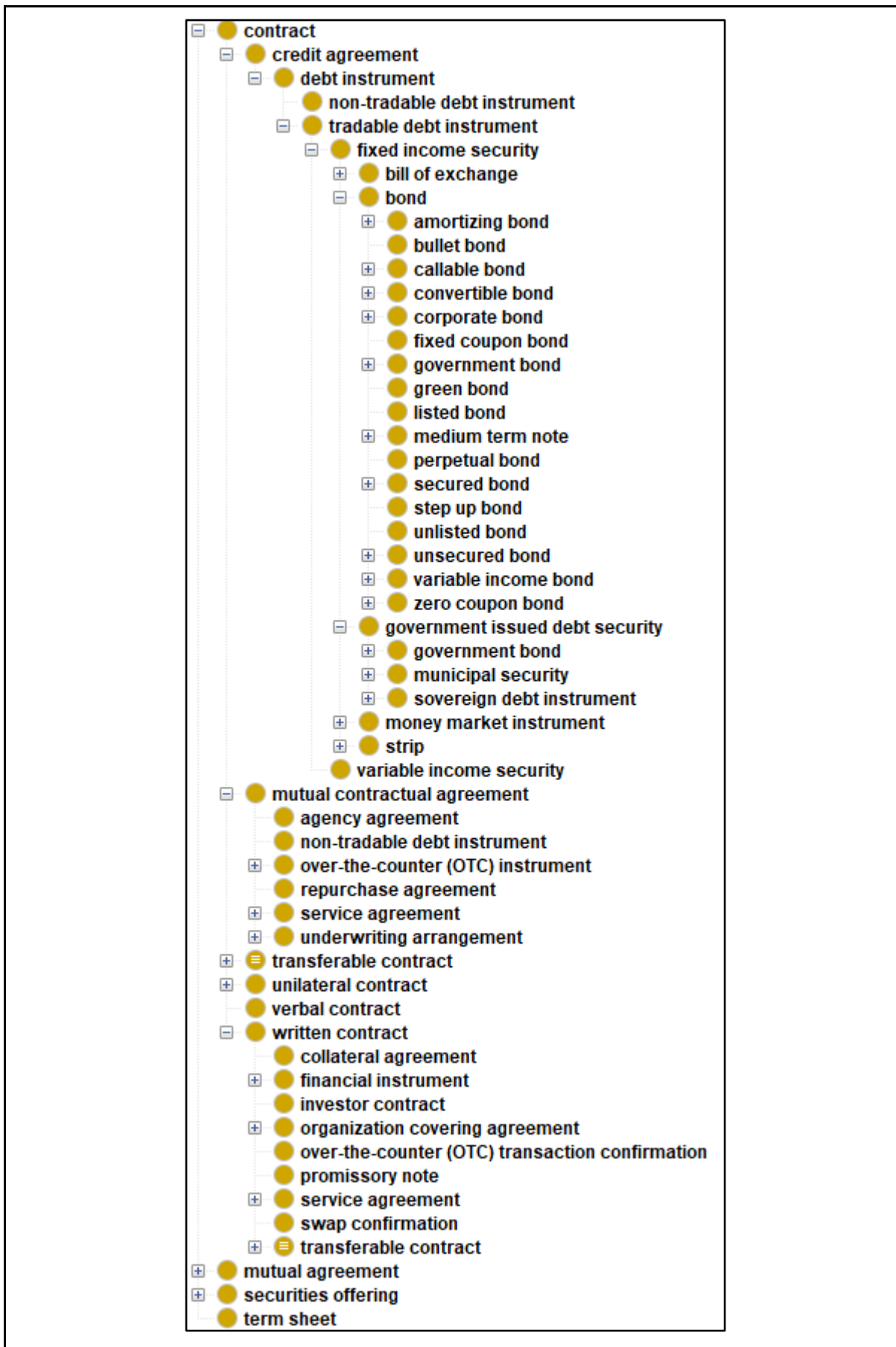
Figure 4-10: FIBO hierarchy of contract concept

## 4.5.6 Agent

FIBO has the concept "**autonomous agent**", while LKIF has the concept "**Agent**". Figure 4-11 shows the hierarchies defined in FIBO and LKIF for this concept.

❑ **FIBO**

**Concept** → **autonomous agent**

**Definition:**

*"An agent is an autonomous individual that can adapt to and interact with its environment."*

**Context:**

| rdfs:subClassOf | ➔ owl:Thing |
|---|---|

❑ **LKIF**

Concept → **Agent**

**Definition:**

*"An agent is any owl:Thing which can act, i.e. play the 'actor' role wrt. an action"*

**Context:**

| rdfs:subClassOf | ➔ owl:Thing |
|---|---|

❑ **Proposition:**
**Equivalent Class**
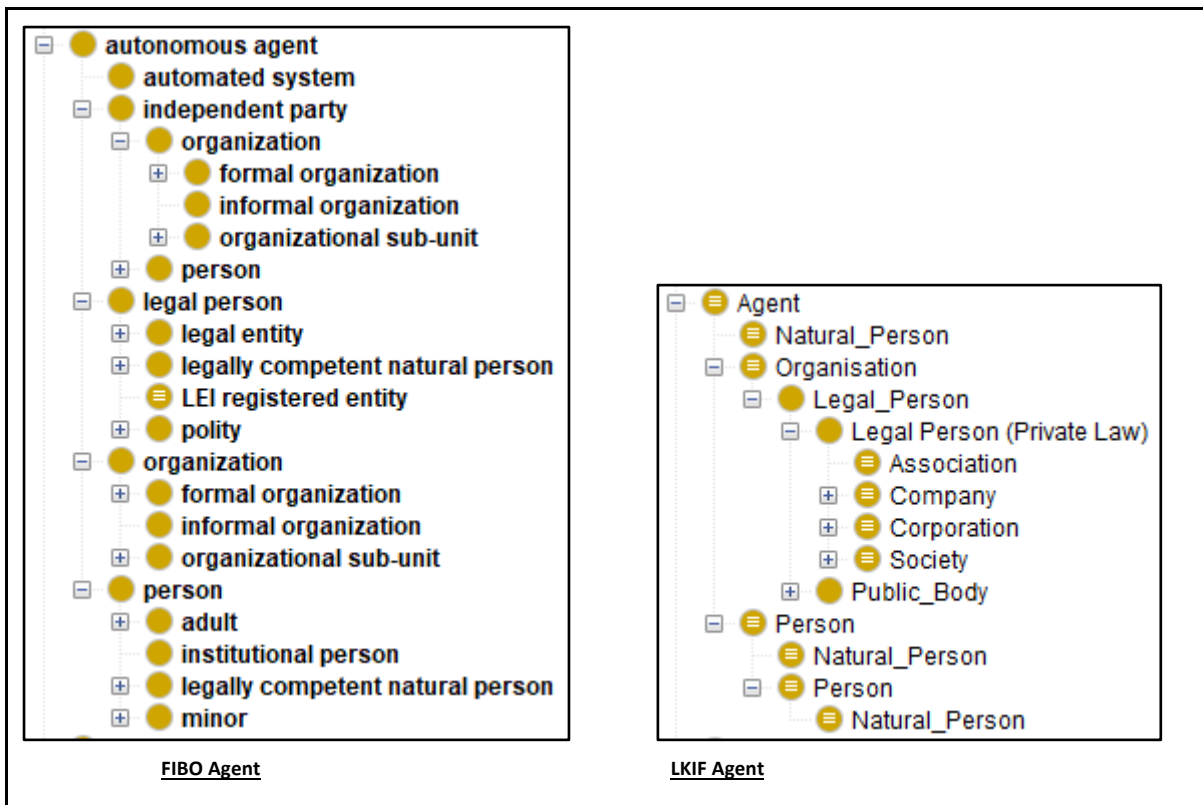
Figure 4-11: FIBO vs LKIF hierarchies of Agent

## 4.5.7 Person

FIBO and LKIF both have the concept "**Person**", as shown as hierarchies in Figure 4-12.

❏ **FIBO**

Concept → **person**

**Definition:**

*"a person; any member of the species homo sapiens"*

**Context:**

| **rdfs:subClassOf** | ➔ **independent party** |
| | ➔ **autonomous agent** |

❏ **LKIF**

Concept → **Person**

**Definition:**

*"A person is an individual agent. Usually associated with 'human being'."*

**Context:**

| **rdfs:subClassOf** | ➔ **Agent** |
| | ➔ **Natural_Object** |
| |    ➔ **Physical_Object** |
| |      ➔ **Physical_Entity** |

❏ **Proposition:**
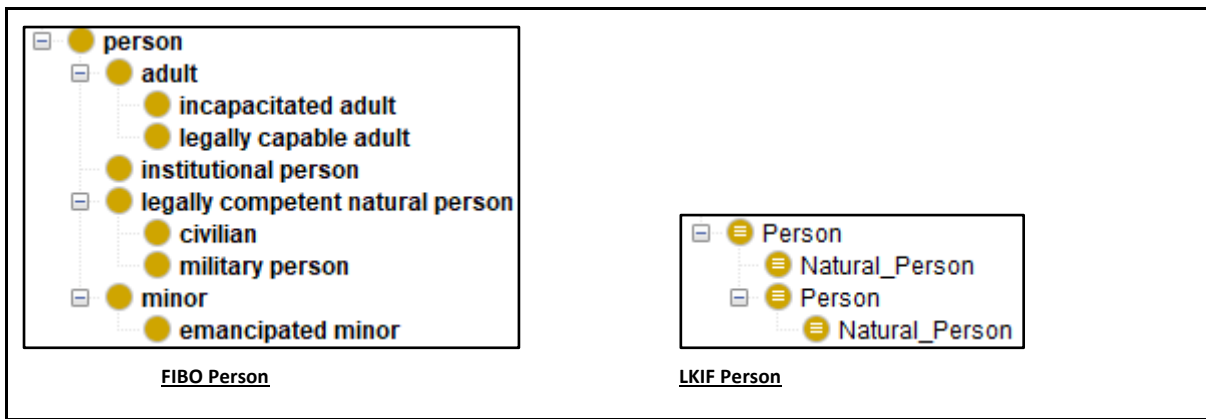**Subclass** OR **Equivalent Class** OR **any other relationship**

Figure 4-12: FIBO vs LKIF hierarchies of Person

## 4.5.8 Legal Person

FIBO has the concept "**legal person**", while LKIF has the concepts "**Legal_Person**" and "**Legal Person (Private Law)**". The respective hierarchies are shown in Figure 4-13.

❑ **FIBO**

Concept → **legal person**

**Definition:**

*"autonomous agent that is recognized as having rights and obligations under the law, including but not limited to the right to sue and be sued, enter into contracts, own property, and incur financial and other obligations"*

**Context:**

| rdfs:subClassOf | → autonomous agent |
|---|---|

❑ **LKIF**

Concept → **Legal_Person, Legal Person (Private Law)**

**Definition:**

*Legal_Person → "A legal entity is a natural person or a legal construct through which the law allows a group of natural persons to act as if it were a single composite individual for certain purposes. The most common purposes are lawsuits, property ownership, and contracts. Sometimes referred to as corporate personhood or legal personality, this concept allows for easy conduct of business by having ownership, lawsuits, and agreements under the name of the legal entity instead of the several names of the people making up the entity.*

*A legal entity is not necessarily distinct from the natural persons of which it is composed. Most legal entities are simply amalgamations of the persons that make it up for convenience's sake. A legal entity that does have a separate existence from its members is called a company or corporation. This distinction gives the corporation its unique perpetual succession privilege and is usually also the source of the limited liability of corporate members. Some other legal entities also enjoy limited liability of members, but not on account of separate existence (Source: Wikipedia.org)"*

*Legal Person (Private Law) → "A legal person as defined in private law"*

**Context:**

*Legal Person*

| `rdfs:subClassOf` | ➜ **Organisation**<br>    ➜ **Agent** |
| --- | --- |

*Legal Person (Private Law)*

| `rdfs:subClassOf` | ➜ **Legal_Person**<br>    ➜ **Organisation**<br>        ➜ **Agent** |
| --- | --- |

❑ **Proposition:**
   **Equivalent Class**
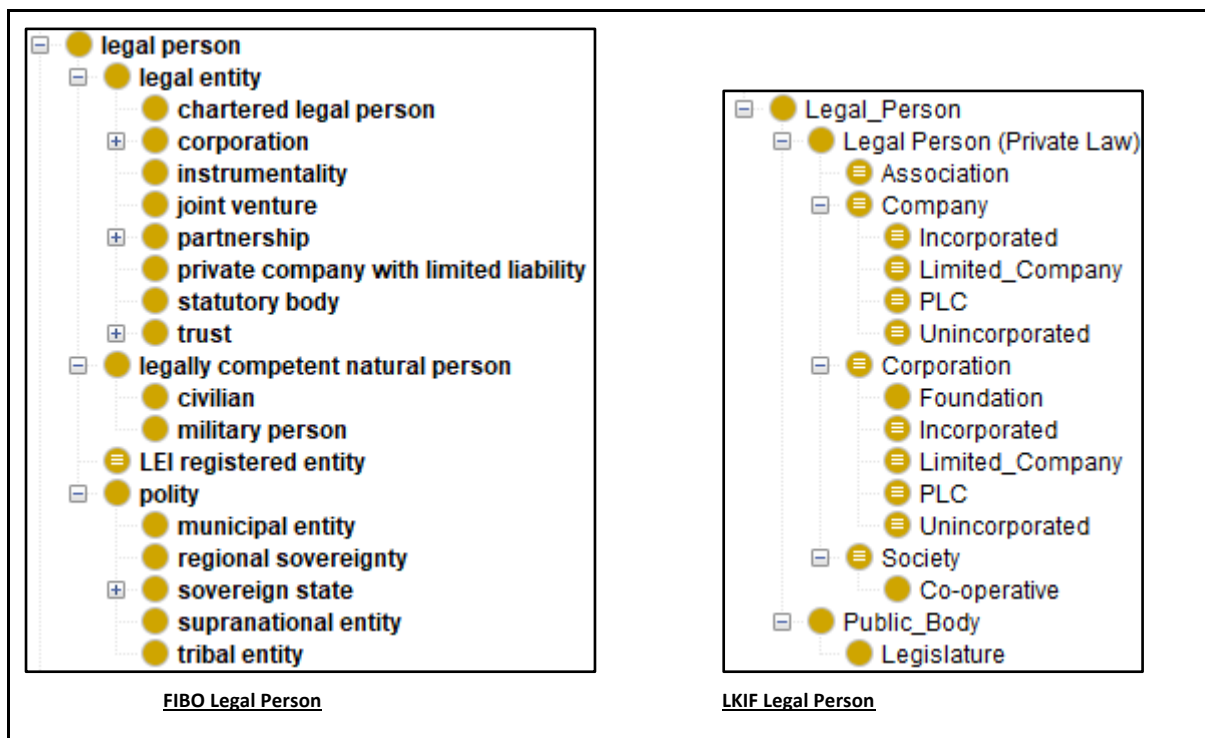


Figure 4-13: FIBO vs LKIF hierarchies of Legal Person

## 4.5.9 Corporation

FIBO and LKIF both have the concept "**Corporation**".

❑ **FIBO**

Concept → **corporation**

**Definition:**

*"a formal organization treated as an entity - an artificial person or legal entity distinct from its owners - created by or under the authority of the laws of a state or nation"*

**Context:**

| rdfs:subClassOf | ➜ legal entity<br>　➜ formal organisation<br>　　➜ Organization<br>　　　➜ autonomous agent |
|---|---|

❑ **LKIF**

Concept → **Corporation, Company**

**Definition:**

*Corporation → "A corporation is a legal entity which, while being composed of natural persons, exists completely separately from them. This separation gives the corporation unique powers which other legal entities lack."*

*Company → "A company refers to a legal entity formed which has a separate legal identity from its members, and is ordinarily incorporated to undertake commercial business. Although some jurisdictions refer to unincorporated entities as companies, in most jurisdictions the term refers only to incorporated entities."*

**Context:**

*Corporation*

| rdfs:subClassOf | ➜ Legal Person (Private Law)<br>　➜ Legal_Person |
|---|---|

*Company*

| rdfs:subClassOf | → Legal Person (Private Law)<br>→ Legal_Person |
|---|---|

❏ **Proposition:**
**Equivalent Class**

## 4.5.10    Role

FIBO has the concepts "**role**", "**thing in role**", "**agent in role**" and "**party in role**" and LKIF has the concept "**Role**", "**Epistemic_Role**", "**Legal_Role**" and "**Social_Role**".

❑  **FIBO**

**Concept** → **role, thing in role, agent in role, party in role**

**Definition:**

*role → "A role is a set of connected behaviours, rights, obligations, beliefs, and norms as conceptualised by actors in the context of some situation."*

*thing in role → "a thing-in-role is a relative concept that ties some thing to a role it plays in a given situational context"*

*agent in role → "An agent-in-role is a relative concept that ties an autonomous agent to a role they are playing in a given situational context."*

*party in role → "a relative concept that ties an independent party to a specific role they are standing in in which they play some part i.e. are party to"*

**Context:**

*role*

| **rdfs:subClassOf** | ➜ **owl:Thing** |
|---|---|

*thing in role*

| **rdfs:subClassOf** | ➜ **owl:Thing** |
|---|---|

*agent in role*

| **rdfs:subClassOf** | ➜ **thing in role** |
|---|---|

*party in role*

| **rdfs:subClassOf** | ➜ **agent in role** <br> ➜ **thing in role** |
|---|---|

❑ **LKIF**

Concept→**Role, Epistemic_Role, Legal_Role, Social_Role**

**Definition:**

*Role* → *"A role is a specification of default behavior and accompanying expectations of the thing 'playing' the role. Similar to actors in a theater who play roles, but are not the roles. Example: student."*

*Epistemic_Role* → *"The role of something used in a (mental) reasoning/inference process"*

*Legal_Role* → *"A legal role is a role played in a legal context. Legal role players can be both Agents and other 'things'"*

*Social_Role* → *"A social role is played by some agent in the context of social activities. The social role brings with it some expectation of 'default' behavior of the role-filler."*

**Context:**

*Role*

| rdfs:subClassOf | ➔ Subjective_Entity |
|---|---|
| | ➔ Mental_Entity |

*Epistemic_Role*

| rdfs:subClassOf | ➔ Role |
|---|---|
| | ➔ Subjective_Entity |
| | ➔ Mental_Entity |

*Legal_Role*

| rdfs:subClassOf | ➔ Role |
|---|---|
| | ➔ Subjective_Entity |
| | ➔ Mental_Entity |

*Social_Role*

| rdfs:subClassOf | ➔ Role |
|---|---|
| | ➔ Subjective_Entity |

| | |
|---|---|
| | ➔ **Mental_Entity** |

❑ **Proposition:**

**Equivalent Class**

➔ **Mental_Entity**

## 4.6 FIBO-LKIF-FIGI Alignments

### 4.6.1 Organisation

FIBO, LKIF and FIGI have the concept "**Organisation**". FIBO has defined a much deeper and detailed hierarchy of the "**Organisation**" concept. Figure 4-14 shows their respective hierarchies defined in FIBO and LKIF.

❏ **FIBO**

Concept → **organization**

**Definition:**

*"collection of one or more people, or groups of people formed together into a community or other social, commercial or political structure to act, or that is designated to act, towards some purpose, such as to meet a need or pursue collective goals on a continuing basis"*

**Context:**

| rdfs:subClassOf | ➔ autonomous agent |
| --- | --- |
| | ➔ independent party |

❏ **LKIF**

Concept → **Organisation**

**Definition:**

*"An organisation is a group of other organisations or persons which acts 'as one'. An organisation can be both formal (i.e. created by law or decree) or informal."*

**Context:**

| rdfs:subClassOf | ➔ Agent |
| --- | --- |

❏ **FIGI**

Concept → **organization**

**Definition:**

*"an entity, such as an institution or an association, that has a collective goal and is linked to an external environment"*

**Context:**

| rdfs:subClassOf | ➔  Concept |
|---|---|

❏  **Proposition:**
**Equivalent Class**
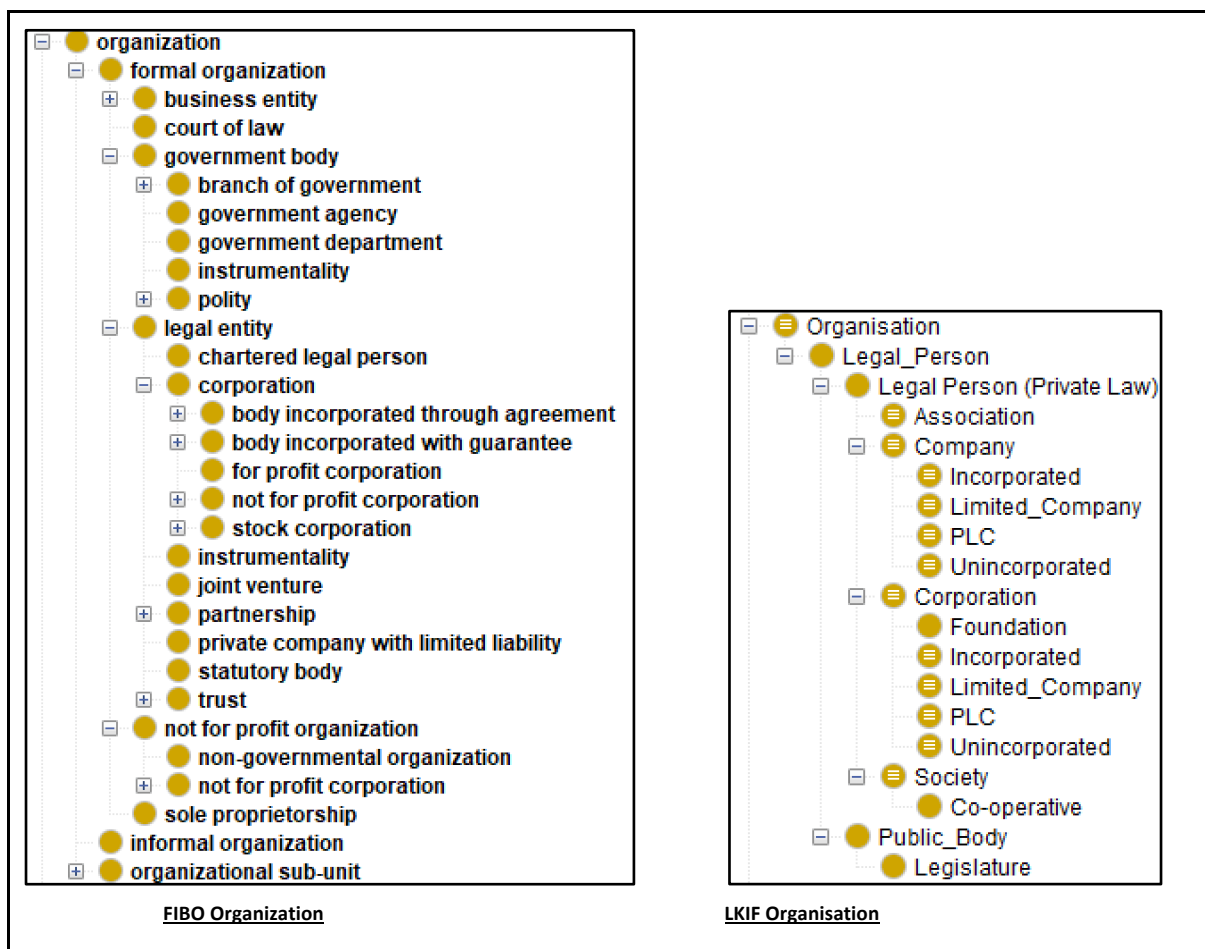


Figure 4-14: FIBO vs LKIF hierarchies of Organisation

## 4.7 FIBO-FIGI Alignments

## 4.7.1 Identifier

FIBO and FIGI both ontologies have the "**Identifier**" concept. The respective descriptions of both FIBO and FIGI "**Identifier**" concepts are below:

❑ **FIBO**

Concept → **identifier**

**Definition:**

*"a sequence of characters uniquely identifying something that it is associated with for some purpose and within a specified context"*

**Context:**

| `rdfs:subClassOf` | ➜ **reference** |
|---|---|

❑ **FIGI**

Concept → **identifier**

**Definition:**

*"An identifier is a name that identifies (that is, labels the identity of) either a unique object or a unique class of objects, where the 'object' or class may be an idea, physical (countable) object (or class thereof), or physical (noncountable) substance (or class thereof). The abbreviation ID often refers to identity, identification (the process of identifying), or an identifier (that is, an instance of identification). An identifier may be a word, number, letter, symbol, or any combination of those.*

*The words, numbers, letters, or symbols may follow an encoding system (wherein letters, digits, words, or symbols stand for (represent) ideas or longer names) or they may simply be arbitrary. When an identifier follows an encoding system, it is often referred to as a code or ID code. Identifiers that do not follow any encoding scheme are often said to be arbitrary IDs; they are arbitrarily assigned and have no greater meaning. (Sometimes identifiers are called 'codes' even when they are actually arbitrary, whether because the speaker believes that they have deeper meaning or simply because he is speaking casually and imprecisely.)"*

**Context:**

| `rdfs:subClassOf` | ➜ `owl:Thing` |
|---|---|

❑ **Proposition:**
**Equivalent Class**

## 4.7.2 Financial Instrument Identifier

FIBO and FIGI both ontologies have the "**Financial Instrument Identifier**" concept. The respective descriptions of both FIBO and FIGI "**Financial Instrument Identifier**" concepts are below:

❏ **FIBO**

**Concept** → **financial instrument identifier**

**Definition:**

*"an identifier for a financial instrument"*

**Context:**

| rdfs:subClassOf | ➔ identifier |
|---|---|

❏ **FIGI**

**Concept** → **financial instrument identifier**

**Definition:**

*"A financial instrument identifier is an identifier that identifies (that is, labels the identity of) a financial instrument with a unique, persistent, semantically meaningless ID. The abbreviation 'ID' often refers to identity, identification (the process of identifying), or an identifier (that is, an instance of identification). A financial instrument identifier consists of a 12 digit alpha-numeric, randomly generated ID covering active and inactive securities. In total there will be more than 852 billion potential combinations available. The first 3 characters begin with 'xxG'; where 'x' can be any upper-case consonant or 'Y' (with certain restrictions), positions 4-11 are alpha-numeric (excluding vowels) and the last digit is a check digit, which is calculated based on a variation of the Modulus 10 Double Add Double Formula."*

**Context:**

| rdfs:subClassOf | ➔ identifier |
|---|---|

❏ **Proposition:**
**Equivalent Class**

### 4.7.3 Financial Instrument Global Identifier

FIBO and FIGI both ontologies have the "**Financial Instrument global Identifier**" concept. The respective descriptions of both FIBO and FIGI "**Financial Instrument global Identifier**" concepts are below:

❏ **FIBO**

**Concept** → `financial instrument global identifier`

**Definition:**

*"financial instrument identifier that is defined as specified in the Object Management Group (OMG) Financial Instrument Global Identifier (FIGI) Specification"*

**Context:**

| `rdfs:subClassOf` | ➜ `identifier` <br>    ➜ `Financial instrument identifier` |
|---|---|

❏ **FIGI**

**Concept** → `global identifier`

**Definition:**

*"A global identifier is the most basic type of identifier that applies to exactly and only one Financial Instrument at the most granular level. For example, AAPL common stock as traded on NASDAQ Global Select. The granularity of this identifier is found in that which it identifies. In particular, the most basic FIGI identifies a financial instrument, where applicable, at the trading venue level. That is, where applicable, the Global Identifier identifies a Financial Instrument within the context of an exchange venue."*

**Context:**

| `rdfs:subClassOf` | ➜ `identifier` <br>    ➜ `financial instrument identifier` |
|---|---|

❏ **Proposition:**
**Equivalent Class**

## 4.7.4 Financial Instrument Name

FIBO and FIGI both ontologies have the "**Financial Instrument name**" concept. The respective descriptions of both FIBO and FIGI "**Financial Instrument name**" concepts are below:

❏ **FIBO**

Concept → **financial instrument short name**

**Definition:**

*"an identifier that is a short name for any kind of financial instrument within a defined structure as specified in ISO 18774"*

**Context:**

| rdfs:subClassOf | ➔ identifier |
| --- | --- |

❏ **FIGI**

Concept → **financial instrument name**

**Definition:**

*"the English language name of the company or the financial instrument, e.g., a particular fund name. It sometimes includes a brief description of the security or a differentiating feature, e.g., the issuance date. The name of an instrument may change in conjunction with corporate actions."*

**Context:**

| rdfs:subClassOf | ➔ identifier |
| --- | --- |

❏ **Proposition:**
**Equivalent Class**

## 4.7.5 Ticker

FIBO and FIGI both ontologies have the "**Ticker**" concept. The respective descriptions of both FIBO and FIGI "**Ticker**" concepts are below:

❏ **FIBO**

**Concept** → **ticker symbol**

**Definition:**

*"exchange-specific identifier for a particular security"*

**Context:**

| rdfs:subClassOf | ➔  listed security identifier<br>  ➔  security identifier<br>    ➔  financial instrument identifier<br>      ➔  identifier |
|---|---|

❏ **FIGI**

**Concept** → **ticker**

**Definition:**

*"the assigned ticker for a financial instrument; the rules for forming the ticker vary according to security class"*

**Context:**

| rdfs:subClassOf | ➔  identifier |
|---|---|

❏ **Proposition:**
**Equivalent Class**

## 4.7.6 Financial Instrument

FIBO and FIGI both ontologies have the "**Financial Instrument**" concept. The respective descriptions of both FIBO and FIGI "**Financial Instrument**" concepts are below:

❑ **FIBO**

Concept → **financial instrument**

**Definition:**

*"a written contract that gives rise to both a financial asset of one entity and a financial liability or equity instrument of another entity"*

**Context:**

| rdfs:subClassOf | ➜ written contract<br>  ➜ contract<br>    ➜ agreement |
| --- | --- |

❑ **FIGI**

Concept → **financial instrument**

**Definition:**

*"Financial instruments are cash, evidence of an ownership interest in an entity, or a contractual right to receive, or deliver, cash or another financial instrument."*

**Context:**

| rdfs:subClassOf | ➜ owl:Thing |
| --- | --- |

❑ **Proposition:**
**Equivalent Class**

## 4.7.7 Code

FIBO and FIGI both ontologies have the "**Code**" concept. The respective descriptions of both FIBO and FIGI "**Code**" concepts are below:

❏ **FIBO**

**Concept** → `code element`

**Definition:**

*"a sequence of characters denoting something that it is associated with for some purpose, within a specified context, according to some rule set"*

**Context:**

| `rdfs:subClassOf` | ➔ `owl:thing` |
|---|---|

❏ **FIGI**

**Concept** → `code`

**Definition:**

*"A system of valid symbols that substitute for specified values, such as alpha, numeric, symbols or combinations thereof."*

**Context:**

| `rdfs:subClassOf` | ➔ `owl:Thing` |
|---|---|

❏ **Proposition:**
**Equivalent Class**

# 5 Exemplary Application Scenario

One of the main objectives and goal of the proposed INFINITECH methodology for ontology engineering and prototyping is to provide to end users and domain experts a systematic, clear and easy to use process to help them to develop application domain ontologies to be easily integrated within the INFINITECH platform. In this landscape the use of exemplary data, as well as, application scenario to show and validate the proposed process is a necessary condition. As a matter of fact, the implementation of a specific real-world and significant scenario by using real data allows domain experts - from one side - to better formalize and describe their own business and - from the other side - to better understand the steps of the methodology while allowing developers to figure out how conceptual models can be concretely implemented.

**This section is an effort in delivering a set of guidelines and guidance to business experts and ontology developers on how to model and implement specific application domains in line with INFINITECH specifications in a way that is easily understandable and quickly applicable according to the learning-by-examples principle.**

## 5.1 Applying the Methodology

INFINITECH pilots have typically their own very specific data with different formats, data structure and 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 have not 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.**

At this stage it is important to observe that the current document is the first version of three and documents the current state of the work realized within the task 4.1. Actually, the *Collecting* activity is almost completed for all the pilots and the *Building* activity is a work-in-progress.

### 5.1.1 Step #1: Collecting

The *Collecting* activity is the first step of the INFINITECH methodology and is aimed to characterize the application domain by providing three fundamental deliverables, namely:

- *Domain Terminology*: the complete list of terms that are relevant for the application domain;
- *Glossary of Terms*: the domain terminology enriched with the description of the term as well as possible synonyms. Furthermore, the Object, Process Actor modelling Language (OPAL) semantic is also used at this stage that provides a first high-level classification of concepts; and
- *Taxonomy of identified concepts*: the list of terms represented/organized into hierarchies according to the "ISA" relationship.

The Figure 5-1 shows the Income/Outcome of the *Collecting* Activity.

Figure 5-1 – Income/Outcome of the Collecting Activity

The pilots and/or testbeds are organized into clusters that basically group pilots that belong to the same application domain. The *Collecting* activity is performed for each pilot however the expected deliverables will be firstly grouped into clusters where the outcome is the union of the deliverables obtained for each one of the pilots (see Listing 5-1).

```
Set pilot_x_1, Set pilot_x_2, … , Set pilot_x_n
pilot_x_1 ∪ pilot_x_2 ∪ ⋯ pilot_x_n = { x : x ∈ pilot_x_1 or x ∈ pilot_x_2 or ⋯ x ∈ pilot_x_n}
```

Listing 5-1 – Pilot data combination rule
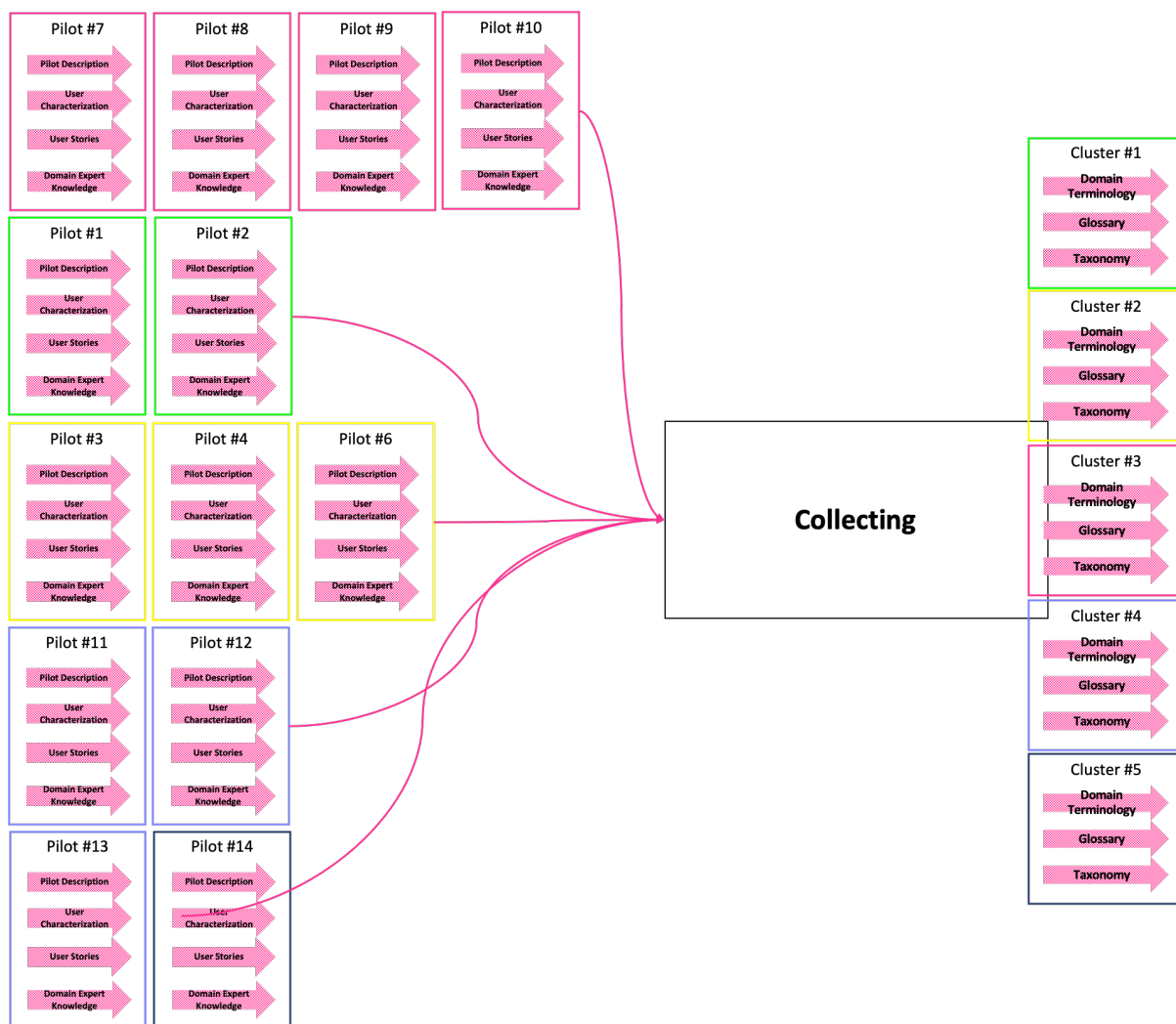


Figure 5-2 – Relationship between pilots and clusters in the Collecting activity

## 5.1.1.1 Supporting Tools

In INFINITECH the collecting activity is carried out through a collaborative approach based on *Trello*[3]. In particular, *Trello* has been used to support the *Collecting* activity by centralizing all the data, information and knowledge about each one of the pilots. This knowledge is then analysed and used by the involved actors, namely: *knowledge Expert, Domain User, End User* and *Ontology Engineer*. Furthermore, Google Docs Suite and especially Google Sheets have been used for collaboratively creating the three main deliverables for each cluster due to the lack of a table feature in Trello.

---

[3] https://trello.com

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

### 5.1.1.2.1 Conceptualization of the Application Domain by using word clouds



Figure 5-3 – Cluster #1: Similarity from Natural Language analysis with Word Clouds

##### 5.1.1.2.2    Deliverable #1: Domain Terminology

Table 5-1 – 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 |

## 5.1.1.2.3 Deliverable #2: Glossary of Terms

Table 5-2 – 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

### 5.1.1.2.4  Deliverable #3: Taxonomy

Table 5-3 – 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 | |

## 5.1.1.3 Cluster #2: Personalized Retails and Investment Banking Services

### 5.1.1.3.1 Conceptualization of the Application Domain by using word clouds



Figure 5-4 – Cluster #2: Similarity from Natural Language Analysis with Word Clouds

### 5.1.1.3.2 Deliverable #1: Domain Terminology

Table 5-4 – 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 |

## 5.1.1.3.3 Deliverable #2: Glossary of Terms

Table 5-5 – 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 |

### 5.1.1.3.4    Deliverable #3: Taxonomy

Table 5-6 – 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 | |

## 5.1.1.4 Cluster #3: Financial Crime and Fraud Detection

### 5.1.1.4.1 Conceptualization of the Application Domain by using word clouds



Figure 5-5 – Cluster #3: Similarity from Natural language Analysis with Word Clouds

### 5.1.1.4.2 Deliverable #1: Domain Terminology

Table 5-7 – 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 5-8 – 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, 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 |

### 5.1.1.4.4    Deliverable #3: Taxonomy

Table 5-9 – 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 | | | |

## 5.1.1.5 Cluster #4: Personalized Usage-based Insurance Products

### 5.1.1.5.1 Conceptualization of the Application Domain by using word clouds



Figure 5-6 – Cluster #4: Similarity from Natural Language Analysis with Word Clouds

##### 5.1.1.5.2    Deliverable #1: Domain Terminology

Table 5-10 – 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 |

### 5.1.1.5.3 Deliverable #2: Glossary of Terms

Table 5-11 – 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 | Actor | It is an institution (public or private) that collects funds (from the public or other institutions) and invests them in financial assets |

| | Company, Bank | | |
|---|---|---|---|
| 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 |

### 5.1.1.5.4 Deliverable #3: Taxonomy

Table 5-12 – 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 | | | |

## 5.1.1.6 Cluster #5: Configurable and Personalized Insurance Product

### 5.1.1.6.1    Conceptualization of the Application Domain by using word clouds



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

### 5.1.1.6.2 Deliverable #1: Domain Terminology

Table 5-13 – 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 |

## 5.1.1.6.3 Deliverable #2: Glossary of Terms

Table 5-14 – 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 Authority | Regulatory agency, regulatory institution | Actor | A regulatory authority is an autonomous authority or agency 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 |

### 5.1.1.6.4   Deliverable #3: Taxonomy

Table 5-15 – 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 | |

## 5.1.2 Step #2: Building

The *Building* activity is the second step of the INFINITECH methodology and is aimed to build the semantic models for each application domain the application domain. It is an iterative process and the result of each iteration is used as input for the next iteration. During this step the three deliverables gathered during the *Collecting* phase are further analyzed, refined and the extracted concepts, descriptions and nomenclature will be aligned as far as possible. Finally, the main result of this step will be five stand-alone semantic models, one for each application domain, connected and integrated with top-reference ontologies.

At this stage, the building process provides a preliminary tentative of concepts alignment and identification of INFINITECH "exclusive" concepts, as well as, integration and inclusion of these concepts within top-reference ontologies.

The tables provided in the following subsections are organized as follow:

- The green color: identifies INFINITECH concepts that have their counterpart in top-reference ontologies. This relation is represented by the *owl:equivalentClass* property;
- The magenta color: identifies INFINITECH "exclusive" concepts; and
- The distinct columns are used to represent the hierarchy of concepts, according to the *rdf:subClassOf* property.

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

Table 5-16 – Cluster #1: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

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

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|---|---|---|---|---|
| | | /FBC/ProductsAndServices/ClientsAndAccounts/ | 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 owl: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: Market Risk | INFINITECH: Credit Risk | | |
| 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) | |

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| | **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) <br> **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) | | | | |

## 5.1.2.2 Cluster #2: Personalized Retails and Investment Banking Services

Table 5-17 – 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/Financial ProductsAndServices/) | | | | |
| 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** **FIBO: 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/o |

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| ([https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/](https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Documents/))<br>**Lkif-expr: Document** | | | | ntology/FBC/DebtAndEquities/CreditRatings/CreditReport)<br>**INFINITECH: Risk Profile**<br>**INFINITECH: Investment Profile**<br>**INFINITECH: Investor Profile**<br>**INFINITECH: Customer Profile** |
| FIBO: Occurrence Kind (https://spec.edmcouncil.org/fibo/ontology/FND/DatesAndTimes/Occurrences/) | **INFINITECH: Assessment**<br>**owl:equivalentClass**<br>**FIBO: Assessment Activity**<br>(https://spec.edmcouncil.org/fibo/ontology/FND/Arrangements/Assessments/) | **INFINITECH: Risk Assessment Activity** | **INFINITECH: Risk Assessment**<br>**owl:equivalentClass**<br>**FIBO: Credit Risk Assessment**<br>(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**<br>**owl:equivalentClass**<br>**FIBO: Trade**<br>(https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/Trade) | | |
| | **INFINITECH: Trade Analysis Activity** | | | |
| | **INFINITECH: Investment Advice**<br>**owl:equivalentClass**<br>**fr-fin-ref: Investment Advice** | | | |
| FIBO: Analytics | FIBO: statistical program | | | |
| | **INFINITECH: Artificial Intelligence** | **INFINITECH: BigData** | | |
| | | **INFINITECH: Optimization** | | |
| **INFINITECH: Product**<br>**owl:equivalentClass**<br>**FIBO:Product**<br>(https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/Product) | **INFINITECH: Financial Product**<br>**owl:equivalentClass**<br>**FIBO:Financial Product**<br>(https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialProduct) | | | |
| **INFINITECH:Asset**<br>**owl:equivalentClass**<br>**FIBO: Asset**<br>(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**<br>**FIBO: Portfolio**<br>(https://spec.edmcouncil.org/fibo/ontol | | | | |

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| ogy/SEC/Securities/SecurityAssets/Portfolio) | | | | |
| 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 | | | |

## 5.1.2.3 Cluster #3: Financial Crime and Fraud Detection

Table 5-18 – Cluster #3: Preliminary Taxonomy of Concepts and Mapping with FIBO, Lkif and FinReg reference ontologies

| Taxonomy | | | | |
|---|---|---|---|---|
| **Top Level Concept**<br>**rdfs: subClassOf** | **First-Level Specialization** | **Second-Level Specialization** | **Third-Level Specialization** | **Fourth-Level Specialization** |
| FIBO: Service Provider (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/ServiceProvider) | **INFINITECH: Regulatory Authority owl:equivalentClass**<br><br>**FIBO: Regulatory Agency** (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency)<br><br>**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**<br>**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**<br>**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**<br>**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**<br>**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**<br>**FIBO: Investor** (https://spec.edmcouncil.org/fibo/ontology/BE/OwnershipAndControl/OwnershipParties/) |

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|---|---|---|---|---|
| | | 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) | | | | |

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|---|---|---|---|---|
| **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: 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** | fro-fin-ref: Professional Service | **INFINITECH: Customer Service owl:equivalentClass** **FIBO: FinacialService** | **INFINITECH: Ancillary Services** | |

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|---|---|---|---|
| (https://spec.edmcouncil.org/fibo/ontology/FND/ProductsAndServices/ProductsAndServices/) | | (https://spec.edmcouncil.org/fibo/ontology/FBC/ProductsAndServices/FinancialProductsAndServices/FinancialService) (Customer Service) | |
| | | **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) | | | |

## 5.1.2.4 Cluster #4: Personalized Usage-based Insurance Products

Table 5-19 – 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** | | | | |

## 5.1.2.5 Cluster #5: Configurable and Personalized Insurance Products

Table 5-20 - 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<br><br>FIBO: Regulatory Agency (https://spec.edmcouncil.org/fibo/ontology/FBC/FunctionalEntities/RegulatoryAgencies/RegulatoryAgency)<br><br>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<br><br>(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<br><br>(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 | | |

# 6 Conclusions

The deliverable presents an overview about the INFINITECH Semantic Interoperability Framework. The core of the framework is the INFINITECH methodology for fast Semantic Models and Ontologies Engineering. It has been developed on the top of state-of-the-art methodologies for ontology engineering. Furthermore, preliminary studies have also been realized on Semantic Annotations Methods and Tools for linking INFINITECH Semantic Models and Ontologies to pilot specific data. This study will build the foundation for the next version of the deliverable when developed ontologies need to be linked to real world. Finally, the document provides an exemplary scenario where the INFINITECH methodology has been applied to characterize the five clusters that under the scope of the INFINITECH project. In particular the first two steps of the methodology have been accomplished and the document reports the several results that have been generated. These two steps provide the necessary background for the next bunch of works to do where prototypes of semantic models and ontologies for each one of the considered clusters will be developed.

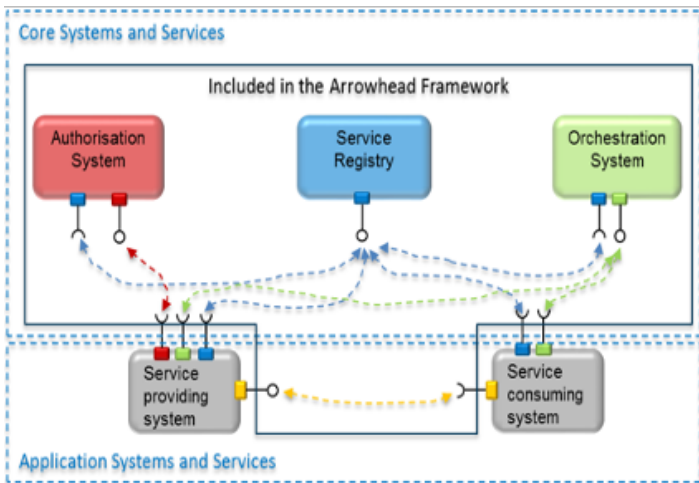Table 6-1 – (map TASK KPI with Deliverable achievements)

| KPI | Description | Comment |
|---|---|---|
| **KPI 1** | Semantic Interoperability Solution to be developed >=1. | The document provides the definition of the INFINITECH Interoperability framework and describes its internal methodology for fast Semantic Models and Ontologies Engineering. Moreover, it provides an exemplary scenario where the five considered domain have been fully characterized. The KPI is partially achieved since the full interoperability solution is planned for the next version of the document. |
| **KPI 2** | Financial & Insurance Sector Ontologies to be covered >= 3. | The document provides an initial alignment of the domain descriptions and characterization with reference ontologies like FIBO/FIGI, Lkif, FinReg. The KPI is fully achieved. |

# Appendix A: Literature

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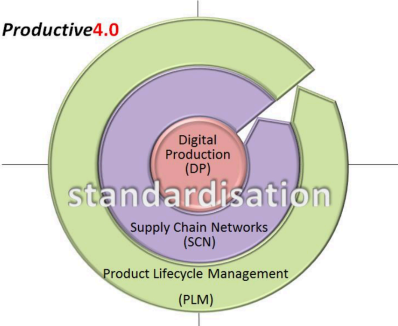
# Appendix B: Relevant Projects/Initiatives

| STUDY | ARROWHEAD |
|---|---|
| **DESCRIPTION** | The Arrowhead project is aimed to provide an intelligent middleware that can be used to allow the virtualization of physical machines into services. It includes principles on how to design SOA-based systems, guidelines for its documentation and a software framework capable of supporting its implementations. The design guidelines provide generic "black box" design patterns on how to implement application systems to be Arrowhead Framework compliant. It already solves relevant issues regarding interface, protocol and semantic interoperability. |
| **THE FRAMEWORK/ ARCHITECTURE** |  |
| **INPUT FOR INFINITECH** | • The Arrowhead framework is an intelligent middleware that can be easily applied for creating CPS. Each physical entity (ex. CNC machine, robot, etc.) can be virtualized as an Arrowhead compliant service and registered into the Arrowhead Framework. Within the Arrowhead Framework each service providing system is discoverable and invokable;<br>• The Arrowhead framework faces several interoperability issues to enable integration of the information between heterogeneous components by deeply analysing the message exchange patterns, the most used communication protocols and semantic data representation. |

| STUDY | MANTIS |
|---|---|
| **DESCRIPTION** | The MANTIS project was aimed to develop a CPS based proactive maintenance service platform architecture for enabling the creation of collaborative maintenance ecosystems. The proposed MANTIS platform provided a practical way for implementing collaborative maintenance strategies in a CPS-populated system. The generic focus was on an architecture that enables service-based business models and improved asset availability at lower costs through continuous process and equipment monitoring, together with data analysis. |
| **THE FRAMEWORK/ ARCHITECTURE** |  |
| **INPUT FOR INFINITECH** | <ul><li>The MANTIS framework provides an interoperability framework to ensure interoperability between concrete implementations of the MANTIS reference architecture</li><li>Analysis of the Standard Reference Architecture for the specific domain</li><li>The MANTIS architecture relies on:<ul><li>the ISO-13374 standard for identifying the basic functionalities of a Condition Based Monitoring (CBM) system and its semantic and ontology; and</li><li>the Industrial Internet of Things (IIoT) reference model for the architectural pattern.</li></ul></li></ul> |

| STUDY | PRODUCTIVE 4.0 |
|---|---|
| **DESCRIPTION** | Productive4.0 is aimed to clear the path for technologies that enable integrating knowledge between different parts of a production's systems – both within companies and between actors. Preparing the digital transformation. The project addresses various industrial domains with one complete approach, focusing on three main interdependent fields: digital production (DP), supply chain networks (SCN) and product lifecycle management (PLM). |
| **THE FRAMEWORK/ ARCHITECTURE** |  |
| **INPUT FOR INFINITECH** | <ul><li>Provides tools and services developed to enable interoperability between distinct IoT platforms;</li><li>provides state of the art interoperability and integrability using service orientation through the open Arrowhead Framework. Support is provided for decentralisation, modularity, real time and security through the local cloud approach.</li><li>Provides a reference platform for manufacturing that unifies previously separate production environments to produce a universal production virtual ecosystem that seamlessly integrates cyber-physical operations, data analytics and decision support tools, while also incorporating the structural characteristics of the entire value chain. This platform addresses in an integrated manner the six design principles of Industry 4.0, namely **Interoperability, Virtualization, Decentralization, Real-time Capability, Service Orientation** and **Modularity**.</li></ul> |

| STUDY | FIESTA-IoT |
|---|---|
| **DESCRIPTION** | FIESTA-IoT provides tools, techniques, processes and best practices enabling IoT testbed/platforms operators to interconnect their facilities in an interoperable way based upon cutting edge semantics-based solutions. |
| **THE FRAMEWORK/ ARCHITECTURE** |  |
| **INPUT FOR INFINITECH** | • Manages data from heterogeneous systems and environments and their entity resources (such as smart devices, sensors, actuators, etc.);<br>• Integration of IoT platforms, Testbeds and their associated silo applications within cloud infrastructures;<br>• Aggregation and of data streams from different IoT platforms or Testbeds while ensuring their interoperability;<br>• Provides tools and techniques for building applications that horizontally integrate diverse IoT Solutions;<br>• Develops (semantic) annotation models for interoperable data/service exchange between the T estbeds and also between T estbeds and higher-level services/applications;<br>• Enables (Semantic) Stream reasoning, provide re-usable components and develop common methods for data analytics for data streams. |

| STUDY | BigIoT |
|---|---|
| **DESCRIPTION** | The objective of the BIG IoT project is to ignite really vibrant Internet of Things (IoT) ecosystems. It achieves this by bridging the current interoperability gap between the vertically integrated IoT platforms and by creating marketplaces for IoT services and applications. Despite various research and innovation projects working on the Internet of Things, no broadly accepted professional IoT ecosystems exist. The reason for that are high market entry barriers for developers and service providers due to a fragmentation of IoT platforms. |
| **THE FRAMEWORK/ ARCHITECTURE** |  |
| **INPUT FOR INFINITECH** | <ul><li>Provides mechanisms for enabling the interoperability for smart object platforms and services at the semantic level</li><li>Provides a modularized semantic model to facilitate the formal descriptions of concepts and properties used;</li><li>Provides design methods and specifications on how to create application and domain specific semantic models and how to connect them to the core semantic model;</li><li>Provides methods for both semantic models development and reuse.</li></ul> |