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Interoperability Framework
Interoperability concept and standardisation

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The communication process

- Any type of social or business relation needs to establish an information exchange between the involved actors, so transferring useful messages based on commonly understood concepts
- This process occurs «automatically» when people talk each other, provided that they share a common set of concepts (culture), a common way to organise them (semantics), a common language (dictionary and syntax) and a compatible way to pronounce words
- The different phases of the process can be clearly identified: if any of the phases is not possible, due to differences in culture, semantics, language or pronunciation, the communication becomes difficult and often impossible

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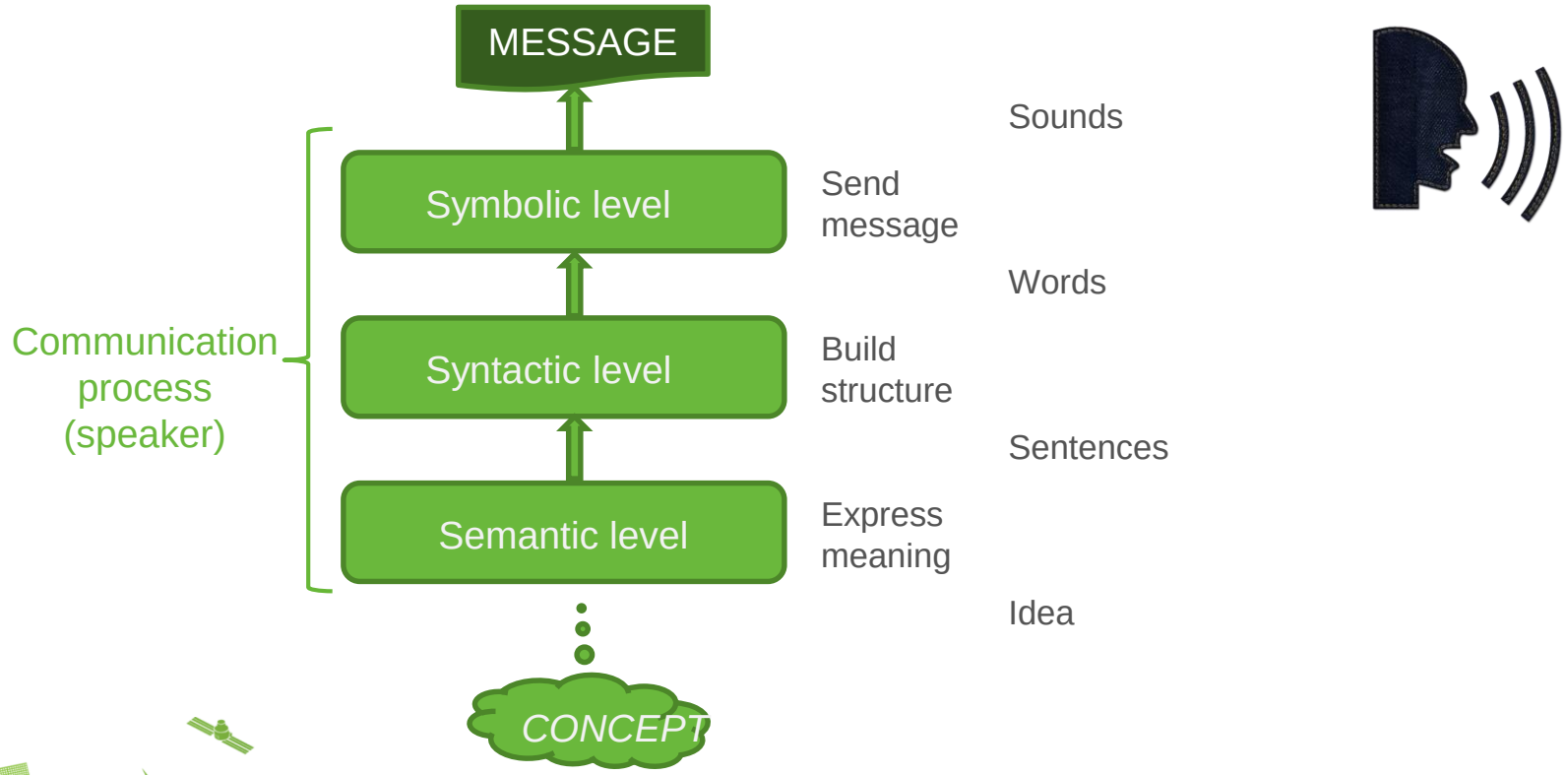
Communication phases: speaker



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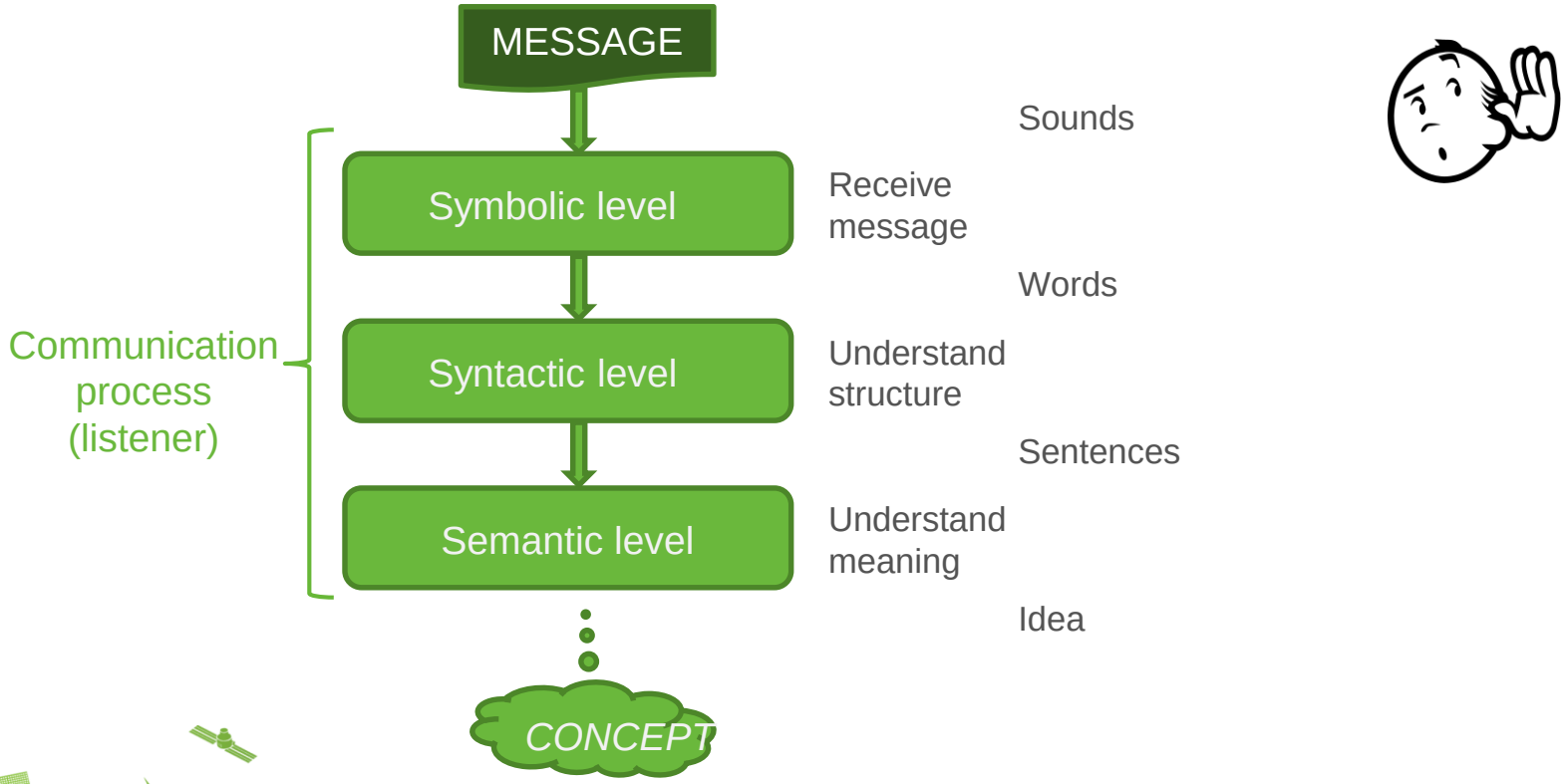
Communication phases: listener



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Extending the process: machine-to-machine

- Business activities today include more and more the need to have communication between computers, which support and often replace communication between humans
- The overall process is exactly the same, so we can generalise the «communication process»

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What is «communication»?

Communication process

Effective communication can occur only when both the sender and the receiver assign the same meanings to the same message

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How to do it

- **Symbolic level**: this part of the process is not a problem today, as there are plenty of means to establish a communication channel between the sender and the receiver, in order to transparently transfer messages without altering them
- **Syntactic level**: this is also a solved problem, as a widespread and flexible solution has been identified in XML, which allows to build any kind of syntax and possibly translate between them by means of suitable transformations
- **Semantic level**: this is the hardest problem, solved in the past by means of shared concepts between programmers working at the sending and receiving applications, so implicitly achieving a common set of concepts

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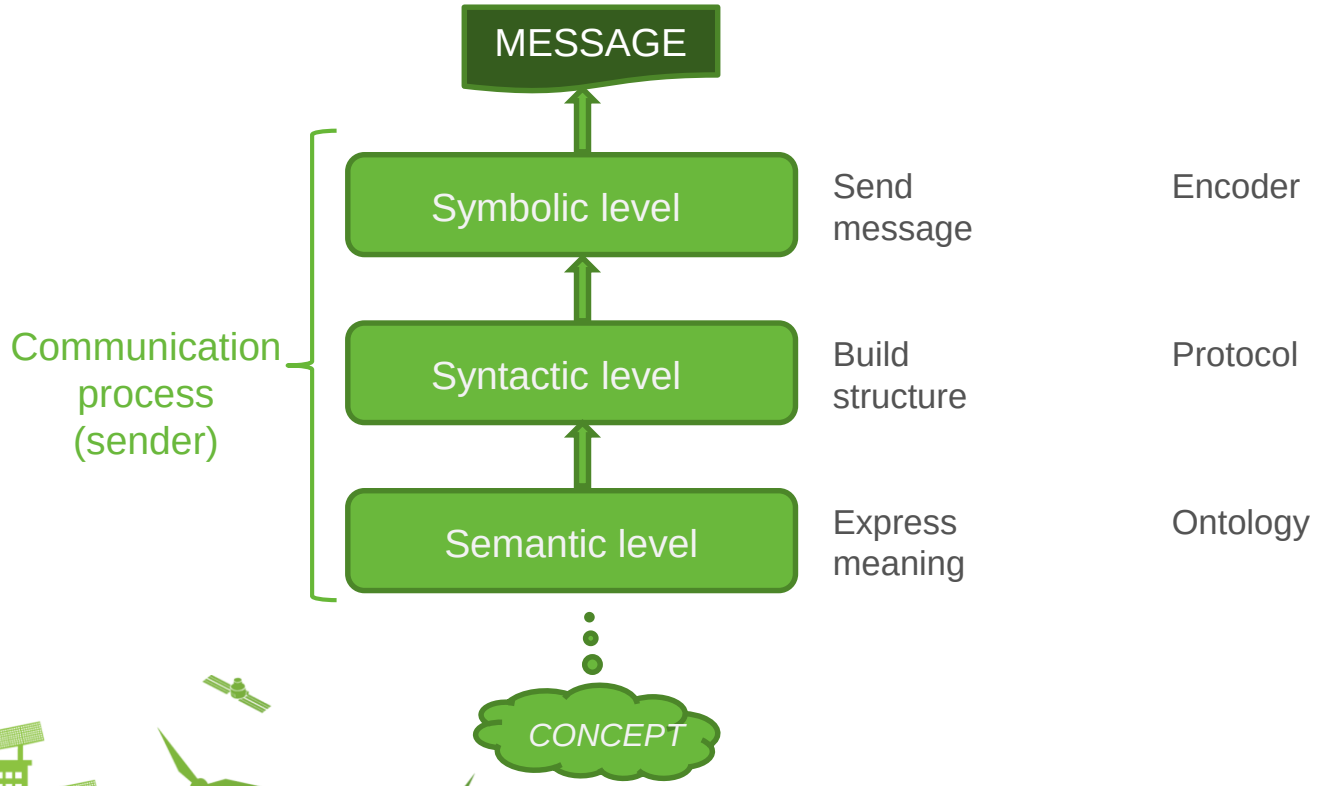
More in detail: sender



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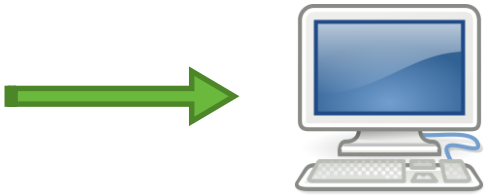
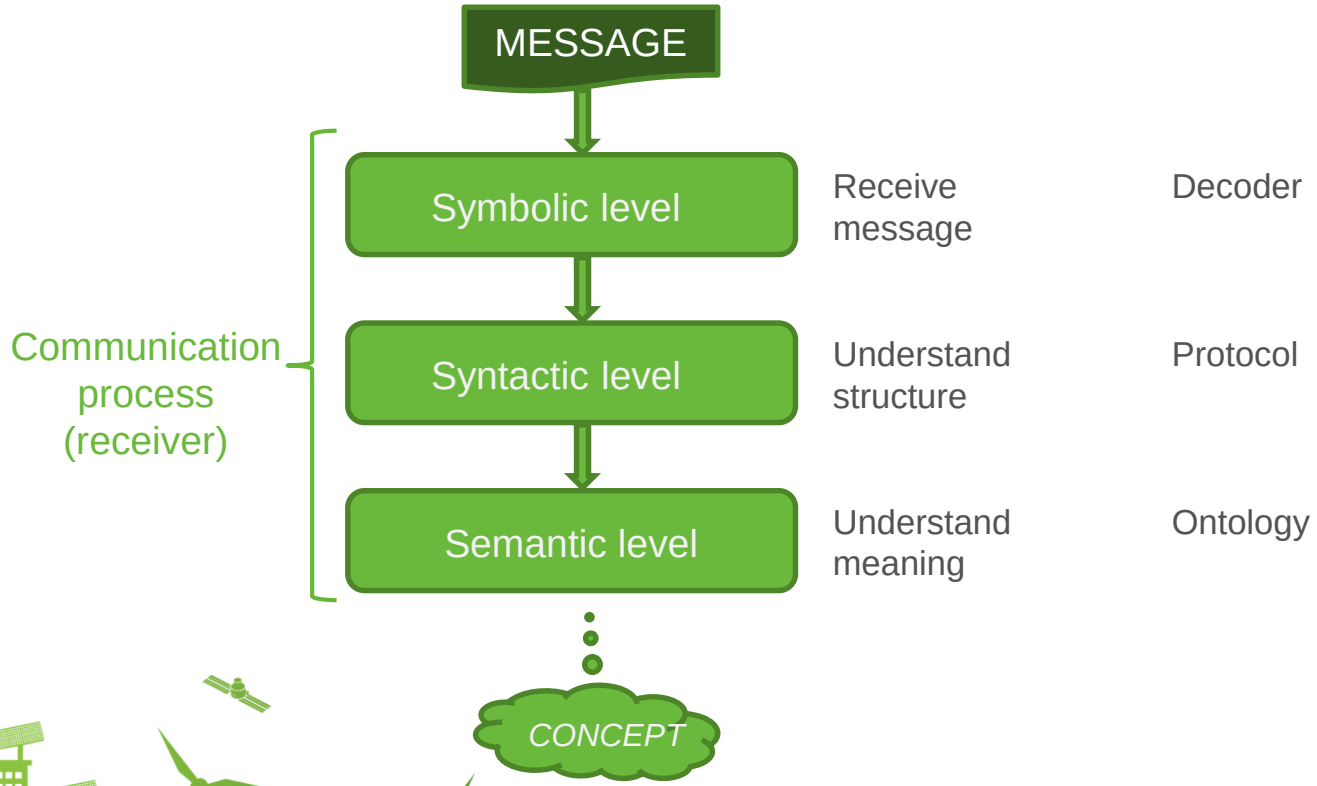


More in detail: receiver



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The problem of semantic interoperability

- A good solution can be to base the semantic level on an Ontology, that is a structure including a set of concepts and the relationships between them.
- It is a way to allow computers to understand each other, exactly the same as human beings do.
- It is not even a new idea: Ontologies are there since 30 years and more. However, today we have the adequate assets (computer with high speed and large memory) and infrastucture (ubiquitous Internet offering wide-band connectivity) to deploy it in real-life large-scale applications.

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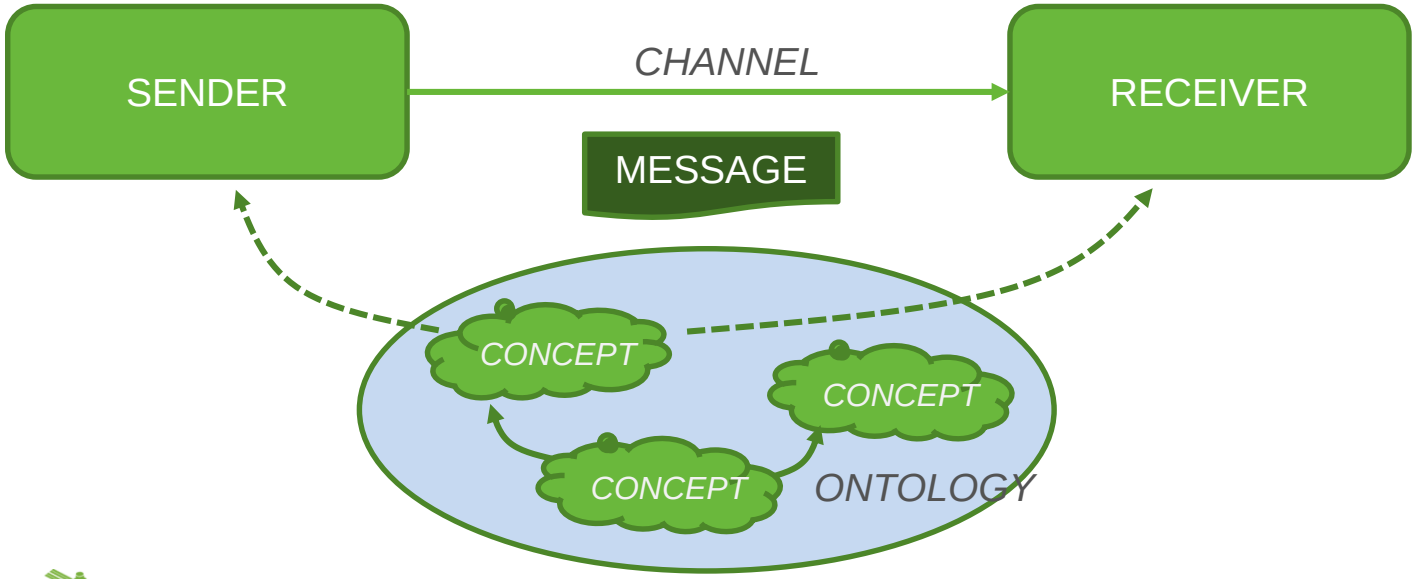
Machine-to-machine communication

Communication process



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Semantic interoperability benefits

- The Ontology can be easily distributed and shared, so it can become the common reference for all applications needing to exchange and understand information, in a specific domain.
- Moreover, the Ontology can be easily extended and modified, without impact on the software of applications using it.
- It is an ideal solution to ensure that heterogeneous, distributed information systems can exchange meaningful information and use it in order to cooperate in achieving a common objective, as part of the same echosystem

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Multimodal transportation services

- This is exactly the type of scenario we face when considering door-to-door transportation services, which need to combine several modes of transport in order to provide a complete journey solution to the traveller.
- The requested application will need to work with a large number of different actors, each having legacy information systems based on heterogeneous protocols and languages.
- To force all of such actors to feed their data into a centralised repository or change their systems to conform to a common protocol and language would be an unmanageable and practically impossible task, with no guarantee of success.

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- As a project dealing with multimodal door-to-door transportation services, it is no surprise that IT2Rail decided to go into the direction of semantic interoperability, in order to include all needed actors into a single echosystem of cooperating applications, thanks to the capability of non-ambigously understanding each other offered by the Ontology.
- Having the Ontology at its centre, the semantic interoperability solution developed by IT2Rail, completed with some additional artefacts, has been named Interoperability Framework.

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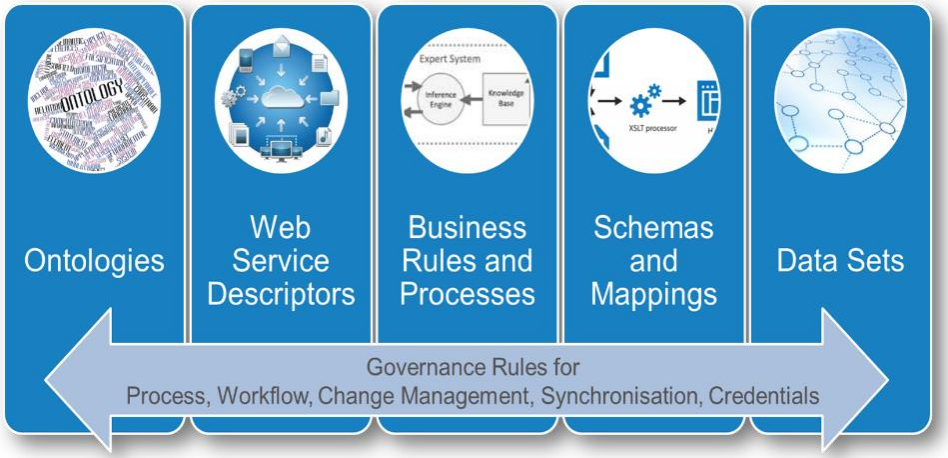
Interoperability Framework

- The IF consists of Ontologies and other Assets which allow to properly interface existing data sets with the semantic environment, using them in accord with specific business rules, with remote access through the Web



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IF Technology Assets - 1

- **Ontologies**: formal specifications of shared conceptualizations of specific domains (or a part of them). An example is the IT2Rail ontology that is an OWL specification of the set of concepts and relationships among them that the IT2Rail partners have proposed as a conceptualization of the transportation domain.
- **OWL** (Ontology Web Language) is a specific language based on XML. It allows to express the Ontology concepts and relationships in a machine-processable format.

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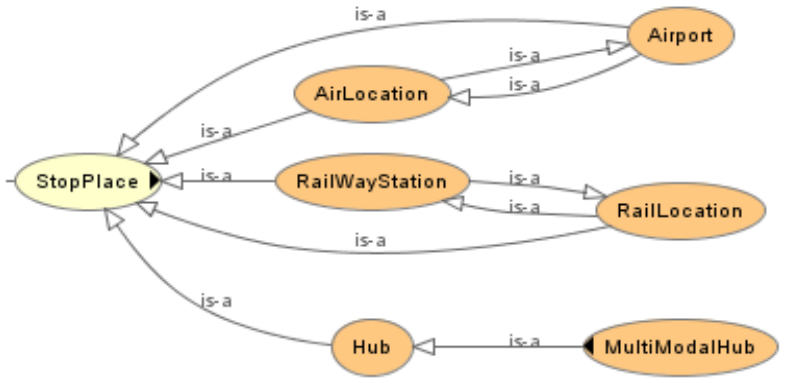
IF Technology Assets - 1




```
<owl:Class rdf:ID="System">
    <rdfs:subClassOf>
      <owl:Restriction>
        <owl:onProperty
rdf:resource="#hasSystem"/>
        <owl:someValuesFrom
rdf:resource="&core;System"/>
      </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
      <owl:Restriction>
        <owl:onProperty
rdf:resource="#OperatedBy"/>
        <owl:allValuesFrom
rdf:resource="&core;TrainOperatingCompany"/>
      </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
      <owl:Restriction>
        <owl:onProperty
rdf:resource="#OperatedBy"/>
        <owl:someValuesFrom
rdf:resource="&core;TrainOperatingCompany"/>
      </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf rdf:resource="&owl;Thing"/>
  </owl:Class>
```

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IF Technology Assets - 2

- **Web Service Descriptors**: metadata descriptions of the functionalities offered by specific Web services and their binding information. An example is a Travel Expert service descriptor that contains a pointer to the **WSDL** specification of the Travel Expert Web service and the specification of the offered functionalities each described by a name, required/optional parameters, output, supported passenger categories and WS security protocol
- **WSDL** (Web Services Description Language) is a language for describing Web Services interfaces. It allows to describe the services provided by a Service Provider, so that a Service Consumer can use them.
- Web Service messages can be defined using **SOAP**, **REST** or **JSON**

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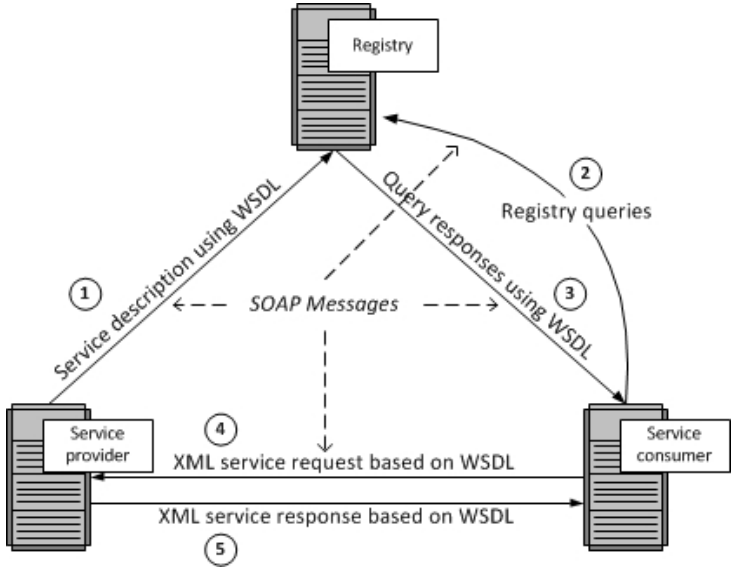
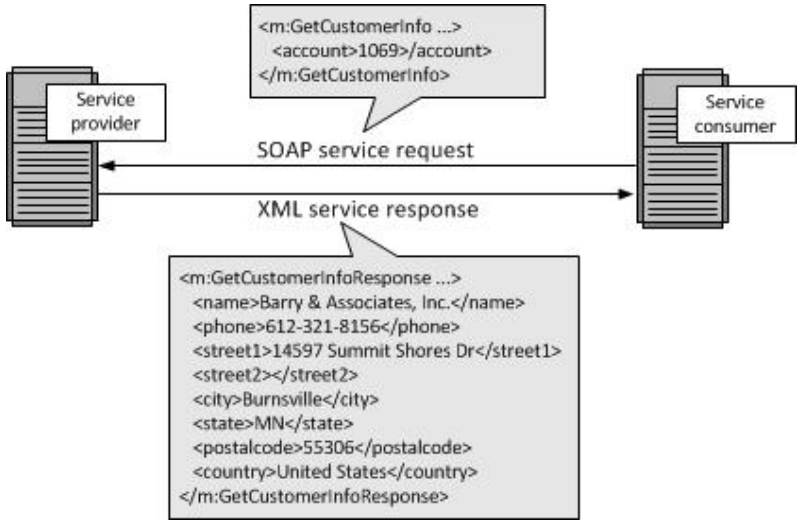
IF Technology Assets - 2





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IF Technology Assets - 3

- **Business Rules and Processes**: inference rules and processes that characterize a specific standard and/or a system adopting it. An example is the business process enabled by the Full Service Model (FSM) specification where the booking of a railway ticket is articulated into three main steps named offering, pre-booking and booking.
- Several languages exist which can be used to define rules, like the **SWRL** (Semantic Web Rule Language). Rules can also be embedded in queries using specific languages like **SPARQL**.
- **SPARQL** is the query language of the Semantic Web.

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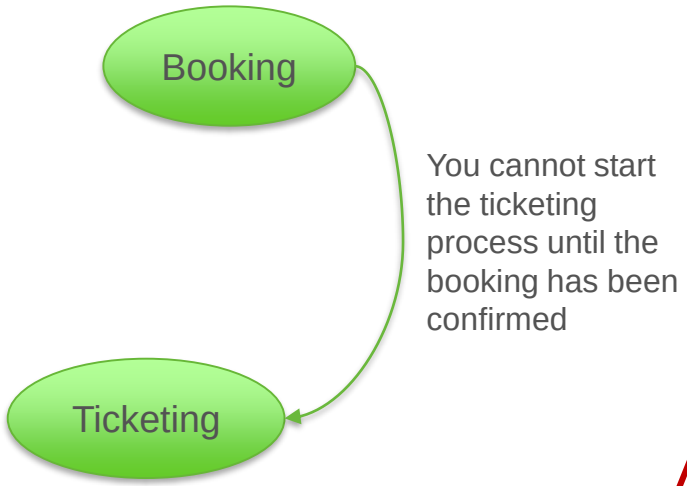
IF Technology Assets - 3

<Example of a Business rule>



<Example of a SPARQL query>

```
PREFIX foaf:  <http://xmlns.com/foaf/0.1/>
PREFIX card:
<http://www.w3.org/People/Berners-
Lee/card#>
SELECT ?homepage
FROM <http://www.w3.org/People/Berners-
Lee/card>
WHERE {
    card:i foaf:knows ?known .
    ?known foaf:homepage ?homepage .
}
```

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IF Technology Assets - 4

- **Schemas and Mappings**: schemas or mappings between schemas/ontologies aiming at supporting the technical interoperability between services/systems in the transportation domain adopting different standards. Examples are the UIC918 suite of standards in XSD Schema and its mappings, e.g. the IT2Rail ontology.

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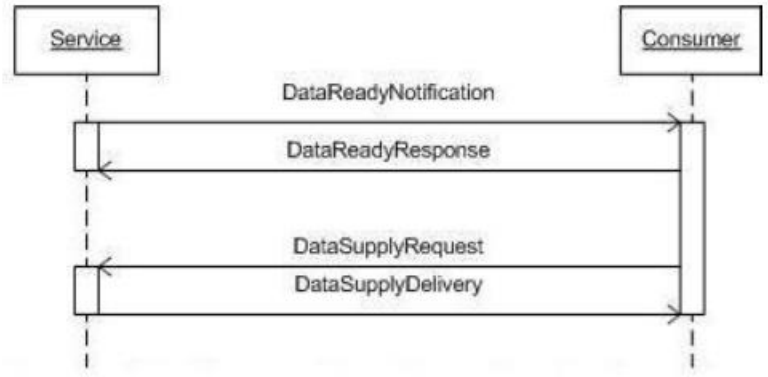
IF Technology Assets - 4




```
<?xml version="1.0" encoding="UTF-8"?>
- <con:soapui-project xmlns:con="http://eviware.com/soapui/config" runType="SEQUENTIAL"
  abortOnError="false" soapui-version="5.4.0" resourceRoot="" name="NeTEX-Producer"
  activeEnvironment="Default" id="8e59a7e9-5991-4552-b106-19440df7f5f3">
      <con:settings/>
    - <con:interface name="NetexProducerDocBinding" id="1399174d-5489-475e-ab9c-397d713284aa"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      definition="http://localhost:8080/it2rail-netex-provider/services/SiriWSPort?wsdl"
      anonymous="optional" soapVersion="1_1" bindingName="{http://www.siri.org.uk/siriWS}
      NetexProducerDocBinding" type="wsdl" xsi:type="con:WsdlInterface" wsaVersion="NONE">
          <con:settings/>
        - <con:definitionCache type="TEXT" rootPart="http://localhost:8080/it2rail-netex-
          provider/services/SiriWSPort?wsdl">
            - <con:part>
                <con:url>http://localhost:8080/it2rail-netex-provider/services/SiriWSPort?
                  wsdl</con:url>
              - <con:content>
                  + <![CDATA[]]>
                </con:content>
                <con:type>http://schemas.xmlsoap.org/wsdl/</con:type>
              </con:part>
            - <con:part>
                <con:url>http://localhost:8080/it2rail-netex-provider/services/SiriWSPort?
                  xsd=../NeTEx_siri.xsd</con:url>
              - <con:content>
```

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IF Technology Assets - 5

- **Data Sets**: data sets associated with their semantics, i.e. “annotated” semantic graphs, providing certain specific information of the transportation domain that needs to be shared by all actors engaged in distributed computational tasks, e.g. coding conventions used for common objects, such as Stop Places, by different systems or transportation modes. This asset type presents two levels: the semantics of the dataset and the data included into the dataset.

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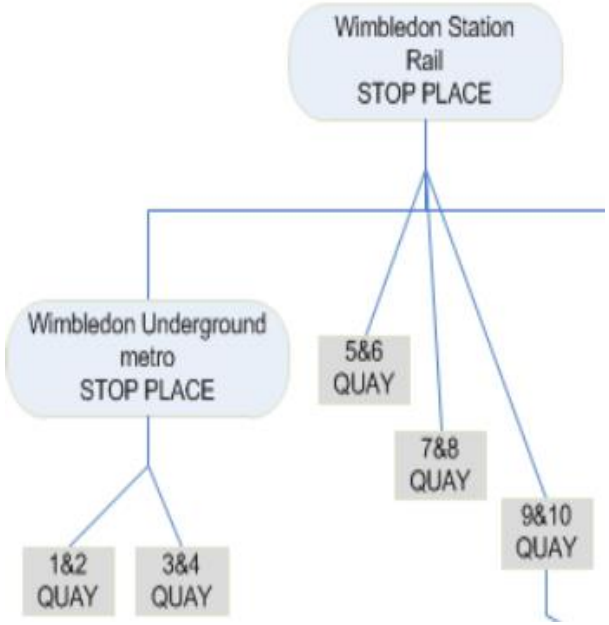
IF Technology Assets - 5




```xml
<?xml version="1.0" encoding="UTF-8"?>
<railml xmlns:xsi=http://www.w3.org/2000/10/XMLSchema-instance
xsi:noNamespaceSchemaLocation="timetable.xsd">
    <timetable version="1.1">
        <train trainID="RX 100.2" type="planned"  source="opentrack">
            <timetableentries>
                <entry posID="ZU" departure="06:08:00" type="begin"/>
                <entry posID="ZWI" departure="06:10:30" type="pass"/>
                <entry posID="ZOER" arrival="06:16:00" departure="06:17:00"
                            minStopTime="9" type="stop"/>
                <entry posID="WS" departure="06:21:00" type="pass"/>
                <entry posID="DUE" departure="06:23:00" type="pass"/>
                <entry posID="SCW" departure="06:27:00" type="pass"/>
                <entry posID="NAE" departure="06:29:00" type="pass"/>
                <entry posID="UST" arrival="06:34:30" type="stop"/>
            </timetableentries>
        </train>
    </timetable>
</railml>
```

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Interoperability Scope

- With the Interoperability Framework, IT2Rail achieved the objective to make data relevant to the multimodal transportation services really available to and understandable by computers
- The real scope of interoperability is not the «data exchange», which today is rather easy to achieve, but the capability to make data meaningful for all the involved actors.

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A European Priority

- European **Interoperability** Framework: https://ec.europa.eu/isa2/eif_en
- Directive (EU) 2016/797 on the **interoperability** of the rail system within the European Union
- Commission Regulation on the technical specification for interoperability relating to the subsystem '**telematics applications for passenger services**' of the trans-European rail system
- Directive 2010/40/EU on the framework for the deployment of **Intelligent Transport Systems** in the field of road transport and for interfaces with other modes of transport
- Regulation (EU) 1315/2013 (**Trans-European Transport Network**)
- **WHITE PAPER** Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system

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Standardisation Scope

- The European Commission wants to establish a complete framework of harmonised standards (supporting the relevant legislation) which can represent a reference for the industry and the society.
- In this way, following such standards offers to users a presumption of conformity to the relevant legislation.
- However, the application of standards is in most cases completely voluntary.
- Only when a standard is explicitely referenced in a regulatory document, its application becomes mandatory.

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Benefits of standards

- To collect state-of-art expertise and knowledge from some of the best experts in the sector, as well as many years of experience on the subject
- To enable compatibility and interoperability of components, products and services
- To guarantee an adequate level of quality and safety
- To accomplish with requirements coming from regulations
- To be a reference in the customer/supplier relationship
- To be a starting point for product development, reducing development costs
- To lower market access barriers
- To foster fair competition
- To support innovation by providing a basis for developing new solutions

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Limits of standards

- A standard can guarantee a good level of interoperability as long as all actors participating in the system use it.
- Unfortunately, it happens sometimes that more than one applicable standard exist in the same domain.
- This is for sure the case of multimodal transport services, as they involve many actors from different sectors, which used to work isolated from each other and developed independently their own solutions and standards.
- The problem for IT2Rail was to allow communication between all actors, whatever solution (standard or not) they were already using.

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Data exchange standards in the transport domain

TS 17118
OPEN API

TS 13149
ITxPT

TS 16614
NeTEx

EN 12896
TRANSMODEL

EN 15531
SIRI

UIC 918

GTFS

Full Service
Model

railML

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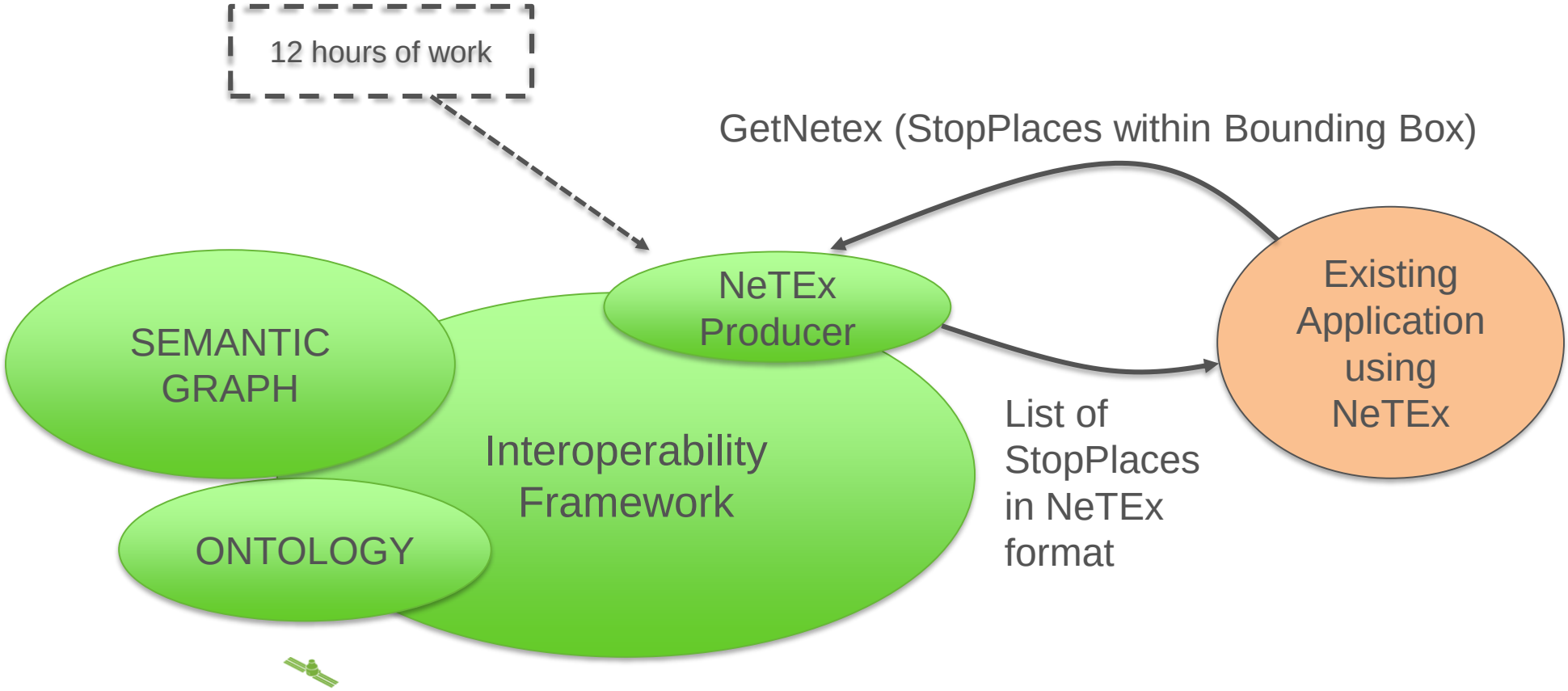
An example



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Goal achieved!

- The Interoperability Framework achieved its goal, as it allows to easily adapt existing systems, enabling them to become part of the overall multimodal echosystem.
- The IF can be seen as a kind of «meta-standard» which is able to make information systems understand each other even when they follow different standards.
- The additional cost to make a new system compatible with the other ones is very limited, so making interoperability economically feasable. Moreover, such cost does not depend on the size of the overall system, making the system itself easily scalable.

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Digital

Multimodal
Ticketing
Tracking
Web of Transportation
Travel Companion
One-stop Shop
Technical Enabler
Cloud
Re-accommodation
Attractive Railway Services
Connectivity
Interoperability
Innovation
Open Interfaces
Door to Door
Seamless Travel
Business Analytics
Shopping
Real time

Thank you very much for your kind attention

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